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Mineralogical and geological investigation of Heraconpolis archaeological site. Upper Egypt

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Abstract

The investigation of geology, stone implements and pottery presented below was performed in 2004 during works conducted by mixed american-egyptian mission at Heraconpolis archaeological site.

The geological examination documents that the site was located on a dry, big delta of big wadi, coming from west into Nile Valley. This location means that while the site was functioning at phases Nagada II and III mentioned wadi did not conduct water i.e. climate was very dry.

The investigation of present geological phenomena shows continuous growth of salinity of the soils at tested area.

The investigation of stone implements discovered at two examined archaeological trenches confirmed the presence of various rocks, chipped flint implements as well as grinders. These objects were discovered at two depths representing various archaeological layers.

Examination of pottery showed advanced technologies of preparation of ceramic mass as well as technology of firing. Data obtained from computer analyses confirm differentiation of tested ceramic masses.

Key words: Nile Valley, geology, mineralogy, stone implements, pottery

Geology

Heraconpolis archeological site as well as the nearest area are located on quaternary mixed sediments (Fig. 1, 2) showing various genesis (Said 1966, Liwingstone 1980, Williams, Williams 1980).

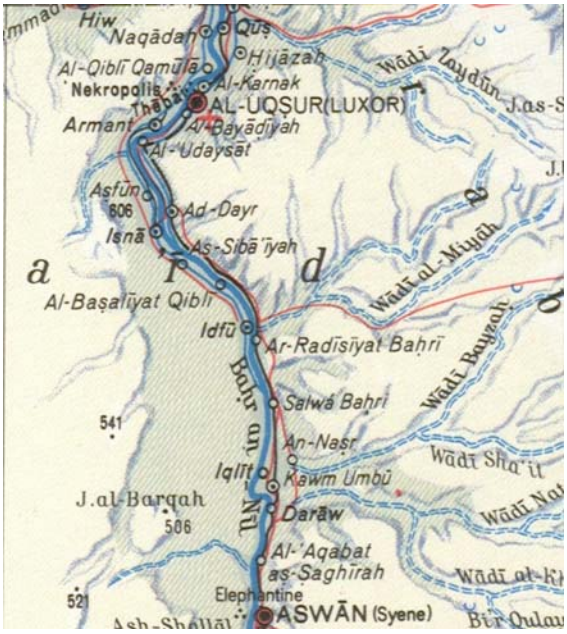


Fig. 1 - Scheme of the location of site Heraconpolis

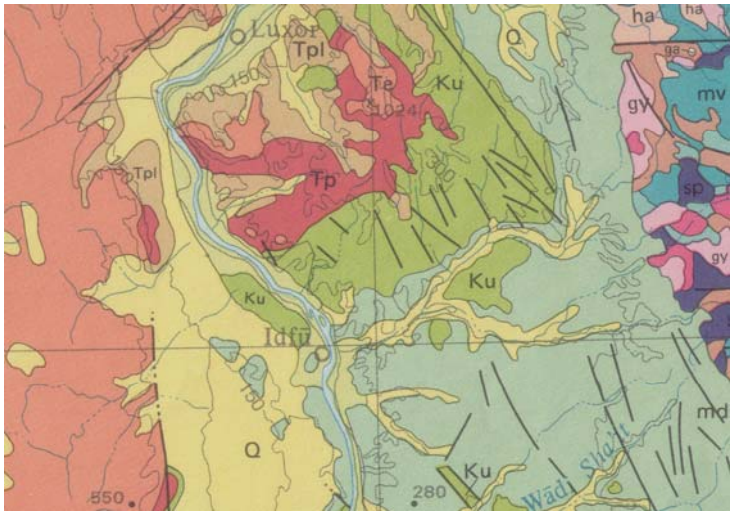


Fig. 2 - Geological map of region of site Heraconpolis (by: Egyptian Geological Survey and Mining Authority). Q - undivided Quaternary, Tpl - Eocene, Te - Eocene, Tp - Paleocene, Ku - undivided Cretaceous, J (blue) - Jurassic, gv - younger Granitoides, ha - Hammamat Group, sp - Serpentinite, mv - geosinclinal Metavolcanics.

Generally, following of the sequence of sediments is observed there (Fig. 3). At the base, on the depth below 3-5 m (various depth at various places) top of silts representing Sahaba formation is present (data 12 000-10 000 B.P. - Said 1966, Ginter et al. 1983, 1986, 1987, 1988, Pawlikowski 1993, 1994 a, b, c, d, 2002 a,b, 2004, Pawlikowski, Wasilewski - in print). They are represented by brownish compact clayey slits containing various admixture of fine sand. The color of mentioned silts is various at various places and depends on admixture of red soils

washed out from local hills - gebel (Pawlikowski 1994 b, c). If admixture is higher silts are reddish if smaller silts are brown but stratigraphic position is always the same.

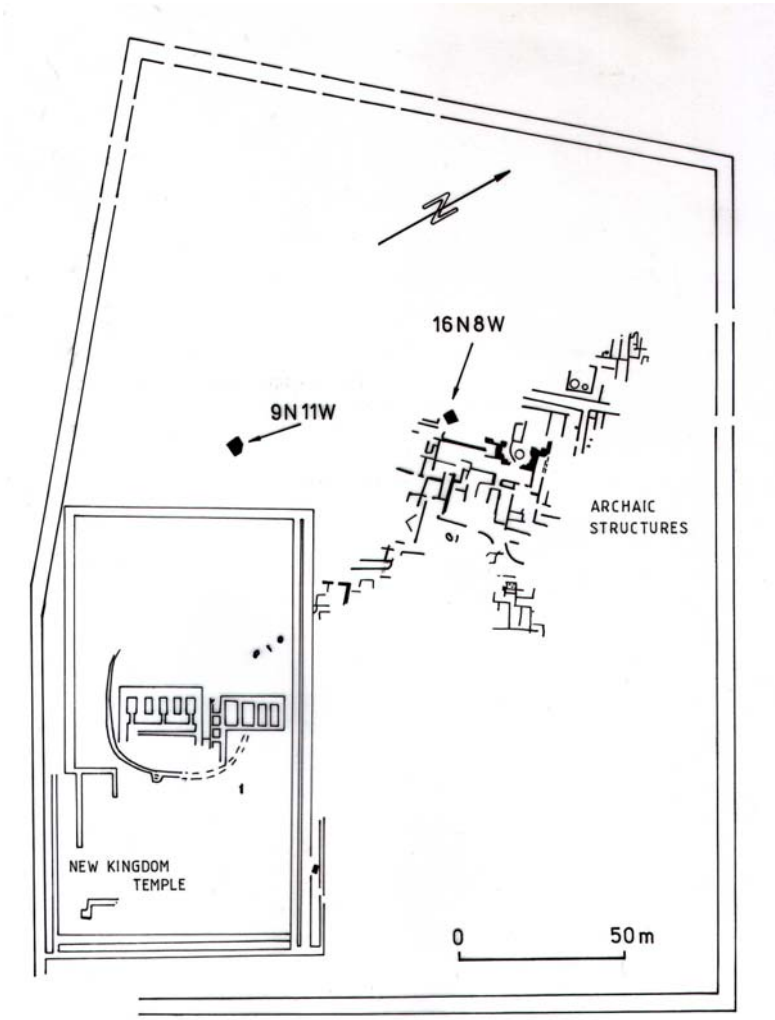


Fig. 3 Localization of tested trenches no 9N/11W and 16N/8W

Above Sahaba formation one can see sandy silts and sometime sands of various thickness not thicker generally than 0.5 m. These sandy silts or even sands represent so called older and younger pediment (water sediments) present between gebel and zone of agriculture (zone of floods - M. Pawlikowski 1994 c, d). At Heraconpolis these sands are composed of material transported there from big Valley (wadi) present just about 1-2 km West from the site. Sands are yellowish, sometime brownish (admixture of brown silt) or white if iron oxides are dissolved and removed by organic substance (organic acids) present at overlaying layers. These sands contain at the top pre- and protodynastic pottery as well as flint artefacts. The temple of Old Kingdom was build exactly on the top of these sands which are locally deposited at secondary position by wind.

All mentioned sediments together with destroyed relicts of temple of Old Kingdom are covered with younger undivided brownish Nile silts of various thickness. These silts represent end of Old Kingdom and Middle

Kingdom (Pawlikowski 2002 a, b, Pawlikowski, 2004). At the bottom they contain pottery of Old Kingdom sometime mixed with older fragments (Nagada). The temple of New Kingdom was constructed just on the top part of these silts.

Mentioned silts contain a lot of New Kingdom pottery, but all these layers i.e. sands and young silts of Nile are strongly mixed because of human activity at this site. Because of this in relatively thin layer (up to 1.m) one can see pottery representing all mentioned archaeological periods.

Fields in Nile Valley at area of Heraconpolis are supplied with water with the use of two methods.

First is surface supply where water is coming to the fields as artificial streams coming from canals. This water is penetrating the soil and supplying plants.

Second way of supply is coming by underground waters coming from artificial canals. This water is supplying plants from site of roots.

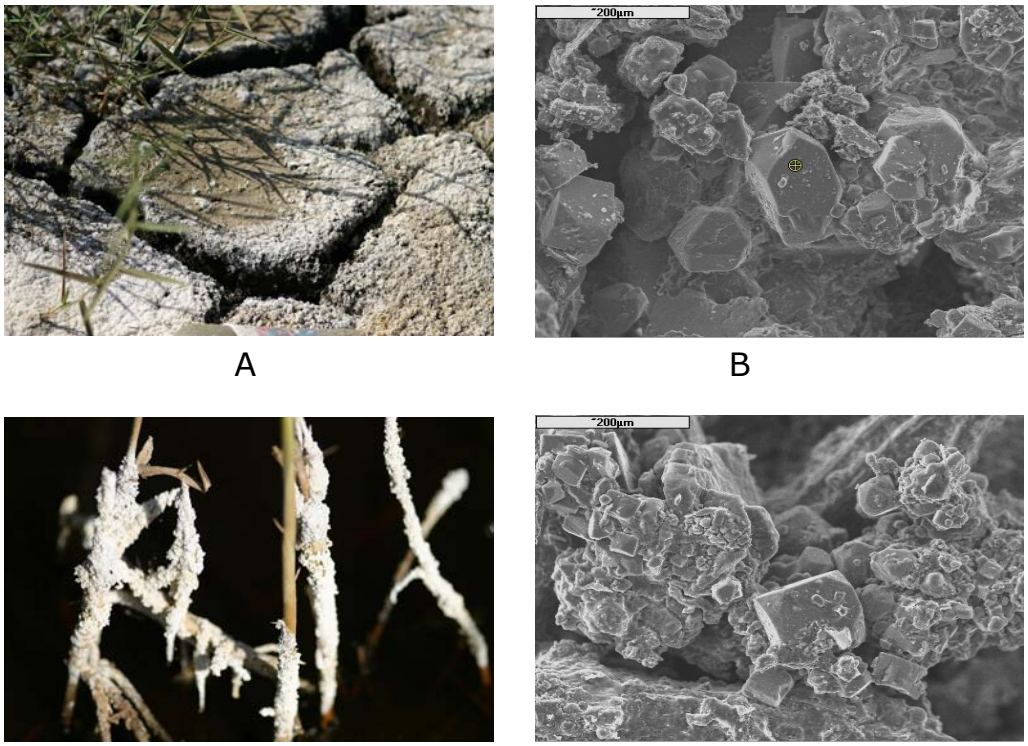
Independently of way of supplying farmed plants with water very strong evaporation of used waters takes place. This phenomenon goes because of solar heating of soil surface as well as due to the consumption of part of water by plants. Both phenomena lead to high concentration of dissolved salts in waters and in consequence to the intensive crystallization of evaporites.

The determination of methods reducing the growth of soil salinity is one of the most important scientific problems of Egyptian agriculture deciding about production of food in this country.

Material and methods

Material for mineralogical investigation was collected at area of Heraconpolis near of Edfu where located is one of most important archeological sites (Fig, 1, 2). The area under the consideration consists of Nile silts intercalated with sandy material and layers containing archaeological artefacts (Fig. 3).

Crystallizing evaporites are present there on the surface of soil (Photo 1) where they form, up to 5-8 cm thick, coatings. Secondary mineralization is well seen on the surface of cracked soil (cracked because of drying i.e. changing the volume of clay minerals (Photo 2)), as well as on various tissues of local plants (Photo 3). Crystallization of various evaporites one can see at natural and artificial depressions where small basins filled up with underground water exist (Photo 4).



A B

C D

Photo 1 Area of investigation. A - dry, cracked soils covered with layer of secondary salts B- crystals of salt crystallizing in soil (SEM), C – fragments of halfa coated with salts, D- crystals of salts coating halfa grass (SEM.

