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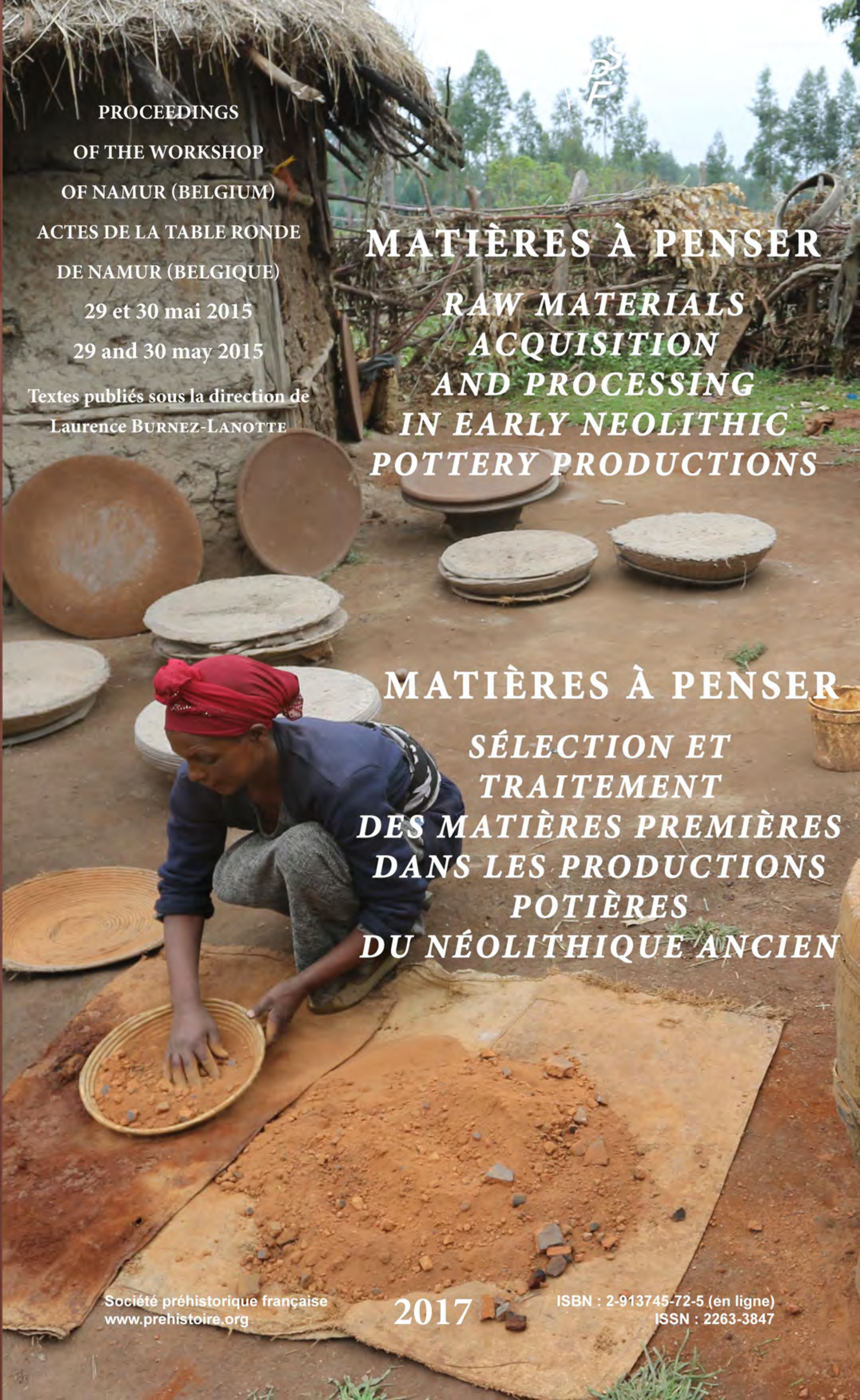

PROCEEDINGS
OF THE WORKSHOP
OF NAMUR (BELGIUM)
ACTES DE LA TABLE RONDE
DE NAMUR (BELGIQUE)
29 et 30 mai 2015
29 and 30 may 2015

Textes publiés sous la direction de
Laurence Burnez-Lanotte

MATIÈRES À PENSER

RAW MATERIALS ACQUISITION AND PROCESSING IN EARLY NEOLITHIC POTTERY PRODUCTIONS

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SÉLECTION ET TRAITEMENT DES MATIÈRES PREMIÈRES DANS LES PRODUCTIONS POTIÈRES DU NÉOLITHIQUE ANCIEN

Société préhistorique française
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Avant-propos / *Foreword*

Laurence Burnez-Lanotte

« Matières à penser : sélection et traitement des matières premières dans les productions potières du Néolithique ancien » est le titre de la séance de la Société préhistorique française organisée en Belgique par le Laboratoire interdisciplinaire d'anthropologie des techniques (LIATEC, Université de Namur) et l'équipe « Trajectoires. De la sédentarisation à l'État », CNRS-université Paris 1 (UMR 8215). Elle s'est déroulée les 29 et 30 mai 2015 à l'université de Namur et a bénéficié du concours du Fonds national de la Recherche scientifique belge, de l'Académie universitaire de Louvain (Belgique) et du programme Marie-Curie de la Commission européenne. Nous adressons nos plus vifs remerciements envers l'ensemble du comité d'organisation de cette réunion : D. Bosquet (Service Public de Wallonie, Belgique), E. Goemaere (Service géologique de Belgique, Institut royal des Sciences naturelles de Belgique), O. Gosselain (Centre d'Anthropologie Culturelle, Université libre de Bruxelles), A. Livingstone Smith (Musée royal de l'Afrique centrale, Bruxelles) et plus particulièrement à B. van Doosselaere (LIATEC, Université de Namur et UMR 8215 Trajectoires. De la sédentarisation à l'état) qui a été la cheville ouvrière de cette rencontre. La séance a également été soutenue par un comité scientifique international : F. Giligny (université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), M. Golitko (The Field Museum Chicago, USA), M. Ilett (université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires) et J. Yans (université de Namur).

L'intérêt de cette réunion est dû à la grande qualité des interventions des 33 conférenciers (issus de 13 instituts scientifiques et universités provenant de 7 pays européens différents et des États-Unis ; Van Doosselaere et Burnez-Lanotte, 2015) et d'une vingtaine de chercheurs français et étrangers qui ont participé aux discussions ; celles-ci ont été prolongées par une demi-journée d'examen microscopique de lames minces issues de matériaux argileux appartenant à des poteries provenant de diverses régions d'Europe. En tout, seize communications ont été présentées en anglais et en français.

Les premières communautés agropastorales néolithiques d'Europe nord-occidentale et centrale sont caractérisées en tant qu'entités chronoculturelles par les variations des attributs morphostylistiques de leurs poteries en rapport avec des contextes immobiliers spécifiques. Incontestablement, la polarisation des recherches sur la constitution, essentielle, d'un cadre chronologique par des analyses classificatoires et diachroniques s'est faite au détriment des approches technologiques, par ailleurs développées de manière très significative pour d'autres catégories de vestiges, et en particulier pour les industries lithiques. Depuis seulement une trentaine d'années, la caractérisation des méthodes de fabrication et les modes d'usage des poteries néolithiques se développe, en s'appuyant sur l'ethnologie des techniques, l'archéologie expérimentale, l'ethnoarchéologie et l'archéométrie. Ce déploiement s'inscrit dans les nouveaux enjeux interdisciplinaires et anthropologiques des néolithiciens qui portent un intérêt plus marqué aux problématiques liées aux fonctionnements sociaux, aux formes d'organisations économiques, aux réseaux d'échanges, et aux processus de transmission et d'innovation.

En Europe du Nord-Ouest, les études morphostylistiques des assemblages céramiques des débuts du Néolithique ont tenu un rôle central dans les nombreux débats qui ont animé la communauté scientifique sur les rapports chrono-culturels entre Mésolithique final, culture à Céramique linéaire (*Linearbandkeramik*, LBK), céramiques du Limbourg et de La Hoguette, et culture de Blicquy/Villeneuve-Saint-Germain (BQ/VSG). Aujourd'hui, les mécanismes de ces successions restent discutés dans la mesure où ils sont liés aux processus de diffusion, de transfert et d'assimilation supposés entre les différentes entités mésolithiques, danubiennes et même pour certains, d'origine méridionale.

La séance qui s'est déroulée à l'université de Namur aborde ces problématiques par le biais de l'approche technologique de la poterie. Au sein du système technique de la poterie, l'identification, la caractérisation et le traitement des matières premières a constitué notre voie d'approche, en gardant comme fil conducteur la chaîne opératoire de fabrication des différentes vaisselles. Plus spécifiquement, les paramètres relatifs à l'exploitation des sources et aux modalités de leur traitement sont interrogés comme clé de lecture de la production-distribution-consommation des vases, afin d'aborder les comportements socio-économiques qui les sous-tendent dans des contextes néolithiques et ethnographiques diversifiés : comment caractériser la circulation et la non-circulation des différentes poteries au sein de chaque ensemble culturel ? Comment mettre en évidence les quantités et les distances concernées? Y at-il des lieux potentiels pour des échanges ? Quels en sont les termes et les finalités ?

Avec comme point de départ une attention particulière à l'étude des modes d'acquisition et de préparation des matières premières dans le contexte des productions céramiques du Néolithique européen (*ca* 6000-2200 cal. BC) et sans prétendre à une inconcevable exhaustivité, cette table ronde s'est centrée sur les recherches en cours, les méthodes analytiques et les modèles interprétatifs que focalisent les premières étapes de fabrication des poteries dans différents contextes chronologiques et culturels. L'accent est mis sur les approches archéométriques, expérimentales, archéologiques et ethnoarchéologiques, mises en œuvre dans une perspective interdisciplinaire. Les nouvelles données techniques relatives à la sélection et aux traitements des matériaux argileux s'articulent à des questions plus larges comme : la localisation et la gestion des aires d'exploitation, les performances techniques, les finalités fonctionnelles, les échanges de biens, mais aussi les dimensions culturelles et/ou symboliques des matériaux transformés, la transmission des savoirs et savoir-faire et, plus largement, tout ce qui relève de l'organisation des communautés de producteurs et de consommateurs de la poterie au Néolithique et en contextes ethnographiques.

Les neuf articles qui composent cet ouvrage ont été rassemblés en quatre sections.

La première est consacrée à l'approche ethnoarchéologique. Dean E. Arnold montre, sur la base d'exemples de productions potières latino-américaines très documentées, la pluralité des éléments qui interagissent pour expliquer les choix des potiers dans la sélection des matériaux bruts. La complexité des motivations qui sous-tendent ces pratiques renvoient effectivement à des facteurs temporels, sociaux, comportementaux, techniques et environnementaux variés. La prudence s'impose donc vis-à-vis de la surinterprétation (en particulier en termes sociaux) des différences de composition chimique des pâtes céramiques. Le deuxième article présente les recherches actuellement conduites par les membres de plusieurs équipes (UMR 5608 Traces, UMR 5060, UMR 6273, UMR 7269 LAMPEA) autour de J. Cauliez, C. Manen, V. Ard et J. Caro, en collaboration avec les communautés de potières en Éthiopie, dans la vallée du Rift, en région Oromiya. Ce programme original vise à relier de manière explicite certaines questions posées au niveau des céramiques archéologiques et une problématique ethnoarchéologique. Un des axes de ce projet développé ici consiste dans l'étude ethnoarchéologique des procédés techniques qui apporteront à court terme un référentiel conséquent et bien documenté. Les premiers résultats obtenus permettent d'affiner les protocoles analytiques des séries néolithiques et ouvrent des perspectives pertinentes sur la relation entre les choix opérés dans la préparation des argiles, la qualité des produits céramiques façonnés et certains paramètres sociaux tels que l'ethnicité, la composition des unités de production, etc.

La section suivante se focalise sur les rapports entre les procédés de sélection des matériaux argileux et les traditions techniques depuis l'est jusqu'au sud de l'Europe. M. Spataro réalise une synthèse des analyses pétrographiques et géochimiques de plus de 1000 échantillons de poterie d'Europe du Sud et du Sud-Est datant du Néolithique ancien et moyen. Les résultats technologiques permettent de caractériser différents traitements appliqués aux matériaux argileux et soulèvent des questions importantes concernant les dynamiques culturelles (traditions, innovations, résistances, imitations) à l'œuvre dans la céramique imprimée et dans les productions potières des cultures de Starčevo-Cris, Danilo/Hvar, Vinča et Korenovo.

A. Czekaj-Zastawny, S. Kadrow et A. Rauba-Bukowska sur la base des analyses minéralogiques et pétrographiques de la céramique examinent les relations entre la culture à Céramique linéaire (LBK) de la région de Cracovie en Petite-Pologne occidentale et la culture à Céramique linéaire de l'Alföld (*Alföld Linear Pottery Culture* : ALPC) de la région à proximité des frontières slovaco-hongroises. Les résultats permettent d'aborder très finement les variations technologiques de la poterie aux différentes étapes de la LBK au sein de groupes régionaux distincts. Ces données révèlent avec beaucoup de pertinence la variabilité technologique et stylistique des mécanismes (emprunt, imitation, échanges d'objets et d'idées) qui sous-tendent les interactions entre les communautés potières de la LBK et de l'ALPC, et qui dynamisent leur évolution culturelle. Pour le Néolithique ancien du sud de l'Europe, L. Angeli et C. Fabbri développent les analyses archéométriques des productions céramiques imprimées du site de Colle Santo Stephano, Ortucchio (L'Aquila, Abruzzes), le plus ancien gisement agro-pastoral identifié dans les Abruzzes (Italie). La description de la matrice argileuse et des inclusions non plastiques par le biais des analyses minéralogiques et pétrographiques en lames minces, croisée avec les résultats d'études technologiques et typomorphologiques des vaisselles, aboutissent à des données très convaincantes sur l'identification, la localisation et les traitements des sources argileuses en relation avec la structure globale des productions céramiques locales traditionnelles et celle des vases d'affinités exogènes (céramique imprimée du faciès de *Guadone* de l'Italie méridionale). De plus, une caractérisation du décor chromatique de la céramique peinte à l'aide d'analyses spectroscopiques Raman et LIBS *(Laser Induced Breakdown Spectroscopy*) met en évidence des choix techniques spécifiques, comme l'utilisation de pigment noir à base d'oxyde de manganèse par les groupes de la céramique *figulina* trichrome du Néolithique moyen.

Dans la troisième section, les structures spatiales et sociales des productions céramiques sont envisagées. Tout d'abord, A. Kreiter et ses collègues étudient les vaisselles de huit unités d'habitation issues du village néolithique de Balatonszárszó-Kis-erdei-dűlő (culture à Céramique linéaire de l'Ouest de Carpates). Les céramiques font l'objet d'une approche analytique plurielle qui s'appuie sur la mise en relation systématique des variations spatiales, chronologiques et stylistiques des choix préférentiels qui concernent : d'une part, les matières premières argileuses et les dégraissants (caractérisées par des analyses pétrographiques), et d'autre part, les différentes pratiques de façonnage à l'échelle des maisonnées. Les résultats obtenus démontrent avec finesse et pertinence la dynamique de fonctionnement socio-économique des communautés de potiers de chaque maisonnée au sein des différentes phases de l'habitat. Cette même problématique est abordée par L. Gomart en collaboration avec C. Constantin et moi-même au sein des productions céramiques rubanées de deux villages de référence. L'analyse des variations spatiales ou chronologiques des recettes de pâtes, croisées avec les méthodes de façonnage, aboutit à des résultats socioculturels originaux de part et d'autre. À Cuiry-lès-Chaudardes (Picardie, France), les potiers conservent les pratiques de façonnage transmises au sein d'un même réseau d'apprentissage alors qu'ils sont susceptibles d'accommoder leurs recettes de pâtes en interaction avec d'autres groupes de potiers selon, par exemple, la localisation de leur activité ou le type de vase réalisé. La production potière à l'échelle de la maisonnée est prise en charge par plusieurs groupes de producteurs, dont les dynamiques d'implantation varient au court des différentes phases d'habitat. À Rosmeer (Limbourg, Belgique), les analyses mettent en évidence des mécanismes d'imitation stylistique et de transferts techniques complexes entre deux groupes de potiers, les uns fabricant communément les vases rubanés et les autres, les céramiques dîtes du Limbourg.

La dernière section est centrée sur les outils analytiques de caractérisation des matériaux argileux dans leur capacité à expliquer l'origine et les traitements des matériaux. D. Jan et X. Savary proposent de faire progresser l'identification des empreintes fines engendrées par l'utilisation de dégraissants végétaux dans les pâtes de céramiques du Néolithique ancien et moyen de Basse-Normandie (LBK, BQ/VSG, Cerny et Chasséen) en utilisant le microscope polarisant. Ces observations sont effectuées sur un corpus très conséquent de céramiques archéologiques mais aussi sur un référentiel expérimental sans équivalent pour le nord-ouest de l'Europe, réalisé à partir d'espèces végétales identifiées dans les pâtes (mousse, pavot, lin) et d'autres, comme les restes céréaliers, susceptibles d'y avoir été également introduits. Les caractères morphologiques observés et comparés permettent d'établir des critères de différenciation des dégraissants végétaux pour atteindre une grande acuité dans la détermination qui, par exemple pour les mousses, peut aboutir jusqu'au genre, voire à l'espèce. Ces données originales tracent les apparitions et disparitions des différents dégraissants au cours du Néolithique, en relation ou non avec certaines formes, des décors spécifiques, et des groupes d'argiles, ouvrant des interprétations cruciales en termes de circulation de personnes et d'échanges d'idées.

Enfin, dans les problématiques de différenciation de l'origine des matières premières argileuses des pâtes céramiques, B. Gehres et G. Querré présentent les dernières avancées méthodologiques réalisées à l'aide de la technique du LA-ICP-MS (*Laser Ablation Inductively Coupled Plasma Mass Spectrometry* ; spectromètre de masse à source plasma, couplé à un système de prélèvement par ablation laser). À travers plusieurs exemples issus du Néolithique ancien au second âge du Fer dans le Massif armoricain, ils démontrent que par l'identification de certains minéraux traceurs inclus dans les pâtes des terres cuites, il est possible de différencier les productions d'ateliers distincts et d'identifier précisément les sources des matières premières argileuses.

Pour clore cette introduction, je souhaite insister avec plaisir et gratitude sur le caractère collectif de l'édition scientifique des actes de cette séance. Il m'est particulièrement agréable de remercier celles et ceux qui ont accepté de réaliser le travail des relectures et des échanges critiques et constructifs avec les différents auteurs, en y consacrant toutes les compétences, l'énergie et la disponibilité utiles ; sans eux, la publication de cette séance n'aurait pas pu être mise en oeuvre : D. Binder (CNRS, UMR 6130 CEPAM), C. Constantin (CNRS, UMR 8215 Trajectoires), F. Convertini (INRAP, UMR 7269 LAMPÈA), G. Fronteau (université de Reims), A. Gallay (Université de Genève), F. Giligny (université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), E. Goemare (Institut royal des Sciences naturelles de Belgique), L. Gomart et C. Hamon (CNRS, UMR 8215 Trajectoires), M. Ilett (université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), C. Manen (CNRS, UMR 5608 TRACES), R. Martineau (CNRS, UMR 6298 ArTeHiS), S. Mery (CNRS, UMR 6566), D. Michelet (CNRS, UMR 8096 ArchAm), T. Nicolas (INRAP, UMR 8215 Trajectoires), V. Roux (CNRS, UMR 7055 Préhistoire et Technologie), J. Vaquer (CNRS, UMR 5608 TRACES) et J. Yans (université de Namur). Nos remerciements s'adressent naturellement à la Société préhistorique française qui a fortement contribué à l'élaboration de cet ouvrage et a accepté sa publication dans la collection des séances en ligne. Plus particulièrement, nous adressons un grand merci à C. Manen (CNRS, UMR 5608; vice-présidente de la Société préhistorique française) et J.-M. Pétillon (CNRS, UMR 5608, Toulouse; secrétaire général de la Société préhistorique française). Une mention particulière s'adresse à M. Ilett (université Paris I – Panthéon-Sorbonne; UMR 8215, Trajectoires) : nous lui devons un amical soutien, notamment dans les discussions éditoriales, pour la traduction de cet avant-propos et pour ce qui est de la qualité de l'expression anglaise de plusieurs articles. Notre reconnaissance est également due à notre reconnaissance est également due à D. Beucher, L. Mevel (UMR 7041 ARSCAN Ethnologie préhistorique; responsable du site internet de la Société préhistorique française) et M. Sauvage (CNRS, USR 3225), secrétaire de rédaction du *Bulletin de la Société préhistorique française*, pour la qualité de son travail. G. Palumbo, doyen de la faculté de philosophie et lettres de l'université de Namur a soutenu le travail d'édition grâce à la collaboration de E. Debu et C. Masse. M. Rhoda-Allanic a assuré la relecture et la traduction de la majorité des textes en anglais. Enfin, J.-P. Collin (université de Namur) a contribué à la révision des figures et tableaux.

'Matières à penser: selection and treatment of raw materials in the production of Early Neolithic pottery' is the title of a Société préhistorique française session organised in Belgium by the Laboratoire interdisciplinaire d'anthropologie des techniques LIATEC, Université de Namur and the 'Trajectoires. De la sédentarisation à l'État' team, CNRS-Université Paris 1 (UMR 8215). It took place on the 29th and 30th of May, 2015, at the Université de Namur with funding from the Fonds National de la Recherche Scientifique belge, the Académie Universitaire de Louvain (Belgium), and the European Commission's Marie Curie Programme. We wish to express our sincerest thanks to the members of the organising committee: D. Bosquet (Service Public de Wallonie), E. Goemaere (Institut Royal des Sciences Naturelles de Belgique), O. Gosselain (Centre d'Anthropologie Culturelle, Université libre de Bruxelles), A. Livingstone Smith (Musée royal de l'Afrique centrale à Bruxelles), and most particularly to B. Van Doosselaere (Université de Namur LIATEC and UMR 8215 Trajectoires) who was the driving force behind the meeting. The session was also backed by an international scientific committee: F. Giligny (Université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), M. Golitko (The Field Museum, Chicago USA), M. Ilett (Université Paris 1 Panthéon-Sorbonne, UMR 8215 Trajectoires) and J. Yans (Université de Namur).

The success of the meeting was due to the quality of the contributions from the 33 speakers (representing 13 scientific institutions and universities from 7 European countries as well as from the USA; Van Doosselaere and Burnez-Lanotte, 2015) and to the 20 or so other researchers from various countries who attended and participated in the discussions. The session was extended by a half-day devoted to the microscopic examination of clay thin sections from pottery from various parts of Europe. In total, 16 papers were submitted for publication in English and French.

As chrono-cultural entities, the first Neolithic agro-pastoral societies of north-western and central Europe are characterised by variations in the morpho-stylistic attributes of their ceramics, in relationship with a range of specific site contexts. Unquestionably, the focus of research on building chronological frameworks, through essential classificatory and diachronic analyses, occurred to the detriment of the technological approaches extensively applied to other types of archaeological find, particularly lithics. It is only over the past 30 years that characterisation of the production methods and use patterns of Neolithic pottery has developed, based on ethnology of techniques, experimental archaeology, ethnoarchaeology and archaeometry. This development offers new interdisciplinary and anthropological challenges for Neolithic researchers interested in the functioning of societies, forms of economic organisation, exchange networks and processes of transmission and innovation.

In north-western Europe, morpho-stylistic studies of ceramic assemblages from the beginning of the Neolithic have played a central role in numerous debates that have enlivened the scientific community regarding the chrono-cultural relationships between the late Mesolithic, the Linearbandkeramik (LBK) culture, Limbourg and La Hoguette ceramics, and the Blicquy/Villeneuve-Saint-Germain (BQ/VSG) culture. Today, the mechanisms underlying these sequences are still a matter of debate, as they relate to the processes of diffusion, transfer and presumed assimilation between the various Mesolithic, Danubian and, in some cases, even southern European cultural entities.

The session held at the University of Namur tackled these research questions through a technological approach to the pottery. Within the ceramic technical system, the identification, characterisation and treatment of raw materials constitute our angle of approach, while the *chaîne opératoire* for the fabrication of the different vessels acts as a common thread. More specifically, parameters relating to the exploitation of resources and to the modalities of their treatment are interrogated as a key to understanding the production/distribution/consumption of the vessels, with a view to tackling the underlying socio-economic behaviour in various Neolithic contexts. How can we characterise the circulation and non-circulation of the various ceramics within each cultural assemblage? How can we identify the quantities and distances involved? Are there potential exchange centres? Under what terms and to what ends did these exchanges occur?

Sharing a common focus on the study of the modes of acquisition and preparation of raw materials in the context of Neolithic ceramic production in southern, north-western, central and southern Europe (ca. 6,000-2,200 cal. BC), and without claiming to be exhaustive, this round-table session is centred on on-going research, on analytical methods and interpretative models that examine the first steps in the fabrication of pottery in various chronological and cultural contexts. The emphasis is on archaeometric, experimental, archaeological and ethnoarchaeological approaches that are implemented within an interdisciplinary perspective. New technical data relating to the selection and treatment of clay materials are structured around broader issues, i.e., the locations and management of areas of exploitation, technical performances, functional ends, the exchange of goods, but also the cultural and/or symbolic dimensions of the materials transformed, the transmission of knowledge and know-how and, more broadly, all that throws light on the organisation of communities of producers and consumers of Neolithic pottery.

The 9 articles that make up this publication have been grouped into 4 sections.

The first deals with the ethnoarchaeological approach. On the basis of examples of Latin American pottery production, Dean E. Arnold demonstrates the multiplicity of elements that interact to explain the choices made by potters in the selection of raw materials. The complexity of the motivations that underlie these practices reflect various temporal, social, behavioural, technical and environmental factors. Thus archaeologists should be aware of dangers of over-interpretation (particularly in social terms) of differences in the chemical composition of ceramic pastes. The second article presents research currently being undertaken by the members of several teams (UMR 5608 Traces, UMR 5060, UMR 6273, UMR 7269 LAMPEA) led by J. Cauliez, C. Manen, V. Ard and J. Caro, in collaboration with communities of potters in the Oromiya Region of the Ethiopian Rift Valley. This novel programme aims to use an ethnoarchaeological approach, in an explicit way, to address questions raised by archaeological ceramics. One of the lines of inquiry developed here involves the ethnoarchaeological study of technical procedures that, in the short term, will provide a substantial and well documented reference collection. The initial results have improved the analytical protocols for Neolithic pottery assemblages, opening up significant perspectives on the relationship between the choices made during the preparation of clays, the quality of the ceramics produced and certain social parameters such as ethnicity, the composition of production units, etc.

The next section focuses on the relationships between the selection processes used for clay materials and technical traditions of eastern and southern Europe. M. Spataro presents an overview of petrographic and geochemical analyses of more than 1000 samples of Middle and Late Neolithic pottery from these regions. The technological results enable the various treatments used for clay materials to be characterised and raise important questions concerning the various cultural dynamics (tradition, innovation, resistance, imitation) involved in the production of Impressed Ware and ceramics originating from the Starčevo-Cris, Danilo/Hvar, Vinča and Korenovo cultures.

On the basis of mineralogical and petrographic analyses of pottery, A. Czekaj-Zastawny, S. Kadrow and A. Rauba-Bukowska examine the relationships between the LBK culture of the Krakow region of western Lesser Poland and the Alföld Linear Pottery Culture (ALPC) of the area around the Slovak-Hungarian border. This involves a detailed examination of the technological variations in pottery from the different stages of the LBK within its various regional groups. The data reveal much important information on the stylistic and technological variation in the mechanisms (borrowing, imitation, exchange of objects and ideas) which underly the interactions between the communities of LBK and ALPC potters and which stimulate their cultural evolution. In the case of the Early Neolithic of southern Europe, L. Angeli and C. Fabbri have undertaken archaeometric analyses of Impressed Ware from the site of Colle Santo Stephano, Ortucchio (L'Aquila, Abruzzo), the earliest known agro-pastoral site in the Abruzzo Region (Italy). The description of the clay matrix and non-plastic inclusions using mineralogical and petrographic analyses of thin sections, cross-referenced with the results of technological and typo-morphological studies of the wares, yields very convincing data on the identification, location and treatment of clay resources with respect to the overall structure of both traditional local ceramic production and wares showing external influences (Impressed Ware of the south Italian Guadone facies). In addition, characterisation of painted decoration on pottery, carried out using Raman Spectroscopy and Laser Induced Breakdown Spectroscopy, reveals specific technical choices, such as the use of black, manganese-oxide-based pigment by groups producing trichrome *figulina* ceramics in the Middle Neolithic.

The third section looks at the spatial and social structures of ceramic production. Firstly, A. Kreiter and his colleagues present a study of pottery associated with 8 houses in the Neolithic village of Balatonszárszó-Kis-erdei-dűlő (Transdanubian LBK). The ceramics are subjected to a multi-faceted approach which systematically examines spatial, chronological and stylistic variation in preferential choices involving clay raw materials and tempers (characterised using petrographic analyses), as well as the different shaping practices at household level. The results reveal important, detailed information on the socio-economic dynamics of the potter communities in each household during the various settlement phases.

The same research question is addressed by L. Gomart in collaboration with C. Constantin and myself in a study of ceramic production on two LBK reference sites. Combined analysis of spatial and/or chronological variations in paste recipes and forming methods provides novel socio-cultural results in both cases. At Cuiry-lès-

Chaudardes (Picardy, France), potters retain the forming methods passed on within a particular apprenticeship network, although they are liable to adjust their paste recipes through interaction with other groups of potters, depending for example on the location of their activity or on the type of vessel manufactured. Pottery production at household level is taken on by several groups of producers, apparently with complex movement through the various settlement phases. At Rosmeer (Limburg, Belgium), the analyses reveal complex mechanisms of stylistic imitation and technical transfer between two groups of potters, with one group usually making LBK vessels and the other the so-called Limburg pottery.

The last section focuses on analytical tools for characterising clay materials, in order to explain the origin of materials and the treatments to which they are subjected. By using a polarising microscope, D. Jan and X. Savary aim to improve the identification of fine imprints resulting from the use of plant tempers in Early and Middle Neolithic clay pastes in Lower Normandy (LBK, BQ/VSG, Cerny and Chasséen). These observations are based on a substantial corpus of archaeological ceramics and also on an experimental reference collection, unmatched in north-western Europe and including plant species (moss, poppy and flax) identified in clay pastes, as well other species, such as cereals, which are likely to have been used. The observed and compared morphological characteristics enable one to define criteria for differentiating plant tempers so as to achieve a high degree of accuracy which in the case of mosses, for example, can be narrowed down to genus or species. These new data provide evidence for the appearance and disappearance of various tempers through the Neolithic, in relationship with certain vessel forms, specific decoration types or clay groups. This leads to important new interpretations in terms of the circulation of people and the exchange of ideas.

Lastly, addressing the issue of identification of origins of clay raw materials in ceramic pastes, B. Gehres and G. Querré present the latest methodological advances carried out with the LA-ICP-MS technique (Laser Ablation Inductively Coupled Plasma Mass Spectrometry). Through several examples from the Early Neolithic to the Later Iron Age in the Armorican Massif, they demonstrate that by identifying certain tracer minerals within fired clay pastes it is possible to differentiate between different ceramic workshops and to identify precisely the sources of the clay raw materials.

In conclusion to this introduction I wish to highlight, with great pleasure and gratitude, the collective nature of the scientific editing of these proceedings. In particular I would like to thank those colleagues who gave generously of their knowledge, energy and time by taking on the peer-reviewing and engaging in critical and constructive exchanges with the various authors. Without them, the publication of these proceedings would not have been possible: D. Binder (CNRS, UMR 6130 CEPAM), C. Constantin (CNRS, UMR 8215 Trajectoires), F. Convertini (INRAP, UMR 7269 LAMPÈA), G. Fronteau (Université de Reims), A. Gallay (Université de Genève), F. Giligny (Université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), E. Goemare (Institut royal des Sciences naturelles de Belgique), L. Gomart and C. Hamon (CNRS, UMR 8215 Trajectoires), M. Ilett (Université Paris 1 – Panthéon-Sorbonne, UMR 8215 Trajectoires), C. Manen (CNRS, UMR 5608 TRACES), R. Martineau (CNRS, UMR 6298 ArTeHiS), S. Mery (CNRS, UMR 6566), D. Michelet (CNRS, UMR 8096 ArchAm), T. Nicolas (INRAP, UMR 8215 Trajectoires), V. Roux (CNRS, UMR 7055 Préhistoire et Technologie), J. Vaquer (CNRS, UMR 5608 TRACES) and J. Yans (Université de Namur). Naturally, our thanks also go to the Société préhistorique française which contributed in a major way by accepting to publish the proceedings of the session in its on-line collection. In particular, we wish to thank C. Manen (CNRS, UMR 5608; Vice-President of the Société préhistorique française) and J.-M. Pétillon (CNRS, UMR 5608, Toulouse ; Secretary-General of the Société préhistorique française). Thanks also go to M. Ilett (Université Paris I - Panthéon-Sorbonne, UMR 8215, Trajectoires) to whom we owe a great debt for his friendly support, particularly during editorial discussions, as well as for his help in improving the quality of the English of several articles. Our thanks also go to D. Beucher, L. Mevel (UMR 7041 ARSCAN Ethnologie préhistorique; responsible of the website of the Société préhistorique française) and M. Sauvage (CNRS, USR 3225) editorial assistant at the Société Préhistorique Française, for the quality of his work. G. Palumbo, Dean of the Faculty of Philosophy and Arts at the Université de Namur gave support to the publication through the collaboration of E. Debu and C. Masse. M. Rhoda Allanic undertook the proofreading and translation of some of the English texts. J.-P. Collin (Université de Namur) was responsible for reviewing the figures and tables.

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Raw Material Selection, Landscape, Engagement, and Paste Recipes : Insights from Ethnoarchaeology

Dean E. Arnold

Abstract: Ancient ceramics are not self interpreting and understanding their meaning is the most central issue facing the archaeologists that study them. Some assume that compositional analysis by various methods can provide this meaning, whereas others assume that the notion of choice explains potters' behavior. Both approaches, however, result in abstractions that need to be related to a variety of social, behavioral, technical, and environmental factors. Ancient ceramics, however, are usually interpreted with reference to archaeologists' inexplicit assumptions about the nature of pottery, and their relationship to society. Are ceramics simply the product of culture and tradition, or are they more complex showing interrelationships between indigenous knowledge, landscape, mineralogy and performance characteristics? After decades of publications showing the limitations and constraints of mineralogy, fabrication technique, and climate on pottery production, some archaeologists still believe that pottery, because it consists of fired plastic clay, reflects the mental template of the potter with no environmental or material constraints. Ethnoarchaeological research over the last 50 years in Latin America and elsewhere, however, reveals that potters use their indigenous knowledge to engage their landscape, the raw materials that came from it, and their performance characteristics. The resulting pastes change over time because of changing raw material sources, particular forming technologies, and different vessel sizes, uses, and shapes. Using ethnoarchaeological examples from Latin America, this paper enumerates some probabilistic generalizations that elucidate the relationship of raw materials to landscape, performance characteristics, paste recipes, and forming technologies. It examines some of the factors that influence potters' raw material selection and suggests that the choices potters make are not necessarily driven by tradition, a mental template, or non, technological criteria. Rather, all choices are multi-causal and linked to the potters' material engagement of their indigenous knowledge with a variety of different external factors.

Keywords: raw material selection, paste variability, engagement, landscape, resource distance, paste recipes.

Résumé : Les céramiques anciennes ne s'interprètent pas d'elles-mêmes et comprendre leur signification constitue le problème central auquel est confronté l'archéologue qui les étudie. Certains considèrent que l'analyse de leur composition à l'aide de différentes méthodes suffit pour accéder à cette signification, tandis que d'autres considèrent que c'est la notion de « choix » qui explique le comportement des potiers. Or, ces approches mènent toutes deux à des abstractions qu'il s'agit de relier à des facteurs sociaux, comportementaux, techniques et environnementaux variés. Et cependant, les céramiques anciennes sont habituellement interprétées par les archéologues sur la base de suppositions non-explicites concernant la nature de la poterie et ses liens avec la société. Les céramiques sont-elles simplement le produit de la culture et de la tradition, ou révèlent-elles des interdépendances plus complexes entre le savoir indigène, le paysage, la minéralogie et les performances ? Après des décennies de publications exposant les limitations et les contraintes imposées à la production de poterie par la minéralogie, les techniques de fabrication et le climat, certains archéologues pensent encore que la poterie, puisqu'il s'agit d'argile plastique cuite, ne reflète que la représentation mentale du potier sans influence aucune de l'environnement et des contraintes matérielles. Cependant, la recherche ethnoarchéologique de ces cinquante dernières années, en Amérique latine et ailleurs, a bien montré que les potiers utilisent leur savoir indigène pour aborder leur environnement et son matériau brut avec ses performances caractéristiques. La pâte qui en résulte change avec le temps parce qu'elle doit rester en harmonie avec des ressources en matériau brut fluctuantes et doit s'adapter à des techniques de fabrication particulières, ainsi qu'à des tailles, des usages et des formes de récipients différents. Sur la base d'exemples ethnoarchéologiques latino-américains, cet article énumère des généralisations probabilistes permettant d'élucider la relation existant entre le matériau brut et le paysage, les performances, les recettes de pâte et les technologies de façonnage. Il examine quelques-uns des facteurs qui influencent la manière dont le potier sélectionne le matériau brut et suggère que les choix faits par le potier ne sont pas nécessairement guidés par la tradition, une représentation mentale ou des critères non-technologiques. En fait, tous ces choix sont plutôt motivés par des causes multiples et sont liés à la manière dont le potier utilise son savoir indigène pour aborder une variété de facteurs extérieurs différents.

Mots-clés : sélection des matières premières, variabilité des pâtes céramiques, paysage, distance des sources, recettes de pâtes.

Pottery is probably the most alluring object of archeological analysis. Its widespread occurrence among cultures of the world, the plasticity of its parent material, and the seeming mystery of its transformation into a stone-like object make it a unique type of material culture left behind by ancient societies. Further, the variability of both the chemical elements and the minerals found in pottery, and the great diversity of its shapes provide opportunities for archaeologists to use a wide variety of approaches in analyzing it.

Since archaeologists deal with artifacts apart from the humans that make and use them, they must rely on interpretive tools to put those artifacts into some social and cultural context that goes beyond the material objects themselves. These interpretive tools take the form of generalizations that are often based upon tradition (e.g. typology), ethnographic analogies with living societies, or theoretical constructs based upon those analogies, and often inexplicit assumptions about the relationship between pottery and people. Such generalizations are often limited because the past is not the same as the present, and human behavior is (and has been) variable for a variety of reasons, but even so, all archaeological interpretations come from the present whether in the form of analogies, or inexplicit assumptions in the mind of the archaeologist. Even the most accepted generalizations, however, still must be contextualized in environmental and cultural circumstances that inevitably affect variability of pottery, and the behavior that produced it. Further, interpretations of the past are underlain by considerable social theory and assumptions about the relationship of objects and society, whether implicit or explicit. This paper seeks to provide some insights from ethnoarchaeology that hopefully will contribute to understanding the selection of raw materials used to produce pottery in the past. Some of the points made here are distilled from more elaborate explanations described elsewhere (Arnold, 1985, p. 1-60, 2000 and 2008), but updated and rethought using new concepts.

TECHNICAL BACKGROUND [1]

The process of making pottery involves recognizing the material agency (Malafouris, 2004 and 2013, p. 119-149) of both its constituent raw materials and the process of transforming those materials into a stone-like object through a process that L. Malafouris calls 'material engagement' (Malafouris, 2013, p. 148). Selecting raw materials involves a practical understanding of the technical constraints of various kinds of clays and those of other materials mixed with the clay (such as temper or another clay) in order to achieve the desired performance characteristics. Generally, a clay with insufficient non-clay minerals is unsuitable to make pottery because it is too plastic to form into a vessel, and it will slump, sag, and crack when drying. Non-plastics in the clay reduce this plasticity, increase its workability, and enhance other performance characteristics such as allowing the water in the fabric to escape during drying and firing, and reduce shrinkage. Consequently, clays used for making pottery must consist of both clay minerals and enough non-plastic material in order to make the resulting paste workable. In some contexts, this non-plastic material consists of natural minerals already present in the raw clay such as quartz, sandstone, feldspar, or limestone. In other contexts, the potter must add non-plastics to the raw clay in order to achieve the desired performance characteristics. Such added temper may consist of a wide variety of mineral inclusions such as volcanic ash, sand, marl, calcite, and/or non-mineral materials such as bone, shell, chaff, ash, grass, and ground potsherds (grog). Although the potter may have many choices in selecting additional non-plastic materials (temper), some of these choices may also include clay minerals that may complicate mixing clay and temper. Some tempering materials, for example, contain both non-plastic materials and plastic materials such as volcanic ash and marl (Arnold, 1971 and 1972). Adding a seemingly non-plastic material with clay minerals in it thus complicates the preparation of the paste mixture, and requires further modification. Some pottery making communities may select several different kinds of clays and tempers to mix together to make the pottery (e. g. Mama in Yucatán; Thompson, 1958, p. 72; Arnold, 2000, p. 356; Gosselain and Livingstone Smith, 2005).

HOW DO POTTERS SELECT RAW MATERIALS?

How do potters know which clay to choose for making pottery? How do they know which kind of temper to use for mixing with it? The answers to these questions are complex and involve several levels of explanation. Potters often have a sophisticated indigenous knowledge of their raw materials that involves understanding the landscape of the sources, the kinds of raw materials available, and their suitability for making pottery.

The first level of explanation involves understanding the landscape within which the potters make their choices. Landscape is not just the geological and topographic characteristics of an area, but the potter's own socially and culturally-defined meaning and perceptions of it (Ingold, 2000). This meaning involves many features, but it involves the portions that potters have used in the past as sources for their materials. In Yucatán, Mexico, for example, potters' meaningful landscape around Ticul is different from that surrounding other pottery making communities such as Mama or Tepakán even though the geology is very similar. Geology is not the only factor that defines the landscape of a community of practice.

Even without knowing how potters define and use their landscape around their community, it has practical boundaries, and serves as the potters' resource area from which they select and use clays and tempers. Each community of practice thus utilizes their own unique landscape as sources of their raw materials, and potters' knowledge of this landscape is circumscribed by a practical limit.

This limit can be ascertained from the distances that potters around the world travel to obtain clays and temper when use their own bodies for transport. Using a graph to plot the data points of these distances (on the X axis) against the number of communities that travel those distances (on the Y axis) reveals a decreasing frequency from one kilometer, the most frequent distance, to a maximum radius of tens of kilometers from their production location. Practically, however, this landscape-based resource area is seldom larger than a radius of 7 km from the production location, such that potters seldom travel more than 7 km to obtain their primary raw materials of clay and temper (Arnold, 1985, p. 32-60, 2005b and 2006). J. M. Heidke (Heidke et al., 2007) and I. Druc (2013) have refined the distances and the model relative to the Southwest and Peru, but generally reaffirmed, in principle, that distances to resources tend to follow this distribution although they are slightly different for each area.

When these cross-cultural data are correlated with a power law trend line (a log-log scale on the X and Y axes), they reveal a high correlation (R^2 = 0.80) between the data and the trend line (fig. 1). A power law distribution reflects a kind of scale-free, self-organizing system that is found in a wide range of phenomena (Bentley and Maschner, 2001; Bentley and Shennan, 2003; Bentley et al., 2004). An explanation for such a distribution is not always known, but a power law distribution does not have a meaningful average (mean) value, and change occurs at all scales (Bentley and Maschner, 2003, p. 14).

The power law distribution of world-wide distances to clays and tempers thus shows that the curve of distances to resources drops steeply after one kilometer and then much more slowly after five kilometers (fig. 1; Arnold, 2011, p. 87). These data suggest that most communities of potters travel no further than five kilometers to obtain their basic ceramic resources, and this distance probabilistically marks the practical limit of the culturally-defined resource landscape of most communities of potters.

Do potters travel greater distance to travel to their resources? Of course they do, but archaeological interpretations are based upon patterns, not on exceptions, and like all human patterns, the distances to raw materials in the model are probabilistic. As I have said before, however, it is important to understand the probabilistic nature of a Power Law curve, and thus the distances to resources in the model (Arnold, 2005b). The distances are not certainties, and not deterministic as some have claimed. High frequency patterns do not incorporate all cases, but the power law distribution can be seen as a graphic statement of crude probabilities that distances to clay and temper sources that are one kilometer away occur more frequently than a distance of say, ten kilometers. With 'energy extenders' such as beasts of burden, and water and motorized transport, however, the resource landscape of a community can be extended to unknown limits beyond the five kilometers. Without generalizations of how far potters go to obtain their resources, however, there is

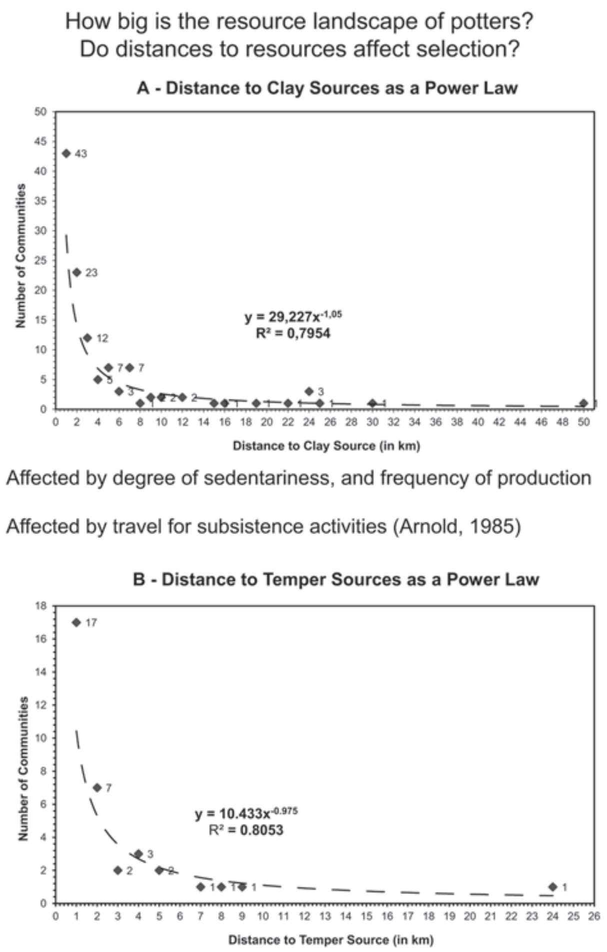

Fig. 1 – Two plots of frequency (Y axis) and distance (X axis) of a cross cultural sample of clays (top) and tempers (bottom). The trend line has been drawn as a power-law curve with the appropriate formula using the power law option from Excel (after Arnold, 1985).

Fig. 1 *– Deux graphes de fréquence (axe vertical) et distance (axe horizontal) d'un échantillon transculturel d'argiles (en haut) et de dégraissants (en bas). La ligne de tendance a été tracée par une loi de puissance à l'aide de la fonction loi de Puissance d'Excel (d'après Arnold, 1985).*

no empirically-based interpretation of ancient local and non-local production unless definite evidence of production debris in a site can be related to a precise geological, geochemical and mineralogical source of the constituents used in its pottery. Nevertheless, the power law curve does indicate that five kilometers is a place to start for ascertaining the limits of the resource landscape of a community.

This notion has been hard for some archaeologists to grasp. One way to think about it is to imagine a person carrying, say, twenty or thirty kilos of clay or temper from a source location to one's house. Frequent production means more frequent trips and greater effort simply to provide the raw materials to make pottery. Less frequent production (or its intensity) involves fewer trips, the likelihood that resources could be further away, or could be procured as a consequence of travel to fields, a hunting trip, or transhumant pattern of seasonal movement of herds. Extended distances beyond the probabilities in the model probably occurred with potters in non-sedentary or partially sedentary societies (Arnold, 1985, p. 109-126). All that was needed was weather that was dry and warm enough for at least a few days, and someone who occasionally procured adequate raw materials as a consequence of another activity such as men traveling past a source on the way back to the household from a trip to their fields, from an (probably unsuccessful) hunting expedition, or from tending their livestock [(2)].

Once pottery production intensified, however, potters needed raw materials more frequently, and those potters that lived closer to sources of raw materials were selected for and those production locations further away were selected against. With greatly intensive production, however, that required massive amounts clay such as brick making, production was located on top of clay deposits as it was in Guatemala City in 1970, on the southern limits of the city of Cuzco, Peru, and in the flood plain of the nearby Vilcanota River east of Cuzco in 1972-1973.

The radius of a resource area around a potter's community of practice thus provides a tentative boundary of a socially and culturally-defined landscape for the community and an initial guideline in discovering the sources of acceptable raw materials. Equally important, this area circumscribes the choices available to potters, but all of their potential choices are not equally viable for making pottery. Potters always have a choice in the materials that they use, but often the sources of clay and tempers are so obvious to both the potters and ethnoarchaeologists that it may appear that potters have no choice at all. In reality, potters' traditional knowledge has taught them to select raw materials from some locations and reject those from other locations, and the rejected options may be unclear, if not unknown, to potter and ethnoarchaeologists alike. Around Ticul, Yucatán, Mexico, for example, clay occurs in pockets in marl deposits and in beds at the base of those deposits that are exposed when the marl and the rock are quarried and used for construction purposes (Arnold, 1967a, 1967b and 1971) virtually anywhere such quarries exist around the community. In the late 1960s, long before the current focus on technological choices, surveys of clay deposits around Ticul by clay mineralogist Bruce F. Bohor and me revealed that almost all of these clays consisted of the clay mineral smectite (montmorillonite). Because of their great plasticity, however, these clays were unusable for making pottery because vessels made from them would sag and crack, and thus potters did not even consider choosing them. Potters may say, however, that if they did use them, they would only make the smallest food bowl. Yet, in almost fifty years of working in Ticul, I have never heard of, or seen, any potter using this ordinary clay for making pottery of any kind. Further, this rejected clay tends not to be mentioned in the literature on Yucatecan pottery making, and although it is technically a choice for potters in their local landscape, they seldom considered it to be so. Unfortunately, ceramic ethnoarchaeologists and archaeologists usually acknowledge and study those materials that potters use, not those that they do not use.

On the other hand, clays that are excellent for making pottery are rare in Yucatán and found in only a few places (Arnold, 2008, p. 154-155; Schultz et al., 1971). Up until early 1992, one of these places was Hacienda *Yo' K'at* located 5 km Northwest of Ticul along the highway to Muna. Unlike the common, more abundant clay found in marl mines around the community, this clay consists of a random mixed layering of kaolinite and smectite and a small amount of kaolinite (Schultz et al., 1971). Although not as plastic as the smectite found universally around Ticul, the *Yo' K'at* clay was still very plastic, so that the potter needed to add a tempering material to reduce its plasticity, and prevent sagging, cracking, and breaking during drying and firing.

This tempering material consists of a unique culturally-defined marl (Arnold, 1971 and 2008, p. 191-214). Marl deposits occur universally in Yucatán near the surface under the limestone cap rock, and it would seem that these ubiquitous deposits would likely be used for tempering pottery because they are relatively easy to mine, and contain abundant non-plastics in the form of calcite and/or dolomite. This material could, in fact, be considered to be a choice for the potters, but again, they do not consider it to be so. Most of these marl deposits, however, also contain varying amounts of the clay material smectite (montmorillonite) that increases the plasticity of the paste mixture, and can have significant negative effects on pottery requiring more modification when it is added to the paste.

Ticul potters thus reject this ubiquitous marl for temper, but rather use a material that consists of a cultural (rather than a natural) mixture of the marl and the clay mineral palygorskite that comes from a unique place in the landscape called *Yo' Sah Kab*, literally meaning 'over marl' (called *sah kab* in Yucatec Maya, see below). In a geological sense, any place in Yucatan is 'over' marl, but the deposit at *Yo' Sah Kab* is unique, and potters recognize it to be so because the marl there is mixed with a material potters call *sak lu'um* ('white earth' in Yucatec Maya) that, in fact, is the clay mineral palygorskite. Palygorskite has a plastic limit that is higher than that of the clay used for forming the body of vessels, a mixed layer kaolinite and smectite (White, 1949). Consequently, even though it is a clay mineral, palygorskite does not act as a plastic in the paste, but rather as a non-plastic (Arnold, 1971).

Similarly, in the pottery making communities in the Valley of Guatemala such as Sacojito, Chinautla, Durazno, Sacoj, clays can come from many sources (Arnold, 1978). In Chinautla, for example, there are many exposed clay beds along the river that runs through the community. Potters prefer, however, to use a white clay that fires to a cream color and comes from a single mine on a farm nearby called Finca Primavera. They have a choice of clay to use to make pottery, and choose the white clay, but again, the other clays that are available are not usually preferred to make pottery. If potters want to make large storage vessels, however, they use the clay occurring along the river.

The temper used in Sacojito, Chinautla, Durazno and Sacoj, on the other hand, is volcanic ash that blankets the entire Valley to a depth of about 500 meters. This ash is universally available, and potters obtain it from several locations (Arnold, 1978).

When ceramic resources are selected from unique places, and consist of a unique high quality material compared to other materials in the area, these places are not just a mine, hole, or a spot on a map, but also have important cultural meaning that makes them a special part of the potters' landscape. This meaning involves a sense of place for potters that sets such sources apart. The tradition behind this meaning is itself sufficient to guide potters to the best sources of their raw materials, and this pattern may make one believe that potters have no choice of raw materials at all because it appears that they have no alternatives.

Such locations with a sense of place may have unique place names. In Ticul, Yucatán, the sources of clay and temper have names derived from the resource in the ground below it. The place name for the source of potter's clay was Hacienda *Yo' K'at* ('over clay'); the name for the source of temper for non-cooking pottery was *Yo' Sah Kab* ('over marl'); and *Aktun Hi'* ('crystal cave') was the place name for the source of the crystalline calcite (*hi'*) used for the temper for cooking pottery that was found within it. All of these places were significant locations in the landscape and potters returned to them again and again to mine their raw materials. For generations since the Terminal Classic Period (800-1000 AD), potters obtained their raw materials from these places (Arnold and Bohor, 1977; Arnold, 2005a). In summary, these traditional sources of clay and temper do not just have a unique sense of place associated with them, but the raw materials obtained from them were mineralogically unique in comparison to other materials in their landscape and resource area (Arnold, 1971 and 2008, p. 155-193).

These places and the unique materials that came from them became so important to potters that they also took on a sacred meaning. The availability of clay at Hacienda *Yo' K'at*, for example, was associated with the patron saint of the Hacienda, San Pedro (Saint Peter). When the clay mine on the Hacienda yielded only inferior clay and rocks in the 1940s, potters paid the expenses for one of the nine nights of prayers (a *novena*) for the Saint so that he would restore the quality of the clay there. Subsequently, potters decided to move the location of the mine and again found high quality clay, answering their prayers for quality clay. To assure continued supply of such excellent clay, the potters reaffirmed their promise to the Saint in the early 1950s by bringing it to Ticul after the *novena* at *Yo' K'at* concluded, and then sponsored an additional *novena* at one of the potter's houses there, continuing that practice until about 1978. When the clay at *Yo' K'at* became exhausted in late 1991, however, one potter instituted a private *novena* to *San Pedro* in his own house to restore the clay at *Yo' K'at*, and also enlisted native Maya priests to perform rituals to thank the spirits of the forest for clay from his newly acquired private source in Campeche. Access to the clay from *Yo' K'at*, however, was not restored (Arnold, 2008, p. 154-183).

Potters in the Valley of Guatemala also had a sense of place associated with their principal clay source. A unique white clay was used to make pottery in Chinautla and Sacojito and was called *espirit ak'al* or 'spirit clay' that was found in single mine at Finca Primavera (Arnold, 1978). In Quinua, Peru, some sources of pottery materials were also associated with the Mountain God, and required offerings of propitiation (Arnold, 2000).

VARIABILITY OF RAW MATERIAL SELECTION

The composition of ceramic pastes can vary based upon the natural variation in the clays and tempers in the deposits (Hein et al., 2004), and social, cultural, and individual causes of selection and paste preparation (Gosselain and Livingstone Smith, 2005). One cause of variability occurs when the sources of raw material change.

One such cause is the seasonal weather. In Ticul, Yucatan, and in Chinautla and Sacojito, Guatemala, traditional sources of raw materials come from deep mines that involved tunneling underground and were subject to collapse during the rainy season. In Chinautla, Guatemala, the traditional white (cream-firing) clay came from an underground mine that collapsed during the rainy season making the clay from there unavailable (Arnold, 1978). If potters did not have enough white clay to sustain themselves, they would either cease production (if they could afford to do so), or use the red-firing clay exposed in beds along the river that flowed through the village. So, even though potters preferred to use the white clay, there were occasions when that clay was not available, and potters had to use the more common clay on the banks of the river.

As long as the clay is consistent in quality based upon its performance characteristics, potters continued to use it with the same paste recipe. When a source becomes exhausted or access to it is denied because of land tenure and/or political issues (Arnold, 2008, p. 153-189), then their sense of place for the sources of their raw materials no longer played a role in raw material selection. Potters thus needed to use their indigenous knowledge based upon their previous material engagement with clay and temper. This knowledge served as a means to evaluate and select materials from new locations with which they had no familiarity. As a result, they had to experiment with the new material and familiarize themselves with its properties and performance characteristics.

Potters engage the properties of the new materials by using their long-term and working memory (Baddeley, 1992; Fusi, 2008) gained from their experience in mining, selecting, mixing and drying those materials used previously for making pottery. Potters in Ticul, Yucatán, for example, recognize five different colors of clays, but color was not an important component of clay selection. Historically, useful clay for making pottery came from Hacienda *Yo' K'at*, and was white or yellow. It had a salty taste and did not open up and fall apart when it was dried in the sun (Arnold, 1971 and 2008, p. 222). When clay mining was not possible at *Yo' K'at* in the past (Arnold, 2008, p. 143-189) and was acquired from other locations, potters had to engage properties of the new clays and depend upon the feedback from their senses in order to evaluate its appropriateness for making pottery considering if changes in the amount of tempering were necessary to prepare the paste.

This happened many times in Ticul over the course of the last 150 years. Although clay was mined at *Yo' K'at* from at least the Terminal Classic Period, 800-1100 AD, (Arnold and Bohor, 1977), there were times when the clay from there was not available, and potters had to go elsewhere to obtain it. One such alternative source was in the Barrio of Mejorada within Ticul itself. Clay was reportedly procured there in the nineteenth century and in the 1930s when access to the clay at *Yo' K'at* was denied by its manager. Potters had to suspend their usual selection criteria in order to engage an unfamiliar clay in order to prepare it properly for making pottery.

When one potter bought the land with the Mejorada clay deposit in 1952 (Arnold, 2015, p. 183), he found that the clay there was better than the more common clays found throughout the area, but not as high in quality as the clay from *Yo' K'at*. So, he mixed the clay from *Yo' K'at* with that from his own private source.

Beginning in the late 1980s, the clay from *Yo' K'at* began to change, and included many more naturally-occurring rocks than previously. Potters adjusted to this change by changing their paste recipe and adding less temper (Arnold, 2000 and 2008, p. 222). These changes were reflected in the changing elemental composition of the pottery based upon INAA analysis (fig. 2).

In late 1991, the clay source Hacienda *Yo' K'at* became exhausted, clay was imported from the State of Campeche 55 km away (straight line distance) where mining marl and rock for building purposes had exposed large clay deposits at the base of several marl quarries. Clay was mined and delivered by truck owners from Dzitbalché (except those two potters who had their own sources), and not by potters or the mining specialists that had mined clay at *Yo' K'at*. As potters used some of this new clay, they came to realize differences in its quality from the *Yo' K'at* clay because large pots made from some of it would sag and crack.

This material engagement with the clay led potters to respond in several ways. The first and most obvious response was to refuse to buy clay from the Campeche supplier known to sell inferior clay, and purchase higher quality clays that came from other suppliers. A second response was to mix the inferior clay that they had already purchased with the higher quality of clay from elsewhere.

A third response that potters made to the new clay sources was to change their paste preparation. As the potters engaged the properties of the new clay, they discovered that it had many more rocks in it than the clay from *Yo' K'at*. So, they adapted in two ways. First, they changed their paste recipe by reducing the amount of temper in the paste. Another less common adaptation to using the new clay was to levigate it in a large pottery vessel. By adding water and stirring the mixture, most of the clay particles would go into suspension, and the rocks would fall to the bottom of the receptacle. The clay was poured out, allowed to dry partially and then mixed with the temper using the traditional paste recipe. The rocks were discarded. All of these changes in sources and paste preparation were also reflected in the changes in the composition of the pottery between 1964, 1988 and 1994 (fig. 2). When the pottery from these same years were plotted with that from Tepakán and Akil, the Ticul pottery showed great overlap with the pottery from Tepakán because it shared a clay source with Ticul potters after their own source near Ticul (*Yo' K'at*) was abandoned (fig. 3). The meaning of these plots of INAA analyses of clay composition means that change in clay sources, paste preparation, and paste recipes may not have a social meaning except the exhaustion of a previous source.

PASTE PREPARATION AND SOCIAL MEANING

It is not unusual for archaeologists to explain the variability of pastes, whether from minerals or chemical elements, as different paste recipes made by the same or different communities of practice. Such an explanation, in fact, is not an explanation at all, but rather is just a different level of description because differing paste recipes still have yet to be related to a social explanation in a meaningful and convincing way. Different paste recipes have no inherent social meaning, and, as described above, a given paste recipe in a community is not immutable. Rather, it may change because of factors unrelated to social explanations. It may result from natural variability within the sources used, changes in the composition of materials from the same source through time, different production units using different sources, the same production unit using different sources over time (fig. 2 and 3), or, as just described, changes in the clay source used by a community. These same explanations of changes in clay sources, paste preparation, and paste recipes have also been described by O. P. Gosselain and A. Livingstone Smith (2005) for Africa.

All of these explanations have occurred in Ticul during the last fifty years. In addition to the change in clay sources over time for most of the potters, two potters had their own sources. Before the clay was exhausted at *Yo' K'at*, some potters began to buy up quantities of the *Yo' K'at* clay, and sell it for a profit to other potters after they could no longer get clay from *Yo' K'at*. Other potters began prospecting for new sources in Campeche. One wealthy potter bought his own source, a large marl quarry that had a deposit

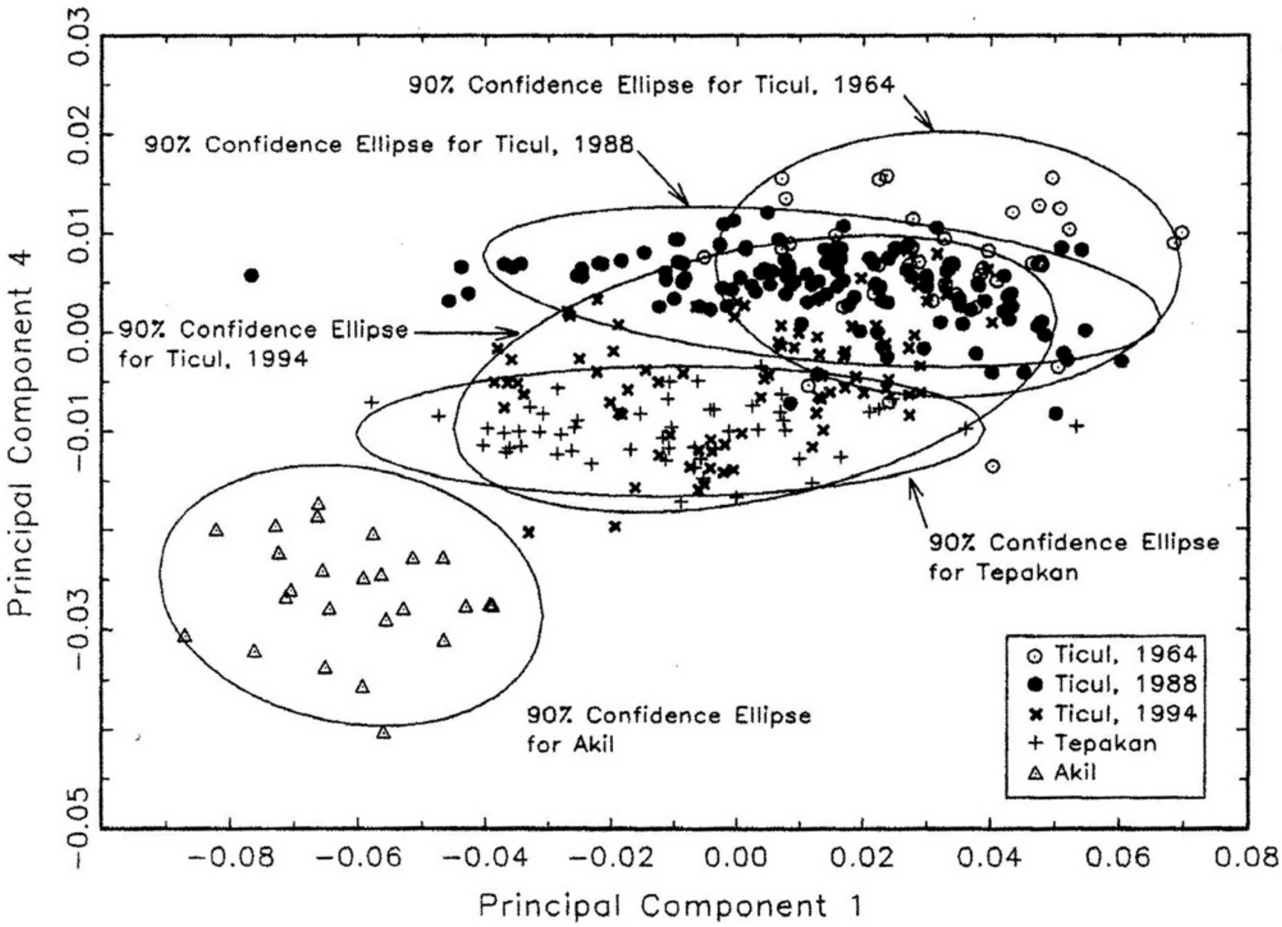

Fig. 2 – Biplot of Principal Components 4 and 1 of data from INAA of ethnographic kiln wasters collected from potters in Ticul Yucatan in 1964, 1988 and 1994, but plotted with the data from kiln wasters from the pottery making communities of Akil and Tepakán. In 1997, Ticul potters were making pottery from the clay used by Tepakán potters, and that shift is revealed by these data. Neutron Activation Analysis was done at the Missouri University Research Reactor (MURR) by Hector Neff and Michael Glascock. Ticul pottery is a combination of two parts temper and one-part clay, and the shift in the change in the composition reflects change in the clay sources and in paste recipes. Ticul and Tepakán analyses are shown in relationship to clay analyzed from Akil, another community with only a few potters that made food bowls for the Day of the Dead rituals, and located 28 km from Ticul and 74 km from Tepakán. All samples collected by the author (table from Arnold et al., 1999, p. 74).

***Fig. 2** – Diagramme de double projection des Composantes Principales 4 et 1 des données INAA concernant des déchets de cuisson ethnographiques collectés auprès des potiers de Ticul Yucatan en 1964, 1988 et 1994. L'échantillon de 1964 a été collecté par Duane Metzger dans le four d'Alfredo Tzum, l'échantillon de 1988 a été collecté par l'auteur auprès de six potiers différents, y compris Alfredo Tzum (déjà échantillonné en 1964), et l'échantillon de 1994 a été collecté auprès de cinq potiers différents (y compris Alfredo Tzum et ceux échantillonnés en 1988). L'analyse par activation neutronique a été réalisée sur le réacteur de recherche de l'université du Missouri (MURR) par Hector Neff et Michael Glascock. La poterie de Ticul est une combinaison de deux parts de dégraissant et d'une part d'argile, et les changements dans sa composition reflètent les changements dans les sources d'argile et dans les recettes de pâte. Les analyses pour Tikul et Tepakan sont représentées en relation avec les analyses d'argile d'Akil, une autre communauté avec seulement quelques potiers qui fabriquaient des bols pour la nourriture dans le cadre des rituels du Jour des Morts, et qui se situe à 28 km de Tikul et à 74 km de Tepakan. Tous les échantillons ont été collectés par l'auteur (d'après Arnold et al. 1999, p. 74).*

of clay at its base. Another potter purchased usufruct rights from the owner of another marl quarry where he mined clay at its base. Meanwhile, entrepreneurs from Campeche began mining and selling clay from both their own land, and from the public *ejido* land of Dzitbalché that had been used as a marl quarry.

Just as in Ticul, the potters in Mama, Yucatán, changed their paste recipes between 1951, when R. H. Thompson (1958, p. 72) visited the community, and my visits there in 1968 and 1992 (Arnold, 2000). The source of their raw materials throughout this period was a large sink-hole 3.75 km outside of town. In 1951, R. H. Thompson (1958, p. 72) noted that the paste mixture consisted of inexact ratios of raw materials, and I tried to quantify these roughly based upon his description (Arnold, 2000, p. 356). Potters classified them into four different culturally-defined types, but they could not easily be grouped into clay and non-plastics because the materials contained varying amounts of both. To adapt to the varying amounts of plastics and non-plastics in these materials over time,

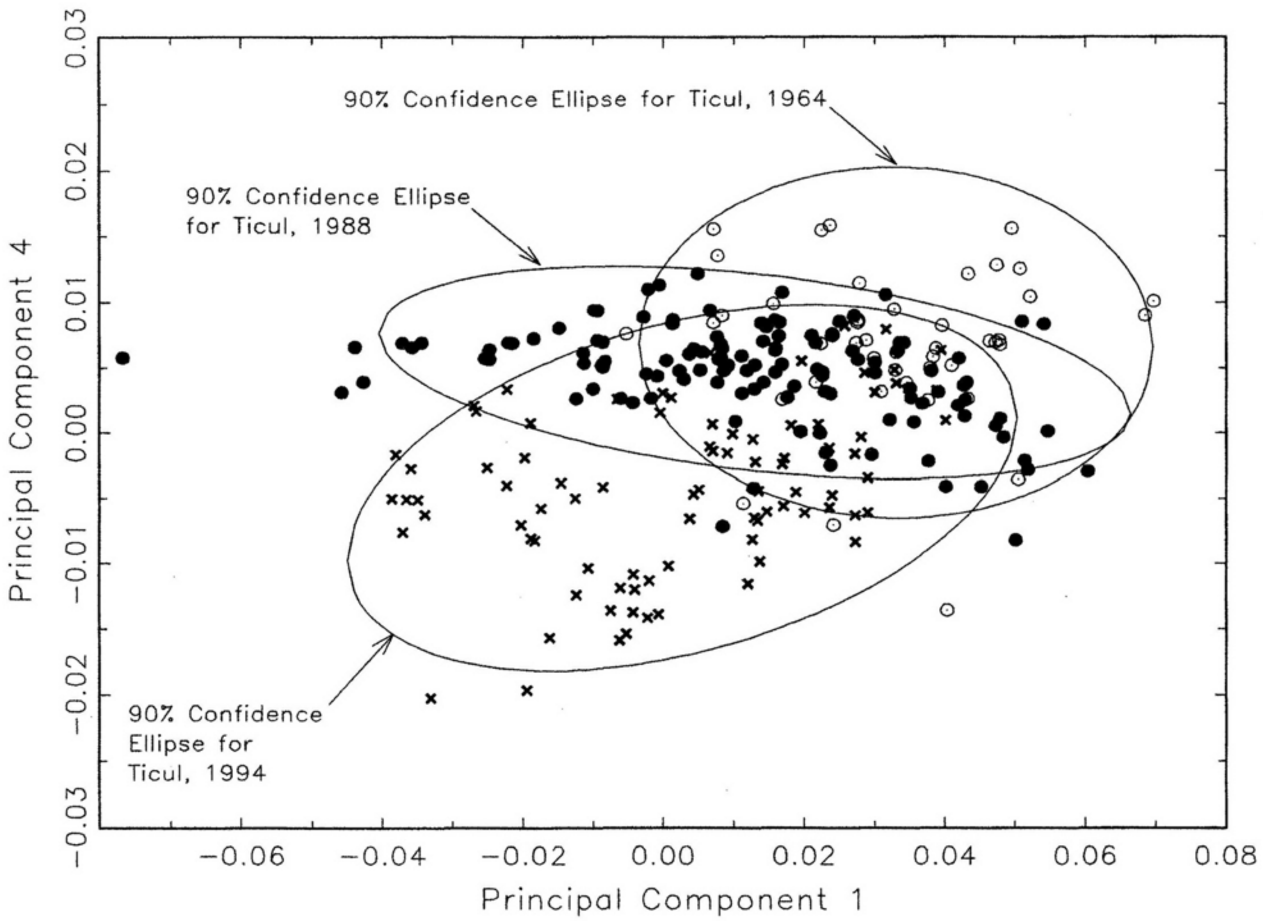

Fig. 3 – Biplot of Principal Components 4 and 1 of data from INAA of ethnographic kiln wasters collected from potters in Ticul Yucatan in 1964, 1988, and 1994. The plots show the changes in the composition of clay based upon changing clay sources. The sample from 1964 was collected by Duane Metzger from the kiln of Alfredo Tzum, the sample from 1988 was collected by the author from six different potters including Alfredo Tzum (also sampled in 1964), and the 1994 sample was collected by the author from five different potters (including Alfredo Tzum and those sampled in 1988). Neutron Activation Analysis was done at the Missouri University Research Reactor (MURR) by Hector Neff and Michael Glascock (Arnold, 2000). Ticul pottery is a combination of two parts temper and one-part clay, and the shift in the change in the composition reflects change in the clay sources and in paste recipes.

***Fig. 3** – Diagramme de double projection des composantes principales 4 et 1 des données INAA concernant des déchets de cuisson ethnographiques collectés auprès des potiers de Ticul Yucatan en 1964, 1988 et 1994, mais figurant cette fois en compagnie des données de déchêts de cuisson provenant des communautés de potiers d'Akil et de Tepakan. En 1997, les potiers de Tikul fabriquaient des récipients à partir de l'argile utilisée par les potiers de Tepakan, et ce changement est mis en évidence par ces données. L'analyse par activation neutronique a été réalisée sur le réacteur de recherche de l'université du Missouri (MURR) par Hector Neff (Arnold, 2000). La poterie de Ticul est une combinaison de deux parts de dégraissant et d'une part d'argile, et les changements dans sa composition reflètent les changements dans les sources d'argile et dans les recettes de pâte.*

potters changed their paste recipes (Arnold, 2000). Consequently, through the forty years after R. H. Thompson visited the community, the paste recipe changed with each of my visits presumably because of variability of plastics and non-plastics in each category of raw material. Even so, firing resulted in breakage rates of 20 - 40%, a rate that could not be sustained if potters wanted reliable returns from their craft. So, by 1992, pottery making was seasonal, and potters only made small food bowls for the annual Day of the Dead rituals.

What do paste recipes tell us? Adding temper to clay has the effect of reducing the plasticity of the clay, and improving its performance characteristics in forming, drying and firing. Clays and tempers in the resource area of a community do not always have a uniform composition. So, if the mineral composition of the clays and non-plastics change, potters may have to alter the proportions of each to achieve desirable results. Paste recipes are not the result of a mental template that the potter materializes when he makes pottery, but rather are the potter's adaptation to the performance characteristics of the paste necessary to make the desired vessel. Because the need to adapt clay recipes to the realities of changing raw materials, using social explanations for the variation (or lack thereof) in paste recipes should be invoked with caution, and then only after the natural variability of the raw materials is taken into account.

RAW MATERIALS AND VESSEL FORMING TECHNIQUES

The quality of clay and the characteristics of the paste also are linked to vessel forming techniques. All clays are not equally useful for every kind of pottery, nor for every kind of fabrication technique. In Ticul, for example, the potter's clay exerts material agency on the fabrication technique and the types of vessel made. The traditional technique used is slab coiling (also called modified coiling) in which large coils of clay are added to a base, then drawn up with a gourd scraper, and then scraped and shaped to make a vessel. Because the clay used before 1992 was a mixed-layered combination of smectite and kaolinite with a small amount of kaolinite, potters could not make a large vessel in one sitting, and could only form about 20 - 25 cm of it at a time allowing that portion to dry before adding another coil, and scraping and shaping it. Otherwise, previous portions of the vessel would sag and/or collapse. So, the forming technique was an adaptation to the performance characteristics of the clay.

In the 1940s, vertical-half molds were introduced into Ticul and their use continued up to the present. The size of vessels that could be made with molds, however, was limited to about 25 cm because they would sag when removed from the mold (Arnold, 2008, p. 254-256). Larger objects were made, but they were coin banks that were totally enclosed with the vessel walls providing mutual support to inhibit sagging. Further, in order to make other larger vessels with molds, or a vessel with a horizontal shoulder upon which a restricted neck rests, potters used two techniques to form the vessel in order to compensate for the limitations of the paste that would make the clay below the shoulder to sag: they used a mold to make the body, and then joined the halves of the molds together, smoothed the mold marks, and after a drying period, used slab coiling to make upper portion of the vessel (Arnold, 1999 and 2008, p. 253).

In the late 1990s, one potter tried to make pottery using a slip casting technique that he had learned in a local ceramics factory (Arnold, 2008, p. 262-265). Slip casting requires a liquid paste, and rather than buying powered clay especially prepared for slip casting, he tried to use the traditional paste. After much experimentation, he managed to come up with a rather complicated paste recipe that was totally different than the traditional recipe. Even though he was ultimately successful, the combination of slip casting, local raw materials, and local firing techniques resulted in many losses during his period of experimentation.

Besides introducing vertical half molds in the 1940s, a government development program also tried to introduce the wheel into Ticul presumably to make pottery production more efficient. There were many problems with the attempt (Arnold, 2008, p. 237-245), but the local paste was too coarse to use on the wheel and it abraded the potter's hands (Arnold et al., 2008, p. 237-245).

In summary, all clay-like material, or any paste, cannot be used to make any vessel, nor can any fabrication technique use any clay to make any vessel (Arnold, 2008, p. 229-279). Rather, the kind of clay minerals in the clay, the paste composition, the particle-size of the paste, the fabrication technique, and the kinds of vessel produced are all inter-dependent variables in pottery production.

ARCHAEOLOGICAL IMPLICATIONS

What does all this mean for archaeology? First, pottery materials are a product of a culturally-defined landscape, and discovering this landscape can be accomplished by surveying for ceramic raw materials around an archaeological site. Since the distances to resources that potters travel to obtain their resources on foot have a cross-cultural pattern, using a radius of 1 km for the survey area and then increasing that area to five kilometers will probably reveal pottery raw materials if pottery was made at the site. By analyzing the raw materials in this resource area, and then evaluating them experimentally to discover their value for making pottery, the archaeologist can then relate them to the analyses of the pottery from the site, the choices made by the ancient potter, link the pottery to the landscape, and assess whether the pottery was locally or non-locally made.

K. Michelaki et al. (2012) did this for the area around a Neolithic site in Calabria in Italy. By analyzing the raw materials found within the different geological provinces within 5 km of the site, testing and experimenting with these raw materials, and comparing the results with the analysis of the archaeological pottery from the site, she and her colleagues showed that the pottery was related to raw material sources from particular geological provinces. They found that the choices that potters made indicated that they had selected some clays and rejected others because some were simply unsuitable to make pottery. In a related paper, K. Michelaki and her colleagues also argued that the pottery from this same site was a congealed landscape (Michelaki et al., 2014). It certainly was, but it represented only that portion of the landscape that existed within the 4-5 km radius around the site that was used to obtain raw materials for making pottery. Using this same kind of methodology in other locations has enabled archaeologists to relate pottery from a site to the local landscape around it and to the choices that the potters made because they surveyed the area for potential pottery raw materials (Hein et al., 2004). Pottery, however, does not encapsulate or distill all aspects of the landscape, but only those from that portion that provides materials for making pottery.

Second, sources that have excellent raw materials for making pottery may have a sacred meaning associated with them, and this association may be one factor in their long term use in antiquity. The persistence of Neolithic steatite-tempered pottery in Silesia through time and its presumable single source suggests that a religious association may have reinforced the value of the temper for improving the thermal properties of cooking pots as well as its use for other pottery (Borowski et al., 2015). Further, just as in Ticul, high quality raw materials in Silesia are not widespread, but have a restricted distribution.

Third, do potters materialize a mental template when they make pottery? The changes in raw materials through time even in the most promising of production locations suggest that potters' indigenous knowledge does consist of some a priori knowledge, but rather potters' long-term and working memory, and their engagement of the raw materials using feedback from them enables the potter to choose appropriate raw materials for their forming technology and vessel shapes, cope with changes in those materials across space and through time, and adjust their paste recipes accordingly. Similarly, just as the raw materials, forming technique, the vessels that potters make change, so the paste recipe may also change.

Finally, there is a strong tendency to over-interpret paste composition, paste homogeneity (or lack thereof), and its change through time as having some social cause. It may or may not, but priority should be given to doing raw material survey, linking those raw materials in the paste to the local landscapes, and using experimental approaches to discover *first* if the choices made by the potter have a technological basis or not. Only then can raw material selection be related to some social or cultural explanation. By evaluating the technological foundations of raw material selection, raw material variability, its changes through time, and the technological foundations of paste recipes and their variability can one begin to understand social and cultural dimensions of ancient pottery that involve the selection of raw materials.

OTHER IMPLICATIONS FOR THE NEOLITHIC: SOME CAVEATS

Although the application of the probabilistic distance model presented above appears to be consistent with the Neolithic data from Calabria in Italy (Michelaki et al., 2012), the general application of these issues to the Neolithic period elsewhere may be rather complicated.

First, the geomorphology of the terrain, especially in alluvial contexts, may have varied significantly from the remote past such that Neolithic clay sources may be deeply buried by alluvial deposits. When mineral materials have been used for temper, however, a search of nearby exposed rocks may be more productive than a search for clay sources.

Perhaps even more important is a more fundamental question: did each localized population in an archaeological site make its own pottery, or was production specialized in communities that possessed superior raw materials and whose products were selected for over time, and then traded or exchanged? Whether or not one agrees with the probabilistic distance to resources model, the cross-cultural data suggest that long distance importation of ceramic resources was improbable, and pots rather than raw materials were imported.

Third, were all Neolithic populations fully sedentary, or did they occupy different niches over the yearly cycle that resulted in migration? Some populations might have been transhumant, living in the low lands during the summer and then moving their herds to higher elevations during the winter. Since making pottery is more difficult, and precarious during periods of low temperatures and precipitation, little if any pottery was probably made in the winter. In any event, S. B. McClure (2015) has argued that Neolithic peoples may have occupied several different niches with varying degrees of non-sedentism.

Further, except for the production of a few vessels, pottery production was probably restricted seasonally in Europe during the Neolithic because of the constraints of temperate and moisture on the drying and firing of clay and pottery. How might seasonality and degree of sedentariness affect raw material selection, and the variability of ceramic pastes?

Finally, such non-sedentary populations could easily collect raw materials from anywhere along their route and use domestic animals to carry it to the production location. Since cross-cultural data on pottery making reveal that women in most cultures were probably potters (Arnold, 1985, p. 99-108), how might sexual division of labor affect raw material selection? At least some evidence indicates that although women are potters, men may select and obtain the raw materials. So, it is possible that even though potters may have been sedentary, men may have brought raw materials from some distance away when the returned from a hunting trip, or returned to the settlement with their cattle, perhaps having the cattle carry some clay. This possibility is heightened when the raw materials used for making pottery possessed a sacred meaning or came from a sacred location.

CONCLUSION

The material presented here closely parallel the data and conclusions presented by O. P. Gosselain and A. Livingstone Smith (2005) in Africa. Their data was synchronic across potters in various communities whereas the data presented here is cross-cultural drawn largely from one community of practice in Yucatan, Mexico, and to a lesser extent from several communities in Guatemala. Further, the Yucatan data is diachronic covering a period of more than thirty-two years.

Potter's selection of raw materials is multi-layered and has multiple explanations. Many potential raw materials may occur across the landscape, but their quality for making pottery may vary; all clays and other potential raw materials may not be equally suitable for making pottery. Nevertheless, potters have extensive indigenous knowledge about them, and select appropriate raw materials by using several criteria: 1) the source's sense of place and its sacred meaning, 2) the obvious physical properties of the raw materials, and 3) their performance characteristics in making pottery. There also may be considerable individual variation.

Raw materials and their sources change across time and space. Access to sources may be denied for political reasons because of issues of land tenure and micro-politics. Sources may also become exhausted for the same reasons. In such situations, potters need to use their indigenous knowledge to find new sources and use their problem solving ability to engage, assess, evaluate raw materials from new sources. These changes may involve paste preparation with multiple raw materials, and result in new paste recipes that adapt to the making pottery using their forming technology. All this is to say that changes in raw materials, pastes, and paste recipes do not necessarily indicate changes in society, cultural complexity, organization of production, or migration, but rather may mean something as simple as a change in sources, or within-source variability. Pastes are not immutable. Rather they are adaptations to local materials to make a viable pot. Changes in raw materials and paste recipes across space and time do not necessarily have social meaning.

Potters' selection of raw materials and paste recipes are usually local, close to communities that are fully sedentary, and have resulted from selecting materials from a landscape with a limited radius. Potters' choices are circumscribed by a highly probable 5 km distance from a production location. Since archaeological budgets are limited, surveying for raw materials around an archaeological site thought to be a production location (or along a hypothetical migration route) at a distance of up to 5 km provides a cost-effect way that is likely to encounter sources of raw materials used in pottery production. Another way of saying this is that based on the distance model, the import of raw materials is possible, and does occur, but it is improbable; the trade and exchange of vessels are more probable. Pottery thus is a distilled landscape of raw materials that are local to a community of practice.

Further, some communities of practice may emerge through time as unique sources of pottery because of more durable viable vessels (e.g. cooking pots, the Silesia example). The development of specialized communities in the Neolithic producing a unique product thus is quite possible, although such community specialization is usually associated with more complex societies that are fully sedentary.

SOME QUESTIONS

In light of what has just been said, the selection of appropriate raw materials in the European Neolithic raises two questions. First, since cross-cultural data on pottery making reveal that women in most cultures were probably potters (Arnold, 1985, p. 99-108), how might sexual division of labor affect raw material selection? At least some evidence indicates that although women are potters, men select and obtain the raw materials. Second, except for the production of a few vessels, pottery production was probably restricted seasonally in Europe during the Neolithic because of the constraints of temperature and moisture on the drying and firing of clay and pottery, how might seasonality and degree of sedentariness affect raw material selection, and the variability of ceramic pastes?

NOTES

(1) This paragraph is a summary of Shepard (1965), Rice (1987), and Rye (1982).

(2) A successful hunting expedition would likely obviate the transport of additional weight back to camp.

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Technical traditions and pottery craftsmanship among the Woloyta and Oromo groups in Ethiopia

Actualist references for refining prehistoric ceramic analytical protocols

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Abstract: In prehistoric archaeology, any examination of the clay raw materials used for producing ceramics brings us back to the question of the supply sources and the localization and extent of the exploited territories. It also involves working on the technical traditions of the first stages of the operational chain as an identity marker of a social group, tracking the technological mixing of attributes from one group and techniques from another, assessing the diachronic development of technical procedures and evaluating the physical and chemical constraints of the raw material in the artisan potter's choices.

For the Neolithic, our team focuses on the north-western Mediterranean zone and the Horn of Africa, and aims to record three types of complementary historic processes, for which it is essential to carry out research on raw materials and how they were processed.

