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Modeling and firing technology - reflected in the textural features and the mineralogy of the ceramics from Neolithic sites in Transylvania (Romania)

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Coarse, semifine and fine ceramic pottery found in Early, Middle and Late Neolithic archaeological sites from Transylvania (Romania) were analyzed.
The fabric of the ceramics depends on raw materials, modeling technology, and firing conditions. The mineralogical changes of the compounds, the X-ray spectra and DTA curves reflect the temperature of the firing. Different pre-wheel modeling techniques were used, mirrored by the arrangement of the lamellar minerals inside the ceramic wall.

Key words: Geoarchaeology, Neolithic ceramics, clay minerals.

Introduction

The study was performed on coarse, semifine and fine ceramic artifacts (pottery) found in different archaeological sites from Romania (Fig. 1), being as follows:

1. Early Neolithic age (around 6,500 b.Chr., acc. to Lazarovici et al., 1995): Baciu site, Cluj county. The ceramics belong to the Starcevo-Cris Culture. The mineralogy of the ceramics as well as some preliminary considerations on the firing temperature and modeling techniques were already made by Lazarovici et al. (1995).

2. Middle Neolithic age (around 6,000 b.Chr., acc. to Lazarovici et al., 1996): Zau site, Mures County. The studied ceramics belong to the great cultural complex called CCTLNI (Cluj-Cheile Turzii-Lumea Noua-Iclod), which began at the end of the Early Neolithic, developed mainly in the Middle Neolithic and finished in the Late Neolithic. The data on the Middle Neolithic ceramic from Zau were presented by Ghergari et al. (2001).

3. Late Neolithic age (around 5,500-5,000 b.Chr., acc. to Lazarovici et al., 1996): Cheile Turzii site (Cluj county). The ceramics belong to the Petresti Culture. The mineralogical data as well as the results of X-ray diffractometry and SEM analyses are new and for the first time presented in this paper.

The main targets of the study were the identification of:

- the mineralogical compounds of the ceramics as support for a correct classification as well as for data base;
- the mineralogical elements which allow the finding of the geological sources used for raw materials;
- the fabric features - as mirroring the different pre-wheel modeling techniques used by ancient man;
- the transformation of mineralogical compounds during the firing as reflecting mainly the temperature, i.e. the level of the Stone-Age technology;

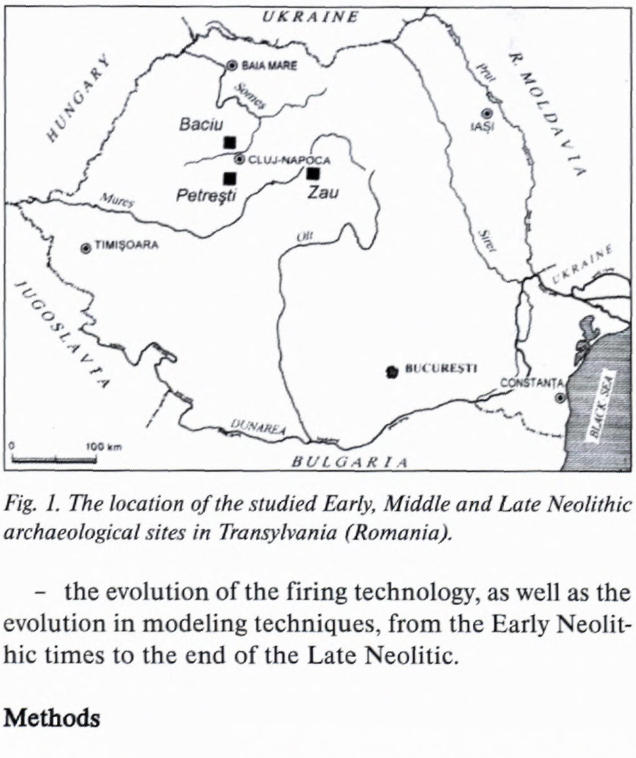

Fig. 1. The location of the studied Early, Middle and Late Neolithic archaeological sites in Transylvania (Romania).

- the evolution of the firing technology, as well as the evolution in modeling techniques, from the Early Neolithic times to the end of the Late Neolitic.