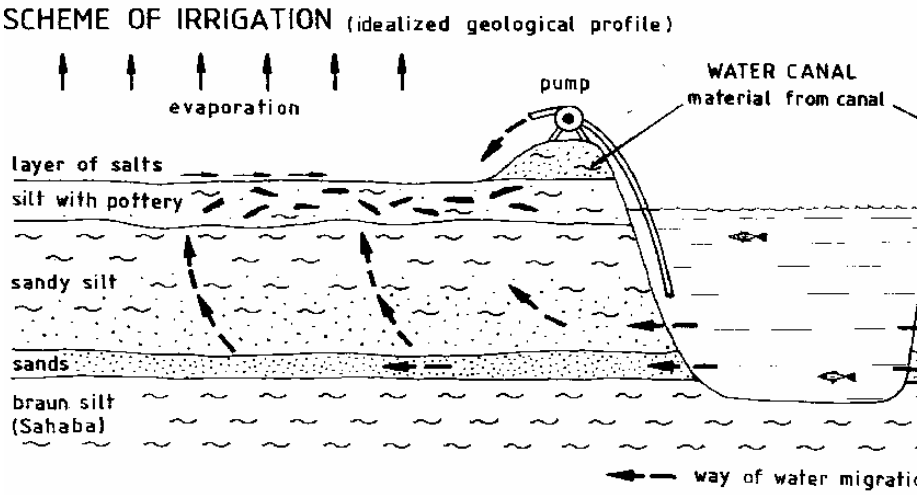


Fig. 4 The scheme of geological profile and functioning of irrigation system at area of Heraconpolis

Geology

Field investigation

About 35 boreholes were done at the archaeological area. Selected data were used for the reconstruction of shallow geological structures used next for the preparation of the cross section of site (Fig 5) and understanding of paleo environment at Heraconpolis.

Profiles of sediments at boreholes used for the construction of geological cross section.

BOREHOLE no 24 / 4	
Depth (cm)	Sediment
0,00 - 0,40	archaeological layer
0,40 - 1,00	silt - empty with gravels at the bottom
1,00 - 1,50	sandy silt with thin layers of sand at the base
1,50 - 2,60	sandy silt with pottery
> 2,60	sand from wadi

BOREHOLE no 16 / 4	
Depth (cm)	Sediment
0,00 - 0,30	archaeological layer
0,30 - 1,50	sandy silt
1,50 - 1,65	sand with fragments of pottery
1,65 - 2,60	silty sand - empty
> 2,60	brownish sand from wadi with fragments of pottery

BOREHOLE no 13 / 4	
Depth (cm)	Sediment
0,00 - 1,10	archaeological layer
1,10 - 1,20	silt - empty
1,20 - 1,70	silt with pottery
1,70 - 2,00	silt with chipped flints at the base
2,00 - 2,70	sandy silt and sand at the bottom

BOREHOLE no 7 / 4	
Depth (cm)	Sediment
0,00 - 0,55	modern sediments
0,55 - 1,80	silt with pottery
1,80 - 2,30	sandy silt with pottery
2,30 - 2,90	sandy silt - empty
2,90 - 3,25	mud bricks
3,25 - 4,40	silt
4,40 - 5,35	brownish silty sand from wadi
> 5,35	sand

BOREHOLE no 6 / 4	
Depth (cm)	Sediment
0,00 - 1,00	archaeological layer, traces of sand at the base
1,00 -1,40	silt - empty
1,40 - 1,80	silt with pottery
1,80 - 2,30	sandy silt with fragments of red polished pottery
2,30 - 2,35	fine gravel - empty
2,35 - 2,60	silt with pottery
> 2,60	yellowish sand

BOREHOLE no 1	
Depth (cm)	Sediment
0,00 - 2,00	sandy silt with pottery and 5cm thick layer of gravel at dept 1,80
2,00 - 2,45	brownish silt - empty
2,45 - 2,80	sandy silt with pottery
2,80 - 3,10	sand from wadi

BOREHOLE no 2 / 4	
Depth (cm)	Sediment
0,00 - 0,55	modern sediments with small graves at the base
0,55 - 1,80	silt with pottery
1,80 - 2,30	sandy silt with pottery
2,30 - 2,90	sandy silt - empty
2,90 - 3,25	gray silt (brick wall ?)
> 3,25	silt with fragments of black top pottery

BOREHOLE no 2	
Depth (cm)	Sediment
0,00 - 1,20	sand with intercalation of gravel at the depth 1,20
1,20 - 1,30	sand - empty
1,30 - 1,35	fine gravel
1,35 - 3,20	sand from wadi

E W

Nile Valley Wadi outcome

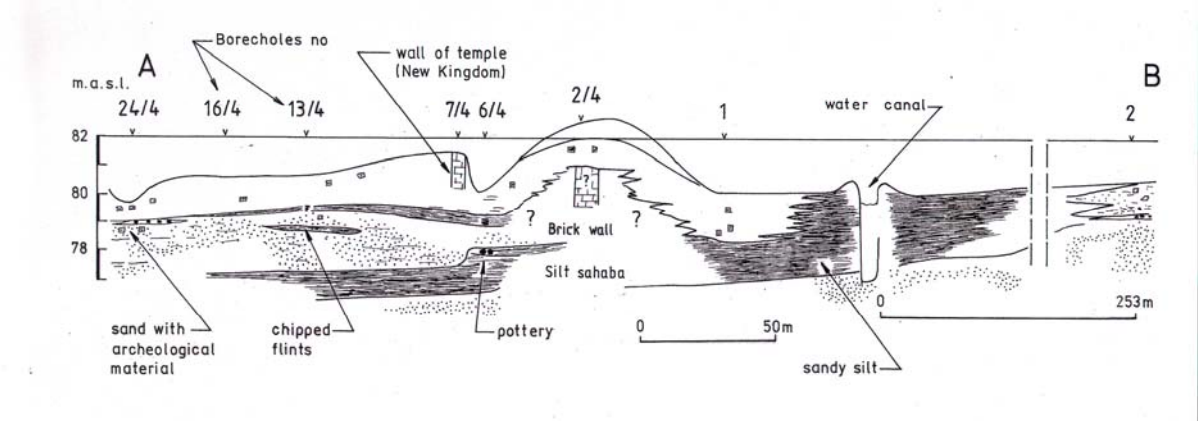


Fig. 5 The cross section of sediments of Heraconpolis archaeological site on the base of geological profiles (drillings).

Conclusions concerning geology

Performed drillings as well as analyses of obtained cores confirm the location of the site at the East edge of big delta formed at the outcom of wadi located west from the site. Geological as well as mineralogical observations confirm dry climate at the phases of human occupation of the site i.e. the climate without rains when mentioned before wadi did not conduct water into the Nile Valley. This climatic situation decided on the location of site low in the morphology, i.e. near of Nile banks.

The presence of silty intercalations in the profile of tested borecholes document high level of Nile and rare, occasional floods of river. Determination of frequency of floods as well as their range and data is possible for determination after detailed examination of geology of east edge of the site.

So, at the time Nagada II and III cultures local climate was very dry (no rains, no rivers supplying Nile). On the other hand floods of Nile were rare. These observations confirm very desertic condition on Sahara and East Desert and necessity of migration of Man at this period to Nile Valley.

Reconstruction of climatic conditions at the period between phases of occupation needs continuation of field and lab. works.

Stone implements

Examination of stone chipped implements was performed at two mentioned trenches (Fig. 3).Material for analyses was collected at depth 00-30 cm and 30-50 cm. Results are collected at tables no 1 and 2.

Trench 9N/11W

ROCK	Depth 00 - 30 cm	Depth 30 - 50 cm
Sedimentary		
Sandstone	62,4	65,1
Limestone	3,5	15,1
Conglomerate	3,1	_
Flint	3,9	4,8
Magmatic		
Granite (Aswan)	3	9,9
Basalt	3,3	_
Porphyre	5,9	_
Metamorphic		
Piroxenite	6,6	_
Minerals		
Quartz	8,1	5,1
Agate	0,2	_

Table 1 Trench 9N/11W. The content of various rocks (implements) at to depths: 00-30cm and 30-50cm at trench (%)

Fig. 6 The content of various rocks (implements) at trench no 9N/11W

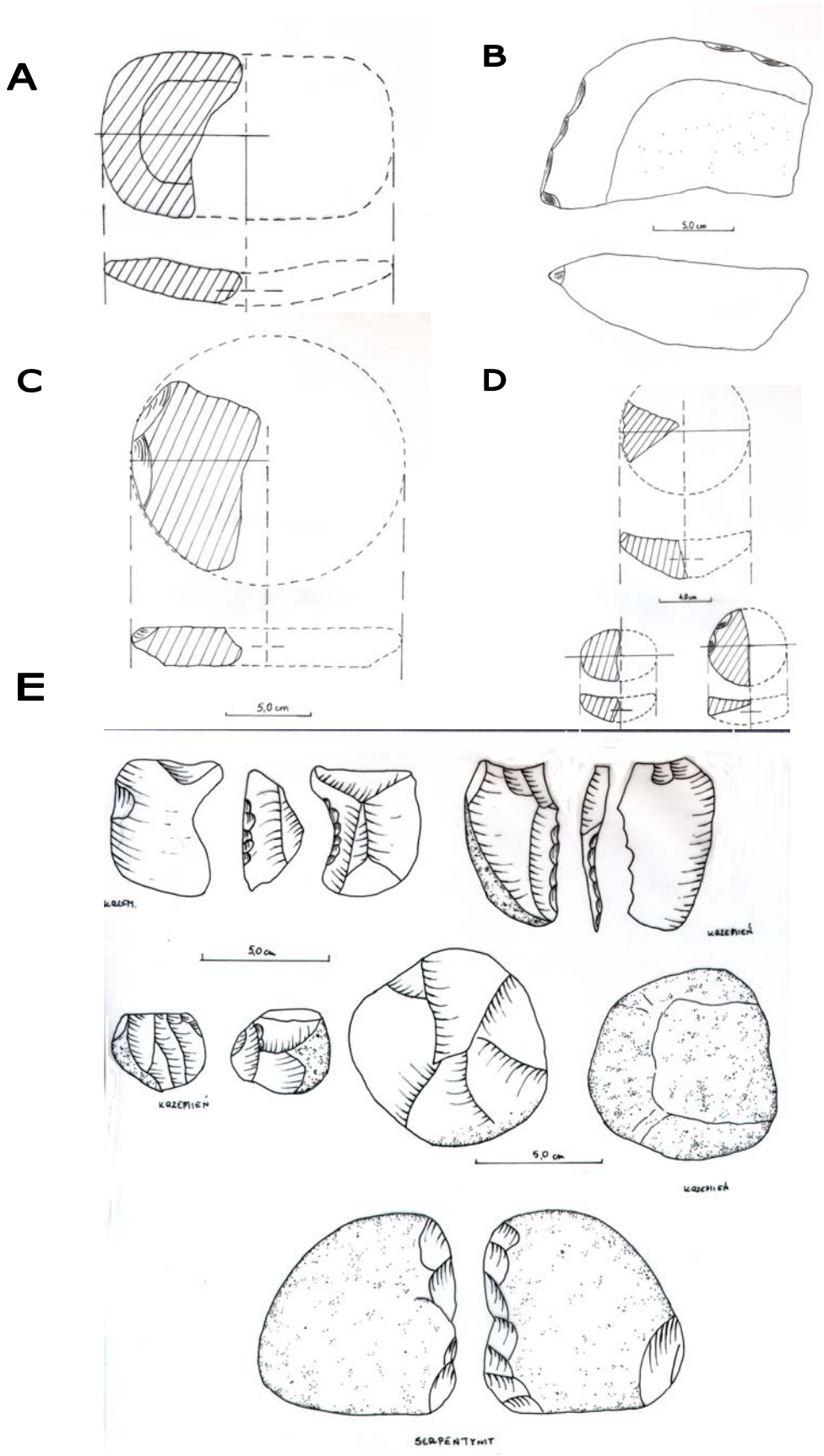


Fig. 7 Examples of stone objects from trench 9N/11W. A- D grinders of various shape and size. E - stone implements done of flints.