First of all, these consist of diffusion processes during the emergence of the first productive societies. Work on Mediterranean Neolithisation involves the consideration of diffusion mechanisms for new techno-economic characteristics and of the long-distance transfer of ceramic know-how. From an economic viewpoint, (domestic?) production structures are also examined, as well as the use of tempers as cultural signatures. At the end of the Neolithic, processes linked to movements of communities outside their boundaries are also clearly observed; they sometimes lead to the gradual re-composition of the operating system of neighbouring societies, as is the case with the extension of the Languedoc group of Ferrières in the Jura on the lakeside sites of Chalain, or in the heart of Provence where unequivocal Italic cultural filiations are observed in ceramic productions and demonstrate strong circulation currents linked to copper metallurgy. For diffusion processes, the analysis of raw materials (localization of sources, unique or multiple supply sources? etc.) is indispensable in order to evaluate whether aesthetic and technical standards spread first and were then adopted or whether, conversely, these processes resulted from human mobility.

Next, we look at cohabitation processes, for example at the end of the Neolithic, when the Bell Beaker culture spread throughout the whole Mediterranean region. Situations involving mixing have been observed throughout the South of France: for example, we find vases affiliated to local groups (such as Fontbouisse) but which contain *chamotte* tempers, which was the dominant Bell Beaker technique, and at the same time, we find Bell Beaker containers presenting calcite tempers, which is one of the main characteristics of regional style Provence products. These situations denote the existence of borrowing and assimilation and can only be analysed through the study of clay paste preparation conditions.

Lastly, we observe processes where cultural isolation is maintained, in marginal, conservative zones represented by the resistance of hybrid communities rethinking their products over time, while at the same time retaining typical characteristics considered as standard during the preceding period. Again, it is vital to take account of actions on materials in order to answer this question.

One of the ways of developing our archaeological reflection with regard to these historic processes and refining our discourse and interpretations of our Neolithic ceramic assemblages is to refer to actualistic data. In this article, we present research conducted since 2011 with Ethiopian potter communities in the Oromiya region in the Rift Valley. The aims of this research include: building up reference collections of the technical procedures in order to increase the efficiency of analytical protocols on prehistoric archaeological series, and working on occurrences of the borrowing or non-borrowing of technical and stylistic ceramic traits, as part of the ANR project led by V. Roux (UMR 7055 Préhistoire et Technologie, Nanterre). The aim is to construct models for interpreting processes of archaeological diffusion in prehistory and to assess the dynamics at work in the development of cultural traits and societies. In keeping with the theme of the workshop, we will concentrate on the first area of our research and on observations of the first stages of the operational chain. This is, above all, a way of presenting our study protocols and our archaeological investigation of these ethnographic reference collections to the wider scientific community.

Keywords: ethnoarchaeology, technical traditions, Neolithic, ceramic artefacts, Ethiopia, Lake Region, Oromo and Woloyta ethnic groups.

Résumé : En archéologie préhistorique, s'interroger sur les matières premières argileuses employées dans le façonnage des céramiques revient à questionner les sources d'approvisionnement et par suite la localisation et l'étendue des territoires exploités, à travailler sur les traditions techniques aux premières étapes de la chaîne opératoire comme marqueur identitaire d'un groupe social, à pister les phénomènes de mixités techniques entre attributs typologiques propres à un groupe et techniques spécifiques à un autre, à mesurer l'évolution des procédés techniques dans la diachronie, et enfin à évaluer les contraintes physiques et chimiques de la matière dans les choix de l'artisan potier.

Pour le Néolithique, notre équipe, sur ses terrains en Méditerranée nord occidentale ou dans la Corne de l'Afrique, vise la documentation de trois types de processus historiques complémentaires, pour lesquels les travaux sur les matières premières et leurs traitements sont des informateurs essentiels.

Tout d'abord, des processus de diffusion au moment par exemple de l'émergence des premières sociétés de production. Les travaux sur la néolithisation méditerranéenne nous entraînent en effet à s'interroger sur les mécanismes de diffusion des nouveautés techno-économiques et sur les transferts à longues distances de savoir-faire céramique. Sont également questionnées d'un point de vue socio-économique, les structures de production (domestiques ?) de même que l'usage de certains dégraissants comme signatures culturelles. A la fin du Néolithique, des processus liés au déplacement de communautés hors de leurs limites sont également clairement avérés ; ils aboutissent parfois à la recomposition progressive du système de fonctionnement de sociétés voisines comme c'est le cas avec l'extension du groupe languedocien de Ferrières dans le Jura sur les sites lacustres de Chalain ou au cœur de la Provence lorsque des filiations culturelles italiques sont sans équivoques dans les productions céramiques et témoignent des puissants courants de circulation liés à la métallurgie du cuivre. Pour ces processus de diffusion, l'analyse des matières premières (localisation des sources, sources d'approvisionnement uniques ou multiples ?, etc.) est indispensable afin de mesurer si ce sont des canons esthétiques et techniques qui ont diffusé, et qui par la suite ont été adoptés ou au contraire si il y a eu mobilité de personnes.

Ensuite, des processus de cohabitation, par exemple à la fin du Néolithique, lorsque le phénomène Campaniforme inonde toute la Méditerranée. Des situations de métissages sont en effet avérées dans tout le sud de la France avec des vases affiliés aux groupes locaux (comme le Fontbouisse) fabriqués à l'aide de dégraissant à la chamotte, technique dominante dans le Campaniforme et, dans le même temps, des contenants campaniformes présentant du dégraissant à la calcite, caractéristique première des produits des styles régionaux de Provence. Ces situations traduisent des phénomènes d'emprunt et d'assimilation que seule l'analyse des modalités de préparation de la pâte est susceptible de documenter.

Enfin, des processus de maintien d'isolats culturels, dans des zones en marges, conservatrices qui vont se traduire par la résistance de communautés hybrides réinterprétant leurs produits selon les codes de leur temps, tout en faisant perdurer les caractéristiques typiques de ce qui était la norme à la période précédente. Là encore, la prise en compte des actions sur la matière est fondamentale pour régler cette question.

Un des moyens d'alimenter notre réflexion archéologique sur ces processus historiques et d'affiner notre discours au moment de proposer des interprétations de nos assemblages céramiques néolithiques est sans aucun doute de faire appel à des données actualistes. Dans le cadre de cet article, nous proposons de présenter les recherches que nous conduisons depuis 2011 avec des communautés de potières en Éthiopie, dans la vallée du Rift, en région Oromiya. Cette recherche poursuit plusieurs objectifs parmi lesquels : constituer des référentiels des procédés techniques pour décupler l'efficacité des protocoles analytiques sur les séries archéologiques préhistoriques et, dans le cadre d'un projet ANR piloté par V. Roux (UMR 7055 Préhistoire et Technologie, Nanterre), travailler sur les phénomènes d'emprunt ou de non-emprunt de traits techniques et stylistiques céramiques. Il s'agit ici d'offrir des modèles pour interpréter en Préhistoire les processus de diffusion archéologique et, dès lors, les dynamiques à l'œuvre dans l'évolution des traits culturels et des sociétés. En accord avec la thématique du workshop, nous concentrerons notre présentation sur le premier axe de notre recherche et sur les observations réalisées sur les premières étapes de la chaîne opératoire. Il s'agit surtout de soumettre à la collectivité nos protocoles d'études et nos questionnements archéologiques sur ces référentiels ethnographiques.

Mots-clés : ethnoarchéologie, traditions techniques, Néolithique, vestiges céramiques, Éthiopie, région des lacs, groupes ethniques Oromo et Woloyta.

INTRODUCTION

Pottery, the expression of a complex craft, the reflection of cultural identity and social strategies

All the technical acts necessary for manufacturing an object (the acquisition of raw materials, their transformation, manufacturing techniques) are established on knowledge learnt in a sociological niche. Each stage of the *chaîne opératoire*, i.e. 'the series of operations that transform raw material into finished products, either consumption object or tool' (Creswell, 1976, p. 13) varies according to constraints related to both the properties of the material and cultural factors. These cultural factors are cultural heritages, traditions, customs, taboos and exchanges, but are also based on political and professional rules. This methodological background allows us to consider the production of an object according to different interactive analytical levels; from cognitive processes related to learning to processes of transmission and the evolution of practices, and thereby attain the cultural expression of a society. The correlation between 'technological traditions' and "social groups" exists all over the world. It is a theory applied by members of the research community focusing on ethnographical and ethnohistorical studies (Creswell, 1976; Rye and Evans, 1976; Rye, 1981; Mahias, 1993; Dietler and Herbich, 1994; Bowser, 2000; Gosselain, 2000, 2002 and 2008; Roux, 2003; Pétrequin and Pétrequin, 2006; Stark et al., 2008; Gallay et al., 2012). This research showed how the study of the ways of doing and manufacturing processes of traditional societies are invaluable for interpretative constructions related to the description and understanding of archaeological artefacts.

Our project focuses on one of the most important manual skills in the world for several millennia - pottery manufacturing - in order to collect different data relating to cultural traditions. Today, the combined study of technological processes and objects (shapes and decoration) is essential for an anthropological interpretation of ceramic assemblages (for an overview see Albero Santacreu, 2014). The cultural value of the manufactured ceramic product no longer needs to be proven. It is a marker of individual (the emblematic person of the potter craftsman) or of collective differentiation (interactions between social groups, exchanges, social boundaries).

In 2011, we began an ethnographic research program in Ethiopia[(1)]. Here, the fabrication of pottery (without a potter's wheel) is still widely practiced. The fabrication techniques and the social status of craftsmanship vary considerably depending on the different regions and ethnic or linguistic groups involved. Studies have rarely been conducted on technical pottery traditions in Ethiopia (Silverman Raymond, 2000; Arthur, 2006; Lyons, 2007 and 2014; Lyons and Freeman, 2009; Harlow, 2011; Wayessa, 2011; Kaneko, 2014).

The diverse aims of our research include increasing the effectiveness of analytic protocols on prehistoric archaeological assemblages by building up ethnographic references in order to refine our interpretation and understanding of technical traditions. The purpose of this is to achieve a better evaluation of technical behaviour and the organization and distribution of production. The main objective is to provide answers to the sociocultural and techno-economic problems of interpretation of Neolithic archaeological assemblages in Africa and Europe (apprenticeship 'niche', codification of social relationships, transmission, transfer of techniques between groups, standardization, and social boundaries). Ultimately, this project aims to understand the complex links connecting material ceramic productions, the identity of the producers, the management of territories and resources, and exchange networks of objects and ideas.

This ethnographic study serves fundamental research, but its main objective is to focus on the conservation and promotion of this singular skill and knowledge, which is an integral part of traditional cultural heritage in Ethiopia, in a global context where ceramic traditions are progressively disappearing as a result of material cultural change or mechanized production. In the neighbouring countries of the Horn of Africa, potters have already totally disappeared from the Republic of Djibouti (Cauliez et al., 2008; Cauliez et al., in press) and are increasingly rare in Somalia (Belkin et al., 2006).

Ethnographic references to refine our interpretation and understanding of prehistoric technical traditions

Our archaeological research at the TRACES laboratory in Toulouse, France, focuses on the Neolithic. Our specialized study zones are located in the north-western Mediterranean area and the Horn of Africa (Manen et al., 2010a; Cauliez, 2011; Ard, 2013 and 2014; Caro, 2013; Gutherz et al., 2015; Defranould and Caro, in press). Our work concentrates on the reconstruction of the historical and social dynamics of Neolithic societies, assessed through the prism of ceramic production analysis. As each project member is specialized in a specific period, the comparison of our different fields enables us to cover a wide chronological scale - ranging from the Early Neolithic to the Final Neolithic - and thus to consider the main issues:

- based on the study of very diverse sites (ranging from more or less large scale permanent habitation sites to temporary stopovers, defensive sites, aggregation sites, and funerary sites),

- based on the study of ceramic assemblages presenting wide variability as regards production modes, styles and conservation status.

In order to assess the different anthropological questions characterizing the Neolithic, such as processes of diffusion and circulation of people and ideas, assimilation and acculturation processes or, conversely, cultural resistance, we analyse technical traditions because they reveal the mechanisms of social identity assertion, human group mobility or transfers and cultural mixing. Our respective studies correspond to a multi-angled approach to our assemblages, highlighting a global approach to the *chaîne opératoire*. During the course of these studies, several difficulties arose for each of us, regarding the interpretation of certain aspects of these ceramic productions. In keeping with the theme of this workshop, we will focus here on raw material processing, from extraction to use, as our ethnographic studies in Ethiopia can provide new data on this topic. However, it is clear that the reference collection built up here responds to questions incorporating the different stages of the *chaîne opératoire*.

OUR ARCHAEOLOGICAL QUESTIONS

Issue 1: tempers – the case of grog (also known as firesand and '*chamotte*')

Many studies, particularly in the domain of petrography, have shown the importance of identifying non-plastic inclusions, i.e., tempers, and especially grog, added to clay by potters (Echallier, 1984; Constantin and Courtois, 1985; Whitbread, 1986; Sénépart and Convertini, 2003). In our studied assemblages, analyses carried out in collaboration with F. Convertini have identified different issues related to this subject.

First of all, the study concerns the Early Neolithic on the French coastline, i.e., ceramic productions made between 5,800 and 4,800 BC, in a domestic production context with significant individual variability, in spite of common cultural norms.

In a research program entitled 'non emprunt Organization and development of first farmer societies. Structure of ceramic productions from Liguria to Catalonia' (Manen et al., 2010a), we studied about forty settlements, mainly located in the South of France but also in Liguria and Catalonia, and more than 800 ceramics/sherds (fig. 1). From a methodological point of view, we tried to conduct global observation of ceramic productions but we were sometimes limited by the characteristics of our assemblages: for example, the problem of fragmentation hampers observations concerning shaping and the organization of decoration on the pot. Questions relating to raw material management, clay modification and the structure of decoration were more detailed. Raw material management was studied through the petrographic analysis of thin sections. The location of raw material sources was investigated following a specific protocol (Convertini, 2010) which also involves geomorphological analysis around settlements and studies of natural soil samples. This work has shown that clay preparation relies on a set of technical practices, ranging from the most simple to the most complex, and in particular, the use of tempers. To summarize these results, which have been published elsewhere (Binder et al., 2010), potters did not add tempers to 40% of the corpus, whereas for the remaining 60%, various types of tempers were added. Of these, the best-represented tempers are grog (including dry clay), crushed calcite, and, more occasionally, bone. As part of this study, by comparing these observations with all stages of the *chaîne opératoire* (from clay acquisition to the decoration stage), we were able to study the geographic distribution of these practices and their chronological evolution. At this scale of observation, we deduced that grog, crushed calcite and bone had strong cultural connotations, in so far as these contributions represented technical traditions and thus distinct, but permeable, social groups.

Nonetheless, in many assemblages, 40% of the pots do not contain tempers, and this technical choice is difficult to interpret. Indeed, these productions are generally very fragmented and do not enable us to determine whether the presence or absence of tempers can be correlated to specific morphofunctional types, for example.

Let us now take as an example the site of Chauve-Souris Cave at Donzère, located on the bank of the Rhone and dated to the end of the Neolithic in southern France (Vital, 2007, 2010 and 2011). Excavations at this site were directed by J. Vital and the chronometry of the stratigraphic sequence is well established. The composition of the assemblage presents exceptional typological variability (fig. 2). Ceramics are related to a micro-local sphere of production, as well as an extra-regional sphere, in the same way as productions with north Italian and Bell-Beaker influences.

For this site, petrographic studies were carried out in order to identify provisioning sources and any possible specific raw material processing (see Convertini, in Cauliez, submitted). These studies enabled us to:

– determine that aesthetic canons may have been diffused and adopted, since Italian-style productions are not exogenous productions (imitation; Colas et al., 2007; Rouillard et al., 2007);

– reveal cultural transfer phenomena since pots of Italian tradition are tempered with grog, and this "way of doing" appears to have been inherited from the Bell-Beaker culture. If both productions are contemporaneous, this could represent a case of technical borrowing which is likely to indicate reinterpretation processes (Colas et al., 2007; Rouillard et al., 2007; Manem, 2008). Unfortunately, in this case, petrographic data related to trans-Alpine productions are still lacking and it is still not certain whether or not grog was used in the area;

– identify provisioning sources; these are never less than 10 km away and can be over 50 km from the site;

– estimate the diversity of acquisition networks: the same finished products (Bell-Beaker or Italian shaped productions for example) were made using clay from various sources, separated by distances of nearly 100 km.

F. Convertini deduced from these observations that the pots were not produced on site: clay extraction sites can provide information on the location of the origin sites of the different occupants of the cave and, given the diver-

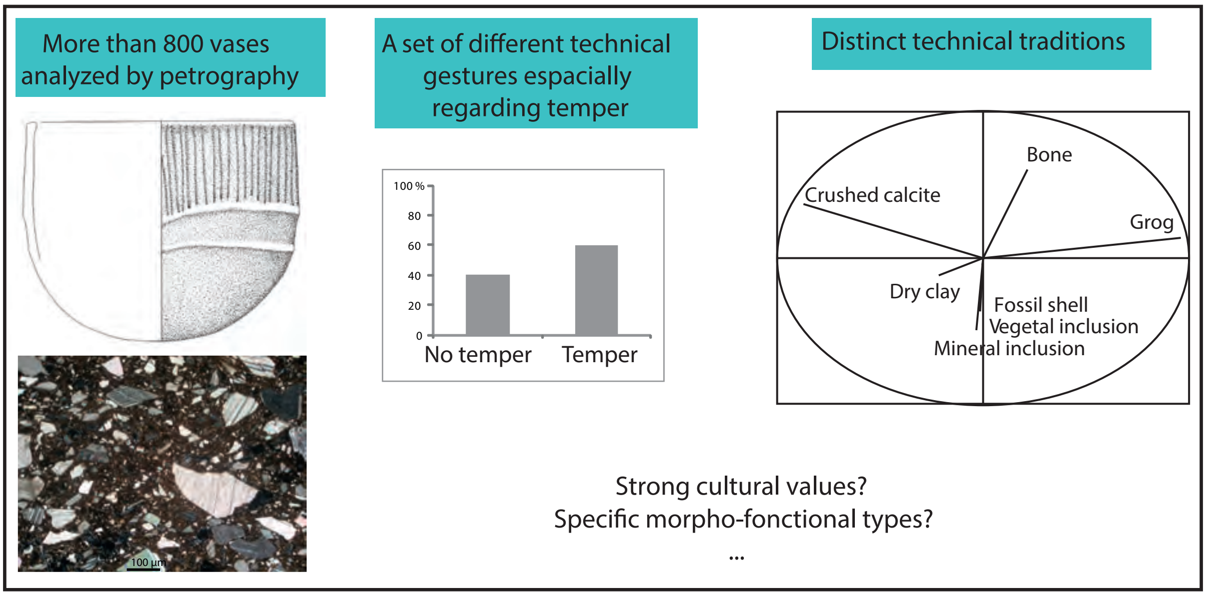

Fig. 1 – Early Neolithic pottery productions (5,800-4,800 cal. BC), Southern France.
Fig. 1 *– Productions céramiques du Néolithique ancien dans le Sud de la France (5800-4800 cal. BC).*

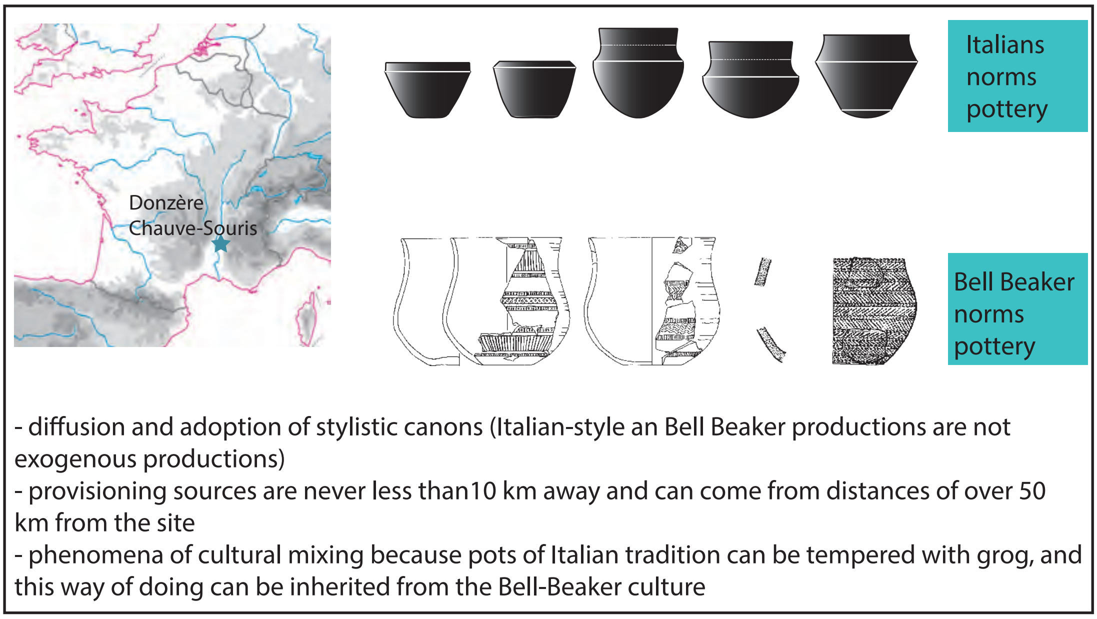

Fig. 2 – Final Neolithic pottery productions (2,800-2,200 cal. BC), Southern France (Drawings of pottery J. Vital *in* Vital, 2007 and J. Cauliez, in Cauliez, submitted).
Fig. 2 *– Productions céramiques du Néolithique final dans le Sud de la France (2800-2200 cal. BC; dessins J. Vital in Vital, 2007 et J. Cauliez,* in *Cauliez, submitted).*

sity of the clays, several different social groups could have acquired them. Thus, the site where these productions with varied stylistic and techno-petrographic attributes are gathered together cannot have been a habitation site. Complementary studies by one of our project team members (Cauliez, submitted) suggest that the cave may have functioned as an aggregation site (Manem, 2010; Roux et al., 2011; Roux and Courty, in press). This obviously implies that the chronology of the occupation is very constrained, as this diversity could denote the simultaneous meeting of several social groups, or a succession of visits to the cave at an unknown rhythm, whereby the different groups did not meet each other.

In this site, ceramic productions with grog tempers are Bell-Beaker forms and conform to Italian-style pots. These are always very small pots, which are either ornately decorated, or very black in colour with no decoration and fine walls with a complex morphology and surfaces subject to intensive burnishing. These productions reflect a high degree of technical investment and are socially very "visible" (in the sense of the term used by C. Perlès: Perlès, 2007, p. 321).

Consequently, with these two examples from the beginning and the end of the Neolithic, we observe a technical practice which involves the addition of grog. This practice may be a response to distinct situations governed either by a technical practice determined by the physical and chemical constraints of the raw material, or by cultural practices, or both, as these two factors are not incompatible. Therefore, we now need to establish reference collections in order to proceed with an in-depth analysis of this technical practice. Let us consider the second question raised by our Neolithic assemblages in relation to raw material processing.

Issue 2: influence of clay paste preparation on the 'quality' of the finished products

Let us now take another Early Neolithic example, but this time in a more continental region, located a considerable distance from the coast (fig. 3). For a long time, the aesthetic aspect of Early Neolithic ceramic assemblages from these regions incited archaeologists to consider these productions as lesser quality productions, resulting from mediocre *savoir-faire*. They finally attributed them to populations with low technical skills, and in this particular case, to hunter-gatherer groups in the process of acquiring Neolithic innovations (Niederlander et al., 1966; Roussot-Larroque, 1977 and 1990; Arnal, 1995 and 2006; Van Willigen, 1999).

It is true that these continental productions provide evidence of less intensive work as regards certain technical or stylistic aspects, such as the scarcity of decoration and gripping elements, thicker walls, less stretched coil junctions (Costantini and Maury, 1986; Maury, 1997; Boboeuf, 2004).

However, two recent site studies (Le Clos de Poujol and Combe-Grèze in Aveyron, France), when compared to data from classic Early Neolithic sites (Le Taï in Gard, France), have shown that technical and stylistic convergences exist between Early Neolithic coastal productions and those from the Early continental Neolithic (Caro, 2013; Defranould and Caro, in press). They are part of the same morphological and ornamental range, with the same buffing type finishing procedures and the same

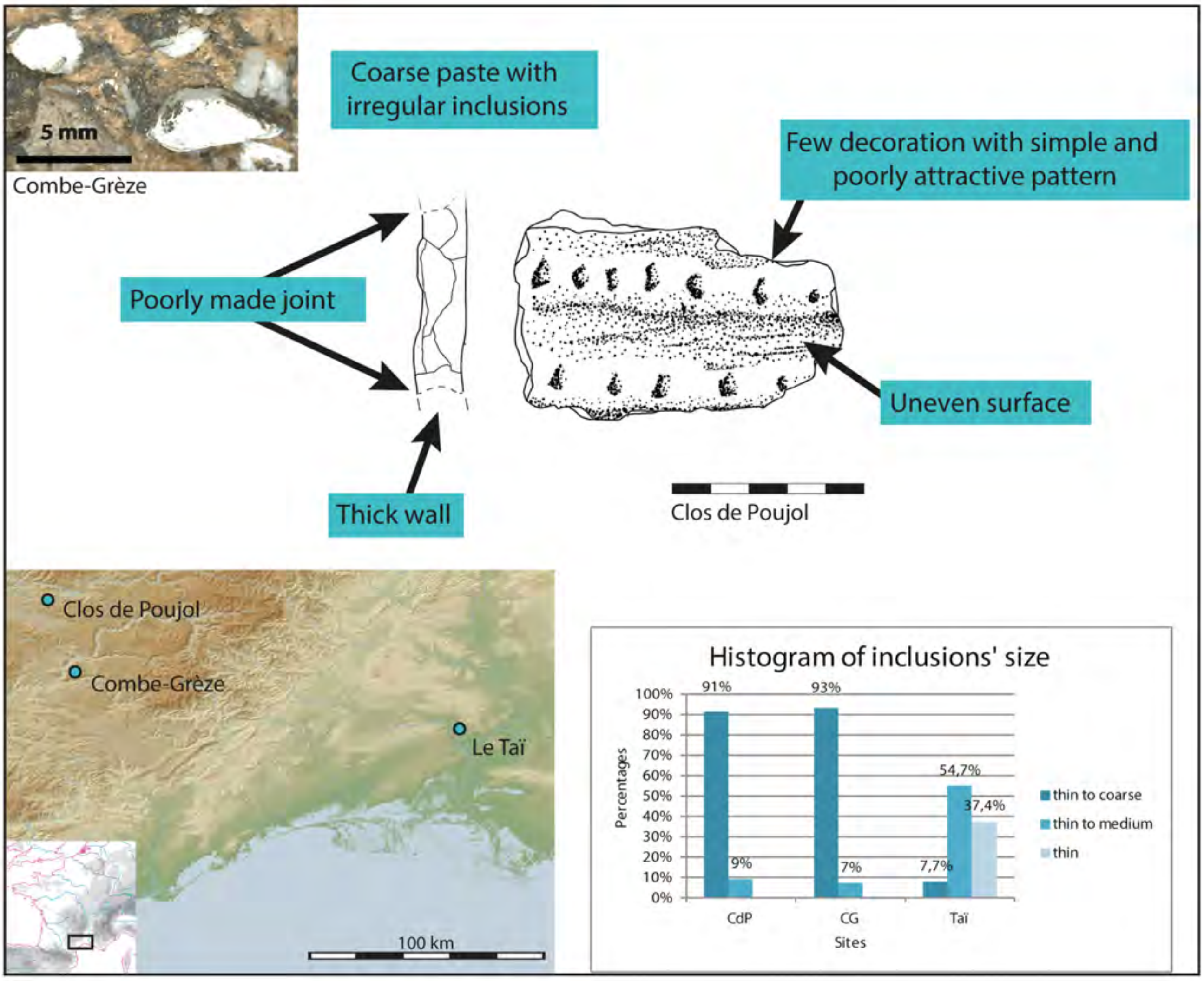

Fig. 3 – Early Neolithic pottery productions (5,800-4,800 cal. BC), Southern France.
***Fig. 3** – Productions céramiques du Néolithique ancien dans le Sud de la France (5800-4800 cal. BC).*

coiling methods. This is also the case for the raw materials: petrographical studies carried out by F. Convertini have revealed evidence for the addition of calcite as a temper (Convertini, 2010; Manen et al., 2010b). These convergences between products from the Early coastal and continental Neolithic point to similar skill levels, and have contributed over the past few years to mitigating the binary interpretation whereby the last hunter-gatherers were associated with products of mediocre quality and the first Neolithic populations were assumed to have produced good quality products. These are important data for understanding Neolithization mechanisms involving demic diffusion based on native networks or cultural transfer processes (Mazurié de Keroualin, 2003).

However, there are differences between coastal and continental productions. Indeed, these new analyses focusing on the first stages of the *chaîne opératoire* show that continental Early Neolithic clays often contain heterometric inclusions with a high proportion of coarse inclusions. This leads us to believe that there was less investment in crushing the clay, sorting inclusions and/or mixing. What might be the significance of this practice?

Productions from the end of the Neolithic in west-central France, between 3,400 and 2,200 cal. BC, raise similar questions (Ard, 2013 and 2014). They are also characterized by 'crudely'-made ceramics: thick walls, clays with a high content of coarse inclusions, slightly smoothed or unsmoothed walls, etc. These ceramics are generally considered to have demanded little technical investment (fig. 4). This type of production is represented during the same period in most contemporaneous cultures, such as the Horgen culture in eastern France and Switzerland or the former Seine-Oise-Marne complex in the Paris Basin. For all these groups, the main problem is our incapacity to define ceramic styles based solely on morphological criteria. For this reason, recent studies take into account all stages of the *chaîne opératoire*, from the choice of raw materials to firing operations (Martineau, 2000; Martineau et al., 2000; Augereau et al., 2007; Ard, 2014; Cottiaux and Salanova, 2014).

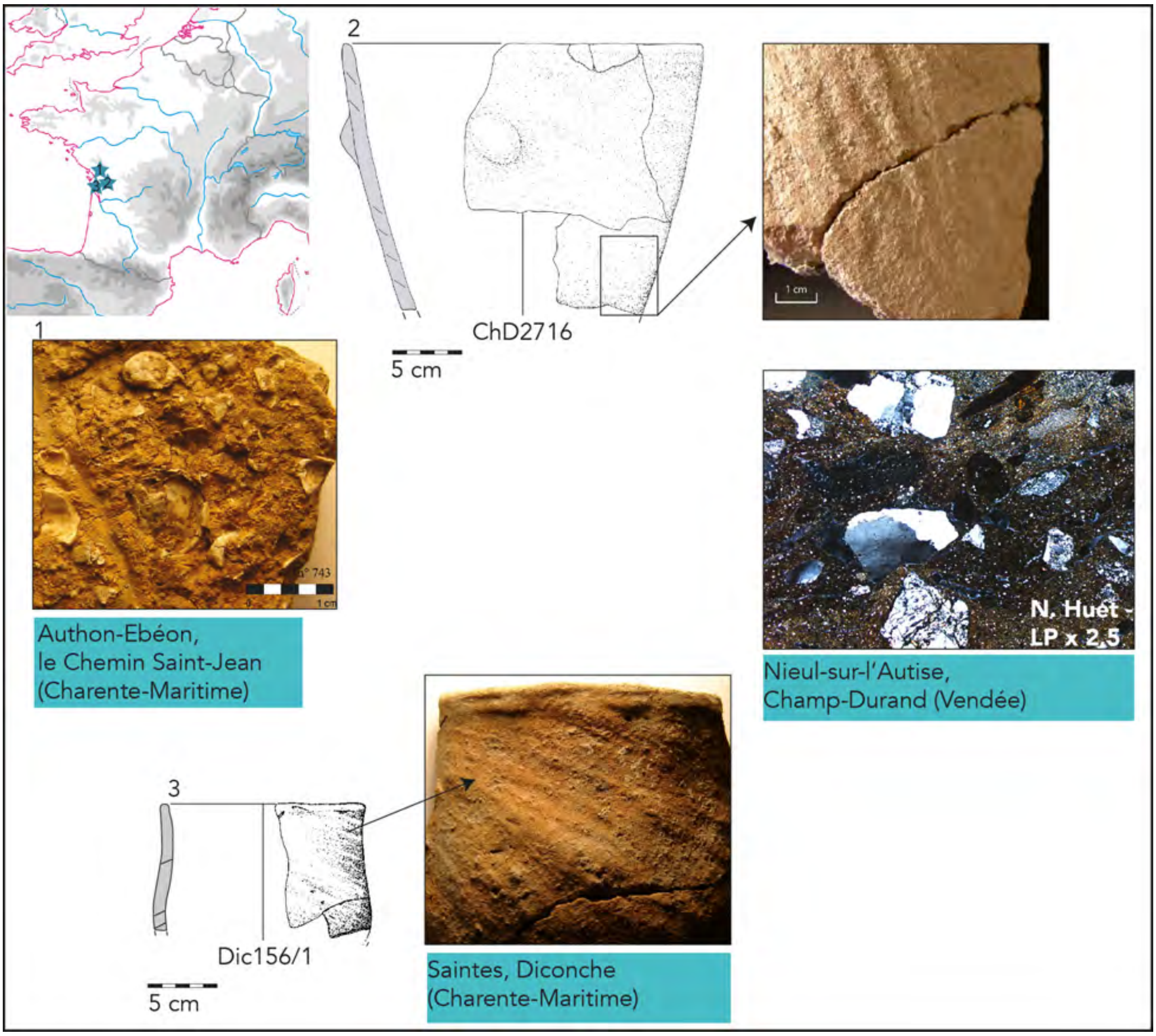

Fig. 4 – Late and Final Neolithic pottery productions (3,400-2,200 cal. BC), West-central France.

Fig. 4 – *Productions céramiques du Néolithique récent et final dans le Centre-Ouest de la France (3400-2200 cal. BC).*

In west-central France, the properties of these ceramic pastes raise several cultural and functional questions. Culturally, unlike for shaping methods, we do not observe any preferential choice of a specific material in the different contemporaneous groups, apart from the use of clay with fossil shell inclusions in certain ceramics from the Seuil du Poitou group. Productions from this period are thus characterized by the quantity rather than the type of inclusions. The use of such materials inevitably raises questions as to the properties of the finished products, particularly in terms of resistance to mechanical and thermal shocks, and thus to the duration of the service life of the pots. Petrographic analyses of several assemblages by F. Convertini and N. Huet show that there was a deliberate choice to use ceramic pastes with a high concentration of inclusions, either by using clays with a naturally high proportion of inclusions, or by adding tempers (sand, plants and grog), in order to obtain pastes with inclusion proportions at times representing more than 30% of the clay matrix (Convertini, 1996 and 1999; Huet and Ard, 2012; Ard, 2014). Therefore, this choice might indicate that most of these ceramics were intended for daily use, like cooking and food storage, and that they required high resistance to thermal and mechanical shocks.

In this context, like for the Early Neolithic, several questions are raised:

- what impact does the use of pastes with high proportions of inclusions have on the shaping, finishing and firing stages of the manufacturing process?
- is it possible to define the preparation process of the paste and the "recipes" used (proportion of added inclusions *vs* natural inclusions, for example)?
- how can we evaluate the hardness and the resistance of ceramics to mechanical and thermal shocks during the use of pots? What is the respective influence of the degree of preparation and the type of material on these properties?

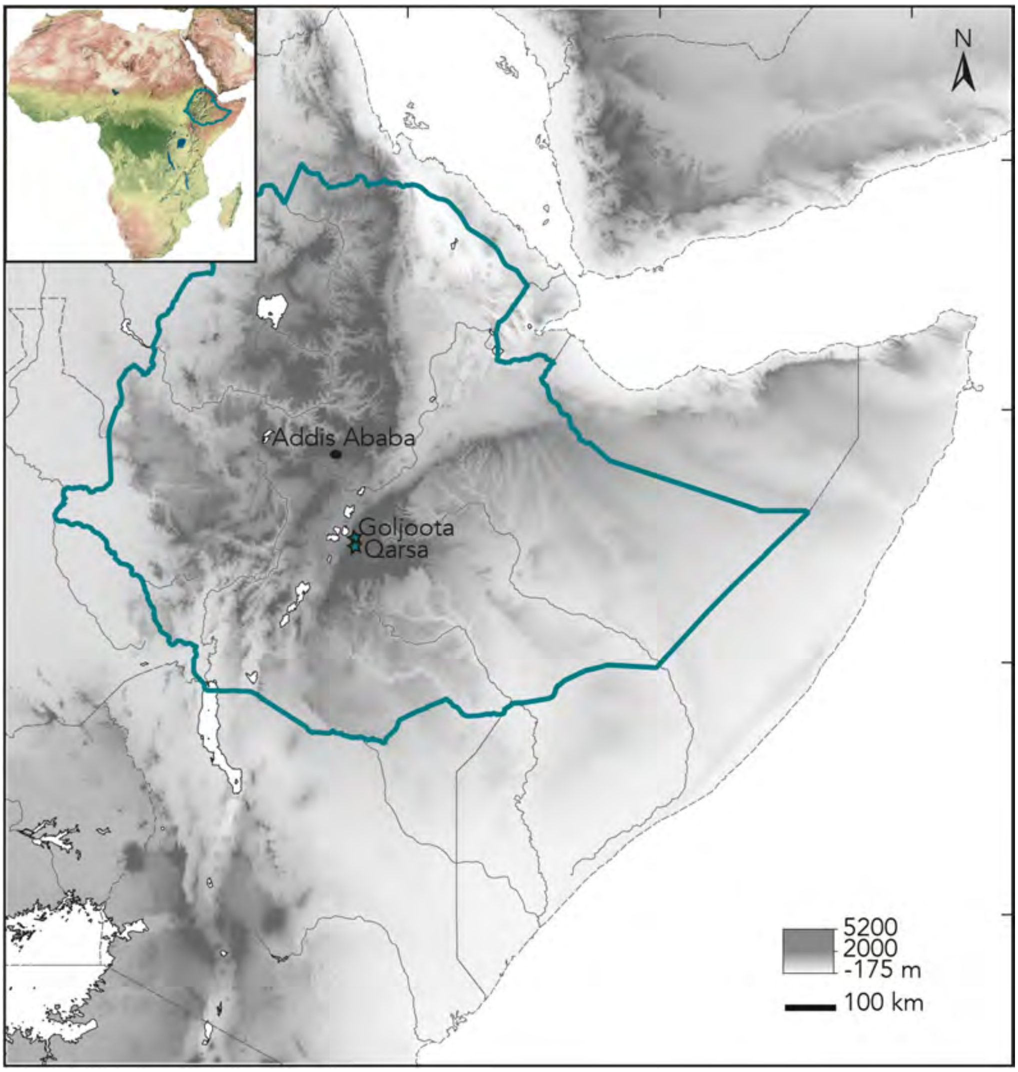

Fig. 5 – Location map of the ethnographical survey area in Ethiopia. Arsi and West Arsi Zones. Oromiya Region, with locations of Goljoota and Qarsa townships.

***Fig. 5** – Carte de localisation de la zone d'enquêtes ethnographiques en* Éthiopie*. Région Oromiya, zones Arsi et West Arsi, avec signalisation des localités de Goljoota et Qarsa.*

- beyond what proportions of inclusions and/or tempers used, can we consider that ceramics are weakened during use?

ACTUALIST REFERENCES FOR ENHANCING THE ANALYTICAL PROTOCOLS FOR PREHISTORIC CERAMICS

In Ethiopia, our work focuses on two localities, the townships of Qarsa and Goljoota located in the heart of the zone of large Ethiopian lakes, in the central-west zone of the Rift Valley within the region of Oromia (fig. 5). From an administrative point of view, the Oromia region or Oromia National Regional State is one of the largest federal regions of Ethiopia. Oromia is divided into 18 administrative zones. The two studied localities are an hour's drive from each other, in a landscape of plains and mid-mountain plateaux, with a climate conducive to agriculture and cattle and goat farming. The vegetation consists of shrubby savannas and rain forests with alpine vegetation on the mountain peaks.

Here, two ethno-linguistic groups make pottery: the Oromo and the Woloyta, alongside other ethnic tribes: the Guragué, Amhara, Kembattinia and Sidamo. Each of these two ceramic producing communities is represented by about thirty households.

Characteristics of the research area and survey methodology

Rural household economies in Arsi and West Arsi (2 of the 18 administrative zones of Ethiopia) are based on ox-plough cereal farming of wheat, barley, teff, millet, sorghum, maize and sometimes lentils and vegetable crops, with many farmers also keeping small numbers of cattle, sheep, goats and, occasionally, bees.

The level of dependency of these two groups on pottery varies, depending on whether or not they own their land. The Woloyta have been moved around over the past forty years and they do not own their own land. Consequently, they are full-time potters, whereas the time the Oromo spends on ceramics depends on agricultural and pastoral activities.

Pottery craftsmanship is a female activity, although the Woloyta men and young boys actively participate in the extraction of clay materials, as well as in the firing and sale of pottery.

The Oromo speak Afaan Oromo or Amharic and the Woloyta speak Woloytania or Amharic. From a general and demographic point of view, the Oromo represent the main group in the Oromia region. They are also in a majority in Ethiopia as a whole and they are present beyond its administrative borders (established in 1994 by the federal state). The Oromo people has split into a number of groups, characterized by cultural and linguistic variability (dialects). They nevertheless share a traditional socio-political, religious, economic and administrative system, the Gada system, which has been transmitted orally for hundreds of years. From a religious point of view, Christianity (Orthodox and Protestant) and Islam are the major religions. Wakefana (Waqeffannaa) is the traditional system of faith.

The Woloyta are migrants originating from the SNNPR region (Southern Nations, Nationalities, and People's Region). They owned no land and thus developed various types of crafts.

For these various communities, the system of filiation is patrilineal. Therefore, the transmission of property and family names by inheritance takes place within the male lineage. When a woman gets married, she leaves her hometown to join the village of her husband.

The Oromo and Woloyta have distinct technical traditions and their everyday products are easily identifiable. The identity of the social group- Oromo, Wataa Oromo or Woloyta- is clearly printed on each stage of the *chaîne opératoire*. These social groups have their own apprenticeship networks. Therefore, technical traditions remain stable in spite of intra-group knowledge of other procedures. These social groups interact at different levels and especially in places of redistribution (small markets), characterized by economic complementarity.

In this vast field of inquiry, using the ceramic technical system as an element of social group differentiation is valid: during the course of apprenticeship, potters from different groups construct their individuality on the basis of the collective model. When they practice their trade, they relate to the social identity of the group. By reproducing technical traditions, they thus perpetuate this identity.

In the field study, our methodology is based on standardized questionnaires, on the direct observation of manufacturing processes (from raw material extraction to product consumption), and on experimental work with potters. The protocol was established as part of the ANR program led by V. Roux and B. Bril.

In this way, over the past four years, we have collected data on:

- the social identity of potters and their families, networks of social relationships;

- the social status of this activity within a local cultural and economic context;

- the procedures implemented at each stage of the *chaîne opératoire* (photographs, questionnaires, films) and an evaluation of the physical constraints likely to influence potters' choices (inventory of sources, exploitation periodicity, clay sampling, purchasing finished products, etc.);

- apprenticeship networks;

- the degree of expertise and the level of technicality of each potter (questionnaires and experiments).

Fig. 6 – The different shapes of the Woloyta ethnic group production.
***Fig. 6** – Les différentes formes de la production du groupe social Woloyta.*

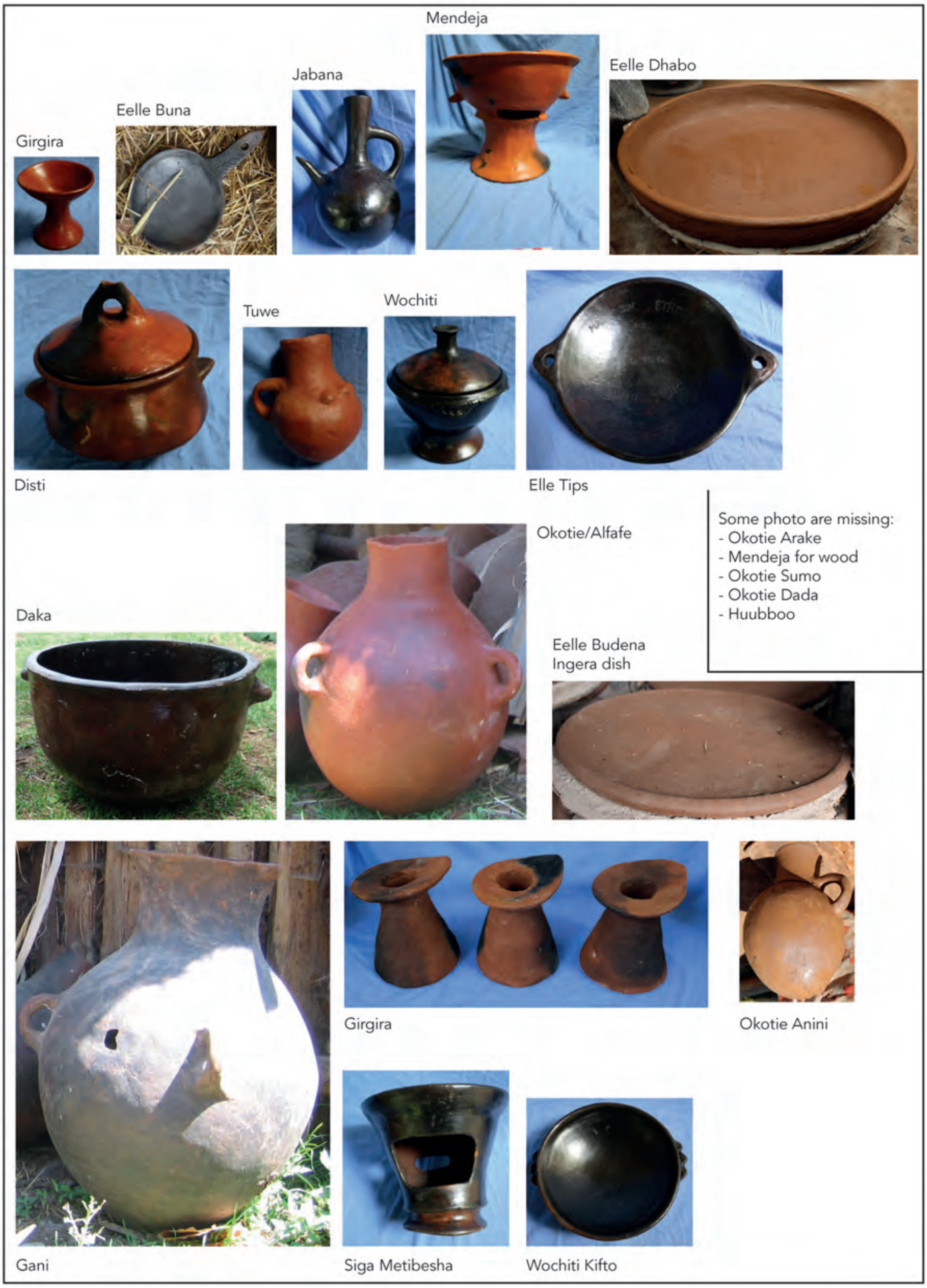

Fig. 7 – The different shapes of the Oromo ethnic group production.
Fig. 7 – *Les différentes formes de la production du groupe social Oromo.*

Fig. 8 – Woloyta social group at Goljoota. 1: source of white clay; 2 and 3: source of red clay; 4: stratigraphic section along the Arsi Negele road.

***Fig. 8** – Les Woloyta de Goljoota. 1 : la source d'argile blanche ; 2 et 3 : la source d'argile rouge ; 4 : séquence stratigraphique en bordure de la route menant de Goljoota à Arsi Negele.*

Oromo and Woloyta technical traditions

The Woloyta produce 18 different types of pottery (fig. 6), as opposed to 22 for the Oromo (fig. 7). These types correspond to productions for domestic use while surplus productions are sold at local markets. Pottery is a domestic activity: the work is carried out at home in workshops or in an annexe to the home environment. There are 15 different shaped pottery types but they are used for the same purposes by both groups (making coffee, carrying water, milk, food conservation, cooking meat, cereal processing, distilling local alcohol and making homemade beer, cooking bread and patties, etc.).

For both groups, clay sources are located near the dwelling places, i.e., between 500 m and 5 km away. Both groups use a mixture of different types of clay (Woloyta) or a mixture of clay and different types of temper (Oromo). Raw-material sources are not the same for both groups.

Fig. 9 – Woloyta social group at Goljoota. 1: drying of two clays; 2: sieving; 3: grinding with a pestle.
***Fig. 9** – Les Woloyta de Goljoota. 1 : séchage des deux argiles ; 2 : tamisage ; 3 : concassage avec un pilon.*

Fig. 10 – Woloyta social group at Goljoota. 1: incorporation of water into the clay once both clays have been mixed; 2: pots broken during drying, recycled, rehumidified and reused in matures clay; 3: mixing of clay.

Fig. 10 *– Les Woloyta de Goljoota. 1 : incorporation de l'eau dans l'argile une fois les deux argiles mélangées ; 2: pots cassés durant le séchage, recyclés, ré-humidifiés et réutilisés en argile maturée ; 3: malaxage de l'argile.*

Fig. 11 – Oromo social group at Qarsa. 1 and 2: red clay source; 3 and 4: white temper source.
Fig. 11 *– Les Oromo de Qarsa. 1 et 2: la source d'argile rouge ; 3 et 4: la source pour le dégraissant blanc.*

The proportions of the different types of clay and temper vary depending on the season – humid or dry – to ensure optimal drying and firing.

Woloyta raw material extraction takes place by pit extraction or quarrying. The Woloyta use a mixture of red (fig. 8, nos. 2 and 3) and white clays (fig. 8, no. 1). These clays are easily identifiable in profiles in the sector around the potters' homes (fig. 8, no. 4). They derive from the ferralitic alteration of ignimbrites; truncated by erosion and cut into by the hydrographic network. This gives the Woloyta direct access to the different levels of the alteration profile. The red plastic clays correspond to the Sk horizon, referred to as 'alteration with a pedological structure'. These clays, coloured by iron oxides, are made up of kaolinites and contain a considerable proportion of sand corresponding to residual sands from the original rock. The white clay is located in the lower part of the alteration profile. It coats blocks of ignimbrite in the process of deterioration. We also find it in horizon C where it may possibly be another type of mineralogical clay. However, we find the same sandy fraction corresponding to quartz initially contained in the ignimbrite.

In order to obtain a functional paste for making pots, it appears to be necessary to mix these two clays. This is clearly not linked to the presence of sand in stable proportions throughout the profile. It seems rather to be linked to the type of clays which are more or less well-suited to kneading and perhaps also to firing if they are not mixed. The less evolved white clay can also act as a clayey temper. Note that other tempers are available in the sector as run-off on these soils naturally accumulates large quantities of sand in ravines. The use of white clay thus represents a choice rather than a necessity.

To prepare the clay paste, the Woloyta conduct drying operations on clay floors, then crush both clays in different ways (fig. 9). The lumps of clay are subsequently broken up by striking them with large wooden sticks. The potters then mix both clays and sieve the dry mixture. The resulting granulometry is not particularly fine, but any undesirable elements are manually removed. This coarse fraction then requires large quantities of water in order to knead the clay and any impurities are extracted during this process (fig. 10). This clay mixture is hydrated by humectation. The Woloyta knead enough clay for their weekly production. This clay mass is made up of a portion of clay matured for several days which is mixed with freshly prepared clay. They thus work material gorged with water, with constant clay supplies, resulting from daily kneading.

The Oromo extract their clay and tempers differently: they use tunnel extraction or quarrying (fig. 11). Unlike the Woloyta, the Oromo mix red clay with a non-clay temper. These red to Burgundy-coloured clays derive from the ferralitic alteration of the ignimbrite substratum (horizon Sk). They are mainly composed of kaolinites but also contain numerous ferruginous pisoliths. In order to extract the clay, the potters exploit small ravines which cut into the

Fig. 12 – Oromo social group at Qarsa. 1 : sieving of white temper; 2: mixing of red clay and white temper; 3: shaping of small lumps of clay in preparation for roughing-out.

Fig. 12 *– Les Oromo de Qarsa. 1 : tamisage du dégraissant blanc ; 2 : mélange de l'argile rouge et du dégraissant blanc ; 3 : mise en forme de petites masses d'argile prêtes à être utilisées pour l'ébauchage.*

earth. Then they follow the plastic clays by undermining, without exploiting the upper horizons. Another type of clay in the same extraction site is not used by potters. This is a black clay in the same alteration profile but which probably contains more manganese. The red clay is mixed with an altered ignimbrite temper which is also exploited in small quarries, by tunnelling or undermining. Thus, unlike the Woloyta, the Oromo do not use a second type of clay, but incorporate this very white temper extracted from the ignimbrite substratum into the clay, when it is available. They use the slightly altered parts of the rock, which are softer. Note that the brown clay veins running down from the surface are carefully avoided during exploitation. This shows a clear resolve not to mix clays of different origin. The white clays at the base of the alteration profile (ignimbrite with clayey fraction), exploited by the Woloyta at Goljoota as second clays, are not used here by the Oromo.

The Oromo dry their clay, break it up quickly by striking it, but only sieve the dry white temper in order to obtain a finer granulometry (fig. 12). Once the red clay is broken up, it is moistened by humectation. The potters then incorporate the white temper by sprinkling it over the red clay and then mixing them together. The fine fraction (the white temper) is hydrated by impregnation when it is in contact with the coarse fraction (the red clay). The potters prepare small lumps of clay during the manufacturing process. The mixing time is not particularly long. They then work the clay directly, with no maturation phase. Primary and secondary shaping follow on directly after these transformation and homogenization operations.

Some Oromo potters add grog for a single specific type of vessel during the mixing phase. These are *ingera* dishes (called *elle budena*), and are used on a daily basis to cook teff flour flatbread. To make this grog, they recycle sherds of similar broken dishes (fig. 13). The Oromo potters break up sherds in a wooden mortar using a wooden pestle in order to obtain a relatively fine fraction. This is then added to the red clay, in variable proportions, while the white temper is excluded from this part of the *chaîne opératoire*. Some Oromo potters who only make these *ingera* dishes (*elle Budena*) do so in a very original manner (fig. 14). After shaping the dish, they systematically plane the lower surface of the vessel once it has partly dried, before firing it. The removed clay is then retrieved by the potters. This clay corresponds to a mixture of red clay and *chamotte* from ground and recycled *ingera* dishes. Potters subsequently rehumidify this retrieved clay and add straw to it. The obtained paste is then used to make small patties, about 20 cm long and about 3-4 cm thick, which are dried and fired. Once fired,

Fig. 13 – Oromo social group at Qarsa. 1: broken Ingera sherds used to make grog; 2: sherds are broken up using a wooden pestle; 3: the relatively fine fraction of grog, after sieving; 4: subsequent addition of the grog to the red clay; 5: ingera dish after shaping.
***Fig. 13** – Les Oromo de Qarsa. 1 : fragments de plats à Ingera utilisés pour fabriquer de la chamotte ; 2 : les potières les brisent dans un mortier au pilon ; 3 : la chamotte obtenue après tamisage est relativement fine ; 4 : les potières incorporent la chamotte à l'argile rouge ; 5 : le plat à Ingera après l'ébauchage et le préformage.*

Fig. 14 – Oromo social group at Qarsa. 1: sieving of red clay; 2: planing of the Ingera dish, after shaping; the removed clay is recycled; 3: potters then rehumidify this retrieved clay and add straw to it to obtain small patties which are dried and fired; 4: small patties after the firing; 5: the Ingera dish after shaping with red clay and the new *chamotte* temper.

Fig. 14 *– Les Oromo de Qarsa. 1 : s*échage *de l'argile rouge ; 2 : rabotage d'un plat à Ingera, après l'ébauchage ; les potières recyclent l'argile enlevée lors du rabotage ; 3 : les potières ré-humidifient cette argile recyclée en incorporant de la paille, de façon à obtenir des petites galettes de chamotte qui seront séchées et cuites ; 4 : les petites galettes de chamotte après la cuisson ; 5 : le plat à Ingera obtenu par un mélange de l'argile rouge à ce nouveau dégraissant de chamotte, après l'ébauchage et le préformage.*

Fig. 15 – 1: one of the extraction sources of red clay used to make red paint which is applied before firing by the Oroma at Qarsa; 2: extraction source of red clay used to make red paint which is applied after firing by the Woloyta at Goljoota.
Fig. 15 *– 1 : une des sources d'extraction de l'argile rouge utilisée pour réaliser les peintures avant cuisson chez les Oromo de Qarsa* ; 2 : *une des sources d'extraction (carrière) de l'argile rouge utilisée pour réaliser les peintures après cuisson chez les Woloyta de Goljoota.*

these patties are ground up like the initial *chamotte*. They are then sieved and the *chamotte* temper (following the definition of: Echallier, 1984, p. 14) is reincorporated into the red clay to recommence the fabrication process for *ingera* dishes.

Both the Oromo and the Woloyta potters sometimes use a third type of purplish-red clay. This clay is only used for the finishing stages to make coatings for certain types of pottery. This reddish clay is less sandy as, unlike the clays used for shaping, it is formed from basaltic outcrops. On account of its fine, soft (talc-like) texture, it possesses the qualities sought after by potters who wish to add colour and shine to their productions during finishing treatments. The Oromo extract this clay from sources slightly further away from the dwelling places (up to about 10 km away; fig. 15, no. 1). For the Woloyta, this clay comes from a neighbouring quarry within the potters' zone (fig. 15, no. 2). It is located on the flank of a former volcanic cone and here, again, the substratum is composed of basalts. The alteration clay derived from slag is fine and highly coloured by iron oxides.

The Oromo add this coating just before firing (fig. 16). The red clay is mixed with water and vegetable oil or diesel, before it is used to coat the vase using a piece of fabric. This mixture gives the ceramics a red and shiny aspect.

The Woloyta apply this coating just after firing (fig. 17). The red clay is mixed with water and vegetable fat from the enset (false banana). The surface of the pot is prepared before firing by burnishing with a pebble in order to facilitate the adherence of coatings.

The Woloyta shape rough-outs from a clay mass using two alternative methods: a conical mass hollowed out with the fist (used for practically all shapes), or a large stretched plate (*Bashe* or *Ingera* dishes; fig. 18). The Oromo make rough-outs using a large flattened coil rolled around itself (fig. 19).

For Woloyta and Oromo potters, the shaping stage usually consists of stretching and continuous finger pressure, particularly for the top of the pot. Then the surfaces are smoothed. Coils can be added to shape the bottom; this last technique is more frequently used by the Oromo group. The Oromo potters start decoration on wet surfaces, mainly by using a grooving technique, before the end of the shaping operation.

The Woloyta potters start the finishing treatments on a leather-hard surface. The technical processes vary according to the types of pots. Smoothing with water, planing and burnishing were observed. Usually, handles and decoration (relief decoration such as clay cords) are added during this stage.

The Oromo potters often carry out the finishing treatment on wet surfaces -planing, smoothing- or on dry surfaces: spreading red soil mixed with oil to shine the surfaces.

Fig. 16 – Oromo social group at Qarsa. 1: red clay is mixed with water and vegetable oil or diesel; 2: finishing stage used to create a shiny coating on Jabana (coffee pots).
***Fig. 16** – Les Oromo de Qarsa. 1 : l'argile rouge est mixée avec de l'eau et de l'huile de lin ou du gasoil ;* 2 : *cette étape de finition sert à faire briller les Jabana (cafetière).*

Firing is carried out in a kind of haystack installed on the ground, sometimes within a small pit. Firing conditions are broadly similar for Woloyta and Oromo potters: pots are installed on the ground and covered with combustible wood and embers. However, the Woloyta potters of Goljoota make use of straw, thatch and wood chips, whereas the Oromo potters of Qarsa use twigs and dried dung. Firing times also differ; the Oromo vessels are fired for shorter periods as they have thinner walls.

Fig. 17 – Woloyta social group at Goljoota. 1: spreading red slip or paint on the internal surface of an Ingera dish; 2: another extraction source of red clay used to make red paint which is applied after firing; 3: spreading animal dung on an Ingera dish edge; 4: spreading a mixture of Abyssinian banana tree roots and water on the internal surface of an Ingera in order create a shiny finish.

***Fig. 17** – Les Woloyta de Goljoota. 1 : peinture rouge sur la face inférieure d'un plat à Ingera ; 2 : une autre source d'extraction de l'argile rouge utilisée pour la peinture après cuisson ; 3 : étalement d'excréments animaux (bouse de vache) sur une partie du plat à Ingera ; 4 : étalement sur la face supérieure du plat à Ingera d'une matière obtenue à partir de racines de l'Ensète (ou faux bananier) mélangées à de l'eau, le tout pour faire briller la surface interne.*

Both groups can pre-fire pots by arranging them around the fire in order to dry the most recently produced pots more completely.

The Woloyta perform various post-firing treatments that differ depending on the types of vessels being produced. The most common is the application of cow dung to the base of the pot but other substances are also used, such as a 'white paint', made from ground limestone, a red clay slip and a coating made from crushed roots to makes the surface glossy (fig. 17). The main aim of these surface treatments is to enhance the appearance of vessels. However, they are also used to camouflage imperfections, as in the case of cow dung and red slip.

We observed a single post-firing treatment during the Oromo manufacturing process that can be, but is not always, performed on different types of vessels. This is the blackening of the outer surface, obtained by the creation of a reducing atmosphere at the end of firing by covering the pot with straw. Again, it seems that the purpose of this operation is aesthetic, to comply with consumer demand.

Based on this fieldwork, it is possible (like for others before us: Balfet, 1965; Rye and Evans, 1976; Arnold, 2005; Livingstone Smith et al., 2005) to:

– test and rationalize the different analytical methods, particularly archaeometric methods, to be used for studying ceramic assemblages in order to reconstruct the *chaîne opératoire* in a Neolithic context.

– build up a reference collection to be used in archaeology.

CONTRIBUTION OF OUR ETHNOGRAPHIC FIELDWORK

Back to issue 1: tempers – the case of grog

The differences observed between the Woloyta and the Oromo for the preparation of clay materials have consequences on the finished products. Woloyta productions seem to resist better to use, due to the type of raw materials used, but also because of the different operations for preparing the materials: intensive clay crushing, more intensive granulometric sorting, mixing matured clays with freshly kneaded clays, longer maturing phase, pre-drying, 12-hour firing, etc. The practices linked to the introduction of a grog temper agent in Oromo productions raise the following question: since grog is only used by Oromo groups for one particular type of vessel, the *ingera* dish, is it used to increase the solidity of these dishes, which are used on a daily basis and are subject to breakage, in order to obtain the same quality as the Woloyta productions? F. Convertini has already demonstrated that grog could be used for very variable types of clays, which indicates that the nature of clay materials is not a systematic criterion, or at least not the only criterion, to explain the use of a temper (Convertini, 1998).

But, we still wish to go beyond the cultural choices related to the Neolithic products and to explore in depth the contribution of grog to the hardness, toughness, durability and resistance of finished products, because there is a dearth of studies regarding these aspects. If we take the case of Chauve-Souris Cave, for example, grog was only used for vases with high technical investment, i.e., those corresponding to Bell-Beaker and Italian norms. These very sought after vessels were also more subject to breakage than the others, as they were transported over long distances.

Thus ethnographic fieldwork can help us to:

- understand the choice of materials in relation to the natural environment and the constraints imposed on the potter;

- reconstruct the modifications induced by adding grog to the raw materials and the effects on the physical and mechanical properties of the finished products;

- better identify the grog in archaeological pottery, as it can be used in varied ways: fired pots, reused, broken and ground or in spontaneous fabrication, as is the case for some Oromo potters who make patties with recycled clay during the scraping stage of *ingera* dish fabrication. It is thus a way of contributing to analysis issues and simply of identifying this special type of inclusion (Whitbread, 1986; Cuomo Di Caprio and Vaughan, 2013). The characteristic features of the particular inclusions must be identified by observing thin sections. The ethnographic contribution will thus be essential to propose features to distinguish between various forms of grogs.

Fig. 18 – Woloyta social group at Goljoota. 1 and 2: shaping of a conical rough-out; 3: pinching of the rough-out; 4: shaping of an Ingera dish rough-out.

***Fig. 18** – Les Woloyta de Goljoota. 1 et 2 : ébauchage à partir d'une motte conique ; 3 : modelage et étirement à partir de la masse ; 4 : préformage du plat à Ingera.*

Back to issue 2: incidence of clay preparation on the 'quality' of the finished products

These ethnographic references also enable us to broach other issues, such as the transformation of clay materials. In archaeology, the correlation between the

Fig. 19 – Oromo social group at Qarsa. 1: processing a big coil manually; 2: pressing of the coil on the ground in order to make a flat coil; 3: winding the coil in a ring to shape a cylindrical rough-out; 4: shaping a Jabana (coffee pot) by stretching the coiled rough-out walls.
Fig. 19 *– Les Oromo de Goljoota. 1 : mise en forme d'un colombin ; 2 ; aplatissement du colombin par pression ; 3 : les deux extrémités du colombin sont jointes pour en faire un anneau qui servira à l'ébauchage ; 4 : préformage de la cafetière par étirement du colombin.*

investment involved in clay preparation and the quality of ceramics often stems from empirical observation.

As stated above, the long and numerous operations in the Woloyta *chaîne opératoire* may have repercussions on the quality of the finished products. Over the past ten years, research carried out by V. Roux and M.-A. Courty involving SEM thin section analyses has shown that it is possible to identify not only shaping techniques, but also the treatments applied to clay as part of rotating kinetic energy production (RKE: Roux and Courty, 1998 and in press). The aim of these works is to build up an identical reference collection for the markers left by these successive operations of transformation and homogenization of clay materials (crushing, maturing, purging, etc.) on products made without the use of a potter's wheel. For the moment, this reference collection is still non-existent. If we succeed in this mission, this will imply that we will be able to provide in-depth descriptions of the first stages of the *chaîne opératoire*, based on the thin section analysis of finished products. Otherwise these early stages are rarely accessible. Yet, ethnographic work conducted over the past 30 years has shown that these first stages are among the most stable phases throughout time (in the same way as primary and secondary shaping stages), and can act as a fixing agent for the prevailing cultural model of a society. Archaeologists thus need to develop the necessary tools and protocols to gain access to these data.

The implementation of the reference collection relies on:
– the analysis of raw materials;
– identifying the different clay preparation operations observed in the field and their repercussions on the rest of the *chaîne opératoire*;
– the analysis of the transformed materials, in particular in order to identify characteristic markers of structural states and textural composition treatments of finished products (following the terms used by M.-A. Courty: Roux and Courty, in press).

But this domain also has other benefits for prehistoric archaeology. As mentioned earlier, both the Oromo and the Woloyta use clay mixes. The proportions of these clay mixes can vary depending on whether the season is dry or wet. For us, it is thus important to establish whether the same social group uses identical clays, or whether households can be identified on the basis of their clay preparation techniques (for example by using different proportions in their mixes, or depending on the amount of time spent on kneading, maturation, etc.). This is an important issue at the scale of an archaeological site. This could signify that it is possible to differentiate households on a Neolithic site, not only by studying rough out and preforming techniques, or the type of earth used, as shown by L. Gomart (Gomart, 2014), but also by documenting the procedures used for the preparation of materials.

TO CONCLUDE: OUR ARCHAEOMETRIC APPROACH

There are many ways of analysing paste and ceramic technology (for an overview see: Rice, 1987 or Albero Santacreu, 2014) and in order to provide answers to all these questions we have established a partnership with several researchers from the IRAMAT laboratory in Bordeaux (N. Cantin and A. Ben Amara), CRAHAM laboratory in Caen (A. Bocquet) and the Calvados Archaeological Services (X. Savary). These researchers will deal with the development of the archaeometric aspects of the study from 2016 onwards.

Generally, the archaeometric approach is applied to finished products and enables us to evaluate the nature and characteristics of the raw materials used. Two types of information are available, at both the environmental (location and nature of supply sources) and economical levels (choices for settlement territories, circulation and distribution of finished products). The identification of raw materials and the observation of fabrics at different scales also enable us to detect anthropological signatures. The goal is to infer the technical processes involved in the *chaîne opératoire*, i.e. the methods used by potters to obtain their clays (decantation, crushing, sieving, mixing, tempering, etc.), firing processes and surface treatments of vessels.

For example, firing techniques can be studied by assessing the porosity, loss of crystalline phases and the presence of newly formed minerals. Various analytical techniques can be used and the choice of a specific technique is dependent on the questions raised and available samples (Regert et al., 2006; Tite, 2008). Prior to mineralogical (petrography, X-ray diffraction, Raman spectrometry, etc.), or chemical analysis (X-ray fluorescence, ICP-AES, PIXE-PIGE, etc.), observations are performed at different scales (macroscopy, optical microscopy, radiography, etc.).

Geological databases are often used to link archaeometric data to environmental information and to identify technical processes. The characteristics of raw materials, their geological origin and knowledge of environment allow us to recognize the nature of non-plastic inclusions and the possible combining of them in the clays used to make pottery and to have evidence of the clay mixtures. The geological data is an advantage for understanding the first stage of the *chaîne opératoire* and for identifying the source of the raw material (local, regional or exogenous; Jorge et al., 2013). Experimentally, it is also possible to reconstruct samples using modern techniques to infer ceramic properties (porosity, hardness, colour) and document different stages of the *chaîne opératoire*. Since modern techniques (firing in electric kilns, use of raw materials, etc.) are obviously different from traditional techniques, conclusions based on archaeometric analyses remain hypothetical (Tite et al., 2001; Allegretta et al., 2015; Müller et al., 2015). Fortunately, ethnography provides reference data including the diversity of the *chaîne opératoire* with respect to environmental, social and economic contexts. The rarely used ethnography-archaeometry combination leads to a better characterisation of certain aspects of the *chaîne opératoire*, in particular the strategies used for selecting and mixing raw materials, controlling proportions of added inclusions or even anticipating the impact of paste preparation on firing or on the hardness and resistance of vessels (Arnold et al., 1991; Buxeda i Garrigos et al., 2003; Van Doosselaere, 2010; Cantin and Huysecom, 2012).

Actualist reference data is well-suited to inferring ceramic sophistication and proposing a new interpretation of the analytical data obtained from archaeological materials. Ethnographic observations, combined with analyses of materials at different stages of the *chaîne opératoire*, should invert the traditional archaeometric approach and reinforce the hypotheses advanced by specialists with regard to the following points:

- Preparation and mixing of raw materials and inclusion processes: Clay mixing and preparation before modelling and the mixing of clay and non-plastic inclusions are often difficult to identify even with petrographic analysis or theoretical models. This stage of the *chaîne opératoire*, which is not always identified, can lead to misinterpretations concerning technical production processes and economic networks. In such cases, actualist references will make it possible to characterise the different *savoir-faire* of potters by analysing the raw materials used in the paste. The final goal is to emphasise the petrographic, chemical, textural and porosimetrical criteria relevant to the archaeological materials (Neff et al., 1988; Schwedt and Mommsen, 2004).
- Technical properties of ceramics: The consequences of mechanical resistance on the use and function of finished products depend on the characteristics and treatment of the clay, but also on shaping and firing techniques. These parameters must also be studied from an ethnological viewpoint (Tite et al., 2001).
- Firing techniques: Parameters such as the nature and preparation of raw materials and the thickness of vessel walls influence firing techniques (duration, temperature, atmosphere, etc.). These effects could be better assessed with enhanced knowledge of the thermal protocols used, in particular the evolution of temperature during firing, or several firing phases, and the ability to control the temperature.
- Finishing stages: The use of vegetal brew at the end of firing is unknown or not considered in the archaeometric approach. Methods to identify this type of finish on recently manufactured, used or buried ceramics must be investigated as part of this research program.
- The different usages: The impact of the use of ceramics on chemical and structural analyses is a topical issue for archaeologists. Comparative analyses before and after use, and even after the burial of vessels, would be relevant.

The protocol followed as part of this combined ethnographic–archaeometric project consists, first of all, of sampling products at different stages of the *chaîne opératoire* for both the Woloyta and Oromo groups, and secondly, in an archaeometric approach based on observation methods (petrography, etc.) and basic chemical analyses. During the first stage, a preliminary study will

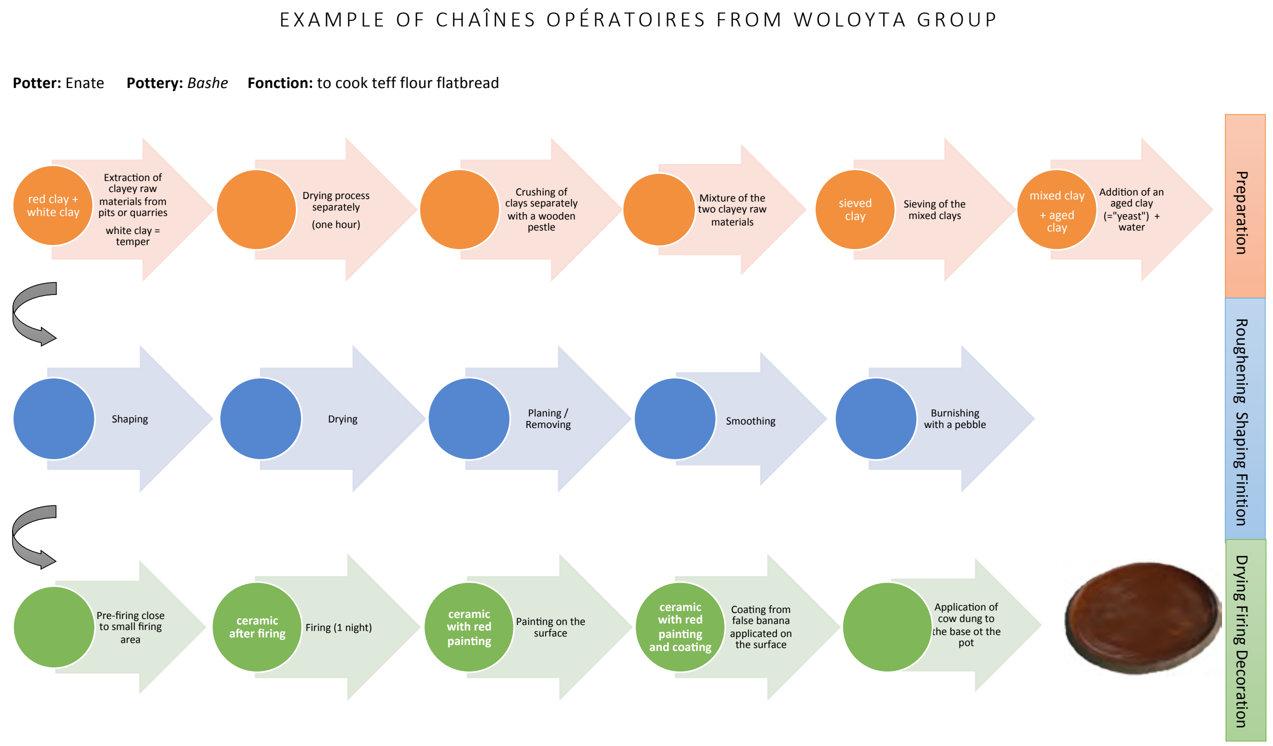

Fig. 20 – Example of the sampling process used for the archaeometric approach. The first samples analysed are presented within the circles. The same proccess of sampling was applied to 9 *chaînes opératoires* (including 2 potters from the Woloyta group and 4 potters from the Oromo group).

***Fig. 20** – Exemple de l'échantillonnage appliqué dans le cadre de l'approche archéométrique. Les premiers échantillons analysés sont mentionnés dans les cercles. Le même procédé a été appliqué à 9 chaînes opératoires de fabrication (comprenant 2 potières du groupe Woloyta et 4 potières du groupe Oromo).*

be carried out on a restricted sample (one or two potters per group) focusing on clay mixes (raw materials, transformed pastes, tempers, non-fired and fired mixes; fig. 20). During the second stage, the variability of practices and their consequences on the *chaînes opératoires* (firing, finishing, use and burial) will be considered through the study of additional potters using refined analysis. Through access to raw materials and finished products and by comparing our questions regarding the archaeological series and initiating research in material science, we hope to formalize the criteria leading to the objective characterization of certain aspects of our ceramic assemblages using well-defined parameters.

In conclusion, we wish to add that these actualist reference collections are kept in the archaeological TRACES laboratory in Toulouse, which is part of the ArchéoSciences platform. These collections are used to train students and can be consulted by all the TRACES teams in order to help them with the description, analysis and interpretation of remains.

NOTES

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Deuxième partie

Raw materials acquisition and technological traditions from east to south Europe

Sélection des matériaux argileux et traditions techniques de l’est au sud de l’Europe

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Innovation and regionalism in the Middle/Late Neolithic of south and south-eastern Europe (ca. 5,500-4,500 cal. BC): a ceramic perspective

Michela Spataro

Abstract: A review of petrographic and geochemical results from over 1000 samples of Early and Middle Neolithic pottery from south and south-eastern Europe provides insights into technological traditions, innovation, resistance and imitation in Impressed Ware, Starčevo-Criş, Danilo/Hvar, Vinča and Korenovo assemblages. The trajectory of technological change varied between regions, and central Balkan potters seem to have become more innovative than their neighbours; Vinča potters in particular seem to have been more innovative than Danilo and Korenovo potters, perhaps due to Vinča social complexity. For the first time they used different materials to make different shapes, according to the function (intended use) of the pot. At the same time, variability in temper choices suggests regionalism in Vinča technical traditions. Some aspects of innovation (e.g. black-burnishing) were spread more readily than others, but the idea seems to have spread and not the whole *chaîne opératoire*. The production of *figulina* ware was an innovation which became a tradition, as it remained unchanged for more than a millennium, without apparently influencing the technology of everyday pottery production.

Keywords: Vinča culture, Danilo/Hvar cultures, Impressed Ware, Starčevo, innovation, imitation, regionalism, change, Early and Middle Neolithic, south and south-eastern Europe, *figulina* ware, ceramic analysis, optical microscopy, SEM-EDX, surface treatment, temper, ceramic class.

Résumé : La mise en perspective des résultats pétrographiques et géochimiques de plus de 1000 échantillons de poterie d'Europe du sud et du sud-est datant du Néolithique ancien et moyen donne un aperçu des traditions, innovations, résistances et imitations technologiques dans l'art de la *céramique imprimée* et le matériel des cultures de Starčevo-Cris, Danilo/Hvar, Vinča et Korenovo. La trajectoire des changements technologiques a varié suivant les régions, et les potiers des Balkans occidentaux semblent avoir été plus innovants que leurs voisins : les potiers de la culture de Vinča, en particulier, semblent avoir été plus innovants que ceux de Danilo et Korenovo, ceci étant peut-être dû à la complexité sociale de la culture de Vinča. Pour la première fois, ces potiers ont utilisé différents matériaux pour produire des formes différentes, en rapport avec la destination fonctionnelle du vase. Simultanément, la variabilité dans le choix des dégraissants suggère un régionalisme dans les traditions techniques de la culture de Vinča. Certains aspects de l'innovation (par exemple, la céramique noire brunie) se sont propagés plus rapidement et plus facilement que d'autres, mais il semble que ce soit le concept et non la chaîne opératoire entière qui se soit diffusé. La production de céramique figulina a été une innovation qui est devenue une tradition, étant donné qu'elle est restée inchangée pendant plus d'un millénaire, sans influencer de manière apparente la technologie de production de céramique usuelle.

Mots-clés : culture de Vinča, cultures de Danilo/Hvar, Céramiques Imprimées, Starčevo, innovation, imitation, régionalisme, changement, Néolithique ancien et moyen, Europe du sud et du sud-est, *figulina*, analyse de céramique, microscopie optique, SEM-EDX, traitement de surface, dégraissants, catégorie de céramique.

INTRODUCTION AND AIMS

The aim of this paper is to examine and identify innovation in ceramic traditions during the transition between the Early and Middle Neolithic of southern Europe.

One of the goals of large-scale diachronic research is to see which aspects of pottery production are most persistent, in time and space, and which are replaced regularly. The fact that clay is a plastic medium permits almost infinite variation in pottery style (form and decoration), allowing archaeologists to construct detailed typochronological schemes. These subdivisions might be expected to correspond to different technical traditions, as pottery design and manufacture must be directly connected through the practice of learning the craft of making pottery, but technical traditions are not infinitely variable, due to the physical attributes of the raw materials. In comparing pottery technology across Neolithic southern Europe, we see both examples of adaptively neutral traditions defined as persistent differences in pottery technology which have no obvious functional explanation (Dunnell, 1978) and of changes in technology that are functionally advantageous, if not essential, for the production of new styles of pottery. Such adaptively advantageous changes may be expected to cross existing cultural boundaries, whereas we would not expect potters to replace one adaptively neutral tradition with another, or for adaptively neutral innovations to spread once pottery-making had become established.

In seeking to understand prehistoric potters, we are fortunate that many aspects of pottery production leave traces in potsherds, which can be interpreted using a suite of archaeometric techniques. We can therefore observe continuity and change in raw material procurement, clay preparation, tempering, forming (partially), finishing, firing and decoration (or decoration then firing), on the same spatial and temporal scale as the evolution of pottery styles. This paper will consider which aspects of Neolithic pottery production in southern and south-eastern Europe reflect cultural continuity or change, and which are technical innovations that confer functional advantages but do not imply cultural transformation. It will also discuss which aspects of technological change may be interpreted as local or regional variations that are not diffused within the wider cultural distribution.

How can innovation and imitation in ceramic traditions be identified? A series of morphological and visual traits can be described and examined, such as shapes, decorative motifs, forming techniques, clay processing, temper, shaping, finishing, firing conditions. Some of these variables can be studied macroscopically, as they are visible to the naked eye (shape, style, forming technique), others (clay processing, temper, firing conditions and surface finishing) need to be studied using more invasive, microscopic techniques.

This paper will focus on clay processing, temper, firing conditions and surface finishing, which will be considered using a large synchronic and diachronic data set, representing a wide geographical area in the Adriatic region and in the central Balkans and spanning almost two millennia, from the Early Neolithic (ca. 6,000-5,400 cal. BC) to the Middle/Late Neolithic (ca. 5,400-4,500 cal. BC).

ARCHAEOLOGICAL BACKGROUND

The earliest Neolithic cultural phenomena in continental Europe are the Impressed Ware (IW) and the Starčevo-Criş or Starčevo (SC) cultures, which began shortly before 6,000 cal. BC (Whittle et al., 2002; Biagi and Spataro, 2002 and 2005; Biagi et al., 2005). IW communities spread mainly along the Mediterranean coastline, whereas SC communities spread along the Danube in the central Balkans. From their earliest appearance, the IW and SC cultures presented the so-called Neolithic package, consisting of agriculture, domestic animals and ceramic production. Pottery is ubiquitous, but kiln structures have very rarely been found at Early and Middle Neolithic sites (Nica, 1977; Minichreiter, 2007).

IW pottery was mainly decorated with impressions obtained with geometric tools (e.g. triangular, rectangular, dots and oval motifs), marine shells, fingers, fingernails, or by pinching, scratching, and incisions (Müller, 1988 and 1994; Cipolloni Sampò, 1998; Spataro, 2002, p. 25-28). Vessel shapes are rather simple; they include large and deep oval-shaped vessels, hemispherical and conical bowls, more rarely biconical vessels, necked jars and flasks (Batović, 1966). Handles are absent in the earliest phases.

At the end of the Early Neolithic, another ceramic type appeared at many IW sites together with pottery decorated with impressed motifs, a finer, light grey, buff, pale-pinkish, yellowish colour, often with a powdery surface, called *figulina* ware (Rellini, 1934, p. 33; Cremonesi, 1965). In contrast to IW everyday pottery, *figulina* ware is plain or painted with elaborate linear or dynamic geometric designs.

Contemporary with the IW in the Adriatic, the SC complex covered a region from Macedonia to Hungary and Slavonia, and from Serbia to eastern Romania. SC communities settled along the Danube and its major tributaries, mainly on alluvial terraces and in some cases in the proximity of salt outcrops. It was a phenomenon of rapid expansion (Biagi et al., 2005).

SC ceramic assemblages feature a wide variety of decorations and surface treatments including, in addition to impressed and incised motifs, monochrome, slipped and/or red-burnished, white-on-red painted, *barbotine* (an uneven extra layer of clay), and in the latest phases, polychrome painted decoration with garland and spiral motifs. SC ceramics include globular vessels with everted rims, short-necked jars, oval-shaped vessels, hemispherical bowls, and during the latest phases, pedestalled vessels (Lazarovici, 1979 and 1993; Minichreiter, 1992).

In the later 6th millennium cal. BC (Forenbaher and Kaiser, 2000), ceramic assemblages changed abruptly in both regions. Along the eastern Adriatic coastline the Danilo/Hvar cultures replaced the IW, with the introduction of new pottery shapes (e.g. carinated bowls, plates) and new motifs and surface treatments (e.g. painted and black-burnished ware decorated with geometric motifs, spirals, S-motifs, hatched triangles) (Korošec, 1958 and 1964).

At about the same time, SC assemblages were replaced in many areas of the central Balkans by the Vinča material culture. The Vinča culture was marked by the appearance of tell sites and the erection of post-built houses and temples, biconical or carinated bowls, pithoi, amphorae, large tronco-conical vessels, etc. Plain and coarse ware is common in Vinča assemblages, whereas decorated pottery is often black-, red-, buff- or brown-burnished, and occasionally painted, probably before firing. The presence of black-burnished pottery with a metallic sheen differentiates Vinča from the earlier SC assemblages. However, particularly during the earliest Vinča phases there are objects such as anthropomorphic and zoomorphic figurines (e.g. Divostin), four-legged altars, *barbotine* ware and biconical pots that are also typical of the latest SC phases (Leković, 1990; Spataro, 2014). Meanwhile, the Korenovo culture appeared in some areas previously occupied by Starčevo communities in Slavonia, north-eastern Croatia, and in south-western Hungary. Korenovo pottery assemblages include spherical, biconical and pedestalled bowls, decorated with deeply incised motifs, individual lines or banded, fingertip impressions, grey and dark-grey burnished surfaces; painted decoration is absent in Croatia (Težak-Gregl, 1993). Interestingly, typical potsherds of the Korenovo Culture (Dimitriević, 1961) were discovered in the Danilo culture layer at Smilčić (Težak-Gregl, 1993, p. 14; Spataro, 2002, p. 203). These finds should be analysed petrographically to understand whether they were made according to Korenovo or Danilo technological traditions.

SAMPLING AND METHODS

The ceramics discussed in this paper were studied and analysed by petrographic techniques during the author's PhD (Spataro, 2002), post-doctoral and later independent research, mainly carried out at the UCL Institute of Archaeology [(1)].

In this paper a dataset of 1,047 potsherds is considered (table 1; fig. 1). All samples were analysed in thin section by optical microscopy and most of them by scanning electron microscopy with energy dispersive spectrometry (SEM-EDX; see below) [(2)].

Pottery from 11 sites of the Impressed Ware culture (228 samples), plus 18 Starčevo-Criş (477 samples), three Danilo/Hvar (108 samples), three Vinča (106 samples) and three Korenovo (69 samples) cultures sites was analysed (table 1). Fifty-nine *figulina* vessel fragments were sampled from 10 sites attributed to different phases of the Neolithic, including the Impressed Ware, Danilo, Hvar, Serra d'Alto, and Squared-Mouthed Pottery Cultures (Spataro, 2009a, table 1).

