

**Research Paper****NEOLITHIC POTTERY PRODUCTION IN SOUTHEAST THESSALY  
THROUGH THE APPLICATION OF PETROGRAPHY AND  
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*The present paper focuses on the raw materials used for the local manufacture of pottery at two Neolithic settlements (Magoula Visviki, Magoula Agrokipiou) in the Velestino region, SE Thessaly, an area characterized by a distinctive ophiolitic sequence and its sedimentary weathering products. The mineralogical composition and rock fragment constituents of pottery fabrics are compared with that of rock and sediment samples from the adjacent area, thus locating the ancient raw material sources that were exploited.*

**Keywords:** *Ceramic petrography, Velestino, Raw materials procurement***Correspondence to:**

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## Περίληψη

*Το παρόν άρθρο εστιάζει στις πρώτες ύλες που χρησιμοποιήθηκαν για την τοπική παραγωγή κεραμικής σε δύο Νεολιθικούς οικισμούς (Μαγούλα Βισβίκη, Μαγούλα Αγροκηπίου) στην περιοχή του Βελεστίνου, ΝΑ Θεσσαλία, μια περιοχή με χαρακτηριστική οφιολιθική ακολουθία και ιζηματογένεση. Η ορυκτολογική σύσταση και τα συστατικά θραύσματα πετρωμάτων που απαντώνται στις κεραμικές ύλες αντιπαραβάλλονται με τα αντίστοιχα συστατικά που διαπιστώνονται σε δείγματα πετρωμάτων και ιζημάτων από την ευρύτερη περιοχή, υποδεικνύοντας με τον τρόπο αυτό τις αρχαίες πηγές πρώτων υλών οι οποίες χρησιμοποιούνταν για την κατασκευή της κεραμικής.*

*Λέξεις κλειδιά:* Κεραμική πετρογραφία, Βελεστίνο, Επιλογή πρώτων υλών

### 1. Introduction

After a century of archaeological research on the Greek Neolithic (7000-4000 BCE), Thessaly remains one of the most extensively investigated areas of Greece, characterized by dense habitation. Pottery is one of the most distinctive elements of this Neolithic material culture, demonstrating numerous decorated and plain ware categories (Demoule et al., 1988; Hauptmann and Miložčić, 1969; Miložčić, 1959; Miložčić -von Zumbusch, 1971; Mottier, 1981; Reingruber, 2008; Weißhaar, 1989). This paper aims to provide a comparative study and an analytical examination of the ceramic assemblages from Visviki and Agrokipiou Magoula, along with a rich sample set of raw materials from Velestino, to: a) characterise petrographically the local pottery production, and b) identify the local fabric recipes.

#### 1.1 The archaeological background

The area of Velestino, in the SE end of the Thessalian plain, hosts several prehistoric communities, of which Visviki Magoula possibly constitutes the larger tell site. During World War II, the area was partially excavated, and successive habitation horizons have been revealed, dating from the late Early Neolithic (EN) until the Chalcolithic period. A recent review of existing archival data on the excavation findings concluded that the settlement had one- or two-

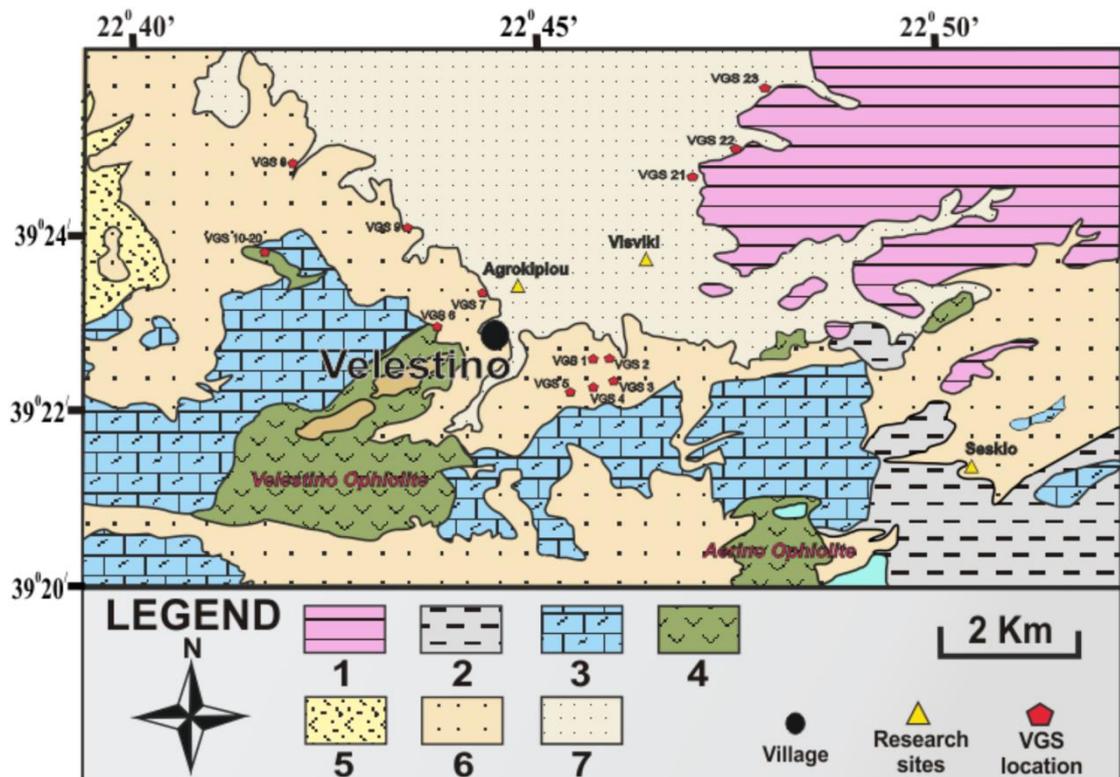
room houses, some of them with multiple building phases, which were surrounded by a ditch during most of the settlement's life (Aram-Stern, 2015a). The unearthed pottery assemblage represents the typical ware repertoire for the Neolithic period in Thessaly (Dürauer, 2015; Aram-Stern, 2015b).