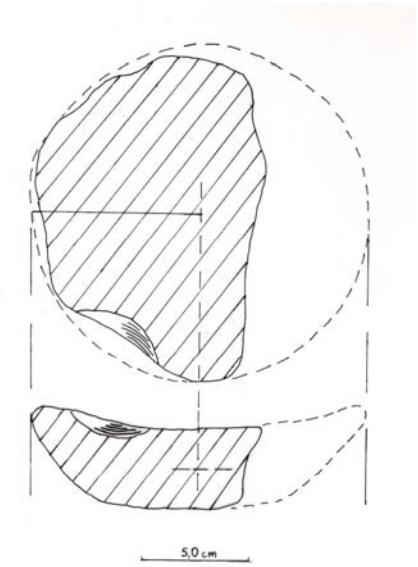
Trench 16N/8W

ROCK	Depth 00 - 30 cm	Depth 30 - 50 cm
Sedimentary		
Sandstone	53,3	62,5
Limestone	10,7	7,3
Conglomerate	0,8	_
Flint	20,6	18,1
Magmatic		
Porphyre	3,8	_
Metamorphic		
Serpentinite	3,7	_
Granitognaiss	1,8	_
Minerals		
Quartz	5,3	12,1
Agate	_	_

Table 1 Trench 16N/8W. The content of various rocks (implements) at to depths: 00-30cm and 30-50cm at trench (%)

Fig. 8 The content of various rocks at trench no 16N/8W

A



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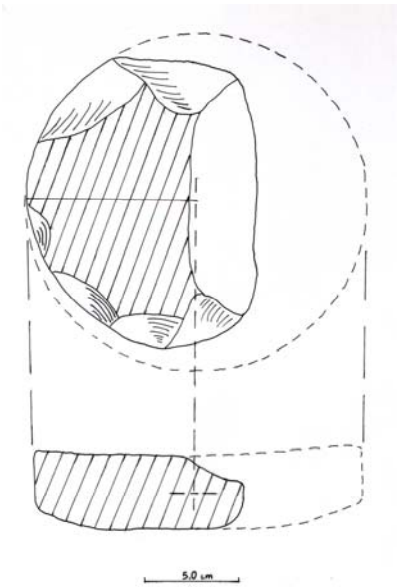

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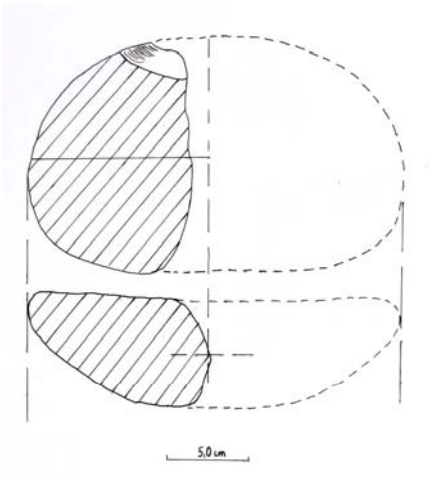

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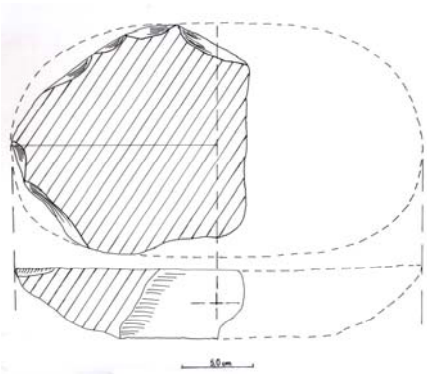


E

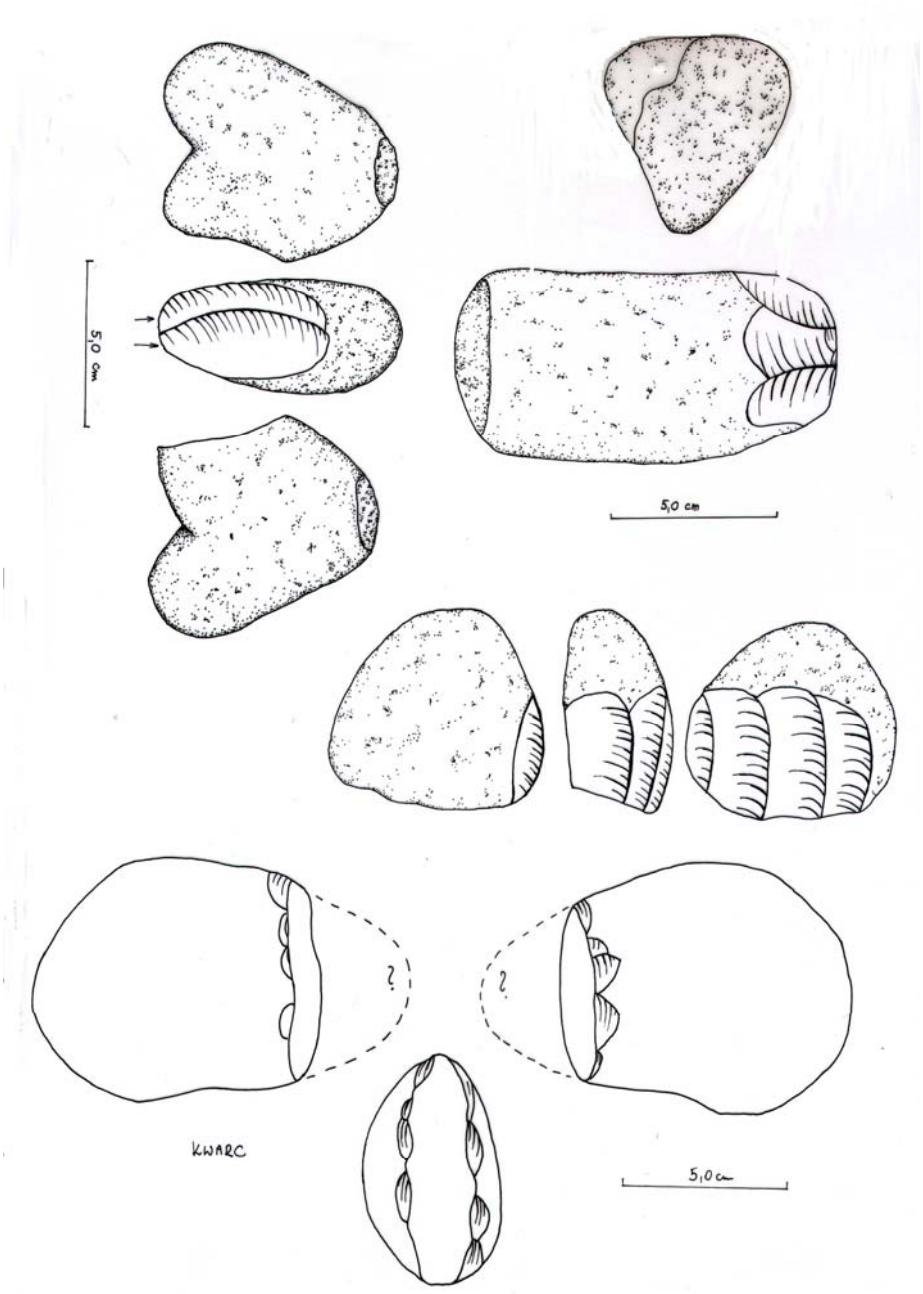


Fig. 8 Examples of stone objects from trench 16N/8W. A- D grinders of various shape and size. E -stone implements done of flints.

Conclusion concerning stone objects

The examination showed presence of various rocks at various depth of trenches as well as at various archaeological layers. Dominating objects made of limestones and sandstones are prepared using local rocks (grinders, plates etc.). Chipped flint objects are made of local flints too. The amount of other rocks documenting imports of material or imports of objects is small - up to 6-7 %. Mentioned relation confirm utilization first of all local sources for preparation of various stone implements. Moreover new method of reconstruction of grinders –similar to the method of pottery vessel reconstruction was showed.

Pottery

Research method

The examination was aimed at mineralogical and petrographical as well as technological description of the archaeological pottery.

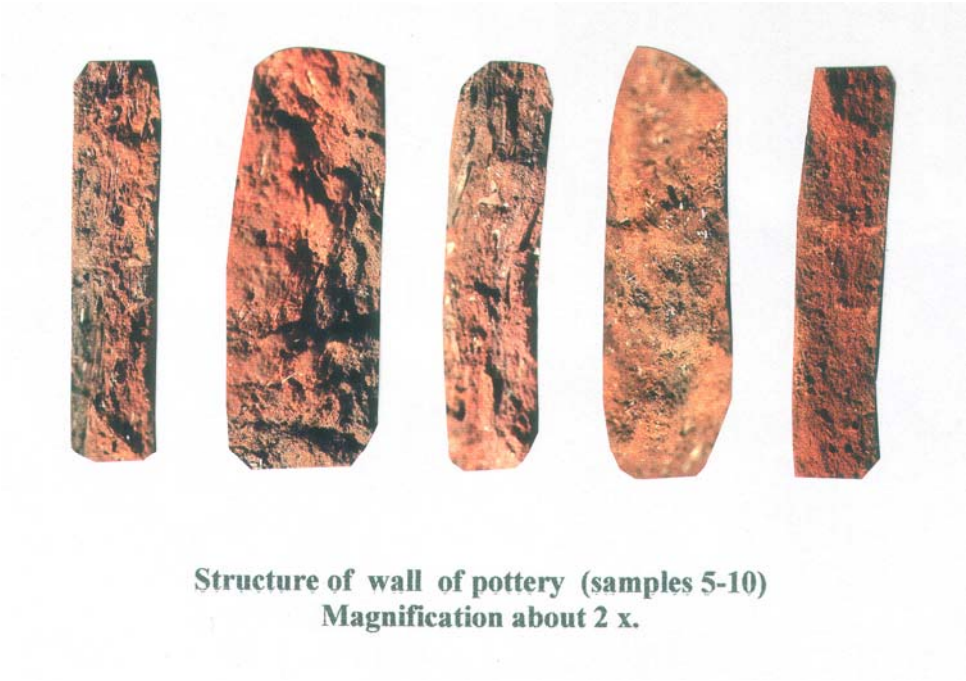
The thin-section of pottery was subjected to examination under the polarizing light microscope of Nicon 120. A slice of the thin-section was taken from standard place i.e. from the wall of the vessel belly.

The research comprised mineral and grain size analyses of the fabric. In each case about 1000 grains were counted for determination of mineral composition and 1000 grains for determination of grain size composition. The counting as well as generally methods of analyzes were standard. Results of investigations were stated in percentage and collected using POTTERY computer program for collecting and analysis of mineralogical and technological data. POTTERY computer program was used for determination of similarity of tested pottery. All 35 features of each fragment collected in the tables were compared with the same features of the rest of analyzed samples. Obtained data of comparison were given as the percents of similarity where 100 % means identity. All similarities above 50 % were printed at separate chapter: Computer analyses of similarity of tested samples.

Pottery Nagada III

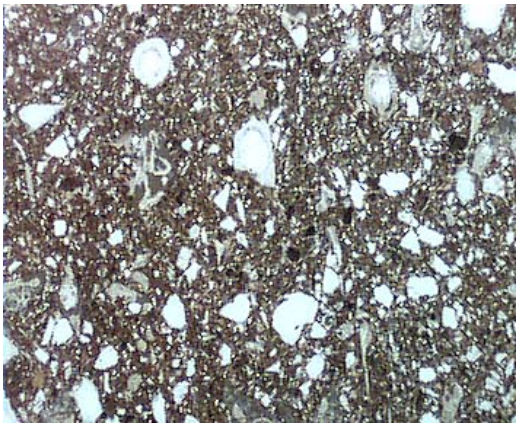
Samples no 1-10

Structure of wall of pottery (samples 1-5)
Magnification about 2 x.

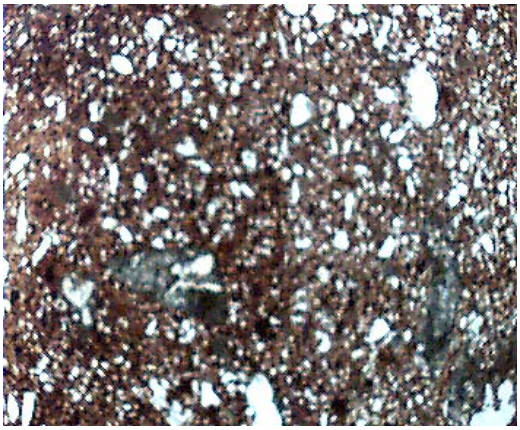


Structure of wall of pottery (samples 5-10)
Magnification about 2 x.