Potsherds were collected from open-air and cave sites, some of which had multiple occupation layers [(3)]. Whenever possible, representative potsherds were chosen according to stratigraphic information. Twenty to thirty potsherds were selected from each site for thin-section analysis, but if a site was occupied over multiple phases, ca. 20 sherds were selected per phase (e.g. at Gura Baciului in Transylvania; Spataro, 2008). The ceramic samples were selected on the basis of potsherd typology and style and of recurrent fabric characteristics, such as thickness, colour, surface treatment (Plog, 1980; Spataro, 2002). Shapes were also considered, when the samples were not too fragmented for the reconstruction of the vessel form. Ceramic cult objects (anthropomorphic and zoomorphic figurines, altars - four-legged vessels), spindle-whorls, and net weights, were also analysed, as well as daub, fireplace and plaster samples. In addition, 1-3 samples of sediment suitable for pot making and occasionally river sand samples were also collected 0.5 - 1 km from each site (see also: Spataro, 2002, p. 36 and 2011, p. 177).

The two main analytical techniques used were optical microscopy of thin sections by polarised microscopy, and scanning electron microscopy used with energy dispersive spectrometry (SEM-EDX). This paper focusses more on the optical microscopy and SEM results, rather than EDX. These complementary techniques can provide very high quality images of ceramic fabrics and their surface treatments. The resolution of SEM images at high magnification (e.g. x 1.0-2.0 K) allows us to study ceramic microstructure (Maniatis, 2009), estimate firing temperatures and detect any changes between the ceramic fabric and any surface treatment, or if present, interfaces or interlayers between the surface and the fabric. In addition, SEM-EDX can be used to create compositional maps of the sections to show the spatial distribution of different elements.

RESULTS

Clay selection and processing

IW potters were non-selective. They used both calcareous and non-calcareous clays to manufacture ceramics, with minimal clay processing, as clay pellets are recurrent in the fabrics. In most cases, the ceramic fabrics are very similar in thin section to local soils (fig. 2, top left and right). They did not select specific clay types to manufacture specific products, as there is no correlation between fabrics and shapes. In the Middle Neolithic, Danilo and Hvar potters along the Dalmatian coastline continued the non-selective approach of their Early Neolithic predecessors, using mainly calcareous clays, with minimal processing, and again using the same clays to manufacture different vessel shapes with different surface treatments.

Culture & pottery type	Number of sites (see map)	Number ceramic samples analysed in thin section[1]	Number ceramic samples analysed by SEM-EDX[2]	Site Names
Impressed Ware	11	228	228	Fornace Cappuccini, Maddalena di Muccia, Ripabianca di Monterado, Scamuso, Vižula, Vela Jama, Jami na Sredi, Smilčić, Tinj-Podlivade, Konjevrate, Vrbica
Starčevo-Criş	18	477	215	Foeni-Gaz, Foeni-Sălaş, Dudeştii Vechi, Giulvăz, Fratelia, Parţa, Cauce Cave, Orăştie-Dealul Premilor, Miercurea Sibiului Petriş, Ocna Sibiului, Limba Bordane, Şeuşa La-cărarea morii, Gura Baciului, Vinkovci, Ždralovi, Golokut- Vitnić, Mostonga, Donja Branjevina
Danilo/Hvar	3	108	108	Smilčić (Danilo and Hvar phases), Danilo Bitinj (Danilo phase), Vela Spilja (Hvar phase)
Figulina ware	10	59	48	Caverna Elia, Danilo Bitinj, Fagnigola, Fiorano Modenese, Ripabianca di Monterado, Gravina di Puglia, Grotta delle Mura, Scamuso, Smilčić (Danilo and Hvar phases), Spilamberto
Vinča	3	106	94	Miercurea Sibiului Petriş, Parţa, Vinča Belo Brdo
Korenovo	3	69	56	Malo Korenovo, Tomašica, Kapelica-Solevarec
Total	48	1047	749	

Table 1 – List of ceramics (vessels only) analysed and considered in this paper. The materials from Kapelica-Solevarec and Vinča-Belo Brdo are still under study. There are only 41 sites; 48 is based on double-commande IW sites with figulina or Danilo pottery etc.
Tabl. 1 *– Liste des céramiques (seulement les récipients) analysés et présentés dans cet article. Les séries de Kapelica-Solevarec et Vinča-Belo Brdo sont en cours d'étude. Il y a seulement 41 sites ; le nombre total de 48 correspond aux ensembles regroupant des céramiques de deux ensembles culturels distincts (par exemple avec de la poterie de type figulina ou de type Danilo etc.).*

By contrast, the potters who made *figulina* ware used only specific clay sources, which were highly calcareous and rich in iron, magnesium and potash (Spataro, 2009a). In south-eastern and central eastern Italy, fossiliferous clays were often used (Spataro, 2002, chapter 5). The *figulina* potters often levigated the clay (dissolving the clay in water so that coarser particles settle out while the finer particles are still in suspension: Rice, 1987, p. 118), to obtain a very fine raw material, which was almost inclusion-free (fig. 3).

Starčevo-Criş potters were also selective. Despite the extent of the study region (fig. 1), and the wide range of clay types available, the potters used only non-calcareous and micaceous clays rich in fine alluvial sand, for all different ceramic products, shapes and styles (Spataro, 2006a; Kreiter and Szakmány, 2011, observed the same pattern at Hungarian sites). Like the IW potters, SC potters processed the clays only lightly, as clay pellets recur in most assemblages (fig. 2, bottom left and right).

Like SC potters, Vinča potters were highly-selective in their use of clay, but they processed the clay much more thoroughly. Clay pellets occur very occasionally, and in some cases clay might have been levigated to obtain a really fine fabric. Furthermore, Vinča potters used specific clay types to make different products. For example, thin-walled burnished ceramics were mainly manufactured using clays with very fine inclusions (e.g. loessic and alluvial), whereas different types of clay were used for the thick-walled vessels and not-burnished ware. At Miercurea Sibiului Petriş, Vinča potters used different clay sources to those used by SC potters at the same site, as shown by the consistently different geochemical signatures of the two assemblages. Nevertheless, mineral inclusions suggest that in both cases clays were sourced locally (Spataro, 2014, fig. 10).

Korenovo potters were also selective in their use of raw materials, using loessic clays to manufacture fine burnished ware and different clay types to make coarse, plain and thick-walled vessels (e.g. Spataro, 2003, fig. 2). However, the clay was not always well-processed, as some clay pellets recur in the pottery fabrics.

Temper selection

In this article the term 'temper' is used to indicate minerals or organic material deliberately added to the clay, usually to improve the clay workability. Multiple parameters (size, shape, quantity) have been used to identify intentional tempering, in particular following M. P. Rice (Rice, 1987, p. 410) and M. Maggetti (Maggetti, 1982, p. 123). The angularity and abundance of calcite in eastern Adriatic IW and in the Danilo and Hvar pottery strongly suggest crushing and addition. It is more difficult to say whether limestone was added deliberately, in particular at eastern Adriatic IW sites, as abundant poorly-sorted angular limestone fragments are also present in the soil samples

Fig. 1 – Locations of the sites discussed in the paper.
△Impressed Ware. 1: Scamuso; 2: Maddalena di Muccia; 3: Ripabianca di Monterado; 4: Fornace Cappuccini; 5: Vižula; 6: Vela Jama; 7: Jami na Sredi; 8: Tinj-Podlivade; 9: Smilčić; 10: Vrbica; 11: Konjevrate.
○ Starčevo-Criş. 12: Foeni-Gaz; 13: Foeni-Sălaş; 14: Giulvăz; 15: Parţa; 16: Fratelia; 17: Dudeştii Vechi; 18: Cauce Cave; 19: Orăştie-Dealul Premilor; 20: Limba Bordane; 21: Şeuşa La-cărarea morii; 22: Miercurea Sibiului Petriş; 23: Ocna Sibiului; 24: Gura Baciului; 25: Golokut- Vitnić; 26: Mostonga; 27: Donja Branjevina; 28: Vinkovci; 29: Ždralovi.
▲Danilo and Hvar cultures. 9: Smilčić (Danilo and Hvar phases); 30: Danilo Bitinj (Danilo phase); 31: Vela Spilja (Hvar phase).
☼ *figulina*. 9: Smilčić (Danilo and Hvar phases); 30: Danilo Bitinj; 1: Scamuso; 32: Grotta delle Mura; 33: Caverna Elia; 34: Gravina di Puglia; 3: Ripabianca di Monterado; 35: Fiorano Modenese; 36: Spilamberto; 37: Fagnigola.
● Vinča culture. 15: Parţa; 22: Miercurea Sibiului Petriş; 38: Vinča-Belo Brdo.
■ Korenovo culture. 39: Tomašica; 40: Kapelica-Solevarec; 41: Malo Korenovo.
Fig. 1 – *Localisation des sites présentés dans cet article.*
△Céramique imprimée. 1 : Scamuso ; 2 : Maddalena di Muccia ; 3 : Ripabianca di Monterado ; 4 : Fornace Cappuccini ; 5 : Vižula ; 6 : Vela Jama ; 7 : Jami na Sredi ; 8 : Tinj-Podlivade ; 9 : Smilčić ; 10 : Vrbica ; 11 : Konjevrate.
○ Starčevo-Criş. 12 : Foeni-Gaz ; 13 : Foeni-Sălaş ; 14 : Giulvăz ; 15 : Parţa ; 16 : Fratelia ; 17 : Dudeştii Vechi ; 18 : Cauce Cave ; 19 : Orăştie-Dealul Premilor ; 20 : Limba Bordane ; 21 : Şeuşa La-cărarea morii ; 22 : Miercurea Sibiului Petriş ; 23 : Ocna Sibiului ; 24 : Gura Baciului ; 25 : Golokut- Vitnić ; 26 : Mostonga ; 27 : Donja Branjevina ; 28 : Vinkovci ; 29 : Ždralovi.
▲ Cultures Danilo and Hvar. 9 : Smilčić (phases Danilo et Hvar) ; 30 : Danilo Bitinj (phase Danilo) ; 31 : Vela Spilja (phase Hvar).
☼ figulina*. 9 : Smilčić (phases Danilo and Hvar) ; 30 : Danilo Bitinj ; 1 : Scamuso ; 32 : Grotta delle Mura ; 33 : Caverna Elia ; 34 : Gravina di Puglia ; 3 : Ripabianca di Monterado ; 35 : Fiorano Modenese ; 36 : Spilamberto ; 37 : Fagnigola.*
● Culture Vinča. 15 : Parţa ; 22 : Miercurea Sibiului Petriş ; 38 : Vinča-Belo Brdo.
■ Culture Korenovo. 39 : Tomašica ; 40 : Kapelica-Solevarec ; 41 : Malo Korenovo.

(see fig. 2, top left and right). In western Adriatic IW, the abundance and bimodal size distribution of flint, grog, granitic rock fragments and volcanic sand, and comparison with local soil samples (which often include similar minerals but in finer and lower proportions) indicate deliberate addition. In SC pottery, the frequency of elongated planar voids and charred remains including cereal chaff imply tempering. In the Vinča and Korenovo cultures, sand or grog is abundant, with a bimodal size distribution.

IW potters used local mineral temper to make most of their pots, exploiting local raw materials, such as crushed calcite in the eastern Adriatic region, and other local minerals and sands (e.g. volcanic sand, flint, radiolarian chert) at sites on the western Adriatic coastline (for details see Spataro, 2002, p. 142, 151, 162 and 172-175). At all IW sites, the same type of temper was used to manufacture different vessel shapes, with a wide variety of decorative motifs (fig. 4).

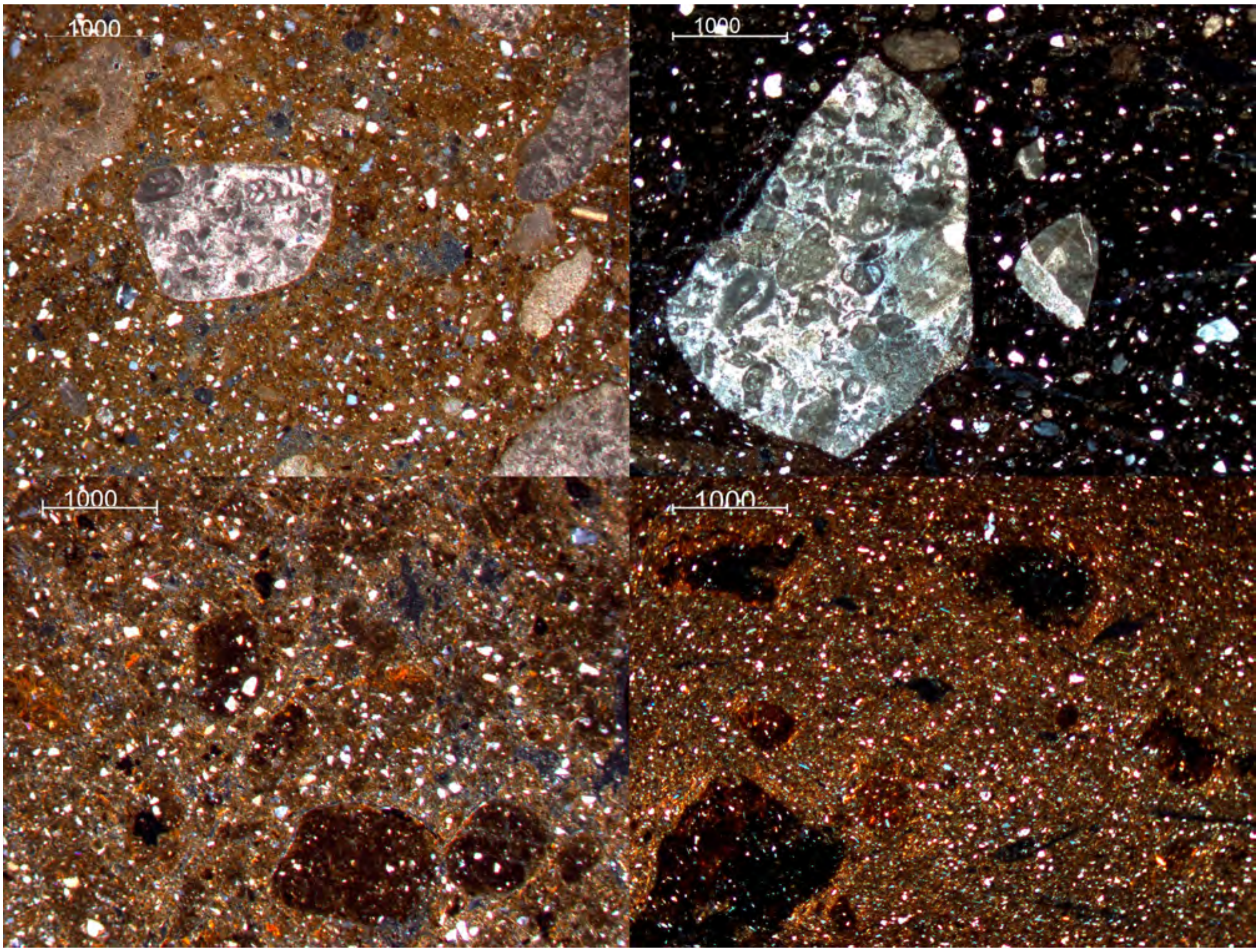

Fig. 2 – Photomicrographs of a thin section of a soil sample (top left) from the site of Tinj Podlivade in Croatia and the fabric of a small body sherd (top right) of Impressed Ware from Tinj (sample TN4) showing similar fossiliferous limestone fragments (cross-polarised light, XPL); the fabric of a soil sample (bottom left) from the site of Gura Baciului (Romania) showing clay pellets in the fabric and a sample (DBR12; bottom right) of a fine burnished oval-shaped pot from Donja Branjevina (Vojvodina, Serbia) showing similar clay pellets (XPL).
***Fig. 2** – Micrographie d'une lame mince d'un échantillon de sol (en haut à gauche) et d'un petit fragment de céramique imprimée (échantillon TN4, en haut à droite) provenant du site de Tinj Podlivade en Croatie, présentant tous les deux des fragments similaires de calcaire fossilifère (lumière polarisée croisée) ; d'un échantillon de sol (en bas à gauche) provenant du site de Gura Baciului (Roumanie), et d'un échantillon (DBR12, en bas à droite) d'un récipient de forme ovale en céramique fine brunie provenant du site de Donja Branjevina (Vojvodina, Serbie), présentant tous les deux des boulettes d'argile semblables dans la pâte (lumière polarisée croisée).*

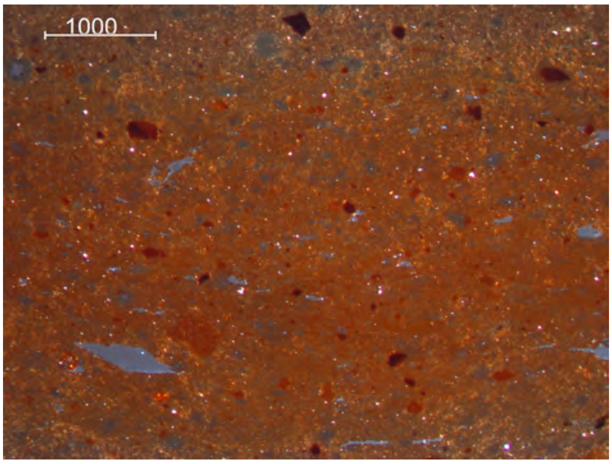

Fig. 3 – Photomicrograph of a thin section of fine *figulina* ware from the site of Danilo Bitinj (Croatia), showing an almost inclusion-free paste that was highly-fired (cross-polarised light, XPL). Only very fine quartz inclusions, and iron oxides are visible in the paste.
***Fig. 3** – Micrographie d'une lame mince d'une céramique fine* figulina *provenant du site Danilo Bitinj (Croatie), présentant une pâte quasiment dénuée d'inclusions et qui a été cuite à haute température (lumière polarisée croisée). Seules de très petites inclusions de quartz et d'oxydes de fer sont visibles dans la pâte.*

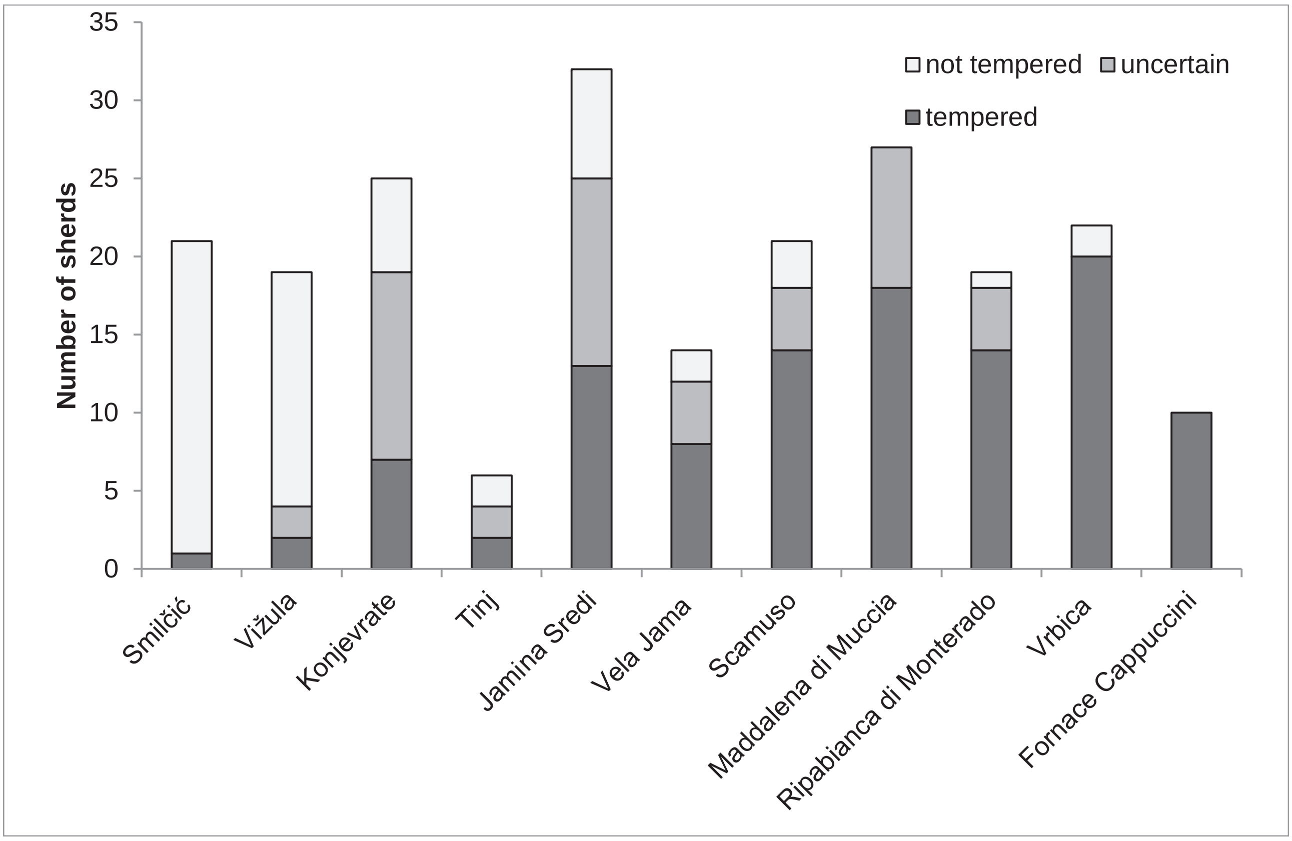

Fig. 4 – Bar chart of temper for the Adriatic Early Neolithic in the 6th millennium cal. BC: a lower proportion of pottery was tempered at the Croatian sites.

Fig. 4 – *Diagramme en bâtons des dégraissants pour l'Adriatique au Néolithique ancien au VIe millénaire cal. BC : la proportion de céramique dégraissée est inférieure sur les sites croates.*

Whereas a significant proportion in the eastern Adriatic (39–62%) of IW pottery was not tempered, Danilo and Hvar potters almost always tempered their pots with locally available minerals, i.e. crushed calcite, regardless of ceramic class, decoration and surface treatment. The makers of *figulina* ware did not use any tempering agent, as their goal was a fabric almost free of inclusions (see above).

SC potters almost always used organic temper (chaff, domestic cereals; e.g. Spataro, 2010, p. 96–97, fig. 2), from the earliest to the latest phases (Spataro, 2010); local minerals were used only occasionally (fig. 5). In contrast to their SC predecessors and Danilo/Hvar contemporaries, Vinča potters used a variety of tempering agents and many vessels, especially the fine ware, were not tempered (fig. 6). Among the temper types, grog (recycled pottery), crushed rock fragments and sand are recurrent (Spataro, 2014, p. 185, 187, fig. 5, 6 and 7, tables 1 and 2); chaff temper almost disappeared, accounting for ca. 1% of Vinča ceramics (Spataro, 2014; see also the Serbian Vinča C2-D1 site of Opovo: Tringham et al., 1985, p. 436).

Although only three Vinča sites have been considered so far, in addition to Opovo, temper choice in the Vinča culture seems to be rather arbitrary, as different types of temper were used at each site. For example, grog recurs at the Vinča B site of Parţa, in Romanian Banat, but not at Miercurea Sibiului Petriş in Transylvania (Spataro, 2014, p. 190, fig. 6). Although it occurs very occasionally at Vinča-Belo Brdo (Spataro, forthcoming), it was the main tempering agent at Opovo, where it was used for ca. 60% of the coarse ceramics (Tringham et al., 1985, p. 436). At Miercurea Sibiului Petriş, crushed rock fragments were relatively common, and were used to temper thin-walled vessels, large and deep pots and a large hemispherical bowl with finger impressions (Spataro, 2014, table 1). At Parţa the coarse thick-walled ceramics, such as globular vessels decorated with plastic cordons or bosses, were tempered with felspatic sand; tronco-conical vessels, oval-shaped pots and a bowl decorated with bosses were tempered with crushed and coarse grog (Spataro, 2014, table 1, fig. 8).

The formulas (recipes) used to make Vinča fine black-burnished ware vary only slightly between sites. At Opovo, thin-walled black-burnished vessels such as highly-polished open bowls and necked jars were not tempered (Tringham et al., 1985, p. 437). At Vinča-Belo Brdo, all the burnished ware is untempered (Spataro, forthcoming). Six of the nine untempered fine vessels from Parţa, are black or grey-burnished, but one black-burnished ware was made with some added finely cut chaff temper, and two small globular black-burnished vessels were made with some very finely crushed grog (Spataro, 2014, table 1). At Miercurea Sibiului Petriş, only one of the fine ware sherds examined was black-burnished, and it was made with a fine untempered fabric (Spataro, 2014, table 1).

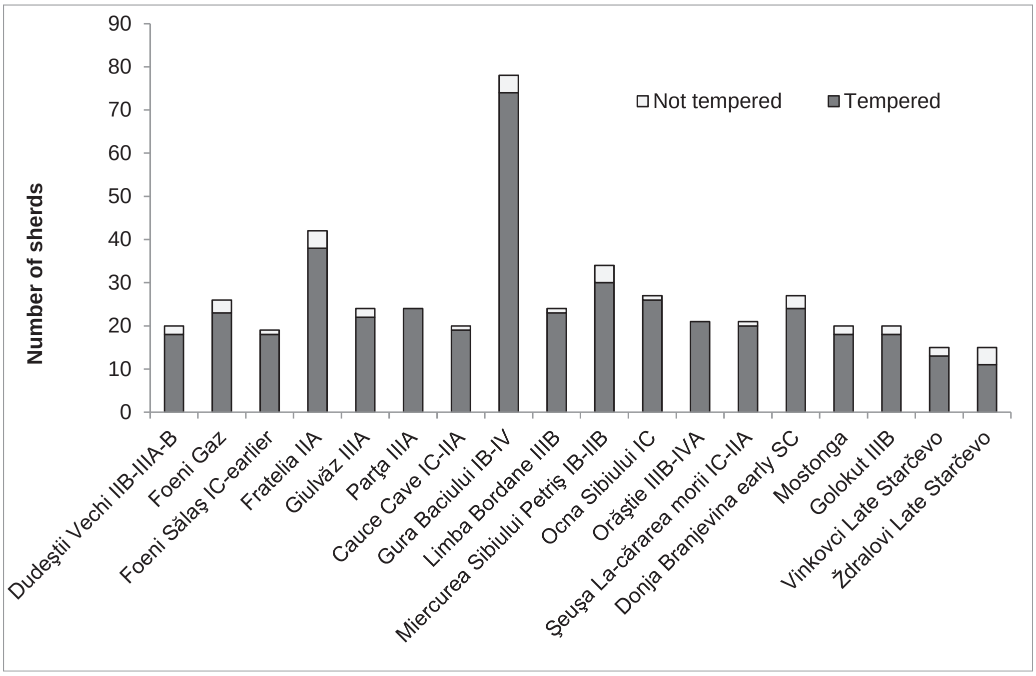

Fig. 5 – Bar chart of temper for the central Balkans Early Neolithic in the 6th millennium cal. BC: most of the pottery was tempered.
Fig. 5 – *Diagramme en bâtons des dégraissants pour les Balkans occidentaux au Néolithique ancien au VIe millénaire cal. BC : la plupart des poteries ont été dégraissées.*

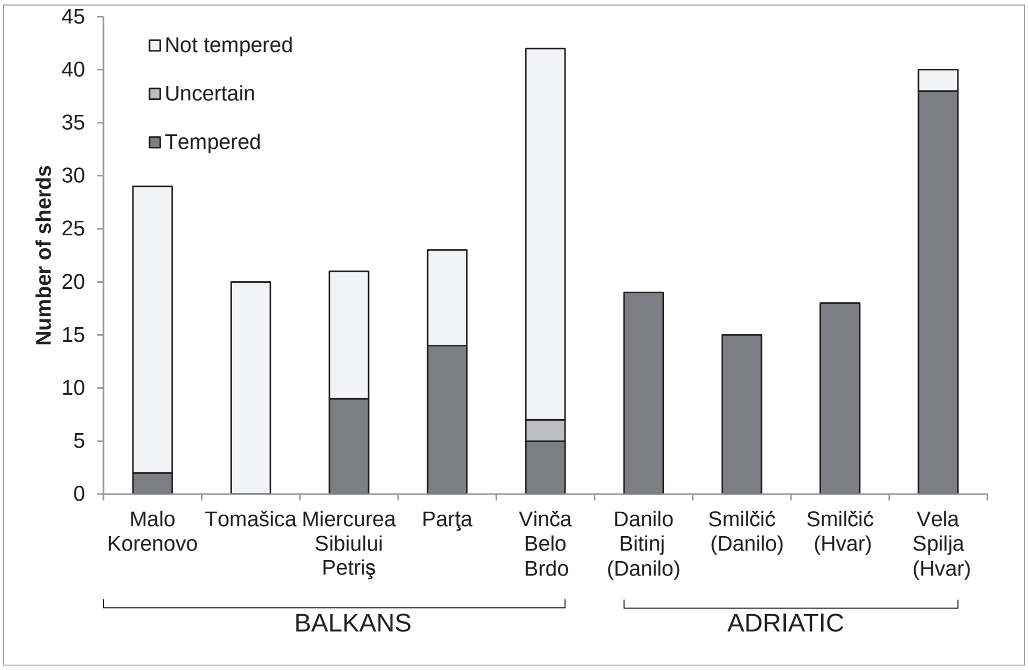

Fig. 6 – Bar chart of temper for the eastern Adriatic and the central Balkans Middle Neolithic in the 5th millennium cal. BC: in the Balkans most of the pottery was not-tempered whereas at the Adriatic sites temper is ubiquitous.
Fig. 6 – *Diagramme en bâtons des dégraissants pour l'Adriatique oriental et les Balkans occidentaux au Néolithique moyen au Ve millénaire cal. BC : dans les Balkans, la plupart des poteries ont été relativement peu dégraissées tandis que pour les sites en Adriatique, les dégraissants sont omniprésents.*

Korenovo potters (fig. 6) used temper for plain, coarse and thick-walled vessels, most probably for functional reasons. They used crushed intrusive igneous rock fragments, which were available close to the sites, but the grey, dark-grey burnished thin-walled vessels were not tempered.

In the 5th millennium cal. BC the pattern of pottery temper is almost the opposite of that in the 6th millennium cal. BC (fig. 5 and 6). Middle/Late Neolithic ceramics from the central Balkans and Slavonia were mainly not-tempered; tempering seems to have been more common at the Romanian Vinča sites.

Surface treatment

The only surface treatment of IW ceramics was impressed or incised decoration, which was added after the vessel was shaped and before firing. SC ceramic surface treatments were more elaborate and varied, with slips, burnishing and painting as well as incisions and impressions. Burnish and slip treatments are sometimes difficult to distinguish by eye, and microscopic analyses are needed to determine whether an extra coating layer (a slip) was added or whether the surface was well-compressed and burnished.

Burnishing became a widespread surface treatment in the Middle Neolithic of southern Europe, being common in the Danilo, Hvar, Vinča and Korenovo cultures. Danilo and Hvar burnished ware was made using the same fabrics used to make coarse ware with untreated plain surfaces. The paste was made of calcareous or non-calcareous clay, which was heavily tempered with crushed calcite. The only technological difference was the burnishing of the surfaces, and compressing and smoothing the external layer of clay platelets using a smooth-surfaced tool (e.g. pebbles, potsherds, bones, cloth, etc.). The pot was then fired in a reducing atmosphere to obtain the red, buff and black glossy surface. The burnished layer is clearly observable in thin section (fig. 7, left).

A different *chaîne opératoire* was followed for the burnished Vinča ceramics. Black-, red-, and buff-burnished wares were mainly manufactured using very fine loessic or alluvial and non-calcareous raw materials, rich in fine quartz inclusions. After shaping the vessel, the potter would burnish the surface with a smooth tool, as a distinct orientation of the clay platelets is visible, and fire it in reducing or oxidising conditions. However, in some instances, e.g. at Parţa, black-burnished ceramics were not only fired in a reducing atmosphere, but were also smudged, as a thin carbon surface layer is visible in some of the sections (fig. 7, right)[(4)]. Smudging implies that the ceramics were deliberately coated with a layer of fine soot, e.g. by adding green wood during the firing, after lowering the temperature (Rice, 1987, p. 158; Skibo, 1992, p. 160; see also Fowler, 2008, p. 497 for smudging as a post-firing treatment). At Opovo, black-burnished ceramics were the product of smudging or just of reducing firing conditions (Tringham *et al.*, 1985, p. 437); the smudged pottery generally looks less shiny.

Korenovo grey and dark-grey burnished ware was made using very similar raw materials to those used by Vinča potters. Well-burnished spherical, biconical and pedestalled bowls were produced with loessic clay, rich in very fine-grained quartz sand, which was ideal for burnishing as it did not contain coarse angular inclusions. After shaping and wetting the surfaces they were very well-burnished using a smooth-surfaced tool. The surfaces were only smoothed and compressed, as the inclusions have a distinct orientation, but are composed of the same minerals found in the rest of the fabric (fig. 8, left and right; fig. 9). Thus Vinča and Korenovo potters selected the most suitable clays to make burnished pottery, whereas Danilo/Hvar potters merely adapted the existing formula, despite the fact that coarse mineral temper made burnishing more difficult.

Figulina ware was also in some cases smoothed and then painted. The ceramic microstructure shows smoothing and compressing of the clay platelets (fig. 10), and ceramic tools made of fine pastes were used as burnishers at central and southern Italian IW sites, such as Colle Santo Stefano di Ortucchio in the Abruzzo region and Trasano in Basilicata (see also Angeli and Fabbri, 2013; Angeli, in press).

Firing conditions

Firing temperatures of prehistoric pottery fired in bonfires cannot be determined exactly, as various factors govern the effective temperature, including clay types, atmosphere conditions, fuel used and in particular the duration of the firing and cooling.

In the Early Neolithic, pots were mainly fired at low temperatures. In the IW the temperatures never exceeded 750 °C, as the crushed calcite used as temper is perfectly intact (Shoval et al., 1993, p. 271). For SC ceramics the average temperature was around 600-650 °C, as charred organic remains are often visible in most of the potsherds (e.g. Rice, 1987, p. 88; Gibson and Woods, 1990, p. 113). Higher temperatures were rarely achieved, as vitrified fabrics are rare in most Early Neolithic assemblages. IW and SC potters fired the ceramics in oxidising conditions, but SC pots often have a darker 'sandwich-core', due to incomplete oxidation of the organic temper or component.

In the Danilo and Hvar cultures the firing temperature was similar to that used for IW production, as in most cases a good sintering of the clay (when the clay particles begin to soften and stick together, see: Rice, 1987, p. 93; Gibson and Woods, 1990, p. 241), can be observed in the fabrics but there is no evidence of vitrification of clay filaments, and crushed calcite is perfectly conserved. However, potters started to use reducing conditions to make black-burnished ceramics (see above, fig. 7).

In contrast, *figulina* ware was fired at high temperatures in an oxidising atmosphere. The fabrics are vitrified, in some cases showing bloating (fig. 11), suggesting firing temperatures of up to 950 °C. The neoformation of

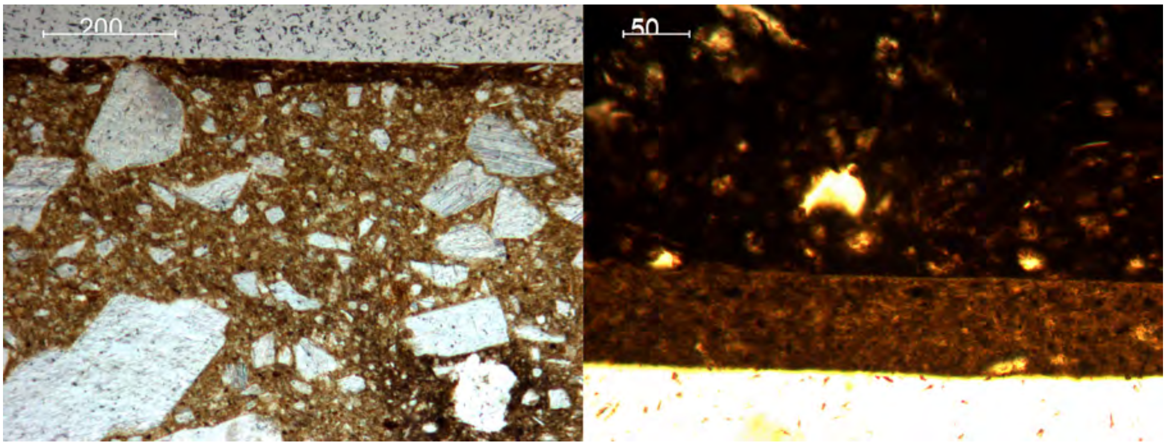

Fig. 7 – Photomicrograph of a thin section of sample VS17 (left; plane polarised light, PPL), a black-burnished vessel from the Hvar site of Vela špilja (Korčula island), showing a coarse fabric rich in crushed calcite and a smoothed and compressed surface layer due to the smoothing and burnishing of the surface which was then fired in reducing atmosphere (fine quartz and mica flakes are still visible in the smoothed layer); right: photomicrograph of a thin section of a small black-burnished globular vessel from Parţa (Romanian Banat), showing a thin layer of carbon deposit on the surface left by smudging (PPL).
***Fig. 7** – Micrographie d'une lame mince de l'échantillon VS17 (à gauche, lumière polarisée) d'un récipient noir bruni provenant du site Hvar de Vela špilja (île de Korčula), présentant une pâte grossière riche en calcite écrasée et une couche de surface lisse et comprimée réalisée grâce au polissage de la surface qui a ensuite été cuite en atmosphère réductrice (de fines paillettes de quartz et mica sont visibles dans la couche polie) ; et (à droite) micrographie d'une lame mince d'un petit récipient noir bruni de forme globulaire provenant du site de Parţa (Banat roumain), présentant une fine couche superficielle de carbone laissée par l'enfumage (lumière polarisée).*

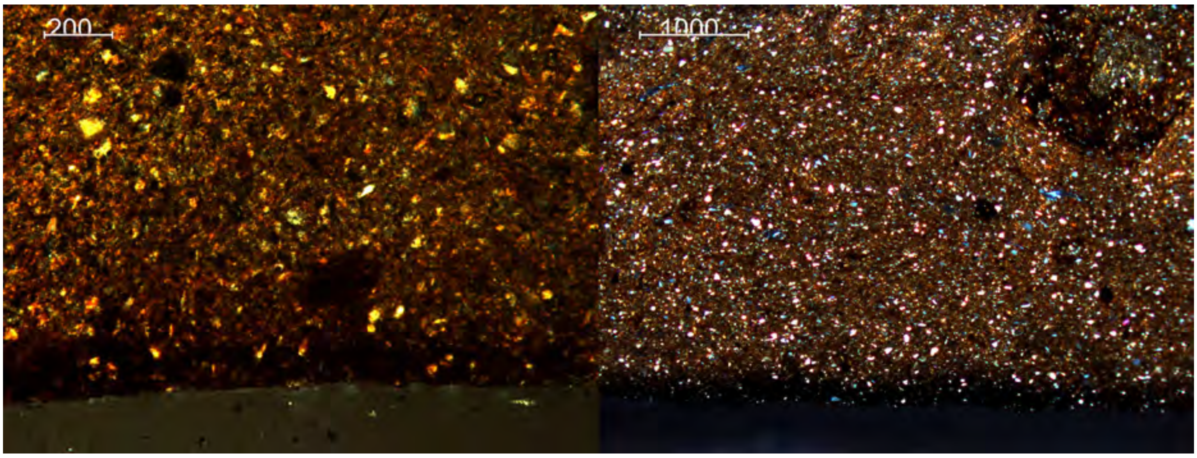

Fig. 8 – Photomicrographs of thin sections of sample MK13 from the site of Malo Korenovo (left) and sample TMS3 from the site of Tomašica (right) in Slavonia. The burnished surface is clearly visible in the smoothed and compressed surface layer on both samples (XPL).
***Fig. 8** – Micrographie de lames minces des échantillons MK13 provenant du site de Malo Korenovo (à gauche) et TMS3 provenant du site Tomašica (à droite) en Slavonie. Pour ces deux échantillons, la surface brunie est clairement visible au niveau de la couche superficielle qui a été lissée et comprimée (lumière polarisée croisée).*

gehlenite in *figulina* ware from Middle/Late Neolithic Serra d'Alto sites in Apulia and Basilicata, indicates firing temperatures of up to 1050 °C (e.g.: Heimann and Maggetti, 1981; Muntoni and Laviano, 2008, p. 128). Despite the availability of *figulina* ware at the Danilo and Hvar sites, everyday pottery continued to be fired at the same low temperature.

On the basis of the SEM microscopy, the majority of Vinča potsherds have well-sintered clays, and in many cases, at all three sites examined, clay filaments began to vitrify. However, Vinča potters did not need a very high firing temperature to make black-burnished ware, although the SEM microstructural analyses show that in some cases they experimented with high-firing, reaching 850-900 °C and even higher temperatures, for coarse ware and occasionally also for black-burnished ware (Spataro, 2014). Some of the pastes are vitrified, particularly at Vinča-Belo Brdo (Spataro, forthcoming). Nevertheless, some black-burnished ware was also low-fired, as suggested by the presence of charred organic remains at Parţa (see fig. 12).

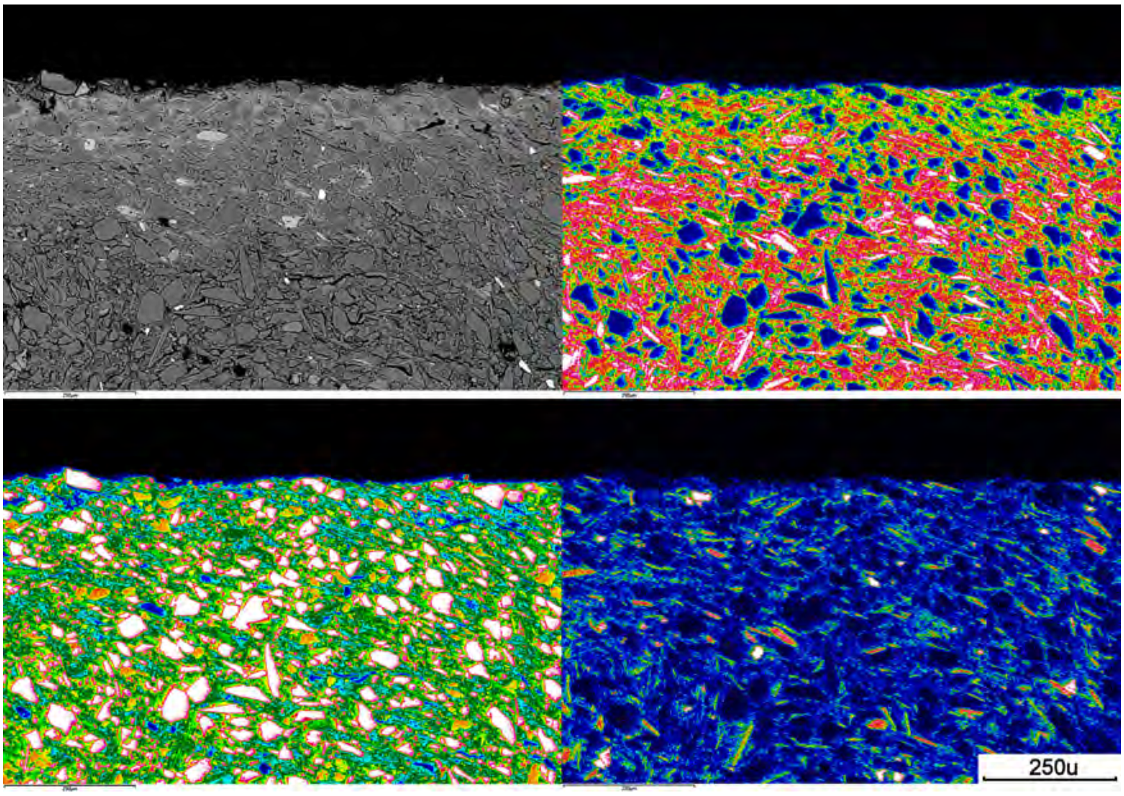

Fig. 9 – SEM-EDX elemental map of sample TMS3 from the Korenovo site of Tomašica (see Spataro, 2006), a black-burnished deep cup with very thin walls, which shows no chemical difference between the paste and the surface of the sample. Top left: mapped area (× 120, covering ca 1.0 × 0.8 mm); top right: the elemental map for aluminium, which is abundant in the fabric throughout the sample; bottom left: the elemental map for silicon, very abundant in the fabric of the samples and no differences can be identified between the paste and the surface layer; bottom right: the elemental map for potassium, concentrating in the mica flakes of the sample, similarly spread in the fabric and surface of the potsherd.

***Fig. 9** – Carte de la répartition des éléments de l'échantillon TMS3 provenant du site de Korenovo de Tomašica (see Spataro, 2006), acquise par analyse MEB-EDX ; cet échantillon vient d'une coupe haute en céramique noire brunie aux parois très fines et ne montre quasiment pas de différence entre la pâte et la surface. En haut à gauche : zone cartographiée (× 120, couvrant environ 1.0 × 0.8 mm) ; en haut à droite : carte de la répartition des éléments pour l'aluminium, qui est abondant dans la pâte dans l'ensemble des échantillon ; en bas à gauche : carte de répartition des éléments pour le silicium, très abondant dans la pâte des échantillons ; aucune différence ne peut être identifiée entre la pâte et la couche de surface ; en bas à droite : carte de la répartition des éléments pour le potassium, qui est concentré dans les paillettes de mica qui sont distribuées de manière homogène entre la pâte et la couche de surface du fragment de poterie.*

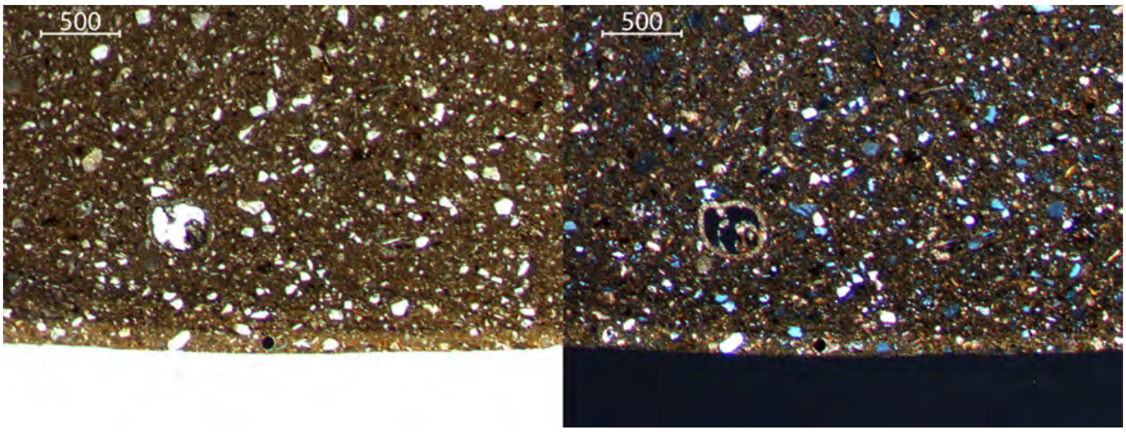

Fig. 10 – Photomicrographs in PPL (left) and XPL (right) of a *figulina* sample RDM23 from Ripabianca di Monterado (Italy) showing a compressed and burnished surface.

***Fig. 10** – Micrographie en lumière polarisée (à gauche) et lumière polarisée croisée (à droite) de l'échantillon RDM23 d'une* figulina *provenant de Ripabianca di Monterado (Italie) et présentant une surface comprimée et brunie.*

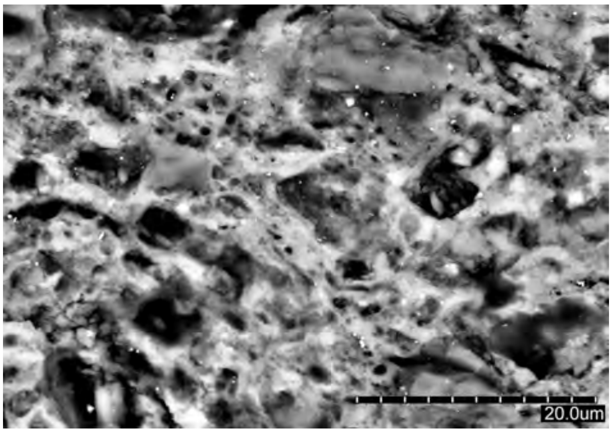

Fig. 11 – SEM backscattered electron image at high magnification of a *figulina* pottery thick-polished sample from Scamuso (South-eastern Italy), showing the high-fired paste with bloating.
***Fig. 11** – Image MEB en électrons rétrodiffusés à fort grossissement d'une section épaisse polie d'une poterie* figulina *provenant du site de Scamuso (Italie du Sud-est) et présentant une pâte cuite à haute température et fortement vitrifiée.*

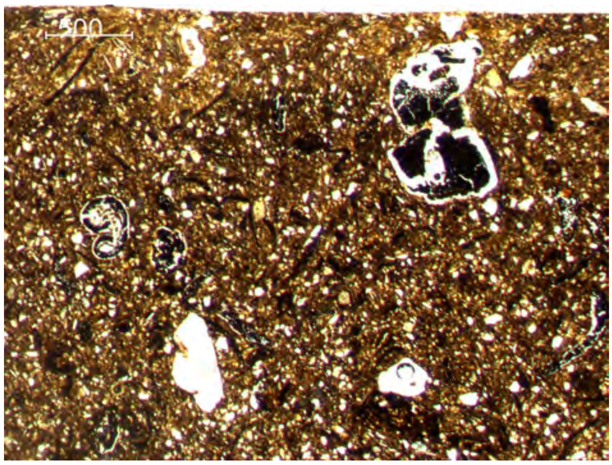

Fig. 12 – Photomicrograph of sample PRTV5, a black-burnished globular vessel with cylindrical neck from Parţa (PPL). The fabric of the sherd is rich in fine quartz sand inclusions and also finely cut plant matter. The burnt charred remains (black areas infilling the voids) are still visible in the fabric of the pot, indicating a low firing temperature.
***Fig. 12** – Micrographie de l'échantillon PRVT5 d'un récipient noir bruni de forme globulaire avec un col cylindrique provenant de Parţa (lumière polarisée). La pâte de ce fragment est riche en fine inclusions de sable de quartz et de matière végétale finement coupée. Les résidus carbonisés (zones noires remplissant les vides) sont encore visibles dans la pâte, ce qui indique une basse température de cuisson.*

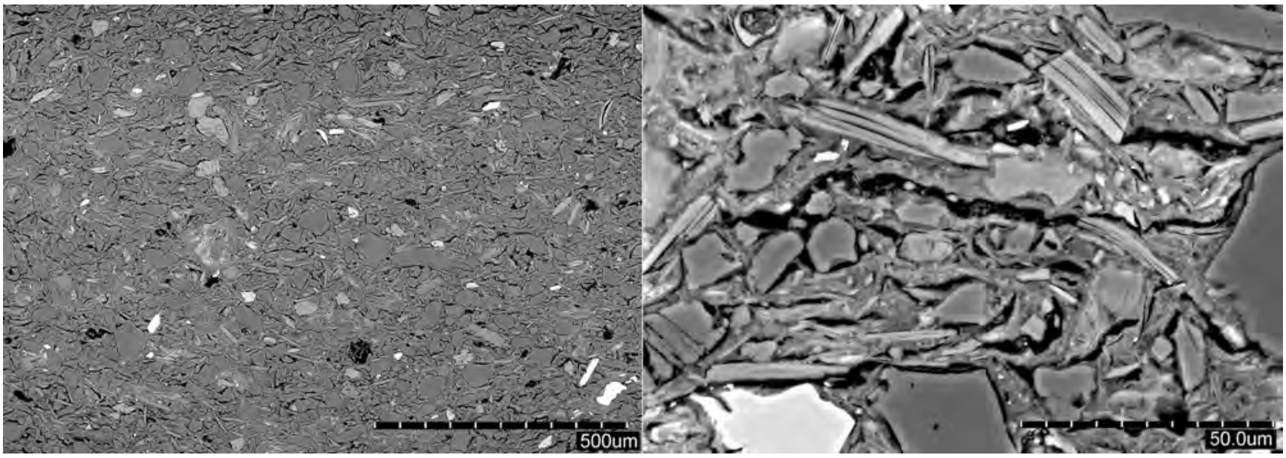

Fig. 13 – SEM backscattered electron image of a thick-polished section of sample TMS4 from Tomašica at low (left) and high (right) magnification, showing a fabric with well-sintered clay, but no initial stage of vitrification.
***Fig. 13** – Image MEB en électrons rétrodiffusés d'une section épaisse polie de l'échantillon TMS4 provenant du site de Tomašica à faible (à gauche) et fort (à droite) grossissement et présentant une pâte bien fusionnée, mais sans l'étape initiale de vitrification.*

There was significant variation in firing temperatures between the sites analysed, which cannot be a temporal trend, as Miercurea and Parţa were attributed to early Vinča, and the high firing temperatures at Vinča-Belo Brdo appear from the earliest phases (Spataro, forthcoming). At Opovo, thick-walled ceramics, which were tempered with grog, were highly-fired (ca. 900-950 °C), whereas untempered vessels were fired at lower temperatures (800-840 °C; Tringham et al., 1985, p. 436).

At Korenovo sites, coarse plain surface and thin-walled dark grey-burnished ceramics were fired respectively in oxidising and reducing conditions. The temperatures did not exceed 850 °C, as vitrification was not identified in the 69 potsherds examined. SEM analysis of their microstructure shows that the clays were well sintered but the clay filaments had not begun to vitrify, suggesting a typical firing temperature around 800 °C (fig. 13).

DISCUSSION: TRADITIONS, INNOVATIONS, IMITATION AND RESISTANCE

Traditions

For more than 1,500 years, from the first appearance of ceramics along the eastern Adriatic coastline, potters used the same fabric and firing conditions for coarse and fine ware production. Ceramics were invariably tempered with crushed calcite, reflecting local geology (5). Although more radiocarbon dates are needed, it appears that the use of calcite temper increased over time. Low firing temperature and heavy reliance on only calcite temper is a low-technology pottery production package (table 2). As all shapes and surface treatments were made using the same package, there is no correlation between different ceramic products and pottery fabric. The potters must have known that calcite temper is incompatible with high firing temperatures (e.g. 850 °C), as these would cause cracking and spalling, with flakes of clay blown out of the surface of the ceramics (see Gibson and Woods, 1990, p. 246). Nevertheless, evidence that Danilo coarse ware was used for cooking is provided by sooting and long-chain ketones identified in material from Nakovana Cave in the Croatian Peliješac peninsula (Debono Spiteri, 2012, p. 250).

Although IW potters seem very conservative, Middle Neolithic Danilo potters experimented with new surface treatments and firing conditions, while continuing to use the same fabrics and firing temperature used by their predecessors. This production mode would imply no particular investment in raw materials, as they were easy to find, or in firing equipment, as the pottery could have been fired in a bonfire. There is no sign of production for a market, and pottery may have been produced at household level (Spataro, 2009b, p. 72). However, the sophisticated and elegant decorative motifs of the Danilo and Hvar cultures required more skills and time. These might have been produced by the most skilled potters. It is likely that the person who decorated the pots was sometimes different to the person who made them, as pots were all made with the same fabric, but some were particularly costly to produce. The IW and Danilo/Hvar technological traditions persisted despite the availability of *figulina* pottery.

In contrast to the originality and variety of decorative motifs and surface treatments, SC potters did not experiment with ceramic fabrics. For ca. 700 years (Spataro, 2010), SC potters used the same formula to make pottery: non-calcareous and micaceous clays tempered with abundant chaff, and fired at low temperature in oxidising conditions. This again would imply no investment in workshops and no sign of production for a market (Spataro, 2014, table 2).

We might ask if this far-reaching, persistent and common formula was a pragmatic choice, or a non-choice as potters saw no advantage in innovation. From a functional point of view, organic temper has some advantages (e.g. the pots are lighter) but also disadvantages, as for example sand-tempered or grog-tempered ceramics are more resistant to thermal shock (Skibo et al., 1989, p. 140; Tite et al., 2001). Petrographic analyses show that a small minority of vessels from a few SC sites were also tempered with sand, or sand with organics. These sand-tempered pots recur through the different SC phases (e.g. from the earliest to the latest phases at Gura Baciului in Transylvania; see Spataro, 2008), but sand temper never replaced chaff temper. Thus organic temper can be regarded as an adaptively neutral tradition. This reinforces the idea of a very conservative society (Spataro, 2014, p. 194), more conservative than the following Vinča.

The IW, SC and Danilo/Hvar pottery productions imply a cultural transmission which is both vertical, from one generation to the next, with the maintenance of local production methods over 700 years, and horizontal, based on the exchange of ideas over a broad geographical area (Spataro, 2007). However, the persistent differences in pottery technology between the Adriatic region and the central Balkans during the Early Neolithic reinforce the idea of a cultural boundary, which is not only typological (Spataro, 2011, p. 43; Spataro and Meadows, 2013, p. 72-73), but also technological. The technological and stylistic boundary persists in the Middle Neolithic, but new types of boundaries appear within the Balkans, once the new Middle Neolithic cultures appear, as typologies and decorative motifs between the northern (Korenovo) and southern (Vinča) regions are different, but similar ceramic technological packages developed. There is more technological variation within the Vinča groups than there is between Vinča and Korenovo ceramic production. These variations reinforce the idea of regionalisation of Vinča technological traditions.

Innovation and Innovative Tradition

After almost a millennium when ceramics were manufactured without any correlation between fabric and shape (e.g.: Spataro 2006a and 2011), the concept of 'ceramic class', requiring a consciously different step in the *chaîne opératoire* system, appeared in southern Europe in the Middle Neolithic. For example, red-burnished SC ceramics were always made using the same fabric used to make the other ceramics, including coarse and plain ware (table 3). By contrast, Vinča potters at Parţa, Miercurea Sibiului Petriş and Vinča-Belo Brdo selected loessic and fine alluvial clays to manufacture thin-walled burnished ware, and used different clays and tempers to produce coarse ware (Spataro, 2014). Similar patterns may be observed at Opovo, where a correlation between vessel type and fabric was suggested (see: Tringham et al., 1985, p. 436 and fig. 10), and in two of the three Korenovo assemblages discussed here (no coarse ware from Tomašica was analysed).

The coarse ware at each Vinča site considered here was made using different tempering agents. At Parţa, for example, globular vessels with plastic decorations and

Aspect	Impressed Ware	Starčevo-Criş
Clay selection and processing	Unselective Minimal processing	Only one type of clay Minimal processing
Temper use and selection	Increasing reliance on calcite as temper; local minerals	Almost exclusive and ubiquitous use of chaff
Surface treatment	Basic, impressions and incisions, before firing	Rough surfaces, barbotine, polished and burnished, red-slipped, painted, plastic, impressed, incised: diverse
Firing conditions	Low-firing; oxidising atmosphere	Low-firing; sandwich-core due to burning of the organics

Table 2 – Comparison of technological aspects of the Early Neolithic Impressed Ware and Starčevo-Criş cultures.
Tabl. 2 *– Comparaison entre les aspects technologiques des cultures de la céramique imprimée et de Starčevo-Criş au Néolithique ancien.*

Attributes	Vinča-Belo Brdo (Vinča A-D)	Parţa (Vinča B)	Miercurea Sibiului Petriş (Vinča A1-B)	Korenovo	Danilo/Hvar	*Figulina* ware
High firing (>850 °C)	√					√
Controlled atmosphere	√	√	√	√	√	√
Clay selection	√	√	√	√		√
Clay levigation	?	?	?			√
Correlation between shape and fabric	√	√	√	√		
Correlation between fabric and appearance	√	√	√	√		
Sophisticated surface treatment	√	√	√	√	√	√

Table 3 – Attributes of innovation in relation to the Middle Neolithic cultures and sites discussed in the paper.
Tabl. 3 *– Attributs d'innovation en relation avec les cultures et sites du Néolithique moyen discutés dans cet article.*

tronco-conical vases with plastic and impressed decorations were tempered respectively with metamorphic sand and grog (Spataro, 2014, table 2). At Opovo, grog was the main choice for coarse thick-walled vessels. Grog seems to be a Middle Neolithic choice and effectively a Middle Neolithic invention in this region, as it is almost absent from the ceramics analysed in the Early Neolithic assemblages. At Miercurea, thick-walled pots were made of sand-tempered pastes (Spataro, 2014). At the three Korenovo sites analysed so far, only vessels with thick walls and plain and unburnished surfaces were tempered; the only temper used was crushed igneous rock.

On these bases, the use of specific temper types (rock fragments and grog) which were effective for thermal-shock resistance purposes, and the fact that the tempered pots were mainly plain coarse ware, would suggest that in both Vinča and Korenovo cultures, temper was used selectively for functional reasons. In addition, different clays were used to make coarse ware from those used to manufacture the mainly untempered burnished ware.

The variations of temper and formulas used to make fine and in particular coarse ware might reflect a temporal or regional pattern. The Miercurea and Parţa samples come from the early Vinča phases, whereas the ceramics from Vinča-Belo Brdo cover the entire Vinča sequence. Opovo, in Vojvodina, is only 60 km north of Vinča-Belo Brdo, but Parţa is in Romanian Banat, and Miercurea is in Transylvania, over 300 km from the Serbian sites (fig. 1).

Burnished Vinča and Korenovo ceramics were mainly made of very fine raw materials, loessic or alluvial sediments, which were ideal for burnishing. On the other hand, although Danilo potters introduced red-, buff- and black-burnished ceramics to the ceramic repertoire of the Dalmatian coast, they did not use different raw materials to those used for coarse ware production. Their calcite-tempered fabrics were not ideal for burnishing, as the many coarse/medium angular inclusions complicated the polishing process. The fact that Danilo/Hvar black-burnished ware was made following local fabric traditions implies that it was made by local potters, and not by itinerant or immigrant potters from the central Balkans. The adoption of black-burnishing can be seen an adaptive change, as Danilo potters used the same solution as Vinča and Korenovo potters to obtain shiny surfaces, without copying the shapes and designs of Vinča and Korenovo pots; the technology spread, not the typology. The idea of the end-product, presumably tied to display, may also have spread. The visibility of black-burnish might have quickly influenced potters' choices and techniques in surrounding areas, even if the process by which it was obtained was not openly displayed (see: Gosselain, 2000, p. 191).

Burnishing is not a Middle Neolithic invention, but was first developed when pots were fired under oxidising conditions. In the Middle Neolithic, with the use of more suitable clays in the Korenovo and Vinča cultures, and the adoption of firing in reducing conditions, this trait crossed cultural boundaries independently of the *chaîne opératoire*, as the temper was not a determinant. The question that arises is whether black-burnishing met a functional requirement that could not be met before. It is doubtful that only burnished ware was used to hold liquids, as residue analyses of Starčevo ceramics from the Iron Gates site of Schela Cladovei and the Hungarian site of Ecsegfalva 23 showed that both slipped burnished and coarse vessels contained dairy products (Craig et al., 2005). It is possible that with increasing social complexity, public display and feasting became more important (Spielmann, 2002).

Another important innovation of the Middle Neolithic is enhanced control over firing conditions. As black-burnished ware is commonly found throughout the area from the eastern Adriatic to Slavonia and eastern Transylvania, potters in all the three Middle Neolithic cultures considered here must have mastered firing with a reducing atmosphere. At Korenovo and Danilo sites, the black-burnished effect was obtained by smoothing and compressing the clay platelets, before firing in reducing atmosphere. On the other hand, some of the Vinča black-burnished ceramics were made with an extra step in the *chaîne opératoire*, the smudging (or smoking) technique. Control of temperature and a constant atmosphere or manipulating the fuel supply is required to manufacture well-sintered vessels and smudged pots or highly-fired ceramics. Vinča ceramics are distinguished from Korenovo and Danilo ware by their firing temperature (table 3). Vinča potters often used higher firing temperatures than those in neighbouring cultures, as testified by vitrified ceramic fabrics or the initial vitrification of clay filaments; highly-fired ceramics are common at Vinča-Belo Brdo and Opovo.

Finally, *figulina* ware can be seen as an 'innovative tradition'. This was a new technology, and there seems to have been no intermediate product between coarse IW pottery and *figulina*, i.e. proto-*figulina* ceramics have not been found. The *figulina* tradition lasted about 1,500 years and yet its production seems not have evolved. *Figulina* production implied a substantial investment of resources, in terms of training and equipment. The potter had to learn to find the right clay sources, to shape the pots without using any temper, and to control the firing conditions exactly. The high contents of calcium, magnesium, and potash suggest a well-defined choice since these elements can promote the vitrification of the ceramics at rather low firing temperatures (Spataro, 2009a, p. 70). In addition, the removal of inclusions might have helped to avoid spalling when reaching high temperatures.

The potter would have been able to control the temperature for these highly-fired products only using a kiln[(6)]. Equipment was also required to levigate the clay (table 3). Considering the greater investment involved, *figulina* production might have been a full-time occupation, in contrast to possible seasonal work for the production of Early Neolithic and perhaps some of the Middle Neolithic pottery. Surprisingly, there seems not to have been communication or exchange of ideas between the *figulina* potters and the potters who produced the Danilo/Hvar found in the same ceramic assemblages. This might imply cultural transmission only within a restricted group of artisans.

Imitation and resistance

Some technological traits spread across Middle/Late Neolithic cultural boundaries and some did not. Firing in reducing conditions to produce black-burnished ware was one of the main developments in south-European Middle/Late Neolithic pottery. Burnishing and painting[7] spread across cultural boundaries (Danilo, Vinča and Korenovo cultures), and may be regarded as having had functional advantages as well as aesthetic appeal. As well as improving the appearance of the ceramics, giving a finer exterior, with a sophisticated sheen, it might have made them less permeable, without the use of a glaze, and limit crack propagation (Kerr et al., 2004, p. 74).

The metallic sheen of Vinča ceramics was probably both an aesthetic and functional trait, and not likely to imitate or substitute any metal vessel, as metal vessels are not known from these phases. Although burnishing is a trait which transcends cultural boundaries, smudging was only identified in the Vinča pottery. This was most likely a Vinča innovation, which so far has only been detected in one assemblage, at Parţa.

The ideal clays used for pots with a burnished surface treatment should contain few or fine inclusions, and the Vinča and Korenovo loessic and alluvial clays were ideal. The use of loess has some advantages, as it has a low drying shrinkage and stability at low firing temperatures (Kerr et al., 2004, p. 101). Nevertheless, Danilo black-burnished bowls and jars were manufactured using a clay which was tempered with abundant, coarse and angular inclusions. This suggests that the Danilo communities did not think they needed to change the traditional fabric, to make new ceramic types, regardless of their function, but they also adopted firing in reducing conditions. They tried to adapt their technical tradition (the fabric) to the new ideas (the burnishing).

Similarly, the very specific choice of clay, processing and firing used for the *figulina* ware did not spread, as these traits were not adopted by other potters. This might be due to the fact that the cultural transmission of these traits was restricted to a very small group of potters, as investment in equipment and skills was essential and high.

Some of the variations identified can be interpreted as regionalism, or local aspects of a single culture. Regional variations are visible in the Vinča culture, from a typological point of view, e.g. between the ceramic assemblages from Vinča-Belo Brdo, Selevac and Gomolava (see Chapman, 1981; Tringham et al., 1985, p. 437), and also from a technological perspective. In contrast to the use of just one formula for ceramic production during the 6th millennium cal. BC, coarse ceramics, in particular, were manufactured with a variety of tempers, clays and firing temperatures, which varied between Vinča-Belo Brdo, Parţa, Miercurea Sibiului Petriş and Opovo.

In some cases, the surface treatment of typical black-burnished ware was more sophisticated. This complexity suggests a possible centre of innovation, which might have influenced potters elsewhere, whereas smaller workshops in different villages might have developed their own, less sophisticated solutions, rather than adopting all aspects of new technology (i.e. high firing and use of smudging technique).

Successful innovation requires an innovator (or user-innovator) and a consumer, as if an innovation is not welcomed or needed, it will not become established. The innovation must provide some benefits and there is always a category of beneficiaries from innovation, a market place (von Hippel, 1986). An important aspect of innovation is to understand "*when* it is economically optimal to be an innovating user, manufacturer or supplier and *how* to manage each role" (von Hippel, 1986, p. 332). The benefit derived from an innovation such as black-burnishing may of course have been a social advantage (e.g. enhanced status or group identity), rather than a strictly utilitarian benefit.

The Middle Neolithic societies were more receptive to innovation, but pottery on its own is not sufficient to explain the reasons of change in society, as other aspects of the material culture should be considered. Two factors to be considered might be the mobility of the artisans and pottery as a culturally learned behaviour (Gosselain and Livingstone Smith, 1995, p. 158; Livingstone Smith, 2000, p. 34). Farming activities in the Vinča world were more established than in the previous millennium and towards the end of the period, pottery standardisation seems to develop from a typological perspective as well (Vuković, 2011).

CONCLUSIONS

In the Early Neolithic of the IW and SC communities, all the vessels were fired with low firing temperatures, and clay processing was minimal, although SC potters were selective about which clays they used. In the Adriatic region, temper use apparently increased over time and eventually became almost universal, whereas in the Balkans temper was always used, throughout the Early Neolithic. Only mineral temper was used in IW pottery, whereas SC pottery was almost always chaff-tempered. IW surface treatments (impressions, incisions) were more basic, whereas SC potters applied a wider range of surface treatments, including *barbotine*, painting and burnishing. The fact that SC pottery technology did not change over time is also reflected in the common traditions of lithic and bone industries at the same sites (Vitezović, 2011). The stability of Early Neolithic pottery technology might be related to the training process required to become a potter, and also to the expectations of the consumers.

Several innovations occurred in the Middle Neolithic: firing in a controlled atmosphere and more sophisticated surface treatment were used in all regions; Korenovo and Vinča potters, but not Danilo and Hvar potters, used different clays and tempers for different types of ceramics; high firing temperatures were only used by *figulina* and Vinča potters, and clay levigation was probably only practised by *figulina* potters (table 3).

Between the end of the Early Neolithic and beginning of the Middle Neolithic, we observe clear signs of specialisation in the Adriatic region. It is possible that *figulina* ware was made by a small elite of specialist potters, who had the requisite training to make untempered pots and fire them at high temperatures. In the central Balkans, after almost a millennium of pottery made using mainly one recipe, the idea of using specific clays and tempers for defined shapes or coarse and fine vessels (ceramic classes), which are often related to the type of surface treatment, suddenly appeared with the Vinča and Korenovo cultures. In both the Adriatic region and the Balkans, the concept of ceramics itself might have changed between the Early and Middle Neolithic, as a wide variety of new products were available and produced in a more systematic way, requiring more skills and being more capital-intensive.

Ethnoarchaeological research shows that ceramic manufacturing processes in contemporary societies are less susceptible to change than styles and post-firing treatments (Stark, 2003, p. 211-212). As O. P. Gosselain explains, "parts of these "aggregates" [pottery-making traditions] appear to be unequally affected by change, such that some may be altered readily at the time of technical transmission or during practice, whereas others are characterized by a remarkable stability. The reason is that the different components of pottery chaînes opératoires do not share a similar technical fluidity or involve similar processes of social interaction. Hence, important differences exist in the potential for technical behavior to be reproduced and to change over time and space and, as we will see, to reflect certain facets of identity. This should render pottery technology especially attractive for those interested in the archaeological reconstruction of social boundaries" (Gosselain, 2000, p. 191).

A natural question would be why some societies are receptive to innovations and other societies are more conservative. The break with SC tradition, the high firing temperatures and the smudging techniques suggest that the Vinča culture was more technologically developed than Korenovo and Danilo, and social complexity might have been behind the technological development. The Vinča tell sites, the erection of temples, the abundance of possible ritual artefacts, the beginning of metal production (Chapman, 1981; Lazarovici et al., 2001), all these aspects seem to show a Neolithic society more complex than those in the surrounding regions, where tells, temples, cult objects and metals, are absent or rare.

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NOTES

(1) I would like to thank Prof. S. Shennan (Institute of Archaeology, UCL) who allowed me to use the facilities of the institute for another year at the end of my post-doctoral research fellowship.

(2) The polarising microscope utilised for the thin section description is a Leica DMLP. The SEM-EDX used with the Impressed Ware ceramics was a Jeol JSM-35 CF with an Oxford ISIS detector with a thin film window. During the project on Starčevo, Korenovo and Vinča, a Philips XL30 ESEM was used, and the EDX data were processed using INCA Oxford Instruments software. I would like to deeply thank Mr K. Reeves (Institute of Archaeology, UCL) for his help and technical suggestions on the SEM throughout my PhD and post-doctorate. The SEM-EDX study consisted of bulk (regional) analyses from 5 different areas of each sherd (each covering an area of ca. 1.5 × 1.0 mm) (Spataro, 2014, p. 177-183).

(3) For example the site of Smilčić along the Dalmatian coastline, which was occupied from the Early Neolithic throughout the Late Neolithic (Impressed Ware, Danilo and Hvar cultures), or the site of Gura Baciului in Transylvania, which was occupied throughout the four SC phases, or the Romanian sites of Parţa and Miercurea Sibiului Petriş which show multilayered of occupation (e.g. SC and Vinča).

(4) The carbon does not usually penetrate the surface deeply, so it is often difficult to detect smudging in pottery thin sections (Gibson and Woods, 1990, p. 245).

(5) Calcite is still used as temper today by some potters in southern Croatia, south-east Slovenia, western Serbia and Bosnia-Herzegovina (see Carlton and Djordjević, 2013).

(6) Two kilns were found yielding *figulina* pots, one kiln with interconnected pits for the *figulina* pottery production has been found in Serra d'Alto near Matera in Basilicata (Ridola, 1924-26) and one at Rivaltella, Ca' Romensini (early Square-Mouthed Pottery Culture), dated to 5,300-4,720 cal. BC (6,070 ± 110 BP; I-12519) (Tirabassi, 1987).

(7) Mainly typical of the Danilo and Hvar cultures.

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Ceramic raw material acquisition and transfer of technological ideas among the Early Neolithic communities in the environs of the Western Carpathians

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and Anna Rauba-Bukowska

Abstract: The subject of this article is the relationship between Linear Band Pottery culture (LBK) from the Karków region in western Lesser Poland and Transcarpathian Eastern (Alföld) Linear Pottery (ALPC) culture from the Slovak-Hungarian borderland, based on mineralogical-petrographic analyses of ceramics. Clear linkages between these areas are attested in the importation of obsidian into Lesser Poland from the South, and of different types of flint into the Carpathian Basin from the North. Significant importation of ALPC pottery has been recorded to the north of the Carpathian Mountains. These relationships not only involved the exchange of goods (raw materials and ceramics) but also the constant transfer of ideas, as evidenced by the frequent occurrence of imitation ALPC ceramics in the LBK settlement centres. It has been found that evolutionary changes in LBK pottery resulted primarily from intensified contact with the ALPC. The growing influence of the ALPC, together with other factors, led to cultural change in Lesser Poland and to the replacement of the LBK by the Malice culture.

Keywords: Neolithic, Linear Pottery Culture, LBK, Alföld Linear Pottery culture, ALPC, Lesser Poland, Carpathian Basin, ceramic mineralogical-petrographic analyses.

Résumé : Le propos de cet article concerne la problématique des relations entre la culture à Céramique linéaire (LBK : *Linearband-keramik*) de la région de Cracovie en Petite-Pologne occidentale et la culture à Céramique linéaire de l'Alföld (*Alföld Linear Pottery* Culture : ALPC) de la région limitrophe slovaque-hongroise, sur la base des analyses minéralogiques et pétrographiques de la céramique. Des relations intensives entre ces régions sont attestées en Petite-Pologne par les importations d'obsidienne provenant du sud, ainsi que dans le Bassin Carpatique par plusieurs types de silex, provenant du nord. Plusieurs importations de céramiques de l'ALPC ont été découvertes au nord du Bassin Carpatique. Les relations ne consistent pas seulement en l'échange de biens comme la matière première ou la céramique, mais aussi en l'échange constant d'idées, ce qui se manifeste par plusieurs imitations de la céramique de l'Alföld (ALPC) dans les ensembles des centres de colonisation de la culture à Céramique linéaire (LBK). On a constaté que les changements évolutifs dans la Céramique linéaire (LBK) résultaient surtout de l'intensification des contacts avec l'ALPC. L'influence croissante de l'ALPC, ainsi que d'autres facteurs amènent aux changements culturels en Petite-Pologne avec notamment comme conséquence le remplacement de la LBK par la culture de Malice.

Mots-clés : Néolithique, culture à Céramique linéaire, LBK, culture à Céramique linéaire de l'Alföld, ALPC, Petite-Pologne, Bassin Carpatique, analyses minéralogiques de la céramique, analyses pétrographiques de la céramique.

THE SPATIAL AND CHRONOLOGICAL RANGE OF THE STUDY

This study covers western Lesser Poland and the northern part of the Carpathian Basin. Ceramic samples have been collected from six sites in Poland, two sites in Slovakia and two sites in Hungary. All the Polish sites lie in the Krakow region: Ojców-Wielka Dolna Cave, Modlniczka 2, Nowa Huta-Mogiła 62 and Nowa Huta-Wyciąże 5 are located north of the Vistula, while Zagórze 2 and Brzezie 17 are located south of that river (fig. 1).

The Slovakian site, Zemplínske Kopčany, lies in the northern part of the Great Hungarian Plain; Šarišské Michaľany is situated in the hilly Šariš region in the Western Carpathians (fig. 1).The Hungarian sites, Polgár-Csőszhalom and Polgár-Piocasi, are located east of the Tisza in the Great Hungarian Plain (fig. 1). All samples recovered from the sites in Poland represent the Linear Band Pottery culture (LBK); all samples from Slovakia and Hungary belong to the Eastern (Alföld) Linear Pottery culture (ALPC).

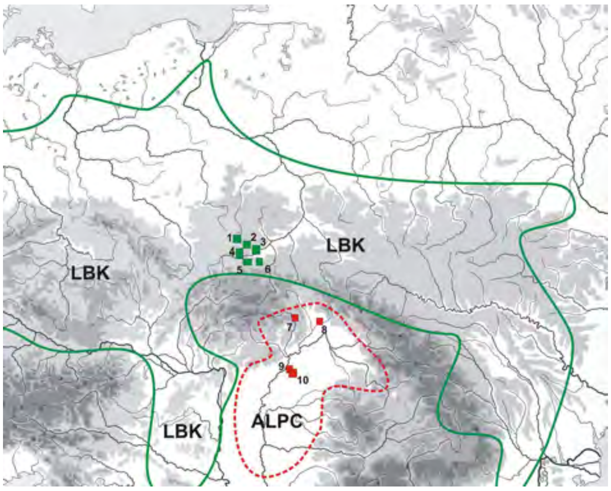

Fig. 1 – Locations of the LBK and ALPC sites with ceramic material analysed in this study. 1: Ojców-Wielka Dolna Cave; 2: Nowa Huta-Mogiła 62; 3: Nowa Huta-Wyciąże 5; 4: Modlniczka 2; 5: Zagórze 2; 6: Brzezie 17; 7: Šarišské Michaľany; 8: Zemplínske Kopčany; 9: Polgár-Csőszhalom; 10: Polgár-Piocasi.

***Fig. 1** – Localisation des sites LBK et ALPC avec la céramique analysée dans le texte. 1 : Ojców- grotte Wielka Dolna ; 2 : Nowa Huta-Mogiła 62 ; 3 : Nowa Huta-Wyciąże 5 ; 4 : Modlniczka 2 ; 5 : Zagórze 2 ; 6 : Brzezie 17 ; 7 : Šarišské Michaľany ; 8 : Zemplínske Kopčany ; 9 : Polgár-Csőszhalom ; 10 : Polgár-Piocasi.*

LBK AND ALPC EVOLUTION AND CULTURAL CHANGE AT THE TRANSITION BETWEEN THE LBK AND THE MC IN LESSER POLAND

The LBK culture spread to Lesser Poland and the Western Volhynian Upland in Ukraine during its pre-music-note (I) phase (the Bíňa and the Milanovce phases in SW Slovakia; Kulczycka-Leciejewiczowa, 1983; Pavúk, 2004; Czekaj-Zastawny, 2008, p. 16-18 and 2009; Dębiec, 2015). The earliest LBK groups migrated to south-eastern Poland from south-western Slovakia and Moravia through the Moravian Gate. There are nearly 30 sites representing the older LBK phase in Lesser Poland (Kozłowski et al., 2014, p. 39).

In the music-note phase (II), the LBK population gradually increased, reaching its peak in the Želiezovce phase (III). During the evolution of the LBK, the internal rhythm of cultural change was the same over almost all Lesser Poland and south-western Slovakia. Stone raw materials were dominated by Jurassic flint imported from the Krakow-Częstochowa Upland (Kadrow, 1990a, fig. 17a and 1990b, fig. 26a).

From the turn of phases II and III, however, large quantities of obsidian (Szeliga, 2007, p. 295-297, fig. 1) started to be imported from the Carpathian Basin, and other kinds of flint also came into use (including Turonian flint, Szeliga, 2014, fig. 8, and Volhynian flint, Kadrow, 1990a, fig. 14). The influx of new raw materials was particularly pronounced in the Rzeszów region in eastern Lesser Poland (Kadrow, 1990a, fig. 14, 17c and 1990b, fig. 26c).

At the same time, there was an increase in the importation of ceramic vessels or in local imitation of ALPC patterns, from the area of the upper Tisza, mainly of the Bükk culture (Kadrow, 1990a, p. 59-63, fig. 14; Kaczanowska and Godłowska, 2009). The influx of ceramics from the ALPC led to changes in the technology of locally produced pottery in the late (III) phase of the LBK (Kozłowski et al., 2014, p. 70).

The ALPC originated and initially developed in the middle and upper Tisza basin. This cultural entity resulted from the expansion of the Körös culture to the area mentioned above. The Méhtelek and the Szatmar groups functioned as transitional units between the Körös culture and the developed ALPC (Kozłowski et al., 2014, p. 42-43).

From the outset, the ALPC pottery showed regional differentiation, diverging thus from the relatively uniform ceramics of the LBK. Both cultural complexes differed clearly in terms of their settlement patterns and dwelling construction. From the second phase of the ALPC, importation of flint from Lesser Poland, including the Jurassic (Mateiciucová, 2008, maps 6-9), Turonian (Szeliga, 2014, fig. 2) and Świeciechów varieties (Szeliga, 2014, fig. 4), increased within the ALPC area.

ANALYSIS METHODS

In recent years, more than 400 samples of Early (LBK) and Middle (Malice culture) Neolithic ceramics and clay have been collected, including ALPC imports and imitations. Samples taken from the ALPC sites in Slovakia and Hungary comprise approximately 30 pieces. Analysis of technological aspects of the ceramics in south-eastern Poland and the northern Carpathian Basin has centred on their mineralogical and petrographic composition and component quantity ratios.

Thin sections taken from the pottery fragments have been examined with a Nikon Eclipse LV100N POL polarized light microscope.

Quantitative petrographic analysis (point counting, see: Quinn, 2013, with references within) has then been used to determine the percentage of individual components: clay minerals, quartz, alkali feldspars, plagioclases, muscovite, biotite, carbonates, grains of sedimentary, igneous or metamorphic rocks, grog fragments and organic materials.

Granulometric analysis was used to measure the diameter of crystal grains and clay clast. Thin sections were prepared for microscopic examination (Quinn, 2013) and measurement of grain cross-sections (500-1000 grains) in the image was then carried out using a code in MATLAB R2007b software which performs automatic image analysis.

Calculation was made within the following ranges: 0.002 – 0.02 mm, 0.02 – 0.05 mm, 0.05 – 0.1 mm, 0.1 – 0.2 mm, 0.2 – 0.5 mm, 0.5 – 1 mm, 1 – 2 mm and Ø > 2 mm.

The classification proposed by the Polish Society of Soil Science served as the point of reference (Polskie Towarzystwo Gleboznawcze, 2009).

Samples were grouped according to hierarchical cluster analysis using MATLAB R2007b (Kozłowski et al., 2014, p. 55-60). The study began with mineralogical-petrographic composition. The following components were chosen for comparison: quartz pellets, quartz grains (> 0.02 mm), rounded grains, angular rock fragments, clay clasts, grog, mica group minerals and organic material.

LBK MATERIALS

The studied regions are dominated by loess soils, particularly in the uplands, which were frequently settled in the Early Neolithic. The loess often covered Miocene sediments. Miocene dust clay was a popular raw material in the production of ceramic vessels. Miocene clays are easy to identify but the reverse is true of alluvial deposits: these tend to be more varied in composition, usually combining sediments such as the substratum of the river valley (Miocene clay in this case), sediments cut by the river valley (loess soil) or detrital material transported by the river (Jurassic material in this case). The alluvial sediments are mostly dominated by quartz silty fraction and particles of flint, chalcedony and micrite (lime mud; Rauba-Bukowska, 2014c; Kozłowski et al., 2014, p. 52-53).

First, a number of basic technological and mineralogical types have been distinguished for LBK pottery (Rauba-Bukowska et al., 2007) from south-eastern Poland. The first technological group is characterized by a high degree of sorting and mixing of the clay mass, sometimes with an admixture of organic temper. This group is typical of fine, ornamented ceramics (fig. 2). The second technological type is characteristic of cooking and storage ceramics. Cooking vessels (medium-walled) were made of silty or heavy clay with an admixture of sand and organic material (fig. 3). Storage ceramics were made of heterogeneous, poorly mixed clay with an admixture of organic material, sometimes with *chamotte* (fig. 3).

Next, local raw materials have been identified. Miocene heavy marine clay, with characteristic relics of plankton, volcanic glass and glauconite, seems to have been commonly used (fig. 4A and B). Other kinds of raw material include Holocene alluvial clay, containing grains of crushed flint and fragments of Carpathian flysch rocks (fig. 4C), and, in fine ceramics, loess-like sediment. In some cases, e.g. in pottery deposited in caves, calcium carbonate and calcium phosphate sediments have been recorded (fig. 5).

All these types of raw material were altered due to their preparation for the production of pottery. The original composition changed in the course of storage, mixing and kneading the clay, which may now complicate the identification of raw materials used in the production.

ALPC MATERIALS

Excavation at numerous LBK sites in Lesser Poland has yielded ceramics, both imitations and imports (fig. 6 and 7), which appear untypical in terms of their ornamentation thus pointing to ALPC influences or origins (Rauba-Bukowska, 2014b). These pottery assemblages come from the Tiszadob-Kapušany group and the early Bükk culture, both cultural entities within the ALPC.

The pottery of the Tiszadob-Kapušany group is characterized by fine-grained paste with a small amount of organic admixture. Its mineralogical composition includes fragments of metamorphic rocks (fig. 6).

Paste used in the production of ceramics in the Bükk culture is very fine-grained, pure and very dense. Characteristic elements are difficult to find in the silty clay, but the fine-grained paste contains small grains of feldspars, mica flakes and pyroxenes (fig. 7).

