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GOLIA MONASTERY FROM IAŞI (ROMANIA) – ALTERATION AND DETERIORATION OF THE BUILDING LIMESTONES

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Abstract

The church of Golia Monastery is considered one of the most representative old architecture monuments from Iaşi, Romania. The monumental construction of the church combines Moldavian, Polish, Russian and even Italian Renaissance architectural elements. The building material is represented by Miocene limestones coming from several quarries nearby Iaşi. Calcareous rocks of different geological ages, from the Badenian to Sarmatian (Basarabian), were exploited from these quarries. Genetically, the limestones accumulated under complex facial conditions, specific to the foreland basins which developed on the Moldavian Platform between Badenian and Sarmatian. The prolonged exposure of the limestones from the masonry of Golia Monastery to the specific alteration factors resulted in a series of effects, some more superficial, others more profound. Therefore, the microscopic analyses of the samples reveals some data concerning extraclasts, intraclasts, oolites and cement that outlines specific alteration processes.

Key words: weathering, Miocene limestones, monuments

Introduction

Located in the heart of Moldavia, Iaşi is the site of an extended range of architectonic monuments, preserved from the years of the first documentary attestation. Among these, we mention as one of the oldest the ecclesiastic settlement from Golia Monastery. Its name, preserved over the centuries, is that of the chancellor Ioan Golia, who founded the old

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"Înălţarea Domnului" church, which, during the times of *hospodar* Vasile Lupu, was rebuild on the scale that we admire nowadays. The reconstruction work took place between 1650 and 1653; yet, it was not finalized during the reign of Vasile Lupu, but in 1660, under his son rule, Ştefăniţă.

The church of Golia Monastery is a monumental construction, combining Moldavian and Russian architectural elements with elements inspired by the Italian Renaissance (photo 1). In 1711, while he was visiting Iaşi, *czar* Peter the Great of Russia said about the church of Golia Monastery that it combined "three kinds of handicraft: Polish, Greek and old Moscow".

Photo 1. The church of Golia Monastery

As we can see from the outside, it is a classical-type, rectangular construction, with faced stone blocks, high walls guarded by Corinthian pilasters, with capitals in leaf having acanthus and baroque cornices supported by consoles. Between the pilasters – six in the altar, eight on each northern and southern wall, and three on the western wall – there are panels of different sizes. In some of the panels there are arcades which display in the central area windows cut in circle arches at the upper part. On both sides, the windows have colonettes supported by consoles, and they are joined at the upper side by a triangular fronton. The roof represents a concentration of derricks and cupolas ranged in line and supported by multi-staged small arches. The church, up to the cross on the derrick above the nave, is 30 m high, 13 m wide and 39 m long. The interior is similar to that of "Trei Ierarhi", but the sided apses are included in the wall, therefore following a traditional Moldavian style. The width of the wall for the apses is of about 2.5 m.

After the secularization process of 1863, the monastery entered an obscure stage, and between 1900 and 1947 it was even closed. During this period, it suffered strong destructive effects on its original building materials, which were not very resistant from a geomechanical point of view. This was because of the fact that the church walls, made up of faced stone blocks, consist, in fact, of sedimentary limestone, coming from a series of quarries on the territory of Moldavia (photo 2, photo 3), such as Vărăria - Miorcani, Repedea-Pietrărie, Şcheia and Răducăneni – Iaşi.

The monastic complex of Golia, including the church of the monastery, is surrounded by a massive stone wall with a height of 5.5-7 m for the inner side, covered with cemented tiles. The stone from this wall was brought from Şcheia and Pietrărie, the quarries that are nearest to Iaşi. The surrounding wall forms an irregular quadrangle, with variable sides of 100-150 m in length. In each corner of the quadrangle there is a massive tower built from the same type of stone, cylindrical and with an arched roof. The towers present defensive crenels, as the wall does.

Limestone used for constructions

1. Petrographic data

Macroscopic description

From a macroscopic point of view, the construction rocks from the Golia masonry are calcareous carbonate rocks with frequent alteration processes. Their provenience is related to the existence of some quarries from which Sarmatian rocks (mainly), as well as Badenian rocks, were extracted.

The main petrographic compounds, namely oolites, bioclasts, intraclasts and the micritic cement, can be noticed.

Oolites represent 40-50%, bioclasts come from bivalves, and they are sporadic (5-10%), and interclasts and extraclasts of quartzite are under 10%.

The micritic cement is strongly altered through dissolution; therefore, it gives the rock a friable aspect, especially at the surface.

This aspect is also accentuated by the presence of bioclast fragments which are more affected by the alteration processes, increasing the rock porosity. Also, for the algae limestone, the alteration processes are increased by the dissolution of the calcite from cement and bioclasts.

The colour of the rocks is white-yellowish, with an increased yellowish coloration especially in the areas strongly affected by alteration.

The texture of the rocks is a sin-depositional chemical one, of oolitic or algal type with transitions to cavernous textures, which increase the cracking degree.