Photo 2 Pictures of shreds and fractures of pots



1



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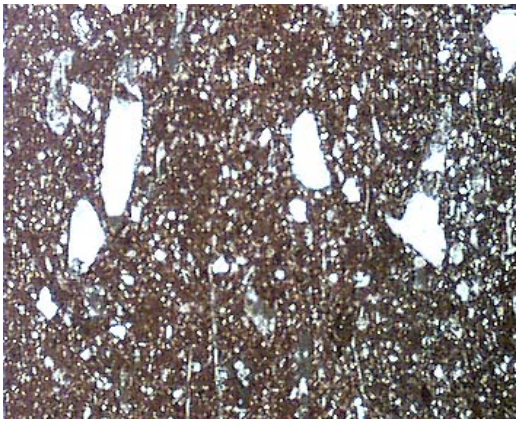

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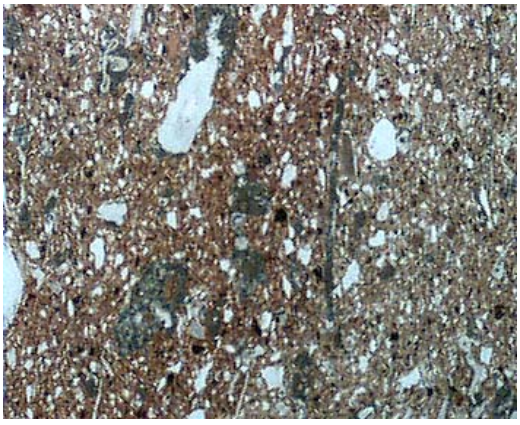

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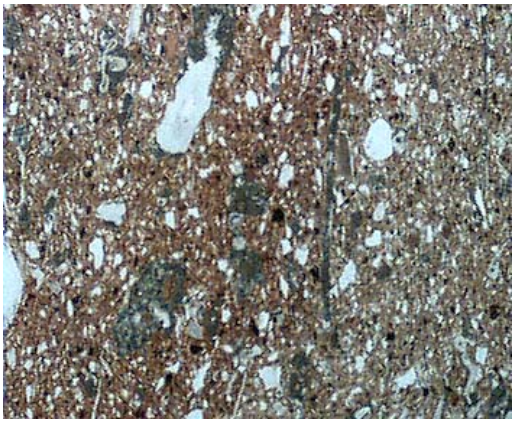

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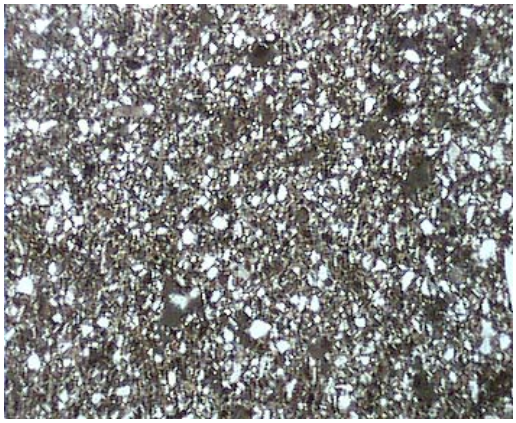

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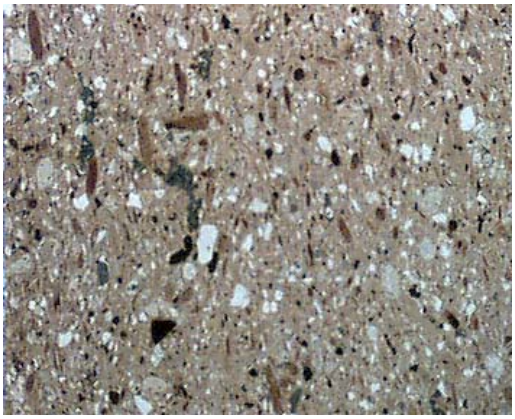

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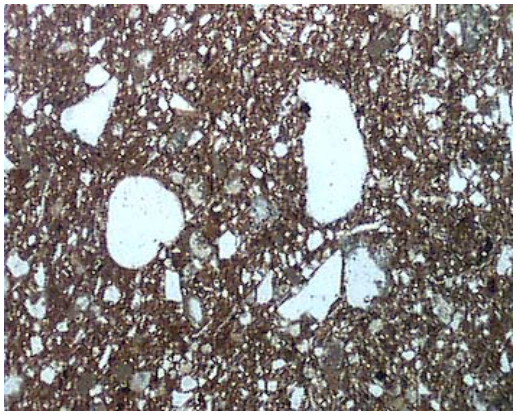

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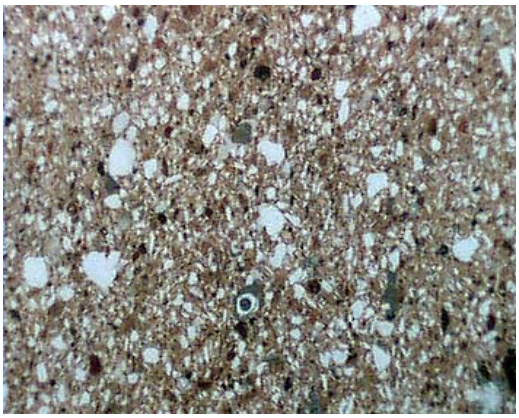

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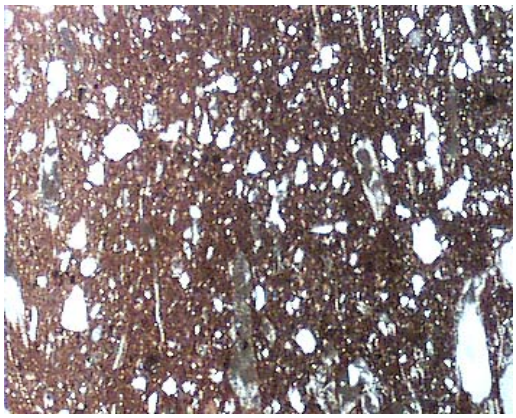

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Photo 3 Internal textures of examined pottery Nagada III samples 1-10. Digital microscope, magnification 45 x.

Investigation of thin sections of pottery. Polarizing light microscopy

Sample 1

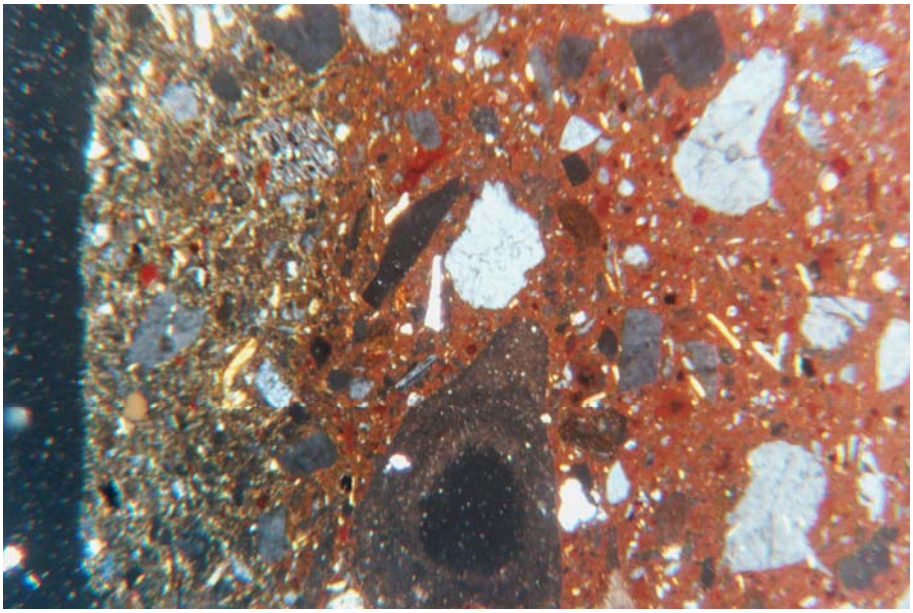


Photo 4 Sample 1. Microscopic picture of ceramic mass just under external wall. Yellowish oxidize zone (right part of photo) contacting with central only slightly oxidize part of wall of vessel. Polarizing light microscope, magnification 80 x.

Results of investigation of sample 1

1. Site: Heraconpolis	Plagioclases: 3.300% Fr.of sed.rocks: 1.000% Fr.of mag.rocks: 0.000% Fr.of met.rocks: 0.000% Muscovite: 0.000% Biotite: 0.600% Heavy minerals: 0.200% Fr.of pottery: 0.100% Carbonates: 0.000% other: 0.900%
2. Sample: E-Her-P1	
3. Colour: reddish	
4. Fracture - internal: reddish - central: grey - external: reddish	
5. Finger grooved: no	
6. Enamel: absent	
7. Painting: no paint	
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 56.000% 60 -100 mm: 37.000% 100 -200 mm: 6.000% 200 -400 mm: 1.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 80.000% Quartz: 11.700% K-feldspars: 2.200%	12. Frequency: no data

Sample 2

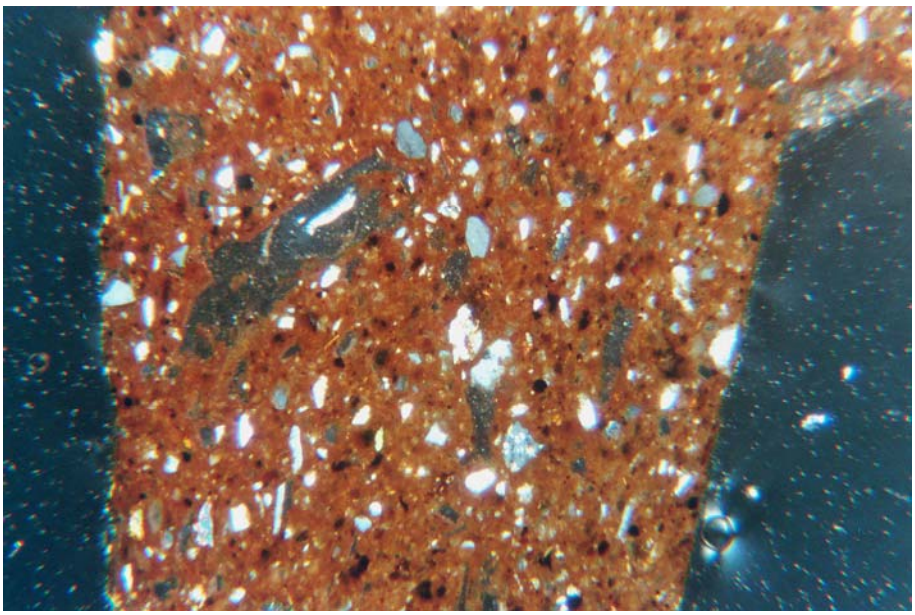


Photo 5 Sample 2. Homogenous ceramic mass just under external wall of vessel. Polarizing light microscope, polaroides x, magnification 80 x.

Results of investigation of sample 2

1. Site: Heraconpolis	Plagioclases: 1.100% Fr.of sed.rocks: 0.000% Fr.of mag.rocks: 0.000% Fr.of met.rocks: 0.000% Muscovite: 0.000% Biotite: 0.900% Heavy minerals: 0.100% Fr.of pottery: 0.000% Carbonates: 0.000% other: 1.300%
2. Sample: E-Her-P2	
3. Colour: light-brownish	
4. Fracture - internal: light-brownish - central: light-brownish - external: light-brownish	
5. Finger grooved: no	
6. Enamel: absent	
7. Painting: no paint	
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 74.000% 60 -100 mm: 11.000% 100 -200 mm: 11.000% 200 -400 mm: 4.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 87.000% Quartz: 8.800% K-feldspars: 0.800%	12. Frequency: no data

Sample 3

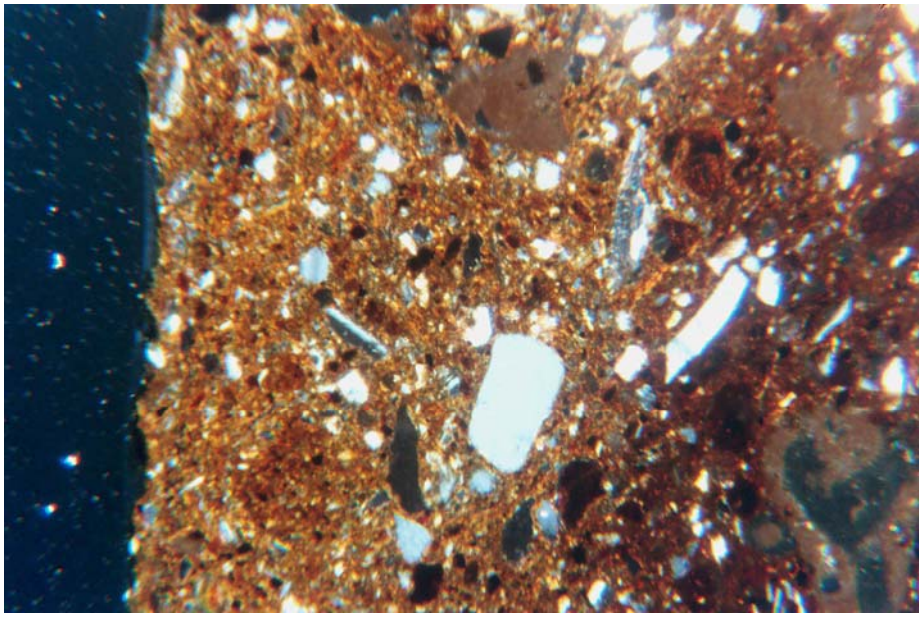


Photo 6 Sample 3. Minerals disseminated at ceramic mass at oxidize zone (yellowish) just under external wall of vessel. Polarizing light microscope, polaroides x, magnification 80 x.