The clay mineral content in the pottery pastes produced both by the Tiszadob-Kapušany and the Bükk

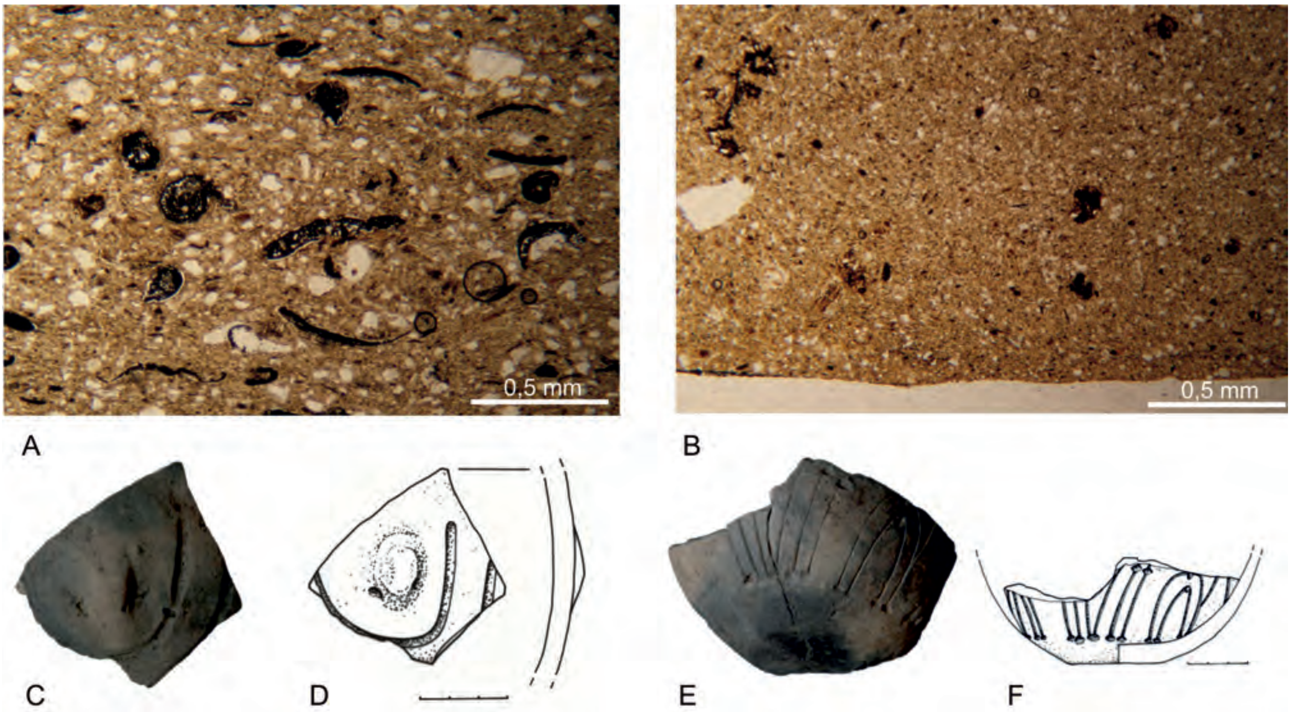

Fig. 2 – Fine pottery. A, C, D: Mogiła, site 62, phase I of LBK; B, E, F: Zagórze, site 2, phase II of LBK.
Fig. 2 *– Céramique fine. A, C, D : Mogiła, site 62, LBK phase I ; B, E, F : Zagórze, site 2, LBK phase II.*

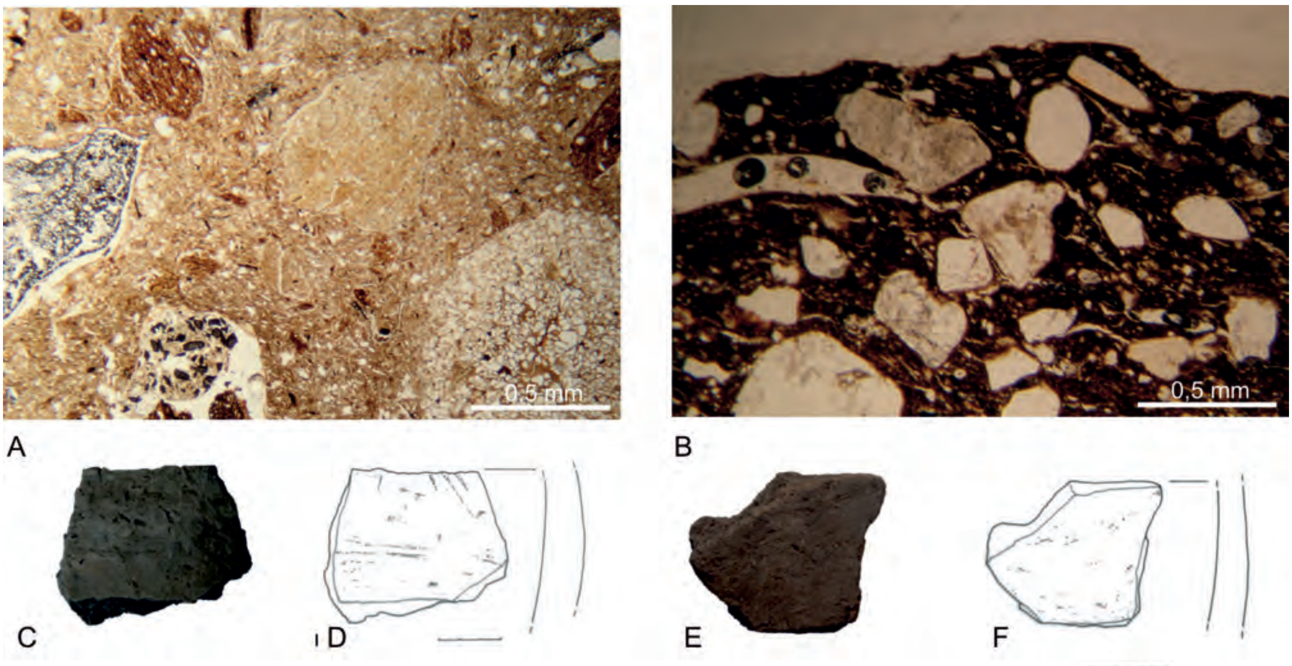

Fig. 3 – Cooking ware. A, C, D: Mogiła, site 62, phase I of LBK; Storage pottery (coarse); B, E, F: Wyciąże, site 5, phase II of LBK.
Fig. 3 *– Céramique culinaire ; A, C, D : Mogiła, site 62, LBK phase I. Poterie de stockage (commune) ; B, E, F : Wyciąże, site 5, LBK phase II.*

cultural groups ranges between 35% and 72%, and that of quartz between 18% and 48%. All of the ceramics are made of a fine-grained and well sorted clay mass, without any admixture of coarser crystallite; organic material is also very rare. A number of the vessels are made of silty clay with low feldspar content; some are enriched with muscovite.

Two kinds of clay can be distinguished. One, characteristic of the Zemplín area, is very silty, with fine material and a significant presence of muscovite and feldspar grains. The other kind of clay, typical of the Šariš region, has a lower content of quartz and muscovite, and its grains are coarser in size. This division corresponds to the two types of ceramic paste.

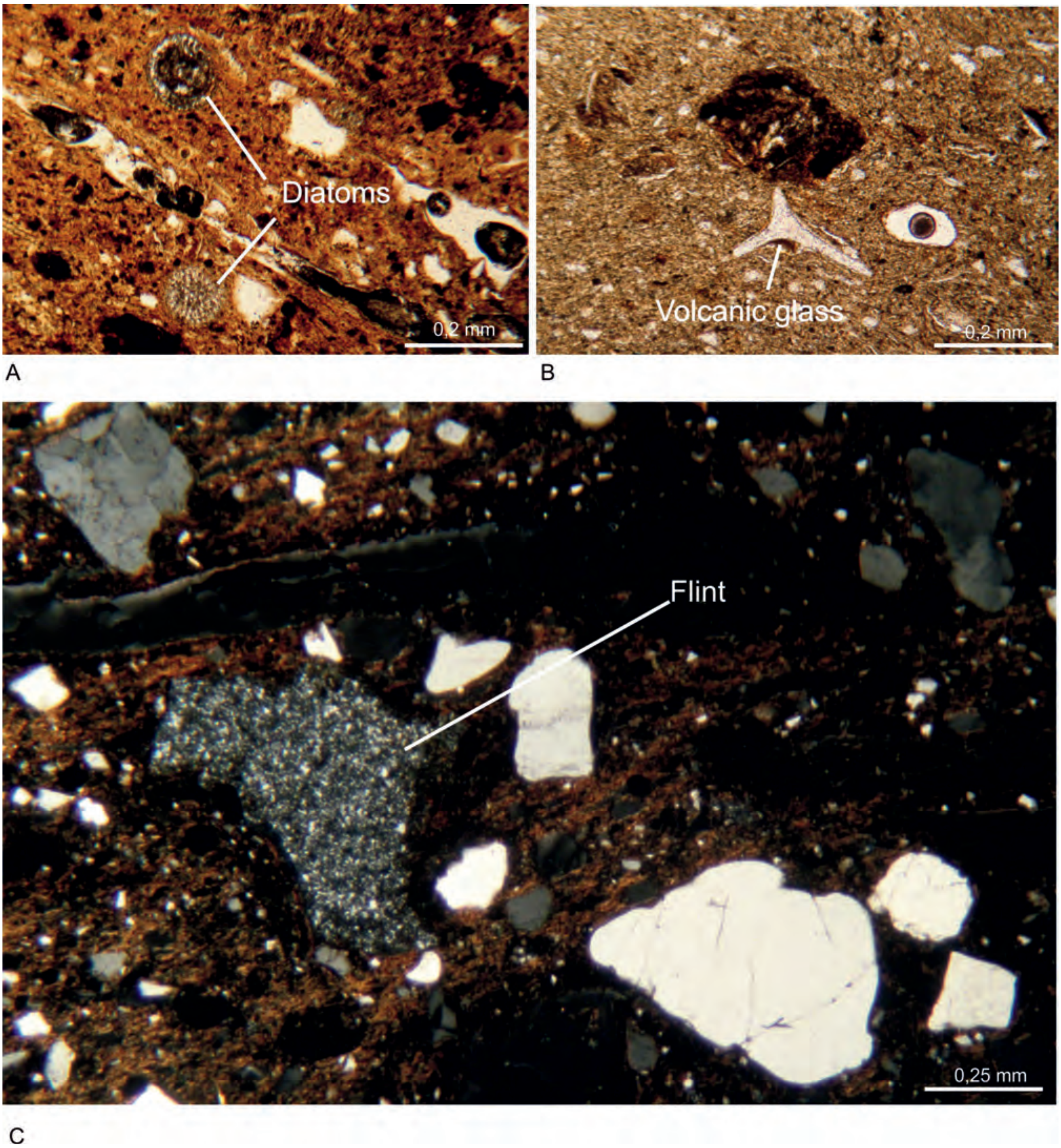

Fig. 4 – Clay raw materials. Miocene clays: A – Mogiła, site 62; B – Modliniczka, site 2. Holocene alluvial clay: C - Mogiła, site 62.
Fig. 4 *– Argile brute. Argile miocène* : *A - Mogiła, site 62 ; B : Modliniczka, site 2. Argile holocène alluviale* : *C - Mogiła, site 62.*

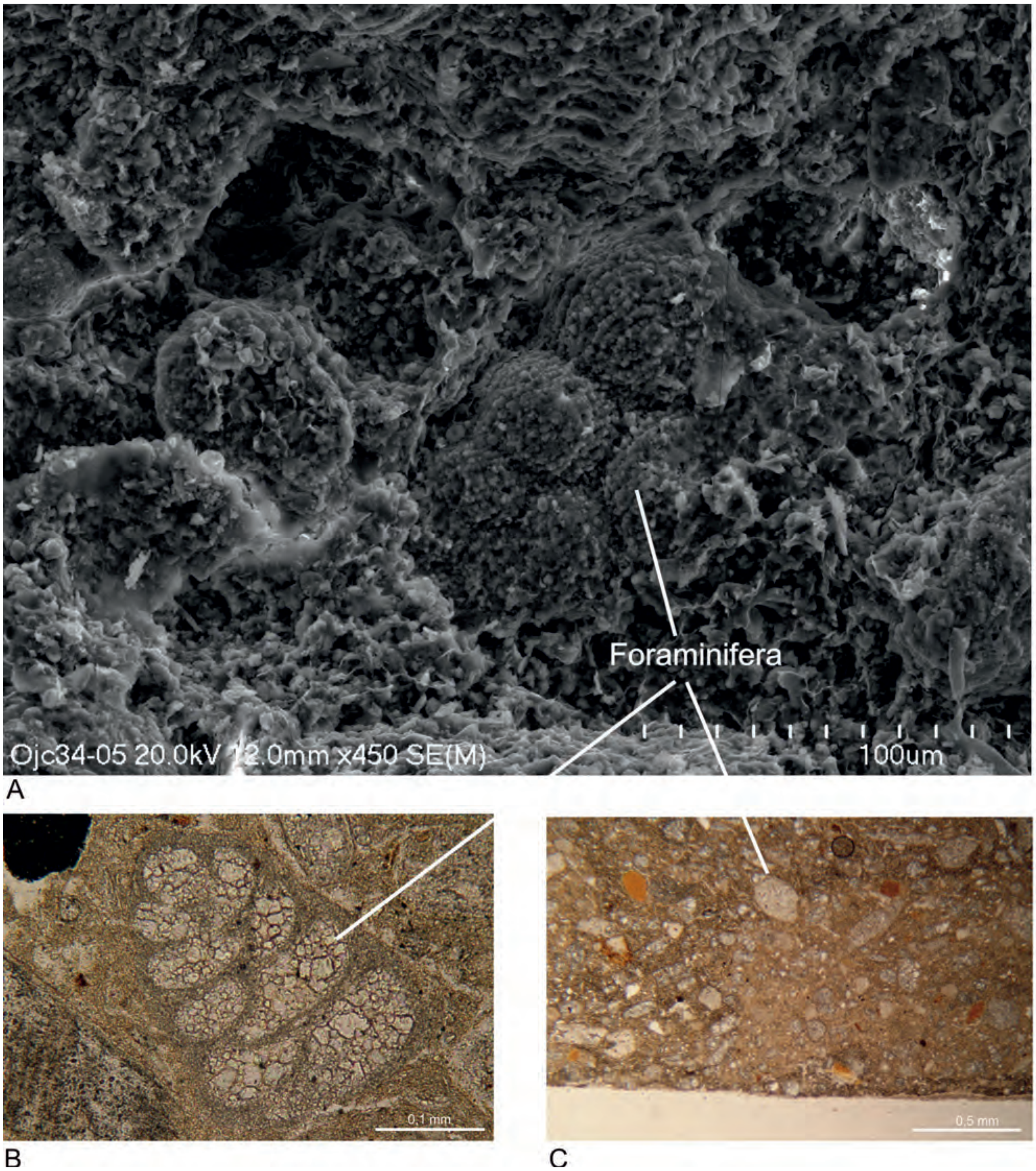

Fig. 5 – Clay raw materials: calcium carbonate and calcium phosphate clay – Ojców, site Wielka Dolna cave (A - C).
Fig. 5 – *Argile brute : argile calco-carbonatée et calco-phosphorée – Ojców, grotte Wielka Dolna (A - C).*

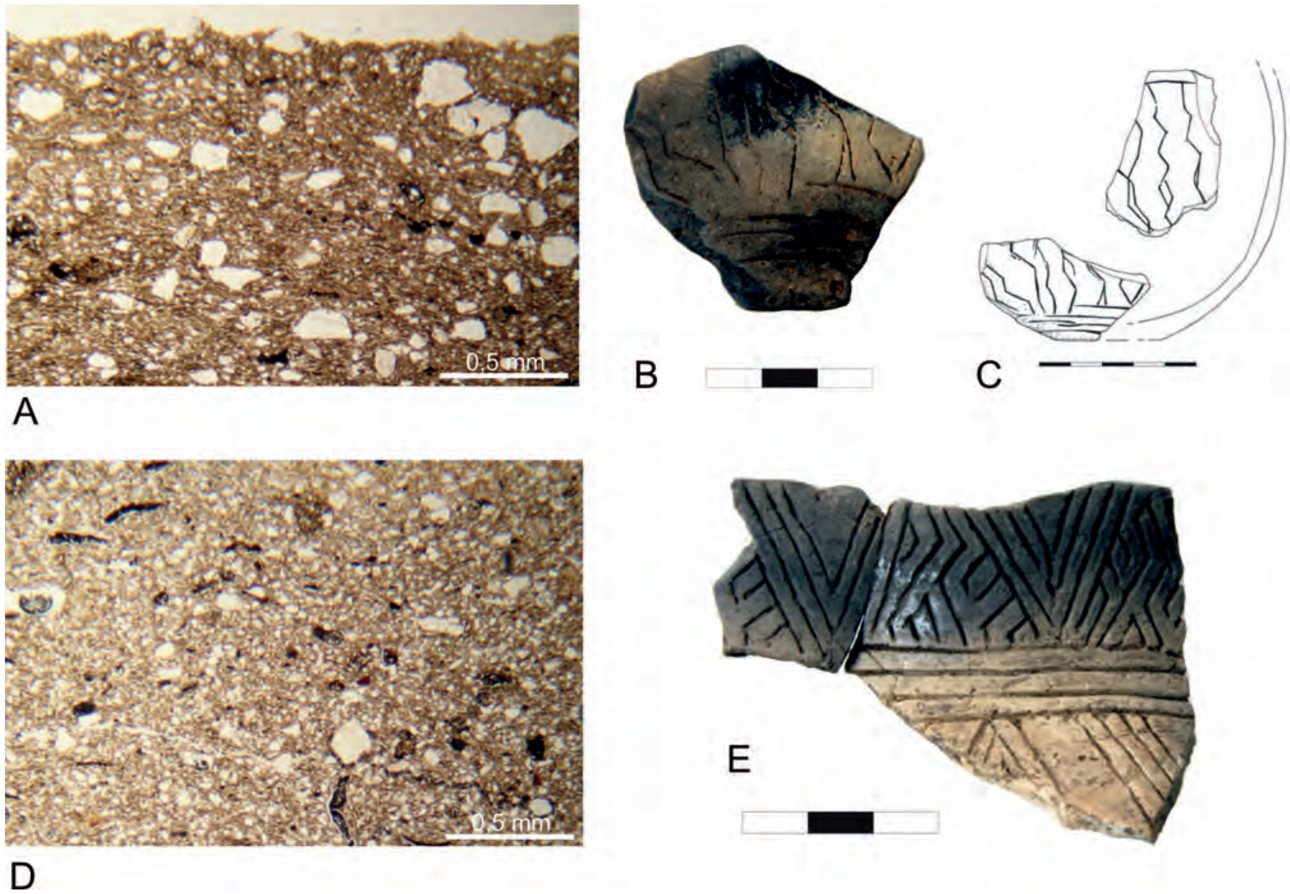

Fig. 6 – Imported ALPC (Tiszadob-Kapušany) pottery in the context of LBK assemblages: Brzezie, site 17.
***Fig. 6** – Céramique importée de l'ALPC (Tiszadob-Kapušany) dans le contexte d'ensemble de la LBK : Brzezie, site 17.*

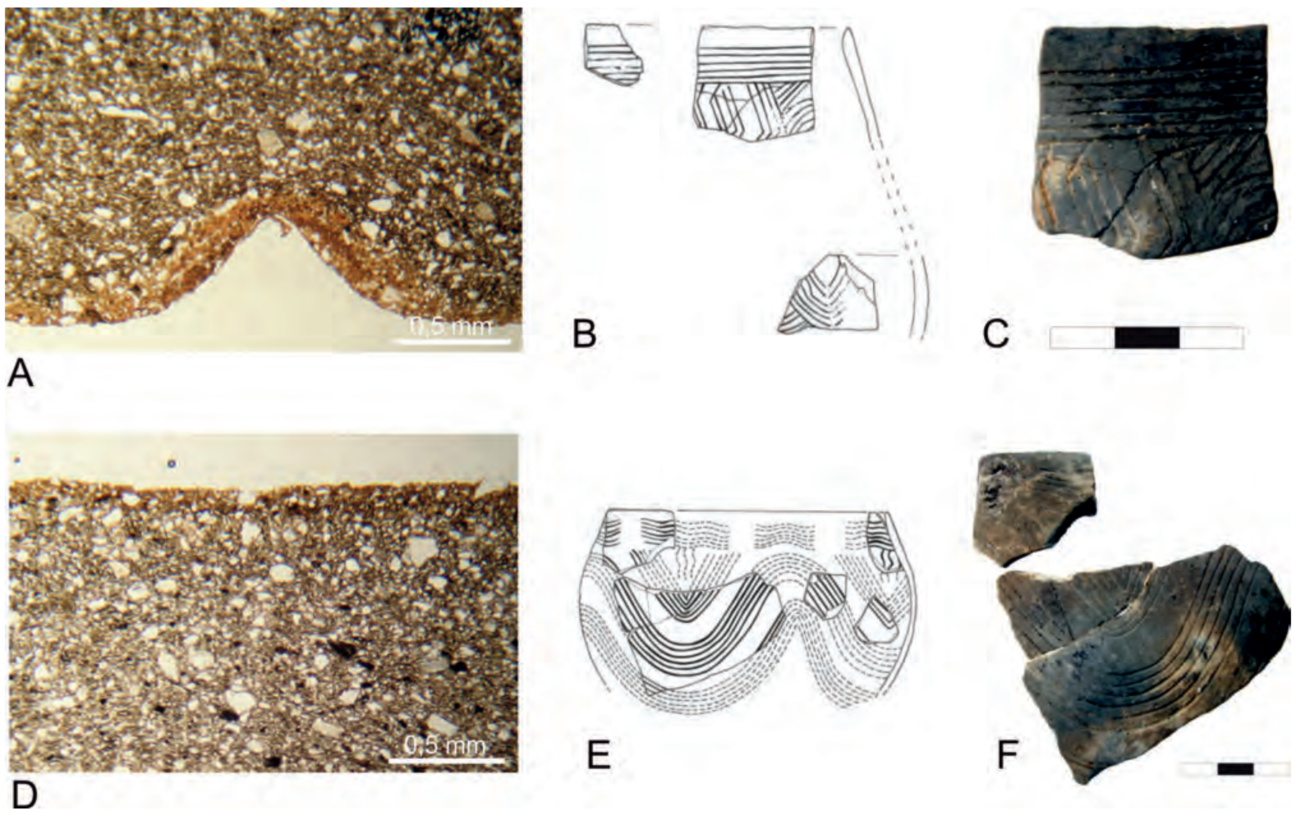

Fig. 7 – Imported ALPC (Bükk culture) pottery in the context of LBK assemblages: Brzezie, site 17.
***Fig. 7** – Céramique importée de l'ALPC (culture de Bükk) dans le contexte d'ensemble de la LBK : Brzezie, site 17.*

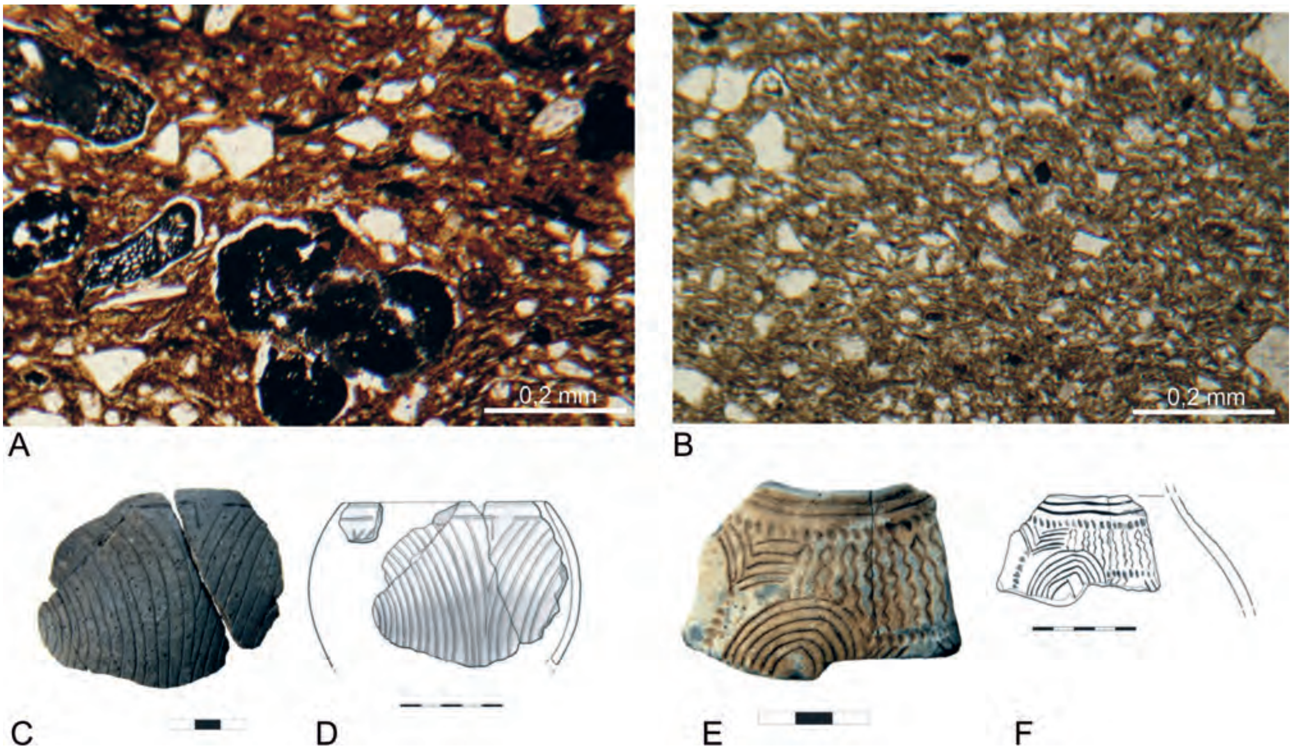

Fig. 8 – Imitated ALPC (Bükk culture) pottery: A, C, D and imported ALPC (Bükk culture) pottery: B, E, F; Brzezie, site 17.
Fig. 8 – *Imitation de la céramique de l'ALPC (culture de Bükk)* : *A, C, D* ; *importations de la céramique de l'ALPC (Culture de Bükk)* : *B, E, F* ; *Brzezie, site 17.*

COMPARISON OF THE LBK POTTERY WITH ALPC IMPORTS AND THEIR LOCAL IMITATIONS AT THE LBK SETTLEMENT AT BRZEZIE 17

Relationships between the imported ALPC ceramics and the local LBK ceramics can be analysed on the basis of the material excavated from Brzezie 17 (Czekaj-Zastawny, 2014). The site, located on a loess-covered slope on the right bank of the Vistula, is known for its LBK settlement with 26 longhouses and over 40,000 pottery fragments. The LBK features from the transition between phases II and III have yielded more than 80 ALPC ceramic fragments, including spherical bowls and amphorae produced by the Tiszadob-Kapušany group and the early Bükk culture.

The LBK ceramics from Brzezie 17 are very diverse in terms of the technology used to produce them. There are significant differences in the individual mineral components in the clay mass. Within the ceramics, a number of basic groups of clay masses, with similar mineralogical and petrographic traits, can be identified. The technological classification presented below corresponds generally to the morphological division of the vessels (Rauba-Bukowska, 2014a).

The first technological group includes very greasy, fine-grained clay masses.

The second group consists of masses which are equally fine-grained, but also contain a slightly larger amount of quartz. They are quite soft and abrasive. The vessels are mainly small and thin-walled, and ornamented with incisions. Due to their composition and technological properties, they are not suitable for cooking and food preparation. They may have been used as serving vessels.

The third group displays a fine-grained loamy matrix with quartz pellets, and contains a greater amount (15%) of larger grains. It also contains a greater quantity of coarser quartz grains, as well as small amounts of sedimentary, igneous or metamorphic rock. Organic admixtures are more frequent, though they are less pulverised than in the first and the second groups. Vessels from the third group could have been used as cooking ceramics. The group comprises medium-sized cups with ornament, including incisions, or they may be plain. The surfaces tend to be smooth.

The fourth group consists of greasy masses, composed of loamy materials, a small amount of fine-grained quartz (up to 15%) and a significant amount of sedimentary rock fragments (up to 30%) in the form of ferruginous slate and lumps of unmixed clay. Like in the third group, a large quantity of organic material has been recorded. Vessels produced from this kind of mass have red colour and are porous. Due to their porosity, weight and size, these ceramics were probably used for storing dry goods.

The fifth group includes clay masses with a large amount of quartz and rock fragments and a small amount of organic material. It has a high sand content

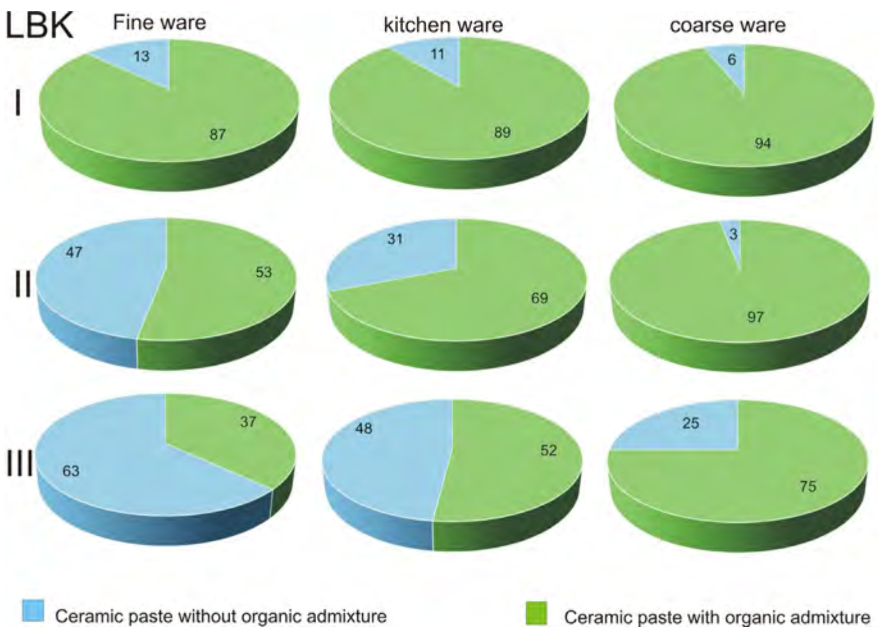

Fig. 9 – Technological characteristics of LBK pottery– frequency of organic temper according to chronological sequence (phases I, II, III) and functional categories of ceramic wares (fine ware, cooking ware and coarse ware); green colour: with organic temper; blue colour: without organic temper.

***Fig. 9** – Caractéristique technologique de la céramique de la LBK : fréquence des inclusions organiques dans le contexte des différentes séquences chronologiques (phases I, II, III) et division fonctionnelle de la céramique (fine, culinaire, poterie de stockage) ; couleur verte : avec inclusions organiques ; couleur bleu : sans inclusions organiques.*

(50%); the proportion of igneous or metamorphic rock fragments amounts to several percent. A high content of non-plastic components corresponds to coarse granulation. There is no doubt that masses of this type were intentionally lean. They were used to produce so-called sand ceramics (Kulczycka-Leciejowiczowa, 1969), whose function has not yet been determined. Technological analysis has indicated that ceramic items of this type have a high porosity, i.e. the vessels have poor physical properties.

Differences between the locally produced imitations and the imported pottery are clearly evident in the material from Brzezie 17. The ceramics differ primarily in the type of raw material used for their production. However, both groups are made of silty clay (fig. 8).

In the imported pottery, the average quartz content amounts to 33%, while clay mineral content amounts to 51%. Similarly, the pottery recovered from Brzezie 17 has an average quartz content of 26%, and an average clay mineral content of 67%. The most striking difference, however, is seen in muscovite and feldspar contents. In the imported ceramics, the muscovite content amounts to 3.8%, and that of feldspars to 4%, while the imitations and the locally produced pottery are characterised by muscovite and feldspar contents of 0.8% and 0.4%, respectively. The quantity of organic material in both types of ceramics is very small. However, the locally produced pottery more often includes destroyed organic temper in the form of black amorphous concentrations. For example, the imitations of imported ceramics found in Brzezie 17 are made of local raw material with a significant organic admixture; cf. sample Br 28 (fig. 8).

TRENDS IN THE TECHNOLOGICAL EVOLUTION OF THE LBK POTTERY

In the younger (III) phase of the LBK, the silty raw material content increased in comparison to phases I and II. The amount of organic material present in the paste used by LBK potters changed over time and depended on the type of pottery being produced (fig. 9). Organic material has been recorded in 90% of the examined pottery fragments from phase I, while in the classical phase (II), it was used in 53% of fine pottery and 97% of coarse pottery; in the late phase (III), organic temper was added to 37% of fine pottery and 75% of coarse pottery. Statistically, the ceramics from the younger (III) phase of the LBK became similar to the ALPC ceramics.

CONCLUSIONS

In the LBK and the ALPC, vessels were made from locally available clay. The raw material sometimes differed to such an extent that its local sources can now be identified. The mineralogical composition of the pottery imported from the Carpathian Basin differs distinctly from that of the ceramics produced locally north of the Carpathians. The development of the LBK, phases I to III, was marked by the following trends: (a) the increasing use of silty clay; (b) the decreasing use of organic material as an admixture; (c) the use of *chamotte* in the clay mass, especially at the end of the LBK evolution. The evolutionary changes evident in LBK pottery resulted primarily from intensified contact with the ALPC. The growing influence of the ALPC, together with other factors, led to cultural change in Lesser Poland and to the replacing of the LBK by the Malice culture. The contacts between Lesser Poland and the northern part of the Carpathian Basin are evidenced in the importation of flint in the south and the importation of obsidian in the north (Kadrow, 2005). The detailed technological analysis of the pottery has provided certain information about the nature of those contacts. It has identified the origin of the imports and has shown that the relationships involved not only the exchange of goods (raw materials or ceramics) but also the constant transfer of ideas, as proven by the frequent imitation of ALPC ceramics within LBK settlements.

The LBK ceramics produced locally as imitations feature the use of native technology, but they borrowed forms of ornamentation and treatment of the exterior surfaces from the south.

The imports and imitations flowed into Lesser Poland mainly from the Šariš region and the Zemplín area in Slovakia or Tokaj in Hungary (Sebők, 2014). The ceramics also originated from more distant areas, such as the upper Tisza basin (Rzeszow-Piastów; Kadrow, 1990b).

Acknowledgements

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Matières à Penser: Raw materials acquisition and processing in Early Neolithic pottery productions
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Matières premières et technologie : l'exemple de la céramique imprimée de Colle Santo Stefano (Italie)

Lucia Angeli, Cristina Fabbri

Résumé : Durant le Néolithique ancien, l'Italie est occupée par des sociétés paysannes qui produisent une céramique décorée d'impressions appelée *Céramique imprimée*. Différents faciès se développent du sud-est de l'Italie aux versants medio-adriatique et Tyrrhénien. Cet article présente l'étude de la production céramique du site à céramique imprimée medio-adriatique de Colle Santo Stefano, Ortucchio (L'Aquila, Abruzzes). Après une brève présentation générale de la morphologie des vases et des traits stylistiques du décor, nous présentons les données concernant les analyses de la production d'un point de vue technologique : tout d'abord les aspects de façonnage et du traitement des surfaces, puis la composition minéralogique des pâtes à partir de la description de la matrice argileuse et des inclusions non plastiques. Enfin, nous identifions les matières premières employées pour la fabrication et le décor peint des vases.
Ces travaux permettent de reconsidérer la structure de la production céramique dans sa globalité et de ré-envisager la question de l'origine locale ou exogène de certains tessons de Colle Santo Stefano qui rappellent ceux du faciès de *Guadone* localisé en Italie du sud.
Cette problématique a été abordée grâce à une approche archéométrique, et plus particulièrement grâce à des analyses minéralogiques et pétrographiques en lames minces pour caractériser les matières premières employées et apporter des informations sur la préparation des pâtes. De plus, une caractérisation du décor chromatique de la céramique peinte a été réalisée grâce à des analyses spectroscopiques *Raman* et LIBS (*Laser Induced Breakdown Spectroscopy*).
L'analyse archéométrique a montré que l'argile locale était choisie en fonction des produits que les artisans souhaitaient réaliser. Nous avons mis en évidence une différence entre les pates du groupe traditionnel à « impression et incision » (Céramique imprimée medio-adriatique) et celles du groupe méridional à « *rocker, microrocker*, *sequenza* », qui rappelle les modèles méridionaux, soit par leur décor, soit par leur exécution (Céramique imprimée du faciès de *Guadone*).
En ce qui concerne le décor peint, l'analyse spectroscopique LIBS a montré que l'utilisation de pigment noir à base d'oxyde de manganèse représente un choix technique spécifique des groupes culturels de la céramique *figulina* trichrome du Néolithique moyen, lorsque les productions céramiques sont effectivement standardisées.

Mots-clés : Céramique imprimée, versant medio-adriatique italien, Néolithique ancien, production céramique, analyses minéralogiques, analyses spectroscopiques.

Abstract: During the Early Neolithic, Italy was inhabited by farming communities who produced pottery with impressed decorations, known as *Impressed Ware*. Different facies developed in the South-eastern, middle Adriatic and Tyrrhenian regions. This article presents a study of pottery production from the Impressed Ware site of Colle Santo Stefano, Ortucchio (L'Aquila, Abruzzi). After a general presentation of typological and stylistic patterns, we are will outline the results of the technological analysis: firstly, aspects of pottery manufacture and surfaces treatments, and secondly, the mineralogical composition of paste groups based on descriptions of the clay matrix and inclusions. Finally, we identify the provenance of the raw materials used to the fabrication and chromatic decoration of pottery.
The study allows us to a reconsider overall pottery production and to clarify the issue of the origin, local or exogenous, of certain Colle Santo Stefano sherds which resemble those of *facies Guadone* type in southern Italy.
The topic has been addressed through an archaeometric approach, and particularly through the carrying out of mineralogical and petrographic analyses on thin sections in order to characterize the raw materials used and to describe the peculiarities of different mixture groups. Moreover *Raman* and LIBS (Laser Induced Breakdown Spectroscopy) analyses have been carried out to determine the nature of the pigment used on painted pottery.
Archaeometric analyses reveal the use of local clay and highlight a difference between mixtures udes for pots decorated with a more traditional 'impressed and incised' technique (medio-adriatic Impressed Ware) and those decorated with '*rockers*, *microrockers*, *sequences*', which more closely resemble southern models in terms of their decoration and manufacture (*Guadone* Impressed Ware).

Regarding painted pottery, LIBS spectroscopic analysis reveals that the use of black pigment containing manganese oxide for painted decorations was probably a technical choice specific to *trichromic* pottery cultural groups from Middle Neolithic, a period characterized by standardized *figulina* pottery that may reflect specialized production.

Keywords: Impressed Ware, Italian Mid-Adriatic slopes, Early Neolithic, pottery production, mineralogical analysis, spectrographic analysis.

CONTEXTE CHRONOCULTUREL DE COLLE SANTO STEFANO

LES IMPLANTATIONS néolithiques les plus anciennes de l'Italie se situent dans la région des Pouilles, de la Basilicate et de Calabre. Le complexe de la *Céramique imprimée du Sud-Est* présente plusieurs stades successifs s'exprimant à travers l'évolution des décors céramiques (Tinè, 1983 ; Cipolloni Sampò *et al*., 1999 ; Radi, 2003 et 2010) :

1. première phase : phase ancienne à décor imprimé couvrant (entre 6000 et 5600 av. J.-C.) ;
2. seconde phase ou phase évoluée à décor imprimé structuré (faciès de *Guadone* entre 5800 et 5500 av. J.-C.) ;
3. troisième phase ou phase récente (environ 5500 av. J.-C.) avec deux aires culturelles : l'une caractérisée par des décors gravés à ligne dentelée au sud (faciès à *graffita dentellata*) et l'autre à décor peint au nord (faciès de *Lagnano da Piede*) ;
4. quatrième phase ou phase finale (entre 5300 et 5200 av. J.-C.) avec deux aires culturelles : l'une à décor peint au nord (faciès de *Masseria La Quercia* dans l'aire septentrionale du Tavoliere) et l'autre à gravure fine au sud (faciès de *Matera-Ostuni* dans l'aire méridionale du Salento, Materano et Brindisi).

Dans le versant medio-adriatique, deux régions aux faciès culturels différents peuvent être distinguées (Radi, 2010) : au nord, les régions des Marches, de l'Ombrie et des Abruzzes septentrionales correspondent au complexe de la *Céramique imprimée « abruzzese marchigiana »* (entre 5600 et 5000 av. J.-C.) ; au sud, la partie interne des Abruzzes, la côte au sud du fleuve Pescara et le Molise montrent des liens avec les décors du sud-est, en particulier avec le faciès de *Guadone* (entre 5800 et 5600 av. J.-C.).

Depuis 1988, des fouilles systématiques menées sur le site de Colle Santo Stefano (L'Aquila, Abruzzes) ont permis de révéler le plus ancien habitat du Néolithique ancien du versant centre-adriatique de la péninsule italienne. Le gisement est situé à la marge sud-est du bassin du Fucino (Radi et Wilkens, 1989 ; Radi, 1991 ; Radi et Verola, 1996 ; Radi *et al*., 2001 ; Radi et Danese, 2003 ; ici : fig. 1a).

L'analyse des structures, de la culture matérielle (céramique, outillage lithique et osseux) et de la faune dans les niveaux d'occupations reconnus (datations d'échantillons de charbon de bois : entre LTL526A 6823 ± 55 BP - 2σ 5840-5620 cal. BC et LTL57A 6579 ± 60 BP - 2σ 5640-5460 cal. BC) ont permis de mieux définir le développement du Néolithique ancien local. Celui-ci est attribuable au faciès de la céramique imprimée medio-adriatique, caractérisée à Colle Santo Stefano par la présence de vases du faciès de *Guadone* (Radi, 2010 ; Fabbri *et al*., 2011 ; ici : fig. 1b).

Deux phases d'occupation chronologiquement assez proches ont été identifiées :

- la phase ancienne, caractérisée par un radier au contour rectangulaire constitué de cailloux enfoncés dans une couche de limon lacustre ;
- la phase récente, à laquelle est associée une rigole orientée est-ouest, interprétée comme la limite d'un enclos. Un foyer en cuvette et une petite fosse contenant un vase zoomorphe fragmenté appartiennent à cette phase.

Enfin, les fréquentations durant le Néolithique récent final et l'âge du Bronze ancien ont été identifiées à partir des restes de structures détruites (Angeli *et al.*, 2011b ; ici : fig. 1b).

CORPUS CÉRAMIQUE ET PROBLÉMATIQUE

L'analyse au microscope binoculaire de la céramique a conduit à la définition de trois groupes de pâtes (grossière, semi-fine et fine) qui se différencient minéralogiquement. Ils sont subdivisés en sous-ensembles (grossière : G1a, G1b et G2 ; semi-fine : SF1 et SF2 ; fine : F1, F2a, F2b et F3) sur la base des traitements de l'argile effectués par le potier dans le but d'en corriger les propriétés plastiques et esthétiques (fig. 2a).

La fréquence de ces groupes évolue au cours de l'occupation du site : dans la première phase, la céramique grossière, caractérisée par des dégraissants calcaires et volcaniques, domine nettement puis, dans la phase récente, les céramiques grossières et semi-fines diminuent en faveur de la céramique fine (Fabbri, 2006 ; Fabbri et Angeli, 2010). La variabilité des groupes de pâtes dans les couches archéologiques est progressive et non linéaire, et si l'on considère les fréquences des différents sous-ensembles et les résultats de l'analyse pétrographique, une importante articulation entre les groupes peut être constatée.

Les changements progressifs observés dans les groupes de pâtes s'opèrent parallèlement à la diminution des décors caractéristiques du faciès méridional de *Guadone.* Ces derniers sont exclusivement identifiés durant la phase ancienne d'installation du village.

Les variations morpho-stylistiques du complexe céramique de Colle Santo Stefano posent les questions suivantes : quelle est l'origine des matières premières

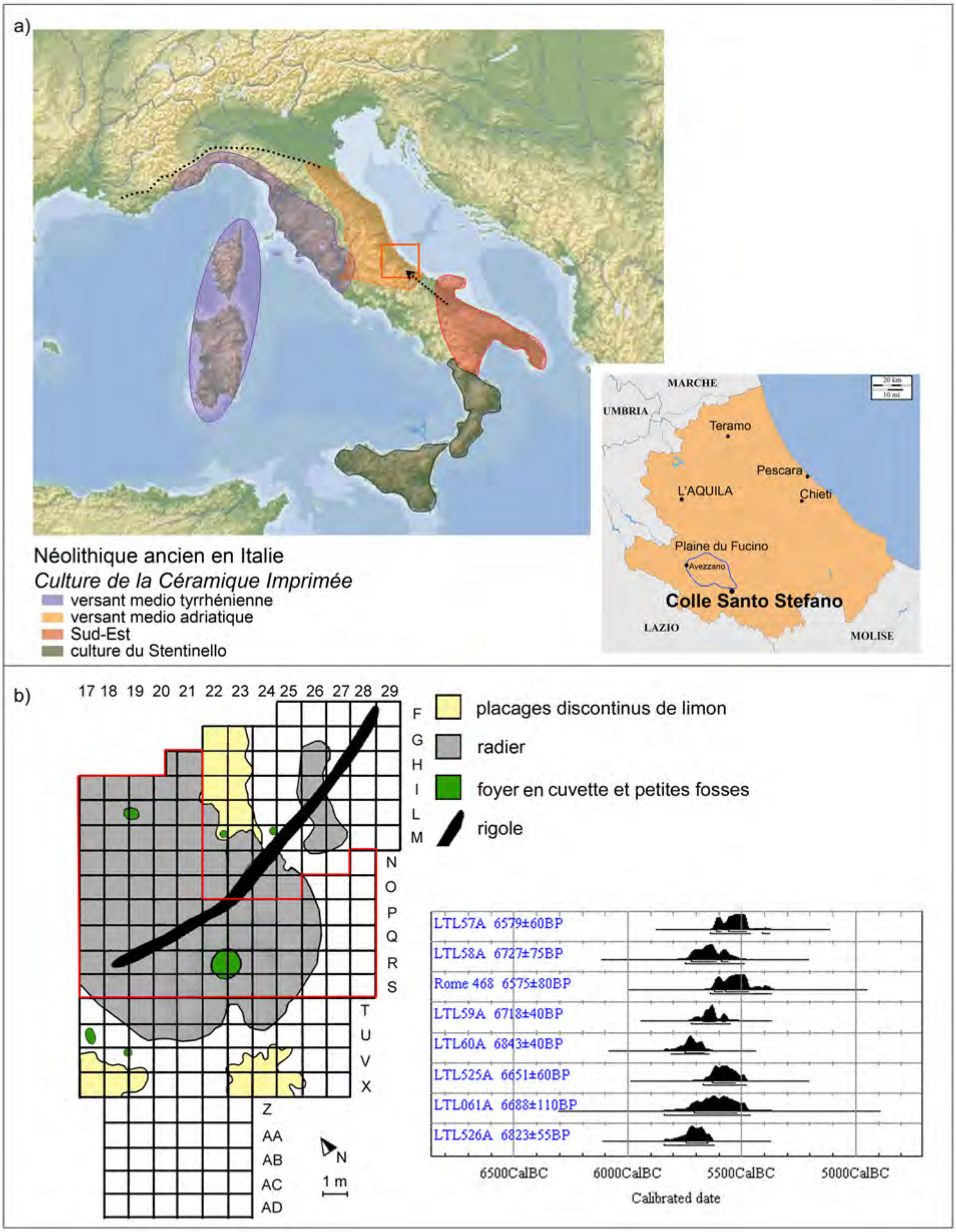

Fig. 1 – a) Néolithique ancien avec les différentes provinces de la Céramique Imprimée en Italie et localisation du site de Colle Santo Stefano dans le versant medio-adriatique (Plaine du Fucino - Ortucchio, L'Aquila) ; b) plan de la zone fouillée et chronologie ^{14}C (software OxCal Ver. 3.10 ; Reimer P. J. *et al.*, 2004).

***Fig. 1** – a) Early Neolithic with the different Impressed Ware provinces in Italy and the location of the Colle Santo Stefano site on the Mid- Adriatic slopes (Fucino Basin - Ortucchio, L'Aquila); b) plan of the excavated area and ^{14}C chronology (software OxCal Ver. 3.10; Reimer P. J. et al., 2004).*

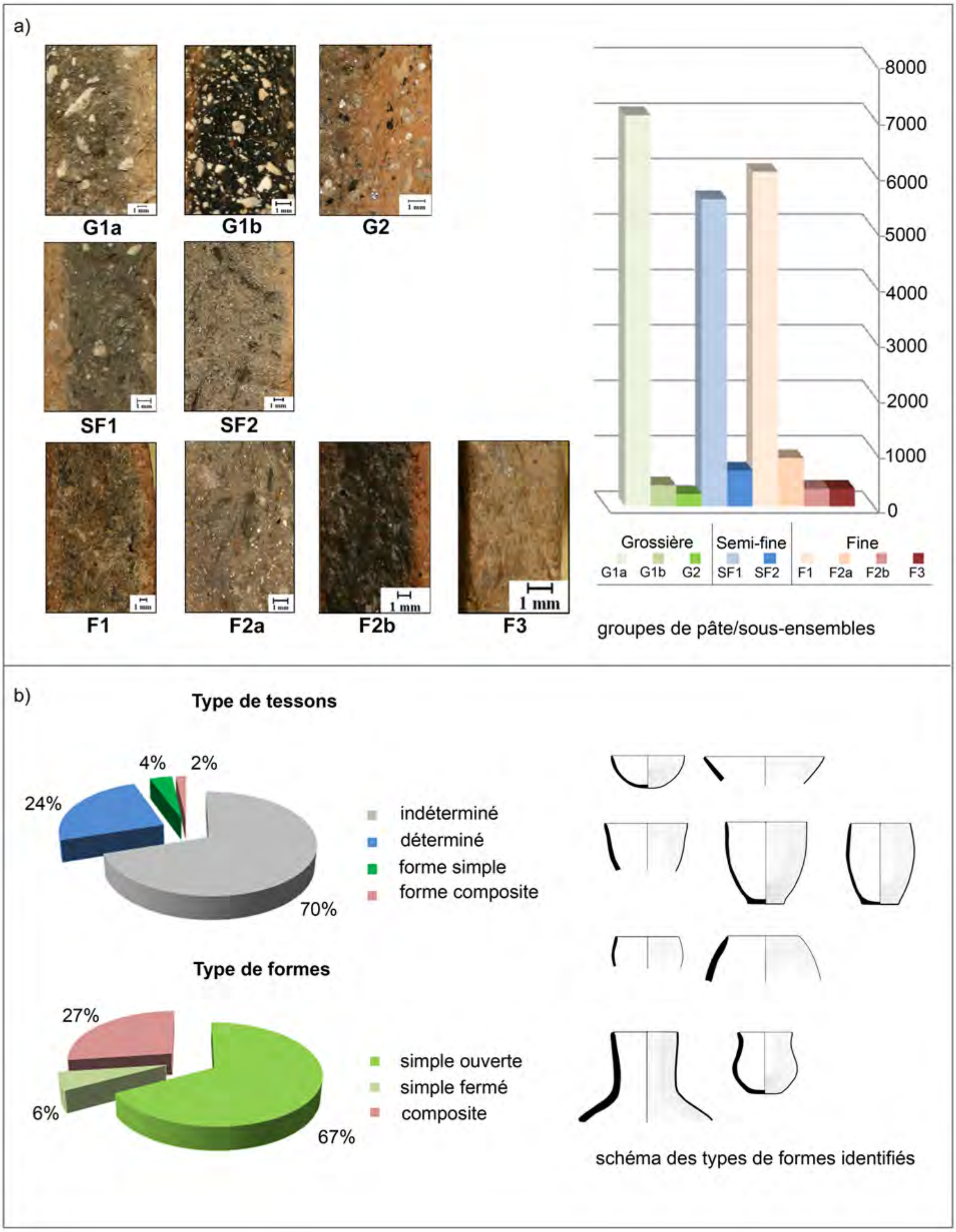

Fig. 2 – a) Groupes de pâtes (grossière, semi-fine et fine) et sous-ensembles (grossière : G1a, G1b et G2 ; semi-fine : SF1 et SF2 ; fine : F1, F2a, F2b et F3) et fréquence dans le corpus céramique (photos et graphique de C. Fabbri) ; b) fréquence de tessons et de formes, et schéma synthétique de la morphologie des vases (graphiques et dessin L. Angeli et C. Fabbri).

Fig. 2 *– a) Pottery groups (coarse, semi-fine and fine) and sub-groups (coarse: G1a, G1b and G2; semi-fine: SF1 and SF2; fine: F1, F2a, F2b and F3) and frequency of pottery groups (photo and graph C. Fabbri); b) frequency of sherds and vessels and diagram of production (graphics and drawing L. Angeli and C. Fabbri).*

employées ? Existe-t-il une sélection et un traitement des matières premières ? Les vases décorés selon le style méridional de *Guadone* sont-ils réalisés localement ou sont-ils importés ?

Ces questions ont été abordées grâce à une approche archéométrique, et plus particulièrement grâce à des analyses minéralogiques et pétrographiques en lames minces pour caractériser les matières premières employées et apporter des informations sur la préparation des pâtes. De plus, une caractérisation du décor chromatique de la céramique peinte a été réalisée grâce à des analyses spectroscopiques *Raman* et LIBS (*Laser Induced Breakdown Spectroscopy*) au CNR de Pise *(Institute of Chemistry of Organometallic Compounds* - ICCOM).

Morphologie des vases et typologie du décor

On doit tout d'abord remarquer l'importante fragmentation de l'assemblage céramique et également, pour le niveau de la phase ancienne correspondant au radier, une certaine dispersion des tessons attribuables au même récipient. En l'absence de mesures des hauteurs, l'identification de la morphologie des vases s'est fondée sur la valeur du diamètre à l'ouverture et par la détermination des fragments sur la base de la comparaison avec les types morphologiques des exemplaires les plus complets. Quelques tessons attestent de la présence de très grands récipients dont la morphologie générale n'est pas restituable (Fabbri, 2006).

La majorité des fragments étudiés est typologiquement indéterminé (N = 13995 ; 70 %). Pour le reste (N = 6005 ; 30 %) on distingue : 4877 tessons appartenant à des formes non individualisées (bord, fond, col, panse et préhension ; 24 %) et 1128 fragments attribués à des types formels, dont 783 à profil simple (4 %) et 345 à profil composite (2 %).

D'un point de vue typologique, les catégories suivantes ont été précisément définies (fig. 2b) : les formes simples ouvertes (507 individus ; 67 %), fermées (43 individus ; 6 %) et les formes composites (205 individus ; 27 %).

Les récipients sont de taille petite, moyenne et grande (diamètre à l'ouverture : 6 - 50 cm ; épaisseur : 1 - 3 cm) et comprennent (fig. 3) :

a) des formes très ouvertes, peu profondes, à profil tronconique ou hémisphérique (diamètre à l'ouverture : 9 - 50 cm ; avec une concentration des mesures entre 9 et 25 cm) ;

b) des formes peu ouvertes et très profondes à profil cylindrique (diamètre à l'ouverture : 10 - 20 cm) ;

c) des formes fermées à profil ovoïde (diamètre à l'ouverture : 16 - 40 cm, avec une concentration des mesures entre 16 et 20 cm) ou globulaires (diamètre à l'ouverture : 6 - 14 cm) ;

d) des formes complexes, c'est-à-dire des vases à col haut ou court (diamètre à l'ouverture : 11 - 50 cm).

Parmi les éléments de préhension, on distingue : les anses en ruban, verticales ou horizontales, appartenant aux vases à col, et les boutons ou tétons, petits appendices plastiques plus ou moins bombés et plus ou moins dégagés. Les bases sont du type *a tacco* (débordant, à savoir : avec un élargissement de l'extrémité inférieure de la paroi) pour les formes fermées et du type plat ou convexe pour les vases à col.

Le complexe décoratif du site présente trois combinaisons différentes (fig. 4) :

1) le groupe « impression et incision » caractérisé par de brefs motifs imprimés/incisés couvrant souvent toute la surface du vase et principalement présents sur les exemplaires à pâte grossière ;

2) le groupe « incision organisée », caractérisé par des motifs décoratifs complexes (chevrons, zigzags, triangles, bandes hachurées, faisceaux, réticulés, etc.) réalisés par incision seule ou en association avec des impressions ;

3) le groupe « impression à *rocker, microrocker, sequenza* », caractérisé par des thèmes décoratifs qui sont fréquents sur les vases à pâte fine aux surfaces soigneusement polies (rappelant le style méridional de Guadone). Cet ensemble comprend également des tessons caractérisés par l'application de protomés anthropomorphes d'affinité méridionale indiscutable.

L'analyse de la répartition stratigraphique de ces caractères stylistiques (Fabbri *et al*., 2011) a montré que les niveaux inférieurs (phase ancienne) sont bien caractérisés par les décors et les types d'affinité méridionale, tandis que dans les niveaux supérieurs, durant la phase récente, les décors deviennent moins fréquents et stylistiquement plus élémentaires, toujours réalisés par les techniques imprimées et incisées.

Dans cette dernière phase, on observe la présence de tessons décorés par impression d'une coquille de *Glycymeris* qui montrent une relation avec le Cardial du versant tyrrhénien. On observe également quelques rares décors chromatiques : motifs peints en couleur brune ou réalisés avec une technique appelée *a negativo* et aussi, emploi d'incrustations de pâtes blanches dans les décors incisés et imprimés, et de pâtes rouges dans les décors à *microrocker* et *sequenza*.

Le façonnage et les traitements des surfaces : observation macroscopique

Nous présenterons ci-dessous quelques résultats de l'étude préliminaire des techniques de façonnage et des traitements de la surface de céramiques provenant des couches inférieures (phase ancienne).

L'observation et l'analyse à l'œil nu des macrotraces sur la cassure des tessons de dimension supérieure à 10 cm a permis d'identifier deux techniques de façonnage : le modelage par pression ou creusement/étirement d'une motte et le montage au colombin. Pour cette dernière technique, on distingue : les colombins à section oblique accolés en chevauchement interne ou externe (configuration en S) ou les colombins à section

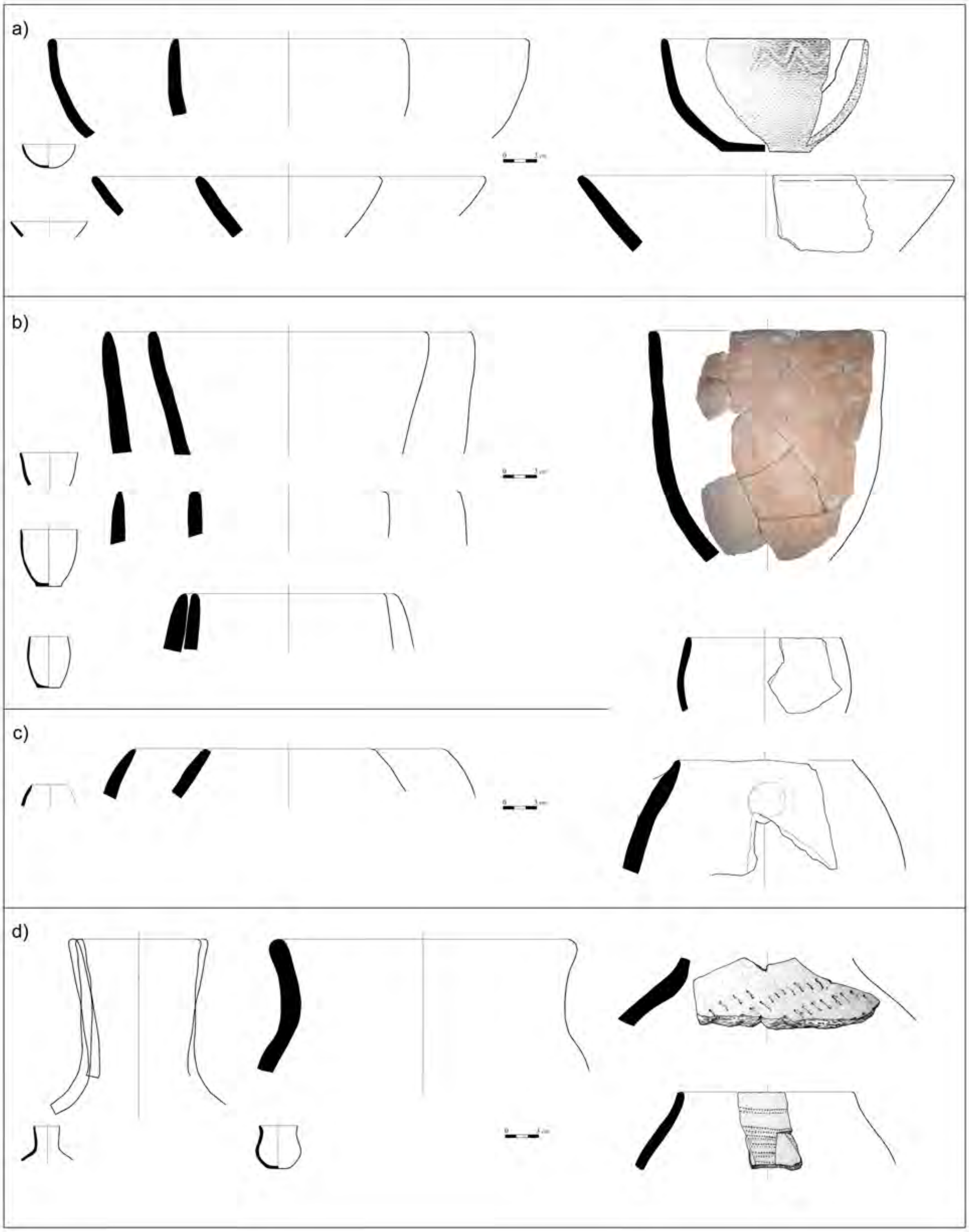

Fig. 3 – Les formes typiques des vases : a) formes ouvertes à profil hémisphérique et tronconique ; b) formes ouvertes à profil tronconique et cylindrique ; c) formes fermées : vases ovoïdes ; d) formes complexes : vases à col (dessins C. Fabbri et S. Martelli).

***Fig. 3** – Typical vase forms: a) open forms with hemispherical and conical profile; b) open forms with conical and cylindrical profile; c) closed forms: ovoid vases; d) complex forms: necked vases (drawings C. Fabbri and S. Martelli).*

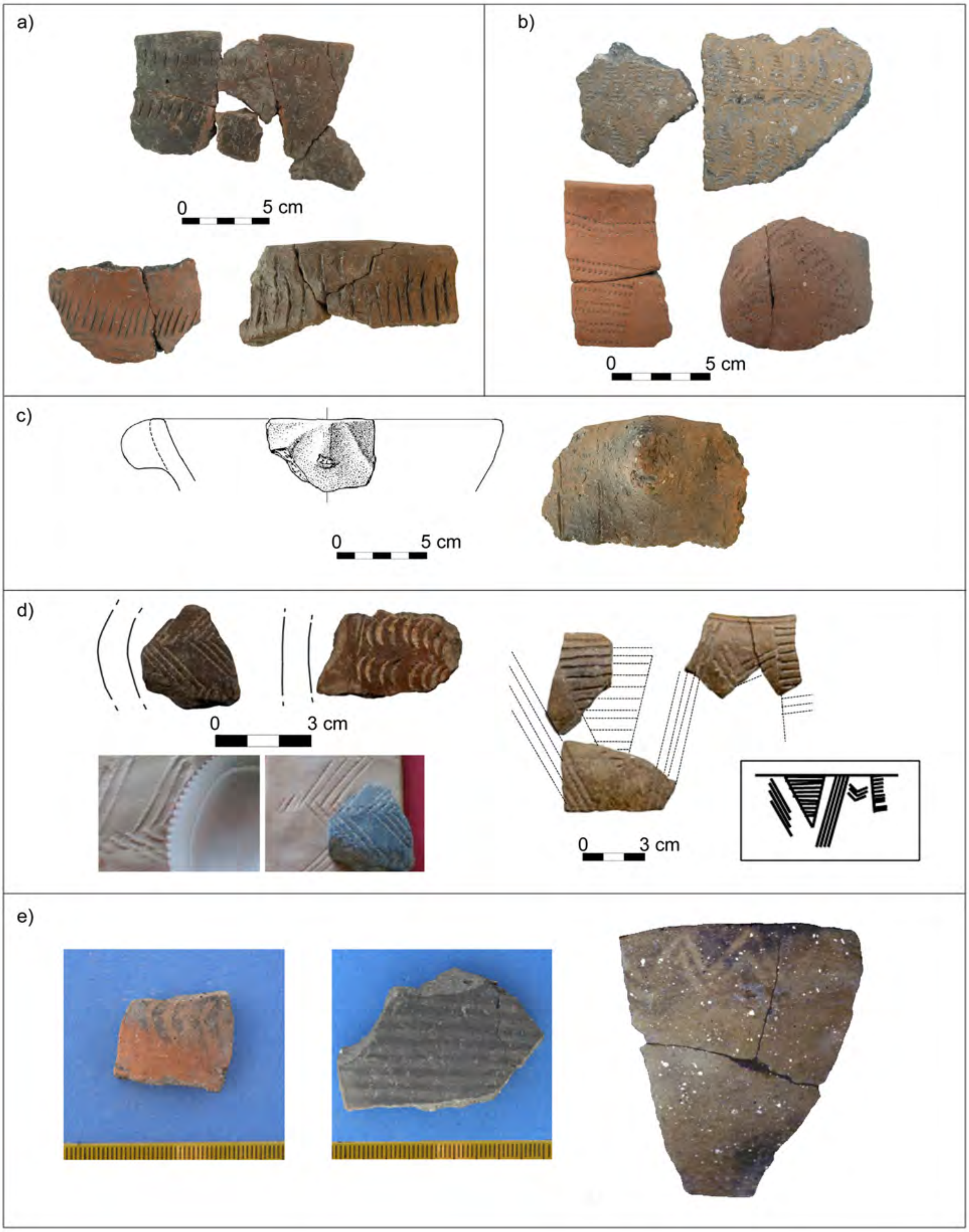

Fig. 4 – Les types de décor : a) impression et incision ; b) impression style de *Guadone* à « *rocker, microrocker, sequenza* » ; c) application de protomés anthropomorphes ; d) décor de style cardial au *Glycymeris* ; e) décors chromatiques de couleur noir et « *a negativo* » (dessins et clichés C. Fabbri et S. Martelli).

***Fig. 4** – Types of decoration: a) impressed and incised; b) Guadone style impressed decoration: 'rocker, microrocker, sequenza'; c) applied of anthropomorphic protomes; d) Cardial style decoration using Glycymeris; e) black painted decoration and 'a negativo' decoration (drawings and photos C. Fabbri and S. Martelli).*

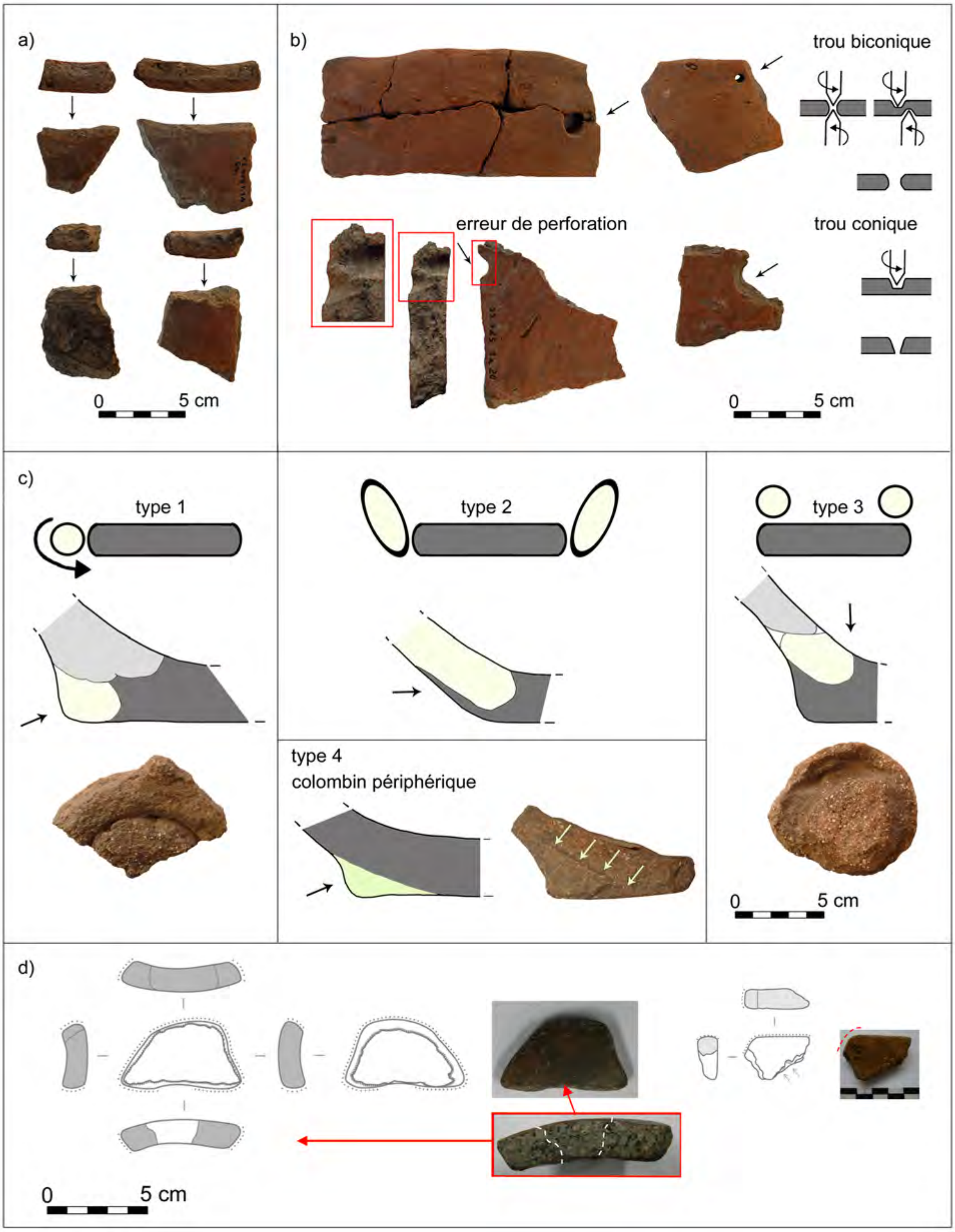

Fig. 5 – Techniques de façonnage : a) colombins ; b) trous de réparations ; c) montage du fond ; d) estèques en céramique (dessins et clichés C. Fabbri, L. Angeli et R. Milano).

***Fig. 5** – Shaping techniques: a) coils; b) repair holes; c) shaping of vessel bottoms; d) pottery smoothers (drawings and photos C. Fabbri, L. Angeli and R. Milano).*

subcirculaire (configuration en O) et les bandes à section elliptique superposées par pression digitale (fig. 5a). Pour les rares exemplaires presque entiers, la variabilité d'épaisseur de la paroi au niveau de la panse démontre l'emploi de colombins de morphologie et de dimensions non régulières (diamètre : 1 - 3 cm) ou une déformation/étirement des colombins (fig. 5b).

On a également observé les techniques de façonnage des fonds, qui ont été constitués par la mise en forme d'une galette circulaire à laquelle un premier colombin a été ajouté, suivi par le montage de la panse par collages successifs de colombins. Les galettes discoïdes d'argile sont rarement de forme et d'épaisseur régulières et plusieurs modes de façonnage du fond ont été identifiées (fig. 5c) :

- trois techniques différentes par modelage d'une plaque d'argile et aménagement d'une concavité/gorge pour faciliter la jonction entre la base et la panse ; type 1 : colombin entourant la galette ; type 2 : bande latérale à la galette ; type 3 : colombin placé sur la galette ;
- la base « *a tacco* » (type 4) est réalisée avec l'ajout d'un colombin à section triangulaire (colombin périphérique débordant) ;
- enfin, pour les bases concaves nous avons identifié une technique de façonnage à partir d'un seul bloc d'argile (type 5).

Rares sont les traces techniques qui permettent d'identifier les outils employés pour la finition de la surface ; celles-ci ont généralement subi un ultime traitement à l'aide d'un instrument souple (tissu, cuir, main), qui a effacé les stigmates des traitements précédents. Le traitement déterminé le plus souvent sur les céramiques à pâte grossière, principalement sur la surface externe, est celui du lissage à la main mouillée. Pour les céramiques à pâte semi-fine et fine, on observe en revanche des surfaces plus soigneusement polies. Les surfaces internes présentent des facettes de polissage qui laissent supposer l'utilisation (à divers degrés de séchage) d'un lissoir en matériau dur (os ou pierre).

Le brunissage à consistance cuir ou sèche est très rare. Il est attesté presqu'exclusivement sur les parois des vases de la classe fine, dans laquelle on identifie fréquemment un décor de style méridional.

Dans ce corpus, huit estèques en céramique ont été identifiées. Les surfaces fonctionnelles des outils sont arrondies et légèrement polies. De plus, elles se caractérisent par l'absence de stries et d'usures mécaniques. Nous pensons que ces estèques ont été employées durant la phase de modelage de l'argile, sur des pâtes sans inclusions émergentes, à consistance plastique dure/humide, pour éliminer de petites quantités d'argile, régulariser les parois et corriger certaines portions du vase, comme par exemple les anses et les points de jonction base/panse (Angeli et Fabbri, 2011 ; ici : fig. 5d).

Les pâtes : analyse microscopique

Au niveau macroscopique, nous avons défini trois groupes de pâtes divisées en sous-ensembles : grossière (G1a, G1b et G2), semi-fine (SF1 et SF2) et fine (F1, F2a, F2b et F3).

Au niveau microscopique, nous avons reconnu une forte variabilité dans les caractéristiques des pâtes et la présence dans le même groupe pétrographique de différents groupes macroscopiques de pâte (Fabbri, 2004 et 2011). Au total, 7 groupes minéralogiques ont été reconnus, dont nous donnerons ci-après une description des plus significatifs et des plus fréquents : groupes I, III, IV et V (fig. 6).

1) Dans le groupe I, les carbonates sont présents en quantités abondantes (30 - 40 %) avec des dimensions variables (160 µm - 4 mm), rapportés quelque fois à du travertin, mais surtout à des roches calcaires avec grains de calcite micritique et micrite fossilifère. Les pyroxènes sont présents en moindre quantité (10 %) ; ils sont caractérisés par des fractures marquées et des dimensions comprises entre 200-800 µm. Dans une proportion mineure on identifie : des quartz (également poly cristallins) et des feldspaths (potassique et plagioclase) de granulométrie inférieure à 80 µm. Plus rares encore sont : les micas (moscovite et biotite), le silex, les oxydes de fer, des résidus de végétaux, des fragments de coquilles lacustres et des foraminifères.

Ce groupe comprend en particulier la pâte grossière G1a et la pâte semi-fine SF1.

2) Dans le groupe III, les carbonates sont présents en quantités plus abondantes (40 - 50 %) avec des dimensions de 400 µm et inférieures. Rares sont les quartz et les feldspaths. Plus rares encore sont les pyroxènes, les micas et les résidus de végétaux carbonisés. Ce groupe comprend la pâte semi-fine SF2.

3) Le groupe IV est très riche en grains de quartz (rarement polycristallin) et en feldspaths (sanidine et plagioclase) de granulométrie variable (400 µm). Rares sont les pyroxènes (2 - 5 %). Plus rares encore sont les micas, le silex et les résidus de végétaux carbonisés. Ce groupe comprend les pâtes fines F1 et F2b.

4) Le groupe V présente une structure à granulométrie de type silt (inférieure à 40 µm) très riche en quartz et feldspaths (10 - 20 %). On observe la présence de micas (biotite et muscovite 5 %). Rares sont les grains de carbonates et pyroxènes, le silex et les bioclastes. Les résidus de végétaux carbonisés avec une structure siliceuse (phytolithes) sont très fréquents. Ce groupe comprend les pâtes fines F2a et F3.

Comparaison avec les matières premières locales et test expérimental

Afin de comprendre la structure de la production, et en particulier les modalités d'approvisionnement en matières premières, des échantillons de terre ont été prélevés dans des dépôts argileux alluviaux, près du Rio di Lecce, à 1 km environ du site (fig. 7a).

Les observations réalisées sur ces terres à la loupe binoculaire, SEM/EDS et aussi en lame mince, ont permis de rapprocher la structure de la pâte des céramiques néolithiques à celle des terres prélevées.

Groupe / Inclusions	I	III	IV	V
ROCHES				
calcaire	D	VD	VF	VF
travertin	VVF	-	-	-
lave	-	-	-	VVF
silex	VVF	VF	VVF	VVF
calcédoine	-	VVF	VVF	-
quartzite	Fw	VF	VF	VVF
MINERAUX				
quartz	Fw	VF	Fw	Fw
sanidine	VF	VF	Fw	VVF
plagioclase	VVF	VVF	VF	VVF
silico-Al	VF	VVF	VVF	Fw
pyroxènes	C/D	VF	Fw	VVF
muscovite	VF	VVF	VVF	Fw
biotite	VF	VF	VVF	VF
oxide	VF	VF	Fw	Fw
AUTRE				
débris végétaux	VF	Fw	VVF	Fw
coquilles	VVF	VVF	VVF	VVF
argile agrégats	VF	Fw	VF	VVF
groupes de pâte	G1a G2 SF1	SF2	F1 F2b	F3 F2a
échantillons d'argile	RL1			RL2

Echelle de référence (Bullock *et al.*, 1985)

VD = very dominant, > 70%

D = dominant, 50-70%

C = common, 30-50%

Fr = frequent, 15-30%

Fw = few, 5-15%

VF = very few, 1-5%

VVF = very very few <1%

Groupe I -
carbonates à granulométrie grains-silt

Groupe III -
carbonates à granulométrie grains moyen-fine

Groupe IV -
quartz et feldspaths

Groupe V -
quartz, feldspaths et micas

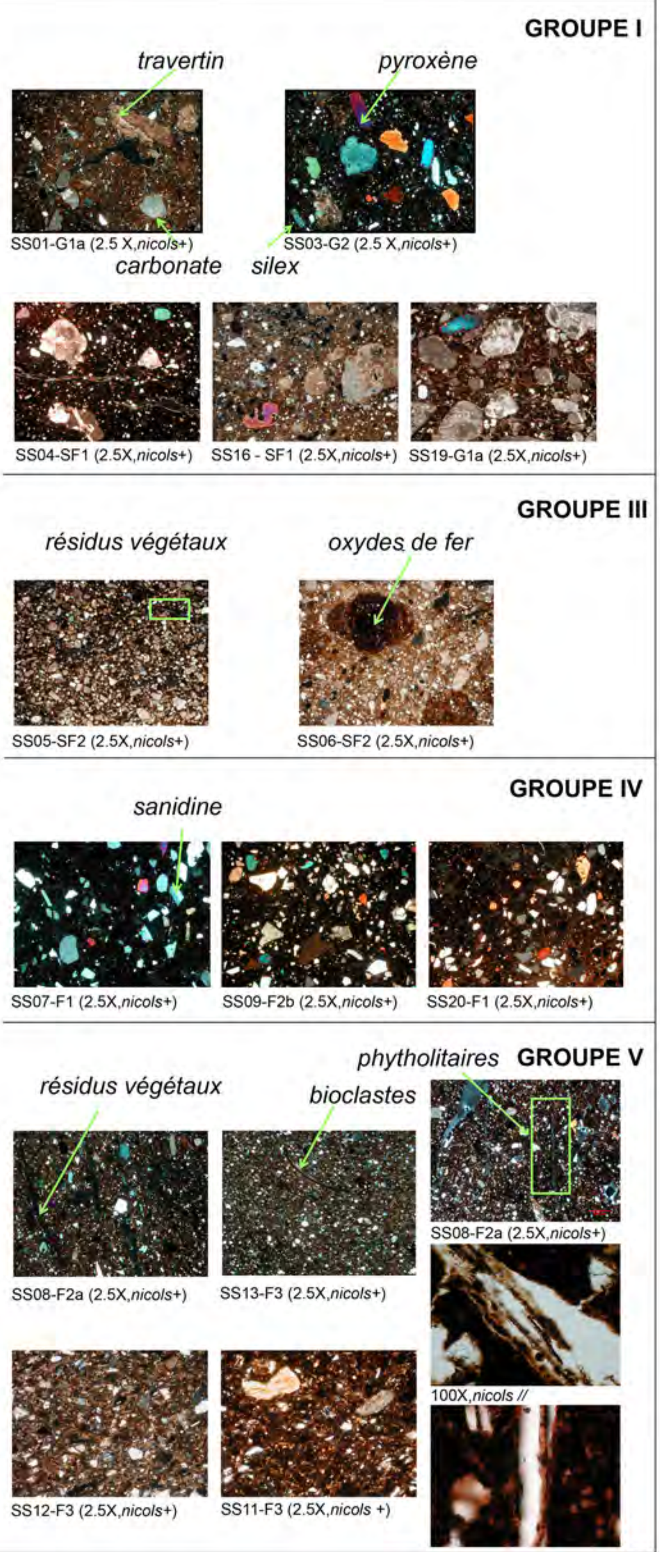

Fig. 6 – Groupes minéralogiques : groupes I, III, IV et V (photos C. Fabbri).
***Fig. 6** – Mineralogical groups: groups I, III, IV and V (photos C. Fabbri).*

Le premier ensemble d'échantillons (RL1) provenant d'une couche de terre rouge est caractérisé par la présence de grains de carbonates. Dans la terre, on remarque la présence de minéraux mafiques, qui ont conservé la morphologie cristalline originale bien identifiable au SEM/EDS (fig. 7b).

Les minéraux volcaniques très répandus dans l'argile naturelle proviennent de la formation des sédiments à la suite de la dispersion de roches pyroclastiques provenant des systèmes volcaniques du Latium, de la Campanie et aussi de l'Etna durant le Pléistocène moyen et supérieur, et au début de l'Holocène (Agostini *et al.*, 2005).

Cette terre trouve des comparaisons avec le groupe minéralogique I et a donc probablement été employée pour la production des pâtes grossières (G1a et G2) et semi-fines (SF1). Plus particulièrement, on constate que :

- les variations entre les groupes G1a et G2 concernent des lithoclastes d'origine calcaire dans le groupe G1a et volcaniques dans le groupe G2 ;

- les variations entre les groupes G1a et SF1 se situent au niveau de la quantité des inclusions carbonatées qui sont plus abondantes dans le groupe G1a. Pour cette dernière pâte, il ne faut pas écarter l'hypothèse d'une préparation pour améliorer la plasticité et donc les propriétés de l'argile. En effet, l'expérimentation conduite avec cette terre a confirmé, d'une part la plasticité excessive durant la phase de façonnage et d'autre part, une forte rétraction durant la phase de séchage à partir de la consistance plastique et humide. Avec l'addition d'inclusions calcaires pilées, la pâte a été façonnée plus facilement par modelage d'une motte et également par montage au colombin (fig. 7d).

Le deuxième ensemble des échantillons (RL 2) provient d'une couche de terre jaune caractérisée par la rare présence d'inclusions très fines et par la forte fréquence de minéraux aluminosilicates en particulier des quartz et des feldspaths. Cette terre trouve des comparaisons avec le groupe minéralogique V et a probablement été employée pour la production de la classe très fine (F2a et F3). La différence entre les deux groupes se situe au niveau de la quantité de résidus de végétaux (phytolithes identifiés comme morphotype des résidus des graminées, et plus particulièrement les céréales, selon la forme du squelette allongée à bord sinueux) qui sont plus abondants dans la classe F2a. Nous suggérons que ces résidus végétaux constituent un dégraissant intentionnellement ajouté pour obtenir cette pâte particulière qui représente une imitation locale des produits du faciès méridional de *Guadone* (fig. 7e).

Le décor peint : analyse spectroscopique LIBS

Des analyses [1] Raman et LIBS (*Laser Induced Breakdown Spectroscopy*) ont été conduites sur le décor chromatique, en collaboration avec le CNR de Pise (*Institute of Chemistry of Organometallic Compounds* - ICCOM). Il s'agissait d'identifier les pigments employés pour le décor de la céramique, en particulier dans les régions du Sud-Est italien et du versant medio-adriatique, où les céramiques peintes se développent à partir des dernières phases du Néolithique ancien et deviennent caractéristiques avec leur pâte dites *figulina* durant le Néolithique moyen (derniers siècles du VI^{e} millénaire av. J.-C. - première moitié du V^{e} millénaire av. J.-C. ; fig. 8a ; Angeli *et al.*, 2006).

La technique spectroscopique LIBS fourni la composition élémentaire avec un *range* dynamique entre les éléments majoritaires (exprimés en pourcentages) et les éléments en traces (exprimés en parties par million). Les échantillons ont été analysés par le prototype MODì, acronyme de *Mobile Dual-pulse Instruments for LIBS material analysis* (Cristoforetti *et al.*, 2005). Les analyses ont été réalisées par la technique de la double impulsion par deux laser au Nd : YAG fonctionnant sur la longueur d'onde fondamentale (1064 nm), avec deux impulsions superposées. L'énergie libérée était d'environ 60 mJ dans 8 ns pour chaque laser. Les spectres ont été obtenus en faisant la moyenne sur 5 coups. La porte d'acquisition était de 2 µs et le retard du premier laser était de 2 µs. Pour chaque échantillon nous avons comparé les spectres obtenus sur la surface céramique non décorée et la partie du décor réalisée en noir.

Sur le site de Colle Santo Stefano, le décor peint est très rare et il est caractérisé par l'emploi de la couleur noire pour la réalisation de motifs de lignes parallèles ou de traits brefs. L'oxyde de manganèse n'a été reconnu que pour un seul tesson. Cependant, le pigment noir n'a pas été obtenu avec de l'oxyde de fer. Nous pensons que la peinture noire a été obtenue par le mélange d'une substance organique (par exemple du charbon) avec une substance liante, puis employée avant ou après la cuisson (fig. 8b).

Nous avons identifié l'emploi récurrent d'oxyde de manganèse au cours du Néolithique moyen-récent, en particulier pour la céramique *figulina* de la culture de Serra d'Alto du Sud-Est italien. Nous disposons de données (17 échantillons) provenant de plusieurs sites (Trasano, Serra d'Alto, Saldone et Masseria Le Fiatte) : tous les spectres présentent les pics caractéristiques du manganèse pour le décor noir (fig. 8c). Pour la culture de Serra d'Alto, nous proposons que l'homogénéité des données atteste de l'adoption d'une technologie très précise dans la production de la céramique *figulina* peinte et nous révisons l'hypothèse d'une relation avec le groupe de Ripoli (Angeli *et al.*, 2011a). En effet, les spectres des analyses conduites sur le décor peint en noir des céramiques *figulina* de la culture de Ripoli (12 échantillons) présentent également les pics caractéristiques du manganèse (fig. 8d).