A few kilometres to the south of Velestino lies Agrokypiou Magoula, another tell settlement, known mainly by surface finds and a trial trench of a short excavation (Theocharis, 1973, 349). The ceramic finds indicate fairly continuous habitation possibly from the EN, and with certainty from the Middle Neolithic (MN) to the Late Neolithic (LN) or even to the Final Neolithic (FN) periods (Gallis, 1992: 103; Rondiri, 2009: 139-141).

## **1.2 Geological setting**

The Velestino region, located at the SE part of Thessaly, includes the northern parts of the Mountains Chalkodonion and Velanidia. It belongs to the Pelagonian zone (Ferrière, 1982; Katsikatsos, 1992; Smith and Rassios, 2003; Figure 1), with its basal sequence (Palaeozoic-M. Triassic) consisting mainly of schists, granitic gneisses, and marbles, followed by L. Jurassic-E. Cretaceous thick-bedded dolomitic marbles (Ferrière, 1982; Perraki, 2003). The aforementioned rocks are unconformably overlain by Late Cretaceous to Eocene medium to thickly layered carbonate sedimentary rocks (locally dolomitic), as well as flysch that consists of red shales and phyllites alternating with thin bedded limestones, sandstones and conglomerates (Ferrière, 1982; Katsikatsos, 1992; Papanikolaou, 2009). The ophiolitic units have been tectonically emplaced above these post-Cretaceous sedimentary rocks (Katsikatsos, 1992; Pe-Piper and Piper, 2002). They are dominated by the presence of serpentinites which are crosscut by a network of dykes consisting of rodingites and in very rare cases of basalts (Koutsovitis et al., 2013), whereas metagabbros outcrop within the serpentinites in the southeastern part of the Velestino ophiolitic unit (Koutsovitis, 2012). These ophiolites have been significantly affected by extensive tectonic processes and also by a regional metamorphic event of greenschist to sub-greenschist facies.

Extensive Neogene alluvial and fluviolacustrine deposits are also attested in Velestino (Katsikatsos et al., 1983). The Miocene lacustrine to brackish deposits consist of grey to whitish friable marls, locally laminated and sometimes argillaceous, underlying the Pliocene-Pleistocene deposits. The Pliocene deposits consist of fluvial (characterised by conglomerates and sandstones alternated with siltstones and mudstones that are not well consolidated) and lacustrine facies with prevailing whitish marls. The Pleistocene deposits mainly consist of red clays, clayey sandy material of low cohesion, with dispersed rounded and angular pebbles or coarser-grained elements of various lithological compositions without any orientation. The "Red Beds" outcrops are included in the Pleistocene deposits and consist mainly of reddish mudstones and sandstones, while several coarser levels of breccias and breccio-conglomerates are also present; all of these deposits are usually poorly consolidated (Caputo, 1990). Their lower parts are of lacustrine-terrestrial facies with a considerable amount of marly material and constitute the upward gradual transition of the underlying lacustrine marly Miocene deposits of the area. The alluvial deposits comprise clayey sandy materials, with gravels of variable lithological composition, scree and fans, torrential terraces and the clayey-sandy deposits of the now drained Lake Karla (Katsikatsos et al., 1983).



**Fig. 1:** Simplified geological map of Velestino, southeast Thessaly area, including the sites mentioned in the text. Legend: 1. M. Triassic-L. Jurassic marbles and crystalline dolomites; at the upper parts mostly mica schists with marble intercalations; 2. Gneisses and schist-gneisses with marble intercalations of the Eohellenic tectonic nappe; 3. L. Cretaceous limestones and Paleocene flysch; 4. Ophiolitic units; 5. Miocene lacustrine to brackish deposits consisting mainly of marls; 6. Fluvio-terrestrial formations: clays, sand and dispersed pebbles; 7. Alluvial deposits: clayey sandy material with gravels of various lithological composition.