Results of investigation of sample 3

1. Site: Heraconpolis	Plagioclases: 0.700%
2. Sample: E-Her-P3	Fr.of sed.rocks: 0.000%
3. Colour: brownish	Fr.of mag.rocks: 0.600%
4. Fracture - internal: brownish - central: brownish - external: brownish	Fr.of met.rocks: 0.500% Muscovite: 0.300% Biotite: 0.600% Heavy minerals: 0.200%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.200%
7. Painting: no paint	other: 1.200%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 58.000% 60 -100 mm: 35.000% 100 -200 mm: 4.000% 200 -400 mm: 3.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 700 C	
10. Mineral comp. Clay mass: 76.000% Quartz: 19.300% K-feldspars: 0.400%	12. Frequency: no data

Sample 4

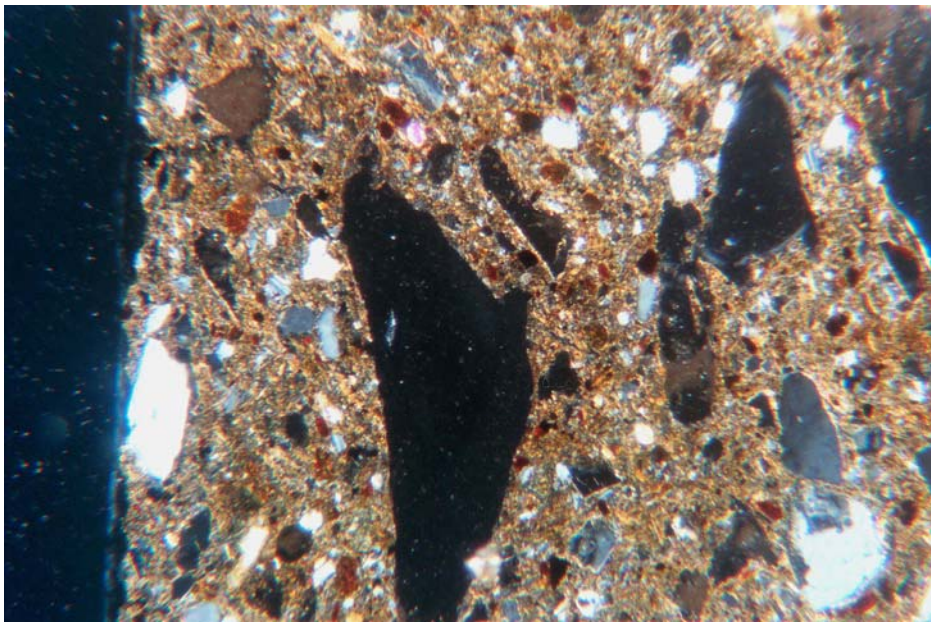


Photo 7 Sample 4. Big pores (black spots) present in ceramic near of external wall of vessel. Polarizing light microscope, polaroides x, magnification 80 x.

Results of investigation of sample 4

1. Site: Heraconpolis	Plagioclases: 4.000%
2. Sample: E-Her-P4	Fr.of sed.rocks: 0.700%
3. Colour: brownish	Fr.of mag.rocks: 4.500%
4. Fracture - internal: yellowish - central: yellowish - external: yellowish	Fr.of met.rocks: 0.000% Muscovite: 0.300% Biotite: 0.700% Heavy minerals: 0.200%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.200%
7. Painting: no paint	other: 0.900%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 61.000% 60 -100 mm: 30.000% 100 -200 mm: 6.000%
9. Temp. Of firing: 650 C	200 -400 mm: 1.000%
10. Mineral comp. Clay mass: 62.000% Quartz: 23.500% K-feldspars: 3.200%	400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
	12. Frequency: no data

Sample 5

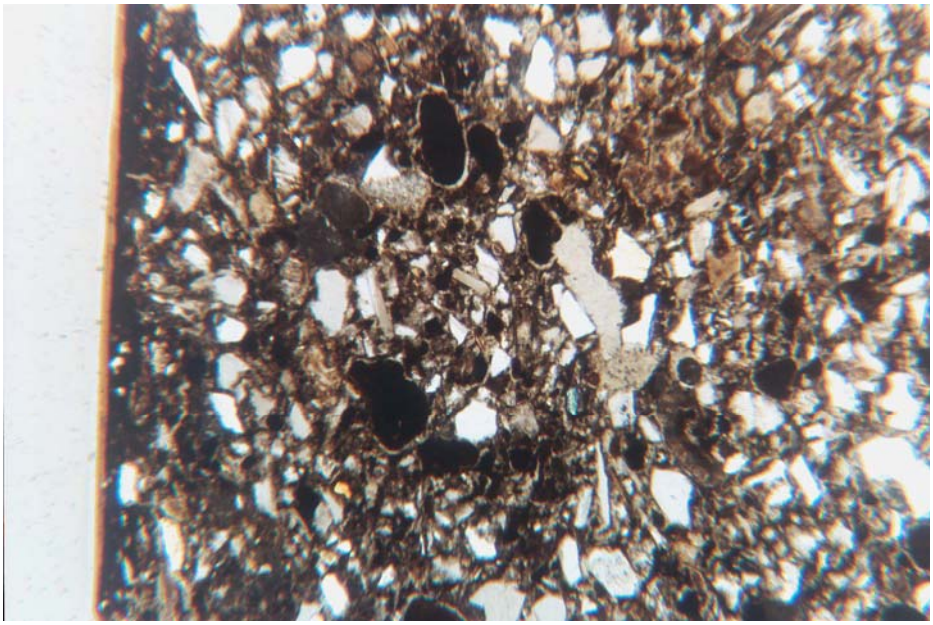


Photo 8 Sample 5. Microscopic picture of ceramic mass under external wall of vessel. One can see surface covered with thin layer of layer of clay. Polarizing light microscope, polaroides in part x, magnification 80 x.

Results of investigation of sample 5

1. Site: Heraconpolis	Plagioclases: 4.000%
2. Sample: E-Her-P5	Fr.of sed.rocks: 0.000%
3. Colour: red-back	Fr.of mag.rocks: 0.600%
4. Fracture - internal: black - central: black - external: black	Fr.of met.rocks: 1.300% Muscovite: 0.400% Biotite: 0.500% Heavy minerals: 0.200%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.700%
7. Painting: no paint	other: 3.100%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 68.000% 60 -100 mm: 20.000% 100 -200 mm: 12.000% 200 -400 mm: 0.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 38.000% Quartz: 45.000% K-feldspars: 6.200%	12. Frequency: no data

Sample 6

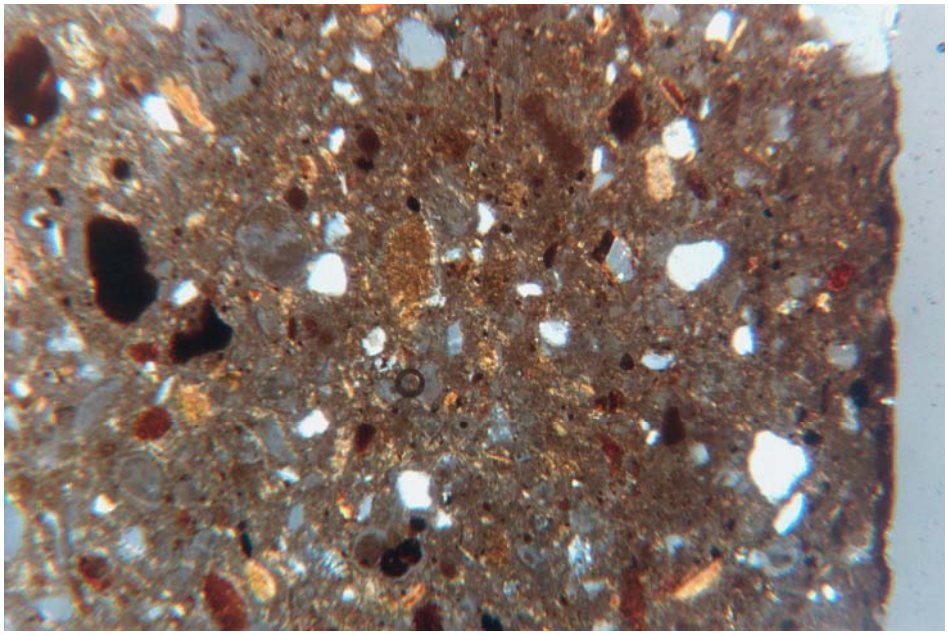


Photo 9 Sample 6. Microscopic picture of ceramic mass under internal surface of vessel. One can see relict of burned organic layer (black spots) coating internal wall of vessel. Polarizing light microscope, polaroides in part x, magnification 80 x.

Results of investigation of sample 6

1. Site: Heraconpolis	Plagioclases: 0.000%
2. Sample: E-Her-P6	Fr.of sed.rocks: 9.600%
3. Colour: light-brownish	Fr.of mag.rocks: 0.000%
4. Fracture - internal: reddish - central: reddish - external: reddish	Fr.of met.rocks: 0.000% Muscovite: 0.300% Biotite: 0.100% Heavy minerals: 0.100%
5. Finger grooved: no data	Fr.of pottery: 0.100%
6. Enamel: absent	Carbonates: 0.700%
7. Painting: no paint	other: 1.200%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 24.000% 60 -100 mm: 56.000% 100 -200 mm: 20.000% 200 -400 mm: 0.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 700 C	
10. Mineral comp. Clay mass: 73.000% Quartz: 15.200% K-feldspars: 0.400%	12. Frequency: no data

Sample 7

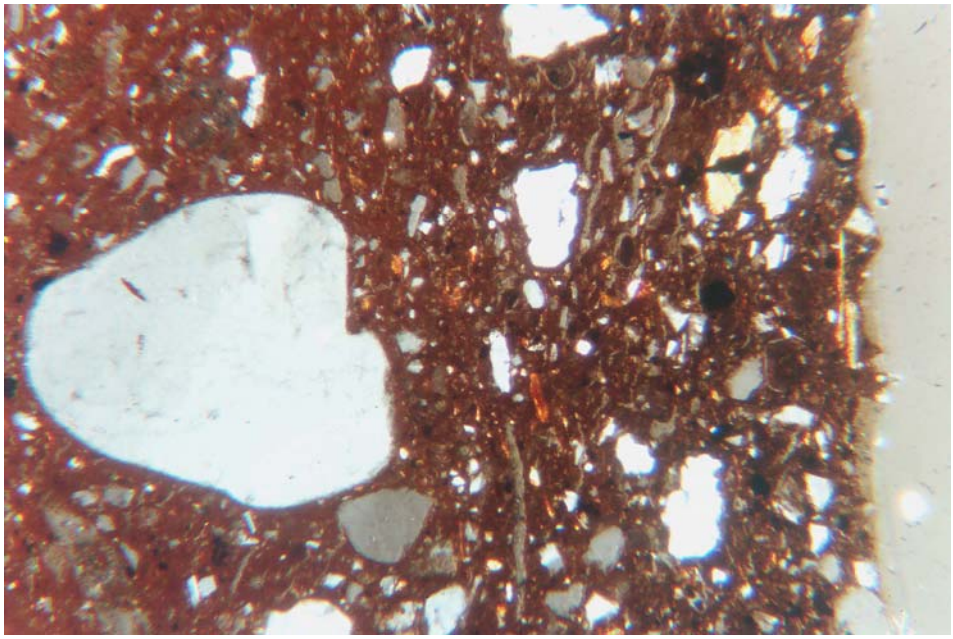


Photo 10 Sample 7. Ceramic mass just under internal wall of vessel. Big, light, rounded grains of quartz disseminated at thermally altered clay background. Polarizing light microscope, magnification 80 x.