DISCUSSIONS

Les variations morpho-stylistiques du complexe de Colle Santo Stefano ont ouvert les problématiques suivantes :

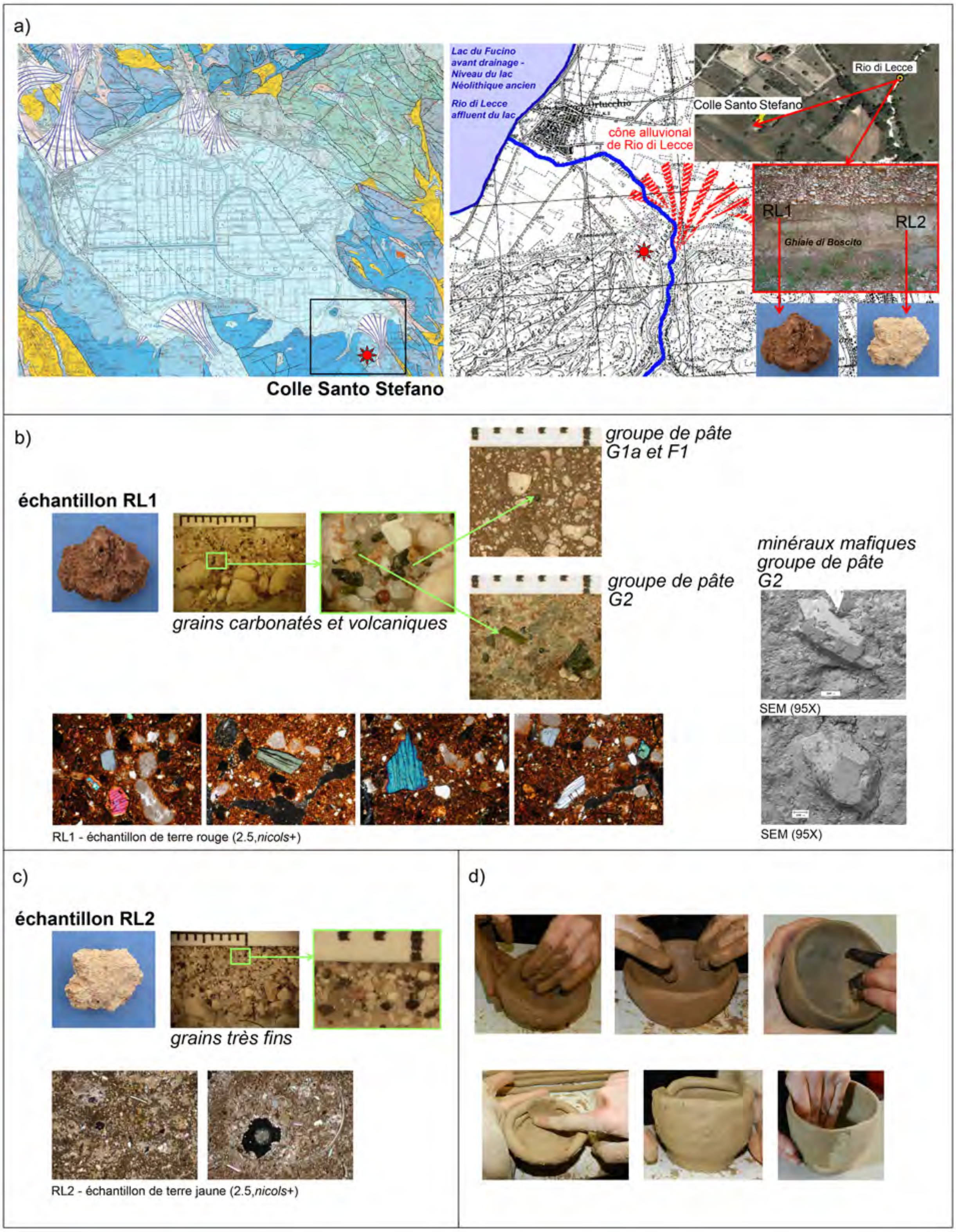

Fig. 7 - a) – Localisation des échantillons de terre : RL1 (terre rouge) et RL2 (terre jaune) ; b) caractérisation échantillon RL1 ; c) caractérisation échantillon RL2 ; d) expérimentation avec les terres (clichés C. Fabbri, L. Angeli et M. Parisi).

***Fig. 7** - a) – Location of clay: RL1 (red earth) and RL2 (yellow earth); b) characterization of RL1 clay; c) characterization of RL2 clay; d) experiments (photos C. Fabbri, L. Angeli and M. Parisi).*

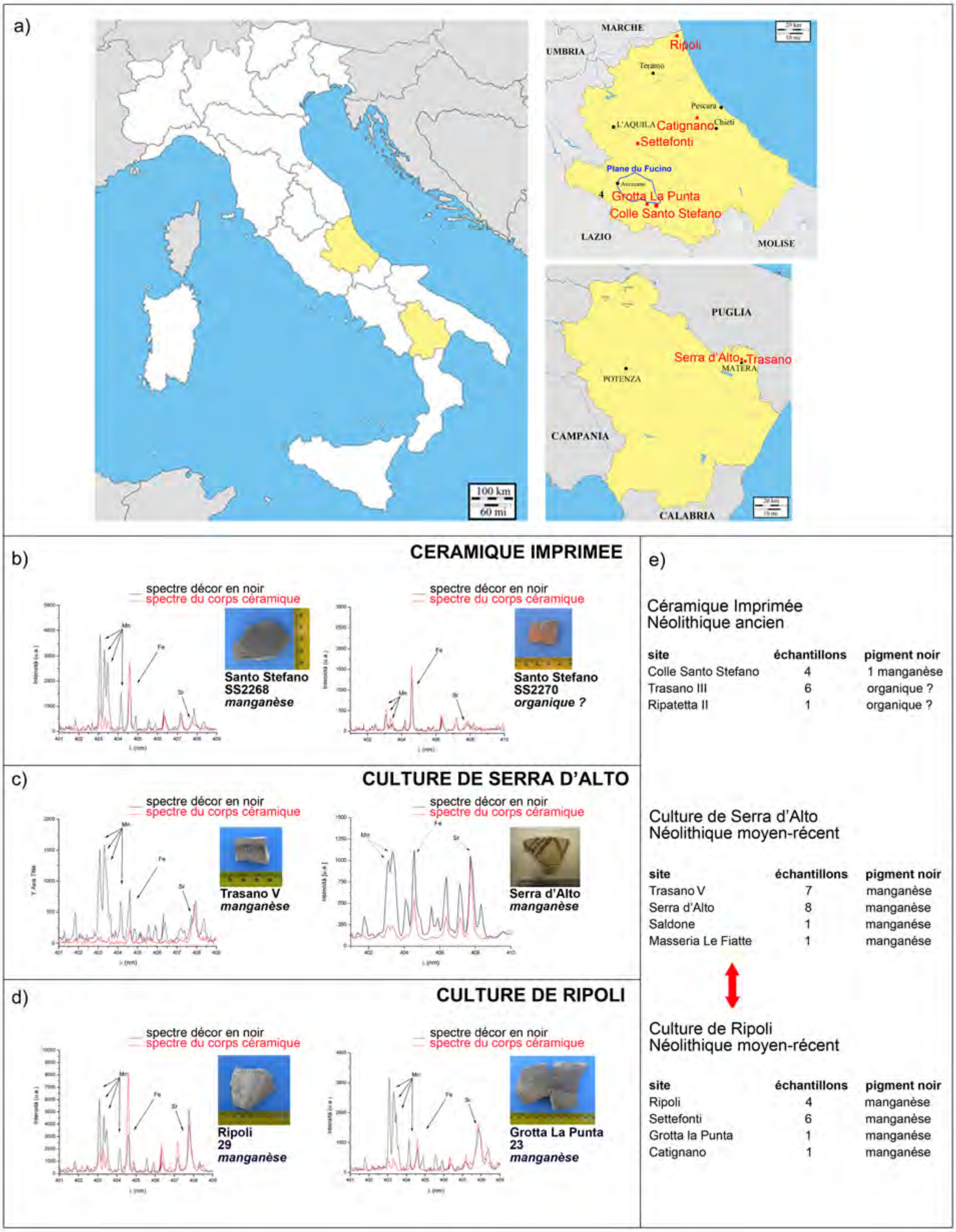

Fig. 8 - a) – Localisation des sites dans les Abruzzes et en Basilicate ; b) Colle Santo Stefano (Céramique Imprimée, Néolithique ancien) ; c) Trasano V et Serra d'Alto (Céramique *figulina* de Serra d'Alto, Néolithique moyen-récent) ; d) Ripoli et Grotta La Punta (Céramique *figulina* de Ripoli, Néolithique moyen-récent) ; e) synthèse d'échantillonnage (spectres S. Legnaioli et clichés L. Angeli).

***Fig. 8 -** a) – Location of sites in Abruzzo and Basilicata; b) Colle Santo Stefano (Impressed Ware, Early Neolithic); c) Trasano V and Serra d'Alto (figulina pottery from Serra d'Alto, Middle-Late Neolithic); d) Ripoli and Grotta La Punta (figulina pottery from Ripoli, Middle-Late Neolithic); e) summary of sample (spectra S. Legnaioli and photos L. Angeli).*

1) Quelle est l'origine des matières premières employées dans la production ?

2) Existe-il une sélection et un traitement des matières premières ?

3) Les vases au décor méridional de *Guadone* sont-ils une production locale ou importée ?

La caractérisation préliminaire des pâtes à la loupe binoculaire a mis en évidence une grande variabilité et l'analyse en lame mince a permis d'identifier des groupes minéralogiques caractérisés par des phases minéralogiques très différenciées, probablement liées à la présence de différents dépôts argileux et donc à l'emploi de plusieurs matières argileuses.

Suivant le modèle de D. E. Arnold (Arnold, 2005), à Colle Santo Stefano les matières premières employées sont locales (< 1 km) et en rapport à la géomorphologie des dépôts encore présents à proximité du site. Les analyses des deux terres de référence (RL1 et RL2) se répartissent de façon équivalente entre les groupes minéralogiques I et V.

Les pâtes qui ont été réalisées à partir de l'argile RL1, riche en inclusions naturelles ont fait l'objet d'un ajout de dégraissants de carbonates pilés (calcaires biodétritiques et micritiques). C'est par exemple le cas pour le groupe G1a.

Dans la mesure où dans l'échantillon de terre rouge RL1 les lithoclastes d'origine volcanique sont très fréquents, on pourrait écarter l'hypothèse qu'ils aient été volontairement ajoutés comme dégraissants dans le groupe G2. De plus, puisque les inclusions volcaniques sont très visibles et émergent à la surface des céramiques, on peut envisager que l'artisan ait procédé à un traitement des surfaces dans le but d'obtenir un résultat esthétique plutôt que fonctionnel.

L'autre type d'inclusion d'origine anthropique introduit dans l'argile RL2 correspond aux résidus de végétaux. Les pâtes fines (groupes F2a et F3) montrent une grande quantité de vacuoles avec parfois des restes de résidus de végétaux carbonisés qui ont été ajoutés de façon préférentielle pour la préparation de la pâte des vases portant le décor de style méridional de *Guadone*.

Abordant la troisième question, nous observons que la connaissance des produits originaux du faciès méridional de *Guadone* s'exprime de plusieurs façons : il s'agit de produits façonnés localement, pour lesquels l'imitation du style méridional se retrouve non seulement au niveau du décor et de la forme du récipient, mais également dans la nature de la pâte (pâte claire et épurée, argile RL2) et dans les traitements de surface (polissage).

Dans la phase ancienne du site, la tradition culturelle méridionale est fortement marquée dans la structure de production céramique puisque le décor méridional est reproduit sur des vases dont les pâtes appartiennent aux autres groupes. En effet, durant la première installation du village, il n'existe pas de correspondance exclusive entre le décor et les types de pâte. Le premier système de production de Colle Santo Stefano pourrait non seulement indiquer un artisanat domestique caractérisé par une grande variété des pâtes et donc une adaptation à la disponibilité des matières premières locales, mais également poser la question du rôle des groupes de paysans provenant du Sud-Est italien dans la première néolithisation de la région medio-adriatique.

CONCLUSION

En conclusion, on a reconnu pour la phase ancienne deux sources locales potentielles d'argiles employées pour la production des groupes de pâte grossière G1a et semi-fine SF1 (groupe minéralogique I) et plus particulièrement pour la production des groupes de pâte fine F2a et F3 (groupe minéralogique V) associés au décor de style méridional. Il reste à vérifier l'évolution interne du site : en effet dans la phase récente, on remarque la diminution des précédents groupes minéralogiques I et V et l'augmentation du groupe minéralogique IV (pâtes fines F1 et F2b) dont l'origine n'a pas encore été identifiée. Cette évolution dans la nature des pâtes s'effectue en parallèle à une diminution générale du décor, avec la quasi-disparition du style méridional de *Guadone* ; cela s'accompagne également de certains changements au sein de la chaîne opératoire (peut-être par exemple, avec l'apparition du façonnage des fonds plats au colombin).

En ce qui concerne le décor peint, nous ne disposons pas de données précises quant à la provenance du manganèse et c'est dans ce but que nous avons programmé l'extension de l'échantillonnage (fig. 8e) pour vérifier l'hypothèse selon laquelle l'utilisation de pigment noir à base d'oxyde de manganèse représente un choix technique spécifique des groupes culturels de la céramique trichrome du Néolithique moyen, lorsque les productions céramiques sont effectivement standardisées.

NOTES

(1) Analyses des pigments noirs par Stefano Legnaioli du CNR de Pise (Institute of Chemistry of Organometallic Compounds - ICCOM).

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Troisième partie

Production modes: a household perspective

Organisation des productions céramiques : la perspective d'une échelle domestique

Matières à Penser: Raw materials acquisition and processing in Early Neolithic pottery productions
Matières à penser : sélection et traitement des matières premières dans les productions potières du Néolithique ancien
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Looking into houses: analysis of LBK ceramic technological change on a household level

Attila Kreiter, Tibor Marton, Louise Gomart, Krisztián Oross, Péter Pánczél

Abstract: Excavations on the Neolithic site of Balatonszárszó-Kis-erdei-dűlő, located in western Hungary in central Transdanubia, on the southern shore of Lake Balaton, revealed several thousand features. On the basis of material culture and architectural features, the settlement can be assigned to the Central European Linearbandkeramik culture (LBK; ca. 5,350–5,000/4,900 cal. BC). Apart from pits, traces of 48 houses were discovered. At least 14 other sets of features could also be interpreted as houses, mainly through the presence of characteristic elongated pits.

In the first model of the site's development, five pottery style groups were distinguished on the basis of stylistic elements such as shape and decoration. These style groups show a spatial pattern within the settlement. Their major characteristics are easy to correlate with traditional typochronological units of the LBK in the western Carpathian Basin. Although chronological relevance can be attributed to the groups, certain typological and stylistic attributes had a long duration and appear in different style groups.

For the purposes of this study, eight houses and their associated features were selected. The ceramics from these features are characteristic of each style group. The aim was to examine the technology of ceramics, in particular choices in raw materials and intentionally added tempers, as well as building techniques.

During a previous analysis of ceramics from the settlement, 461 sherds were chosen for macroscopic analysis, from which 131 samples were selected for further petrographic thin section analysis. Of these samples, 99 come from the eight houses and pits examined in this study. These features produced a total of 9,161 sherds. As part of the analysis of vessel building techniques, all the available material from the examined houses was assessed, out of which 109 vessels could be attributed to a forming method.

Ceramic petrographic results show that there is a clear change in ceramic technology at household level. The earliest houses of the site show little variability in choices of raw materials and tempers, while houses of Style groups 2–5 show increased choice in raw materials and purposefully added tempers. As far as vessel fashioning is concerned, an opposite trend can be observed. Style group 1 ceramics show considerable variety in technical practices, with at least three forming methods, while ceramics in Style groups 2–3 and 5 are characterized by only one or two forming methods. Thus it seems that variability in building methods slightly decreased towards the end of the settlement.

Ceramic technological changes could be identified on a household level, providing an insight into settlement dynamics. These patterns in the use of raw materials/tempers and building methods may be related to the fact that producers came from different learning networks and had different conceptions of how to build a culturally appropriate vessel. The strength of analysing ceramic technologies on a household level is that we are able to model where ceramic technological changes first appeared within a given settlement and we can assess the nature of these changes. In turn, these patterns can be correlated with typochronology and the analysis of other types of material culture from the part of the site where the changes appeared. In this way we can improve our understanding of settlement dynamics and social changes.

Keywords: Neolithic, LBK, ceramic technology, household, learning network.

Résumé : Dans la partie centrale de la Transdanubie (ouest de la Hongrie), sur la rive sud du lac Balaton, plusieurs centaines de structures ont été mises au jour sur le site néolithique de Balatonszárszó-Kis-erdei-dűlő. Sur la base de sa culture matérielle et de son architecture, le site peut être attribué à la Céramique Linéaire centre européenne (LBK ; environ 5350–5000/4900 cal. BC). En plus des fosses, les traces de 48 bâtiments ont été découvertes. Au moins 14 autres ensembles de structures peuvent également être interprétés comme d'anciens bâtiments.

Dans le cadre de l'établissement d'un premier modèle de développement du village, cinq groupes de poteries ont pu être distingués sur la base de leurs attributs stylistiques (formes et décors). Ces groupes stylistiques montrent une distribution spatiale spécifique au sein de l'habitat et sont rattachables aux étapes chronologiques traditionnelles de la Céramique Linéaire de l'ouest de Carpates. Bien

qu'une valeur chronologique puisse leur être attribuée, certains traits typologiques et stylistiques sont identifiés sur la longue durée et sont communs à plusieurs groupes.
Pour la présente étude, huit maisons ainsi que les structures qui y sont associées ont été sélectionnées. Ces unités d'habitation ont livré un matériel céramique représentatif de chacun des groupes. L'objectif est d'appréhender les techniques mises en œuvre pour la fabrication des céramiques, en particulier les choix opérés pour les matières premières et les dégraissants volontairement ajoutés, ainsi que les techniques de façonnage. Les données sont analysées à l'échelle de la maisonnée et par rapport aux différents groupes stylistiques.
Lors d'une précédente analyse de la céramique du site, 461 tessons ont été sélectionnés pour analyse macroscopique, parmi lesquels 131 ont ensuite été analysés en lame mince. Parmi ces échantillons, 99 sont issus des huit maisons et fosses examinées dans le cadre de la présente étude (ces dernières ayant livré un total de 9 161 tessons). L'analyse des méthodes de façonnage a porté sur l'ensemble du matériel issu des maisons et fosses sélectionnées et un total de 109 vases a pu être attribué à une méthode de façonnage.
Les résultats pétrographiques montrent un changement net dans les techniques céramiques à l'échelle de la maisonnée. Les maisons les plus anciennes du site montrent une faible variabilité dans les choix opérés en termes de matière première et de dégraissants, tandis que les maisons associées aux groupes stylistiques 2-5 témoignent d'une grande diversité de choix pour ces mêmes étapes de la chaîne opératoire. En ce qui concerne le façonnage, une tendance inverse est observée. Les poteries rattachées au groupe stylistique 1 sont en effet caractérisées par une diversité des pratiques techniques, avec la mise en œuvre d'au moins trois méthodes de façonnage, tandis que les céramiques appartenant aux groupes stylistiques 2-3 et 5 sont associées à seulement une ou deux méthodes de façonnage. Il semble que la variabilité des pratiques liées au façonnage diminue légèrement à la fin de l'occupation.
L'analyse des modifications qui s'opèrent dans les pratiques techniques à l'échelle de la maisonnée fournit des informations sur les dynamiques de l'habitat. Les modèles observés quant aux matières premières et aux méthodes de façonnage pourraient être liés à la présence de producteurs issus de réseaux d'apprentissage distincts, ayant des conceptions différentes de la manière de fabriquer un vase qui soit « culturellement adapté ». Cette réflexion à l'échelle de la maisonnée permet de comprendre où les changements techniques apparaissent au sein d'un habitat donné et d'évaluer précisément la nature de ces changements. Les modèles sont corrélés avec la chronologie et comparés aux autres éléments de la culture matérielle dans les zones de l'habitat où ont lieu ces changements techniques. La démarche développée permet de saisir finement les dynamiques de l'habitat ainsi que les changements sociaux qui peuvent y survenir.

Mots-clés : Néolithique, Céramique Linéaire, technologie céramique, maisonnée, réseaux d'apprentissage.

INTRODUCTION

The investigations that led to the discovery of the Neolithic settlement at Balatonszárszó-Kis-erdei-dűlő (fig. 1), on the southern shore of Lake Balaton in central Transdanubia, Hungary, started prior to the construction of the M7 Motorway in 2000.

The site is located on a tongue-shaped natural plateau that begins with a mild slope towards the lake and is bordered by 20–22 m deep small valleys on its eastern, southern and western sides. The modern shoreline lies at a distance of 2–2.5 km from the excavated areas, but was most probably closer to the settlement during the Neolithic.

Targeting the Neolithic settlement, extensive areas were investigated in three campaigns between 2001 and 2003, and a smaller excavation was also carried out in 2006. The total area uncovered on the site is about 12 hectares; Neolithic settlement features were recorded over approximately 10 hectares (Oross, 2004 and 2013).

Posthole structures representing typical timber-framed, above-ground buildings of the Central European Linearbandkeramik culture (LBK) were identified, together with long pits flanking the longitudinal walls of the constructions. The latter features are considered to be integral parts of the LBK house units. Traces of 48 houses were investigated and documented as building remains of the Neolithic community (Oross, 2010), and were designated as Category A house plans (fig. 1). The presence of 11 additional houses could be reconstructed on the basis of long pits and some scattered postholes between them, and were designated Category B house plans (Oross, 2013; here fig. 1). The modelling of the settlement layout enabled the identification of 3 further possible house plans, so that 62 house units now provide the basis for further analysis (Oross, 2013, p. 322–323). The northernmost part of an LBK enclosure was also investigated.

The houses in the northern settlement area were built at a considerable distance from each other, as far as 50 or even 80 metres. In contrast, houses were more densely spaced in the southern part of the settlement. The timber-framed buildings form clusters, each consisting of 3–6 houses. The short, façade sides of the buildings are often aligned with each other, forming groups. Of course this does not mean that all the houses within a house cluster stood at the same time; questions related to the building sequence and dynamics of the houses in the clusters are among the most complicated issues involved in the analysis of the site.

At Balatonszárszó, LBK ceramics were present in 1,477 archaeological features, even though the number of features belonging to the Neolithic settlement is much higher if we include the postholes of the timber-framed houses. Over 40,000 sherds were recorded from these 1,477 features.

According to the density of the Neolithic features and spatial distribution of house plans, a well-separated northern and southern settlement part can be distinguished. The ceramic finds from these two areas also show specific differences: the northern part contains stylistic elements of the early LBK period, while the southern part contains late LBK elements (Marton and Oross, 2009, p. 57). Although the evaluation of the assemblage is still in progress, it appears that the settlement was established as a small hamlet during the early LBK period and developed southwards into a larger settlement in the later and late LBK phases.

The preliminary analysis of individual radiocarbon dates from the site broadly refers to an interval between 5,350–5,000/4,900 cal. BC; the larger, southern settlement part was most probably founded during the 53rd century BC.

An initial modelling of the site's development and dynamics, based on pottery styles, house clusters, and some individual radiocarbon dates, identified five phases. They correspond in fact to style groups and must be regarded as a framework, mostly inspired by traditional typochronology. Considering common elements of different style groups, there is also a possibility that the use periods of various pottery style groups overlapped each other or some of them were even contemporary. In fact, similarities between style groups and some contradictions between radiocarbon dates and associated pottery assemblages suggest a more complex site development, rather than the existence of successive typochronological phases.

The technological study of ceramics concentrates on vessels associated with selected houses from the different style groups, in order to assess possible technological similarities or differences on a household level through the ceramic style groups of the settlement.

MATERIALS AND METHODS

In the last few decades a significant amount of research has been undertaken on the relationship between ceramic production, identity, social boundaries and organisation of production (e.g. Barley, 1994; Sillar, 1997; Gosselain, 2000; Arnold, 2011 and 2012; Jeffra, 2015; Michelaki et al., 2015; Roux, 2015). Ethnographic

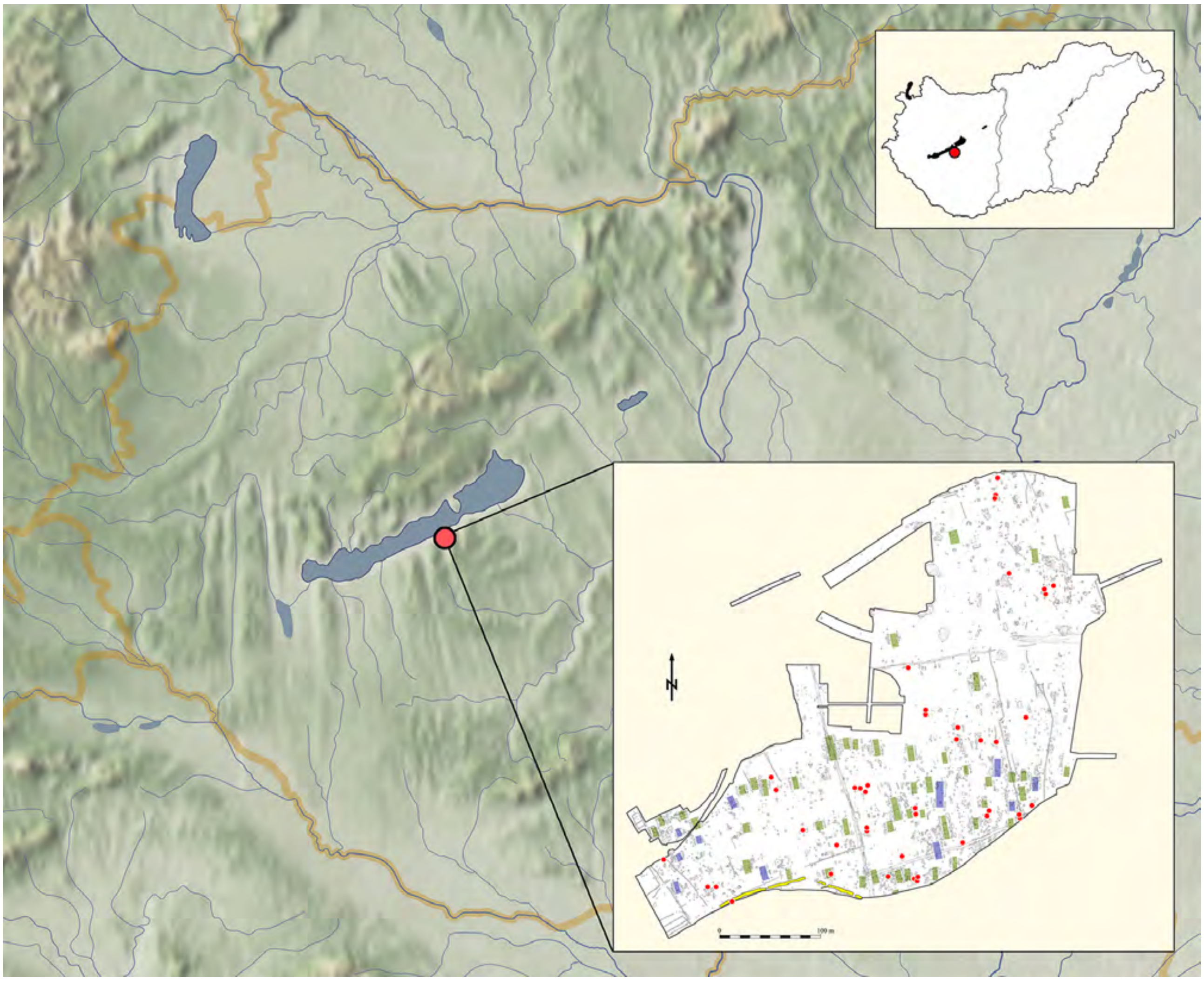

Fig 1 – Location of Balatonszárszó-Kis-erdei-dűlő in Hungary and plan of the excavated area of the Neolithic settlement. Colour coding for site plan: green – house category A; purple – house category B; red – burials; yellow – ditch.

***Fig 1** – Localisation du site de Balatonszárszó-Kis-erdei-dűlő en Hongrie et plan de la zone fouillée de l'habitat néolithique. Code couleur du plan du site : vert – maison catégorie A ; violet - maison catégorie B ; rouge – sépultures ; jaune - fossé.*

examples clearly indicate that potting is dynamic, involving both active and passive choices; that is, choices derived from learned and lived-through practices. These studies also show that the most visible aspects of pottery manufacture are embedded in local symbolic systems, carrying cultural values; but these practices are more exposed to social manipulations than the invisible aspects of technology (Gosselain, 1999 and 2000). Raw material selection and fashioning techniques, on the other hand, represent a more stable aspect of pottery traditions and are expected to reflect more enduring facets of identity (Woods, 1984; Gosselain, 1999 and 2000). It has been shown that patterns in vessel building techniques closely correspond with social boundaries such as those of language groups (Arnold, 1981), specialist groups (Miller, 1985; Mahias, 2002), and gender (Hosler, 1996). These practices become internalised motor habits that are acquired through repeated practice during early learning. For this reason, these are the most resistant to change (Foster, 1966; Nicklin, 1971; Hill, 1977; Reina and Hill, 1978; Saraswati, 1978; Arnold, 1981, 1985 and 1994; Hayden and Cannon, 1984; Roux and Corbetta, 1990; Gosselain, 1998 and 2000).

In light of this, the investigation of preferences in ceramic raw materials/tempers and building techniques on a household level provides information on settlement dynamics, which in turn can help archaeologists understand where and how changes occurred within a settlement. This can further be compared with the results of other types of analyses, such as stone tools, consumption habits, agricultural production, animal husbandry, traditional typochronology and so on.

We have a fairly complete view of the development of Neolithic ceramic traditions in Hungary, which is suitable for highlighting 'tendencies' in the dynamics and changes in ceramic technologies (Szakmány, 1996 and 2001; Szakmány et al., 2005; Szakmány and Starnini, 2007; Szilágyi et al., 2008; Kreiter et al., 2009; Kreiter, 2010; Kreiter et al., 2011; Kreiter et al., in press; Kreiter and Szakmány, 2011; Kalicz et al., 2012; Zsók et al., 2012). However, no analyses have so far been carried out on a Hungarian Neolithic settlement with an aim toward exploring the nature and extent of changes in ceramic technologies on a household level and assessing where changes first appeared within a given settlement.

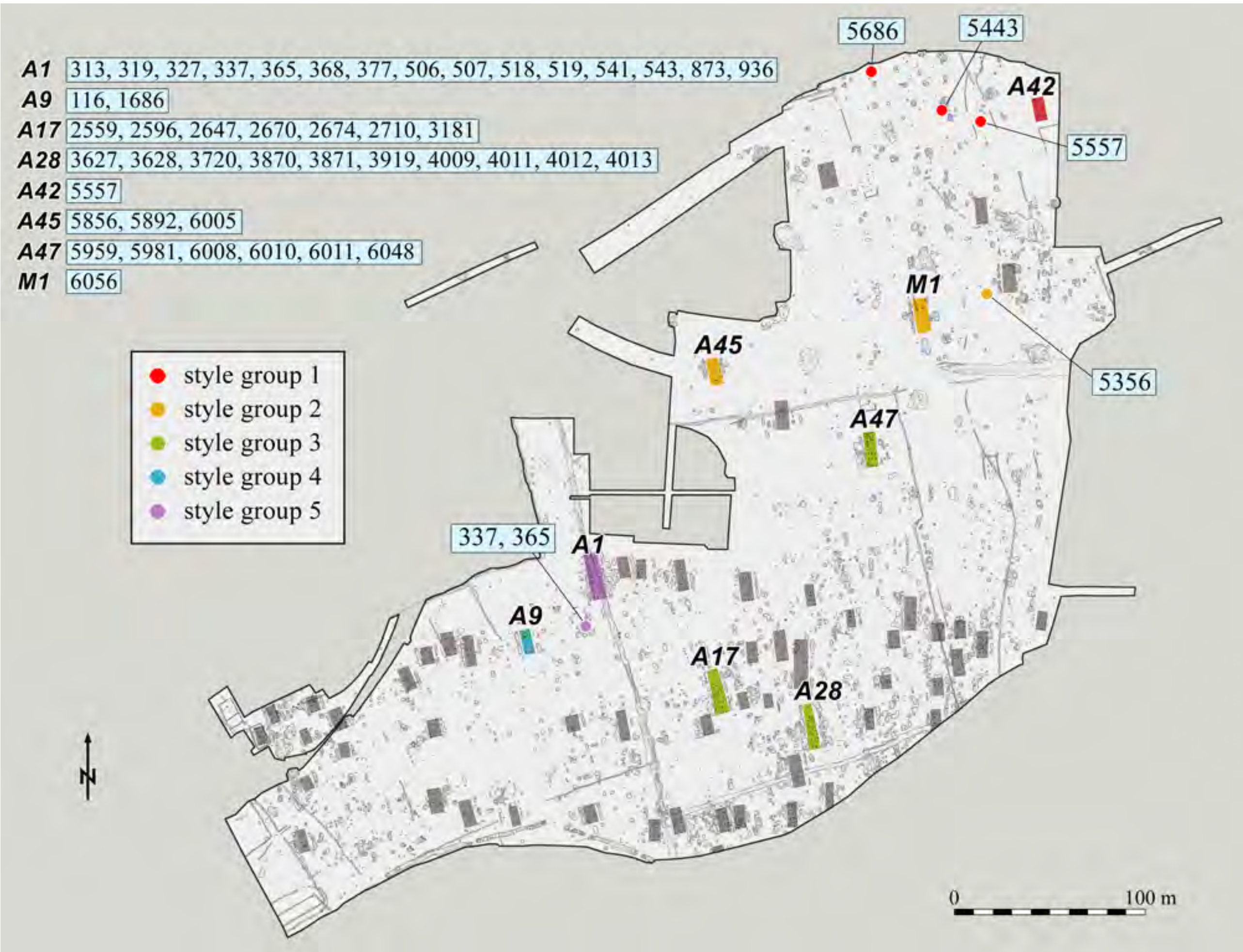

Fig. 2 – The eight houses analysed in this study. Isolated features integrated in the analysis are indicated by dots.

***Fig. 2** – Les huits maisons analysées dans cette étude. Les structures isolées intégrées dans l'analyse sont signalées par des points.*

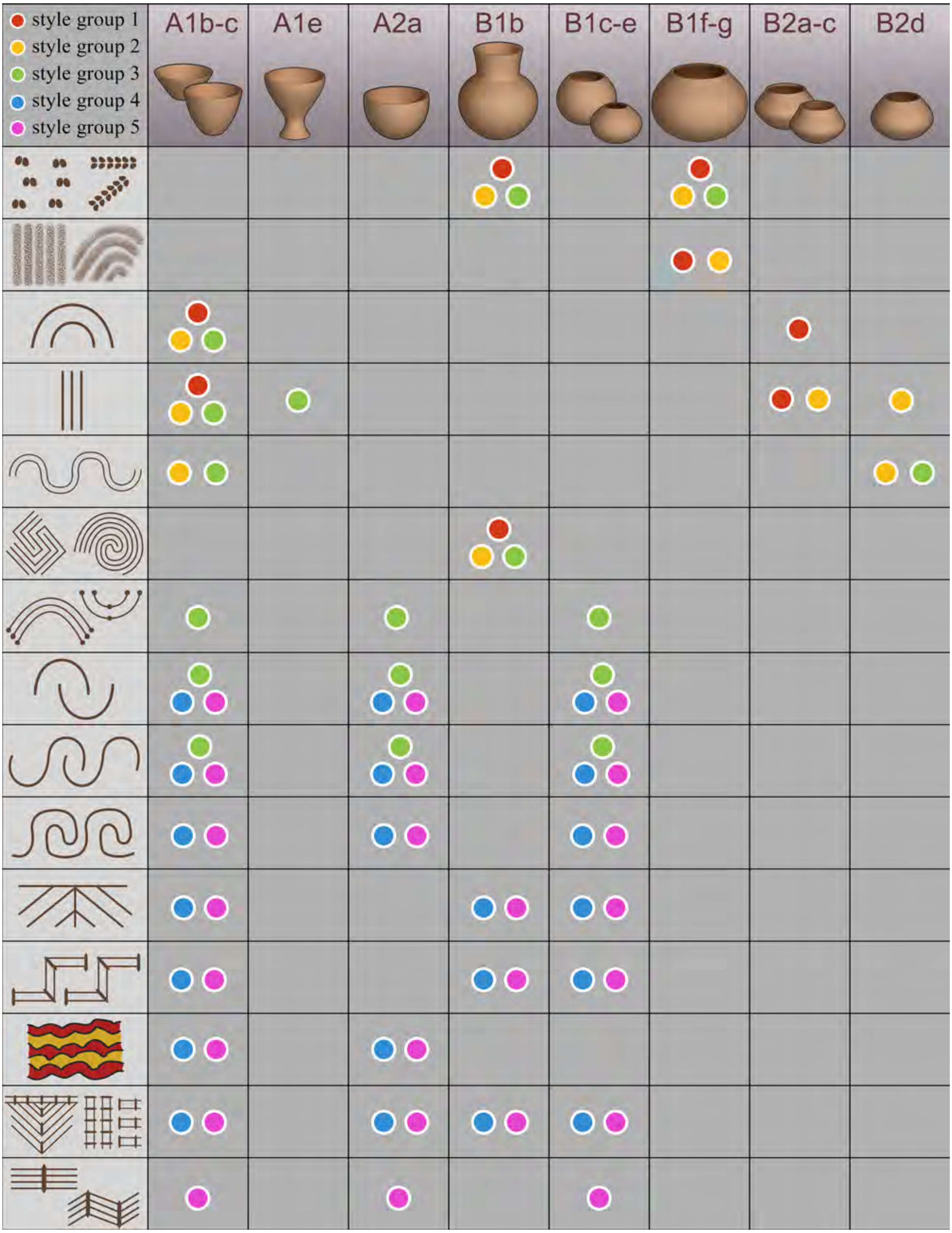

Fig. 3 – Characteristic combinations of vessel forms and decorations according to style groups of Balatonszárszó.
Fig. 3 *– Associations caractéristiques de formes et de décors céramiques, et styles céramiques identifiés à Balatonszárszó.*

As far as ceramic production at Balatonszárszó is concerned, an assessment of the scale of production, together with the identification of areas of production within the settlement, would shed more light on the meaning of technological variability on a household level. However, the scale of pottery production could not be assessed since to date there is no clear evidence for pottery production at any Neolithic settlement in Hungary. In order to define a pottery production site, one has to consider a range of data that may accompany ceramic production such as wasters, production tools, raw materials, structural evidence for the curing/mining of clay and the presence of distinctive manufacturing assemblages (Wardle, 1992, p. 63-73). On these criteria, no pottery production sites have yet been found anywhere within the Hungarian Neolithic.

In this study, the examined ceramics are considered household-related objects. Although the place and nature of the ceramic production is unknown, vessels ended up in households that reflect both the identity of their users and the social settings in which the vessels were produced and utilised. Technological change can thus be identified on a household level, enabling us to gain a better understanding of the spatial organisation of production behaviour, or at least ceramic use.

With a view to identifying changes in raw materials through the ceramic style groups and on a household level, all the available ceramics were examined macroscopically. Subsequently, 461 sherds were chosen for further macroscopic analysis, mainly from features associated with buildings. The selection of samples was based on typological and technological attributes. The aim was to include samples from all ceramic style groups at the site, including variations within the main forms and also taking into account macroscopically observable differences in fabrics. The selected samples are thus considered to represent the technological variability of the site in terms of raw materials and tempers. As a result of our macroscopic analysis, 131 samples were selected for petrographic analysis, from which 99 come from the eight houses and associated features examined in this study (fig. 2). These houses provided the largest quantity of ceramics, and their relative chronology is also well established.

During the petrographic analysis, the inclusion density, size categories, inclusion sorting and roundness of the components were determined according to the guidelines of the *Prehistoric Ceramic Research Group* (PCRG, 2010). Inclusion density: rare (< 3%), sparse (3–9%), moderate (10–19%), common (20–29%), very common (30–39%) and abundant (> 40%). Size classification: very fine (< 0.1 mm), fine (0.1–0.25 mm), medium (0.25–1 mm), coarse (1–3 mm) and very coarse (> 3 mm). Inclusion sorting: poorly-sorted, moderately-sorted, well-sorted, and very well-sorted. Roundness classes: angular, subangular, subrounded, rounded and well-rounded.

The eight examined houses and pits produced 9,161 sherds, 109 of which, all belonging to different vessels, could be attributed to a forming method. The analysis of forming methods focused on characteristics of surface topography, lines of fractures, variation in wall thickness, change in surface texture, as well as orientation of particles and porosity in cross-section (Livingstone Smith, 2001). Each macrotrace was recorded, coded, photographed and replaced on the profile of the recorded vessel. The identified macrotraces were interpreted in terms of techniques and methods of fashioning on the basis of several experimental and ethnographic reference works (e.g. Shepard, 1956; Rye, 1981; Livingstone Smith, 2001; Gosselain, 2002; Gelbert, 2003).

On the basis of the spatial distribution of typological groups and their characteristic combinations the ceramic material was divided into style groups (fig. 3; Marton, 2008, p. 198–201 and 2015, p. 107–142). The spatial pattern of different style groups could be described with five characteristic combinations, meaning that the common occurrence of particular pottery forms and decorations in certain features and house units could be observed repeatedly in the course of the study. The local assemblage does not include all typochronological horizons of the Transdanubian LBK sequence, as the formative LBK phase was not present (Marton, 2008, p. 202; Marton and Oross, 2009, p. 60 and 2012, p. 223). The validity of the style groups was confirmed by multivariate statistical methods (Marton, 2015, p. 202–214). At Balatonszárszó, the earliest horizon (characterized by Style group 1) could be linked to the northeastern part of the excavated area (fig. 2). The stylistic attributes of the ceramics represent the early LBK period of the western Carpathian Basin, and show extensive similarities to finds from Budapest-Aranyhegyi út and the earliest phase of the Neolithic occupation at Bicske-Galagonyás (Makkay, 1978, p. 28, Plates III–VI; Kalicz-Schreiber and Kalicz, 1992, p. 51, Abbildung 3–5), as well as with the material from Bíňa in southwestern Slovakia (Pavúk, 1980, p. 10, Abbildung 23).

House A42 and its associated feature (Pit 5557) were analysed from Style group 1. In the distribution area of Style group 1, house plans are widely spaced, and their flanking pits could not be observed. Therefore, it was necessary to use a different approach to collect more ceramic technological data, for subsequent comparison with the households of other parts of the settlement. For this reason, Pit 5443 was also considered. Although it is located about 30 metres from House A42, the pottery is very similar to the assemblage from this house. In order to gather more comparative data from the earliest occupation of the site, another feature was also included (Pit 5686), which is about 50 metres from House A42. Even though the association of these latter pits with the house is uncertain, they were included in the study because they contain a very distinctive early LBK assemblage. Furthermore, we wanted the number of samples included from the early LBK period to be similar to the number included from the late LBK period, in order to avoid skewing the ceramic technological data.

Style group 2 is representative of the northeastern area of Balatonszárszó and, within that, its southern edge. The typological characteristics of ceramics in this area show broad similarities to the material from Milanovce (Pavúk, 1980, p. 47, Abbildung 19, 2 and Abbildung 41, 1–2), representing the latest phase of the early LBK period, in a purely typochronological approach (Marton, 2013, p. 171). It is worth noting that settlements with Milanovce pottery were recently dated to 5,300–5,200 cal BC, a time when later LBK units already existed (Stadler and Kotova, 2010, p. 338). This information is another sign of a more complex site development rather than a series of consecutive typochronological phases. In order to analyse the ceramic technology of this style group, Houses A45 and M1 were chosen. The postholes were well preserved, and the flanking pits in an ordered position around House A45 are also characteristic. For the analysis of House M1 a nearby pit (Pit 5356) was also included because its assemblage was very similar to that of the house. These houses seem particularly suitable for household analysis because their associated features contained comparative amounts of ceramics.

In the eastern area of the southern and densely built-up part of the settlement, Style group 3 characterizes some house clusters. This group represents the early stage of the so-called Keszthely style (Kalicz, 1991) and some Notenkopf elements (Marton, 2008, p. 203). Style group 3 is also labelled as late LBK and serves as a transitional phase towards the late LBK pottery styles. This type of pottery is well represented in the northern part of Transdanubia as well, for example at Bicske-Galagonyás (Makkay et al., 1996, p. 62, fig. 48–51). Three houses were chosen from this period, characterised by increased variability in vessel shape and decoration.

House units and house clusters associated with Keszthely style ceramics and with pottery of the so-called Zseliz/Želiezovce type decoration (Pavúk, 1969, p. 295, Abbildung 36 and 51, and 1994, p. 145, Tafel 51–52) are typical in the southern part of the settlement. Two further style groups (4 and 5) could also be distinguished based on the frequency and variability of Zseliz/Želiezovce attributes in the pottery assemblage. Two houses (A1 and A9) were analysed from these style groups. These houses are located in the southern part of the settlement and they belong to two neighbouring house groups. House A9 represents Style group 4 while House A1 represents Style group 5. For the analysis of House A1, a pit complex (Pit 337) situated 15 metres from the house was also included. The relationship between House 1 and the pit complex is indicated by conjoining sherds.

In light of the above, the ceramic assemblage of Balatonszárszó offers an exceptional opportunity to analyse the technology of pottery sequences on a household level and to understand intrasite dynamics of pottery use. In the following, the ceramic technology in the examined houses is analysed and possible correlations between technology and the different style groups of the settlement are highlighted.

RESULTS OF PETROGRAPHIC AND CERAMIC BUILDING TECHNOLOGY ANALYSIS

The examined samples are classified into three main fabric groups (fig. 4):

1) Fabric 1 is characterised by very fine (VF) visible non-plastic elements, although it has two subgroups (fig. 4, nos. 1–2); 1a shows chaff tempering (VF/CH) while 1b does not (VF). Nothing other than chaff tempering was identified in association with this raw material. The amount of visible non-plastic elements is moderate to common (10–29%) and the dominant grain size is very fine (< 0.1 mm). The porosity of samples tempered with chaff is high. The pores are elongated and mostly parallel to the vessel wall. The majority of elements are mainly monocrystalline quartz with straight or undulated extinction, but plagioclase, potash feldspar, and muscovite mica are also present.
2) Fabric 2 is characterised by very fine to fine-grained visible non-plastic elements (VF-F) (< 0.1 mm and 0.1–0.25 mm), but sub-groups could also be identified according to the presence/absence of chaff tempering and naturally present calcareous elements (fig. 4, nos. 3 – 6). The basic raw materials of the subgroups in Fabric 2 seem very similar. As the appearance or disappearance of calcareous elements in clays depends on environmental conditions, these elements can appear or disappear within a small area of a given clay source. Therefore, raw materials, which are very similar petrographically to the other samples in this group but show calcareous elements, were also classified into this group.

- Fabric 2a (VF-F) is characterised by very fine to fine (< 0.1 mm and 0.1–0.25 mm) visible non-plastic elements, but neither calcareous elements nor chaff tempering are identified. No intentional tempering could be recognised in this subgroup. The amount of elements is medium to common (10–29%), their size distribution is serial (0.1–0.25 mm); they are well sorted. The majority of elements are monocrystalline quartz with normal or undulated extinction. Potash and plagioclase feldspar and muscovite mica also appear, while biotite mica is less common. Rare amounts of argillaceous fragments are also identified.
- Fabric 2b (VF-F/CH) has a very similar raw material to 2a, but 2b is tempered with chaff. The samples are porous, with elongated pores mainly parallel to the vessel wall. Fabric 2c (VF-F-Ca) shows naturally present calcareous elements. Approximately half of these are micritic, mainly very fine in size (0.05–0.1 mm). There are also larger (0.5–5 mm) calcareous concretions composed of well-rounded micritic and sparry grains.
- Fabric 2d (VF-F-Ca/CH) shows naturally present calcareous elements and chaff tempering.

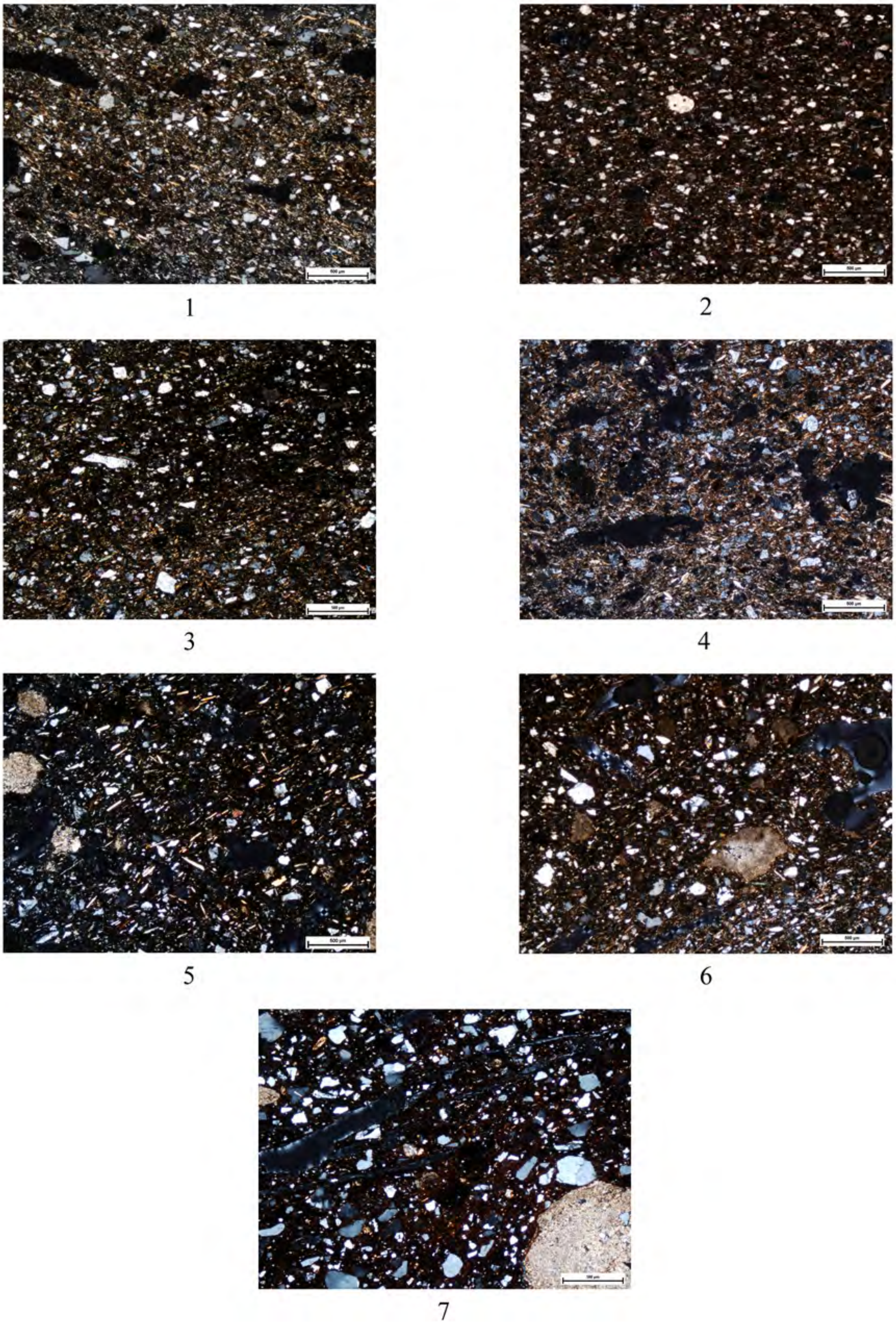

Fig. 4 – Micrographs of fabric groups (40x, +N). 1: Fabric 1a; 2: Fabric 1b; 3: Fabric 2a; 4: Fabric 2b; 5: Fabric 2c; 6: Fabric 2d; 7: Fabric 3.

Fig. 4 *– Microphotographies des groupes pétrographiques de pâte (40x, +N). 1 : Groupe de pâte 1a ; 2 : Groupe de pâte 1b ; 3 : Groupe de pâte 2a ; 4 : Groupe de pâte 2b ; 5 : Groupe de pâte 2c ; 6 : Groupe de pâte 2d ; 7 : Groupe de pâte 3.*

Fig. 5 – Schematic representations of building methods and associated macrotraces.
***Fig. 5** – Représentation schématique des méthodes de façonnage et des macrotraces associées.*

3) Fabric 3 (F-M-Ca/CH) is distinct from other fabrics in that it has a coarser matrix (fig. 4, no. 7). This fabric is characterised by fine to medium visible non-plastic elements (0.1–1 mm); naturally present calcareous elements also appear, as does chaff tempering. The amount of elements is moderate to common (10–29%) and the dominant size range is fine and medium (0.1–0.7 mm). The visible non-plastic elements show serial size distribution. The elements are moderately sorted. The majority of elements are monocrystalline quartz, with normal or undulated extinction. Rare amounts of potash and plagioclase feldspar and muscovite mica also appear. Calcareous elements appear in the form of medium to very coarse (0.5–5 mm) concretions.

As far as fashioning techniques are concerned, three forming methods were identified (fig. 5):

1) Method 1. The first forming method (fig. 5, no. 1) is characterized by a base formed with a thin coil in spiral, as shown by the presence of a sub-circular configuration on edges of vertical fractures (fig. 5, no. 3). Longitudinal depressions on the inner surface of the base suggest shaping by compression against a support (fig. 5, no. 4). The body and the rim present, on the edge of vertical fractures, sub-oval sections of coils (fig. 5, no. 2), sometimes associated with a foliated internal structure. On the outer surface of the belly and the rim, overlapping sub-circular flat areas are often observed (fig. 5, no. 1). The combination of these macrotraces indicates that the body and the rim were formed by superposition of thin coils and then shaped using the beating technique. It is important to note that the intensity of the beating seems to vary from one vessel to another. Thus, on the vessels shaped with an intense beating, the regular taps of the paddle on outer surfaces cause a change in the internal structure of the clay, giving it a foliated aspect. On vessels shaped with a less intense beating, the macrotraces related to the percussion of the paddle are less clear and more difficult to distinguish on surfaces and in cross-section.
2) Method 2. The second fashioning method (fig. 5, no. 2) includes vessels whose base is formed with two overlaid slabs: the joins between the slabs are often visible in cross-section (fig. 5, nos. 7 and 8). Each of these slabs shows, in cross-section, a sub-circular pattern, which suggests the use of coils in spiral. The body and the rim of these pots also show, on the edges of vertical fractures, sub-circular sections of coils which suggest that they were formed by superposition of thin coils, slightly or not deformed during their placement.
3) In Method 3 (fig. 5, no. 3), the vessel bases (when preserved) show a wide range of technical macrotraces, which suggests fashioning in three phases. First, a slab is formed with thin coils in spiral, as shown by the sub-circular pattern visible in cross-section. Secondly a coil, often visible in cross-section, is applied on the junction between the base and the body, to form an annular foot. Third, a slab is applied at the centre of the base in order to fill the previously formed annular foot (fig. 5, nos. 11 and 12). The body and the rim of these vessels show sections of very elongated elements (fig. 5, nos. 9 and 10). The pots present many oblique to vertical fractures and several sherds are vertically broken. These observations suggest initial forming with slabs or very elongated coils, probably followed by thinning operations.

COMPARISON OF VESSEL FORMS, FABRICS AND HOUSEHOLDS – DISCUSSION

In the following section the ceramic types and their technological characteristics are examined through the houses and style groups of the settlement, and changes in raw material use and fashioning techniques are highlighted. Five style groups have been distinguished based on vessel forms and decoration. At this site, Style groups 1 and 2 represent the early LBK, and Style groups 3–5 represent the late LBK.

Style group 1

From Style group 1, House A42 and Pits 5557 and 5443 were analysed along with Pit 5686, according to the previously mentioned principles (tables 1–3). The ceramics from these features show similarities in terms of vessel forms, surface treatments and decorations. Fine wares such as conical bowls and biconical bowls, the latter type with three-fold symmetrically repeated decoration, are characteristic in all features. Similar decoration combinations are also observed in several cases. Fine wares can clearly be characterised by surface burnishing. Coarse vessels show channelled barbotine and different types of applied rib and knob decoration. Vessels with cylindrical necks and combined incised spiral and meander motifs are typical.

Petrographic data indicate that raw material selection in Style group 1 (early LBK part of the settlement) was restricted to the use of a few raw materials (tables 1–3) that were all tempered with chaff. Moreover, these fabrics remained in use and were the most characteristic until the end of the site (see the presence of Fabrics 1a, 2b and 2d: tables 1–11 and fig. 6). It seems that the earliest potters of the site were conservative, using a restricted number of raw materials and tempering these with chaff. Studies from other Neolithic sites also indicate that chaff tempering was ubiquitous in the Early Neolithic (Körös and Starčevo) and in the early phases of the Middle Neolithic of Hungary, and other tempering practices were hardly used (Kreiter, 2010; Kreiter et al., 2011). In this respect the earliest ceramic raw material selection at Balatonszárszó is very uniform, showing little variability and a strong resemblance to Early Neolithic ceramic traditions (Kreiter et al., 2013).

House A42	Fabric 1a - VF/CH	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Forming method
Conical bowl with straight wall (type A1b)		1		nd
Conical bowl with arched wall (type A1c)		1	1	Method 1 (1pc)
Conical bowl with pedestal (type A1e)		1		nd
Hemispherical bowl (A2a)		1		nd
Vessel with cylindrical neck and incised decoration (type B1b.5)		1	2	Method 1 (1 pc)
Globular fine vessel (type B1e)	1			nd
Globular storage vessel (B1f)	2	1		nd
Globular vessel (type B1g)		1		Method 2 (1 pc)
Biconical fine vessel (type B2b)		2		Method 1 (2 pcs)
Not thin sectioned				Method 1 (1 pc)
Total	**3**	**9**	**3**	**5**

Table 1 – Distribution of fabrics and building methods to vessel types associated with House A42 (nd = non determinable).
Tabl. 1 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A42 (nd = indéterminé).*

Pit 5686	Fabric 1a - VF/CH	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Forming method
Conical bowl with straight wall (type A1b)		1		nd
Vessel with cylindrical neck (type B1b)		2		nd
Vessel with cylindrical neck (incised decoration) (type B1b.5)		1		nd
Globular vessel (type B1g)	1	1		nd
Biconical vessel (pedestal) (type B2c)		1		Method 3 (1 pc)
Pedestal			1	nd
Not thin sectioned				Method 1 (2 pcs)
Total	**1**	**6**	**1**	**3**

Table 2 – Distribution of fabrics and building methods to vessel types in Pit 5686 (nd = non determinable).
Tabl. 2 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la fosse 5686 (nd = indéterminé).*

Pit 5443	Fabric 2b - VF-F/CH	Forming method
Globular vessel (type B1g)	2	Method 2 (1 pc)
Globular vessel (pedestal) (type B1d)	1	nd
Hemispherical bowl (type A2a)	1	nd
Not thin sectioned		Method 1 (6 pcs), Method 3 (2 pcs)
Total	**4**	**9**

Table 3 – Distribution of fabrics and building methods to vessel types in Pit 5443 (nd = non determinable).
Tabl. 3 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la fosse 5443 (nd = indéterminé).*

Concerning the fashioning techniques of Style group 1, the vessels are characterized either by coiling followed by beating (Method 1; House A42, Pits 5443 and 5686), by the overlapping of two slabs to form the base and the use of fine coils to build the walls (Method 2; House A42, Pits 5443 and 5686), or by the technique of the 'filled base' followed by the use of slabs (or very elongated coils) to build the body (Method 3; Pit 5686). In House A42, a combination of Methods 1 and 2 could be observed on one vessel: two slabs were overlapped to form the base, then the body was roughed out with coils and then shaped using the beating technique. No relationship can be established between vessel shapes and forming methods. Biconical vessels could thus be formed using Method 1 (House A42) or Method 3 (Pit 5686). Moreover, in the same house (A42), Method 1 had been used for the fashioning of several shapes (e.g. conical bowl, vessel with cylindrical neck or biconical fine vessel).

Methods 1 and 3 are predominant in all features, while Method 2 is rarely identified (House A42). Nevertheless, the representativeness of Method 2 in one of the earliest houses of the site is assured by its occurrence in the early LBK pits studied as part of a larger sampling of the Balatonszárszó ceramic assemblage.

The three identified forming methods are often simultaneously distributed in the different features, which raises the question of the organisation of pottery production and exchange (do the products of one or several producers appear in a single house? Were there exchanges or gifts of vessels between contemporary houses?). Nevertheless, the occurrence of a vessel in House A42 that was built using Method 2 for its base (overlapping of two slabs) and Method 1 for its walls (coils then beating) suggests interactions between these different groups of producers. The exact nature of these interactions is difficult to assess, but this 'mixed' way of vessel forming evokes meetings and know-how sharing between producers and/or apprentices during ceramic production.

Since no relationship could be established between forming methods and vessel shapes, this suggests no adaptation of the fashioning gestures to the desired pottery shape. The three different "ways of doing" at the settlement probably indicate three distinct learning networks. This hypothesis is reinforced by the fact that Methods 1 and 3 were predominant in the Starčevo material of Vörs

House A45	**Fabric 1a - VF/CH**	**Fabric 2b - VF-F/CH**	**Fabric 2d - VF-F-Ca/CH**	**Forming method**
Conical bowl with straight wall (type A1b)	1	1		Method 1 (1 pc)
Conical bowl with straight wall (incised decoration) (type A1b)	1			nd
Conical bowl with arched wall (type A1c)			1	nd
Elongated spherical vessel (type B1a)			1	nd
Elongated spherical vessel (pinch decoration) (type B1a)		1		nd
Vessel with cylindrical neck (type B1b)			1	nd
Globular storage vessel (type B1f)	1			nd
Globular vessel (pinch decoration) (type B1g)		1		nd
Total	**3**	**3**	**3**	**1**

Table 4 – Distribution of fabrics and building methods to vessel types associated with House A45 (nd = non determinable).
Tabl. 4 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A45 (nd = indéterminé).*

House M1	**Fabric 1a - VF/CH**	**Fabric 1b - VF**	**Fabric 2b - VF-F/CH**	**Fabric 3 - F-M-Ca/CH**	**Forming method**
Conical bowl with arched wall (type A1c)			1		nd
Vessel with cylindrical neck (type B1b)			1		nd
Vessel with cylindrical neck (incised decoration) (type B1b.5)	1				Method 1 (1 pc)
Globular storage vessel (type B1f)		1		1	nd
Biconical vessel (fine ware) (type B2a)			1		nd
Slightly biconical vessel (fine ware) (type B2d)	1				nd
Total	**2**	**1**	**3**	**1**	**1**

Table 5 – Distribution of fabrics and building methods vs vessel types associated with House M1 (nd = non determinable).
Tabl. 5 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison M1 (nd = indéterminé).*

Pit 5356	Fabric 1a - VF/CH	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Forming method
Conical bowl with straight wall (type A1b)		1	1	nd
Hemispherical bowl (type A2a)			1	nd
Globular storage vessel (type B1f)	1			nd
storage vessel	1			nd
Total	**2**	**1**	**2**	**0**

Table 6 – Distribution of fabrics and building methods vs vessel types in Pit 5356 (nd = non determinable).
Tabl. 6 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la fosse 5356 (nd = indéterminé).*

Máriaasszony-sziget, while Method 2 was predominant in the Körös assemblage from Nagykörű-Tsz. Gyümölcsös (Gomart, forthcoming). Thus, similarly to raw materials, the forming methods identified in the earliest features of Balatonszárszó show strong similarities to Early Neolithic forming processes.

Style group 2

The characteristics of vessels in Style group 2 are similar in general to those observed in Style group 1. However, one of the main distinguishing features between them is the appearance of incised wavy lines around the circumference of the vessel. Another specific change is that burnishing appears less often; however, this may be caused by abrasion, since vessel surfaces from both examined houses are quite worn. As the number of sherds in each house is similar, they provide a good comparative assemblage for assessing household ceramic technologies. Although there are high numbers of conical bowls in both houses, there are clear differences in the number of fine wares. Biconical vessels in rounded versions, which were characteristic in Style group 2, are more common in House M1 than in House A45. Amongst the coarse wares, large storage vessels are more common in House M1. As a result, different types of knob decoration (mainly on storage vessels) show more variability, and rounded knobs with multiple finger impressions are particularly common. Different types of pinched decoration are clearly characteristic of House A45.

Style group 2 shows changes in the raw materials of vessels (tables 4–6). The most characteristic fabrics (1a, 2b, 2d) of Style group 1 are still present, but new raw materials also appeared. One is a very fine-grained raw material without tempering (Fabric 1b); the other is coarser (and calcareous) but still tempered with chaff (Fabric 3). An interesting point here is that House A45 does not show change, while House M1 does, indicating that different households were affected differently by changes in ceramic technologies.

The most notable change is the appearance of raw materials without chaff tempering. Thus one observes towards the later periods of the site a marked difference in the use of chaff tempering, as well as the use of calcareous raw materials and a clear preference for coarser raw materials with or without chaff tempering. These changes have been observed at a site level in general (Kreiter et al., in press) and also at a regional level (Kreiter et al., 2013). However, by examining these changes at a household level it seems that they appear gradually and differently in the examined houses. Thus, houses belonging to the same style group show differences in the technology of their vessels. This implies that different households adapted to changes differently, showing different social dynamics.

Data on fashioning are scarce for Style group 2. Only two vessels, both associated with Method 1 (coiling followed by beating), could be determined. One of them comes from House A45 (conical bowl), the other from House M1 (vessel with cylindrical neck).

House A47	Fabric 1a - VF/CH	Fabric 1b - VF	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Forming method
Conical bowl with arched wall (type A1c)		1	1		nd
Vessel with cylindrical neck (type B1b)	1				nd
Globular storage vessel (type B1f)			2	1	nd
Globular vessel (type B1g)			1	1	nd
Total	**1**	**1**	**4**	**2**	**0**

Table 7 – Distribution of fabrics and building methods vs vessel types associated with House A47 (nd = non determinable).
Tabl. 7 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A47 (nd = indéterminé).*

House A28	Fabric 1b - VF	Fabric 2b - VF-F/CH	Fabric 2c - VF-F-Ca	Fabric 2d - VF-F-Ca/CH	Forming method
Conical bowl with straight wall (type A1b)		3	1		nd
Conical bowl with arched wall (type A1c)		1			nd
Vessel with cylindrical neck (type B1b)		1		1	Method 1 (1 pc)
Globular vessel (fine ware) (type B1c)	1	1			nd
Globular storage vessel (type B1f)				1	Method 3 (1 pc)
Not thin sectioned					Method 1 (18 pcs), Method 3 (15 pcs)
Total	**1**	**6**	**1**	**2**	**35**

Table 8 – Distribution of fabrics and building methods vs vessel types associated with House A28 (nd = non determinable).
Tabl. 8 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A28 (nd = indéterminé).*

House A17	Fabric 1a – VF/CH	Fabric 2a – VF-F	Fabric 2b - VF-F/CH	Fabric 2c - VF-F-Ca	Forming method
Conical bowl with arched wall (type A1c)		1			nd
Conical bowl with arched wall (Notenkopf) (type A1c)	1				nd
Vessel with cylindrical neck (type B1b)			1		nd
Globular storage vessel (type B1f)				1	nd
Globular storage vessel (pinched decoration) (type B1f)			2		Method 3 (1 pc)
Storage vessel			1	1	Method 1 (1 pc)
Not thin sectioned					Method 1 (12 pcs), Method 3 (6 pcs)
Total	**1**	**1**	**4**	**2**	**20**

Table 9 – Distribution of fabrics and building methods vs vessel types associated with House A17 (nd = non determinable).
Tabl. 9 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A17 (nd = indéterminé).*

Style group 3

This group shows more diversity, not only in technology but in typology as well. Several elements of the early LBK (Style groups 1 and 2), such as vessels with incised spiral decoration and meander motifs, are still present. In some features, rounded biconical vessels also appear. In correlation with the appearance of raw materials without tempering, fine wares with thinner walls and arched conical bodies become common. These vessels are usually decorated with incised arched intertwining lines around the circumference of the vessel and with secondary motifs, occasionally with lines ending in music notes. Burnishing the whole surface of the vessels is also common.

The typological characteristics of vessels of the selected houses show clear differences. This perhaps resulted from differences in customs among the houses, and/or their chronology was slightly different. The use life of vessels, like the use life of houses, can obviously be different. For example, in the case of House A47 the spatial distribution of ceramics and the stratigraphy of postholes and some pits suggest that this house may have been extended into a larger building (Oross, 2013, p. 249-250). Characteristics of early LBK ceramics mainly appear in House A28, while the early Keszthely style is more characteristic of House A47, despite the fact that the latter house is located on the southern edge of the northern part of the settlement, which is connected to the early LBK occupation. Notenkopf ceramics are characteristic of both houses. In the pits of House A17 however, apart from Keszthely type ceramics, Notenkopf vessels with red painted bands also appear. Moreover, the western flanking pit of this house also contained some Zseliz/Želiezovce style fragments decorated with intersected bands. These typological observations place House A17 at the transition from Style group 3 to 4.

Style group 3 shows that changes in raw materials and temper, which started in Style group 2, continued (tables 7–9; fig. 6). Assemblages corresponding to Style group 3 are regarded as representing the earliest stage of the late LBK period. However, our study suggests that Style groups 2 and 3 are both part of a broader process of transition with many substantial changes, which can be similarly observed in these style groups.

In the examined houses (A47, A28, A17) the most characteristic fabrics (1a, 2b, 2d) of Style groups 1 and 2 are still present, but chaff tempering started decreasing. New raw materials also appeared (fig. 6), such as very fine to fine without chaff tempering (Fabric 2a) and very fine to fine calcareous raw material without chaff tempering (Fabric 2c).

Similarly to the previous style groups it seems that changes appeared differently at household level: House A28 does not have the finest fabric with chaff tempering (1a), while the other two houses do. In a similar vein, A47 does not have a naturally calcareous fabric without tempering (2c), while the other two houses do. It seems that Style group 3 provides strong evidence for diversification of potting traditions within the community.

Fashioning techniques could be determined for Houses A28 and A17. In these two houses, the vessels were made either using Method 1 (coiling then beating) or Method 3 (slab building). Here again, no direct relationship between the shape of the vessels and their forming methods can be established. For example, the identified storage vessels from House A17 are made using either Method 3 or Method 1.

Style groups 4 and 5

These groups could only be distinguished from each other by the frequency of Zseliz/Želiezovce type ceramics, which are decorated with intersected bands (Marton, 2008, p. 204). Ceramics show similarities in these style groups in terms of surface treatment, such as burnishing and red painting. In the case of fine ceramics the presence of Keszthely style vessels is characteristic, but they show increased variability compared to Style group 3. A new element in the ceramic repertoire is the appearance of coarse wares with thinner walls, practically without decoration. In Style group 4, Zseliz/Želiezovce type vessels with incised or often painted decoration appear sporadically, while in Style group 5 they became much more common. As a result, the two houses (House A1 and A9) chosen from these style groups show considerable differences at the household level. There are remains of further four houses in the vicinity of House A9 which altogether seem to form a row (Marton, 2015, p. 70). Conjoining sherds from these houses, and considerable stylistic similarities between vessels, suggest that changes in ceramic technologies not only show correlations with individual houses but also with house groups. This assumption is strengthened by the fact that several pits around House A9 contained fragments of a number of special face-pots with incised and painted decoration. Such face-pots did not appear in other parts of the settlement.

House A1 and its associated pit complex (their relationship is attested by conjoining sherds) can be characterised by a large number of Zseliz/Želiezovce type ceramics showing high variability in incised decoration – and uniquely at this site, sherds with Sopot typological characteristics were also found; this cultural unit followed the LBK.

As regards raw material use in these style groups that represent the late LBK period, we see similar patterns to

House A9	Fabric 1b - VF	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Fabric 3 - F-M-Ca/CH	Forming method
Conical bowl with arched wall (type A1c)			1		nd
Hemispherical bowl (type A2a)		1			nd
Elongated spherical vessel (type B1a)			1		nd
Vessel with cylindrical neck (type B1b)			1	1	nd
Globular vessel (fine ware with Zseliz/Želiezovce decoration, type B1c)	1				nd
Globular vessel (type B1g)		1			nd
Total	**1**	**2**	**3**	**1**	**0**

Table 10 – Distribution of fabrics and building methods vs vessel types associated with House A9 (nd = non determinable).
***Tabl. 10** – Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A9 (nd = indéterminé).*

House A1	Fabric 1b - VF	Fabric 2a - VF-F	Fabric 2b - VF-F/CH	Fabric 2d - VF-F-Ca/CH	Fabric 3 - F-M-Ca/CH	Forming technique
Conical bowl with straight wall (type A1b)				1		nd
Hemispherical bowl (type A2a)				2		Method 1 (1 pc)
Flat bowl (type A2c)			1			nd
Vessel with cylindrical neck (type B1b)				2		nd
Globular vessel (fine ware) (type B1c)	1	1	1			nd
Globular storage vessel (type B1f)			2	1	1	Method 1 (1 pc)
Globular cooking vessel (type B1f)			1			nd
Globular vessel (type B1g)			2			nd
fragments with Zseliz/Želiezovce decoration		1		1		nd
Not thin sectioned						Method 1 (24 pcs), Method 3 (9 pcs)
Total	**1**	**2**	**7**	**7**	**1**	**35**

Table 11 – Distribution of fabrics and building methods vs vessel types associated with House A1 (nd = non determinable).
Tabl. 11 *– Distribution des groupes de pâte et des méthodes de façonnage en fonction de la morphologie des vases dans la maison A1 (nd = indéterminé).*

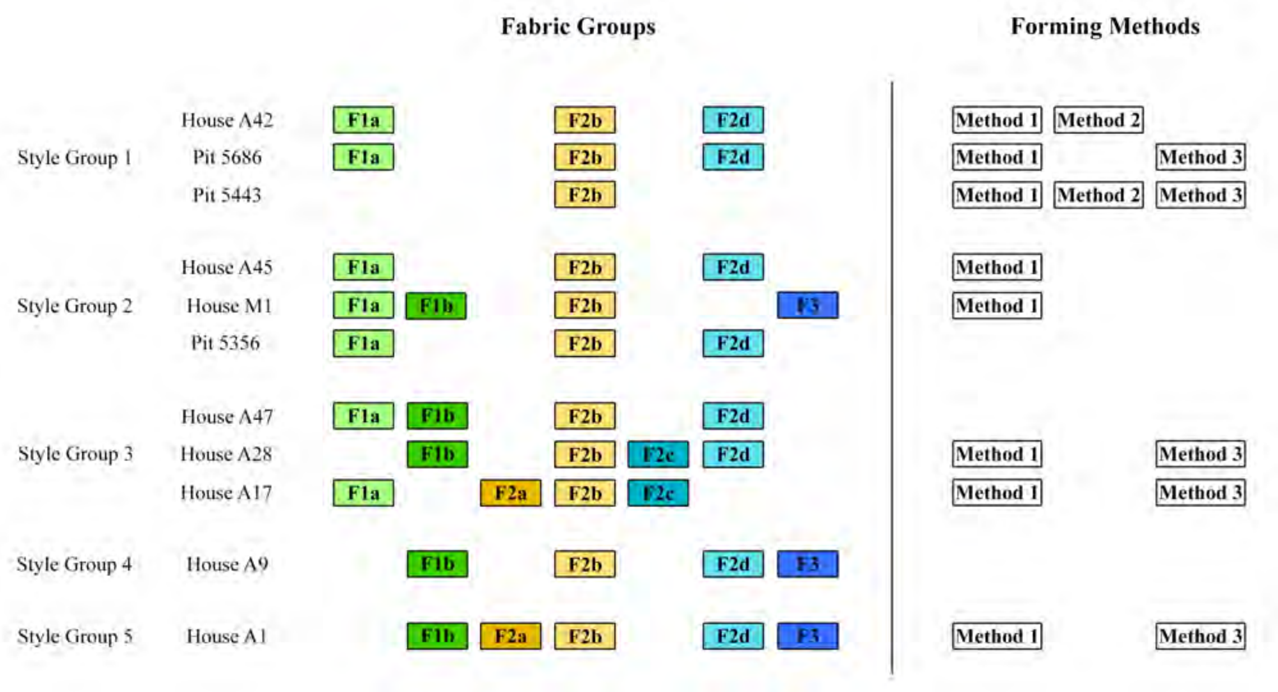

Fig. 6 – Changes in raw materials (potter's clay and added temper) and changes in fashioning techniques: the style groups of Balatonszárszó. Note the opposite tendency as for the variability of the raw materials and of the fashioning techniques. The number of raw materials increases while the number of forming methods decreases towards the late phases.
Fig. 6 *– Changements dans les matières premières (matériaux argileux et dégraissants ajoutés) et les méthodes de façonnage en fonction des groupes stylistiques à Balatonszárszó. On note des tendances opposées entre les matières premières et les méthodes de façonnage : le nombre de matières premières augmente, tandis que le nombre de méthodes de façonnage diminue au cours des phases récentes.*

those emerging in Style groups 2 and 3 (tables 10–11). Here again the most characteristic fabrics (Fabrics 2b and 2d) of Style groups 1 and 2 dominate, but the new raw materials that appeared previously are also present here. Fabrics without tempering (Fabrics 1b, 2a), which appeared in Style group 2, are present, as well as coarse, naturally calcareous raw materials (Fabric 3).

The fashioning techniques of House A1 show that vessels were made using either Method 1 or Method 3, while in House A9 fashioning techniques were not identifiable. As for changes in fashioning techniques in Style groups 3–5, Method 1 and 3, which were predominant in Style group 1, remain the most characteristic in the studied samples. On the contrary, Method 2, which is characteristic of the Körös site of Nagykörű-Tsz. Gyümölcsös, is no longer present. This trend was also observed in the larger studied sample from Balatonszárszó. The possible disappearance of Method 2 from the settlement could be related to specific social processes. In the current state of data, it could be interpreted either as the departure of one group of producers from the settlement or as an homogenisation of forming practices over time, caused by increasing interactions between different groups of producers. The latter hypothesis is reinforced by the identification of a 'mixed' vessel, made using techniques characteristic of both Method 1 and Method 2, suggesting close interaction between producers originating from different learning networks from the beginning of the settlement occupation. Other examples of technically 'mixed' vessels have also been found in the larger examined sample. Bearing in mind that fashioning constitutes a very stable step of the *chaîne opératoire*, these changes in forming practices over time could indicate profound social changes in the course of occupation of the settlement (Gosselain, 2002). On the other hand, higher variability in raw materials may also indicate diversification between potters, including intensified ceramic production when the number of producers increased.

By breaking down our analysis to vessel types and their raw materials/tempers and correlating these with houses (tables 1–11), we see that conical bowls (A1b, A1c, A1e) were made from the most common fabrics (Fabrics 1a, 2b, 2d) up until Style group 3, when their untempered versions appeared (Fabrics 1b, 2a, 2c) in all three analysed houses. Hemispherical bowls (A2a) were also made from the most common fabrics; however, their raw materials do not change in the late LBK period of the site. Vessels with cylindrical necks (B1b) also show only minor changes in their fabrics in Style group 4, when their coarser versions appeared with chaff tempering (Fabric 3). Globular fine wares (B1c, B1e) show similar patterns to conical bowls: changes appeared in Style group 3, and in Style groups 4 and 5 their untempered versions appeared in all analysed houses (A28, A9, A1). Two samples of globular fine wares with Zseliz/Želiezovce decoration are also untempered (Style groups 4 and 5). One sample from Style group 5 is chaff tempered. The fabrics of globular storage vessels do not show a clear pattern; untempered versions (Fabric 1b) of this type (B1f) appear in Style groups 1 and 2 but were not observed in other style groups. Elongated spherical vessels (B1a) do not seem to have changed. They were made from the most common fabrics even in Style group 4, but no vessel of this type was found in the analysed houses from Style group 5. Biconical fine vessels (B2a, B2b, B2c) were also made from the most common fabrics. In the case of this type it is important to note that its form gradually became more globular (B1c, B1e). The untempered versions of the latter types appeared in the late LBK related style groups. To summarize the raw material changes in vessel types, it seems that conical bowls and globular fine wares were the most susceptible to changes. What is more, changes in their raw materials could be detected in all analysed houses.

The changes that we find in raw materials of the different vessel types correspond well with changes in vessel forms. The late LBK related style groups (Style groups 4 and 5) at Balatonszárszó are associated with greater vessel form diversity, increasing elaboration, and diversity in decoration (mainly for globular forms). Decorations and vessel forms are considered to be susceptible to change and more exposed to social relationships (e.g. Dietler and Herbich, 1994; Gosselain, 2000; Arnold, 2008). This is because, by living close to each other, sharing similar activities, or attending the same market places or other sites of social interaction, people have and use the opportunity to exchange goods and ideas without necessarily engaging in close relationships (Gosselain, 1999 and 2000). Our results are in direct correlation with Gosselain's observations, and it seems that conical bowls and globular fine wares were the most affected by changes. The reason why the technology of these particular vessel types changed the most requires further research. Nevertheless, we witness profound changes at Balatonszárszó, which started in Style group 2 and continued in Style group 3. These changes, together with other developments at the site in settlement patterns, stone tools, burial customs and animal husbandry, are presumably key components of growing house identity and increasing social inequality (e.g. Dueppen, 2015). The earliest settlement shows loosely arranged houses—the settlement was farmstead-like—while in the late phase, in the southern part of the settlement, houses were closely built in rows (Marton and Oross, 2009, p. 56). The size of regular stone tools also shows changes: their size notably increased from the early phase to the late (Marton and Oross, 2009, p. 68). The absolute dating evidence shows that the dates of burials in the early phase match the dates of features close to them. Thus, burial within the settlement took place close to settlement features which were still in use. In the late phase, burials were located in the parts of the settlement that had aready been abandoned (Marton and Oross, 2012, p. 281). According to stable isotope analyses, in the early phase cattle grazed in forested areas and in the late phase on open pasture (Whittle et al., 2013, p. 96).

Petrographic results also suggest that wider selections of raw materials may have been governed by social strategies rather than by practical issues such as potters using the least effort to obtain their raw materials (e.g. DeBoer, 1984, p. 530–549). In Style groups 2–5 new raw materials emerged; but the oldest ones (Fabrics 1a, 2b, 2d in Style group 1) still remained in use. Furthermore, Style groups 2 and 3 are very similar to each other in terms of raw material preferences and stylistic attributes. This suggests a close relationship or interaction between the people of these style groups. In a similar vein, Style groups 4 and 5 are also very similar to each other. These observations offer some support to the preliminary assessment of site development, according to which the style groups could have overlapped chronologically – or some could even have been contemporary. Thus, Style groups 2 and 3 could have been contemporary and the same applies to Style groups 4 and 5. Consequently, a more dynamic picture emerges in which site development is not simplified into successive chronological phases.

Several studies show that clay selection involves technical and economic aspects as well as social and symbolic strategies (Barley, 1984; Sillar, 1997). Individual life histories and social relationships between potters influence their knowledge and learning techniques. Thus technological knowledge is influenced by social behaviour, which is constructed and re-negotiated by potters (Barley, 1984; Chávez, 1992; Sillar, 1997; Gosselain, 2008). Therefore, the selection of appropriate recipes depends on several factors such as social status, notion of tradition, conceptions of technical and functional constraints, relationships between potters and customers, and symbolic meaning of materials and practices (Barley, 1984; Chávez, 1992; Arnold, 2000; Gosselain and Livingstone Smith, 2005). That is, 'potters do not act randomly, but navigate throughout a narrow channel of culturally defined and shared practices' (Gosselain and Livingstone Smith, 2005, p. 41).

According to ethnographic studies, the most explicit changes occur when potters move into a new community as a result of marriages, or for other personal or economic reasons (for sub-Saharan African studies see Gosselain and Livingstone Smith, 2005, p. 42). These can considerably affect clay selection and processing strategies. If potters move to a community where there is pottery production already, they may be confronted with other practices while working with neighbours or meeting potters at clay mines or market places. In this way potters become aware of different practices which are also suitable for producing the desired vessel (Herbich, 1987; Longacre et al., 2000; Gelbert, 2001). Alternatively, they can maintain their practice for social, economic or identity reasons, or simply because they believe that changing their technological practice would change the quality of their products (David and Henning, 1972; Woods, 1984; Sillar, 2000; Wayessa, 2015). Change can also be driven by individual ambitions of potters when they see social and/or economic advantage (Gosselain and Livingstone Smith, 2005, p. 42).

Raw material preferences and forming techniques are considered to be the strongest traditions in potting (Gosselain, 2000; Gosselain and Livingstone Smith, 2005). Since there were changes in these technologies in the style groups, more fundamental changes have to be assumed in the social order at Balatonszárszó, which affected several aspects of the community's life. These changes were not 'superficial', affecting only the visible aspects of technology – in our case vessel forms and decorations – but raw material preferences and probably building techniques as well. While increased variability in raw materials seems to have led to random collections of individual strategies at site level, at household level these changes highlight the importance of the social context (houses) within which the vessels were used. Thus, in order to understand the social nature of variability in ceramic technology, we should also analyse it at a household since this is the context in which the vessels were used. The interesting point is that changes in raw materials and building techniques show at first glance opposite trends, but could in fact be related to the same social dynamics, namely increased interactions between producers. This observation offers potential to explore the different rhythms of change within one learning network, as well as the social dynamics they mirror.

CONCLUSIONS

In this study we analysed the ceramic technology of eight LBK houses and their associated features at Balatonszárszó, Hungary. A particular focus was placed on change and continuity in houses, across the ceramic style groups of the site. It has been shown that ceramic technology at Balatonszárszó was very dynamic through time. During the early LBK occupation only a restricted number of raw materials were used, which were all tempered with chaff. Moreover, some of these fabrics remained in use and were the most characteristic until the end of the site. Three forming methods have been recognized in the early LBK occupation, but no relationship could be identified between forming methods and vessel shapes, suggesting no adaptation of the fashioning gestures to the desired pottery shape. The same method could be used to make several shapes, and two different methods could be implemented to build the same shape. Thus at least three different "ways of doing" were present at the settlement, probably mirroring three distinct learning networks. The three identified forming methods are often simultaneously distributed in the different houses, which suggests strong interactions between different groups of producers.

In the late LBK occupation of the site new raw materials appeared, the most notable change being the appearance of raw materials without chaff tempering. This is a marked difference, revealing a clear break from the oldest ceramic technological tradition in the Hungarian Early and Middle Neolithic. Changes are also indicated by the use of calcareous raw materials and a clear preference for coarser raw materials, with or without chaff tempering, in the late LBK occupation of the site. Houses of the late LBK period show differences in the technology of their vessels, implying that different households adapted to changes differently and showing different social dynamics.

As regards vessel building techniques, Method 1 and 3, predominant in the earliest houses (Style group 1), remained the most characteristic among the studied samples. The possible disappearance of Method 2 from the settlement could be related to specific social processes, involving an increase in interaction between different groups of producers. Raw material preferences, along with fashioning techniques, are considered to be strong traditions in potting (Gosselain, 2000; Sillar, 2000; Gosselain and Livingstone Smith, 2005). Since changes in raw materials and tempers appeared in the style groups, and changes are identified in stone tools, burial habits and animal husbandry as well, fundamental changes have to be assumed in the social order at Balatonszárszó, affecting several aspects of the community's life. As far as pottery was concerned, these changes not only involved the visible aspects of technology, in this case vessel form and decoration, but raw material preferences and probably building techniques as well. Petrographic results show that conical bowls and globular fine wares were the most susceptible to change, the raw materials of these vessel types changing the most. Furthermore, changes in their raw materials could be detected in all analysed houses. The changes that we found in raw materials of the different vessel types correspond well with changes in vessel forms. The late LBK style groups of Balatonszárszó are characterised by greater vessel form diversity, increased elaboration, and diversity in decoration. The results suggest that the process of increased social differentiation at Balatonszárszó appeared in Style group 2 and Style group 3. The use of assemblages of these two style groups can be linked to the process that led to the establishment of the more extensive late LBK occupation in the southern part of the investigated area (Marton and Oross, 2009, p. 56).

As was highlighted above, fundamental developments occurred at the site which affected the whole community during the late LBK period. These changes have yet to be understood, but the analysis of ceramics at household level is a useful methodological tool for finding out where and how changes occurred within a settlement, thus providing evidence that can in turn be used to assess the nature and scope of social changes.

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Ceramic production and village communities during the Early Neolithic in north-eastern France and Belgium.