## 2. Materials and Methods

After macroscopic examination of the Visviki and Agrokipiou pottery assemblages, 117 sherds were selected to represent the variety observed in ware, decoration motifs, vessel size and shape, and in some cases also fabric (i.e. type, quantity and size of inclusions, clay colour, core appearance, hardness etc.) (Table 1).

**Table 1:** Summary table of the analysed ceramic samples.

Pottery ware and date	Area - Samples	Vessel shapes
Visviki Magoula		
Coarse ware (EN-Chalcolithic)	MV4-7, MV23-25, MV27-32	large open vessels, pithoid and hole-mouth jars
Red monochrome and burnished (EN-LN)	MV1-3, MV8-14, MV17, MV19-21, MV36, MV83-85	medium-sized bowls of various profiles, basins, pithoid and wide-mouth jars
Brown monochrome and burnished (LN)	MV18, MV26, MV86	basin, pithoid jar, hole-mouth jar
Black burnished (LN)	MV39-42	deep bowl/basins, pithoid jar
Incised decoration (LN)	MV33, MV87-91	deep bowl/basins, scoop, hole-mouth jar
Bichrome decoration (black on white) (LN)	MV48, MV66-68, MV79	closed vessels, fruit stands, pithoid jar
Black on red decoration (LN)	MV22, MV69-80, MV82, MV98	bowls, fruit stands, deep bowl/basins, closed vessels, pithoid and hole-mouth jars

Brown on cream decoration (LN)	MV92-97	bowls, fruit stands
Matt-painted decoration (LN)	MV43-47	bowls, deep bowl/basins, fruit stands
Polychrome decoration (LN)	MV49-65	bowls, deep bowl/basins, fruit stands, pithoid jars
Red on white decoration (MN)	MN15-16, MV37-38	bowls, deep bowl/basins
White on red decoration (LN)	MV81	deep bowl/basin
parts of spit holders, architectural remains	MV34-35, MV99-100	
Agrokipiou Magoula		
Red monochrome and burnished (LN)	AGR8-9	carinated bowls
Black burnished (LN)	AGR1-3, AGR6-7, AGR10-13	bowls, fruit stands
Bichrome decoration (black on white) (LN)	AGR4	fruit stands
Black on red decoration (LN)	AGR5	fruit stands
Polychrome decoration (LN)	AGR14-17	bowls, fruit stands

Petrographic analysis was applied on all samples included in the study (polarising microscope ZEISS AXIOSKOP 40 POL). The microscopic descriptions followed the descriptive system and terminology proposed by I. K. Whitbread (Whitbread, 1986; Whitbread, 1989; Whitbread, 1995). Comparative charts were used to estimate voids and inclusions frequency, sorting, and roundness (Bullock et al., 1985, Figs. 24, 27, 31 respectively). Inclusions frequency characterisation adopt Kemp's frequency groupings (predominant >70%, dominant 50-70%, frequent 30-50%, few 5-15 %, very few 2-5%, rare 0.5-2%, very rare/absent <0.5%; Kemp, 1985), while the size characterisation corresponds to the Wentworth size scale.

Additionally, all samples were subjected to refiring tests in controlled laboratory conditions at 1050°C, in oxidising atmosphere using a Naberthem L5/P furnace. Refiring of the ceramic samples at higher temperature (and possibly longer duration) aimed to distinguish different clay compositions (or slip/paint, reflected in colour) by eliminating any variation in clay colour caused by ancient

firing conditions (Whitbread, 1995: 390-1, Daszkiewicz and Schneider, 2001; all colour characterisations follow the Munsell Soil-Colour Chart, 2009 edition). Raw material prospection yielded 23 raw material samples (clayey, loose sandy sediments and rock fragments) providing insight to the range of raw materials available in the wider vicinity of Velestino (Table 2).

**Table 2.** Summary table of the raw material samples from the Velestino area.

Type of deposit/raw material	Sample
Pleistocene fluvioterrestrial deposit	VGS1, VGS4- VGS7, VGS22-23
Possibly Miocene marl appearance within the Pleistocene fluvioterrestrial deposit	VGS2-3
Possibly Pleistocene fluvioterrestrial sediment, just below the soil horizon	VGS8-10
Holocene deposit	VGS21
Clastic sediment	VGS11
Serpentinite fragment	VGS12-14, VGS17, VGS20
Ophicalcite fragment	VGS15
Limestone fragment	VGS16, VGS19
Greenschist (metadolerite) fragment	VGS18

### 3. Results

The petrographic analysis of the raw material samples shed light on the mineralogical and textural features of the available sources for pottery production in the area of Velestino (for detailed presentation and discussion see Pentedeka, 2015). At Visviki Magoula, nine fabric groups and twenty-two outliers were distinguished. Approximately 60% of the samples fall into three fabric groups (MVFG1-3) and are compositionally characterised as local (for detailed presentation and discussion see Pentedeka, 2015).

At Agrokypiou Magoula, seventeen samples were classified into three fabric groups and six outliers were distinguished; more than half of the samples fall into fabric groups AGRFG1 and AGRFG2, which present very strong compositional and textural similarities to MVFG1 and MVFG3, respectively.