Results of the investigation of sample nr 7

1. Site: Heraconpolis	Plagioclases: 4.300%
2. Sample: E-Her-P7	Fr.of sed.rocks: 0.700%
3. Colour: light-brownish	Fr.of mag.rocks: 4.100%
4. Fracture - internal: brownish - central: brownish - external: brownish	Fr.of met.rocks: 0.000% Muscovite: 0.200% Biotite: 0.200% Heavy minerals: 0.300%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 4.500%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 45.000% 60 -100 mm: 34.000% 100 -200 mm: 17.000% 200 -400 mm: 3.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 67.000% Quartz: 16.800% K-feldspars: 1.900%	12. Frequency: no data

Sample nr 8

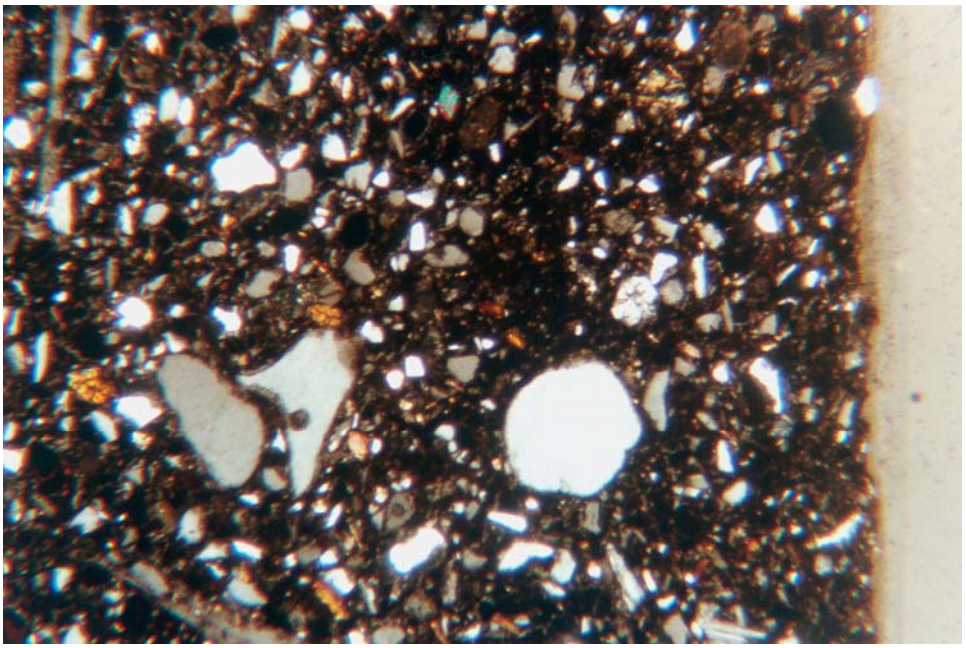


Photo 11 Sample 8. Thermally altered ceramic mass just under internal wall of vessel. Polarizing light microscope, polaroides in part x, magnification 80 x

Results of the investigation of sample nr 8

1. Site: Heraconpolis	Plagioclases: 3.700%
2. Sample: E-Her-P8	Fr.of sed.rocks: 0.000%
3. Colour: light-brown	Fr.of mag.rocks: 0.600%
4. Fracture - internal: reddish - central: reddish - external: reddish	Fr.of met.rocks: 0.000% Muscovite: 0.300% Biotite: 0.200% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 3.200%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 42.000% 60 -100 mm: 41.000% 100 -200 mm: 15.000% 200 -400 mm: 1.000% 400 -1000 mm: 1.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 57.000% Quartz: 30.000% K-feldspars: 5.900%	12. Frequency: no data

Sample nr 9

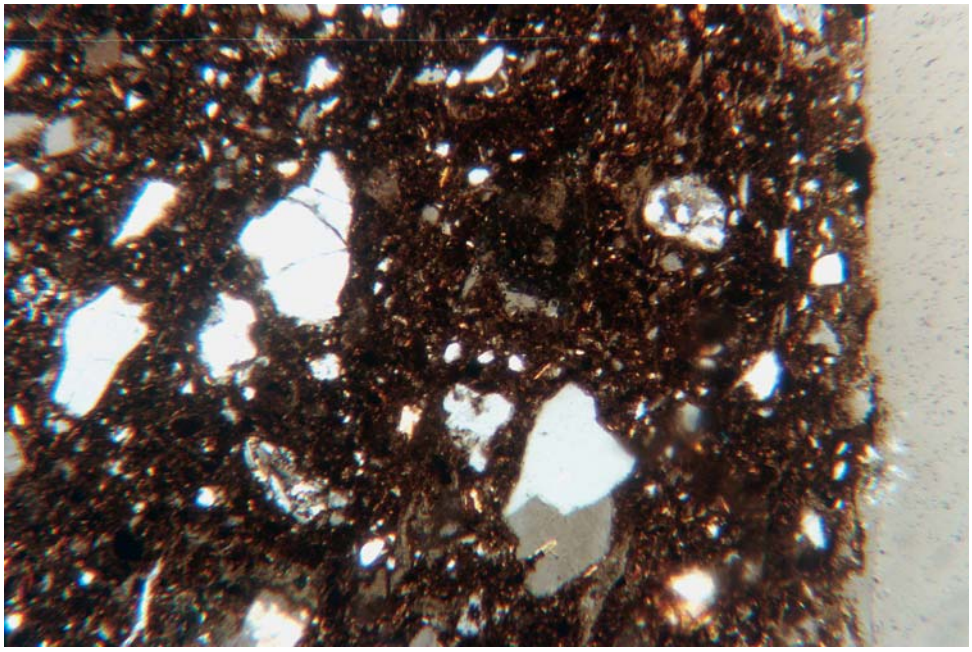


Photo 12 Sample 9. Thermally altered ceramic mass just under internal wall of vessel. Light sharp grains of quartz constitute tempering material. Polarizing light microscope, polaroides in part x, magnification 8

Results of the investigation of sample nr 9

1. Site: Heraconpolis	Plagioclases: 2.600%
2. Sample: E-Her-P9	Fr.of sed.rocks: 0.000%
3. Colour: light-brownish	Fr.of mag.rocks: 0.500%
4. Fracture - internal: reddish - central: reddish - external: reddish	Fr.of met.rocks: 0.000% Muscovite: 0.300% Biotite: 0.000% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 2.300%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 46.000% 60 -100 mm: 37.000% 100 -200 mm: 14.000% 200 -400 mm: 3.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 700 C	
10. Mineral comp. Clay mass: 73.000% Quartz: 15.700% K-feldspars: 5.500%	12. Frequency: no data

Sample nr 10

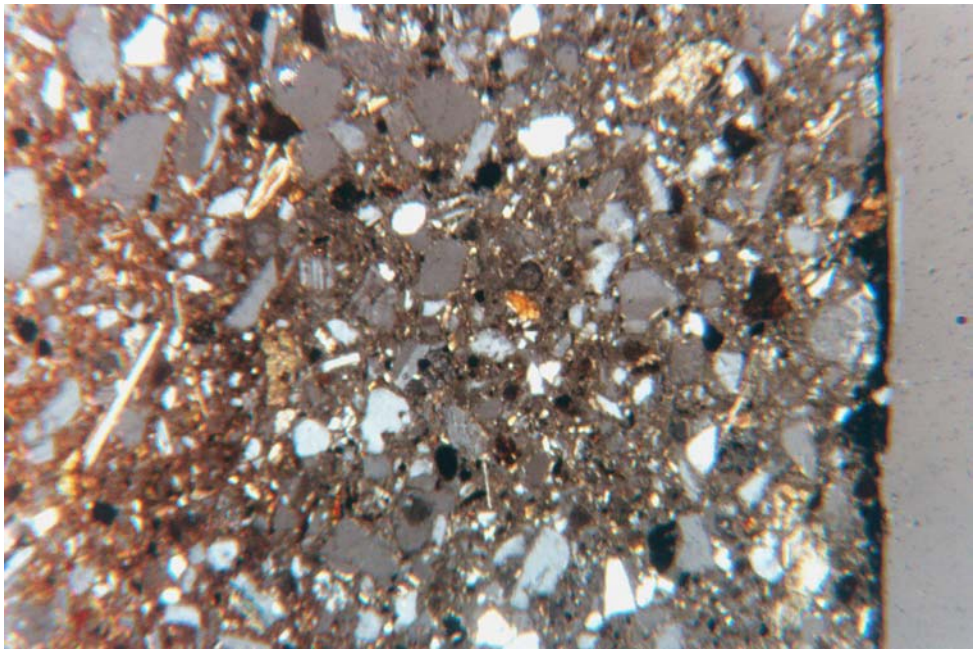
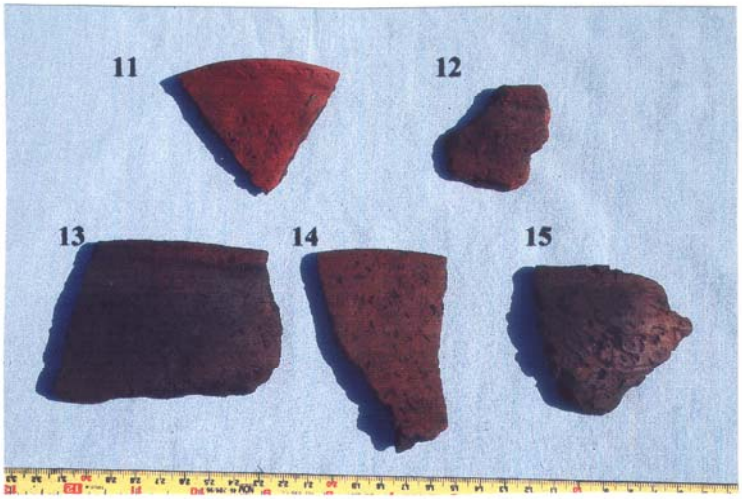


Photo 13 Sample 10. Ceramic mass just under internal wall of vessel. Relicts of burned organic substance (meal) on internal wall (thin, black layer). Polarizing light microscope, 1 polaroid, magnification 80 x.

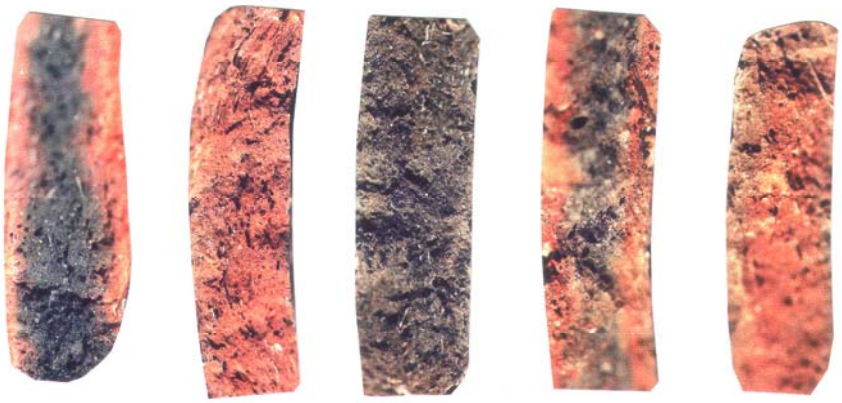
Results of the investigation of the sample nr 10

1. Site: Heraconpolis	Plagioclases: 1.300%
2. Sample: E-Her-P10	Fr.of sed.rocks: 0.000%
3. Colour: brownish	Fr.of mag.rocks: 2.700%
4. Fracture - internal: yellowish-reddish - central: reddish-yellowish - external: reddish-yellowish	Fr.of met.rocks: 0.700% Muscovite: 0.300% Biotite: 0.400% Heavy minerals: 0.200%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 3.800%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 70.000% 60 -100 mm: 25.000% 100 -200 mm: 5.000% 200 -400 mm: 0.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 700 C	
10. Mineral comp. Clay mass: 63.000% Quartz: 25.100% K-feldspars: 2.500%	12. Frequency: no data

Pottery Nagada II

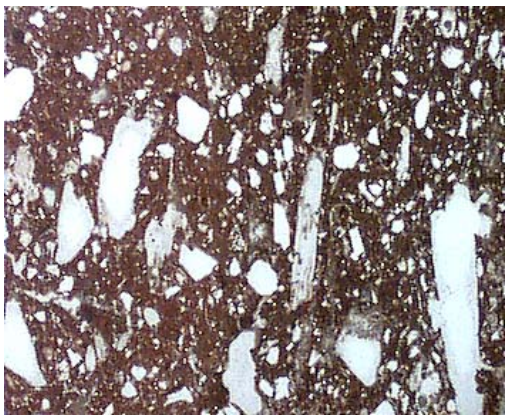


Samples no 10-15

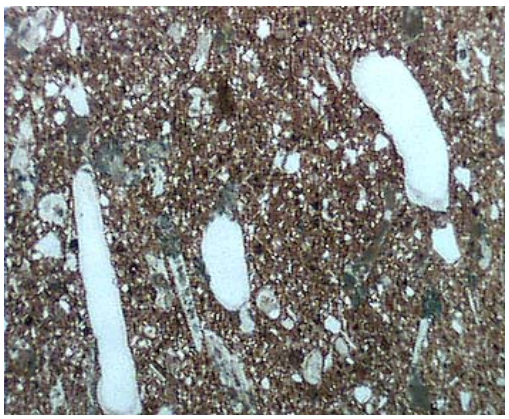


Structure of wall of pottery (samples 10-15)
Magnification about 2 x.