Issues regarding tempers and pot-forming processes

Louise Gomart, Claude Constantin, Laurence Burnez-Lanotte

Abstract: This article examines the links between tempers and forming processes within Linear Pottery (LBK) and Limburg ceramic production in north-eastern France and Belgium. Its aim is to analyse, by means of two case studies, variation patterns within these two key steps in the *chaîne opératoire*, for which several ethnographic studies have shown different variation patterns over space and time, and according to several social processes.

The questions asked involve the issue of archaeological recognition of ceramic traditions and their interpretation in terms of social and cultural identity: does the morpho-dimensional unity of LBK ceramics go hand in hand with a uniformity in technical behaviours spanning the various stages of the operational sequence? How is ceramic production organised within settlements? How are the different distribution networks organised? Do Linear Pottery vessels and Limburg vessels involve shared know-how? The identification of clay recipes and their correlation with various forming methods offers a complex vision of the ceramic production contexts. In fact, this approach allows us to understand the dynamics of persistence *versus* transformation of technical practices and also sheds light on knowledge exchanges between groups of producers.

The analyses carried out on both sites have not revealed a clear-cut relationship between clay recipes and pot-forming methods. The spatial and temporal variations identified suggest that within the same apprenticeship network, producers maintain their habitual practices in terms of the forming of vessels, but may change or adjust their clay recipes depending on the production site or the type of vessel that they intend to produce. While actions associated with pot-building are stable over time, the stages of clay preparation appear to vary depending on the interactions between producers.

This investigation also offers new elements for understanding the social structure of the LBK communities. For the site of Cuiry-lès-Chaudardes (Picardy, France), analysis of the spatial distribution of LBK technical traditions, defined on the basis of forming processes relative to the distribution of temper types, suggests a domestic production carried out by several groups of producers with complex settlement dynamics throughout the occupational sequence. For the site of Rosmeer (Limburg, Belgium), data regarding the LBK and Limburg vessels do not allow analysis at a house scale. Nonetheless, cross-analysis of clay-mixes and forming processes has allowed us to identify mechanisms of stylistic imitation and technical transfer between a group of producers, whose production is spread out among the various houses in the village, and who were engaged in the manufacture of Linear Pottery-style ware, and a group of producers who where essentially making Limburg vessels distributed within a particular sector of the village.

Keywords: Linear Pottery (LBK), Limburg, clay, temper, forming techniques, *chaîne opératoire*, know-how, household, apprenticeship networks.

Résumé : Cet article traite des liens entre recettes de pâtes et façonnage au sein des productions céramiques rubanées et Limbourg dans le quart nord-est de la France et en Belgique au début du Néolithique. L'objectif est d'analyser, au travers de deux cas d'étude, les structures de variation de ces deux étapes clés de la chaîne opératoire, pour lesquelles plusieurs études ethnographiques ont montré qu'elles pouvaient varier différemment dans l'espace et dans le temps et selon divers processus sociaux.

Les questions posées engagent la problématique de la reconnaissance archéologique des traditions céramiques et de leur interprétation en termes d'identités sociales et culturelles : l'unité morpho-dimensionnelle de la céramique rubanée se double-t-elle d'une uniformité des comportements techniques au cours des différentes étapes de la chaîne opératoire ? Comment s'organise la production céramique au sein des villages ? Comment se structurent les différents réseaux de transmission ? Les vases rubanés d'une part et les vases Limbourg d'autre part intègrent-ils des savoir-faire communs ? La caractérisation des recettes de pâtes et leur confrontation aux méthodes de façonnage offre une vision complexe des contextes de production céramiques. Elle permet en effet d'appréhender les dynamiques de

« persistance versus transformation » des pratiques techniques, ainsi que les transferts de connaissance entre groupes de producteurs.
Les analyses menées sur ces deux sites ne permettent pas de conclure à une relation univoque entre recettes de pâtes et façonnage en contexte rubané. Les variations spatiales et temporelles identifiées suggèrent qu'au sein d'un même réseau d'apprentissage, les producteurs maintiennent leurs habitudes en ce qui concerne le façonnage, mais peuvent changer ou ajuster leurs recettes de pâte selon le lieu de production ou le type de récipient qu'ils souhaitent réaliser. Tandis que les gestes liés au façonnage paraissent stables dans le temps, les étapes de préparation des pâtes semblent varier au gré d'interactions entre producteurs.
Ces investigations offrent aussi de nouveaux éléments de compréhension de la structure sociale des communautés rubanées. Sur le site de Cuiry-lès-Chaudardes (Picardie, France), l'analyse de la distribution spatiale des traditions techniques rubanées définies sur la base des méthodes de façonnage par rapport à la répartition des types de dégraissants suggère une production domestique prise en charge par plusieurs groupes de producteurs, dont les dynamiques d'implantation au court de la séquence semblent particulièrement complexes. Sur le site de Rosmeer (Limbourg, Belgique), les données récoltées sur les vases rubanés et Limbourg n'autorisent pas une analyse à l'échelle de la maisonnée. L'analyse croisée des recettes de pâte et des méthodes de façonnage permet néanmoins d'identifier des mécanismes d'imitation stylistique et de transferts techniques entre un groupe de producteurs en charge de la production de style rubané répartie dans les différentes maisons du village et un groupe de producteurs fabriquant essentiellement des vases Limbourg concentrés dans un secteur du village.

Mots-clés : Rubané, Limbourg, poterie, matériau argileux, dégraissant, façonnage, chaîne opératoire, savoir-faire, maisonnée, réseaux d'apprentissage.

INTRODUCTION

As part of this workshop, we were invited to discuss the variation structures of clay recipes according to the forming processes in the context of the western Linear Pottery Culture (LBK). Several ethnographic studies showed that these two steps of the '*chaîne opératoire*' can vary differently over space and time and according to different types of socio-economical processes: they constitute in that sense key elements to assess producer trajectories and interactions (Gosselain, 2002; Gelbert, 2003; Gosselain and Livingstone Smith, 2005). Thus, while offering a refined understanding of the pottery production structure, this integrated analysis provides new insights into the sociology of the LBK villagers communities. In this paper we present, by means of two case studies, the variation patterns of these two steps of the operational sequence at the village level in order to understand who was in charge of the ceramic production, and also how the producers interacted through time (e.g. transmission of know-how) and space (e.g. borrowings, collaborations and exchanges).

Within LBK ceramic production, the morpho-dimensional homogeneity of which has often been highlighted, the decorative system appears at first sight to be the most variable element. A large number of ceramic studies have focused on this parameter: such works have given rise to extremely fine periodisation, which today constitutes the most precise sequence for the European Neolithic, with an analysis scale of 50 years (Soudský, 1962; Meier-Arendt, 1966; Modderman, 1970; Constantin, 1985; Pavuk, 2004; Lefranc, 2007; Marton, 2008; Ilett and Constantin, 2010; Meunier, 2012; Blouet et al., 2013). However, when it came to reconstructing the *chaînes opératoires* for the making of these vessels, there were very few elements available for understanding the social and technical contexts of production (Constantin, 1994; Bosquet et al., 2005; Gomart, 2014). While the formal characteristics of western LBK ceramics are particularly stable, two categories of vessels, distinguishable by their often open shape, their large size and their all-over ornament, occur in small quantities in certain assemblages: La Hoguette ware (mainly found in the Rhine basin in Germany and in eastern France), and Limburg ware (mainly found in Dutch Limburg, Belgium and north-eastern France; fig.1). The interpretation of the presence of these vessels in LBK sites has been the subject of intense debate for the past thirty years (for a detailed account of this research and a complete bibliography see: Manen and Mazurié de Keroualin, 2003; van de Velde, 2007; Crombé, 2009; Pétrequin et al., 2009; Constantin, Ilett et al., 2010). However, very little research was conducted with the aim of understanding the gestures implemented in their fabrication and in assessing their production context.

The current questions on LBK and Limburg/Hoguette wares raise the issue of archaeological recognition of the ceramic traditions and their interpretation in terms of social and cultural entities: does the morpho-dimensional unity of LBK ceramics go hand-in-hand with homogeneity of techniques? Can we highlight the coexistence of several apprenticeship networks in the LBK settlements? Was the ceramic production organised at the level of the household? Are LBK vessels, and Limburg/La Hoguette vessels, part of a shared know-how or do they instead reflect distinct technical milieus?

MATERIAL AND METHODS

In order to shed light on these questions, several LBK ceramic assemblages from north-eastern France and Belgium, occasionally including groups of Limburg ware[1], were studied from the point of view of clay recipes (Constantin and Courtois, 1985; Constantin, 1985 and 1994; Ilett and Constantin, 2010; Constantin, Allard et al., 2010; Gomart and Burnez-Lanotte, 2012; Constantin,

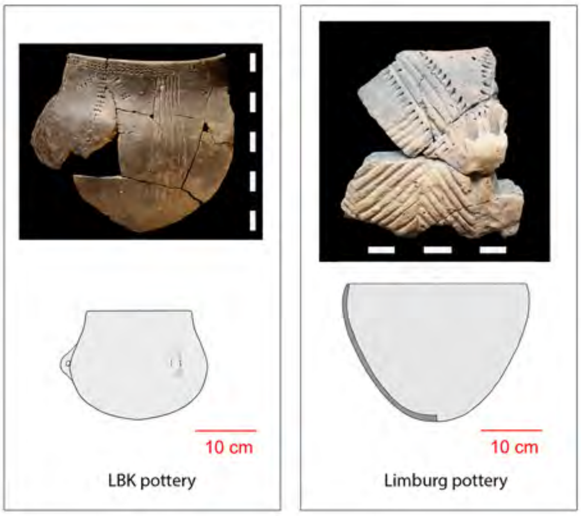

Fig. 1 – Characteristic decoration and morphology of LBK vessels (left) and of Limburg vessels (right).
Fig. 1 – *Décors et morphologie caractéristiques des vases rubanés (à gauche) et des vases Limbourg (à droite).*

forthcoming) and forming processes (Gomart, 2010; Gomart and Burnez-Lanotte, 2012; Gomart, 2014). All of these studies highlight the diversity in the technical behaviours of Early Neolithic pottery producers, a diversity that is evident in various steps of the *chaîne opératoire*. Here, we build on these studies in order to carry out the integrated analysis of the different ways of treating clay through the addition of temper and the 'ways of doing' (Roux, 2010) used for the forming of vessels.

Each step in the *chaîne opératoire*, defined as 'a series of operations which transform a raw material into a finished product' (Cresswell, 1976), may vary according to constraints related to the material and to cultural factors (Roux, 2010, p. 6). This double dynamic is a constituent of particular ways of doing things, the transmission of which leads to the creation of traditions. It is precisely the transmission mechanism that leads to the continuation of traditions. The traditional techniques employed by an individual are the result of a process of learning 'actions observed within a social group' (Roux, 2010, p. 6). At the end of this apprenticeship process, the skills necessary for creating a vessel are 'incorporated', so that the individual will have difficulty modifying his concepts and techniques before in turn passing them on (Bril, 2002; Roux, 2010). As a consequence, it is possible to establish a link between a technical tradition and a social group. These groups, or 'communities of practice' (Roux 2010, p. 6), correspond to dissemination networks or learning pathways. The sociological nature of these groups varies considerably because it is the result of different learning rules: it may, for example, involve distinct gender groups, a family, a caste, a faction, a class, a lineage, a clan, an ethnic group, a tribe, an ethno-linguistic group, etc. (Roux 2010, p. 4). The limits or 'frontiers' that can be observed between different technical traditions ultimately delineate the dissemination networks (Stark, 1998; Gosselain, 2008; Roux, 2010).

Technical traditions should not be seen as being frozen in time and space. In particular, studies of present-day situations describe instances of innovation (Shennan, 2002) and borrowing (Gelbert, 2003) which occur as a result of various processes such as direct or indirect contact, migration or wandering (Gosselain, 2010; Roux, 2010). Such changes do not necessarily affect all steps of the *chaîne opératoire*: producers may change their way of carrying out a single step as a result of innovations or borrowings from producers from different learning pathways, but may, at the same time, maintain their own methods for the other steps of the production process (Gelbert, 2003). More than any other formal or technical parameters, it seems that roughing out techniques are relatively resistant to change (Mayor, 2011). This stability may be linked to the process of 'incorporation' of skills at the conclusion of the apprenticeship period, resulting in 'automatisms that are difficult to alter' (Gosselain, 2002, p. 26), but may also be due to the fact that actions carried out in this step are invisible, or little visible, in the finished product (Gosselain, 2002). Other steps in the *chaîne opératoire*, which do not require specific technical competence or which are visible in the finished vessels (for example preparation of clay), may be more likely to undergo changes (Gosselain, 2002; Roux, 2010).

Taking these assumptions as a starting point, a cross-analysis was undertaken on the site of Cuiry-lès-Chaudardes 'Les Fontinettes' (Aisne, France). Featuring many houses, as well as a large corpus of ceramic finds, this site was ideal for a spatial and diachronic study of LBK pottery production. A second analysis was conducted for the site of Rosmeer (Limburg, Belgium). With a considerable amount of Limburg ware, the ceramic assemblage of this site lent itself particularly well to an evaluation of the technical know-how employed in the production of both LBK ware and Limburg ware.

For both assemblages, temper analysis (C. Constantin) was carried out on each individual vessel using a binocular microscope. This analysis focused on coarse-ware vessels, characterised by inclusions which were clearly visible to the naked eye (Constantin, 1985), as well as Limburg vessels, also characterised by the presence of clearly visible, non-plastic elements (Constantin, 1985). Fine-ware vessels characterised by the absence of inclusions which are clearly visible to the naked eye and the absence of intentionally added temper, were not included in this analysis. In the case of the pottery from Cuiry-lès-Chaudardes, thin sections were examined in order to validate the groups that were identified macroscopically. For the assemblage from Rosmeer, the observations made using a binocular microscope were compared to already existing reference material for Hesbaye and Hainaut in Belgium (Constantin, 1985; Constantin, Allard et al., 2010).

Secondly, the fine and coarse wares were examined in terms of the techniques and methods used in their forming (L. Gomart). In this regard, the characteristics of the surface topography (variations in texture and thickness, orientation of fracture networks), as well as the orientation of the non-plastic inclusions and the porosity in cross-section, were described for each vessel. The interpretation of macro-traces identified in terms of techniques and forming methods was based on several ethnographic and experimental reference studies (Shepard, 1956; Rye, 1981; Livingstone Smith, 2001; Gelbert, 2003).

It is important to note that the petrographic characterization of clay materials was exclusively conducted on fine-ware vessels from Cuiry-lès-Chaudardes (Ilett and Constantin, 2010; Gomart, 2014, p. 59). It is therefore too early to establish a petrographic classification of all vessels (fine- and coarse-ware vessels as well as Limburg ceramics in Rosmeer).

TEMPERS, FORMING AND LBK CERAMICS: THE EXAMPLE OF CUIRY-LÈS-CHAUDARDES (AISNE, FRANCE)

The site of Cuiry-lès-Chaudardes 'Les Fontinettes', which is the reference site for the LBK in the Aisne Valley, was the ideal site to address the issue of organisation of pottery production within LBK settlements. It has been extensively excavated and thirty-three, east-west oriented buildings of varying size have been discovered. No overlapping pits or buildings have been noted, which was optimal for spatial studies. In addition, the periodisation of the pottery decoration revealed three chronological phases (Ilett and Constantin, 2010; Ilett, 2012; Blouet et al., 2013) thus facilitating fine diachronic studies. Occupation of the settlement is estimated to have spanned about 150 years, covering the entire

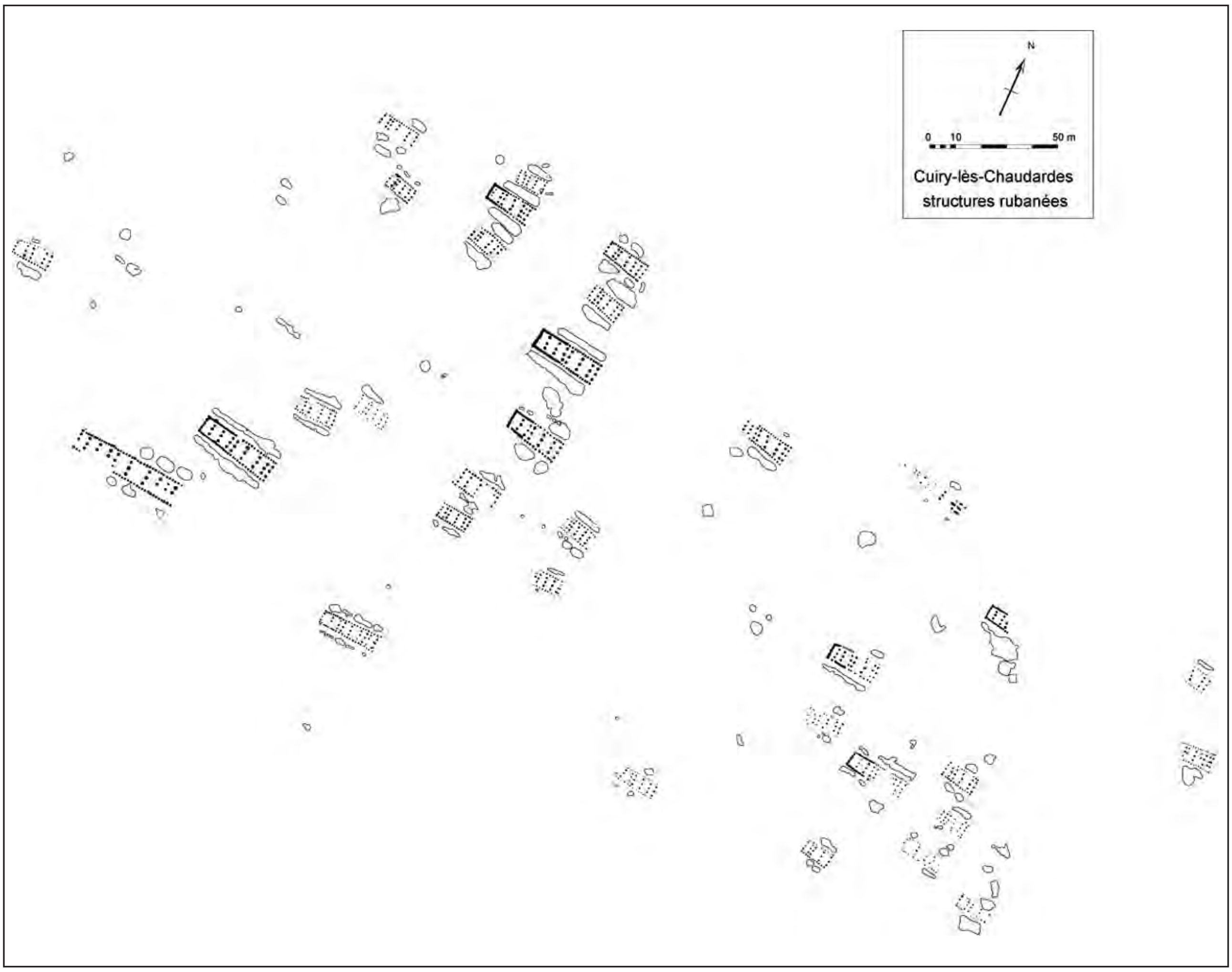

Fig. 2 – Plan of the LBK settlement of Cuiry-lès-Chaudardes (Aisne valley, France). The excavation limits are not shown.
***Fig. 2** – Plan du site rubané de Cuiry-lès-Chaudardes (Vallée de l'Aisne, France). Les limites de fouille ne sont pas indiquées.*

LBK sequence for the Aisne Valley i.e. 5,100-4,950 cal. BC (Dubouloz, 2003). The settlement was concentrated in the eastern part of the site during the first occupation phase, and then it spread westward during the second and third phases (fig. 2). Lateral pits flanking the buildings have yielded abundant and well-preserved archaeological assemblages for the entire chronological sequence, allowing us to investigate the daily activities of the village community.

The fact that no overlapping was observed between pits and that there are many instances where we can reassemble sherds from different pits associated with the same house leads us to suggest that the lateral pits are closely linked to each house. This theory is reinforced by the fact that all of the domestic units have yielded ceramic assemblages that are comparable in terms of morphology and dimensions, with equal proportions of decorated fine ware, undecorated fine ware, and coarse ware present, suggesting a complete set of vessels (Ilett and Constantin, 2010). Furthermore, the faunal assemblage from each house is systematically comprised of the same three domestic species (cattle, sheep/goat, and pig) and two wild species (deer and aurochs; Hachem, 2011). This regularity in the composition of the refuse assemblages of the site does not suggest random discard of waste within the village and leads to the assumption that remains in the lateral pits are generally a reflection of activities carried out within the household (Ilett and Hachem, 2001; Allard et al., 2013).

In terms of the study of the ceramic assemblage from Cuiry-lès-Chaudardes, 1,767 individual vessels displaying clearly visible technical macro-traces of building techniques and methods were included in the analysis. The vessels examined came from pits adjacent to the houses. After data processing, 1,145 individual vessels could be associated with a particular forming method: these included 537 fine-ware vessels and 555 coarse-ware vessels. Temper analysis focused on the coarse ware component of the assemblage: in the case of 497 vessels, it was possible to identify the inclusions added to the clay (Gomart, 2014, p. 59, table 4).

RAW MATERIALS AND TEMPERS

Locally-made pottery?

At Cuiry-lès-Chaudardes, the only direct evidence for ceramic production in the village takes the form of six bone tools, made from cattle ribs or fractured long bones, which use-wear analysis has revealed to have been used as potter's ribs (modelling tools) on soft clay (Maigrot, 1997).

Clay analysis (C. Constantin) carried out on the vessel assemblage (1,154 fine-ware vessels), using a binocular microscope and thin-sections, supports the hypothesis of on-site ceramic production. Over the entire period of occupation, two clay raw-materials were used: a clay material characterised by the presence of frequent limestone inclusions (Clay material 1: fig. 3a), as well as a clay material characterised by the presence of frequent quartz inclusions of sub-rounded to sub-angular form. (Clay material 2: fig. 3b; Ilett and Constantin, 2010; Constantin, forthcoming). Preliminary petrographic analysis carried out on six coarse-ware vessels suggests that the fine-ware and the coarse-ware were built using the same raw material.

By comparing the characteristics of these two ceramic materials with twelve clay deposits recorded in the surrounding area, it was apparent that Clay 1 originated from the Aisne floodplain silts, while Clay 2 originated from the remnants of an eolian deposit which survives on the limestone alluvial terrace and in shallow hollows within in the site itself.

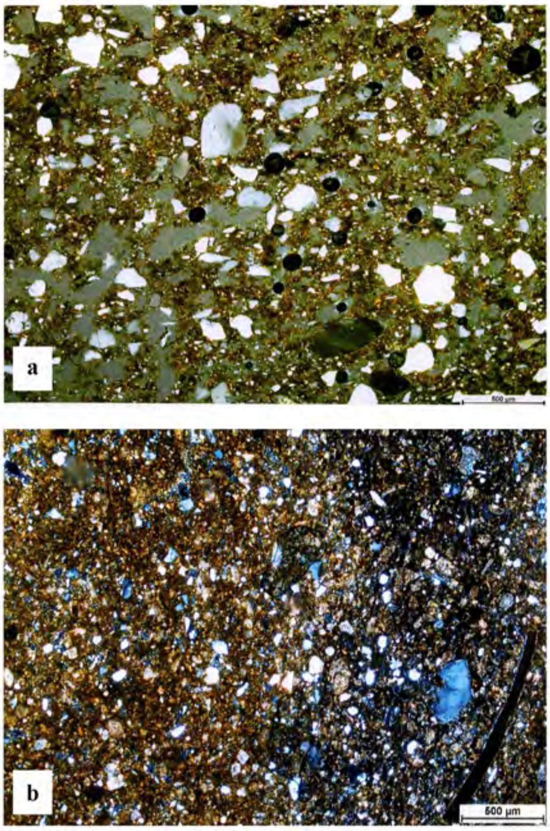

Fig. 3 – The two types of clay materials identified at Cuiry-lès-Chaudardes. a: clay material 1 characterised by the presence of frequent limestone inclusions; b: clay material 2 characterised by the presence of frequent quartz inclusions.

***Fig. 3** – Les deux types de matériaux argileux identifiées à Cuiry-lès-Chaudardes. a : matériau argileux 1 caractérisé par la présence de nombreux débris calcaires ; b : matériau argileux 2 caractérisé par de nombreux quartz.*

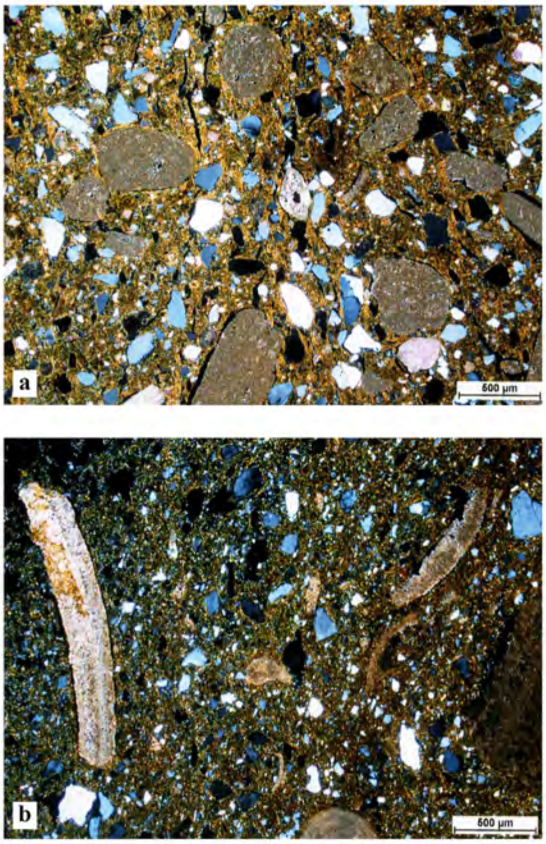

Fig. 4 – The two types of tempers identified at Cuiry-lès-Chaudardes. a: sand and limestone gravel; b: shell fragments.
***Fig. 4** – Les deux types de dégraissants identifiées à Cuiry-lès-Chaudardes. a : sable et gravier calcaire ; b : fragments de coquille.*

Two categories of temper

Analysis of the Cuiry-lès-Chaudardes pottery indicates the use of two types of temper, which were deliberately added to the clay and were very rarely mixed in the same pot.

First, sand and gravel (limestone) have been observed. They have a granulometry of between 1 mm and 5 mm (most commonly around 2 mm) and their relative quantities vary: they generally represent more than 10% of the volume and frequently represent up to 20-30% (fig. 4a).

Second, we find shell fragments and other calcareous debris, 1 to 5 mm in length and 0.2 to 0.5 mm in thickness, which occur in quantities of about 10 to 15% of the volume (fig. 4b). Some of these inclusions could be identified: they include bivalves (*Cyrena* cunéiformes), gastropods (*Turritella*), urchins (*Scutellina*) and miliolid limestone (identification by Christian Montenat, Institut Géologique Albert de Lapparent de l'Institut Catholique de Paris).

The pottery producers of Cuiry-lès-Chaudardes appear to have had ready access to these two types of temper. The sand and gravel temper was sourced on the alluvial terrace on which the site is situated and could be obtained during the digging of post holes and construction pits. The shell fragments could have been sourced in geological strata close to the site. The geological survey (Laurentiaux et al., 1972) indicates a limited zone of fractured Bartonian deposits, featuring decimetric *Coquina*, located on the south bank of the Aisne, less than 4km from the settlement site: this material includes diverse faunal remains including *Cyrena* which has been identified in temper. In addition, the lower Lutetian layers adjacent to and underlying the aforementioned area, and accessible within 2 km of the settlement site, contain abundant and diverse shell facies which include gastropods.

Finally, Thanetian and Ypresian layers, also accessible within 2 km of the site, contain macro-fauna including Turitella which has also been found among the temper fragments.

Diversity in pot-forming

The processing of data relating to methods for building pots has revealed significant technical variability. Twelve distinct 'ways of doing' have been identified (CCF1 to CCF12), four of which dominate the assemblage: CCF1, CCF2, CCF7 and CCF12. These different ways of forming are essentially distinguished on the basis of shaping techniques (use of a support to shape the base, use of the beating technique) and assembling procedures (differences in coils overlapping).

The first most commonly used way of doing, CCF1 (148 fine vessels and 204 coarse vessels), is characterised by the roughing-out of the base by arranging thin coils of clay in a spiral, and then pressing the base into shape in a concave mould. The body, neck and rim of the pot are then roughed-out using thick elongated coils, with alternate overlapping, which are then shaped with discontinuous finger pressure (see fig. 5 for a description of the diagnostic macro-traces). The second way of doing, CCF2 (239 fine vessels and 207 coarse vessels), comprises vessels that are entirely built using thin coils, which may or may not be slightly deformed when being laid down (see fig. 6 for a description of the diagnostic macro-traces). The bases of vessels associated with the third way of doing, CCF7 (42 fine vessels and 73 coarse vessels), have not survived. However, the bodies and rims of these vessels display very diagnostic macro-traces: the body is built of thin, non-deformed coils, while the rim is formed using a large folded band of clay (see fig. 7 for a description of the diagnostic macro-traces). The fourth common way of doing, CCF12 (20 fine vessels and 22 coarse vessels), also includes pots without preserved bases (see fig. 8 for a description of the diagnostic macro-traces). These vessels present macro-traces indicating that the body and rim were formed by superposition of thin coils which were then shaped using the beating technique.

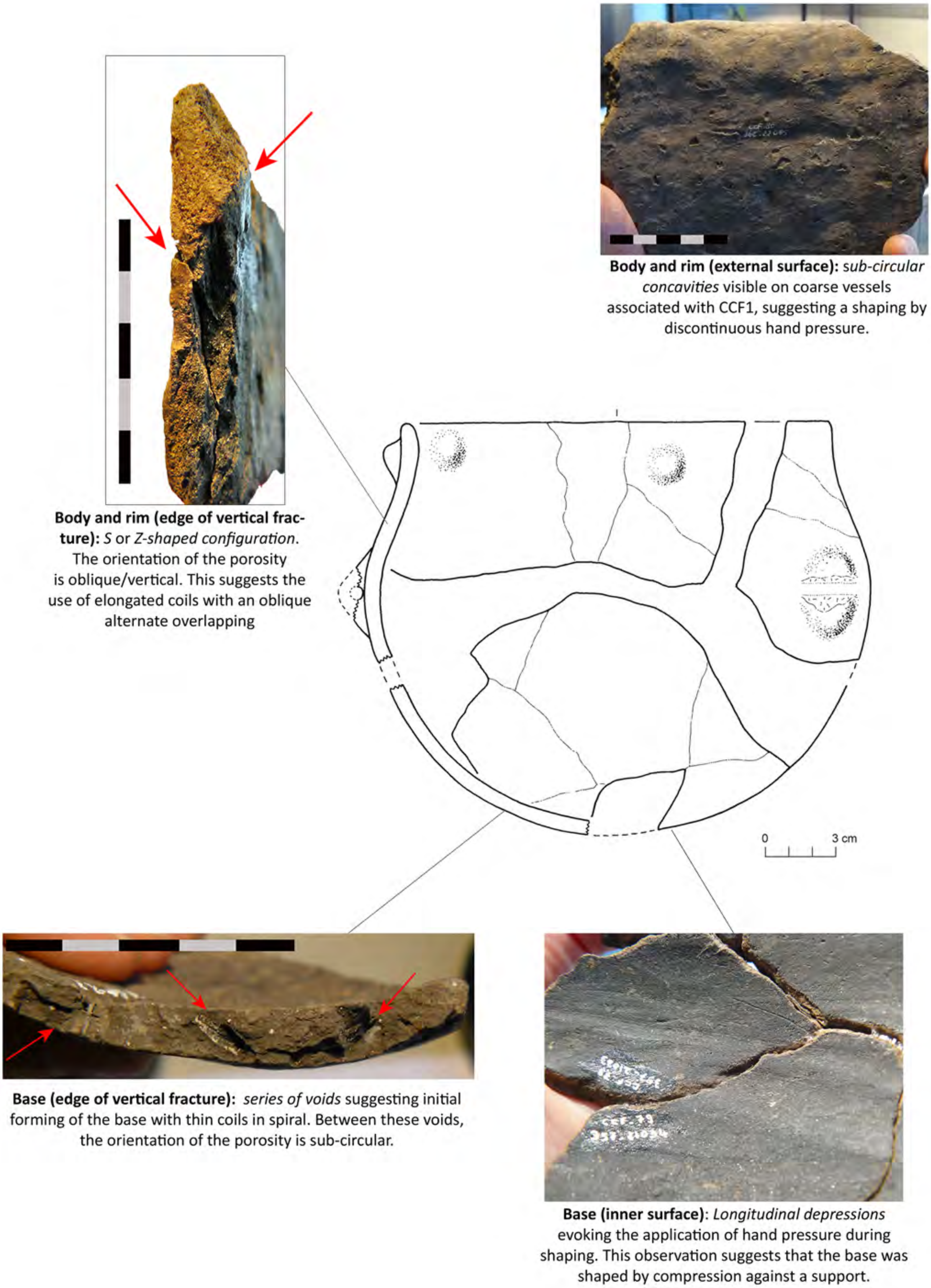

Fig. 5 – Characteristic macrotraces of the ceramic forming method CCF1 identified at Cuiry-lès-Chaudardes.
Fig. 5 – *Macrotraces caractéristiques de la méthode de façonnage CCF1 identifiée à Cuiry-lès-Chaudardes.*

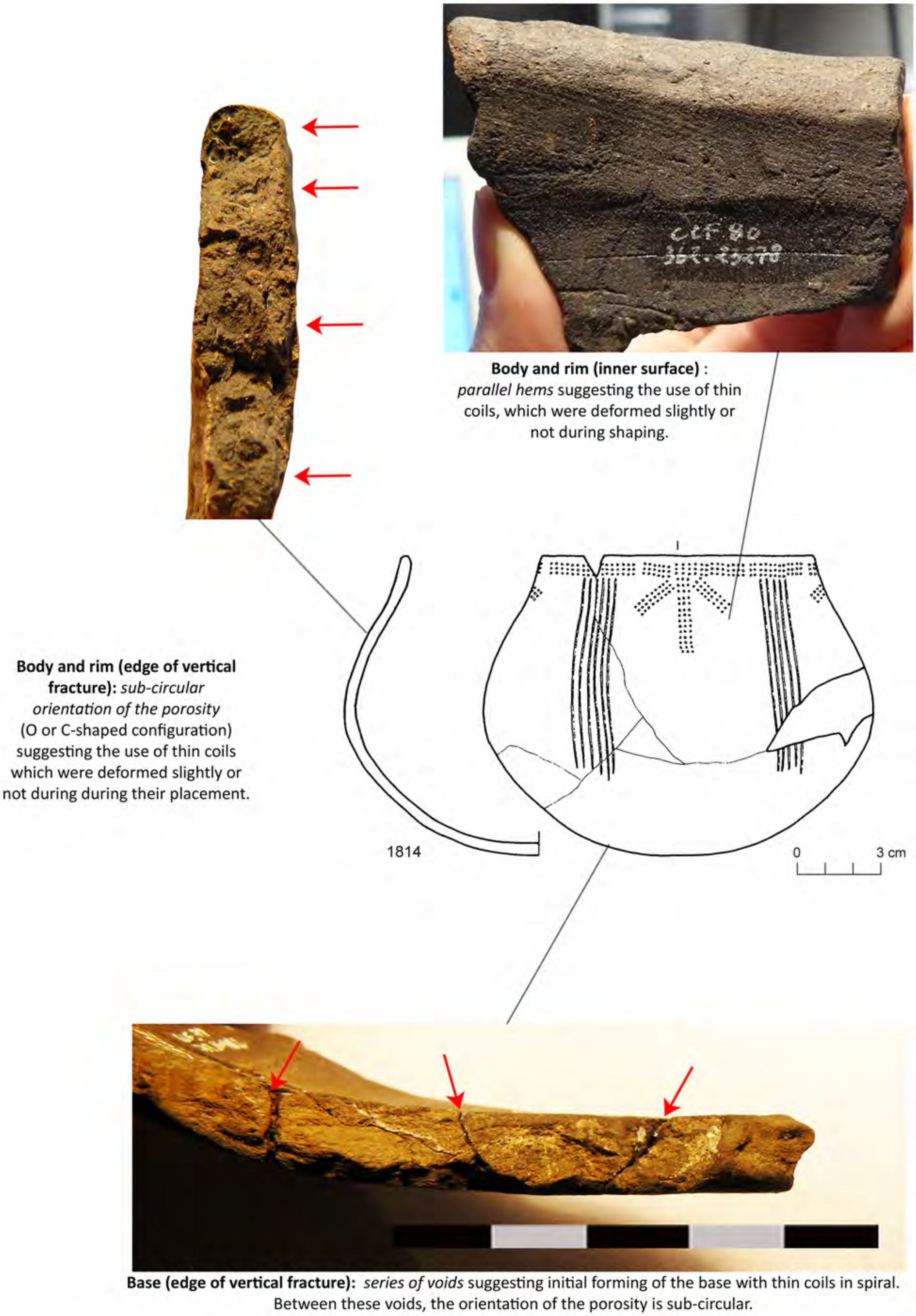

Fig. 6 – Characteristic macrotraces of the ceramic forming method CCF2 identified at Cuiry-lès-Chaudardes.
***Fig. 6** – Macrotraces caractéristiques de la méthode de façonnage céramique CCF2 identifiée à Cuiry-lès-Chaudardes.*

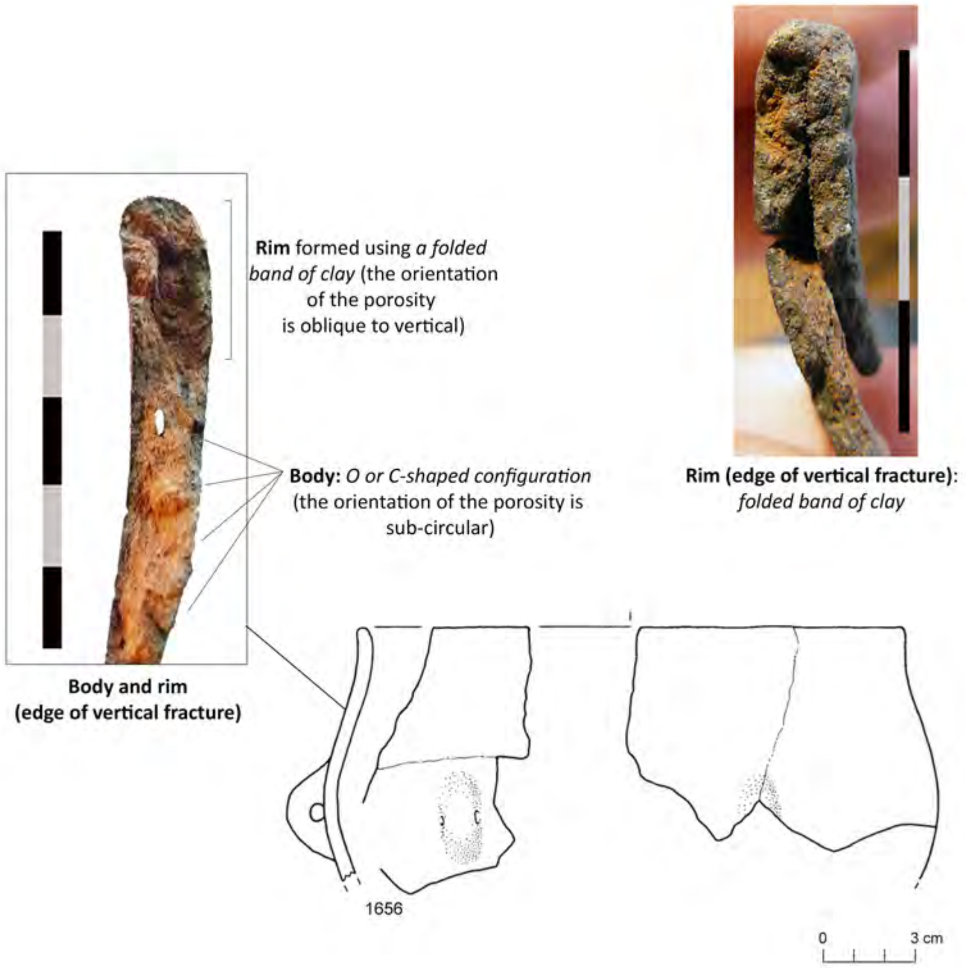

Fig. 7 – Characteristic macrotraces of the ceramic forming method CCF7 identified at Cuiry-lès-Chaudardes.
***Fig. 7** – Macrotraces caractéristiques de la méthode de façonnage céramique CCF7 identifiée à Cuiry-lès-Chaudardes.*

Tempers and pot-forming over time

The combined analysis of the two types of temper identified in the coarse-ware vessels and the four most common ways of forming shows some preferential associations during certain chronological phases (fig. 9 and 10; for detailed data, see: Gomart, 2014). CCF1, CCF 7 and CCF12 are thus predominantly associated with shell temper (70%, 86% and 70% respectively), while within CCF2 the limestone temper dominates (60%). Considering the variations of these associations throughout the three chronological phases, CCF1 is the only way of doing to present a gradual inversion in terms of temper use: the use of shell temper decreases from 91% during the first phase, to 55.8% during the second phase and finally to only 45.5% during the third phase. Thus, over the entire occupational sequence, there is no exclusive relationship between one forming method and one type of temper.

Tempers and pot-forming over space

On the basis of these observations, we have analysed the spatial distribution of the different temper types relative to ways of forming, for each occupation phase of the site. The results obtained were plotted on a plan of the village (fig. 11, 12 and 13): the way of forming that dominates the ceramic assemblage of each domestic unit is indicated by a specific colour on the plan. The tempers used for each predominant way of forming are represented in the form of pie charts. Only the four most common ways of doing (CCF1, CCF2, CCF7 and CCF12) are taken into account because the number of vessels representing the eight other ways of doing is too small to permit cross-analysis. These observations enable the following spatial and temporal schema to be proposed:

- during the earliest phase of occupation, there is remarkable homogeneity in the technical behaviour observed (fig. 11). CCF1 dominates in five out of the six houses present (houses 45, 390, 640 and 112, 126). House 90 situated at the centre of the settlement cluster, is the only house with a majority of vessels produced using CCF2. Houses 126 and 112, situated to the south of the centre of the settlement, are characterised by the use of CCF1 but have also yielded a significant proportion of vessels produced using CCF2. In terms of the tempers used,

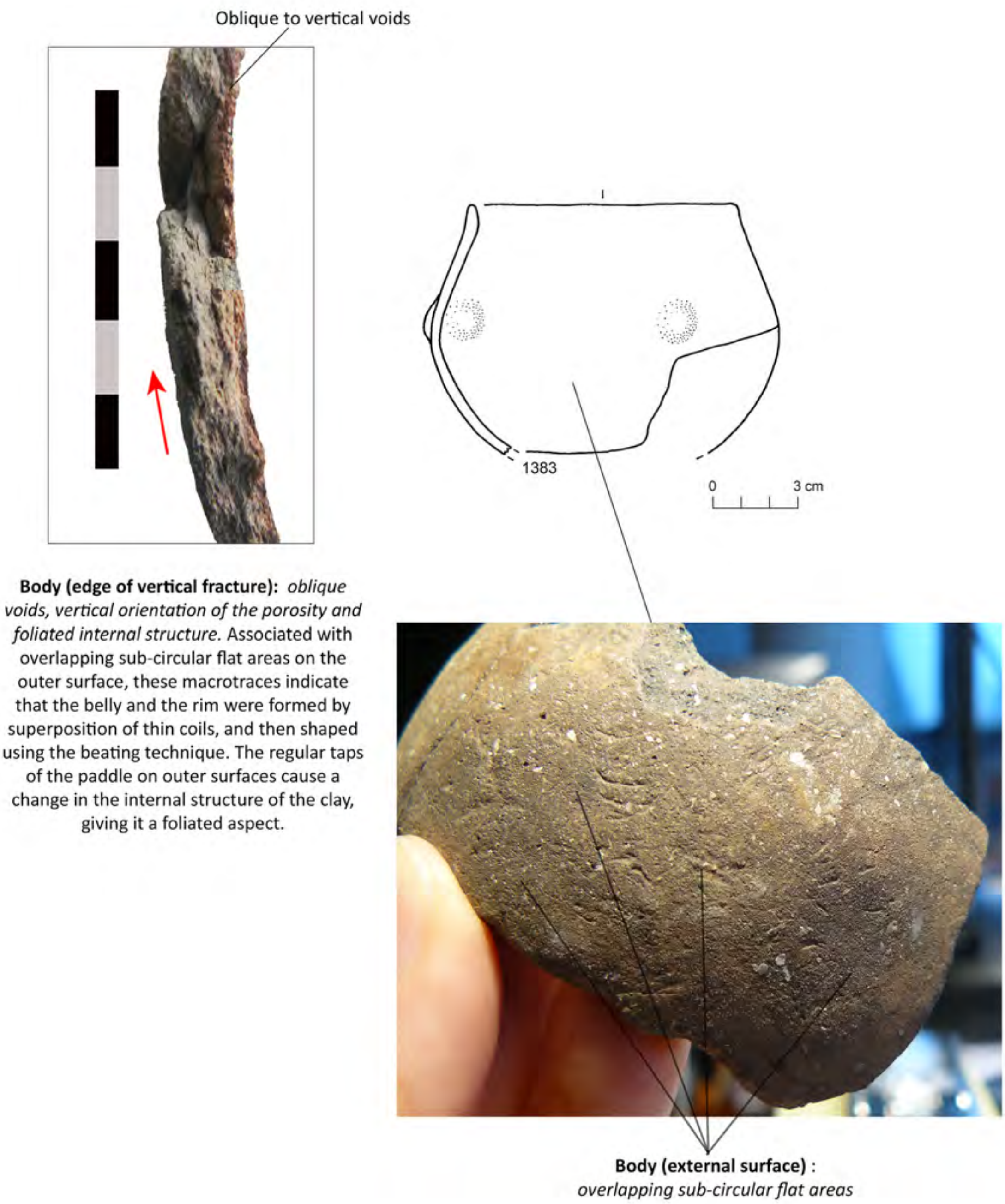

Fig. 8 – Characteristic macrotraces of the ceramic forming method CCF12 identified at Cuiry-lès-Chaudardes.
Fig. 8 – *Macrotraces caractéristiques de la méthode de façonnage céramique CCF12 identifiée à Cuiry-lès-Chaudardes.*

shell is clearly the predominant temper used in all of the houses characterised by CCF1. In house 90, the vessels associated with CCF2 are preferentially tempered using limestone, while those produced using CCF1 contain shell temper;

- during the middle phase, a diversification in the ways of pot-forming is observed (fig. 12). Certain houses are dominated by CCF1 (houses 330 and 400) while others are dominated by CCF2 (houses 570, 580 and 425; the last two also yielded a significant proportion of vessels produced using CCF1). A number of houses are characterised by two or three ways of forming in almost equal proportions: this is the case for house 440, which features a mixed assemblage of vessels produced using CCF1 and CCF2; house 89, characterised by a CCF7/CCF2 assemblage; and house 380 characterised by the presence of CCF1, CCF2 and CCF7. It was possible to identify the tempers used in all of the houses except from house 425. The distribution of tempers as a function of the pot-building methods used is not as homogenous as it was in the early phase. The two houses characterised by CCF1 (houses 330 and 400) do not present the same types of inclusion: shell temper prevails in house 330, while limestone temper is dominant in house 400. In houses 570 and

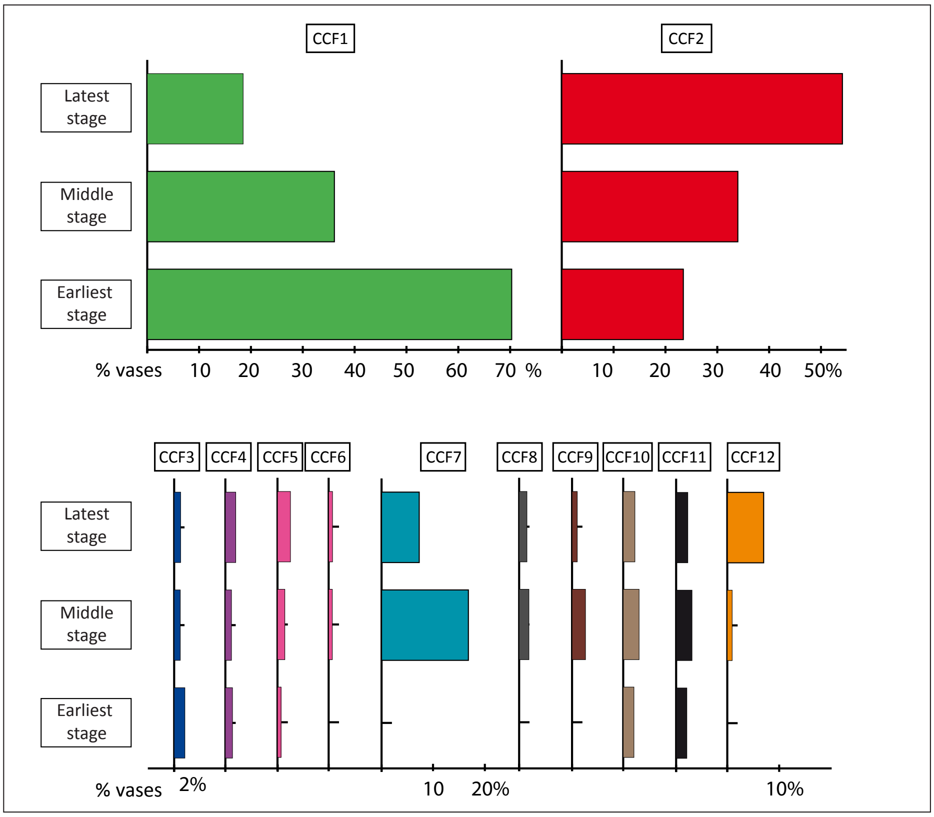

Fig. 9 – Percentage of vessels attributed to each of the twelve forming methods identified at Cuiry-lès-Chaudardes, for each occupation phase (diagram based on 968 vases).
Fig. 9 *– Pourcentage de vases attribué à chacune des douze méthodes de façonnage identifiées à Cuiry-lès-Chaudardes, par étape d'occupation (diagramme fondé sur 968 vases).*

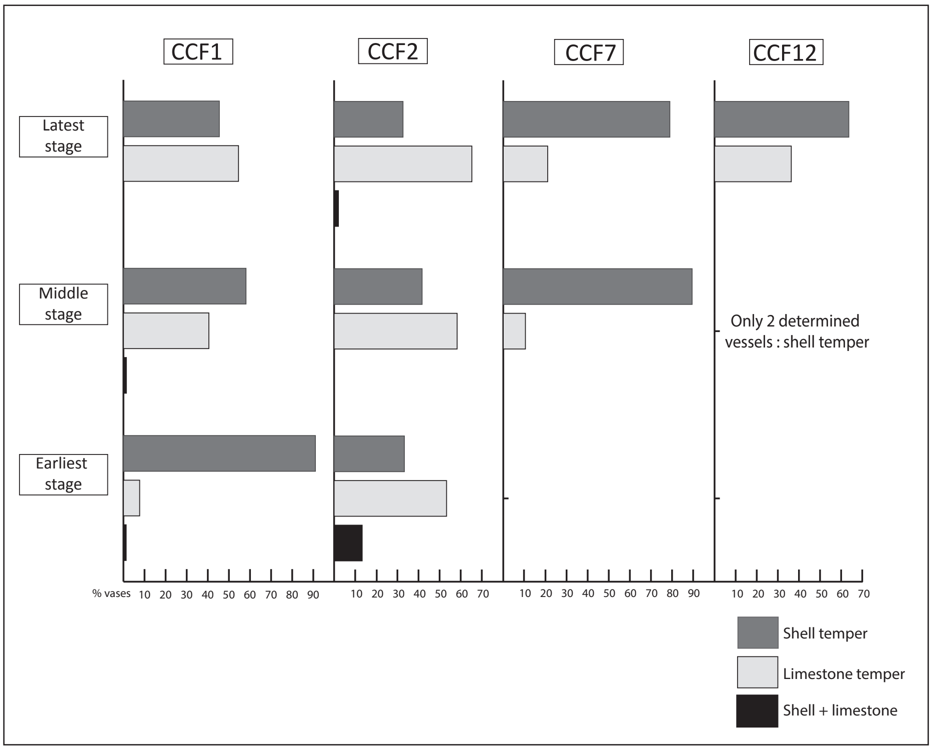

Fig. 10 – Use of the two types of tempers within the four prevailing forming methods in Cuiry-lès-Chaudardes, for each occupation phase (diagram based on 497 vases).
Fig. 10 *– Utilisation des deux types de dégraissants dans le cadre des quatre méthodes de façonnage prédominantes à Cuiry-lès-Chaudardes, par étape d'occupation (diagramme fondé sur 497 vases).*

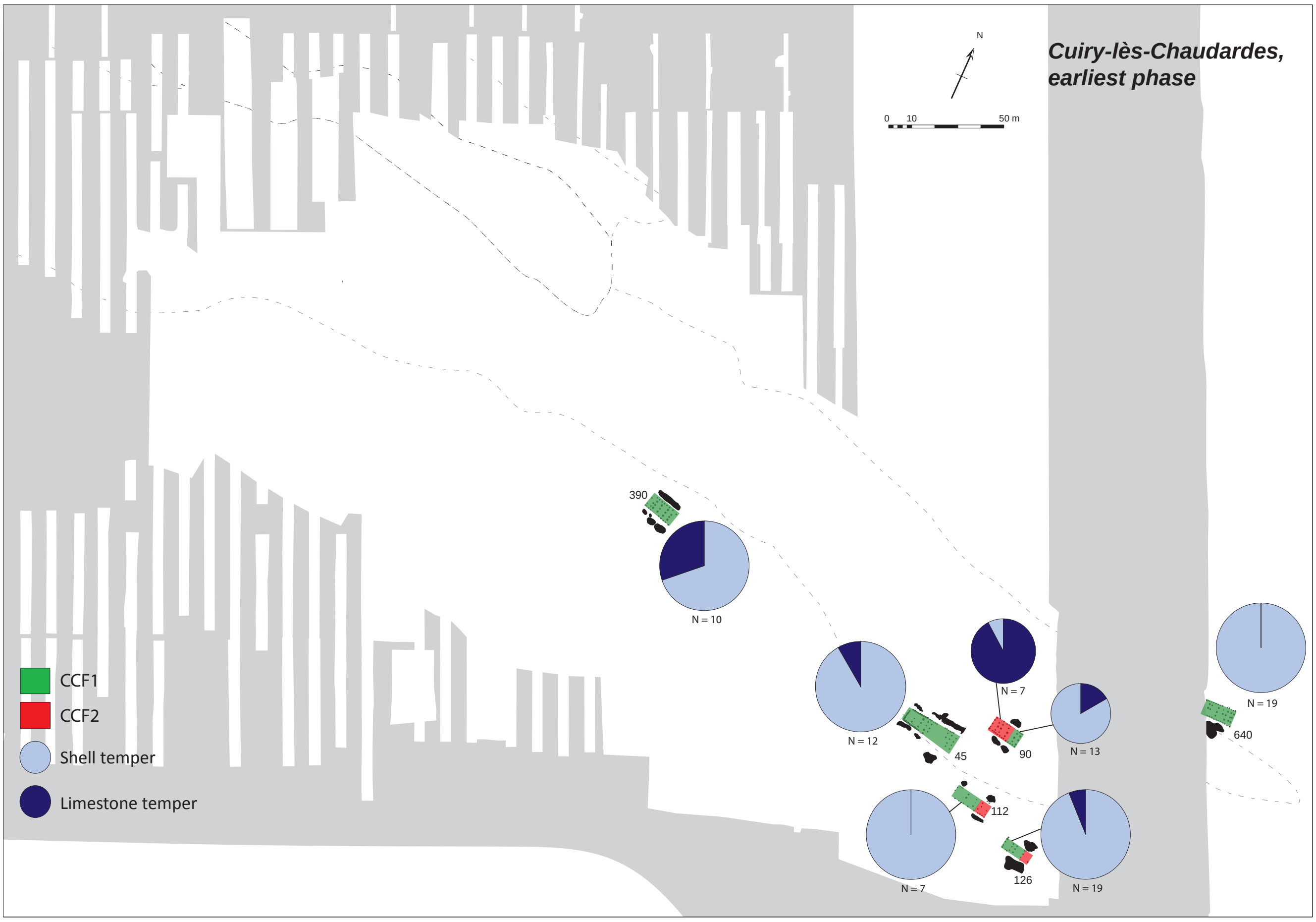

Fig. 11 – Distribution of the two types of tempers according to the forming method(s) prevailing in each housing unit at Cuiry-lès-Chaudardes, during the earliest occupation phase (step 1).

***Fig. 11** – Distribution des deux types de dégraissants en fonction de la ou les méthode(s) de façonnage majoritaire(s) dans les unités d'habitation de Cuiry-lès-Chaudardes, au cours de l'étape ancienne.*

580, characterised by CCF2, limestone temper predominates. In house 89, all of the vessels produced using CCF7 are tempered with shell. In house 440, shell dominates in vessels made using CCF1, but limestone dominates in vessels made using CCF2. In house 380, the nature of the temper varies from one way of forming to another: in terms of CCF1, the proportions of shell and limestone temper are almost equal; vessels produced using CCF2 are preferentially tempered with shell; finally, most of the vessels associated with CCF7 contain shell temper;

- the latest phase of occupation is characterised by a renewed homogenisation of pot-forming (fig. 13). Here, CCF2 dominates in five out of seven houses (225, 245, 280, 360 and 530), with CCF1 also present in the house 225 assemblage. These houses (225, 245, 280 and 360) are all situated in the southern part of the settlement core. The other two houses (690 and 420), which have yielded a mixed CCF1/CCF2/CCF12 assemblage, are located in the northern part of the village. As regards the tempers used, only the five houses characterised by the use of CCF2 can be used to draw conclusions regarding the nature of the materials used. Houses 225, 245 and 280 are all characterised by the use of limestone temper, while in houses 360 and 530 shell temper is predominant.

The distribution of pot-forming methods and tempers varies greatly over the entire occupation sequence for the site. All of the houses, without exception, are dominated by one to three ways of pot-forming and the tempers used are not correlated to the forming process used, except during the initial phase of the village when the majority of houses are dominated by the same clay recipe/pot-forming process.

When we correlate our observations with house size, it appears that homogeneity of manufacturing processes, namely the predominance of only one dominant way of pot-forming associated to one prevailing type of temper, mostly occurs in the largest houses, defined by 2 or 3 back units (CCF1: houses 45 and 360; CCF2: houses 225, 245, 280, 500 and 570). On the contrary, diversity of manufacturing processes, namely the presence of two to three prevailing ways of pot-forming that are not dominated by the same type of temper, mostly occurs in the smallest houses defined by a single back bay (houses 440, 580, 89, 690, 90, 126, 112 and 425). Differences

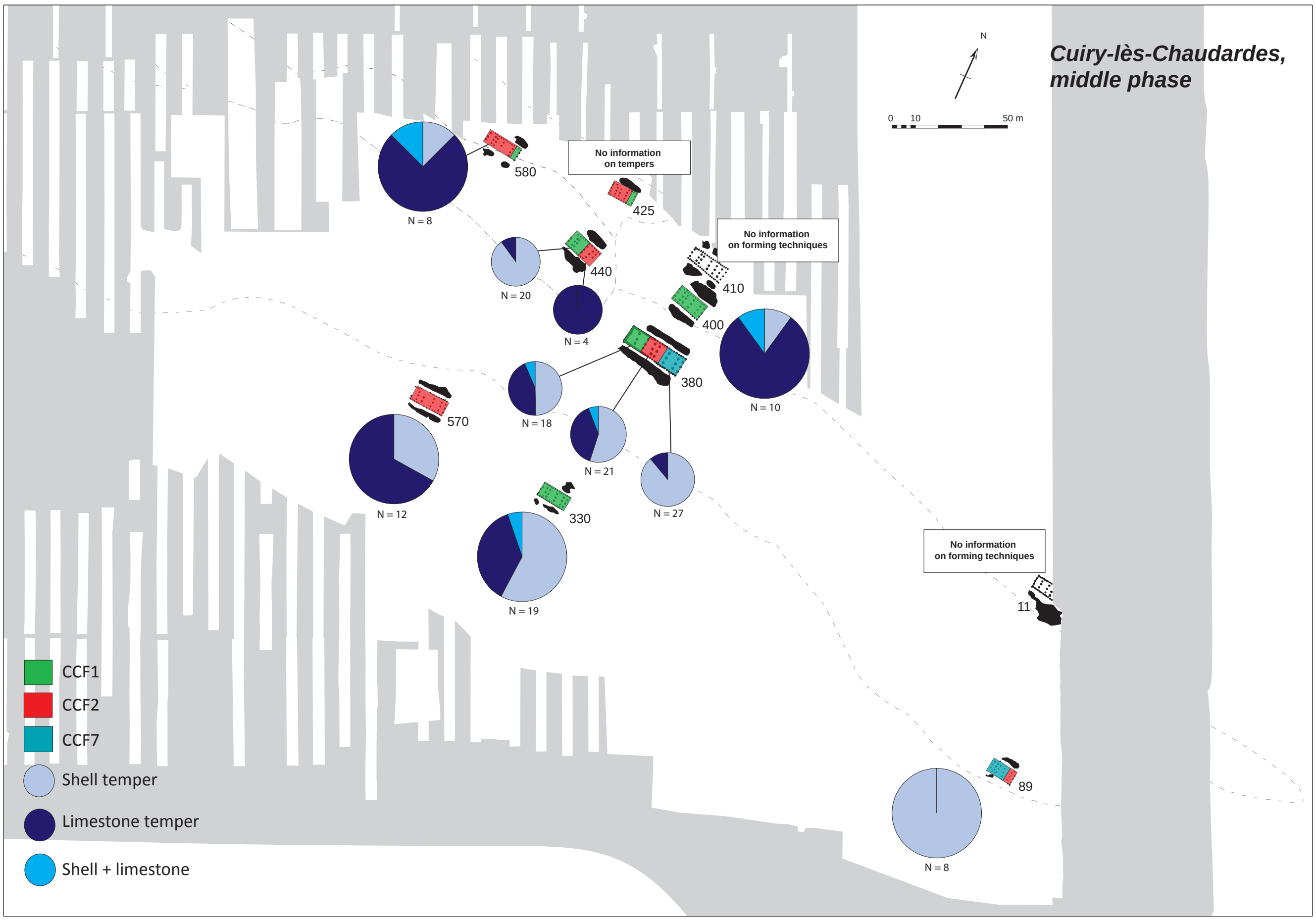

Fig. 12 – Distribution of the two types of tempers according to the forming method(s) prevailing in each housing unit at Cuiry-lès-Chaudardes, during the middle occupation phase.
***Fig. 12** – Distribution des types de dégraissants en fonction de la ou les méthode(s) de façonnage majoritaire(s) dans les unités d'habitation de Cuiry-lès-Chaudardes, au cours de l'étape moyenne.*

between the largest and the smallest houses can also be observed in terms of *continuity vs. novelty* of the forming processes (Gomart et al., 2015). The largest houses attributed to the second and third chronological stages are indeed all characterized by forming processes that were identified in the earlier phase (houses 330, 225, 245, 280, 500 and 360). In contrast, the emergence of new ways of forming throughout the sequence (CCF7 during the second phase and CCF12 during the third phase) occurs preferentially in the smallest houses (houses 89 and 690), which are located outside of the main settlement core (houses 89, 690 and 420).

Based on these results, several questions can now be asked in order to improve our understanding of the context of pottery production and the settlement dynamics of its makers.

Discussion

Structure of the pottery production and distribution within the settlement

None of the ways of doing identified is confined to a particular morpho-dimensional type and all of the vessels analysed were built using local raw materials: the technical diversity revealed cannot, therefore, be explained either in terms of function or non-local contributions. It appears, instead, to reflect diversity in the apprenticeship affiliations within the village (Gomart, 2010 and 2014).

The fact that the prevailing ways of pot-forming have been identified for several chronological phases of the site (fig. 9) and/or on other Western LBK settlements (Gomart 2014) implies that they were transmitted over time and suggests that each represents a technical tradition (Bonte and Izard, 2010; Roux, 2010). Inferring from ethnographic evidence, each of these technical traditions, reflecting a particular learning pathway, would have been unique to a particular group of producers (Latour and Lemonnier, 1994; Roux, 2010). At Cuiry-lès-Chaudardes, the ceramic assemblage thus suggests that there were four distinct groups of producers. In the current state of research, the eight other pot-forming methods identified, which occur in small quantities or within a single chronological phase, cannot currently be regarded as traditions but, rather, may reflect variability in terms of an individual producer or groups of producers.

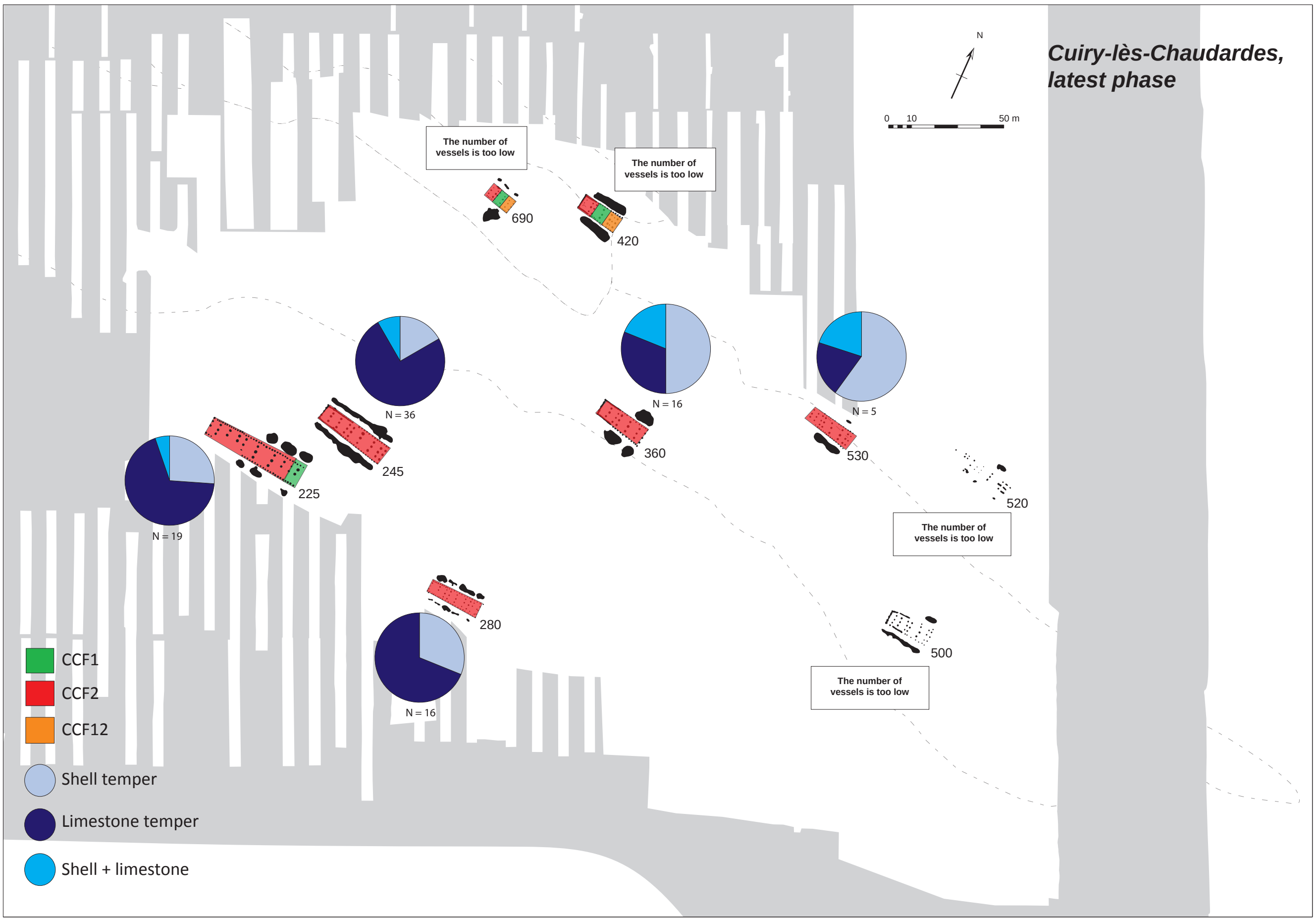

Fig. 13 – Distribution of the two types of tempers according to the forming method(s) prevailing in each housing unit at Cuiry-lès-Chaudardes, during the latest occupation phase.
Fig. 13 *– Distribution des types de dégraissants en fonction de la ou les méthode(s) de façonnage majoritaire(s) dans les unités d'habitation de Cuiry-lès-Chaudardes, au cours de l'étape récente.*

One of the issues to be tackled before we can attempt to assess the history of the village concerns the context of the pottery production. By examining the parallels between the four predominant traditions and the two types of temper used, we can make a number of important observations.

Thus, two houses attributed to the same chronological phase are not necessarily dominated by the same way or ways of building pots. Moreover, two domestic units dominated by the same way of building pots do not necessarily use the same temper when preparing their clay. This is for example the case in the third phase at Cuiry-lès-Chaudardes, where the houses in the south of the settlement are all dominated by CCF2, but do not appear to share the same temper (fig. 13). This observation suggests that the making of pots was not centralised. It seems that the producers shared the same way of doing to build their pots, but made different choices regarding the acquisition and use of tempers. If pottery production had been in the hands of a small group of producers and the vessels redistributed among the various houses, the production would undoubtedly be more homogenous at site level (Constantin, 1994). In fact, at Cuiry-lès-Chaudardes, all the evidence suggests that production was carried out at a domestic scale, in other words 'carried out by, and for, the household' (Jamard, 2010, p. 603). It appears therefore that most of the houses in the village were self-sufficient in terms of producing most of the vessels they required, just as they were self-sufficient in regards to their food supply (Hachem, 2011), grinding and abrading activities (Hamon, 2006) and activities related to the lithic industry (Allard et al., 2004).

Based on the assumption that ceramic production was local and domestic, a number of hypotheses can be proposed to explain the technical diversity of the assemblages from the smallest houses:

(1) The lateral pits associated with these houses may have been left open longer than those associated with other domestic units: the mixed assemblages would, therefore, reflect the production of a succession of different producers over time. However, recent data on material from LBK sites in the Aisne valley tend to suggest that the lateral pits associated with houses were left open for a relatively short period of time, perhaps 3 to 5 years (Allard et al., 2013). It seems unlikely, therefore, that the diverse nature of certain assemblages from Cuiry-lès-Chaudardes reflects the activity of successive producers.

(2) Pottery production in these houses may have been undertaken simultaneously by several producers coming from different apprenticeship affiliations. However, we have seen that the majority of the houses associated with mixed pottery assemblages were small-sized (houses 112, 126, 440, 580, 425 and 690), and were, therefore, probably inhabited by a small number of individuals (Dubouloz, 2008 and 2012). In these cases it seems unlikely that there would have been multiple producers living under one roof.

(3) Since mixed assemblages are composed of at least one pot-forming tradition present (or predominant) in several contemporary houses, it is possible that exchanges took place between houses. From our point of view, this hypothesis is the most plausible. In fact, in all of the houses with a mixed assemblage, at least one of the forming traditions identified is also predominant in one or more other contemporary houses, which are often larger in size. Moreover, in the houses characterised by heterogeneity of pot-forming methods, we observed associations between forming processes and tempers that also occur in some of the larger houses dating to the same phase. This is, for example, the case for house 90 belonging to the first phase, which may have received some pots from the other contemporary houses characterized by CCF1 and the use of shell temper. It may also be the case for house 440 during the second phase, which might have received some vessels from houses 330 or 570. This observation enables us to suggest that small houses with mixed assemblages were dependent on larger houses for some of their range of pottery.

Thus the inhabitants of the largest houses may have produced and provided a certain number of vessels for the inhabitants of smaller houses. Consequently, the inhabitants of the small houses with mixed assemblages may have been producers of one part of their range of ware, and mere users of the other. Ultimately, we cannot exclude the possibility that forms of co-operation existed between houses.

Sociological variation of pottery traditions Arrival of new population in the village

It appears, therefore, that small houses were engaged in a system of exchange or complementarity with larger houses (Hachem and Hamon, 2014; Gomart et al., 2015). We have seen that in three houses (89, 420 and 690), a pot-forming tradition which is very rare or absent in earlier phases was identified in significant quantities in addition to one or two traditions associated with a category of temper which predominates in contemporary larger houses.

In other words, in addition to vessels that probably originated in contemporary larger houses, the range of pottery produced in the houses 80, 690 and 420 may be linked to non-local technical practices in terms of their forming. Since the forms and decoration of the vessels made according to non-local methods are typical of the LBK style, it is possible that we are seeing the arrival in these three houses of producers from other LBK villages.

Hence, during the third phase of occupation, the appearance in houses 420 and 690 of the CCF12 tradition, which is rare in the Paris Basin, Alsace and Belgium, but which seems predominant in Lorraine (Gomart, 2014), may indicate that individuals from this latter area had established themselves in these particular houses. One can recall here that the results of bio-archaeological studies suggest that LBK communities were patrilocal with a high level of female mobility (Price et al., 2001; Bentley et al., 2012; Rasteiro et al., 2012; Rasteiro and Chikhi, 2013). It is, therefore, tempting to suggest that women from other LBK villages came to live in these small houses as part of marriage alliances (Gomart et al., 2015). Movements of women from one village to another through marriage networks have been observed for example by O. P. Gosselain in Cameroon (Gosselain, 2002): the women move into their husbands' communities but continue to make pottery using techniques and methods acquired in their home villages.

In the case of houses 420 and 690, the temper used as part of the CCF12 tradition is shell or limestone, which are typical for the Aisne Valley. These types of temper have not been identified in Lorraine (Gomart, 2014). Therefore, if we accept the hypothesis of an arrival of pottery producers, we can assume that the newcomers maintained their own forming methods while changing or adapting their clay recipes. It is particularly interesting to note that present-day potters sometimes modify their way of preparing clay through contact with other potters but continue to maintain their own tradition of pot-forming (Gosselain, 2002; Gelbert, 2003; Gosselain and Livingstone Smith, 2005). Such rapid and frequent changes might be explained by the fact that the procedures for preparing clays, particularly the use of a particular type of temper, do not require specific skills, unlike the steps involved in actually building the pot (Gosselain, 2002). In the case of the later Neolithic site of Chalain (Jura), a comparative study of the different parameters of the ceramic technical system (i.e. clay recipe, forming methods and decorative style) yielded a result similar to the situation observed at Cuiry-lès-Chaudardes: in fact, it appeared that the three parameters evolved independently of each other, according to different rhythms (Giligny, 1993; Pétrequin et al., 1994).

From ceramic cross-analysis to producer dynamics within the settlement

The production of LBK pottery at Cuiry-lès-Chaudardes seems to have been undertaken by different groups of producers whose dynamics appear to vary over time.

At the initial establishment of the village, we see uniformity in technical know-how. The producers in seven out of eight houses share the same technical practices in terms of tempers and pot-forming. These individuals, who appear to have belonged to the same social group, had a preference for using shell temper. This homogeneity suggests that the village was established by a group who shared the same technical traditions, at least in regards to clay recipes and the building of pots. When the village was founded, or very shortly before or after, a producer (or group of producers) following a different tradition (CCF2) came to occupy house 90. This producer (or group of producers), perhaps coming from a different social group, shows a preference for using limestone temper.

A diversification in technical know-how can be observed over the course of the second phase of occupation. Three dominant pot-forming traditions, perhaps reflecting three distinct social groups, co-existed within the village. The first group, maintaining the CCF1 tradition, remained present in the village and occupied houses 330 and 400. The producers in these two houses appear to have made different choices regarding their clay recipes: limestone is preferred in house 400 while shell is predominant in house 330. The CCF1 tradition is also well represented in houses 440 and 380, which are characterised by mixed assemblages. In house 440, vessels made using CCF1 are, for the most part, tempered using shell, as is also the case in house 330. This similarity may indicate that vessels were transferred from house 330 to house 440. The second group, following the CCF2 tradition, is more important than it was in the earlier phase. Producers belonging to this group apparently occupied three houses (570, 580 and 425), all of which are located at the west of the village. We know that the producer (or producers) in house 570 had a preference for using limestone temper. The same temper characterises the majority of vessels made using the CCF2 tradition in house 440. A third producer, or group of producers, following the CCF7 tradition of pot-forming, appears to have arrived in the village in the course of this phase and to have occupied a house outside the main core of the village: house 89. The producer(s) in this house had a preference for shell temper. The assemblage from house 380, located at the centre of the village, is exceptionally rich and unique in terms of its ceramic traditions: it is the only assemblage to contain, in almost equal proportions, the three technical traditions (CCF1, CCF2 and CCF7) which dominate the other houses within the phase. From this observation, we can suggest an intermittent or regular input of vessels from various houses to house 380, which might indicate a specific function, perhaps as a communal building (Gomart et al., 2015).

At the end of the period of occupation, we see village-scale standardisation in technical know-how. The group using the CCF2 forming process appears to grow in importance compared to the earlier phases. Producers belonging to this group occupied the five largest houses located in the south of the village (houses 225, 245, 280, 360 and 530). Even though they share the same pot-forming tradition, these producers make distinct choices regarding their clay recipes. In houses 225, 245 and 280, limestone temper is preferred, while in houses 360 and 530, shell temper is dominant. Houses 420 and 690, which are smaller in size and located in the north of the village, have mixed assemblages characterised by three forming traditions: CCF1, CCF2 and CCF12. The presence of significant quantities of vessels built in the CCF12 tradition in these assemblages suggests the appearance of a new social group in the village. The presence of CCF1 and CCF2 traditions in these houses may indicate an input of pots from other houses within the village. Therefore, the end of the period of occupation of Cuiry-lès-Chaudardes is characterised by the firm establishment of the group bearing the CCF2 pot-building tradition, as well as the probable arrival of a new group of producers in the village, bearers of the CCF12 tradition (which is characteristic of some ceramic assemblages from Lorraine: Gomart, 2014). The groups who followed the CCF1 and CCF7 traditions appear not to have maintained a presence in the village.

TEMPERS, FORMING AND LIMBURG WARE: THE EXAMPLE OF ROSMEER (LIMBURG, BELGIUM)

The site of Rosmeer is located in the province of Limburg, Belgium. An area of 1.6 ha was excavated by H. Roosens in the 1950s and 1960s, but the total area of the settlement is estimated to have been about 4 ha (Roosens, 1962). The excavation uncovered eighteen typical LBK buildings (fig. 14): the fourteen best-preserved buildings were subsequently published (Roosens, 1962). The site is one of the earliest LBK settlements in Belgium, as there are houses with Y- settings of posts (houses 10 and 13) which are typical of the Flomborn stage, corresponding to Period 1 Phase B in the Dutch chronology (Modderman, 1970). The ceramic decoration confirms this early date and suggests a long period of occupation, spanning periods Ib, IIa and IId (Janssens, 1974). Examination of a sample of decorated LBK sherds from Rosmeer has enabled us to make a number of typo-chronological observations and to associate certain houses to a chronological period. Houses 9 (north-eastern pits), 10 and 12 can thus be attributed to Period Id. House 14, features ceramic decoration characteristic of Periods Id and IIa (Gomart and Burnez-Lanotte, 2012).

One of the particularities of the ceramic series is that it has yielded a significant number of sherds of Limburg pottery. These have been published many times (De Laet, 1967; Modderman, 1981; Constantin, 1985). More recently, the decorative diversity of the vessels has

Fig. 14 – Plan of the LBK site of the 'Staberg' in Rosmeer (Limburg, Belgium). The excavation limits are not shown (CAD Y. Maigrot).
***Fig. 14** – Plan du site rubané du « Staberg »* à *Rosmeer (Limbourg, Belgique). Les limites de fouille ne sont pas indiquées (DAO Y. Maigrot).*

triggered a debate on their attribution to the Limburg ceramic tradition. P. -L. van Berg has suggested that two of the vessels should be reattributed to the Blicquy/Villeneuve-Saint-Germain and five others to the La Hoguette (van Berg, 1990). Other authors view the Limburg vessels discovered at Rosmeer as transitional variants in a continuous development between La Hoguette pottery, regarded as being earlier, and Limburg pottery, which is later (Constantin et al., 2010).

It is difficult to evaluate the exact number of individual ceramic vessels uncovered at Rosmeer. While we had access to all of the Limburg pottery discovered on the site (34 individual vessels; 110 sherds), we had access to only a limited number of the LBK style vessels (146 individual vessels; 870 sherds). Within this series, the representativeness of which cannot be estimated, 121 vessels can be classified as fine ware and 25 as coarse ware. Within our study, a total of 174 vessels were recorded because they displayed diagnostic technical traces.

Of the 34 Limburg vessels analysed, 32 could be associated with specific structures: they came from 12 pits, 8 of which were lateral pits associated with houses. Of the 121 LBK style vessels examined, 92 came from 45 pits spread out over the whole site. Of these, the majority (77 vessels) were from isolated pits. Only a small number of them (15 individuals) came from the lateral pits associated with houses. A large portion of the ceramic series cannot be linked either to a structure or a chronological period. As a consequence we decided to start by treating the corpus as a whole. Specific remarks regarding chronological and spatial issues will then be proposed for the vessels with an established provenance.

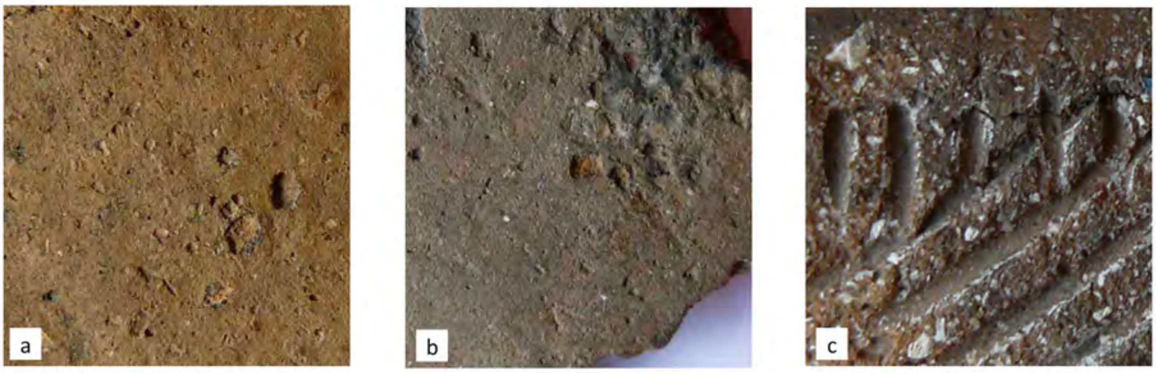

Fig. 15 – The three types of tempers identified at Rosmeer. a: grog; b: haematite; c: bone particles.
Fig. 15 – *Les trois types de dégraissants identifiées à Rosmeer. a : chamotte; b : hématite ; c : particules osseuses.*

Fig. 16 – Characteristic configuration observed on the edge of vertical fractures of the vessels associated with the forming method ROS1 (coils with oblique alternate overlapping).
Fig. 16 – *Configuration caractéristique observée en plan radial sur les vases associés à la méthode de façonnage ROS1 (colombins écrasés en chevauchement oblique alterné).*

Fig. 17 – Characteristic configuration observed on the edge of vertical fractures of the vessels associated with the forming method ROS2 (coils with oblique external overlapping).
Fig. 17 – *Configuration caractéristique observée en plan radial sur les vases associés à la méthode de façonnage ROS2 (colombins écrasés en chevauchement oblique externe).*

Diversity of tempers

The nature of the temper used has been recorded for each vessel. These inclusions fall into three distinct classes (fig. 15):

– grains characterised by a powdery consistency and having a pale grey to pinkish colour, or less frequently brown. This is probably grog (crushed fired clay);
– orange-coloured inclusions, which we suggest are haematite. This type of material has previously been identified in La Hoguette vessels (Lüning et al., 1989), but in certain cases, such as at Friedberg-Bruchenbrücken in Hesse, it has been interpreted as being a natural part of the clay rather than a deliberate addition (Maletschek, 2010);
– particles of burnt and crushed bone.

The majority of vessels belonging to the category of decorated fine ware includes a temper, although at times the concentration is low. Certain vessels reveal mineral inclusions, such as small grains of rolled quartz, which appear to form part of the clay matrix. Visible inclusions were not apparent in 39 vessels, although it should be noted that it is always difficult to affirm the presence of temper on the basis of a single sherd. While grog was normally used on its own, bone was nearly always used in association with at least one other type of inclusion, i.e. grog and/or haematite (only one vessel has bone inclusions on their own).

Within the assemblage, two distinct groups can be identified:

– vessels containing only powdery grains;

– vessels with bone particles as well as grog and/or haematite, the latter possibly present naturally in the clay.

Dichotomy in pot-forming

Analysis has revealed two predominant forming processes, mainly distinguished by the way the vessel body is made. The first way of doing, ROS1, is characterized by the use of coils, with oblique alternate overlapping, to form the body of the vessel (fig. 16). The second way of doing, ROS2, is defined by the use of coils, with oblique external overlapping, to form the body (fig. 17).

The ROS1 way of forming has been identified for most vessels within the series; it represents 88 vessels, while ROS2 represents only 12 vessels. When looking at the morphological distribution of these two methods, it appears that ROS1 encompasses almost all of the vessels of LBK style, namely globular-shaped pots with typical LBK decoration, as well as about half of the vessels of Limburg style, generally having open shapes. In contrast, ROS2 is only identified in vessels of Limburg style. Two different ways of doing were thus used to build the Limburg vessels at Rosmeer.

What are the links between forming methods and tempers?

Opposing tendencies have been observed between the ROS1 and ROS2 ways of doing:

– in the case of ROS1, powdery grains are predominant (62 LBK vessels and 5 Limburg vessels);

– in the case of ROS2, bone, accompanied by powdery grains and/or haematite, is most common (10 Limburg vessels). The two LBK vessels associated with ROS2 are tempered only with grog.

When we look at the spatial distribution of the two identified technical groups (fig. 18), namely the vessels made according to ROS1 with grog temper, and those made according to ROS2 with bone and grog and/or hematite temper, we find that they are often associated in the same features. This suggests that they were both used at the same time, especially if we take into account recent work showing that LBK refuse pits only remained open for a relatively short period of time (Allard et al., 2013). Moreover, most of the Limburg style vessels associated either with the first or the second technical group come from five houses located in the south-eastern part of the site and attributed to at least two different settlement phases (Gomart and Burnez-Lanotte, 2012). This indicates that the two methods were transmitted over time in the Rosmeer settlement, thus allowing them to be defined as technical traditions (Roux, 2010).

Discussion

In summary, at Rosmeer two distinct technical traditions characterise the bulk of the ceramic production. The ROS1 technical tradition encompasses the vast majority of fine- and coarse-ware LBK vessels and half of the total number of Limburg vessels. The tradition is characterised by the predominant use of grog as a temper, regardless of the style of vessel being produced. Vases falling within this technical group are found throughout the site.

The ROS2 technical tradition almost exclusively encompasses Limburg style vessels (and 2 vases of LBK style). It is distinguishable by the predominant presence of bone particles (along with grog and/or haematite). The vessels associated with this tradition mainly come from the south-eastern sector of the site. This technical tradition has been identified on several LBK sites within the Limburg pottery distribution zone, such as Cuiry-lès-Chaudardes, Aubechies, and Fexhe-le-Haut-Clocher (Constantin, Allard et al., 2010; Gomart, 2014).