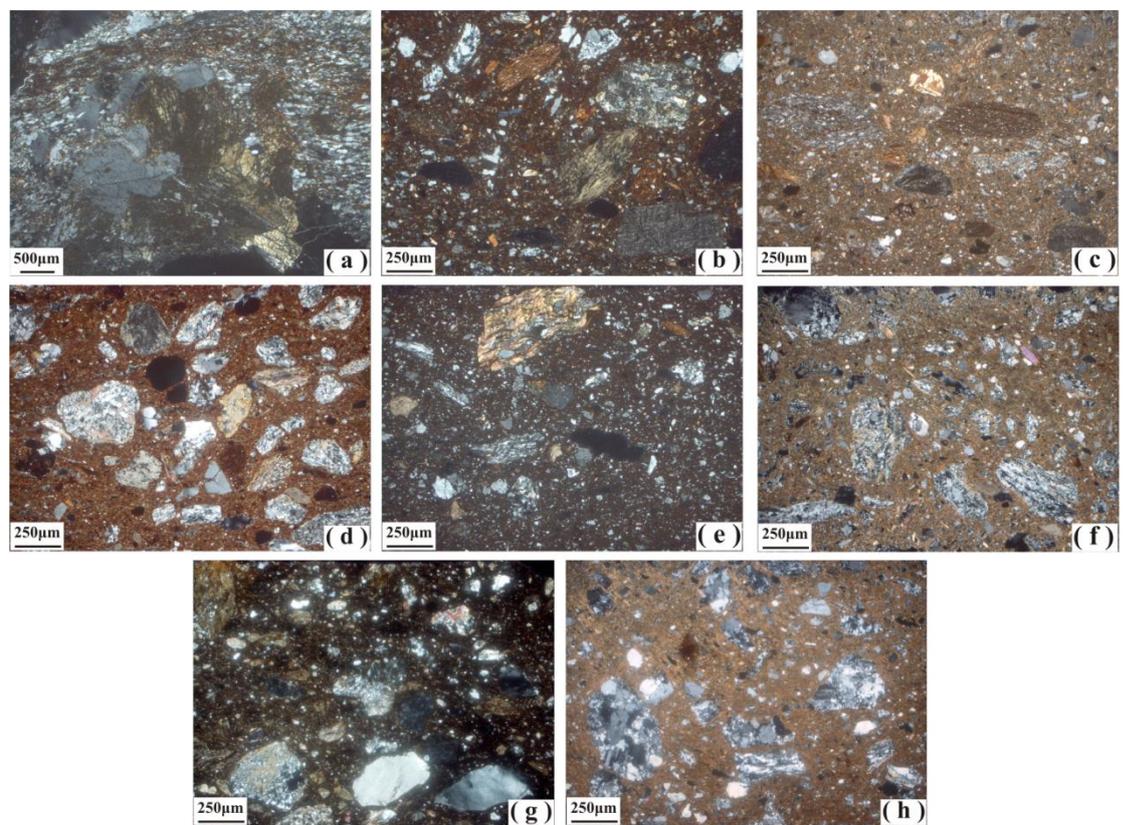
### 3.1 The raw materials of the Velestino area

Samples VGS1-VGS5 are mostly red Pleistocene deposits of variable coherence, coarse in texture, and usually containing angular pebbles. Samples VGS2 and VGS3 have a high marl content, and might constitute small appearances of the Miocene marly deposits not reported on the geological map. Petrographic analysis showed that all samples contain the same variety of inclusion types, such as serpentinite, phyllite and/or shale, limestone or marble, quartz-rich metamorphic rock fragments, as well as meta-igneous rock fragments typical of the prehnite-pumpellyite and pumpellyite-actinolite metamorphic facies (essentially greenschist rock fragments), or of metasomatic processes (rodingite). The meta-igneous rock fragments are present in all samples at a fairly stable percentage (ca. 5%), while the frequency of the other mineral components vary from one sample to another (Figure 2a).

Samples VGS6 and VGS7 derive from the upper fluvio-terrestrial Pleistocene deposits at different parts of its streambed. Sample VGS6 is rather fine textured being composed of flysch-related argillaceous rock fragments, limestone, quartz-rich metamorphic rock fragments along with serpentinite. Sample VGS7 is coarser, and is characterised by meta-igneous rock fragments (very similar to those identified in VGS1-VGS5), serpentinite and opicalcite, related to the ophiolitic units. It also contains limestone and marble fragments, as well as flysch-related low-metamorphosed rock types (schist, mudstone, shale, and sandstone) (Figure 2b).