Methods

For this study, a DRON 3 - type X-ray diffractometer (Cu anticathode; Ka radiation, with la = 1,54051 A), a polarizing petrographic microscope Nikon and a BF 450 - TESLA Brno type Scanning Electron Microscope (surface of the samples covered with gold or copper) were used, as well as.

Sample description

A number of 42 Neolithic ceramic samples (9 of Early Neolithic, 13 of Middle Neolithic and 20 of Late Neolithic age) were studied. The pottery has mainly smoothed, seldom polished surfaces. Macroscopically, the firing is either good or poor, of reducing or oxidizing character.

About 20-30% of Early Neolithic ceramics is painted, proving the presence of the local pottery workshops. The quantity of painted ceramics increases in the Middle and Late Neolithic times, reaching up to 50%. The base colours of the ceramics are variable, from gray and grayish-black to brick-red, brown, red, orange or reddish-brown. For the decoration, incisions as well as red, brown and black paintings were used.

The fabric and the mineralogical features of the Neolithic ceramics

Texturally, the Neolithic ceramic pottery belongs mainly to the coarse (lutito-arenito-siltic) and semifine (lutito-silto-arenitic) categories, and subordinately to the fine (lutito-siltic) one. The prevalence of semifine ceramics is increasing in the Middle and Late Neolithic times.

The four types of the arrangement of some of the phase compounds (mainly lamellar minerals as micas, clay minerals) noticed in cross section to the ceramic wall, allow us to figure the modeling techniques used by the Neolithic man:

a) Slight orientation in the outer parts of the ceramic wall and changes in the direction (in oblique rows or chaotically arranged) in the center of the ceramic wall: modeling from clay lumps pressed on a wooden form; this technique is common for all Neolithic times;

b) Parallel to the wall: modeling by repeated beating-and-pressing of already flattened clay slabs, on a wooden form or an anvil; this technique is common for all Neolithic times;

c) Short changes of the direction (loosely circular): modeling by pressing of clay rolls coiled on a wooden form; this style of modeling is found in the Middle Neolithic ceramics from Zau;

d) Variable arrangements: in the core of the ceramic wall loosely circular orientation; in the outer parts of the wall, the lamellae are oblique to the wall surface; modeling from an almost sphaerical clay lump, in which a hollow is made by striking it with the right fist; afterwards the walls are thinned by pressing-modeling with both hands. This technique is specific only for the Late Neolithic ceramics from Cheile Turzii site.

One has to notice that the Neolithic times knew various styles of pottery pre-wheel modeling, each of it being specific for a certain period of time.

The Neolithic ceramics is constituted from a paste (matrix) in which lithoclasts, crystalloclasts, bioclasts and ceramoclasts occur (Ghergari et al., 1999).

Formed by thermally altered clay minerals, the matrix has a sintered, microcrystalline-amorphous to microcrystalline-vitreous, low-porous character. Mainly illite, kaolinite and montmorillonite occur, in variable percents, defining in general polymictic clays.

The lithoclasts, crystalloclasts, bioclasts and ceramoclasts have a variable composition, depending mainly on the raw clay materials as well as on the temper (non-plastic material[1] added in order to lower the plasticity of the ceramic mixture, respectively to reduce excessive shrinkage). The lithoclasts are represented by sedimentary, magmatic and metamorphic rocks. As crystalloclasts, quartz, plagioclase and potassic feldspars, biotite, muscovite occur.

As characteristic features for the Early Neolithic ceramics, the presence of the chaff as well as the high amount of the bioclasts, both specially added as temper, are prevailing. In the Middle Neolithic ceramics, the bioclasts are very rare. The ceramoclasts (tiny fragments of shards) are frequent and obviously were added as temper. The Late Neolithic ceramics reveals rare ceramoclasts but the presence of bioclasts, as foraminifera remnants, is a characteristic feature.

The firing temperatures as deduced from mineralogical, X-ray diffraction and DTA data

Comparing the experimental data[2] and reference sources (Shepard, 1976; Velde and Druc, 1999) and changes (as partial or total irreversible destroying of the crystalline structure) of some minerals (carbonates, clay minerals) noticed by polarized light microscopy and scanning electron microscopy observations, as well as the modifications of the X-ray diffraction spectra and DTA curves[3], the average temperature ranges were estimated as presented in table 1.