These two technical traditions appear to reflect the existence of two distinct social groups. A first group (represented by the ROS1 technical tradition), which is predominant, was responsible for the bulk of the LBK style vessels and only a portion of the Limburg style vessels. The products of this group appear to be present throughout the village. A second group (represented by the ROS1 technical tradition), was more limited in size, and created vessels of non-LBK style (and perhaps occasionally LBK style vessels). The ware produced by this group is concentrated in the south-eastern sector of the village, in houses that were built or re-built in close proximity to each other (fig. 18).

These observations allow us to envisage a situation where part of the Limburg style production was carried out by individuals who made virtually only this type of ware (followers of the ROS2 tradition), the other part of this production being carried out by individuals who usually made a wide range of LBK style vessels (followers of the ROS1 tradition). On the basis of this hypothesis, we can suggest that producers within the ROS1 tradition imitated the 'Limburg style' (form and decoration), while conserving their own technical tradition.

It should be noted that the use of grog (accompanied or not by bone particles) in almost all of the Limburg style vessels associated with the ROS2 tradition, could indicate an instance of technical borrowing: followers of the ROS2 tradition may have borrowed the temper preferred by followers of the ROS1 tradition. Moreover, the presence in the assemblage of two vessels of LBK form, made following the ROS2 tradition of pot-forming, but

Fig. 18 – Spatial distribution of the two prevailing forming methods at Rosmeer, according to the formal style of the vessels (squares: LBK vessels; stars: Limburg vessels).

***Fig. 18** – Distribution spatiale des deux méthodes de façonnage prédominantes à Rosmeer, en fonction du style formel des vases (carrés : vases rubanés ; étoiles : vases Limbourg).*

only using grog temper (no bone), suggests occasional imitation of the LBK style by followers of the ROS2 tradition.

While no direct evidence for on-site ceramic production has been identified at Rosmeer, and a complete study of the clay raw materials has yet to be undertaken, the fact that producers within the ROS2 technical tradition used grog as well as bone, which was usually added to Limburg vessels, suggests that there were close interactions with the producers of LBK pottery.

CONCLUSION

The characterisation of the clay recipes and their correlation with the forming processes offers a complex view of the contexts of pottery production at Cuiry-lès-Chaudardes and Rosmeer. It enables a better understanding, at a fine resolution, of the dynamics of persistence *versus* transformation of the technical practices and knowledge transfers between groups of producers. We could not identify any unequivocal relationship between clay recipes and forming processes: the spatial and temporal variations identified suggest that, within a single apprenticeship network, producers maintained their traditional practices for forming of vessels but could change their clay recipes depending on the production site or the type of vessel to be made. Thus, during the middle and late occupation phases of Cuiry-lès-Chaudardes, incoming producers, who appear to have come from other villages or regions occupied by LBK communities, retained their non-local forming tradition but preferentially adopted a clay recipe that was dominant during the village's founding phase (addition of shell temper). In Rosmeer, the producers usually engaged in the manufacture of LBK style vessels maintained their methods of forming pots when they imitated the Limburg style, but changed their approach when it came to preparing the clay: in the majority of cases they added bone to the grog which they normally used when making LBK vessels.

This investigation also provides insights into LBK sociology. At Cuiry-lès-Chaudardes, the spatial analysis of the clay recipes and the forming processes revealed a production carried out at the house scale, by several social groups with complex settlement dynamics. Thus, a first group, present during the village's founding, seems to be gradually replaced by another group towards the end of the occupation. Moreover, throughout the village occupation, the largest houses show a strong continuity in forming processes, suggesting a transmission of technical know-how within the village. In contrast, new technical traditions are observed in some smaller houses, suggesting arrivals of new populations in the village. Collaboration between the larger and the smaller houses can be hypothesised: in some small houses, the inhabitants might have produced only one part of the house pottery range, and they would have received some pots from the contemporary largest houses. At Rosmeer, the data collected do not permit analysis at the house scale. Nevertheless, cross-analysis of the clay recipes and forming methods allows the identification of mechanisms of stylistic imitation and of technical transfers between (i) a group of producers involved in the production of LBK style ware spread throughout the village and (ii) a group of producers mainly producing Limburg vessels distributed in a particular sector of the village, and recognized in other LBK settlement areas (Constantin, 1985; Gomart, 2014). Ultimately, the ideas and hypothesis outlined in this paper need to be further tested through large-scale cross analyses, which should extend to include the study of the clay raw materials used by LBK and Limburg ware producers, both in representative chronological and regional contexts and at the scale of the LBK culture.

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NOTES

(1) La Hoguette ware was not present in the assemblages studied.

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Quatrième partie

Ceramic recipes and raw materials: analytical perspectives

Recettes de pâtes et caractérisation des matériaux : les outils analytiques

Matières à Penser: Raw materials acquisition and processing in Early Neolithic pottery productions
Matières à penser : sélection et traitement des matières premières dans les productions potières du Néolithique ancien
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Petrographic study of tempers in Early and Middle Neolithic pottery in Lower Normandy (France)

Denis Jan, Xavier Savary

Abstract: Pottery is the result of several operations that translate specific choices made by the potter. The use of a vegetal temper is observed for the Neolithic period in the North of France and Belgium, although it is not always possible to distinguish between accidental or deliberate additions. Macroscopic observation of plant material stored in ceramics enables us to identify common mosses, such as *Neckera crispa*, and more rarely seeds of wild flowers such as poppies. A corpus of 331 thin sections of pottery, from 26 Norman sites covering the beginning of the Neolithic period, was constituted in order to determine which plant species were used as additives for the recipients and to specify when these made their appearance (146 thin sections from the Early Neolithic and 185 thin sections from the Middle Neolithic). A plant recognition process using a polarizing petrographic microscope was developed to identify imprints observed in thin sections of pottery. Clay briquettes tempered with different plant species were fired to form an experimental thin sections database. A polarizing microscope was then used to observe moss, poppy, flax, and seed prints within these briquettes, in order to establish criteria for identifying and differentiating species. The morphological characteristics resulting from the experimental protocol were compared to vegetal additives in thin sections from Neolithic pottery. We were able to identify very fine prints produced by the mosses used in our reference samples, but were unable distinguish genera and species. Pottery tempered with mosses often presents globular forms, either voids or containing charred material, the cell tissues of which can sometimes be distinguished. These tissues, probably parenchymal cells, show strong similarities with stems of present day mosses. Some tempers present longitudinal sections with leaf attachments and sometimes even with sectioned leaves. These enable us to specify moss identification to the genus or even species levels. The polarizing microscope observations have also enabled us to identify the presence of fragments of wood in a thin section. A total of 92 vases sampled contain within their fabric fine imprints bearing witness to the use of mosses. In Lower Normandy, proven use of this temper is identified mostly for the Middle Neolithic period, first on Cerny culture settlements and then more particularly on Chassean funerary and habitat sites. The use of this plant temper is not limited to a particular vessel form or to a particular group of clay soils. Other tempers added to the fabric were observed through petrographic analysis and two can be combined in the clays used. Grog is regularly identified within the corpus of ceramic fabrics, usually appearing as a fine clayey and ferruginous mass, well defined and containing minerals that are absent or rare in the rest of the fabric. Identification of this temper is delicate because it can be confused with clay lumps left after the kneading process, or with residual aggregates accidentally incorporated. However, grog does seem to be used in the manufacture of 47 pottery recipients of the Early to Middle Neolithic corpus. About 38 ceramics of the corpus include silicified remains in fabrics that can naturally contain rounded flint or silicified limestone. These elements are considered to be naturally present in the clays used. Finally, bone splinters are also observed in the studied ceramics. More specifically, 24 examples contain bone tempering for the Early Neolithic in the vases of the Blicquy/Villeneuve-Saint-Germain culture, and for the Middle Neolithic in those of the Cerny and Castellic cultures.

Keywords: pottery, petrography, temper, vegetal, moss, grog, bone, Early Neolithic, Middle Neolithic, Lower Normandy.

Résumé : La céramique est le résultat de plusieurs opérations qui intègrent des choix spécifiques de la part du potier. L'utilisation d'un dégraissant organique d'origine végétale est bien observée pour le Néolithique du Nord de la France et de Belgique, bien qu'il ne soit pas toujours possible de statuer entre un apport accidentel ou volontaire. Les observations macroscopiques du matériel végétal conservé dans les céramiques permettent d'identifier l'emploi courant de mousses, notamment *Neckera crispa*, et plus rarement de graines de plantes à fleurs comme celles du pavot sauvage. Un corpus de 331 lames minces de céramiques, provenant de 26 sites de Basse-Normandie et couvrant le début de la période néolithique, a été réalisé afin d'identifier quelles espèces végétales sont mises en œuvre pour dégraisser les récipients et de préciser les périodes d'apparition de leur utilisation (146 lames minces du Néolithique ancien et 185 lames minces du Néolithique moyen). Un procédé de reconnaissance des végétaux au microscope polarisant a été élaboré afin d'identifier les empreintes observées dans les lames minces de céramique. Des briquettes d'argiles dégraissées avec différentes espèces végétales ont été réalisées et cuites pour constituer une base de données de lames minces expérimentales. Ces briquettes permettent alors d'observer, au microscope polarisant, les empreintes laissées par des mousses, du pavot, du lin, des céréales et d'établir des critères de différenciation entre ces espèces. Les caractères morphologiques observés à partir du protocole expérimental ont ensuite été comparés aux inclusions végétales présentes dans les lames minces issues de céramiques néolithiques. Il a été possible d'identifier dans les tessons les empreintes très fines produites par les mousses du référentiel, sans pourtant pouvoir discerner les genres et les espèces. Les céramiques dégraissées avec des mousses renferment souvent des inclusions circulaires vides ou contenant du matériel carbonisé dont il est parfois possible de distinguer les tissus cellulaires. Ces tissus montrent de fortes analogies avec ceux des tiges de mousses actuelles, il s'agirait vraisemblablement d'un tissu parenchymateux. Quelques inclusions présentent des sections longitudinales avec les insertions des feuilles et parfois des coupes de feuilles. Ces dernières inclusions permettent de pousser la détermination des mousses au genre voire à l'espèce. Les observations au microscope polarisant ont permis de mettre en évidence la présence de fragments de bois dans une lame mince. Au total, 92 récipients échantillonnés pour l'étude renferment au sein de leur pâte les empreintes fines engendrées par l'utilisation de mousses. En Basse-Normandie, l'usage avéré de ce dégraissant est surtout identifié durant le Néolithique moyen, d'abord sur les sites d'habitats Cerny et surtout sur les sites funéraires et d'habitats Chasséen. L'emploi de ce dégraissant végétal n'est pas limité à une forme particulière ni à un groupe particulier de terre argileuse. D'autres dégraissants ont été remarqués pendant l'analyse pétrographique et peuvent être combinés par deux dans les terres employées. La chamotte est régulièrement identifiée au sein des pâtes céramiques du corpus. Elle se présente généralement comme une masse argileuse et ferrugineuse fine, bien délimitée et contenant des minéraux qui ne sont pas ou peu présents dans la pâte. L'identification de ce dégraissant est délicate puisqu'il peut également s'agir de grumeaux d'argile imputables au malaxage de l'argile ou encore d'agrégats résiduels inclus accidentellement dans la pâte. Toutefois, la chamotte semble être mise en œuvre dans la fabrication de 47 céramiques du corpus du Néolithique ancien au Néolithique moyen. Près de 38 vases du corpus comportent des silicifications dans des pâtes qui peuvent contenir naturellement des silex émoussés ou des calcaires silicifiés. Ces éléments sont considérés comme étant naturellement présents dans les argiles mises en œuvre. Enfin, des esquilles osseuses sont aussi observées dans les céramiques étudiées. Plus précisément, 24 céramiques renferment un dégraissant osseux, au Néolithique ancien dans les vases de la culture de Blicquy/Villeneuve-Saint-Germain et au début du Néolithique moyen dans ceux des cultures de Cerny et de Castellic.

Mots-clés : céramique, pétrographie, dégraissant, végétal, mousse, chamotte, os, Néolithique ancien, Néolithique moyen, Basse-Normandie.

INTRODUCTION

Problematic

The main objective of this study is the identifications and description of microscopic tempers added to ceramic fabrics from the Early Neolithic to the end of the Middle Neolithic in Lower Normandy. It involves a collaborative university project, conducted by the University Paris 1 and Geoarchaeology Unit of the Archaeology Department of Calvados County Council, which aims to determining the plant traces observed in Neolithic ceramics from Normandy (Jan, 2010 and 2011). Since the petrographic study of the site of Ernes 'Derrière les Prés' at the end of the 1990s (San Juan and Dron, 1997), the presence of carbonised herbaceous inclusions has been repeatedly observed in ceramics from Middle Neolithic 'Plaine de Caen' sites, as is the case recently from the sites of Condé-sur-Ifs 'La Bruyère Hamel' or Cairon 'La Pierre Tourneresse' (Dron et al., 2010; Ghesquière and Marcigny, 2011). Furthermore, macroscopic impressions of moss leaves are identified in pottery from the Middle Neolithic of northern France and Belgium. The oldest use of moss as a temper in Normandy and Brittany seams to date to the Middle Neolithic (Constantin and Kuijper, 2002). These observations prompted us to carry out petrographic analysis on a ceramic corpus encompassing the main Neolithic sites of Lower Normandy with the aim of identifying vegetal temper (using polarizing microscopy), the period of use, the clay used, and a typology of the pots. This work, undertaken in the archaeology department, focused on the characterization of clays and also included the localisation of potential deposits and the identification of other tempers observed.

Geography and geology

The study was limited to Lower Normandy (fig. 1). This region, in north-western France, groups together three departments, Calvados, Manche and Orne, encompassing an area of 17,589 km². This area drained by rivers flowing into the Channel, the coastline of which stretches 450 km from the Bay of the Seine to the Bay of the Mont-Saint-Michel. To the west, Lower Normandy incorporates part of the Armorican Massif, and to the east, part of the sedimentary Paris Basin: it, therefore, spans two geological histories (fig. 2). The Armorican massif consists of ancient sedimentary and magmatic rocks, locally interspersed with granitic intrusions, and deformed by several orogenies. The sedimentary formation concerns the western end of the Paris Basin, and consists of successive non-folded sedimentary layers. The traces of these geological events are preserved in the substratum, offering a wide variety of lithic raw materials. The differences in geology are also expressed in the landscapes; the Armorican area is characterized by *bocage*, grassland and dairy farming, while the sedimentary area is occupied by plains and plateaux which are dominated by cereal growing.

Study corpus

For the purposes of this study, pottery was sampled from 26 sites dating to the Early Neolithic and Middle

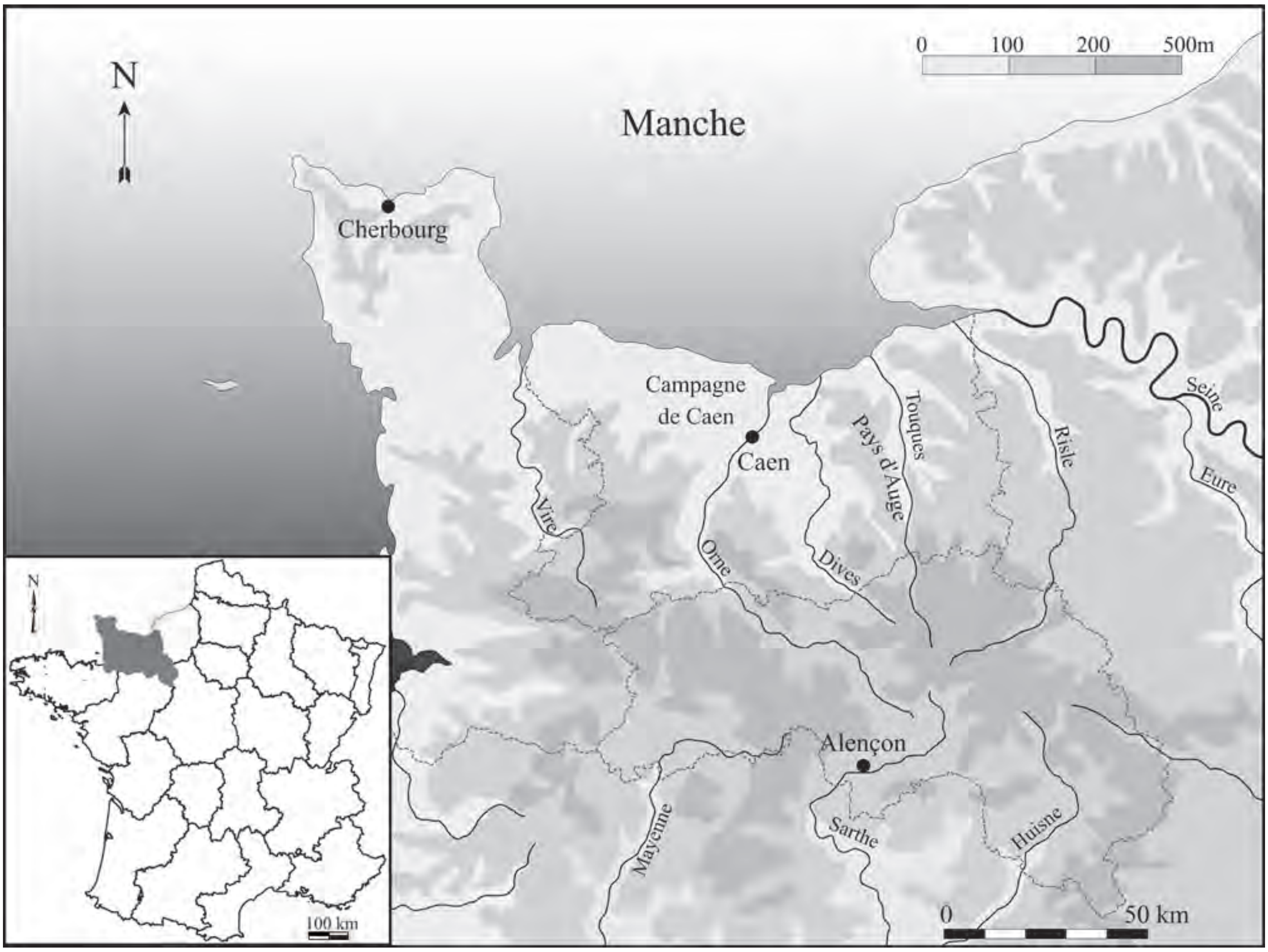

Fig. 1 – Geographical location of Lower Normandy.
***Fig. 1** – Localisation géographique de la Basse-Normandie.*

Neolithic (fig. 3; table 1). The first Neolithic occupations in Lower Normandy are examined through seven sites (5,000—4,700 BC). The village of Colombelles 'Le Lazzaro', probably consisting of ten house units belonging to the final Paris Basin Late Bandkeramik stage, is the earliest site analysed. The middle stage of the Blicquy/Villeneuve-Saint-Germain culture (BQ/VSG) is represented by the sites of Fontenay-le-Marmion 'Le Grand Champ', consisting of a single house unit, Verson 'Les mesnils', composed of five house units and the site of Jort 'Carrière Macé', consisting of several pits. The recent stage of the BQ/VSG culture is identified at Tilly-la-Campagne 'Chemin de Liaison RN 158', Valframbert 'La Grande Pièce', and at Mondeville 'Le Haut Saint Martin', through an isolated pit for the first, two concentrations of artefacts for the second and a single house unit for the latter. Samples from ten sites are studied for the first part of the Middle Neolithic in Lower Normandy, nine sites are considered for the second part. The Middle Neolithic 1 (4,700–4,200 BC) is represented by seven settlements attributed to the Cerny culture: Hébécrevon 'Le Village de l'Hôtel Torquet' and 'La Couesnerie', Fleury-sur-Orne 'Z.A.C. Parc d'Activité', paleosols fossilized under the megaliths of Ernes 'Derrière les Prés', Condé-sur-Ifs 'La Bruyère du Hamel', Colombiers-sur-Seulles 'La Commune Sèche' and, for the end of the period, Cairon 'La Pierre Tourneresse'. The settlement sites of Barneville-Carteret 'Le Castel', of Herqueville 'Les Treize Vents' and the megalithic ensemble at Vierville 'La Butte à la Luzerne' are attributed to the Castellic culture.

The Middle Neolithic 2 (4,200–3,500 BC), attributed to the regional Chassean culture, is represented by five settlement sites: Grentheville 'Z.I. Mondeville Sud', Cagny 'Projet Décathlon', Biéville-Beuville 'La Haie du Coq', Fontenay-le-Marmion 'La Grande Pièce', Argentan 'Le Grand Beaulieu'. Four funerary sites complete the range of sampling for the period: the megaliths of Fontenay-le-Marmion 'La Hoguette', Ernes 'Derrière les Prés', Colombiers-sur-Seulles 'La Commune Sèche' and Fontenay-le-Marmion 'La Hogue'.

This study is based on the analysis of 331 pottery samples mounted as thin sections, specifically 146 pots for the Early Neolithic, 109 for the beginning of the Middle Neolithic and 76 for the second part of the Middle Neolithic. Sampling is based on the macroscopic observation of fabrics presenting visible inclusions using a binocular lens. Archaeologically complete ceramic vessels are chosen, when possible.

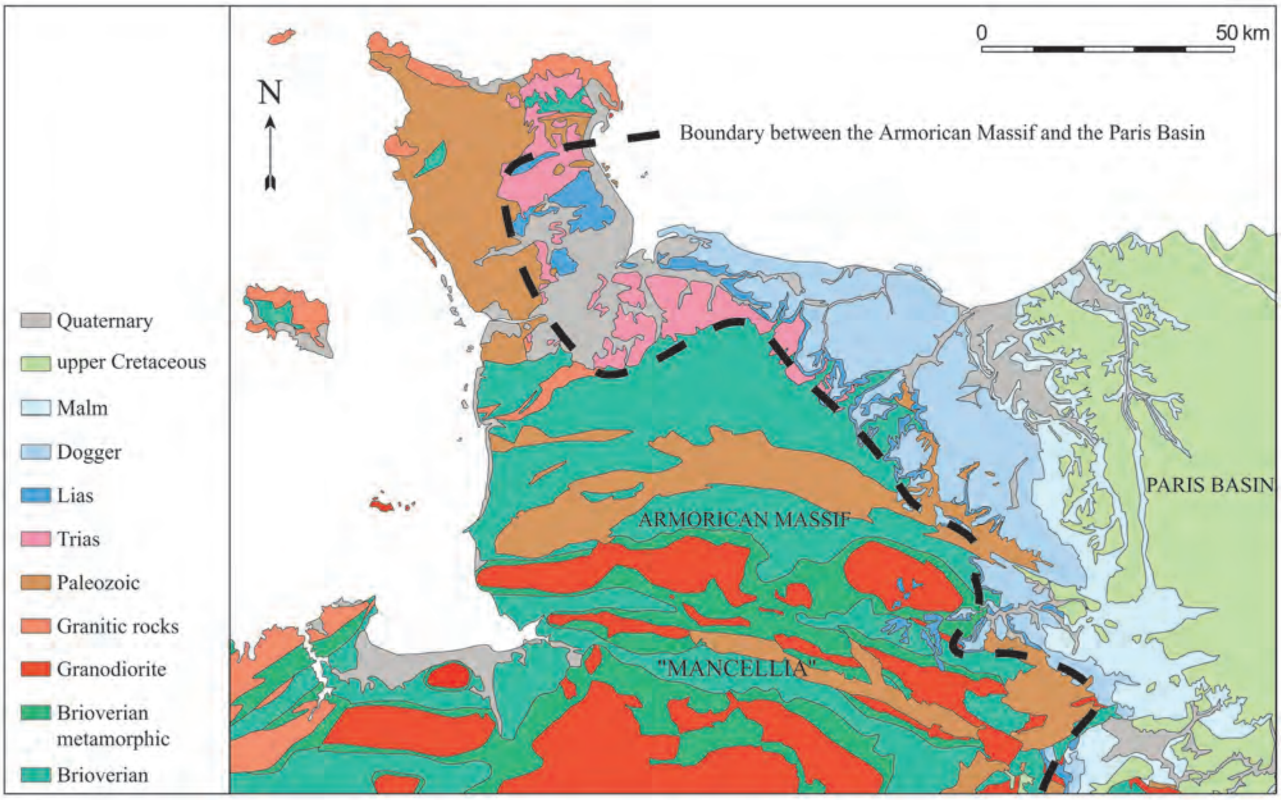

Fig. 2 – Simplified geological map of Lower Normandy.
Fig. 2 – *Carte géologique simplifiée de la Basse-Normandie.*

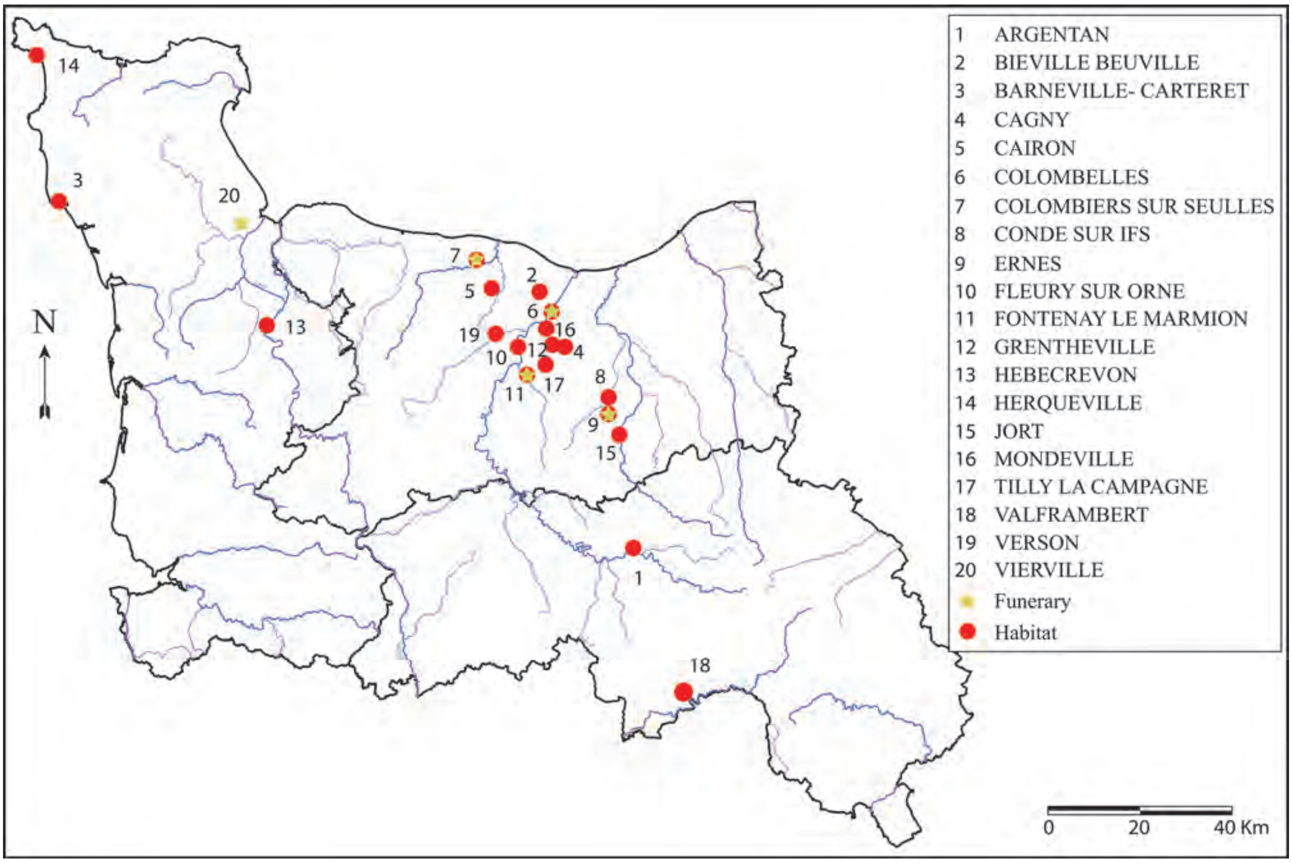

Fig. 3 – Distribution map of the studied sites.
Fig. 3 – *Carte de répartition des sites étudiés.*

Neolithic	Site	Department	Occupation	Thin sect.	Bibliography
RRBP	Colombelles 'Lazzaro'	Calvados	Hab/Fun	57	Billard et al., 2014
B-VSG	Fontenay-le-Marmion 'Grand champ'	Calvados	Habitat	10	Giraud et al., 2012
B-VSG	Jort 'Carrière Mace'	Calvados	Habitat	13	Chancerel, Desloges et al., 1992
B-VSG	Mondeville 'Haut saint martin'	Calvados	Habitat	3	Chancerel et al., 2006
B-VSG	Tilly-la-campagne 'Chemin RN 158'	Calvados	Habitat	6	Charraud et al., forthcoming
B-VSG	Valframbert 'Grande pièce'	Orne	Habitat	6	Chancerel, Desloges et al., 1992
B-VSG	Verson 'Mesnils'	Calvados	Habitat	51	Germain-Vallée et al., 2014
Cerny	Colombiers-s/-seulles 'Commune sèche'	Calvados	Habitat	7	Chancerel, Kinnes et al., 1992
Cerny	Condé-sur-ifs 'Bruyère du hamel'	Calvados	Habitat	27	Dron et al., 2010
Cer/Chambon	Ernes 'Derrière les prés'	Calvados	Habitat	6	San Juan, Dron, 1997
Cerny	Hébécrevon 'Couesnerie'	Manche	Habitat	2	Ghesquière et al., 1999
Cerny	Hébécrevon 'Village hôtel torquet'	Manche	Habitat	15	Ghesquière et al., 1999
Castellic	Barneville-Carteret 'Castel'	Manche	Habitat	18	Billard, 2009
Castellic	Herqueville 'Treize vents'	Manche	Habitat	3	Chancerel et al., 1996
Castellic	Vierville 'Butte à la luzerne'	Manche	Funerary	6	Chancerel et al., 1986
Cerny/Chasséen	Cairon 'Pierre tourneresse'	Calvados	Habitat	19	Ghesquière and Marcigny, 2011
Cerny/Chasséen	Fleury-sur-Orne 'Parc d'activité'	Calvados	Habitat	6	Clément-Sauleau et al., 2003
Chasséen	Argentan 'Grand beaulieu'	Orne	Habitat	25	Ghesquière and Marcigny, 2004
Chasséen	Biéville-Beuville 'Haie du coq'	Calvados	Habitat	11	Germain-Vallée, 2013
Chasséen	Cagny 'Projet décathlon'	Calvados	Habitat	14	Giraud, 2008
Chasséen	Colombiers-s/-seulles 'Commune sèche'	Calvados	Funerary	7	Chancerel, Kinnes et al., 1992
Chasséen	Ernes 'Derrière les prés'	Calvados	Funerary	2	San juan and Dron, 1997
Chasséen	Fontenay-le-Marmion 'Grande pièce'	Calvados	Habitat	1	Giraud, 2006
Chasséen	Fontenay-le-Marmion 'Hogue'	Calvados	Funerary	5	Lagnel and Verron, 1995
Chasséen	Fontenay-le-Marmion 'Hoguette'	Calvados	Funerary	1	Caillaud and Lagnel, 1972
Chasséen	Grentheville 'Mondeville sud'	Calvados	Habitat	10	Chancerel et al., 2006

Table 1 – Studied sites and associated bibliographies.
Tabl. 1 *– Sites étudiés et bibliographies associées.*

The main petrographic groups

Analysis of the nature and organization of minerals enabled us to divide the samples into broad petrographic fabric groups (Jan, 2010). Not taking into account singularities, five main petrographic fabric groups have been identified (fig. 4): the glauconious group, the origin of which seems to be located in the east of Lower Normandy, in the Pays-d'Auge; the sand particles group whose origin is more complex to determine, sharing very diverse components; the magmatic elements group whose origin seems to be the Armorican massif in the west of the region or beyond; the fossil bioclast group, certainly derived from calcareous marl and clay, available north of the Caen urban area. For older sites the bioclasts are decarbonated by soil transformations of taphonomic origin; the vacuolar group contains no elements which allow us to determine the origin of the clay. The matrix is characterized by significant porosity accompanied by occasional quartz particles the size of fine to coarse grains of sand. Vacuoles probably correspond to the disappearance of organic or carbonated elements such as bioclasts.

VEGETAL TEMPER: THE RESULTS

The vegetal remains

Vegetal remains may be accidentally or voluntarily present in ceramics fabrics. The different phases of storage, weathering, clay preparation and pot making can all unintentionally introduce plant debris. The deliberate addition of vegetal fibres to the clay, to change the characteristics of the fabric, is referred to as added temper (Rye, 1981). The distinction between accidental or deliberate occurrence is likely to be found in a variation in abundance or the use of specific plants (Rye, 1981).

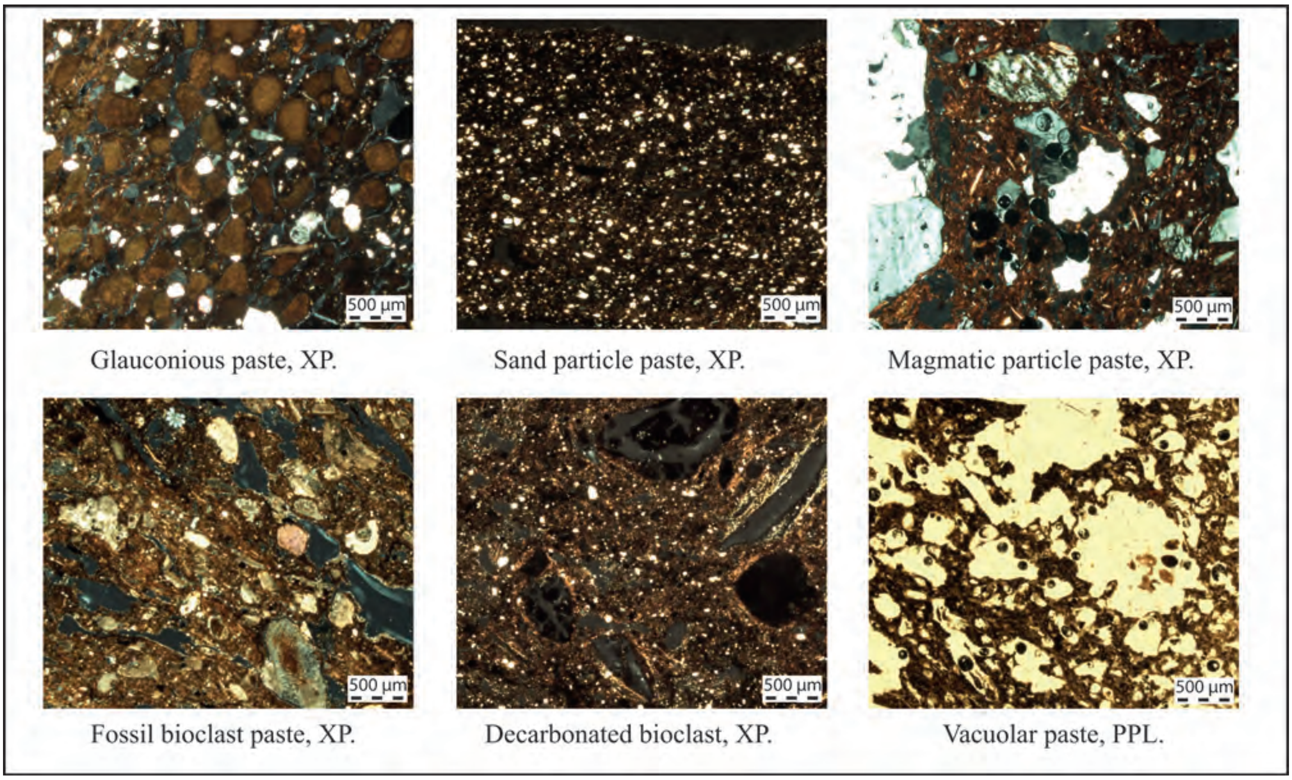

Fig. 4 – Photomicrographs of the main petrographic groups of paste.
***Fig. 4** – Microphotographies des principaux groupes pétrographiques de pâte.*

In our corpus, 135 thin sections contain some organic plant material, appearing differently according to the sectional plane of the sherd (table 2). It is thus possible to observe inclusions taking the form of fine filaments, rectilinear and oval fragments or plant structures, often containing carbonized material (fig. 5). Since it would be unwise to consider cases where plant inclusions are limited to occasional occurrences in the fabric as voluntary inclusions, we have decided to exclude from the study 36 vases containing very occasional plant debris (table 2). The remaining thin sections contain sufficient plant fibres to suggest their intentional addition. For the Early Neolithic, less than 2% of pottery sampled contain a plant temper, i.e. two of the ten vases studied from the site of Fontenay-le-Marmion 'Le Grand Champ' (table 2). For the first part of the Middle Neolithic, samples of pottery attributed to the Cerny group regularly contain vegetal fibres, i.e. ten out of fifteen pots from the site of Hébécrevon 'Le Village de l'Hôtel Torquet', and five out of six from the site of Ernes. The square mouthed vase of Chambon influence, found on the latter site, also contains abundant plant temper. The end of the period, identified at the settlement sites of Fleury-sur-Orne and Cairon, is also marked by the effective use of plant material as a temper. All samples from the first site, and thirteen samples out of nineteen from the second, contain plant debris. The pottery sampled for the three sites attributed to the Castellic culture does not seem to have been tempered using plant material as no organic inclusions are observed. Just over 43% of vases sampled for the period are tempered with vegetal matter (table 2). For the second part of the Middle Neolithic, plant temper is very often used in pottery attributed to the Chassean culture. All vases studied for the sites of Biéville-Beuville, Ernes and Fontenay-le-Marmion 'La Hogue' contains vegetal fragments. Nearly 71% of pots sampled for the period contain vegetal temper (table 2). Three density levels of inclusions have been observed, although these differences may be specific to the part of the pot sampled, or a zone that may not necessarily be representative of the entire pot. Among the samples, 27 vases are sparsely tempered with vegetal matter, 53 contain an abundance of vegetal matter and 19 pots have a very high density of vegetal matter (table 2). The use of plants as temper is observed for the beginning of the Middle Neolithic in pottery of the Cerny culture. Use of plant debris is more common for the second part of the Middle Neolithic in vases of the Regional Chassean. Pots tempered with plant fibres are more numerous and the quantity of plant matter used is greater.

The experimental reference data

In general, plants used as temper in pottery fabric can be determined by macroscopic observation, with reference to with fresh specimens. The vegetal inclusions are determined through impressions in the ceramic, by extraction of the organic material or by substitution of the plant matter with a resin incorporated within the sherd (Bakels et al., 1992; Constantin and Kuijper, 2002; Sestier et al., 2011). In our case, we did not find any references

Neolithic	Site	Thin sect.	Vegetal temper	Very few	Few	Abundant	Very abundant
RRBP	Colombelles 'Lazzaro'	57	12	12			
BQ/VSG	Fontenay-le-Marmion 'Grand champ'	10	3	1	1	1	
BQ/VSG	Jort 'Carrière Mace'	13	1	1			
BQ/VSG	Mondeville 'Haut saint martin'	3	1	1			
BQ/VSG	Tilly-la-campagne 'Chemin RN 158'	6	3	3			
BQ/VSG	Valframbert 'Grande pièce'	6	2	2			
BQ/VSG	Verson 'Mesnils'	51	9	9			
Cerny	Colombiers-s/-seulles 'Commune sèche'	7	4		2	2	
Cerny	Condé-sur-ifs 'Bruyère du hamel'	27	7	2	2	2	1
Cerny/Chambon	Ernes 'Derrière les prés'	6	5			1	4
Cerny	Hébécrevon 'Couesnerie'	2	0				
Cerny	Hébécrevon 'Village hôtel torquet'	15	12	2	5	5	
Castellic	Barneville-Carteret 'Castel'	18	1	1			
Castellic	Herqueville 'Treize vents'	3	0				
Castellic	Vierville 'Butte à la luzerne'	6	0				
Cerny/Chasséen	Cairon 'Pierre tourneresse'	19	13		1	7	5
Cerny/Chasséen	Fleury-sur-Orne 'Parc d'activité'	6	6			6	
Chasséen	Argentan 'Grand beaulieu'	25	14	2	9	3	
Chasséen	Biéville-Beuville 'Haie du coq'	11	11		3	6	2
Chasséen	Cagny 'Projet décathlon'	14	13		1	9	3
Chasséen	Colombiers-s/-seulles 'Commune sèche'	7	4		1	2	1
Chasséen	Ernes 'Derrière les prés'	2	2			2	
Chasséen	Fontenay-le-Marmion 'Grande pièce'	1	0				
Chasséen	Fontenay-le-Marmion 'Hogue'	5	5			2	3
Chasséen	Fontenay-le-Marmion 'Hoguette'	1	1			1	
Chasséen	Grentheville 'Mondeville sud'	10	6		2	4	
		331	135	36	27	53	19

Table 2 – Sites with pottery containing vegetal temper.
***Tabl. 2** – Sites avec de la céramique comprenant un dégraissant végétal.*

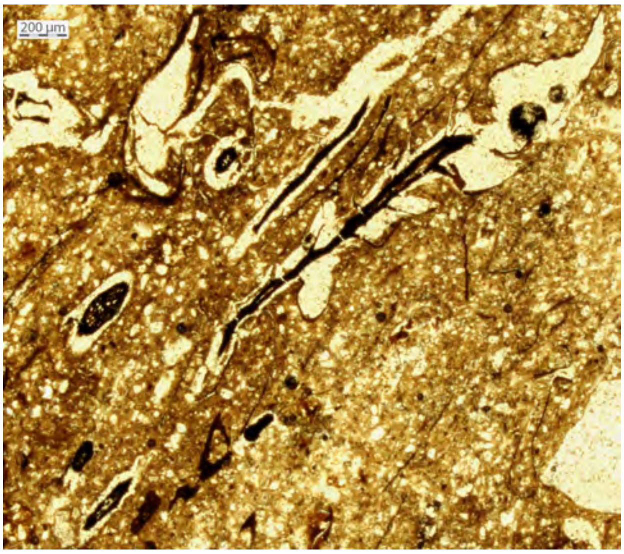

Fig. 5 – Photomicrograph commonly observed vegetal inclusions, PPL.
***Fig. 5** – Microphotographie des inclusions végétales souvent observées, lumière polarisée non analysée.*

dealing with plant identification using the polarizing microscope. Therefore, an experimental reference database has been developed in order to compare the inclusions generated by plants known today with those present in the potsherds. Industrial clay was tempered with different vegetal species, and was then modelled in the form of briquettes in order to obtain experimental thin sections. This earth, with a clay fraction of over 80%, contains rare quartz and micas inclusions, facilitating observation of plant inclusions. In all, 16 plants are represented in the experimental database: 4 monocot flowering plants i.e. einkorn (*Triticum monoccocum*), oat (*Avena sativa*), emmer (*Triticum dicoccum*) and six-rowed barley (*Hordeum vulgare*); 2 dicotyledonous flowering plants such as poppy (*Papaver somniferum*) and linseed (*Linum usitatissimum*); and 10 bryophytes (only mosses including *Hypnum cupressiforme*, *Neckera crispa* and even *Rhytidiadelphus triquetrus*). After firing the briquettes at 600 ° - 800 ° C and creating the experimental thin sections, it was then possible to observe inclusions corresponding to known plants using the polarizing microscope.

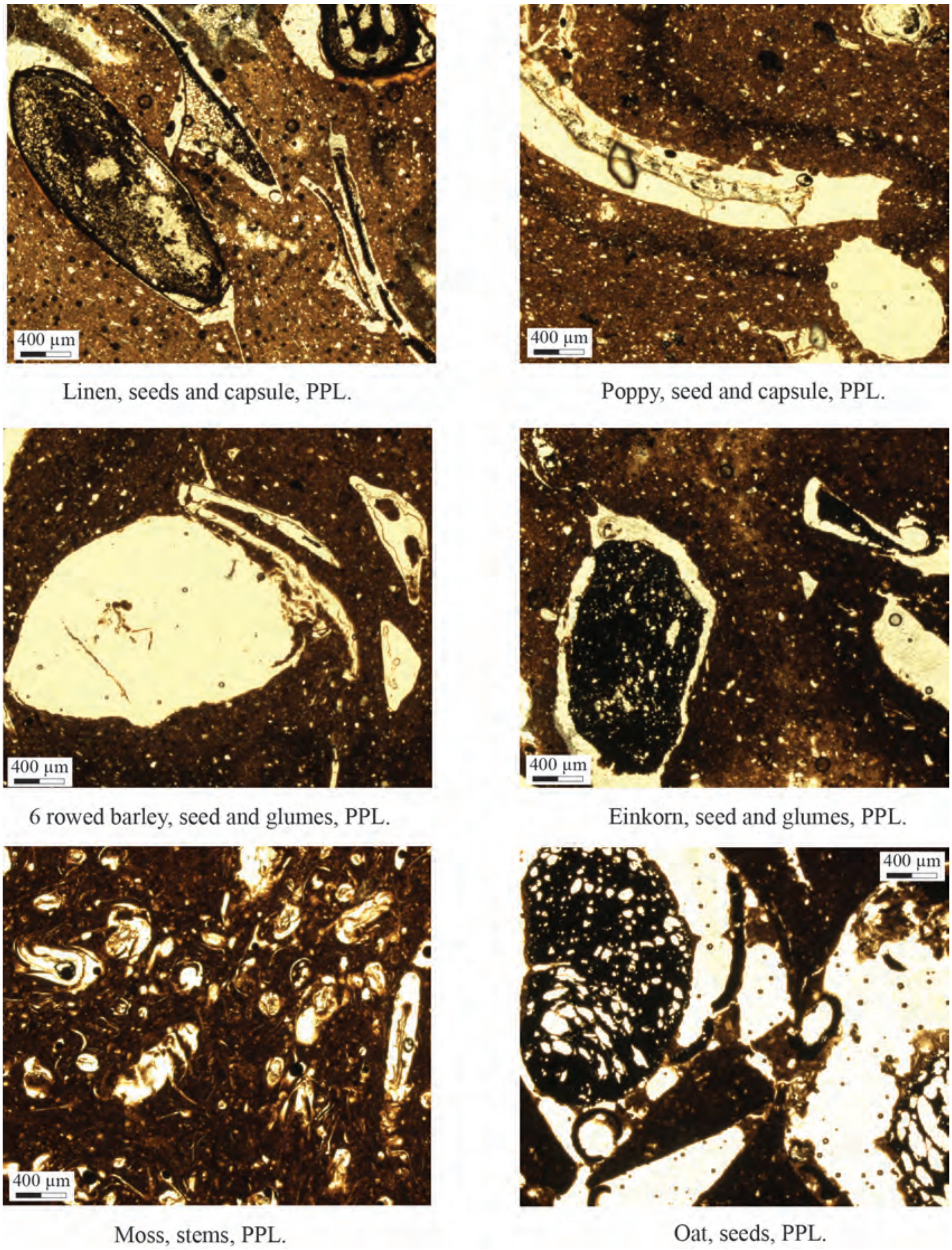

Fig. 6 – Photomicrographs of imprints of vegetal matter used in the experimental protocol, PPL.
Fig. 6 – *Microphotographies des végétaux utilisés dans le référentiel expérimental, lumière polarisée non analysée.*

All micrographs of the experimental database are available on the following web page: (*http://jandenis2.wix.com/petrographycd14*). The analysis of experimental thin sections enabled us to distinguish the imprints of the mosses from those of flowering plants, using both size and shape criteria (Jan, 2011; here: fig. 6). Flowering plants generate voluminous inclusions measuring over a millimetre, the shapes corresponding to the part of the plant involved (seeds, capsules, husks). We can distinguish species among the different flowering plants, particularly on the basis of seeds. Mosses usually leave smaller inclusions around a millimetre in size. Only experimental thin sections of moss reveal fine inclusions of filament shape, around 5 microns thick, both curved and straight, of various lengths not exceeding 800 µm, spread throughout the

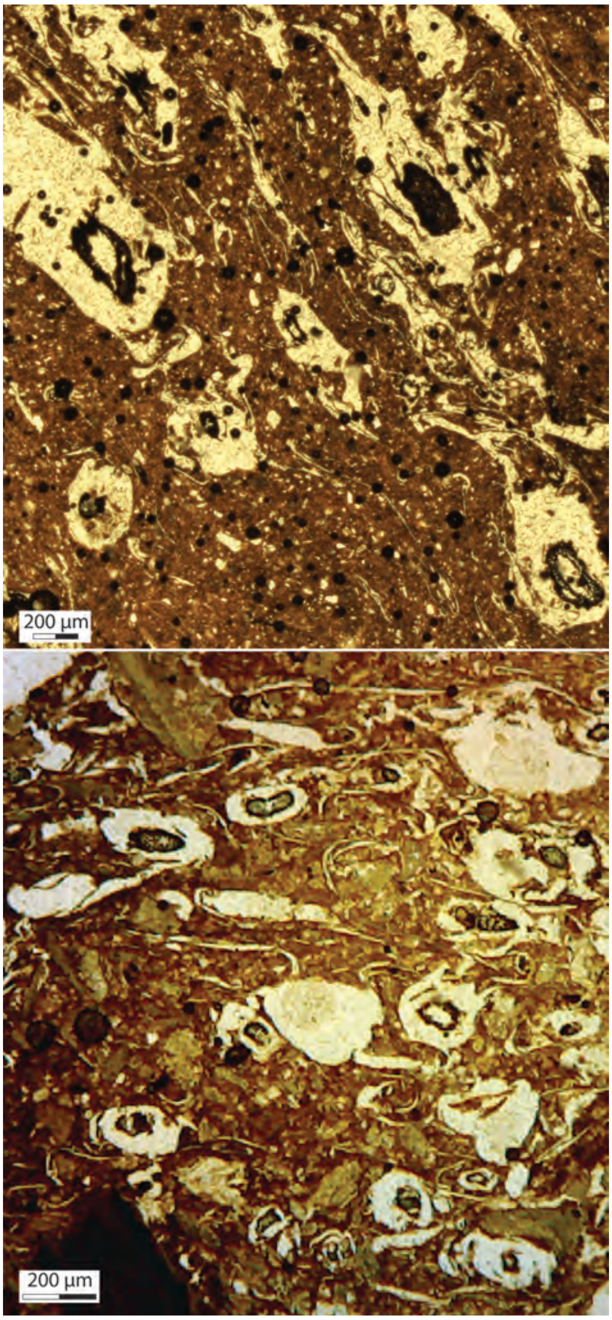

Fig. 7 – Comparison between the experimental inclusions of mosses from the reference data and those in the archaeological ceramics, PPL.

***Fig. 7** – Comparaisons entre les inclusions de mousses du référentiel et celles des céramiques, lumière polarisée non analysée.*

matrix. These inclusions correspond to longitudinal and oblique sections of leaves. Mosses have leaves made of a basis of cells, some of them with leaves with a central nervure consisting of several layers of cells (Raven et al., 2000). It seems possible to distinguish mosses to genus level, from the size of the inclusions and their morphology. These observations are then compared to visible vegetal inclusions in the archaeological potsherds.

Determination of vegetal temper

The impressions made by the reference mosses are very similar to those identified in the archaeological ceramics (fig. 7). Mosses generate small fine filament inclusions corresponding to the longitudinal sections of their leaves, conferring a laminated appearance to the fabric. Thin sections of 92 vases in the corpus contain these fine filament impressions, which are also visible in the briquettes. Following on from this observation, the cross sections comprising carbonized cells and sections with vegetal morphology, present in the sherds together with leaf imprints, were compared to the anatomical atlas of present day mosses (Augier, 1966; Crandall-Stotler and Bartholomew-Began, 2007). The archaeological samples contain circular or oval inclusions comprising an arrangement of carbonized cells. The diameters of these plant fibre cross sections range from 60 to 260 µm, the cells contained therein around 7 to 10 microns. These are delimited by a carbonized margin, about fifteen microns thick. These inclusions are very similar to the different cross sections of present day moss stems. Their diameters measure between 200 and 300 µm and they consist of a succession of cellular tissues. Thus, the visible vegetal fibres in the corpus may correspond to the cross sections of moss stem systems. The carbonized cells observed strongly resemble parenchyma tissue cells, median cellular tissue the function of which is storage and transmission. These have a smaller diameter than the present day mosses described in the atlas, around 20 - 30 µm, which could be explained by the firing of the paste and the carbonization of fibres. Indeed, the carbonized margin and the empty peripheral portion of these sections may result from the carbonization and the disappearance of the cellular tissues enclosing the parenchyma tissue. In the same way, analogies are observed between the present day moss stems and some empty or carbonized longitudinal sections visible in ceramics. These longitudinal impressions with vegetal morphologies probably correspond to moss stems, branched or otherwise, still bearing leaves (fig. 8). In most samples, rectilinear fragmentary inclusions, empty or carbonized, 200 µm to about 1 mm in length, are visible but difficult to characterize. These also probably correspond to the longitudinal and oblique sections of stems or branches of mosses. These observations, based on the reference data and studies of bryophytes show that vegetal debris observed in pottery results from the use of mosses. In Lower Normandy, the use of mosses as temper is proven for the Middle Neolithic. First of all, it has been identified in the ceramics from the Cerny settlement sites of Colombiers-sur-Seulles, Condé-sur-Ifs, Hébécrevon, Ernes, Fleury-sur-Orne and Cairon. Mosses are then used more regularly and in greater proportions on regional Chassean sites, in funerary contexts on the sites of Colombiers-sur-Seulles, Ernes, Fontenay-le-Marmion ‘La Hogue’ and ‘La Hoguette’ and also in settlement contexts at Cagny, Argentan, Biéville-Beuville, Grentheville and Fontenay-le-Marmion ‘La Grande Pièce’.

THE RESULTS OF OTHER TEMPERS IDENTIFIED

This study of vegetal tempers also led to the observation of other tempers.

Siliceous inclusions

The fabrics of 38 vases contain siliceous material (flint, chert, silicified fossils). These different siliceous elements are particularly visible in pottery from the Early Neolithic, discovered at Colombelles, Verson, Jort and Valframbert, and for the Early Middle Neolithic at Hébécrevon, Condé-sur-Ifs, Cairon and Barneville-Carteret. Only rare observations of siliceous material have been made for the regional Chassean sites, one vessel each from Argentan, Colombiers-sur-Seulles and Fontenay-le-Marmion 'La Grande Pièce'. In general, these siliceous elements, which vary from sub-rounded to sub-angular in form, occur in small numbers in fossil bioclast, sand particle and glauconious fabrics. These groups can contain naturally rounded flints, silicified limestone or occasional siliceous inclusions. Furthermore, the observed silicifications are rarely of pluri-millimetre dimensions and do not present the characteristic shapes induced by thermal or mechanical shocks inherent to voluntary anthropic additions. Thus, the siliceous elements encountered in the fabrics of our corpus are considered to be naturally present in the clay used.

Grog

Inclusions considered to be grog are regularly identified within the corpus. Grog is a temper resulting from the voluntary re-use of fired waste or broken vases (Rye, 1981). A readily available, inexpensive temper, it also has the advantage of getting rid of unnecessary waste material. The grog inclusions identified are characterized by sub-rounded to angular elements, usually well-defined within the fabric

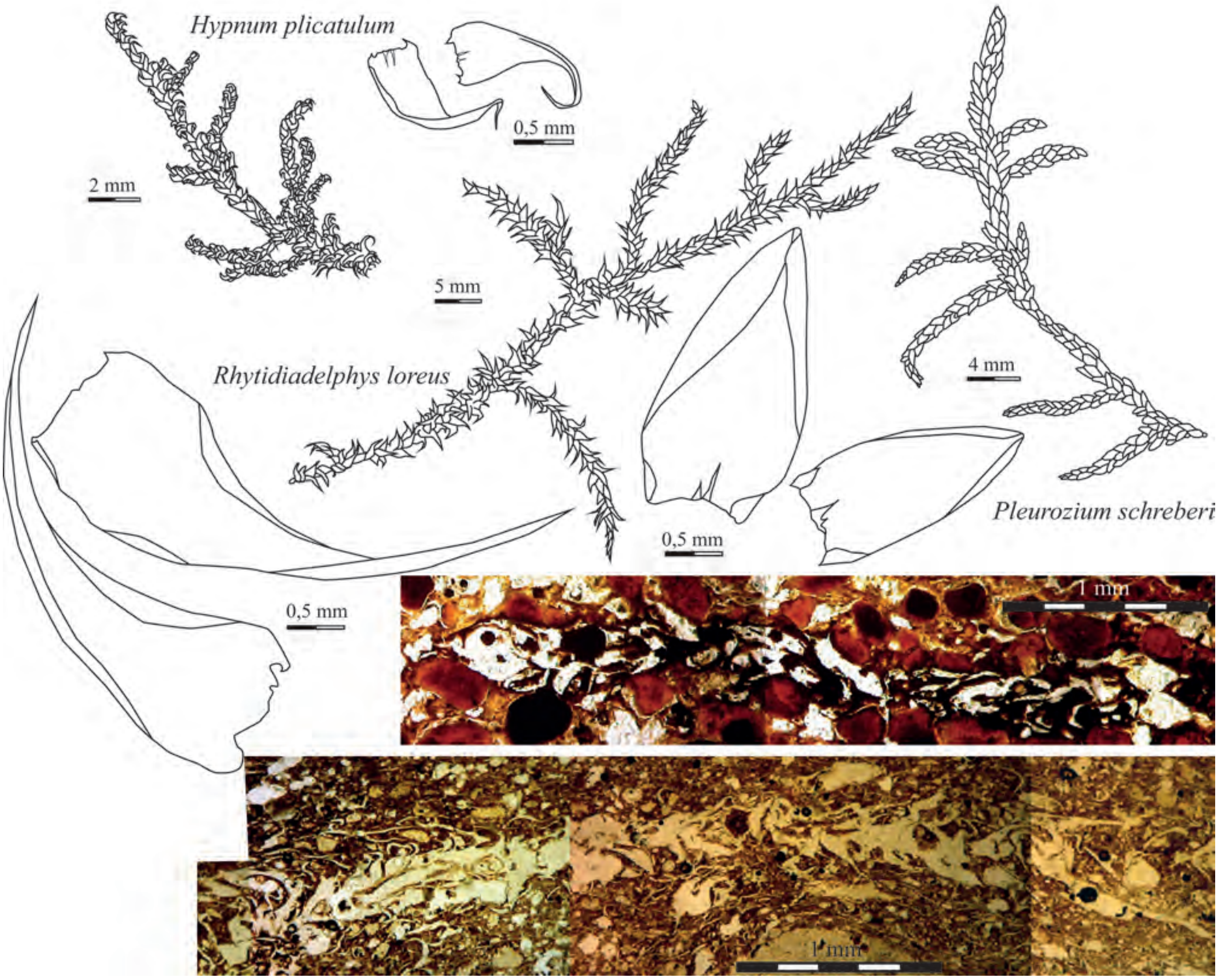

Fig. 8 – Comparison between current mosses (drawings) and those in the archaeological ceramics (photomicrographs, PPL).
***Fig. 8** – Comparaison entre les mousses actuelles (illustrations) et celles observées dans les céramiques (microphotographies, lumière polarisée non analysée).*

by small cracks (fig. 9). The composition of grog presents a different aspect to the matrix when viewed under crossed-polarised lights, regardless of whether it contains similar minerals to the fabric or not. However, in some cases, doubt remains regarding the identification of grog. Indeed, variations include lumps of clay inadequately incorporated during preparation and residual aggregates involuntarily introduced during the process of pottery manufacture. Grog is observed in 47 thin sections of pottery spanning the Early Neolithic to the end of the Middle Neolithic in Lower Normandy (table 3). The Early Neolithic, on BQ/VSG sites, is the period when the percentage of vases containing grog is the highest. Pottery from the Verson site, in particular, presents quite a high ratio of vases containing grog. The Middle Neolithic reveals fewer pots tempered with grog, 8 for the beginning of the period and 4 for the end. Grog is essentially introduced to sand particle pastes, and to a lesser extent to pastes with magmatic elements, sand particles and glauconious inclusions, and fossil bioclast pastes.

Bone temper

Bone splinters are also observed in the studied ceramics. The presence of bone temper manifests an anthropic voluntary addition. Theoretically, no clay naturally contains crushed splinters of bone, even in fossil deposits (Echallier, 1984). However, it is possible that these particles may be related to the proximity of bone working zones to the pottery production process, so it is judicious to treat these additions in the same way as vegetal tempers. More precisely, 24 ceramic thin sections were found to contain bone fragments (table 4). For the Early Neolithic, bone temper is found mostly on BQ/VSG sites and especially in 2 vases from Jort, 1 pot from Valframbert and 6 pots from Verson. Bone temper is added to glauconious and sand particle pastes, on their own or with glauconious inclusions. More significant quantities are observed for the following period, the Middle Neolithic, in Cerny contexts. The site of Condé-sur-Ifs has 12 pots tempered with bone and Hébécrevon 1 single pot (fig. 10). For the same period, 2 ceramics from the site of Barneville-Carteret, attributed to the Castellic culture, also contain bones as temper. In Cerny contexts, the fragments are added to fossil bioclast or sand particle pastes, on their own or accompanied by glauconious inclusions; for the Castellic contexts they are added to sand particle pastes. Bone splinters appear under the microscope in various forms, with sub-rounded to angular contours, depending on the sectional plane (fig. 10). Bone is isotropic in XP and is orange to brown, even black, in PPL. Very low birefringence is noted for the clearest elements in PPL, translucent white to yellow. Sizes vary from 25/50 µm for the smaller splinters, and more generally from 100 to 400 µm. Larger elements measure 800 µm to 1 mm, even up to 2 mm. Certain fragments present the histological structure of compact bone, particularly the Haversian system. Indeed, we can sometimes observe quite large holes in the splinters, Haversian canals, in which nerves ran, or small dots, doubtlessly corresponding to osteocyte bone cells (Morzadec, 1992; here: fig. 11). Bone temper use is well attested in the Early Neolithic, in BQ/VSG ceramics and in the Middle Neolithic, in Cerny and Castellic cultural contexts.

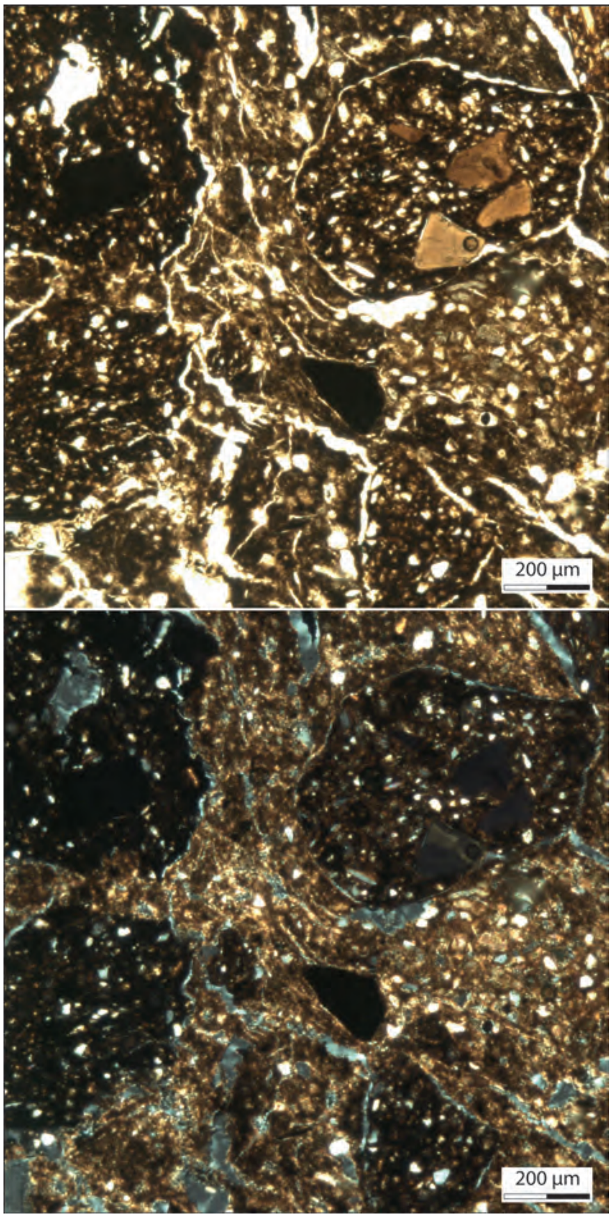

Fig. 9 – Photomicrographs of grog in the sample 570.4 from the Vierville site with PPL (up) and XP (down).
Fig. 9 *– Microphotographies de la chamotte de l'échantillon 570.4 du site de Vierville en lumière polarisée non analysée (haut) et lumière polarisée analysée (bas).*

Summary of the tempers identified at the beginning of the Neolithic in Lower Normandy

Tempers identified in this pottery corpus are not novel and some of them have been the subject of other studies. In Western Europe, the use of plant tempers is clearly evi-

Neolithic	Site	Thin sect.	Grog temper
RRBP	Colombelles ‘Lazzaro’	57	3
BQ/VSG	Fontenay-le-Marmion ‘Grand champ’	10	2
BQ/VSG	Jort ‘Carrière Mace’	13	2
BQ/VSG	Mondeville ‘Haut saint martin’	3	0
BQ/VSG	Tilly-la-campagne ‘Chemin RN 158’	6	1
BQ/VSG	Valframbert ‘Grande pièce’	6	4
BQ/VSG	Verson ‘Mesnils’	51	23
Cerny	Colombiers-s/-seulles ‘Commune sèche’	7	1
Cerny	Condé-sur-ifs ‘Bruyère du hamel’	27	1
Cerny/Chambon	Ernes ‘Derrière les prés’	6	0
Cerny	Hébécrevon ‘Couesnerie’	2	0
Cerny	Hébécrevon ‘Village hôtel torquet’	15	2
Castellic	Barneville-Carteret ‘Castel’	18	1
Castellic	Herqueville ‘Treize vents’	3	0
Castellic	Vierville ‘Butte à la luzerne’	6	2
Cerny/Chasséen	Cairon ‘Pierre tourneresse’	19	1
Cerny/Chasséen	Fleury-sur-Orne ‘Parc d’activité’	6	0
Chasséen	Argentan ‘Grand beaulieu’	25	2
Chasséen	Biéville-Beuville ‘Haie du coq’	11	1
Chasséen	Cagny ‘Projet décathlon’	14	0
Chasséen	Colombiers-s/-seulles ‘Commune sèche’	7	0
Chasséen	Ernes ‘Derrière les prés’	2	0
Chasséen	Fontenay-le-Marmion ‘Grande pièce’	1	1
Chasséen	Fontenay-le-Marmion ‘Hogue’	5	0
Chasséen	Fontenay-le-Marmion ‘Hoguette’	1	0
Chasséen	Grentheville ‘Mondeville sud’	10	0
		331	47

Table 3 – Sites with pottery containing grog temper.
Tabl. 3 – *Sites avec de la céramique incluant de la chamotte.*

dent in Neolithic pottery. A vase from the Vaux-et-Borset site in Hesbaye, attributed to the BQ/VSG culture, is tempered with wild poppy seeds (Bakels et al., 1992). Other ceramics discovered on sites in the North of France and Belgium, presenting fine hollow rectilinear lines on their surface, have been the subject of temper determination. The botanical identification of vegetal imprints enables us to recognize the use of mosses, more particularly *Neckera crispa*, *Fissidens dubius* and *Tortula* sp. (Constantin and Kuijper, 2002). Pottery from the Middle Neolithic enclosure at Spiere, in Belgium, is also tempered with moss; more precisely an imprint of *Neckera crispa* has been identified (Vanmontfort, 2005). According to some authors, there may have been continuity in the use of mosses as temper, first within the Cerny culture in Normandy, spreading to the end of the Rössen culture in the north of the Paris Basin, and then to the Michelsberg culture, in Belgium (Constantin and Kuijper, 2002). The use of moss as temper is attested in Lower Normandy from the first part of the Middle Neolithic, in the Cerny settlement sites of Colombiers-sur-Seulles, Condé-sur-Ifs, Hébécrevon and Ernes. In the second part of the Middle Neolithic, moss is often used in regional Chassean funerary or settlement sites. No correlation between the ceramic forms and the use of moss could be demonstrated. Indeed, both the most common and the rarest vessels include moss tempered individuals. In the same way, the use of moss is not limited to a particular group of clay types: it occurs both in those which naturally contain few minerals and those with abundant natural inclusions alike. The use of plant matter as temper raises questions about the circumstances of that use, namely its purpose and if there are preferential species for pottery manufacture, or if it is related to a secondary use, involving the recycling of plant remains. Indeed, mosses can be used for other purposes, such as the sealing of Bandkeramik culture wells (Constantin and Kuijper, 2002), additives to building earth on the site of Chalain 3 (Bailly, 1997) or even in clothing manufacture: Ötzi (Acs et al., 2005). The use of flint as a temper is not identified in the corpus. Siliceous elements encountered in small numbers in some clay pastes are considered to be natural inclusions.

Neolithic	Site	Thin sect.	Bone temper	Few	Abundant	Very abundant
RRBP	Colombelles ‘Lazzaro’	57	0			
BQ/VSG	Fontenay-le-Marmion ‘Grand champ’	10	0			
BQ/VSG	Jort ‘Carrière Mace’	13	2		1	1
BQ/VSG	Mondeville ‘Haut saint martin’	3	0			
BQ/VSG	Tilly-la-campagne ‘Chemin RN 158’	6	0			
BQ/VSG	Valframbert ‘Grande pièce’	6	1	1		
BQ/VSG	Verson ‘Mesnils’	51	6	1	5	
Cerny	Colombiers-s/-seulles ‘Commune sèche’	7	0			
Cerny	Condé-sur-ifs ‘Bruyère du hamel’	27	12	1	7	4
Cerny/Chambon	Ernes ‘Derrière les prés’	6	0			
Cerny	Hébécrevon ‘Couesnerie’	2	0			
Cerny	Hébécrevon ‘Village hôtel torquet’	15	1			1
Castellic	Barneville-Carteret ‘Castel’	18	2		2	
Castellic	Herqueville ‘Treize vents’	3	0			
Castellic	Vierville ‘Butte à la luzerne’	6	0			
Cerny/Chasséen	Cairon ‘Pierre tourneresse’	19	0			
Cerny/Chasséen	Fleury-sur-Orne ‘Parc d’activité’	6	0			
Chasséen	Argentan ‘Grand beaulieu’	25	0			
Chasséen	Biéville-Beuville ‘Haie du coq’	11	0			
Chasséen	Cagny ‘Projet décathlon’	14	0			
Chasséen	Colombiers-s/-seulles ‘Commune sèche’	7	0			
Chasséen	Ernes ‘Derrière les prés’	2	0			
Chasséen	Fontenay-le-Marmion ‘Grande pièce’	1	0			
Chasséen	Fontenay-le-Marmion ‘Hogue’	5	0			
Chasséen	Fontenay-le-Marmion ‘Hoguette’	1	0			
Chasséen	Grentheville ‘Mondeville sud’	10	0			
		331	24	3	15	6

Table 4 – Sites with pottery containing bone temper.
Tabl. 4 *– Sites avec de la céramique comprenant des esquilles osseuses.*

The addition of crushed flint is, however, very common in Chassean pottery, such as at the Neolithic site of Louviers, in the Eure department, which has yielded a pottery assemblage that includes tempering with flint splinters (Giligny and Colas, 2005). The deliberate addition of flint as temper is well documented in pottery from the Paris Basin, especially in the Aisne valley and on the site of Berry-au-Bac (Barray, 2013). Regarding the use of grog, it is observed throughout the Neolithic period in various regions. For regions close to Lower Normandy, including Brittany, grog is particularly present during the Middle Neolithic. The addition of this temper is frequent at the beginning of the period, but becomes increasingly rare towards the end of the Middle Neolithic (Hamon et al., 2005). In our regions, grog is identified from the beginning of the Neolithic, in the BQ/VSG culture pottery. It is also used to temper vases during the Middle Neolithic, though to a lesser degree. It appears that grog is mostly added to sand particle pastes. No link between the use of grog and pottery forms has been observed. In the North of France and Belgium, bone splinters have been identified as temper for the Early Neolithic in Limburg pottery and it is often used in BQ/VSG ceramics (Constantin and Courtois, 1985). Bone tempering is still used in Cerny culture pottery but is not used thereafter (Constantin and Courtois, 1985; Prost, 2014). This sequence for the use of bone as temper is appreciably the same in Lower Normandy. Indeed, bone is identified in pottery from the Early Neolithic BQ/VSG culture, and at the beginning of the Middle Neolithic Cerny and Castellic cultures. Vases tempered with bone fragments have simple forms such as hemispherical vases or composite forms such as bottles. It appears that the use of bone tempering is neither restricted to specific ceramic forms, nor to particular clay types. Finally, in our pottery corpus, tempers can occur singly or in combination (2) in the fabrics. In the Early Neolithic, two vases from the site of Jort contain both bone splinters and grog in glauconious pastes. In the Middle Neolithic, one ceramic item containing magmatic elements from the site of Barneville-Carteret also contains bone splinters associated with grog (fig. 12). Two pots from Condé-sur-Ifs reveal a combination of mosses and

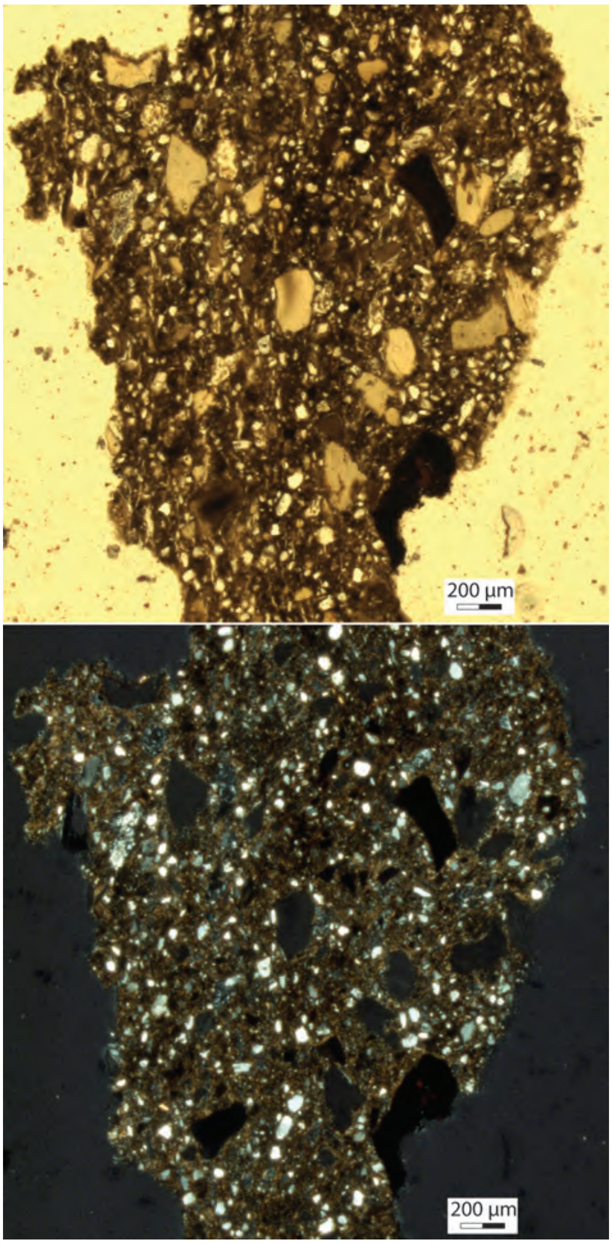

Fig. 10 – Photomicrographs of bone splinters in the sample 313.13 from the Hébécrevon site with PPL (up) and XP (down).
Fig. 10 *– Microphotographies des esquilles osseuses de l'échantillon 313.13 du site d'Hébécrevon en lumière polarisée non analysée (haut) et lumière polarisée analysée (bas).*

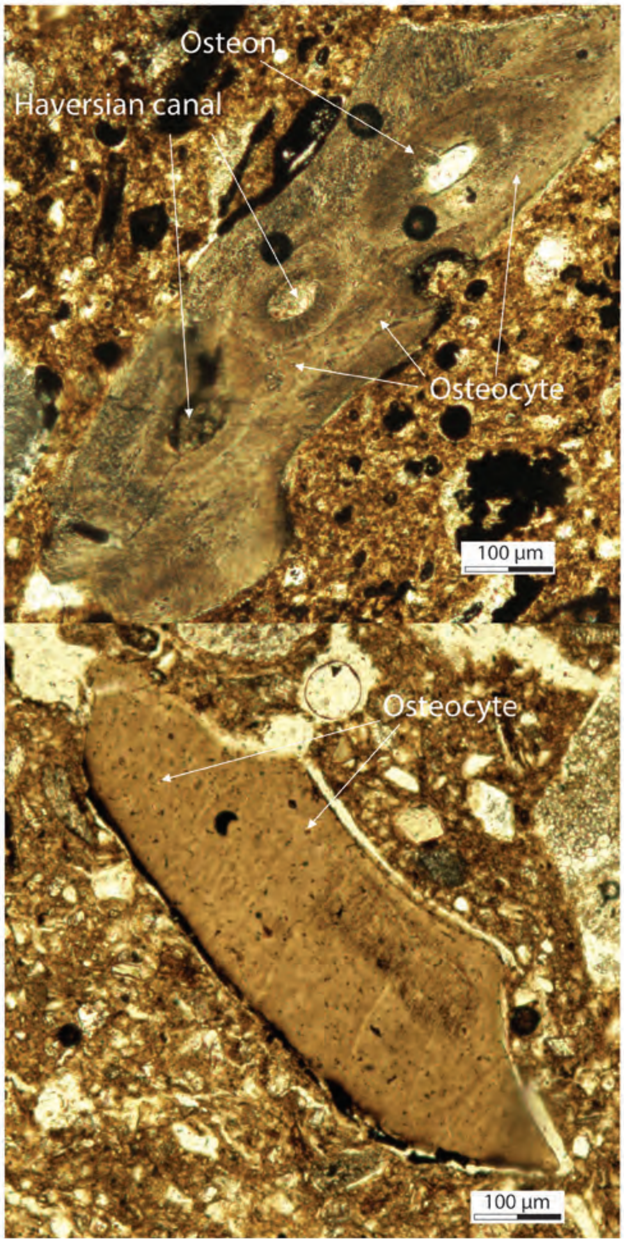

Fig. 11 – Photomicrographs of histological structure of bone in the samples 416.35 and 416.4 from the Condé-sur-Ifs site with PPL.
Fig. 11 *– Microphotographies de la structure histologique de l'os des échantillons 416.35 et 416.4 du site de Condé-sur-Ifs en lumière polarisée non analysée.*

bone splinters, within a fossil bioclast fabric for the one, and within a sand particle fabric for the other. Finally, a sand particle vase from Cairon, a glauconious vase from Argentan and a fossils bioclast pot from Biéville-Beuville contain moss associated with grog.

CONCLUSION

This study on the voluntary addition of inclusions in pottery clays dating to the Early and the Middle Neolithic in Lower Normandy demonstrates the importance of the phenomenon at this period. These additions are not exclusive to Lower Normandy, however, as they have also been identified in Ile-de-France and in the North of France and Belgium, for the Neolithic period. The question of tempers is thus pertinent with regard to the issues of this round table, temper as an added material, and also as food for thought. Indeed, many questions can be referred to here but remain unanswered. For example, can we consider adding temper as a cultural act or a simple technical gesture? The preferential use of moss as temper raises questions about the function of tempering: to enhance plasticity? For resistance during firing? A technique to make vases lighter? Are particular species

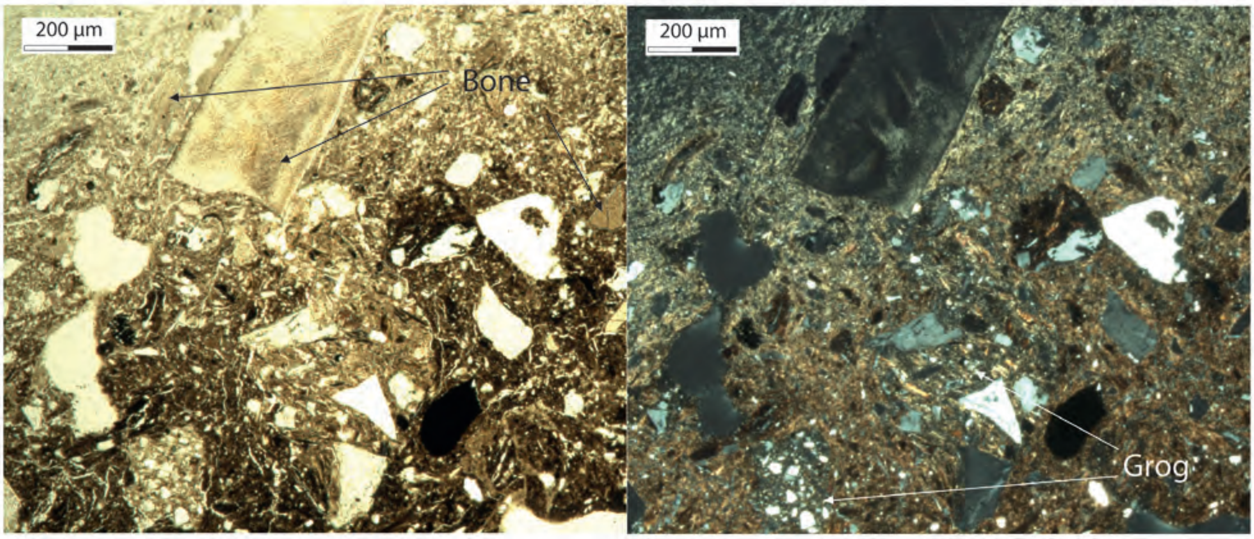

Fig. 12 – Photomicrographs of bone and grog in the sample 568.1 from the Barneville-Carteret site with PPL (up) and XP (down).
***Fig. 12** – Microphotographies des esquilles osseuses et des chamottes de l'échantillon 568.1 du site de Barneville-Carteret en lumière polarisée non analysée (haut) et lumière polarisée analysée (bas).*

chosen for making pottery or can we envisage recycling of materials as with grog? Without doubt it is also necessary to question the origin of the phenomenon, in particular the addition of mosses. Should we consider, for example, the northwest of France as a precursor in the expansion of this phenomenon? This article does not aim to answer these questions which, for the most part, are widely discussed in other publications, but it has the merit of stating them clearly, by presenting a comprehensive overview of tempered pottery in Lower Normandy for a given chronological period based on the material available at a specific time. We hope the methodology established and the study of the traces left by the combustion of plant materials will contribute to furthering plant identification and will stimulate thought. To this purpose, the on-line publication of this experimental data aims at facilitating contributions to a common database and the sharing of our experiences.

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Matières à Penser: Raw materials acquisition and processing in Early Neolithic pottery productions
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La signature chimique des inclusions minérales comme traceur de l'origine des céramiques

L'apport des analyses par LA-ICP-MS

Benjamin Gehres, Guirec Querré

Résumé : L'analyse de la matière première des céramiques, qu'il s'agisse d'observations pétrographiques des inclusions au microscope polarisant ou d'analyses chimiques globales, peut se heurter dans certains cas à des difficultés liées à la nature des terres employées par les artisans. C'est notamment le cas dans les massifs cristallins, comme le Massif central ou le Massif armoricain, où la redondance de certaines roches comme le granite ou le gabbro, dont les argiles d'altérations ont été employées pour fabriquer les poteries, ne permettent pas de différencier précisément les productions. Ainsi, des vases, montés à partir de terres granitiques éloignées de plusieurs centaines de kilomètres, pourront présenter des inclusions minérales similaires et posséder des signatures chimiques globales proches. Il en va de même pour des poteries façonnées à partir des argiles d'altération de gabbros ou de serpentinites, dont les affleurements bien que moins nombreux peuvent également semer le doute quant au traçage de l'origine géographique des matières premières argileuses. Ces verrous méthodologiques oblitèrent donc la discussion quant aux échanges ayant pu avoir lieu entre les communautés et bloquent ainsi notre compréhension des relations entre les groupes humains. Il s'agit donc de développer de nouvelles approches dans l'étude des matières premières des céramiques, aux travers notamment d'outils comme le spectromètre de masse à source plasma, couplé à un système de prélèvement par ablation laser (LA-ICP-MS). Cette technique a permis de renouveler l'étude des inclusions des céramiques, comme le montrent les travaux sur la détermination de l'origine de dégraissant coquillier fluviatile ou encore la datation U/Pb par LA-ICP-MS d'inclusions de zircons détritiques, mais aussi de tracer les sources d'approvisionnement à partir de l'analyse des matrices argileuses englobant les inclusions. Cet article présente les dernières avancées méthodologiques réalisées à l'aide de la technique du LA-ICP-MS dans les problématiques de différenciation de l'origine des matières premières argileuses, pétrographiquement et géochimiquement semblables. Ainsi, au travers de plusieurs exemples, situés sur le Massif armoricain et répartis chronologiquement du Néolithique ancien au second âge du Fer, nous verrons que certains minéraux inclus dans les pâtes des terres cuites peuvent servir de traceurs pour différencier les productions et identifier précisément les sources des terres et les roches mères.

Il sera dans un premier temps question de décrire comment la composition chimique de tablettes de biotite permet de distinguer les origines des céramiques dont les inclusions correspondent à l'assemblage minéralogique d'une roche granitique. Dans un second temps, nous présenterons les résultats obtenus grâce aux analyses de grains d'amphibole contenus dans les pâtes de poteries façonnées à l'aide d'argiles d'altération de roches gabbroïques et nous verrons que cette méthode permet d'identifier et de distinguer les productions des deux principaux ateliers de potiers du second âge du Fer. Par la suite, nous verrons que la singularité d'une pâte ne permet pas toujours d'identifier son origine, au travers de l'exemple unique d'une céramique paléo-onctueuse de l'âge du Bronze. Cette poterie a été montée à partir d'argiles d'altération d'une roche ultrabasique, la serpentinite, formation géologique n'affleurant qu'à deux endroits en Bretagne. Dès lors, l'analyse de minéraux opaques nous permettra de surmonter cet obstacle et d'identifier la zone géographique d'où provient ce vase.

Dans les bassins sédimentaires peuvent exister des productions de terres cuites basées sur des argiles de décalcification de calcaires coquillers, comme dans la plaine de Caen. Ces vases présentent des bioclastes fossiles, qui peuvent être cimentées à du calcaire, il s'agit d'un des principaux indices permettant de déterminer l'origine fossilifère des bioclastes. Cependant, dans le cas d'une découverte de céramiques à inclusions bioclastiques et de l'absence de fragments de calcaires associés à ces bioclastes, la question est de savoir si les potiers ont utilisé des terres où sont naturellement présents des fossiles, ou s'il s'agit d'un dégraissant à base de bioclastes ramassés sur l'estran et adjointes aux pâtes par les artisans. Nous verrons que le LA-ICP-MS fournit un procédé pour distinguer la nature de ces deux types d'inclusions à l'aide de leurs compositions chimiques. Enfin, l'application de ces méthodes sur le site du Néolithique ancien de Kervouyec-Névez (Finistère) fournira un exemple de croisement des données que l'on peut obtenir à partir des analyses de plusieurs types d'inclusions minérales.

Mots-clés : Origine de la matière première, céramique, LA-ICP-MS, analyse de minéraux, Néolithique, Protohistoire, Massif armoricain.