Samples VGS8-10 derive from the upper Pleistocene deposits that underlie the soil horizon. Mineralogically, sample VGS8 mainly contains meta-igneous rock fragments (of the same types as previously described) and phyllite, along with small amounts of serpentinite and other flysch-related low-metamorphosed rock types (metasandstone, shale, and schist). The main rock fragment constituents of VGS9 are associated with flysch-related low-metamorphosed rock types (phyllite, shale, mudstone, and schist), along with meta-igneous rock fragments (as described for all previous samples), limestone and serpentinite (Figure 2c). Sample VGS10 derives from the upper Pleistocene deposits of the overthrust ophiolitic units above the Late Cretaceous limestones. Its mineralogical

components (serpentinite, limestone, and opicalcite) are in agreement with the prevailing geological formations of the sampling area, i.e. serpentinites and limestones. Similarly, VGS11 constitutes erosion material deriving from these formations. The rock samples VGS12-20 present a representative range of the different rock types observed in this area, which mostly include serpentinite (VGS12-14, VGS16-17, VGS20) and limestone (VGS16, VGS19), along with greenschist meta-lava (metadolerite in the case of VGS18) and opicalcite (VGS15).



**Fig. 2:** Microphotographs of selected samples: (a) VGS5 (700°C); (b) VGS7 (700°C); (c) VGS9 (700°C); (d) MVFG1 (MV5); (e) MVFG2 (MV4); (f) MVFG3 (MV21); (g) AGRFG1 (AGR8); (h) AGRFG2 (AGR13). All thin section photographs were taken under crossed polars.

Samples VCS21-23 are located to the northeast of Visviki and Agrokipiou Magoulas, where the prevailing geological formation comprises marble along with minor gneiss and gneiss/schist outcrops. Sample VGS21 derives from Holocene deposits of erosion material from the aforementioned formations,

while samples VGS22 and VGS23 are Pleistocene fluvio-terrestrial sediments. All three samples are coarse in texture, and their composition is in agreement with the surrounding geological setting, since they include marble and gneiss/quartzite or gneiss/schist fragments, along with sporadic serpentinite and phyllite fragments.

### 3.2 Visviki Magoula fabrics

Fabric group MVFG1 is a coarse-grained fabric, with an orange brown to dark reddish brown/dark red micromass in XPL and 5-7% voids (Figure 2d). Inclusions are frequent to common, subangular to subrounded, with the mode grain size ranging from medium to very coarse sand, and the maximum grain size reaching pebble grade. It is characterised by quartz-rich metamorphic rock fragments, meta-igneous rock fragments (a. products of metasomatic processes, particularly garnet from rodingitization; b. essentially greenschist fragments, of the prehnite-pumpellyite and actinolite-pumpellyite facies, e.g. i. epidote + pumpellyite ± prehnite fragments, ii. actinolite / tremolite + epidote / pumpellyite ± biotite fragments, iii. chlorite-rich fragments, iv. fibrous amphibole of green pleochroism ± chlorite ± cryptocrystalline masses / uralite), phyllite, shale, limestone and serpentinite fragments in variable amounts from sample to sample, or even within the same sample. Other less frequent components are textural concentration features (henceforth Tcfs; mostly clay pellets and grog), quartz, mica, plagioclase, alkali feldspar, epidote group minerals, amphibole, opaque inclusions, and schist fragments of variable composition, along with traces of organic material, spinel, titanite, microfossils, clinopyroxene, marble, sandstone/metasediment, chert, siltstone and radiolaria. A variant of this fabric includes grog (crushed pottery) in high frequency; the grog fragments are of the same fabric as the parent clay paste. Vessels of all wares, shapes and sizes are produced in this fabric, as are the two clay lumps belonging to unknown architectural features, thus verifying the generalised exploitation of near-by raw material sources for all the needs of the settlement.

Fabric group MVFG2 is a medium-coarse grained fabric, with a very dark red to black micromass in XPL and ca. 5% voids (Figure 2e). Inclusions are common, subangular to subrounded, with the mode grain size ranging from

medium to very coarse sand, whereas maximum grain size reaches granule/pebble grade. It is characterised by quartz-rich metamorphic rock fragments, along with quartz, mica, and phyllite fragments. Other, less frequent, components include limestone fragments, opaque inclusions, clay pellets, plagioclase, alkali feldspar, epidote group minerals, brown amphibole, meta-igneous rock fragments (garnet and/or epidote/pumpellyite aggregates), chert, titanite, chlorite, spinel, clinopyroxene, and microfossils. This fabric is confined to vessels dating to the MN only, both decorated (Red on white) and undecorated (Red monochrome), mostly medium-sized bowls.

Fabric group MVFG3 is a coarse-grained fabric, with an orange brown to dark orange brown micromass in XPL and ca. 5% voids (Figure 2f). Inclusions are frequent, subangular (to subrounded), with the mode grain size ranging from medium to very coarse sand, whereas maximum grain size reaches pebble grade. It is characterised by gneiss/schist fragments, along with limestone fragments, quartz, phyllite fragments and mica, and accompanied by feldspar, meta-igneous rock fragments (as in MVFG1), opaque inclusions, epidote group minerals, amphibole, marble, amphibole schist and serpentinite fragments. This fabric has a diachronic use from the MN to the LN almost exclusively for the manufacture of monochrome vessels (Red monochrome and burnished and coarseware) of large size, in particular hole-mouthed jars. The smaller vessels appearing in this fabric are bowls, one decorated (Black on red) and one monochrome (Red monochrome and burnished).