The temperatures of firing are almost at the same level in Early and Middle Neolithic, being in general between 600 and 850°C, only ocasionally reaching the level of 900°C. During the Late Neolithic, the temperatures of firing are significantly higher (700-900°C, with some values around 1000°C and over.

Conclusions

As inferred from ceramic characteristics (composition, fabric, thermal transformations), the technology used for the Neolithic ceramics involves:

- mixing of clay + temper ± chaff + water;
- modeling by pressing flattened slabs or lumps on a wooden form or on an anvil or by coiling rings or spirals;
- firing at various temperatures, ranging between

[1] Sands, volcanic ash, chaff as well as crushed ceramics, shells, bones.

[2] Unpublished.

[3] The lowest-temperature thermal effect that appears on the DTA diagram corresponds to the highest temperature reached during the pottery firing; the thermal effects produced during firing are not any more present in DTA analysis.

Table 1. The main firing temperatures for the Neolithic ceramic as inferred from mineralogical changes (seen in polarized light and in SEM) and from X-ray powder diffraction.

Estimated temperature	Mineralogical changes (seen in polarized light and in SEM)	Features of X-ray powder diffraction spectra
Early Neolithic		
600-700°C	Beginning of sintering of clay minerals: >500°C Siderite transformed in hematite: 550-650°C Not decomposed dolomite: <700-750°C	Absence of 7Å line of kaolinite: >600°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°C
650-750°C	Partly decomposed dolomite: ~700-750°C Not decomposed calcite: <850-900°C	
750-850°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C	
Middle Neolithic		
600-700°C	Beginning of sintering of clay minerals: >500°C Not decomposed calcite: <850-900°C Not decomposed dolomite: <700-750°C	Absence of 7Å line of kaolinite: >600°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°C
700-800°C	Decomposed dolomite: >750-800°C Not decomposed calcite: <850-900°C	
800-900°C	Decomposed dolomite: >750-800°C Partly decomposed calcite: ~850-900°C	Absence of 7Å line of kaolinite: >600°C The 14Å line of chlorites intensifies: 650-850°C Presence of 4.5Å line of clay minerals: <900-950°C Presence of 3.03Å calcite line: < 900°
Late Neolithic		
700-800°C	Beginning of sintering of clay minerals: >500°C Partly decomposed dolomite: ~700-750°C Not decomposed calcite: <850-900°C	Absence of 7Å line of kaolinite: >600°C The 14Å line of chlorites intensifies: 650-850°C Presence of 3.03Å calcite line: <900°C Presence of 4.5Å line of clay minerals: <900-950°C
800-900°C	Decomposed dolomite: >750-800°C Partly decomposed calcite: ~850-900°C	Absence of 7Å line of kaolinite: >600°C Presence of 3.03Å calcite line: <900°C Presence of 4.5Å line of clay minerals: <900-950°C
900-1000°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C Partly melted (vitrified) clay minerals: ~950°C	Absence of 7Å line of kaolinite: >600°C Absence of 10Å and 5Å lines of illite: >900°C Absence of 3.03Å calcite line: >950°C Absence of 4.5Å line of clay minerals: >950°C
1000-1050°C	Decomposed dolomite: >750-800°C Decomposed calcite: >900°C Melted (vitrified) clay minerals: >950°C Kaolinite transformed in mullite: >1000°C	Absence of 7Å line of kaolinite: >600°C Absence 10Å and 5Å lines of illite: >900°C Absence of 3.03Å calcite line: >950°C Absence of 4.5Å line of clay minerals: >950°C Presence of 3.39Å and 3.43Å lines of mullite: >1000°C Absence of all lines of clay minerals: >1000°C

600-850°C for Early Neolithic, 600-900°C for Middle Neolithic, and 700-1000°C for Late Neolithic ceramics. Higher temperature, as 1050°C, for Late Neolitic ceramics, was also estimated.

Most probably, the firing was performed in open fires for Early and Middle Neolithic ceramics. Semiclosed structures, the lower part being excavated in the ground, allowed the firing of the Late Neolithic ceramics at high temperature.

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