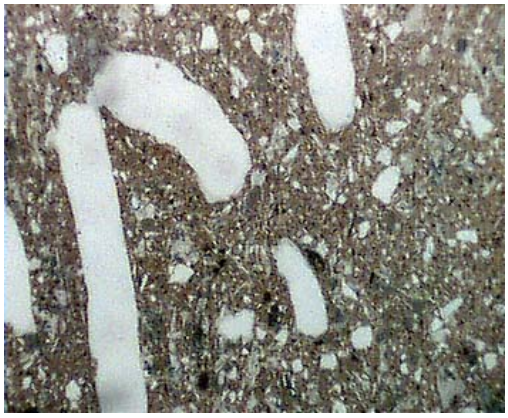
Photo 14 Pictures of shreds and fractures of pots



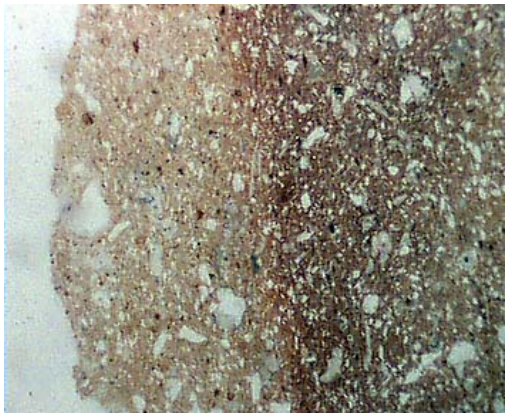
11



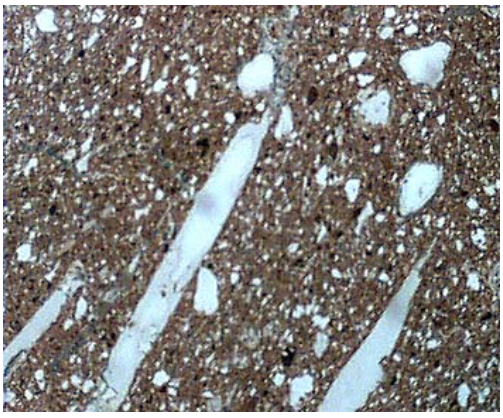
12



13



14



15

Photo 15 Internal textures of examined pottery Nagada II, samples no 11-15. Digital microscope, magnification 45 x.

The investigation of thin sections of pottery Nagada II Polarizing light microscopy

Sample 11

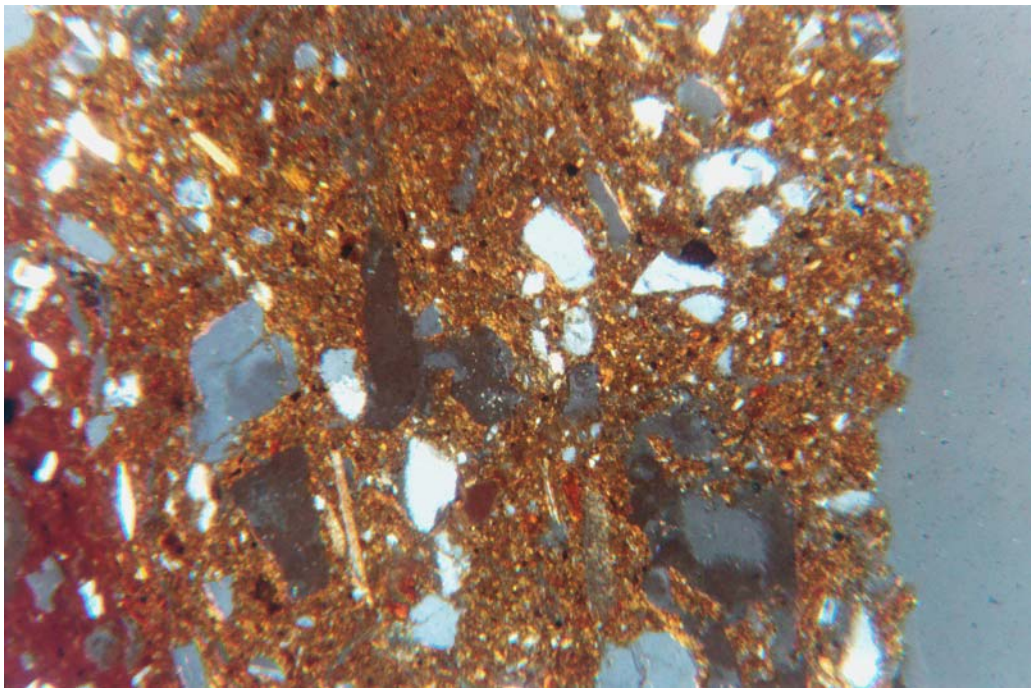


Photo 16 Sample 11. Ceramic mass just under internal wall of vessel. Grains of quartz and feldspars dispersed at thermally altered clay background. Polarizing light microscope, polaroides in part x, magnification 80 x.

Results of the investigation of sample nr 11

1. Site: Heraconpolis	Plagioclases: 2.300%
2. Sample: E-Her-P11	Fr.of sed.rocks: 0.000%
3. Colour: red	Fr.of mag.rocks: 1.800%
4. Fracture - internal: red - central: black - external: red	Fr.of met.rocks: 0.300% Muscovite: 0.100% Biotite: 0.100% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 2.500%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 41.000% 60 -100 mm: 42.000% 100 -200 mm: 14.000% 200 -400 mm: 3.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 68.000% Quartz: 22.800% K-feldspars: 2.000%	12. Frequency: no data

Sample nr 12

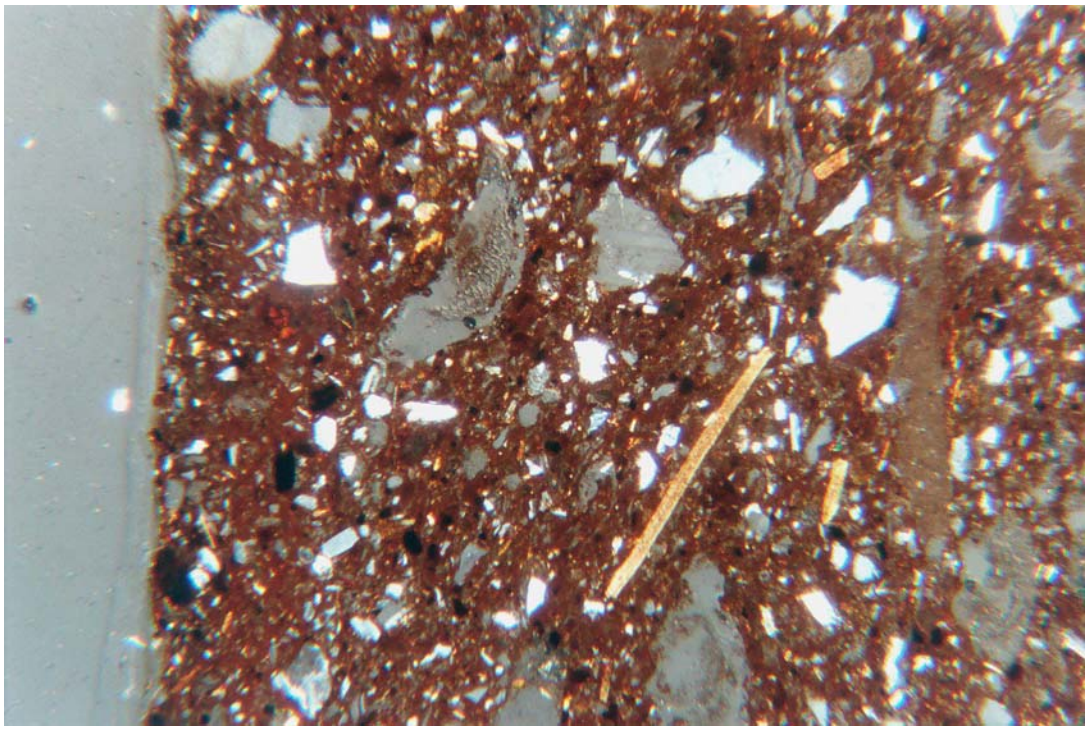


Photo 17 Sample 12. Ceramic mass just under internal wall of vessel. Yellowish long forms – organic compounds. White – grains of quartz and feldspars. Beige-light gray – pores. Polarizing light microscope, polaroides in part x, magnification 80 x.

The results of the investigation of sample nr 12

1. Site: Heraconpolis	Plagioclases: 3.100%
2. Sample: E-Her-P12	Fr.of sed.rocks: 0.000%
3. Colour: dark brown	Fr.of mag.rocks: 0.500%
4. Fracture - internal: red - central: red - external: red	Fr.of met.rocks: 0.000% Muscovite: 0.200% Biotite: 0.400% Heavy minerals: 0.300%
5. Finger grooved: no	Fr.of pottery: 0.100%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 3.100%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 57.000% 60 -100 mm: 34.000% 100 -200 mm: 8.000% 200 -400 mm: 1.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 60.000% Quartz: 28.000% K-feldspars: 4.300%	12. Frequency: no data

Sample 13

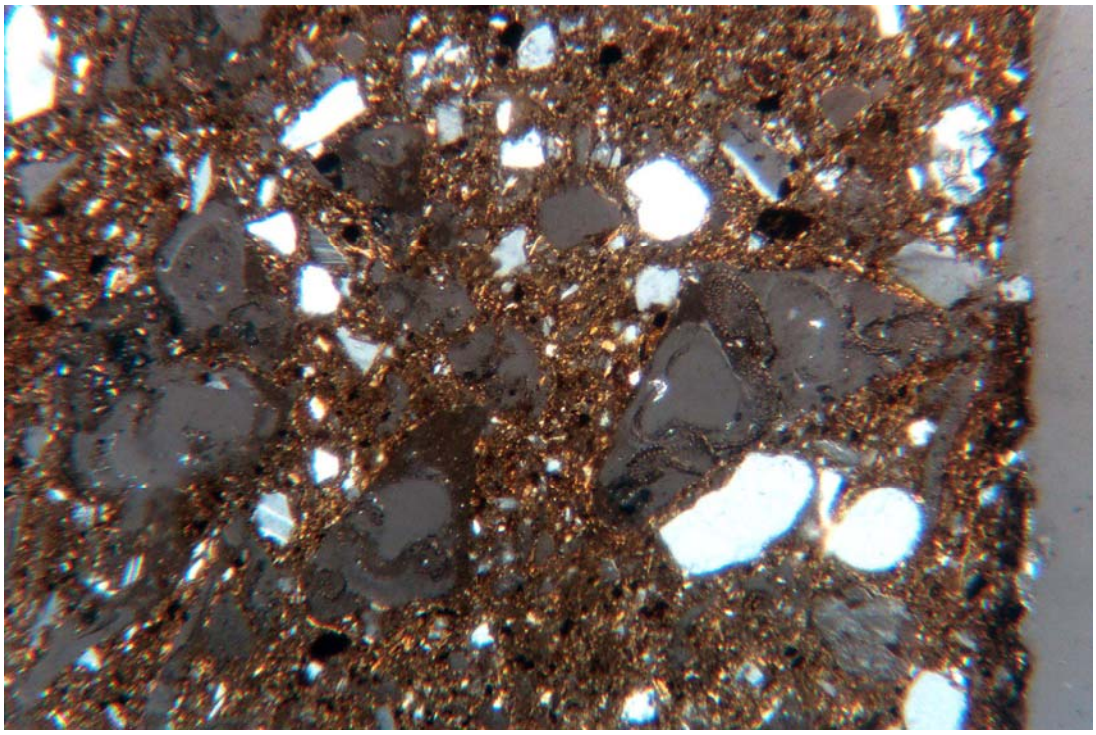


Photo 18 Sample 13. Ceramic mass just under internal wall of vessel where are one can see black relicts of organic substance (burned meal - arrows). Polarizing light microscope, polaroides in part x, magnification 80 x.