### **3.3 Agrokipiou Magoula fabrics**

Fabric group AGRFG1 is a medium-coarse grained fabric, with an orange brown to dark reddish brown micromass in XPL and ca. 5% voids (Figure 2g). Inclusions are common, angular to sub-rounded, with the mode grain size ranging from medium to very coarse sand, whereas the maximum grain size reaches granule grade. It is characterised by quartz-rich metamorphic rock fragments, meta-igneous rock fragments (a. essentially greenschist fragments, of the prehnite-pumpellyite and actinolite-pumpellyite facies, with actinolite-rich fragments being the most frequent component; b. products of metasomatic processes, particularly garnet from rodingitization), limestone, phyllite, and

shale, fragments in variable amounts from sample to sample. Other less frequent components are Tcfs (clay pellets), quartz, mica, plagioclase, alkali feldspar, epidote group minerals, amphibole, opaque inclusions, and schist fragments of variable composition, along with traces of organic material, spinel, microfossils, and clinopyroxene. This fabric contains samples from vessels dating to the LN, both decorated (Black burnished) and undecorated (Black burnished and Red monochrome and burnished) medium-sized bowls.

Fabric group MVFG3 is a coarse-grained fabric, with an orange brown to dark orange brown micromass in XPL and ca. 5% voids (Figure 2h). Inclusions are frequent, angular to subrounded, with the mode grain size ranging from medium to very coarse sand, whereas the maximum grain size reaches pebble grade. It is characterised by gneiss/schist fragments, quartz and meta-igneous rock fragments (as in AGRFG1), accompanied by feldspar, phyllite and limestone fragments, mica, opaque inclusions, epidote group minerals, amphibole, Tcfs (clay pellets), along with traces of organic material and clinopyroxene. This fabric contains samples from vessels dating to the LN, both decorated (Black burnished) and undecorated (Black burnished and Red monochrome and burnished) medium-sized bowls and a large fruit stand.

#### **4. Discussion**

The petrographic analysis of the raw material and ceramic samples yielded very interesting results with regard to the exploitation of specific sources for pottery production.

The mineralogical composition of MVFG1 is compatible with the main geological formations of the Velestino area, namely the flysch formation and ophiolitic units to the south of Visviki Magoula. Moreover, there is a strong compositional similarity to the raw material samples VGS1-10 collected from the vicinity of the site, as they contain the same range of rock fragments. Therefore, MVFG1 should be considered as local to Visviki Magoula. The exploitation of the sediments relating to the flysch formation and ophiolitic units situated south of Visviki Magoula seems to be diachronic and uninterrupted from the Early/Middle Neolithic to the Chalcolithic.

The mineralogical composition of MVFG2 is consistent with the main geological formations of the Velestino area (in particular flysch), and bears a fair resemblance to geological samples VGS2 (in particular VGS2C) and VGS9, which include brown amphibole grains only. It should, therefore, be considered as local to Visviki Magoula, at the same time indicating the consistent use of a specific raw material source in the vicinity of the site.

The mineralogical composition of MVFG3 is compatible with the gneiss/schist formations flanking from the east the flysch and ophiolitic units extending south of Velestino (Figure 1). A large watershed is formed by Megavouni Mountain and the hilly area north of Sesklo, draining out to the southeast of the Velestino plain. In this respect, the resemblance to Sesklo fabrics owes to the exploitation of raw materials deriving from the same gneiss/schist formations extending from southeast of Velestino to the Pagasitic Gulf. Schneider et al. (1991: 37) also note the similarity observed in the chemical composition between the alluvial clays from Velestino and the Pleistocene clays in the north-north-east of Sesklo (for description and discussion of the Sesklo fabrics see Pentedeka and Kotsakis, 2008; for descriptions of raw materials from the vicinity of Sesklo, see Dimoula, 2012, Table 5.1, Fig. 5.25). Thus, MVFG3 can be considered as broadly local to the site, pointing to the exploitation of a distinctly different raw material source.

The mineralogical composition of AGRFG1 is consistent with the main geological formations of the Velestino area, namely the flysch formation and ophiolitic units to the south of Visviki Magoula. There is a strong compositional similarity to MVFG1, the only difference being the higher frequency of actinolite-rich meta-igneous fragments, thus suggesting a different (yet very similar) raw material source. Moreover, this fabric bears strong resemblance to the raw material samples VGS1-10 collected from the vicinity of the site, as they contain the same range of rock fragments. Therefore, AGRFG1 should be considered as local to Agrokipiou Magoula.

The mineralogical composition of AGRFG3 is compatible with the gneiss/schist formations flanking from the east the flysch and ophiolitic units extending south of Velestino (Figure 1). This fabric is almost identical to MVFG3, the only

difference being the significantly lower frequency of limestone fragments. Fabric AGRFG2 can be considered as broadly local to the site, pointing to the exploitation of a distinctly different raw material source, yet located in the same area as that of MVFG3, i.e. the southeast part of the Velestino plain which forms the watershed of the surrounding hills.