Abstract: The analysis of ceramic raw materials, whether through petrographic observations of the inclusions using a polarizing microscope or through general chemical analysis, may, in some cases, encounter difficulties related to the nature of the clay used by potters. This is particularly the case in the crystalline massifs, such as the Massif Central or the Armorican Massif, where the ubiquity of certain rocks such as granite or gabbro (weathered clays of which have been used by potters to make vessels) does not allow us to accurately identify the origins of the products. In fact, ceramics fashioned using granitic clays from locations several hundred kilometres apart, may have similar mineral inclusions and chemical signatures. The same is true for pottery made with rock alteration products such as gabbro and serpentinite, whose outcrops (although less numerous) may also cause doubt as to the exact geographical origin of the clays.

These methodological obstacles curtail discussion regarding the exchanges which may have taken place between communities, and thus hamper our understanding of the relationships between human groups.

It is, therefore, necessary to develop new approaches to the study of ceramic raw materials, in particular using tools such as the plasma mass spectrometer coupled with a laser ablation sampling system (LA-ICP-MS). This technique has allowed renewed studies of ceramic inclusions, as demonstrated by the work on the sourcing of fluvial shell tempers or the dating of detrital zircon inclusions using U/Pb methods. However, it also allows the sources of ceramic raw materials to be identified through analysis of the clay matrix, including mineral inclusions.

This article presents the latest methodological advances made using the LA-ICP-MS technique for distinguishing the origin of ceramic pastes that are petrographically and geochemically similar. By means of several examples, located on the Armorican Massif and chronologically spanning the Early Neolithic to the Late Iron Age, we will demonstrate that some of the minerals included in these pastes can be used as tracers to differentiate between productions and to precisely identify clay sources and parent rocks.

We will describe how the chemical composition of biotite tablets allows us to distinguish the origins of ceramics whose inclusions correspond to the mineral assemblage of granitic rock. Secondly, we will present the results obtained from the analysis of the biotites included in the clay paste of a Bronze Age urn discovered on Belle-Ile-en-Mer (Morbihan), an island whose geology does not feature granitic outcrops. This urn is, therefore, an import, which may have come from the neighbouring islands of Houat or Hoedic, or from the mainland.

Next, we will present the results obtained from the analyses of amphibole grains included in pottery made from alteration clay derived from gabbroic rocks and we will see that this method allows us to identify and distinguish between two main pottery productions from workshops dating to the Late Iron Age. In fact, during this period in Brittany, two production areas used gabbroic clay to produce ceramics: these are located on two different gabbroic massifs, one at Trégomar (Côtes-d'Armor) and the other at Saint-Jean-Du-Doigt (Finistère). Their products were exported over several hundred kilometres, as far as the site of Hengistbury Head in southern England (Morzadec, 1995). However, until analysis of the amphibole grains using LA-ICP-MS, it was very difficult to identify the precise origin of the products.

Furthermore, through the unique example of a Bronze Age '*paléo-onctueuse*' ceramic discovered on the site of Kermenguy (Finistère), we will see that the singularity of a paste does not always allow us to identify its origin. This vessel was made with clay which derived from serpentinite, an ultra-basic rock, only two outcrops of which exist in Brittany: one located at Ty-Lan (Finistère) and the other at Belle-Isle-en-Terre (Côtes-d'Armor). However, since Kermenguy is equidistant from the two outcrops, it is difficult to identify the exact origin of the raw material used. Furthermore, clay from Ty-Lan was used by potters during the late Iron Age to make '*proto-onctueuses*' ceramics. We will outline the results of the analyses of the opaque minerals present in the paste of the '*paléo-onctueuse*' and '*proto-onctueuse*' ceramics and in the two serpentinites, in order to identify their chemical signatures.

In sedimentary basins, such as the Caen Plain, certain ceramic workshops may have existed that used clays derived from the decalcification of shelly limestone. These vessels are naturally tempered with fossil shells which are more or less cemented by limestone. This is one of the main clues permitting the origin of fossil shells to be determined. Examples of this type of pottery are common in the sedimentary basin of the Caen Plain, where Bronze Age and Early Iron Age potters produced pottery known as Caen Plain ware (Manson et al., 2011). However, in the case of shell-tempered pottery discovered in a crystalline massif we need to determine whether the inclusions are fossils shells derived from shelly limestone, or if the potters deliberately added crushed shells to their pastes. This is the case on the Late Iron Age site of La Batterie-Basse (Manche) where several ceramics containing crushed shell temper were found on the shore. We will see that the LA-ICP-MS can help us to determine the nature of these inclusions on the basis of their chemical compositions.

Finally, the application of the methods presented in this article to ceramics from the Early Neolithic site of Kervouyec-Nevez (Finistère) provides us with an example of data crossover which can be obtained from analysis of several types of mineral inclusions. In fact, we will see that the inclusions within a section of wattle and daub can be used as a reference to determine the chemical compositions of several local minerals which can then be compared to the inclusions in the pottery discovered on the site.

Keywords: Raw material origins, ceramics, LA-ICP-MS, mineral analysis, Neolithic, Protohistory, Armorican Massif.

INTRODUCTION

Déterminer l'origine géologique et géographique des artéfacts archéologiques est primordial pour identifier les réseaux d'échanges et les relations établies entre les différents groupes humains pour une région et une période données.

Ces objectifs reposent sur des analyses qui peuvent porter sur de nombreuses matières différentes, comme les roches, haches polies en jadéite alpine du Néolithique ancien (Pétrequin *et al.*, 2012), perles en variscite importées depuis l'Espagne jusqu'en Armorique (Querré *et al.*, 2013), circulation de l'obsidienne (Poupeau *et al.*, 2010), les échanges de silex (Andreeva *et al.*, 2014), ou de quartzite (Pitblado *et al.*, 2013), également pour le verre (Gratuze, 2014) ou les métaux (Blet-Lemarquand *et al.*, 2014 ; Leroy *et al.*, 2014). Il en va de même dans l'étude des terres utilisées pour façonner les céramiques archéologiques, dont l'apport complémentaire de la typochronologie permet de retrouver les centres de production. Afin de déterminer l'origine géologique et géographique de ces argiles et donc des terres cuites, des méthodes issues des Sciences de la Terre sont employées. Elles ont notamment été développées par P.-R. Giot, ou encore J.-C. Échallier (Échallier, 1984 ; Giot et Querré, 1987). Il s'agit le plus souvent d'analyses minéralogiques et pétrographiques par microscopie en lumière polarisée, afin d'identifier la nature des inclusions non plastiques, qu'elles soient présentes naturellement, elles caractérisent alors une source géologique particulière, ou rajoutées par les potiers. Il s'agit dans ce second cas de dégraissant, qui a vocation à rendre les terres moins plastiques ou bien à répondre à des pratiques traditionnelles. Il peut alors s'agir d'éléments minéraux (calcite : Sénépart et Convertini, 2003), ou d'inclusions biominérales (coquille : Manson *et al.*, 2011 ; os : Constantin et Kuijper, 2002), ou encore végétales (van Doosselaere et Oberweiler, 2009).

Des analyses chimiques élémentaires globales peuvent également être réalisées selon plusieurs techniques (spectrométrie de fluorescence des rayons X portable : HH-XRF, analyse par activation neutronique instrumentale : INAA, la spectrométrie à émission optique : ICP ICP-OES, la spectrométrie de masse à source plasma : ICP-MS...). Une liste plus complète détaillant les avantages de ces méthodes est disponible dans différents ouvrages généraux tels que ceux de Rice (Rice, 2006) et de Quinn (Quinn, 2009 et 2013). L'existence de différences entre les minéraux inclus dans les pâtes des céramiques et ceux du substratum géologique du site permet de déduire qu'il s'agit de productions importées. Par exemple en contexte insulaire, où la présence de céramiques façonnées à partir d'argiles d'altération de roches absentes de l'île est une preuve de leurs importations (Boileau *et al.*, 2009). Dans d'autres cas, c'est la singularité ou la rareté des inclusions minérales qui permettent d'identifier des productions importées ou de proposer des parallèles avec des formations géologiques locales (Peacock, 1988 ; Martineau *et al.*, 2007 ; Quinn et Day, 2007). Cependant, des massifs cristallophylliens, comme le Massif armoricain ou encore le Massif central, sont composés notamment de roches granito-gneissiques constituées de cristaux de quartz, de plagioclase, de feldspath potassique comme principaux minéraux, mais aussi de micas comme la biotite ou la muscovite, ou de roches gabbroïques à amphibole, pyroxène, plagioclase et olivine.

Ainsi, contrairement aux terres issues de roches sédimentaires, les terres accumulées sur les massifs cristallins sont pour la plupart issues de la dégradation mécanique et chimique de roches cristallophylliennes. Il s'agit notamment de la désagrégation des cristaux de micas et de feldspath qui va former ces argiles primaires. Ces couches ou poches d'altération seront alors composées de terres peu ou pas transportées (terres développées *in situ*). Cela aura pour conséquence la formation de gisements certes plus nombreux, mais plus localisés et plus petits que dans les bassins sédimentaires, mais aussi dont l'identité reflète celle du substrat dont ils sont issus. Leurs exploitations pourront dès lors mettre en péril la ressource et l'épuiser.

Il est dès lors très difficile a priori, à partir des argiles d'altération de ces roches, de distinguer les origines géographiques des matières premières utilisées, tant les formations et les massifs sont minéralogiquement similaires.

Au niveau des analyses chimiques globales, le problème est le même ; les céramiques possèdent des signatures chimiques reflétant l'assemblage minéralogique présent en son sein et donc le type de roche qui a été altéré et dont la terre a été utilisée. Cependant, il est très difficile de distinguer, par ces méthodes, des origines de matières premières différentes et encore plus de pouvoir préciser de quels massifs ou formations géologiques sont issus les produits d'altérations utilisés.

Ainsi, il existe de nombreux verrous méthodologiques à notre compréhension de la production des céramiques, dès lors que les potiers ont utilisé des argiles dont les inclusions minérales sont communes à de nombreuses roches et ne présentent pas de singularité. Il est donc difficile de mettre en perspectives ces résultats et nous nous privons de données essentielles permettant de tracer les transferts à plus ou moins longues distances entre les groupes humains.

MÉTHODOLOGIE

Depuis quelques années, les méthodes d'analyses spectrométriques ponctuelles ont ouvert la voie à de nouvelles perspectives comme : l'identification des sources de dégraissant coquiller fluviatile (Peacock *et al.*, 2007), l'analyse élémentaire des céramiques (Kennett *et al.*, 2004 ; Golitko et Terrel, 2012), la datation U/Pb par spectrométrie de masse à source plasma, couplée à un système de prélèvement par ablation laser (LA-ICP-MS) d'inclusions de zircons détritiques présentes dans du sable utilisé comme dégraissant dans les pâtes des poteries (Tochilin *et al.*, 2012).

Cet article porte sur l'analyse des micas et d'autres espèces minérales, approche inédite dans la détermination des origines des terres.

Nous avons appliqué la technique du LA-ICP-MS à ces problématiques de différenciation et de regroupement des productions de céramiques. Différentes phases minérales ont été analysées afin d'obtenir leurs signatures chimiques pouvant être extrapolées à la céramique puis au groupe pétrographique et d'ainsi définir les origines géographiques des terres cuites.

Afin de développer cette application, nous avons travaillé sur des céramiques archéologiques provenant de plusieurs sites localisés sur le Massif armoricain (fig. 1, partie gauche), datés du Néolithique au second âge du Fer, soit du Ve millénaire au Ier siècle avant notre ère. Ces vases ont été façonnés à partir d'argiles d'altérations de roches différentes (fig. 1, partie droite) : des granites, des gabbros et des roches ultrabasiques de type serpentinite, permettant ainsi d'établir plusieurs méthodes d'analyses, correspondant à des phases minérales distinctes comme : les biotites, les amphiboles et les minéraux opaques. En effet, les compositions chimiques de ces minéraux peuvent fluctuer en fonction des conditions physico-chimiques des différents magmas dans lesquels ils cristallisent (Wones et Eugster, 1965 ; Haslam, 1968 ; Czamanske et Wones, 1973 ; Helz, 1973 ; Speer, 1984). Enfin, dans l'optique de caractériser les origines des inclusions, nous avons travaillé sur la différenciation chimique de fossiles, comme les huîtres, les brachiopodes, les bryozoaires ou les échinodermes comme les crinoïdes, présents originellement dans les argiles, et de coquilles contemporaines de bivalves, rajoutées par les potiers en tant que dégraissant. En effet, il n'est pas toujours aisé de distinguer les coquilles fossiles emballées dans de l'argile, des coquilles ramassées sur l'estran et rajoutées à la pâte.

PRINCIPE DE LA MÉTHODE ET PARAMÈTRES D'ANALYSE

Afin d'obtenir lors de nos analyses le dosage d'une large gamme d'éléments allant du plus léger comme le lithium au plus lourd comme l'uranium, nous avons choisi d'utiliser un spectromètre de masse à source plasma, couplé à un système d'ablation laser (LA-ICP-MS). En effet, l'ICP-MS a la faculté de mesurer un éventail étendu d'éléments, avec une précision permettant de mesurer les teneurs en éléments majeurs, mineurs, traces et ultra-traces. Le système d'ablation laser permet quant à lui de réaliser des microprélèvements directement sur la céramique, la roche, ou bien directement sur la section épaisse d'une lame mince non couverte. La présence d'un polarisateur dans le système permet de déterminer les espèces minérales et donc d'analyser un ou plusieurs types d'inclusions. Cet aspect permet un gain de temps considérable et une préparation très peu contraignante, contrairement à d'autres méthodes comme la spectrométrie d'émission atomique par plasma (ICP-AES), où il serait nécessaire de pratiquer une séparation magnétique au Frantz

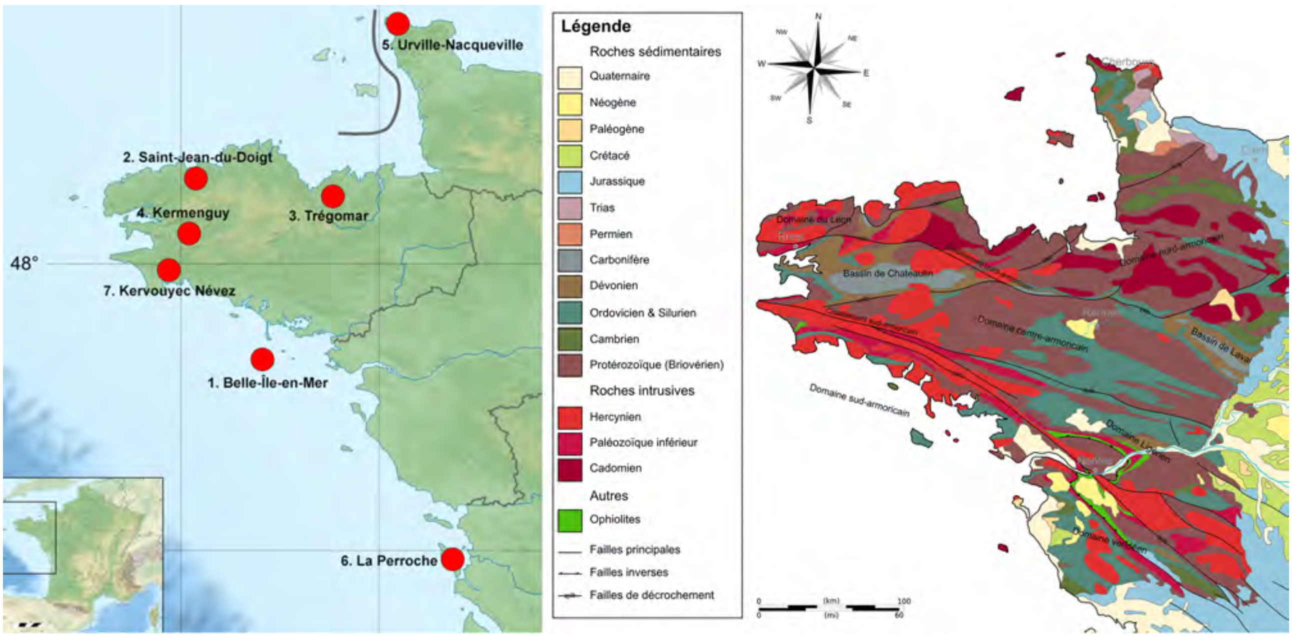

Fig. 1 – Localisation des principaux sites mentionnés dans l'article et carte géologique du Massif armoricain. 1 : analyse des tablettes de biotite ; 2-3 : analyse des grains d'amphibole ; 4 : analyse des grains de minéraux opaques ; 5-6 : analyse des inclusions bioclastiques ; 7 : analyses des tablettes de biotites et des grains d'amphibole.

***Fig. 1** – Locations of the main sites mentioned in the paper and geological map of the Armorican massif. 1: analysis of the tablet-shaped crystals of biotite; 2-3: amphibole grain analysis; 4: opaque mineral grain analysis; 5-6: bioclastic inclusion analysis; 7: analysis of biotite tablets and amphibole grains.*

(Konings *et al.*, 1988) des grains, ainsi qu'une mise en solution, pour obtenir la composition chimique d'une espèce minérale. On pourra dès lors faire le lien direct entre les céramiques archéologiques et les roches dont les argiles d'altération ont été utilisées pour façonner les poteries, sans avoir à passer par des prélèvements d'argiles de la région concernée.

Enfin, cet outil offre la possibilité de réaliser des tracés d'ablation permettant de s'adapter à la forme de l'inclusion ou encore des analyses ponctuelles, contrairement à d'autres méthodes comme l'émission gamma induite par particules chargées (PIGE ; Calligaro *et al.*, 2000 ; Bugoi *et al.*, 2008).

Ces analyses ont été réalisées à l'aide d'un spectromètre de masse quadripolaire à source plasma (*Agilent Technologies*, *7700 Series*) et les prélèvements réalisés par un système d'ablation laser Nd : YAG de 213 nm (*Cetac Technologies*, *LSX-213*, *G2*). L'instrument a été calibré à partir d'étalons géologiques internationaux : DR-N, DT-N, UB-N (Govindaraju et Roelandts, 1989) et MICA-Fe (Govindaraju et Roelandts, 1988). C'est au total 46 éléments qui ont été dosés (au-dessus des limites de détection) : Na, Mg, Al, Si, K, Ca, Ti, Mn, Fe, Li, Sc, V, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Cd, Sb, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Tl, Pb, Th, U.

Les paramètres pour l'ablation laser qui ont été utilisés sont : temps d'analyse total 180 s, diamètre du spot : 20 µm, < 2.5 mJ/pulse, largeur du pulse > 5 ns, fréquence des pulses 20 Hz, et une vitesse d'ablation de 20 µm/s en mode balayage et ligne suivant la forme des inclusions.

EXEMPLES D'APPLICATIONS ET D'IMPLICATIONS ARCHÉOLOGIQUES

L'idée n'est pas ici de présenter des résultats analytiques, mais les principes des nouvelles approches que nous avons développées dans l'identification des origines des matières premières des poteries. Les analyses précises de chaque occupation sont consultables dans la thèse de doctorat de B. Gehres (Gehres, 2016).

Les tablettes de biotite : traçage des sources des céramiques à pâtes de nature granitique. Le dépôt de l'âge du Bronze de Bordustard à Belle-Île-en-Mer, Morbihan

Il existe sur le Massif armoricain de nombreux massifs granitiques dont les produits d'altérations ont très souvent été exploités par les potiers des différentes époques. Ces céramiques représentent dans la plupart des cas l'ensemble pétrographique le plus important et il est très souvent difficile de proposer une origine géographique précise pour ce type de vase (Gehres, 2016).

Le dépôt de Bordustard a été découvert à proximité d'un tumulus de l'âge du Bronze, sur la commune du Palais au lieu-dit Champ du Héron sur l'île de Belle-Île-en-Mer, Morbihan (fig. 2). Cent dix-neuf objets et fragments métalliques ont été retrouvés, ainsi qu'un morceau de lignite et quatorze tessons, correspondant à une urne contenant le dépôt (Audouard *et al.*, 2010). L'ensemble métallique a été daté de l'horizon Bronze final III atlantique (Taraud, 2009).

L'analyse pétrographique en lame mince de la céramique a permis de déterminer que le potier a employé une terre provenant de l'altération d'une roche granitique à deux micas (fig. 3 et 4). Ces terres sont caractérisées le plus souvent par des grains de quartz, d'orthose et de feldspath plagioclase acide de type albite et oligoclase, plus ou moins altérés, et de micas (biotite et muscovite), dont la taille moyenne est d'environ 250 µm. Dans certains cas, des lithoclastes plurimillimétriques (sans schistosité) associant ces minéraux sont observables (fig. 3 et 4) et caractéristiques de granites à deux micas. Cependant, il n'existe aucun massif granitique sur Belle-Île-en-Mer, composée presque exclusivement de roches métamorphiques en faciès schistes verts (Audren *et al.*, 1982). Dès lors, la question de l'origine de ce vase est posée. Provient-il des îles à socle granitique que sont Houat ou Hoedic, situées à proximité de Belle-Île, ou du continent (fig. 2) ?

Si l'on étudie les compositions chimiques globales des poteries à pâte granitique provenant des occupations situées sur les îles d'Houat et d'Hoedic, et de l'urne de Belle-Île-en-Mer par HH-XRF, on remarque une forte dispersion des teneurs de plusieurs éléments majeurs comme le SiO_2, le CaO, le Fe_2O_3 ou encore le K_2O. Par exemple, dans le diagramme SiO_2/K_2O (fig. 5), l'ensemble des points représentatifs se place dans un très large domaine de composition ne permettant pas de distinguer les éventuelles différentes roches mères à l'origine des terres. Ces fluctuations sont dues aux variations de quantité de certaines espèces minérales au sein des pâtes. Il s'agit d'un problème récurrent sur les céramiques dont les pâtes présentent une forte hétérogénéité tant au niveau des espèces minérales que de leurs quantités.

Nous avons donc analysé la composition chimique des paillettes de biotite incluses dans la pâte de l'urne belliloise, du granite formant Houat et Hoedic, ainsi que des tablettes de biotite contenues dans plusieurs céramiques du Néolithique et du second âge du Fer, découvertes sur ces deux îles. Entre 10 et 20 tablettes de biotite ont été analysées par échantillon.

Les résultats analytiques ont montré une dispersion des compositions chimiques en fonction des gisements et des céramiques. Comme pour les analyses par HH-XRF, les éléments majeurs dosés par LA-ICP-MS ne permettent pas de différencier d'éventuelles sources différentes. Cependant, d'autres éléments chimi-

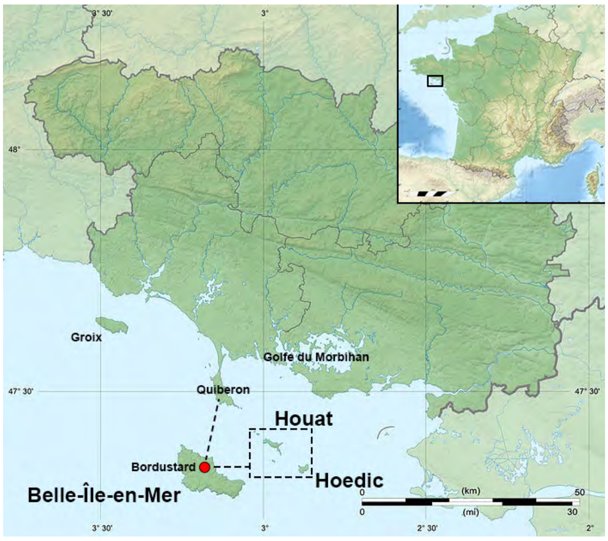

Fig. 2 – Localisation du site de Bordustard sur l'île de Belle-Île-en-Mer (Morbihan) et hypothèses d'origine de la matière première de l'urne.
Fig. 2 – *Location of the site of Bordustard on the island of Belle-Île-en-Mer (Morbihan) and suggested origin of the raw material used to make the urn.*

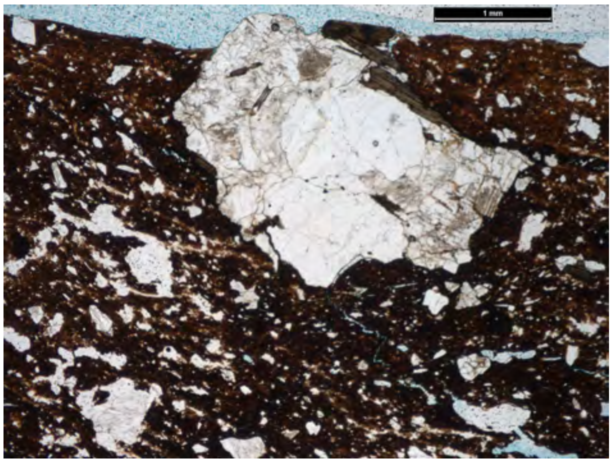

Fig. 3 – Micrographie d'une lame mince de la céramique de Bordustard en lumière doublement polarisée non analysée (LPNA).
Fig. 3 – *Thin section photomicrograph of the Bordustard vessel in non-analysed double polarised light (PPL).*

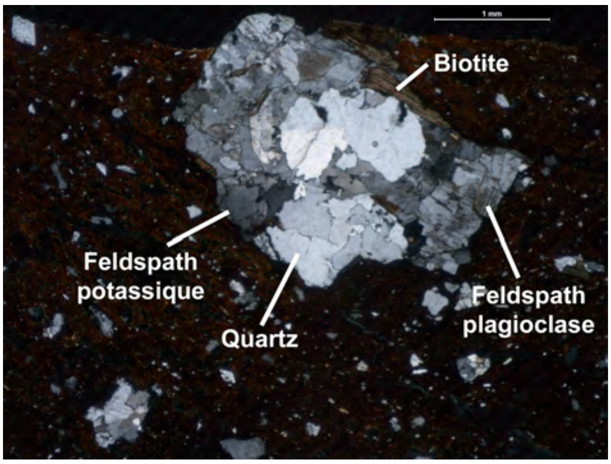

Fig. 4 – Micrographie d'une lame mince de la céramique de Bordustard en lumière polarisée (LP).
Fig. 4 – *Thin section photomicrograph of the Bordustard vessel in polarised light (XPL).*

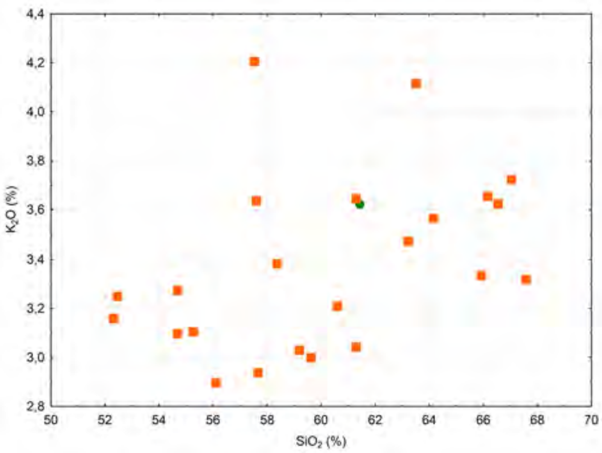

Fig. 5 – Diagramme binaire représentant les concentrations en SiO_2 et K_2O des céramiques d'Hoedic et de l'urne de Belle-Île-en-Mer analysées par HH-XRF.
■ Céramiques d'Hoedic
● Urne de Belle-Île-en-Mer
Fig. 5 – *Binary diagram representing the concentrations of SiO_2 and K_2O of the ceramics from the island of Hoedic and the urn from Belle-Île-en-Mer, analysed using HH-XRF.*
■ *Ceramics from Hoedic*
● *Urn from Belle-Île-en-Mer*

ques sont discriminants, comme le Li et le V dont les concentrations permettent de distinguer différentes formations granitiques entre elles (fig. 6). En effet, deux ensembles se distinguent à partir des concentrations en Li et en V dans les tablettes de biotite des céramiques et des granites.

Le premier groupe d'analyses présentant un rapport Li/V très élevé et à faibles teneurs en V, correspondant aux tablettes de biotite de la céramique de Belle-Île-en-Mer (fig. 6). Les gammes de concentration de ces deux éléments sont comprises entre 882 et 2400 ppm pour le Li et 36 à 105 ppm pour le V. Le second ensemble regroupe les analyses du granite d'Hoedic ainsi que celles des tablettes de biotite des céramiques découvertes sur cette île (fig. 6). Les concentrations du Li y sont comprises entre 90 et 860 ppm et celles du V, entre 49 à 530 ppm. On notera que les variations des teneurs du Li dans les biotites sont attribuées, le plus souvent, à l'intensité des altérations hydrothermales des granites (Konings *et al.*, 1988).

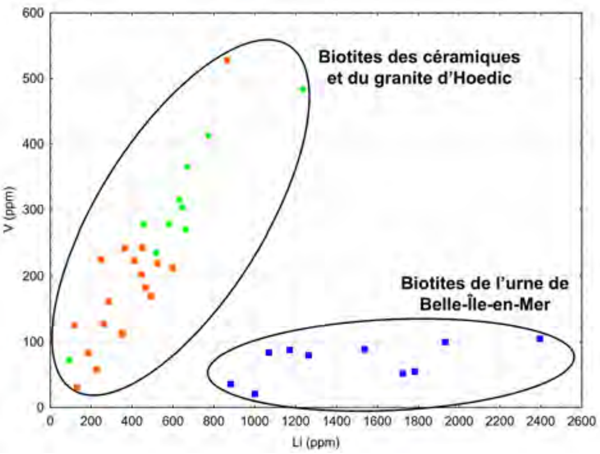

Fig. 6 – Diagramme binaire représentant les concentrations en Li et V des tablettes de biotites analysées par LA-ICP-MS, contenues dans le granite formant l'île d'Hoedic et de Houat, dans des poteries découvertes sur l'île d'Hoedic et dans l'urne de Bordustard. Chaque point correspond à un cristal de biotite analysé.
■ Grains de biotite des céramiques d'Hoedic
■ Grains de biotite l'urne de Bordustard
● Grains de biotite du granite d'Hoedic
On observe que les points forment deux ensembles distincts et sont répartis autour de deux droites dont les coefficients directeurs sont différents.
***Fig. 6** – Binary diagram representing the concentrations of Li and V of the LA-ICP-MS analysis of biotites contained in the Hoedic granite, in the pottery discovered on Hoedic and in the urn from Bordustard. Each point corresponds to an analysed biotite tablet.*
■ *Biotite grains in the ceramics*
■ *Biotite grains in the Bordustard urn*
● *Biotite grains in the granite*
The points form two separate sets, and are distributed around two lines whose directrix coefficients are different.

Ces résultats démontrent que l'urne belliloise n'a pas été façonnée à partir des argiles d'altération du granite d'Hoedic. Comme il s'agit d'une importation, elle est probablement continentale. De plus, nos analyses nous permettent de confirmer le lien génétique existant entre les terres cuites des différentes périodes découvertes sur l'île d'Hoedic et le granite formant son socle, puisque les rapports Li/V des tablettes de biotite sont les mêmes que celles des roches locales.

Les céramiques à pâtes « gabbroïques » : des ateliers de productions de poteries du second âge du Fer en Bretagne, recherche des sources à partir de l'analyse des grains d'amphibole

Les potiers gaulois du second âge du Fer ont implanté leurs ateliers sur plusieurs massifs gabbroïques armoricains afin d'exploiter leurs argiles d'altérations de manière plus intensive. Ces zones de productions n'ont, à ce jour, pas été découvertes sur le terrain, mais sont uniquement caractérisées par les études pétrographiques des céramiques. Ainsi, la répartition des nombreuses découvertes autour de deux massifs gabbroïques bretons a amené les chercheurs à supposer l'existence de deux zones de productions de poteries dans ces régions. L'un est situé à Trégomar (fig. 1), dans les Côtes-d'Armor (Morzadec, 1995) et l'autre, à Saint-Jean-Du-Doigt (fig. 1), dans le Finistère (Giot *et al.*, 1986 ; Giot et Querré, 1987). Ces vases ont connu beaucoup de succès vu leur découverte sur des sites éloignés de plusieurs centaines de kilomètres, dont le port d'Hengistbury Head en Angleterre (Morzadec, 1995). Ces poteries sont caractérisées par un mélange naturel d'argiles d'altérations issues de gabbros mais aussi de roches granitiques (fig. 7 et 8). Ainsi, de nombreuses inclusions d'amphibole (verte et incolore), de feldspath potassique et de feldspath plagioclase basique (de type labrador) sont observables, tout comme des grains de quartz et de micas (biotite et muscovite). Dans certains cas, la présence de grains de pyroxène est attestée (Morzadec, 1995). Sur la base de la composition chimique globale, ces productions de vases sont difficilement discernables et présentent toutes deux de fortes variations dans les concentrations en éléments majeurs (Fe_2O_3, SiO_2, Al_2O_3, K_2O et CaO) et en V et Cr (éléments mineurs). Par exemple, dans le diagramme CaO/Al_2O_3 (fig. 9), les points correspondant aux poteries considérées comme étant originaires des zones de productions de Saint-Jean-Du-Doigt et de Trégomar se placent dans une même gamme de composition ne permettant pas de distinguer les origines des matières premières.

Des poteries montées à partir de terres d'origine gabbroïque ont été mises en évidence sur le site de Mez Notariou sur l'île d'Ouessant (Finistère), mais aussi dans l'occupation portuaire de la Batterie-Basse à Urville-Nacqueville (Manche) ou encore sur le site de Thaon, Calvados (fig. 10). Les observations pétrographiques et les analyses chimiques de ces poteries n'ont pas

Fig. 7 – Micrographie d'une lame mince d'une céramique façonnée à partir des argiles d'altération d'un gabbro (LPNA). On observe une texture fine de la pâte et la forte angularité des grains, synonymes d'un broyage de l'argile par les potiers.
Fig. 7 *– Thin section photomicrograph of a ceramic made with a clay alteration of gabbro (PPL). The paste is characterized by a fine texture and the grains are angular, synonymous with the grinding of the clay by the potters.*

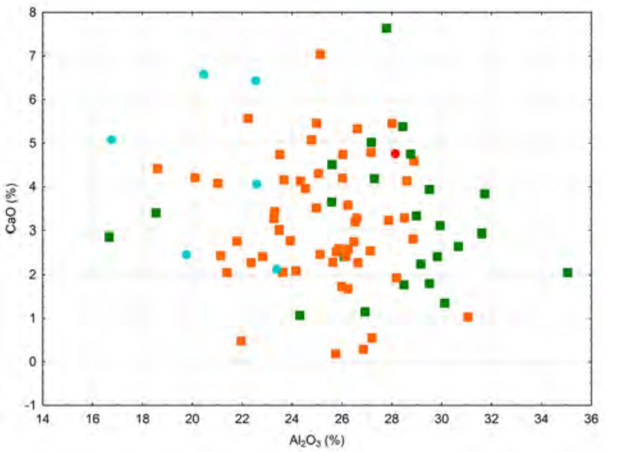

Fig. 9 – Diagramme binaire représentant les concentrations en CaO et Al_2O_3 de plusieurs céramiques à pâte gabbroïque découvertes sur le massif Armoricain et analysées par HH-XRF.
■ Céramiques à pâte gabbroïque considérées par les analyses pétrographiques comme provenant de la zone de production de Saint-Jean-Du-Doigt
■ Céramiques à pâte gabbroïque considérées par les analyses pétrographiques comme provenant de la zone de production de Trégomar
● Céramiques découvertes sur le site de Mez Notariou (île d'Ouessant)
● Céramique découverte sur le site de la Batterie-Basse (Urville-Nacqueville)
Fig. 9 *– Binary diagram representing the concentrations of CaO and Al_2O_3 of several vessels made with gabbroic clays, found on the Armorican Massif, and analysed using HH-XRF.*
■ Gabbroic clay ceramics attributed to the Saint-Jean-Du-Doigt production area on the basis of petrographic analysis
■ Gabbroic clay ceramics attributed to the Trégomar production area on the basis of petrographic analysis
● Gabbroic clay ceramics found on the site of Mez Notariou (Island of Ouessant)
● Gabbroic clay ceramics found on the site of la Batterie-Basse (Urville-Nacqueville)

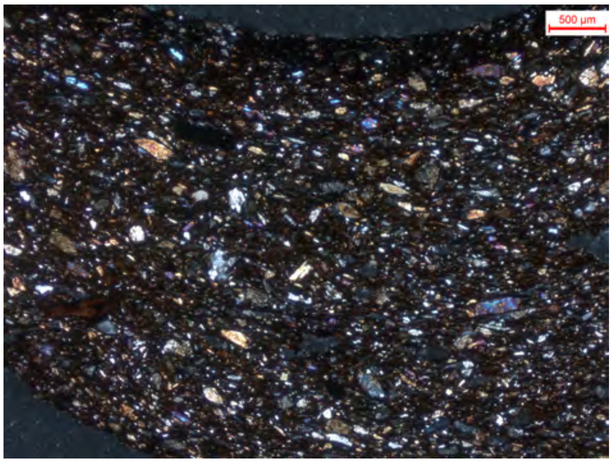

Fig. 8 – Micrographie d'une lame mince d'une céramique façonnée à partir des argiles d'altération d'un gabbro (LP). On observe de nombreux grains anguleux d'amphibole de couleur jaune dorée.
Fig. 8 *– Thin section photomicrograph of a ceramic made with a clay alteration of gabbro (XPL). There are several angular amphibole grains which have a golden yellow color.*

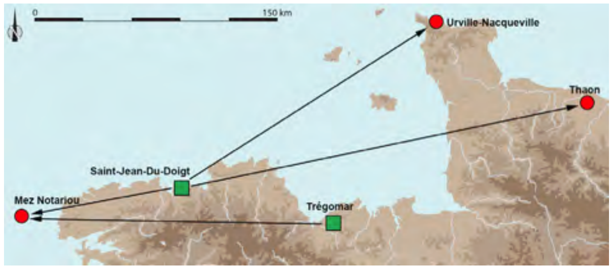

Fig. 10 – Localisations des deux zones ateliers de productions de céramiques à pâte gabbroïque du second âge du Fer et circulation des productions.
Fig. 10 *– Locations of the two workshop areas which produced pottery using gabbroic clay during the late Iron Age, and the circulation of their products.*

permis de déterminer s'il s'agit de productions issues de Trégomar ou de Saint-Jean-Du-Doigt. Le point commun à ces céramiques étant la grande quantité d'inclusions d'amphiboles dans leurs pâtes, il a été décidé d'analyser par LA-ICP-MS ces minéraux dans les vases, ainsi que ceux présents dans les gabbros de Saint-Jean-Du-Doigt et de Trégomar. Nous avons complété notre corpus à l'aide de terres cuites à pâte gabbroïque ayant été précédemment analysées en lame mince, provenant des sites du souterrain de Bellevue à Plouégat-Moysan, Finistère (Giot et Querré, 1987) et du Moulin de la Rive, Finistère (Giot *et al.*, 1986) localisé dans la région de Saint-Jean-Du-Doigt .

Les résultats montrent la présence de deux types d'amphibole dans chacune des productions de vase : des grains de hornblende verte et d'actinote/trémolite. Ainsi, deux groupes de grains se distinguent au travers de plusieurs éléments majeurs : MgO, Al_2O_3, Fe_2O_3 (fig. 11). Le premier groupe correspond aux cristaux

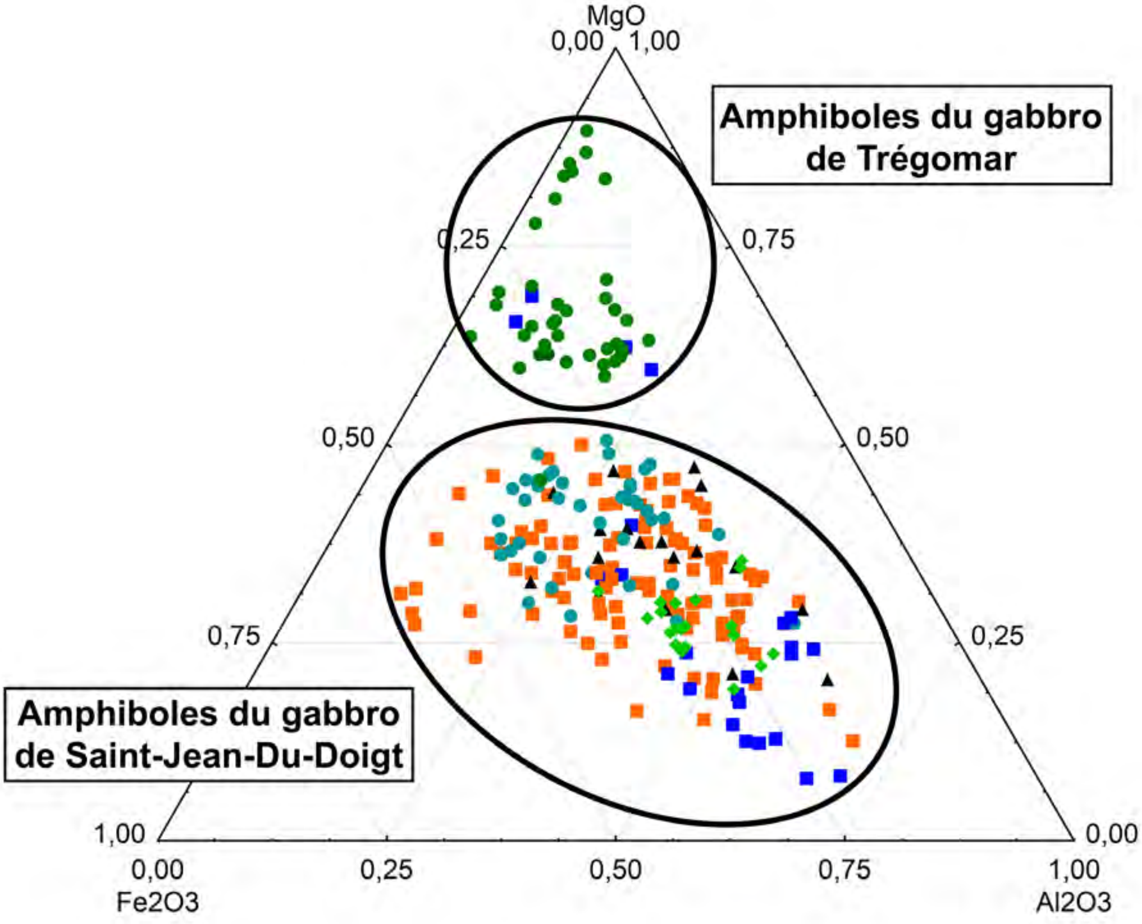

Fig. 11 – Diagramme ternaire représentant les teneurs en MgO, Al_2O_3 et Fe_2O_3 des grains d'amphibole des gabbros de Trégomar (Côtes-d'Armor) et de Saint-Jean-Du-Doigt (Finistère) et de plusieurs poteries à pâte à empreinte gabbroïque, analysés par LA-ICP-MS. Chaque point correspond à l'analyse d'un grain d'amphibole.

● Grains d'amphibole du gabbro de Trégomar

● Grains d'amphibole du gabbro de Saint-Jean-Du-Doigt

■ Grains d'amphibole des céramiques à pâte gabbroïque comme provenant de la zone de production de Saint-Jean-Du-Doigt, par les analyses pétrographiques

■ Grains d'amphibole des céramiques à pâte gabbroïque du site de Mez Notariou (île d'Ouessant)

◆ Grains d'amphibole des céramiques à pâte gabbroïque du site de Thaon (Manche)

▲ Grains d'amphibole des céramiques à pâte gabbroïque du site de la Batterie-Basse (Urville-Nacqueville)

On observe deux ensembles correspondant aux deux différentes roches.

Fig. 11 *– Ternary diagram representing the MgO, Al_2O_3, Fe_2O_3 contents of the analyzed amphibole grains from the gabbros of Trégomar (Côtes-d'Armor) and Saint-Jean-Du-Doigt (Finistère) and from pottery made from gabbroic paste, analysed by LA-ICP-MS. Each point corresponds to an analyzed amphibole.*

● *Amphibole grains from Trégomar gabbro*

● *Amphibole grains from Saint-Jean-Du-Doigt gabbro*

■ *Amphibole grains from gabbroic clay ceramics considered as coming from the Saint-Jean-Du-Doigt production area on the basis of petrographic analysis*

■ *Amphibole grains from gabbroic clay ceramics considered as coming from the Trégomar production area on the basis of petrographic analysis*

◆ *Amphibole grains from gabbroic clay ceramics from the site of Thaon (Manche)*

▲ *Amphibole grains from gabbroic clay ceramics from the site of la Batterie-Basse (Urville-Nacqueville)*

The points form two separate sets corresponding to the two different rocks.

ayant la concentration en MgO la plus forte. Il s'agit des grains d'amphibole du gabbro de Trégomar et de plusieurs céramiques provenant du site de Mez Notariou. Le second groupe est représenté par les grains ayant des teneurs plus fortes en Al_2O_3 et Fe_2O_3 et plus faibles en MgO, provenant du gabbro de Saint-Jean-Du-Doigt et des poteries des sites du Moulin de la Rive et du souterrain de Bellevue (fig. 11).

L'analyse par LA-ICP-MS des grains d'amphibole nous a permis également de déterminer l'origine des poteries à pâte à empreinte gabbroïque des sites de Mez Notariou (Île d'Ouessant, Finistère), Thaon (Calvados) et de la Batterie-Basse (Urville-Nacqueville, Manche). Ainsi, les vases découverts à Ouessant proviennent des deux zones d'ateliers de potiers. Les céramiques de Thaon ont été importées depuis l'aire de production de Saint-Jean-Du-Doigt situé à 250 km à vol d'oiseau, tout comme la terre cuite du site de la Batterie-Basse en Normandie (fig. 10). Il est intéressant de noter que ce dernier site était probablement en lien avec l'Angleterre comme l'ont démontré les nombreuses découvertes qui y ont été faites (Lefort *et al.*, 2010 ; Lefort *et al.*, 2011 ; Lefort et Rottier, 2013) et le site portuaire anglais d'Hengistbury Head, où ont été retrouvées des céramiques à pâte gabbroïque, supposées provenir de Trégomar (Morzadec, 1995). Il serait donc nécessaire de réétudier ces vases. L'outil LA-ICP-MS, serait très utile pour confirmer ou infirmer cette origine.

Les minéraux opaques ; provenance des céramiques à pâtes ultrabasiques : le cas unique d'une poterie « paléo-onctueuse » de l'âge du Bronze

La serpentinite est une roche métamorphique issue de l'altération de roches ultrabasiques (péridotites). Elles sont principalement constituées de minéraux d'antigorite (ancienne famille des serpentines), de cristaux d'olivine, de pyroxène et d'amphibole incolore (Plaine *et al.*, 1979). L'argilisation (altération atmosphérique) donne une terre grasse dont les inclusions sont principalement des grains de serpentinite et de minéraux opaques ainsi que des rubans de talc. Il n'existe que deux zones restreintes où affleurent ces roches en Bretagne (fig. 12) : l'une dans la région de Belle-Isle-en-Terre, Côtes-d'Armor et l'autre à Ty-Lan, Finistère. Ce second affleurement et ses gisements d'argiles ont été utilisés durant le second âge du Fer afin de réaliser des « céramiques proto-onctueuses ». Ce terme est dérivé des poteries onctueuses médiévales issues de la même région (Giot, 1971 ; Giot et Querré, 1987 ; Le Noac'h, 2009). Ces poteries sont bien connues dans le Sud-Finistère (Giot et Querré, 1987 ; Giot *et al.*, 1988 ; Daire, 1990 et 1992 ; Morzadec, 1995 ; Daire et Querré, 2006 ; Daire et Hamon, 2013 ; Gehres, 2015) et ont été exportées sur des sites situés dans un rayon de 40 km autour des affleurements (Daire et Querré, 2006 ; Gehres, 2015). Ces poteries se distinguent par leurs compositions minéralogiques ainsi que par leur toucher doux et savonneux, provenant de la présence d'un fort taux de talc. Le reste de l'assemblage minéralogique étant composé de grains de serpentine (fig. 13) et de minéraux opaques (chromite, magnétite, spinelle) principalement (Giot et Querré, 1987 ; Morzadec, 1995 ; Gehres, 2015).

Ces productions sont uniquement connues au second âge du Fer, cependant, sur le site de Kermenguy à Châteauneuf-du-Faou, Finistère (Tinévez, 2011) une poterie de l'âge du Bronze a été trouvée dont l'analyse pétrographique de la pâte a mis en évidence l'utilisation d'une argile correspondant à l'altération de serpentinite. Il s'agit donc du premier exemplaire de céramique que nous avons baptisée du fait de son antériorité à l'âge du Fer « paléo-onctueuse ». Le site de Châteauneuf-du-Faou est localisé à équidistance des deux gisements d'argiles d'altération des serpentinites de Ty-Lan ou de Belle-Isle-en-Terre (fig. 12), il est donc *a priori* impossible de déterminer à partir de quelles terres cette poterie a été façonnée sans recourir à des analyses géochimiques.

La comparaison des compositions chimiques globales des poteries proto-onctueuses et de la céramique paléo-onctueuse nous permet d'observer une différence entre les deux types de vase. En effet, on remarque des teneurs plus élevées dans la poterie paléo-onctueuse de certains éléments, notamment en K_2O et en Al_2O_3 (fig. 14). De plus, au sein du groupe des poteries proto-onctueuses, trois ensembles de pâte se différencient selon les concentrations en Ni et en Cr (Morzadec, 1995 ; Gehres, 2015). Ces céramiques possèdent donc des compositions chimiques hétérogènes, pouvant s'expliquer par des origines géologiques différentes ou par des variations des proportions de certaines espèces minérales.

Des comparaisons plus fines doivent donc être faites afin de mieux appréhender ces variations dans les compositions chimiques globales. Ainsi, des analyses par LA-ICP-MS des minéraux opaques, tels que la chromite, la magnétite ou encore du groupe des spinelles (Deer *et al.*, 2013), d'échantillons de serpentinites de Ty-Lan et de Belle-Isle-en-Mer, et de céramiques proto-onctueuses gauloises ont servi de référentiels de comparaison à la signature chimique des minéraux opaques de la poterie paléo-onctueuse de Kermenguy. Ainsi, les rapports V/Cr et Fe_2O_3/Al_2O_3 des minéraux opaques de la serpentinite de Belle-Isle-en-Terre sont élevés, tandis que ceux de la serpentinite de Ty-Lan sont plus faibles (fig. 15). Ces analyses confirment dans un premier temps les liens existant entre les terres utilisées pour façonner les céramiques proto-onctueuses du second âge du Fer et dans un second temps, que l'origine de la matière première de la poterie paléo-onctueuse du site de Kermenguy est également originaire des gisements de serpentinite de Ty-Lan. Ainsi, ce vase a été transporté sur plus de 50 km de distance, depuis le sud-Finistère.

Fig. 12 – Localisations du site de Kermenguy (Finistère) et des deux zones d'affleurement de serpentinite.
Fig.12 *– Location of the site of Kermenguy (Finistère) and of the two areas where serpentinite outcrops occur.*

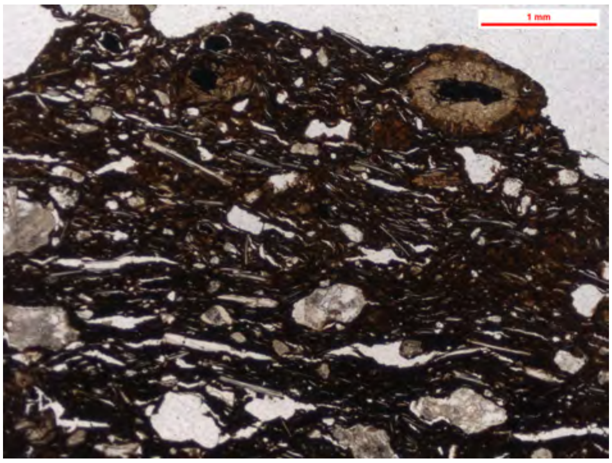

Fig. 13 – Micrographie d'une lame mince d'une céramique paléo-onctueuse de l'âge du Bronze (LPNA). On observe de nombreux grains incolores de quartz et de feldspath potassique, ainsi qu'un « œil » de serpentine dans le coin supérieur droit de l'image.
Fig. 13 *– Thin section photomicrograph of a 'paléo-onctueuse' ceramic from the Bronze Age (PPL). There are several colourless grains of quartz and potassium feldspar, and an 'eye' of serpentine in the upper right corner of the image.*

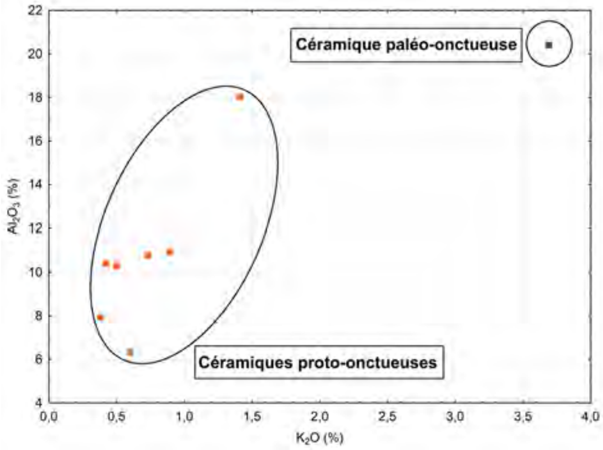

Fig. 14 – Diagramme binaire représentant les concentrations en K_2O et Al_2O_3 des céramiques proto-onctueuses et paléo-onctueuse, analysées par HH-XRF.
■ Céramiques proto-onctueuses gauloises
■ Poterie paléo-onctueuse
Fig. 14 *– Binary diagram representing the concentrations of K_2O and Al_2O_3 of the 'proto-onctueuse' and 'paléo-onctueuse' ceramics, analysed using HH-XRF.*
■ Proto-onctueuse Gallic ceramics
■ Paléo-onctueuse ceramic

Le très faible nombre de céramiques de l'âge du Bronze analysées en Bretagne laisse la place à de nombreuses questions sur l'exploitation de ces terres à cette période : s'agit-il d'exploitations domestiques et d'échanges limités ou bien d'une utilisation réfléchie et tournée vers l'exportation de ces céramiques, ce qui poserait la question de la période d'apparition des ateliers de potiers en Armorique, située actuellement au second âge du Fer, avec l'arrivée des outils de potiers comme le tour et le tour rapide (Daire, 1992).

La distinction entre inclusions fossiles et dégraissant bioclastique : un indicateur des actions anthropiques sur la matière première

L'utilisation d'argiles de décalcification de calcaire coquiller ou de marnes fossilifères est attestée sur de nombreux sites à différentes périodes, comme au Néolithique final à Chalain (Martineau *et al.*, 2007), durant l'âge du Bronze et l'âge du Fer (fig. 16) en plaine de Caen (San Juan, Meniel *et al.*, 1999 ; San Juan, Savary *et al.*, 1999 ; Carpentier *et al.*, 2002 ; Besnard-Vautrin *et al.*, 2009 ; Manson *et al.*, 2011), ou encore au Moyen Âge (Leclercq, 2008). Il s'agit d'une terre où sont naturellement présentes des inclusions de bioclastes fossiles.

D'autres sites ont, quant à eux, permis d'observer des vases dégraissés à partir de débris de coquilles qui n'étaient pas présentes naturellement dans la matière première argileuse. Il peut s'agir soit de fossiles ajoutés comme sur le site Néolithique final de La Perroche

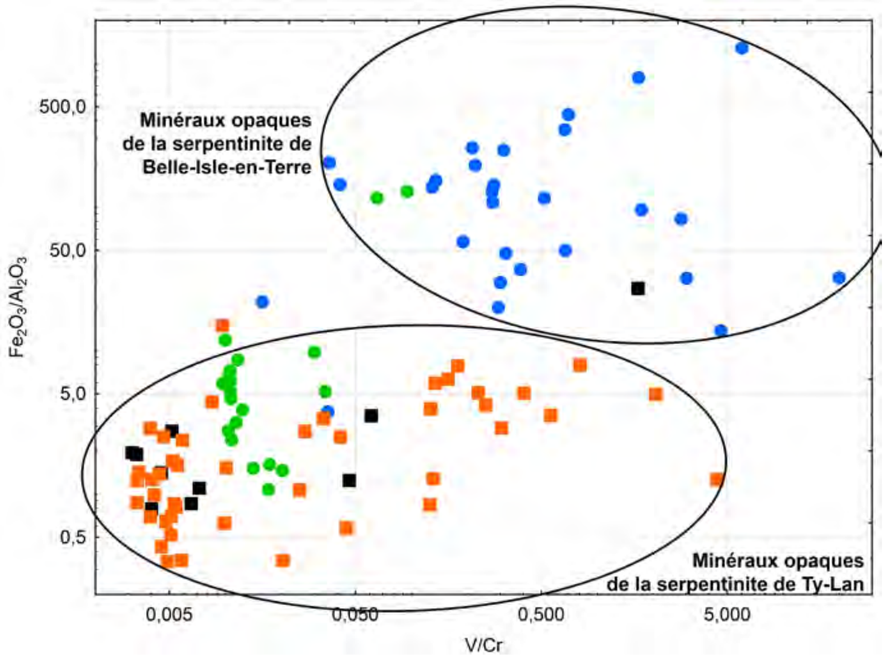

Fig. 15 – Diagramme binaire représentant les rapports entre les teneurs des minéraux opaques en V/Cr et Fe_2O_3/Al_2O_3, contenus dans les serpentinites de Ty-Lan (Finistère) et Belle-Isle-en-Terre (Côtes-d'Armor) ainsi que dans plusieurs poteries proto-onctueuses du second âge du Fer et dans la céramique paléo-onctueuse de l'âge du Bronze. Chaque point correspond à l'analyse d'un grain de minéral opaque.
■ Grains de minéral opaque des céramiques proto-onctueuses gauloises.
■ Grains de minéral opaque de la poterie paléo-onctueuse.
● Grains de minéral opaque de la serpentinite de Ty-Lan.
● Grains de minéral opaque de la serpentinite de Belle-Isle-en-Terre.
On observe deux ensembles correspondant aux deux différentes roches.

***Fig. 15** – Binary diagram representing the ratios between the concentrations of V/Cr and Fe_2O_3/Al_2O_3 of the opaque minerals in the serpentinites of Ty-Lan (Finistère), Belle-Isle-en-Terre (Côtes-d'Armor), and in several 'proto-onctueuses' ceramics of the late Iron Age and in the 'paléo-onctueuse' pottery from the Bronze Age. Each point corresponds to an analyzed amphibole.*
■ *Opaque minerals from the 'proto-onctueuses' ceramics*
■ *Opaque minerals from the 'paléo-onctueuse' pottery*
● *Opaque minerals from the serpentinite of Ty-Lan*
● *Opaque minerals from the serpentinite of Belle-Isle-en-Terre*
The points form two separate sets, corresponding to the two different rocks

(fig. 1 ; Guiavarc'h et Querré, 2009) soit d'éléments ramassés par l'artisan sur l'estran (bioclastes marins) ou dans les rivières (coquilles d'eau douce) pour la consommation et/ou leur adjonction à la pâte, comme sur le site Néolithique moyen des Gouillauds (Rousseau *et al.*, 2001). Comme l'ont démontré les expérimentations et l'éthnoarchéologie, les bioclastes sont préalablement passés au feu, afin de retirer les chairs pouvant rester, mais aussi pour les rendre plus faciles à broyer (Bronitsky et Hammer, 1986 ; Rice, 2006).

Toutefois, il n'est pas toujours aisé de distinguer la nature fossilifère ou non des bioclastes. En effet, l'absence de critères discriminant comme la présence de fragments de calcaire dans la pâte ou cimentés à des bioclastes (fig. 17, 18, 19 et 20), synonymes d'inclusions de fragments de roches fossilifères, n'est pas observée. C'est notamment le cas sur le site gaulois de la Batterie-Basse (fig. 16) à Urville Nacqueville, Manche (Lefort *et al.*, 2010 ; Lefort *et al.*, 2011 ; Lefort et Rottier, 2013), où les analyses pétrographiques (fig. 17 et 18) ont permis de relever la présence de nombreux bioclastes dans la pâte des céramiques (Gehres *et al.*, 2015). Cependant, l'absence d'indices pouvant indiquer une origine géologique aux inclusions de bioclastes de la pâte n'a pas permis, à la seule lumière des observations pétrographiques en lame mince, de définir s'il s'agit de bioclastes contemporains rajoutés par les potiers ou de fossiles présents naturellement dans les terres. Ainsi, l'analyse chimique ponctuelle par LA-ICP-MS des fragments de coquilles, en s'inspirant notamment des travaux de Peacock (Peacock *et al.*, 2007) et Eerksen (Eerksen *et al.*, 2007) sur la détermination de l'origine géographique des coquillages fluviatiles incorporés comme dégraissant dans des céramiques du Mississippi a fourni des éléments offrant la possibilité de différencier ce type d'inclusions. Les détails de cette étude ayant été publiés précédemment, nous résumerons donc les résultats obtenus ci-dessous (Gehres *et al.*, 2015). On notera cependant que la technique du LA-ICP-MS ne permet pas de déterminer l'espèce minéralogique constitutive des coquilles (aragonite ou calcite).

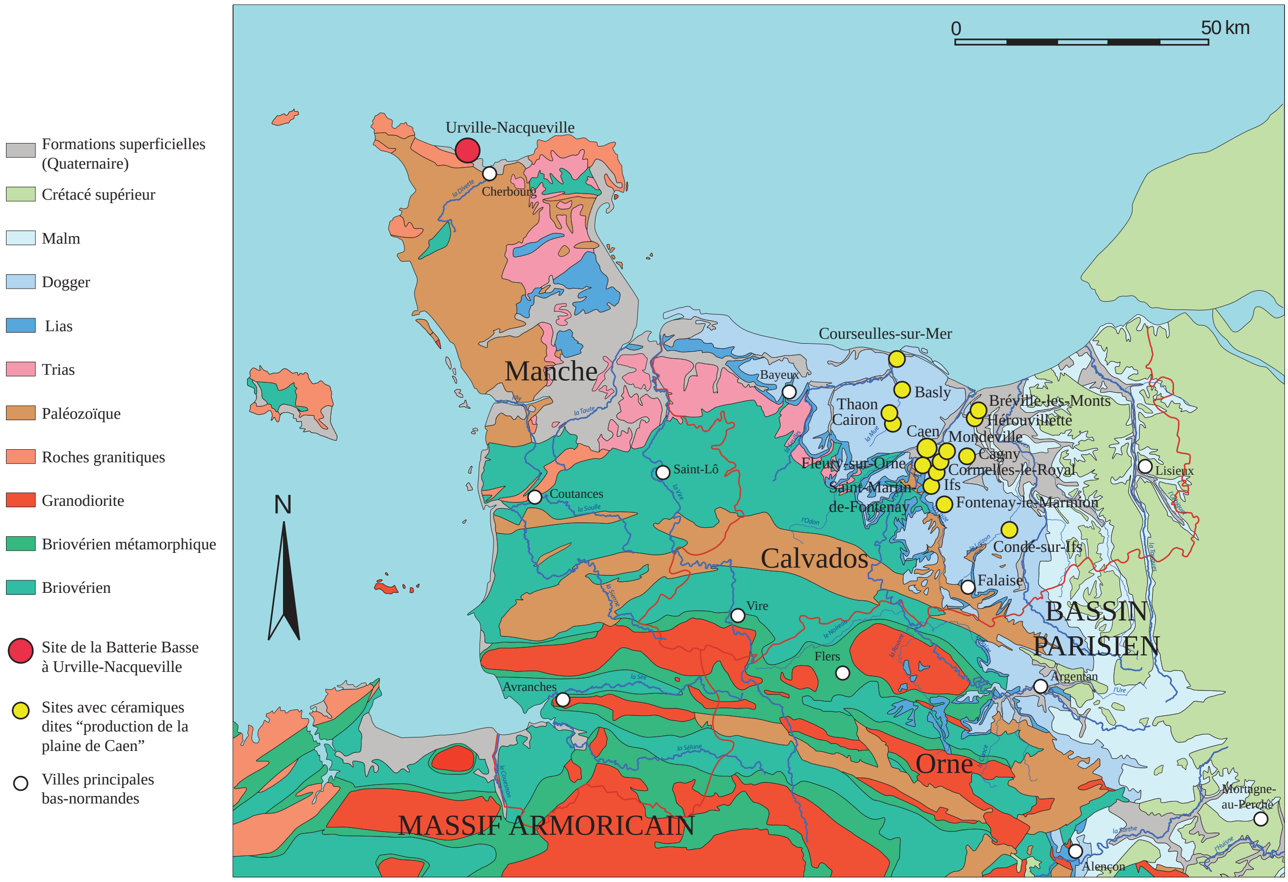

Fig. 16 – Carte géologique et localisation des sites et de la zone de production de poterie à inclusions fossiles de La Plaine de Caen (d’après X. Savary *in* Gehres *et al.*, 2015).

***Fig. 16** – Geological map and locations of the sites and the production area of the shell tempered pottery of the Caen Plain (after X. Savary in Gehres et al., 2015).*

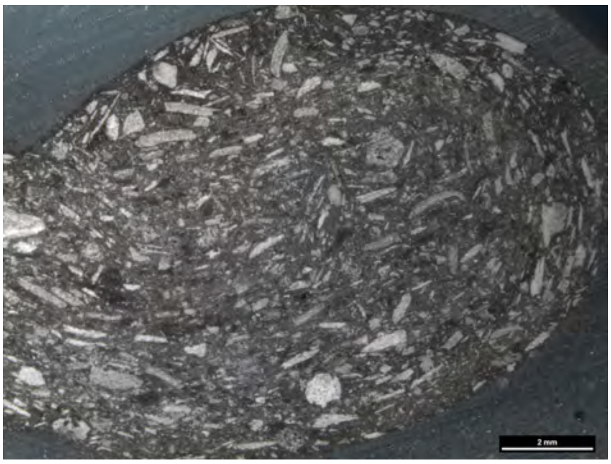

Fig. 17 – Photographie de la coupe d’une céramique du second âge du Fer, présentant de nombreuses inclusions de coquilles ramassées sur l’estran et broyées avant d’être incorporées comme dégraissant dans les argiles. Les fragments quadrangulaires blancs correspondent aux inclusions de coquilles.

***Fig. 17** – Photograph of a cross-section of a shell tempered ceramic from the late Iron Age. The shells were collected on the beach and crushed before being incorporated into the paste by the potters. The white quadrangular fragments are shell inclusions.*

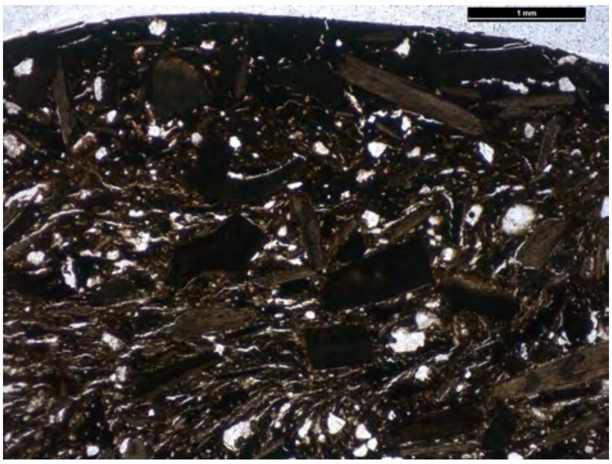

Fig. 18 – Micrographie d’une poterie dégraissée à l’aide de fragments de coquilles fraiches (LPNA). Les inclusions quadrangulaires brunes correspondent à des morceaux de coquilles broyées.

***Fig. 18** – Thin section photomicrograph of a shell tempered ceramic (PPL). The brown quadrangular inclusions correspond to the crushed shells.*

Fig. 19 – Micrographie d'un vase à inclusions de coquilles fossiles (ici une huître), façonnées à partir des altérations d'un calcaire coquillier (LPNA).
Fig. 19 *– Thin section photomicrograph of a fossil-shell tempered pottery (oysters in this case), made with shelly limestone derived clay (PPL).*

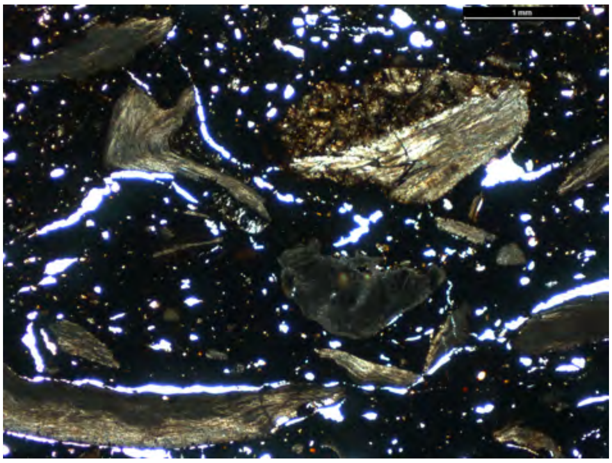

Fig. 20 – Micrographie d'un vase à inclusions de coquilles fossiles (LP). On observe notamment une coquille cimentée à du calcaire, caractéristique des inclusions fossilifères.
Fig. 20 *– Thin section photomicrograph of a fossil-shell tempered ceramic (XPL). We can see a shell cemented to limestone, characteristic of fossil inclusions.*

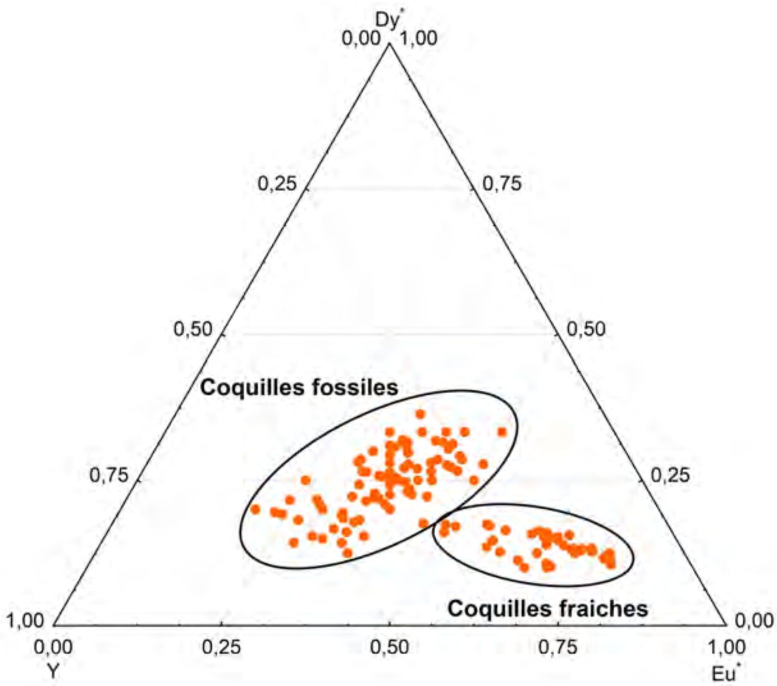

Fig. 21 – Diagramme ternaire représentant les concentrations en Dy*, Eu*, Y. Chaque point correspond à l'analyse d'une inclusion coquillère dans des céramiques issues de la Plaine de Caen (Calvados), du site du Néolithique récent de la Perroche sur l'île d'Oléron (Charente-Maritime) et du site de la Batterie-Basse à Urville-Nacqueville (Manche). On observe deux groupes de points, correspondant aux deux types d'inclusions, fossilifère et contemporaine.
Fig. 21 *–Ternary diagram representing the concentrations of Dy*, Eu*, Y. Each point corresponds to the analysis of a shell or fossil shell inclusion in ceramics from the Caen Plain (Calvados), the late Neolithic site of La Perroche on the Island of Oleron (Charente-Maritime) and the site of La Batterie-Basse at Urville-Nacqueville (Manche). The points form two groups, corresponding to the two types of inclusions: shells and fossil shells.*

Pour construire un référentiel de comparaison, environ 60 bioclastes inclus dans des céramiques, datées du Néolithique au second âge du Fer, dont la nature fossilifère des bioclastes a été prouvée par les études pétrographiques, ont été analysés (San Juan, Meniel *et al.*, 1999 ; Besnard-Vautrin *et al.*, 2009 ; Guiavarc'h et Querré, 2009). Il s'agit pour les sites localisés en Plaine de Caen, de fossile d'huîtres, de brachiopodes, de bryozoaires, d'échinodermes et de crinoïdes (Gehres *et al.*, 2015) ou de lamellibranches pour les poteries néolithiques de la Perroche sur l'île d'Oléron (Guiavarc'h et Querré, 2009). Ces résultats ont ensuite été comparés aux analyses des inclusions coquillères des poteries du site de la Batterie-Basse.

Sur la base de notre référentiel, une relative homogénéité des concentrations en éléments majeurs a été observée entre les coquilles fossiles et contemporaines. Toutefois, les teneurs en Li, Cr, Sr, Y et Ba, ainsi que celles des terres rares légères (La, Ce, Pr, Nd, Sm, Eu) sont plus hétérogènes et permettent de distinguer les fossiles des coquilles contemporaines utilisés par les potiers. Il sera intéressant par la suite d'analyser des coquilles d'eau douce afin d'augmenter notre référentiel. Ceci nous permettra notamment d'observer s'il existe au niveau géochimique des distinctions possibles entre les origines des coquilles d'eau douce et de mer.

Il existe une relation de proportionnalité entre le Dy*(1) et l'Eu* au sein des coquilles. Les teneurs de ces éléments sont, en effet, localisées autour de deux droites ayant des coefficients directeurs différents. L'une correspondant aux coquilles fossiles et l'autre aux coquilles contemporaines, en supposant qu'elles soient d'une même espèce ou qu'elles aient eu un même comportement biogéochimique. Sur les diagrammes ternaires : Dy*-Eu*-Y ou Dy*-Eu*-Th, il est possible de distinguer clairement deux groupes (fig. 21). L'un représentant les inclusions fossiles et l'autre les coquilles contemporaines. On remarque enfin que les coquillages contemporains possèdent des teneurs plus élevées en terres rares légères que les fossiles analysés.

Ces analyses ont donc permis de déterminer que les artisans du site de la Batterie-Basse ont utilisé des bioclastes frais préalablement broyés comme dégraissant de leurs argiles, mais aussi qu'une poterie à inclusions fossilifères et typologiquement comparable à des productions de la plaine de Caen a été importée sur le site.

Cette approche a permis de déterminer que le site de la Batterie-Basse est, en l'état actuel de la recherche, le seul site du second âge du Fer, dans l'Ouest de la Gaule, où ont été découvertes des céramiques volontairement dégraissées à l'aide de bioclastes contemporains préalablement broyés (Gehres *et al.*, 2015).

Cette pratique qui rallonge nécessairement la chaîne opératoire, ne trouve donc pas d'équivalent dans la région étudiée et semble se référer à des traditions existantes dans le sud de l'Angleterre comme celles des sites d'Hengistbury Head ou de Cambourne (Cunliffe *et al.*, 1987 ; Wright *et al.*, 2009). Ainsi, alors qu'en plaine de Caen les potiers utilisent des argiles de décalcification des calcaires coquillers du Jurassique moyen de la zone où sont naturellement présents des fossiles de coquillages (Manson *et al.*, 2011), les artisans de la Batterie-Basse utilisent des coquilles passées au feu puis les broient afin de les rajouter à leurs pâtes. Ces tests peuvent être issus d'une consommation des coquillages ou d'un ramassage prédestiné à cette pratique artisanale. Il s'agit selon nous de deux pratiques bien distinctes, bien que comme le montrent les analyses des bioclastes par LA-ICP-MS, une importation de céramique de la plaine de Caen a eu lieu (Gehres *et al.*, 2015). S'agit-il dès lors d'une importation d'une tradition technique anglaise ou bien de populations britanniques ayant occupé le site de la Batterie-Basse ? La question reste posée pour l'instant, mais on notera la présence sur le site de formes de céramiques, de pratiques d'inhumations et d'architectures, inconnues en Gaule à cette période, mais présentes dans le sud de l'Angleterre. Il existerait donc bien à l'époque des liens entre les deux régions (Lefort *et al.*, 2010 ; Lefort *et al.*, 2011 ; Lefort et Rottier, 2013).

Le site néolithique ancien de Kervouyec-Nevez à Quimper : un exemple d'approches multiples par LA-ICP-MS

Le site de Kervouyec-Nevez (Finistère) fouillé par J.-Y. Tinévez est une occupation datée du Néolithique ancien (culture Villeneuve-Saint-Germain ; ^{14}C : 4991-4800 cal. BC ; Tinévez *et al.*, 2015).

Les fouilles ont mis au jour des fosses et des trous de poteaux, mais aussi de nombreux vestiges de cette période, comme des anneaux en schiste, des fragments de terres cuites et d'un clayonnage, induré par une cuisson volontaire ou lors d'un incendie (Tinévez *et al.*, 2015). Des analyses pétrographiques des céramiques et du clayonnage (ce dernier servira *in fine* de référentiel des terres locales) ont été menées par G. Querré. Elles ont permis de mettre en avant l'utilisation de terres essentiellement locales, à empreintes granitiques ou gabbro-granitiques. Ces observations sont confirmées par le clayonnage, fabriqué à partir de terres à inclusions gabbro-granitiques.

Une poterie à dégraissant de chamotte et de grains de quartz roulés révélant une origine probablement sédimentaire est vraisemblablement le résultat d'une importation. En effet, l'utilisation de chamotte n'étant pas connue durant cette période sur le Massif armoricain (Morzadec, 1995), il pourrait s'agir d'une importation depuis le Bassin parisien (Tinévez *et al.*, 2015). Toutefois, une céramique fabriquée en terre locale a été dégraissée à l'aide de chamotte. Il semblerait donc que les néolithiques ont également introduit l'utilisation de chamotte (Tinévez *et al.*, 2015), qui reste cependant limitée à une seule terre-cuite.

Nous avons souhaité étayer ces observations à partir d'analyses par LA-ICP-MS des tablettes de biotite et des grains d'amphibole contenus dans le clayonnage d'une part, et dans plusieurs céramiques découvertes sur le site de Kervouyec-Nevez, d'autre part. Ceci permettra également de comparer les résultats obtenus pour chaque espèce minérale et d'ainsi mettre en avant les possibilités offertes par la méthode du LA-ICP-MS. Les signatures chimiques des minéraux analysés dans le clayonnage serviront, comme pour les observations pétrographiques, de référentiels locaux et seront comparées à celles des inclusions présentes au sein des poteries.

Dans un premier temps l'analyse des tablettes de biotite incluses dans le clayonnage et dans deux céramiques, représentant les deux types de pâtes observées (granitique et gabbro-granitique), ont été réalisées. On soulignera que les biotites des pâtes gabbro-granitiques sont issues des roches granitiques, les gabbros ne contenant pas de cristaux de biotite. La poterie façonnée localement et dégraissée à la chamotte ne présentait pas de cristaux de biotite suffisamment grands pour être analysés (fig. 22). Ainsi, les concentrations en Li et V permettent d'observer deux groupes de cristaux de biotite, répartis selon deux droites. Les biotites du clayonnage (groupe 1) où la concentration en Li est faible et celle en V élevée. Un second groupe montre des teneurs inverses, le Li est fortement concentré et les teneurs en V sont plus faibles, correspondant aux poteries à pâte granitique et gabbro-granitique (fig. 22). Les biotites des deux types de pâtes sont donc issues de la même roche.

Dans un second temps, les grains d'amphibole ont été analysés. Il s'agit des mêmes terres cuites analysées précédemment : le clayonnage, la poterie à pâte gabbroïque et le vase dégraissé à la chamotte. La céramique à pâte

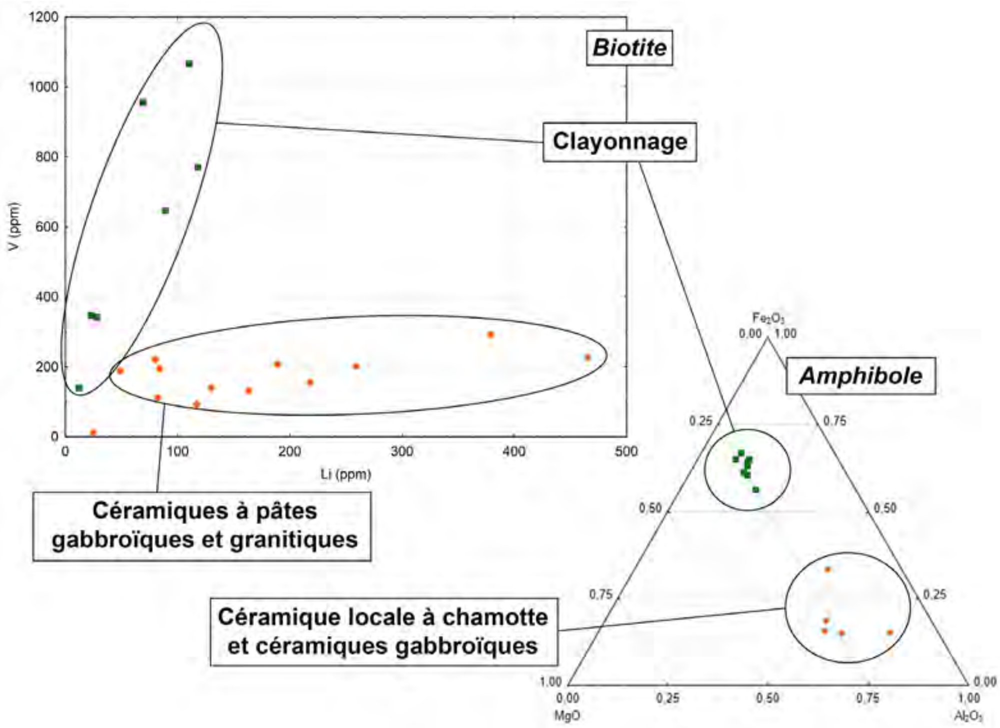

Fig. 22 – Diagrammes binaires et ternaires représentant les analyses des grains de biotite et d'amphibole contenus dans les céramiques du Néolithique ancien de Kervouyec-Névez (Finistère) et dans le clayonnage, servant de référentiel local.
■ Minéraux du clayonnage
● Minéraux des poteries
On observe que les inclusions de biotite des céramiques et du clayonnage ne possèdent pas les mêmes signatures chimiques, démontrant qu'il ne s'agit pas des mêmes matières premières, analyses confirmées par celles des grains d'amphiboles.
***Fig. 22** – Binary and ternary diagrams representing the analysis of biotite and amphibole grains included in the Early Neolithic ceramics of Kervouyec-Névez (Finistère) and in a wattle and daub sample found on the site which is used as a local chemical reference.*
■ *Minerals from the wattle and daub*
● *Minerals from the pottery*
The inclusions of biotite in the ceramics and the wattle and daub do not have the same chemical signatures, demonstrating they are not made with the same raw materials. This is confirmed by the analysis of the amphibole grains.

granitique n'a pas pu être analysée, du fait de l'absence de grains d'amphibole en son sein (fig. 22). Les concentrations en Fe_2O_3, Al_2O_3 et MgO des différents grains permettent d'observer deux groupes d'amphibole. Les plus concentrées en Fe_2O_3 correspondent au clayonnage tandis que celles dont les teneurs en Al_2O_3 et MgO sont les plus élevées sont incluses dans les céramiques à pâte gabbroïques et dégraissées à la chamotte (fig. 22).

L'analyse par LA-ICP-MS des tablettes de biotite et des grains d'amphibole nous démontre donc qu'il n'existe pas de lien entre le clayonnage et les céramiques étudiées (fig. 22). Il semblerait dès lors que ces poteries n'aient pas été montées avec la même terre que le clayonnage. En partant du postulat que cet élément d'architecture a été façonné à l'aide de terres localisées dans le périmètre immédiat du site, il est probable que les sources des matières premières utilisées pour monter les poteries soient plus éloignées. Il faudra réaliser des prélèvements des différentes roches composant le territoire aux alentours de l'occupation, afin de déterminer l'origine précise des terres employées. Cet échantillonnage permettra d'identifier les roches dont les altérations ont été utilisées, mais aussi de mieux cerner les modalités d'exploitation du territoire par les populations du Néolithique ancien et son étendue. Enfin, les données obtenues par LA-ICP-MS de différentes phases minérales sont complémentaires et permettent de confirmer les résultats antérieurs. Il est également intéressant de noter que les tablettes de biotite ont les mêmes signatures chimiques que ce soit dans les pâtes à empreinte gabbro-granitique que dans les terres granitiques. L'origine de la part granitique des inclusions présentes dans les céramiques à pâte gabbro-granitique est donc la même que pour les poteries à pâte granitique. Nous pouvons en déduire que les terres gabbroïques utilisées ont été mélangées, probablement naturellement, avec des produits d'altération granitiques. Ainsi, la zone de recherche se restreint aux interfaces entre les deux types de roches et précise donc les origines de ces terres.

CONCLUSIONS

L'analyse chimique ponctuelle par LA-ICP-MS d'inclusions minérales bien choisies contenues dans les pâtes des céramiques archéologiques ouvre de nouvelles perspectives en termes de recherche des sources de matières premières. Les comparaisons des différentes phases minérales analysées dans les céramiques et dans les roches supposées être à l'origine des argiles, confirment la validité des différentes méthodes présentées. La technique du LA-ICP-MS permet ainsi d'obtenir des analyses fiables et de manière rapide, avec un faible investissement préparatoire, les risques de contamination étant moindres, la préparation ne nécessite pas l'utilisation d'une salle blanche. En effet, il est possible d'analyser les inclusions directement sur le tesson, sur un fragment de roche ou sur une lame mince découverte.

Nous avons pu voir qu'étendre ces analyses à plusieurs espèces minérales au sein d'une même céramique ou d'une série de poterie permet de croiser les résultats et d'obtenir des indications plus précises sur l'origine des matières premières employées. Ainsi, selon les cas de figures, il est possible de choisir d'étudier l'une au l'autre des phases minérales ou de croiser les données.

Ainsi, le rapport entre le lithium et le vanadium des cristaux de biotite inclus dans les pâtes des céramiques permet de relier les argiles aux roches primaires granitiques. Il s'agit d'une avancée permettant de passer outre les limites inhérentes à l'étude pétrographique et de mettre en avant des échanges de vases, pouvant jusqu'alors être considérés comme locaux.

Les analyses par LA-ICP-MS des grains d'amphiboles ont permis de démontrer que leurs signatures chimiques peuvent être comparées à celles des roches dont sont issus ces minéraux et ainsi déterminer le lien de filiation entre des roches mères et des vases façonnés par les artisans. Pour le second âge du Fer armoricain, cette technique a confirmé l'hypothèse émise par P.-R. Giot et G. Querré (Giot et Querré, 1987) sur l'existence d'un autre atelier de production de poterie en Bretagne, mais aussi a déterminé l'origine de vases exportés sur plusieurs centaines de kilomètres. Il a également été possible d'observer la présence des deux types de productions au sein d'un même site, laissant supposer que ces ateliers ont fonctionné dans des laps de temps proches voire de manière concomitante.

Cette méthode permet également d'exploiter des minéraux non différenciables en microscopie optique en lumière transmise. En effet, du fait de leur nature, les minéraux opaques ne laissent pas passer la lumière. Leur détermination n'est donc pas possible à partir de cette méthode. Ainsi, l'analyse par LA-ICP-MS permet non seulement de déterminer leur nature, mais aussi de les utiliser comme traceur, permettant de remonter à la roche mère, dont les altérations ont été utilisées pour façonner des poteries.

S'ouvrent dès lors à nous de nouvelles perspectives de recherche. Ainsi, grâce à ces nouvelles approches, nous avons pu déduire des échanges à des échelles plus restreintes, régionales à microrégionales, et mieux appréhender les mouvements des populations et des biens et leurs intégrations au sein de territoires donnés.

NOTE

(1) Le symbole * signifie que l'élément a été normalisé par rapport aux chondrites.

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