The results of the investigation of sample nr 13

1. Site: Heraconpolis	Plagioclases: 2.100%
2. Sample: E-Her-P13	Fr.of sed.rocks: 0.300%
3. Colour: dark grey	Fr.of mag.rocks: 0.500%
4. Fracture - internal: grey - central: grey - external: grey	Fr.of met.rocks: 0.000% Muscovite: 0.100% Biotite: 0.200% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.100%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 1.300%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 49.000% 60 -100 mm: 39.000% 100 -200 mm: 12.000% 200 -400 mm: 0.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 700 C	
10. Mineral comp. Clay mass: 76.000% Quartz: 27.800% K-feldspars: 1.600%	12. Frequency: no data

Sample 14

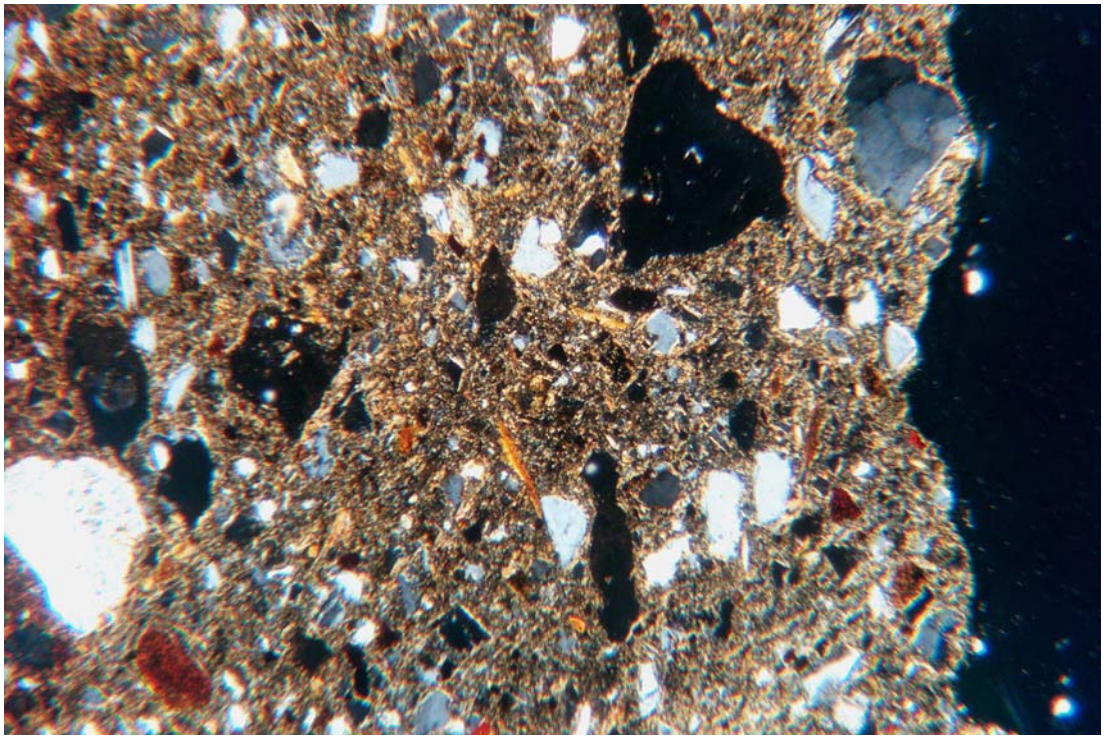


Photo 19 Sample 14. Ceramic mass just under internal wall showing medium intensive thermal alternation. Polarizing light microscope, polaroides x, magnification 80 x.

The results of the investigation of sample nr 14

1. Site: Heraconpolis	Plagioclases: 3.600%
2. Sample: E-Her-P14	Fr.of sed.rocks: 2.300%
3. Colour: dark grey	Fr.of mag.rocks: 0.700%
4. Fracture - internal: red - central: black - external: red	Fr.of met.rocks: 0.000% Muscovite: 0.100% Biotite: 0.100% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.100%
6. Enamel: absent	Carbonates: 0.100%
7. Painting: no paint	other: 1.300%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 63.000% 60 -100 mm: 30.000% 100 -200 mm: 5.000% 200 -400 mm: 1.000% 400 -1000 mm: 1.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 750 C	
10. Mineral comp. Clay mass: 68.000% Quartz: 20.600% K-feldspars: 3.000%	12. Frequency: no data

Sample nr 15

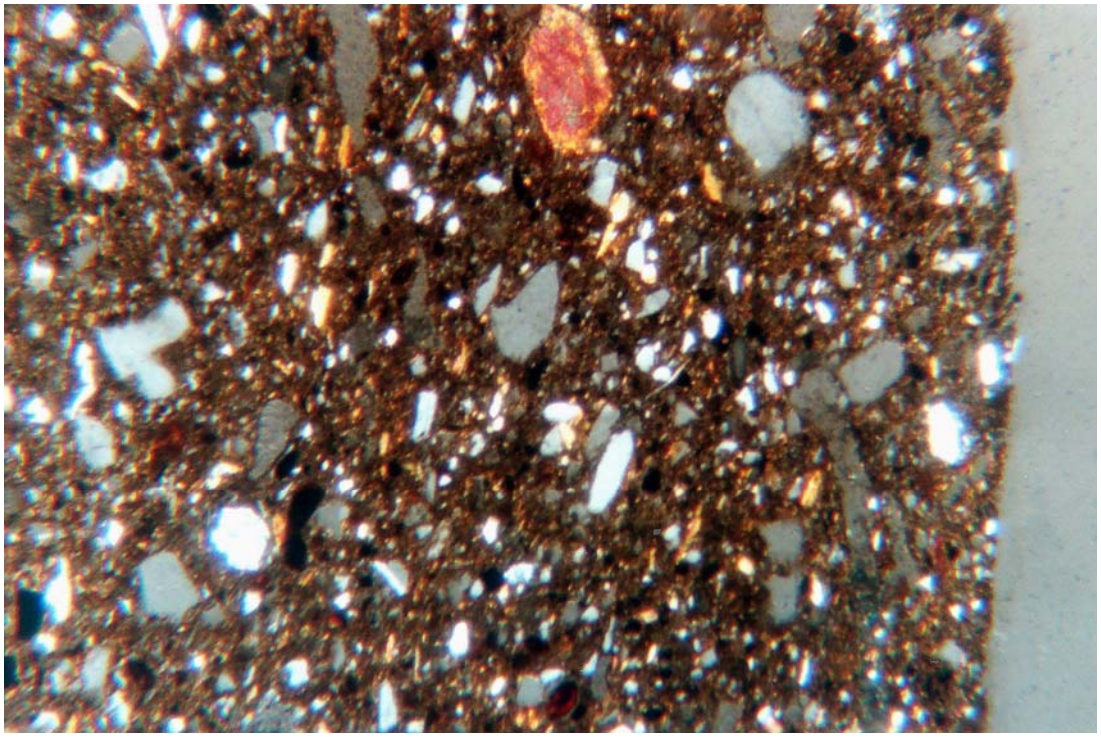


Photo 20 Sample 15. Ceramic mass just under internal wall of vessel. One can see homogeneous texture of mass. Polarizing light microscope, polaroides in part x, magnification 80 x.

The results of the investigation of sample nr 15

1. Site: Heraconpolis	Plagioclases: 2.600%
2. Sample: E-Her-P15	Fr.of sed.rocks: 0.500%
3. Colour: dark brown	Fr.of mag.rocks: 0.700%
4. Fracture - internal: red - central: red - external: red	Fr.of met.rocks: 0.000% Muscovite: 0.100% Biotite: 0.100% Heavy minerals: 0.100%
5. Finger grooved: no	Fr.of pottery: 0.000%
6. Enamel: absent	Carbonates: 0.000%
7. Painting: no paint	other: 2.700%
8. Gravering - lines: no - points: no - zigzag: no	11. Grain size comp. 15 -60 mm: 15.000% 60 -100 mm: 56.000% 100 -200 mm: 25.000% 200 -400 mm: 9.000% 400 -1000 mm: 0.000% 1000-2000 mm: 0.000% > 2000 mm: 0.000%
9. Temp. Of firing: 800 C	
10. Mineral comp. Clay mass: 50.000% Quartz: 38.500% K-feldspars: 4.700%	12. Frequency: no data

The results of comparative computer analyses of obtained data

The results of comparative computer analyses were performed with the use POTTERY computer program. Analyses were done on the base of 32 features listed in tables. The base of similarity was established on the 50%. This means that only similarity above 50 % was tested and printed.

Enclosed list (Tab. 3) of similarities inform for example that :

EG – Her – P3 LCZ = 55 % EG - Her - P7

This means that sample P3 is similar (all data collected in tables) in 55% to pottery P7.

Obtained data of comparative analyses document that tested pottery of Nagada II and Nagada II is differentiated much more than one can say making macroscopic and microscopic examination.

Similarity of tested features of investigated pottery Nagada II and Nagada III (%)

EG – Her – P3	LCZ = 55 %	EG - Her – P7
EG – Her – P3	LCZ = 52 %	EG - Her – P9
EG – Her – P6	LCZ = 58 %	EG - Her – P9
EG – Her – P3	LCZ = 55 %	EG - Her – P7
EG – Her – P8	LCZ = 58 %	EG - Her – P9
EG – Her – P9	LCZ = 52 %	EG - Her – P3
EG – Her – P9	LCZ = 52 %	EG - Her – P7
EG – Her – P9	LCZ = 52 %	EG - Her – P11
EG – Her – P9	LCZ = 52 %	EG - Her – P13
EG – Her – P10	LCZ = 52 %	EG - Her – P4
EG – Her – P11	LCZ = 55 %	EG - Her – P15
EG – Her – P11	LCZ = 52 %	EG - Her – P9
EG – Her – P11	LCZ = 52 %	EG - Her – P14
EG – Her – P12	LCZ = 52 %	EG - Her – P15
EG – Her – P13	LCZ = 52 %	EG - Her – P9
EG – Her – P14	LCZ = 52 %	EG - Her – P11
EG – Her – P14	LCZ = 52 %	EG - Her – P15
EG – Her – P15	LCZ = 55 %	EG - Her – P11
EG – Her – P15	LCZ = 52 %	EG - Her – P12
EG – Her – P15	LCZ = 52 %	EG - Her – P14

Results of analyses of similarity showed the similarity between tested samples in percents. Obtained data confirm that similarities does not exceed 58 %. This means that pottery looking like similar is differentiated mainly because of primary raw materials while technology of preparation and firing are similar.

Conclusions concerning pottery

All vessels belong to the group of pottery made of silts of Nile Valley.

Pottery made of silts of Nile Valley is characteristic due to the presence of small, well rounded grains of quartz and admixture of disseminated organic matter coloring ceramic mass. Generally one can say that silts from region of Heraconpolis contain admixture of coarser sharp grains. Primary silts present at this area contain, as clay mineral, mainly kaolinite while silts from Delta contain first of all Ca-smectite and admixture of kaolinite.

Kaolinite (covering Eocene limestones as red soils - red residuum –so called terrarossa) was washed out from hills surrounding Nile Valley and deposited at the bottom of the Valley. Part of red kaolinite soils were redeposited from Gebel, awhile part have been transported there from Sudan. This mineral (kaolinite) decide about good technical parameters of pottery done at Nile silts.

Investigation showed that the pottery was fired relatively long time, at temperatures up to 750°C. Good preservation of small „calcitic" components at ceramic masses, observed under the microscope, confirms proposed temperatures of firing.

Good technical parameters of pottery were obtained by long heating rather than by higher temperatures. This opinion is confirmed by delicate thermal alternation of clay minerals which can be observed microscopically as their izotropization. Coarse grains of quartz as well as grains of limestones are mainly natural admixture of ceramic masses.

The atmosphere of firing was generally slightly or fully oxide. It is confirmed by, observed under the microscope, thin layer containing iron, secondary formed minerals just under the external surface of vessels.

Technologically some ceramic masses were poorly prepared. This is confirmed by the presence of small „nodules" of not mixed raw clay and documents rather fast preparation of vessels.

Comparative computer analyses of mineralogical and technological data showed similarity of examined pottery that does not exceed 58 %. This means that ceramic masses used for pottery production are differentiated.

Generally, good comparison of pottery representing this group with local sediments is impossible due to very poor and insufficient mineralogical investigation of Nile primary at tested area.

Future sampling of various local raw materials (silts), their artificial firing in laboratory (preparation modern pottery) at various temperatures and investigation of these materials identically as archaeological Egyptian pottery is suggested. Possible comparison of old and modern pottery using POTTERY computer program may help discover sources of raw materials used for pottery production.

On the base of tested samples one can say that there are no evidences for import from East or West Desert as well as from North Sudan. This means that most of the pottery was of local production with the use of various Nile silts.

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