Summarizing the above, fabric group MVFG1 is related to the flysch formation and the Velestino ophiolitic formation. Moreover, there is a strong compositional similarity to the raw material samples VGS1-10, whereas MVFG2 is related predominantly to the flysch formation. MVFG3 is mostly related to the gneiss formations SE of Velestino and to a lesser extent to the flysch and ophiolitic units. With regard to Agrokipiou, AGRFG2 is identical to MVFG3, whereas AGRFG1 indicates a flysch-related raw material source. The appearance of altered basaltic fragments and garnet within the pottery fabrics (Figure 2d-e, g) can be justified by their presence within the ophiolitic sequence of Velestino (Koutsovitis et al., 2013) and the sedimentation processes, especially in the northern part of this formation. All other sequences of the Pelagonian zone do not include these rock types; the only other possible source is the Aerino ophiolitic formation. Nevertheless, the sparse outcrops of these rocks in the northern part of this formation, as well as the form of the stream branches in the drainage system of the basin, favour the Velestino ophiolite formation as the only possible source of altered and metasomatized basaltic rocks. Therefore, the occurrence of meta-igneous fragments within the pottery fabrics implies that the raw material sources exploited for pottery production of MVFG1 and AGRFG1 should be located to the SW and very close to Visviki.

## 5. Conclusions

The present paper focuses on the raw materials used for the local manufacture of pottery at two Neolithic settlements (*Magoula Visviki*, *Magoula Agrokipiou*) in the Velestino region in SE Thessaly. This area is characterized by a distinctive ophiolitic sequence, highly affected by metasomatic and low-grade metamorphic processes, accompanied by the sedimentary products from the weathering of these parent rocks. The mineralogical composition and rock fragment constituents of the pottery fabrics are compared with that of the rock

and sediment samples from the adjacent area, thus locating the ancient raw material sources which were exploited.

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## 7. References

- Aram-Stern, E., 2015a. Stratigraphie und Baureste. In: Alram-Stern, E., Dousougli-Zachos, A. (Eds.), *Die deutschen Ausgrabungen 1941 auf der Visviki-Magoula/ Velestino. Die neolithischen Befunde und Funde. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 36*. Rudolf Habelt Verlag, Bonn, 69-90.
- Aram-Stern, E., 2015b. Die Keramik: Das Spätneolithikum und Chalkolithikum. In: Alram-Stern, E., Dousougli-Zachos, A. (Eds.), *Die deutschen Ausgrabungen 1941 auf der Visviki-Magoula/ Velestino. Die neolithischen Befunde und Funde. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 36*. Rudolf Habelt Verlag, Bonn, 125-219.
- Bullock, P., Federoff N., Jongerius A., Stoops G., Tursina T., 1985. Handbook for Soil Thin Section Description. Wayne Research, Wolverhampton.
- Caputo, R., 1990. Geological and Structural Study of the Recent Active and Brittle Deformation of the Neogene - Quaternary Basins of Thessaly (Central Greece). PhD diss., University of Thessaloniki, Thessaloniki.

Daszkiewicz, M., Schneider G., 2001. Klassifizierung von Keramik durch Nachbrennen von Scherben. *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte (ZAK)*, 58, 25-31. DOI: 10.5169/seals-169606.

Demoule J.-P., Gallis K., Manolakakis L., 1988. Transition entre les cultures néolithiques de Sesklo et de Dimini: les catégories céramiques. *Bulletin de Correspondance Hellénique*, 112, 1-58. DOI: 10.3406/bch.1988.1737.

Dimoula, A., 2012. Early pottery technology and production. The case of Thessaly. PhD diss., University of Thessaloniki, Thessaloniki.

Dürauer, K., 2015. Die Keramik: Das ausgehende Frühneolithikum und das Mittelneolithikum. In: Alram-Stern, E., Dousougli-Zachos, A. (Eds.), *Die deutschen Ausgrabungen 1941 auf der Visviki-Magula/ Velestino. Die neolithischen Befunde und Funde. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 36*. Rudolf Habelt Verlag, Bonn, 102-124.

Ferrière, J., 1982. Paleogeographie et tectoniques superposées dans les Hellénides internes: les massifs de l'Othrys et du Pélion (Grèce septentrional). Société Géologique du Nord Publication No 8. Villeneuve d'Ascq, Cedex.

Gallis, K., 1992. Atlas of prehistoric settlements in the eastern Thessalian plain. *Etaireia Istorikon Erevnon Thessalias*, Larissa.

Hauptmann, H., Miložić V., 1969. Die Funde der frühen Dimini-Zeit aus der Arapi-Magula Thessalien. *Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 9*. Rudolf Habelt Verlag, Bonn.

Katsikatsos, G., 1992. *Geology of Greece*. Organismos Ekdoseos Didaktikon Vivlion, Athens.

Katsikatsos, G., Mylonakis J., Triantafyllis E., Papadheas G., Psonis C., 1983. *Geological Map of Greece 1:50.000 Velestino Sheet*. Institute of Geology and Mineral Exploration, Athens.

Kemp, R.A., 1985. Soil Micromorphology and the Quaternary. Quaternary Research Association Technical Guide No 2. Quaternary Research Association, Cambridge.

Koutsovitis, P., 2012. Gabbroic rocks in ophiolitic occurrences from East Othris, Greece: petrogenetic processes and geotectonic environment implications. *Mineralogy and Petrology*, 104, 249-265. DOI: 10.1007/s00710-011-0191-5.

Koutsovitis, P, Magganas A, Pomonis P, Ntaflos T., 2013. Subduction-related rodingites from East Othris, Greece: Mineral reactions and physicochemical conditions of formation. *Lithos*, 172-173, 139-157. DOI: 10.1016/j.lithos.2013.04.009.

Milojčić, V., 1959. Ergebnisse der deutschen Ausgrabungen in Thessalien 1953–1958. *Jarhbuch des Römisch-Germanischen Zentralmuseums*, 6, 1–56.

Milojčić -von Zumbusch J., Milojčić, V., 1971. Die deutschen Ausgrabungen auf der Otzaki Magula in Thessalien I: Das frühe Neolithikum. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 10–11. Rudolf Habelt Verlag, Bonn.

Mottier, Y., 1981. Die deutschen Ausgrabungen auf der Otzaki Magula in Thessalien II: Das mittlere Neolithikum. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer- Kulturraumes 22. Rudolf Habelt Verlag, Bonn.

Papanikolaou, D., 2009. Timing of tectonic emplacement of the ophiolites and terrane paleogeography in the Hellenides. *Lithos*, 108, 262–280. DOI:10.1016/j.lithos.2008.08.003.

Pentedecka, A., 2015. Technological and provenance study of the Visviki Magoula ceramic assemblage. In: Alram-Stern, E., Dousougli-Zachos, A. (Eds.), *Die deutschen Ausgrabungen 1941 auf der Visviki-Magula/ Velestino. Die neolithischen Befunde und Funde. Beiträge zur ur- und frühgeschichtlichen*

*Archäologie des Mittelmeer- Kulturraumes* 36. Rudolf Habelt Verlag, Bonn, 222-297.

Pentedeke, A., Kotsakis, K., 2008. Thin Sectioning Neolithic Identities: the Red Monochrome Ware (A1) from Middle Neolithic Sesklo, Thessaly. In: Facorellis, Y., Zacharias, N., Polikreti, K. (Eds.), *Proceedings of the 4th Symposium on Archaeometry of the Hellenic Society of Archaeometry, National Hellenic Research Foundation, Athens, 28-31 May 2003, BAR International Series 1746*. Archaeopress, Oxford, 305-311.

Pe-Piper, G., Piper, D. J., 2002. The igneous rocks of Greece. Gebrüder Borntraeger, Berlin/Stuttgart.

Perraki, M., 2003. Petrological study of the metamorphic rocks of the E. Thessaly area, Central Greece. PhD diss., National Technical University, Athens.

Reingruber, A., 2008. Die Argissa-Magula: Das frühe und das beginnende mittlere Neolithikum im Lichte transägäischer Beziehungen. Die deutschen Ausgrabungen auf der Argissa-Magula in Thessalien II. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes Band 35. Rudolf Habelt Verlag, Bonn.

Rondiri, V., 2009. Thessalian Neolithic pottery: technology and spatial distribution. PhD diss., University of Thessaloniki, Thessaloniki.

Schneider, G., Knoll H., Gallis K., Demoule J.-P., 1991. Transition entre les cultures néolithiques de Sesklo et de Dimini: recherches minéralogiques, chimiques et technologiques sur les céramiques et les argiles. *Bulletin de Correspondance Hellénique*, 115, 1-64. DOI: 10.3406/bch.1991.4673.

Smith, A.G., Rassios, A., 2003. The evolution of ideas for the origin and emplacement of the Western Hellenic ophiolites. In: Dilek, Y., Newcomb, S. (Eds.), *Ophiolite Concept and the Evolution of Geological Thought. Geological*

*Society of America Special Paper 373*. The Geological Society of America, Colorado, 337-350.

Theocharis, D.R., 1973. Neolithic Greece. National Bank of Greece, Athens.

Weißhaar H.-J., 1989. Die deutschen Ausgrabungen auf der Pefkakia-Magoula in Thessalien I: Das späte Neolithikum und das Chalkolithikum. Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes Band 28. Rudolf Habelt Verlag, Bonn.

Whitbread, I.K., 1986. The Characterisation of Argillaceous Inclusions in Ceramic Thin Sections. *Archaeometry*, 28, 79-88. DOI: 10.1111/j.1475-4754.1986.tb00376.x

Whitbread, I.K., 1989. A proposal for the systematic description of thin sections. Towards the study of ancient ceramic technology. In: Maniatis, Y. (Ed.), *Archaeometry: Proceedings of the 25<sup>th</sup> International Symposium*. Elsevier, Amsterdam, 127-138.

Whitbread, I.K., 1995. Greek Transport Amphorae. A petrological and Archaeological Study. Fitch Laboratory Occasional Paper 4. The British School at Athens, London.