Microscopic analyses

a. Oolitic Limestone from Repedea

Detailed chemical and mineralogical investigations are annexed to a series of sedimentogenetic observations on Repedea Oolite made by Kalmár (1991). They are supported by 44 samples yielded from an old quarry situated nearby, under the television relay of Iaşi. In the sampled area, Repedea Oolite shows a succession of layers of 2-40cm in width, separated by fine sand intercalations with shells of 0.5-10cm (photo 2). The layers present irregular surfaces, with a noticeable graded transition from compact oolitic limestone or sandstone towards the same rocks being increasingly porous and friable, up to inter-layered sands. At the upper part of the succession, there is an alternation between levels with *Mactra* shells, mixed oolitic and shell limestone and oolitic limestone, cyclically grouped; the author remarks the concoidal crossed structures at the upper part with oolitic sandstone and the total lack of the bioturbations. The banks of rocks are crossed by crack systems with rugged surfaces filled with fine sand.

Photo 2. Şcheia quarry with Sarmatian limestones (photo: D. Ţabără).

The analysis of microscopic slides shows the following petrographic compounds for these rocks: extraclasts, intraclasts, figured corpuscles, oolitic corpuscles, cement, and minerals of neoformation.

Extraclasts. They are represented by quartz, often with inclusions (of muscovite, apatite, zircon, rutile, sillimanite, magnetite and ilmenite) and weakly argillised feldspars (acid plagioclases, microcline, orthoclase, perlite), often with an aureole of sericite;

according to their frequency, they are followed by muscovite, zircon, tourmaline, hornblende, calcite, glauconite, titanite, rutile, chlorite, epidote and magnetite. There also appear fragments of rocks, respectively granites, gneisses, metaquartzites, sericite-bearing quartzites, chlorite-bearing quartzites, amphibolic schists, quartz arenites, cherts, micritic and sparitic limestones, and bioclastic limestones. Quartz is prevalent and feldspar and micas appear subsequently, the rest having a sporadic presence. Between extraclasts which form the oolite nuclei and the free ones there are only dimensional differences, the latter often exceeding 0.5mm comparing to the former, which show diameters between 0.08 and 0.15mm.

The X-ray study of the $< 2\mu m$ fraction from the acetic residue of some samples proved the presence of kaolinite and illite.

Bioclasts. According to their frequency, they are represented by bivalves, bentonic foraminifers sometimes entirely preserved with loges filled with micritic or sparitic calcite; rarely there appear small gastropods of several centimetres (*Mactras, Cerithiums, Solens*) of 0.05 - 1.00mm; the bioclast surfaces often present limonitic crusts and botryoidal sideritic separations.

Figured corpuscles. From this category we have to mention within Repedea Oolite the pellets, the lumps and the oncoids; the latter might have 1-2mm, with a filamentous structure, including fine quartz grains, and showing island areas of microsparitic recrystallization; also there appear sections with intermediary forms between oncolites and oolites without nucleus.

Oolites. Within the rocks from the Repedea level, the oolites represent a variable proportion, between 5 and 85%; they show spherical forms, rarely ovoid or irregular, and do not exceed 0.4mm in diameter. For most of the cases, the oolites are simple and centred by sand; rarely there appear oolites with two or three nuclei successively attached and covered by common layers closer to the spherical form.

Within the oolites, we can distinguish: one nucleus, at least two (but most of the times up to ten) concentric covers of filamentous (oomicritic), fine grain calcite; complete and discontinuous sideritic crusts, partially or totally limonitised at the contact between two successive oomicritic crusts; siltic particles included in oomicrites; sharp quartz grains stiffed in the oomicrite from the last covers; corrosion areas of the last oomicrite cover; microsparitic recrystallisation areas, crossing the oomicritic covers; goethite needles which also cross the micritic covers. As a formation succession, the oomicrite, the siderose crusts and the silt inclusions, as well as the mechanical effects of the stiffed quartz grains, represent primary formations; the limonitic crust process and the corrosion are penecontemporaneous.

Intraclasts. There are angular fragments up to 1mm, represented by bioclastic limestone or calcisiltites with fragmentary oolites, similar to the rocks from the outcrop; they could be included as nuclei in oolites.

Cement. Excepting some reduced areas from the bioclastic limestones with micritic-microsparitic cement, in the majority of these rocks, the mentioned compounds are tied by calcisparitic cement, mosaicked due to the contact, to the filling process or basal.

Minerals of neoformation. Within the oolitic corpuscles, bioclasts and intraclasts, as well as in the cement, there are botryoidal agglomerations of siderite, dolomite crystals and goethite needles.

Petrographically, for the mentioned rocks, the generic term of *Repedea Oolite* was well-used. Actually, this term includes some varieties.

Referring to the genetic process of the oolites, Kalmár (1991) observed that the pure chemical precipitation of silica carbonates cannot take place in environments with a reduced alkaline reserve. This is the reason why the process that generates oolites must be regarded as a complex process and, according to some authors (Bathrust, 1967; Kahle, 1978), in direct connexion with the algal activity.

Therefore, around the prospective nuclei, respectively around the grains of different compositions, a prime pellicle of green-blue algae is formed, which, by photosynthesis, assimilates the carbon dioxide from the water and from the soluble bicarbonates, precipitating the microgranular calcium carbonate at the same time with the accretion process of the carbonatic and non-carbonatic material, including the annexed trace elements.

Therefore, there will appear a filamentous depositional layer of 5-10µm width, which will suffocate the algal colony installed around the nucleus-grain; this layer will represent the support for a new algal colony which will continue the precipitation activity, the phenomenon repeating until a form with critical dimensions is reached, corresponding to the agitation state of the surrounding environment; after that, the multi-layered corpuscles are either redeposited, or enter a disaggregation process; with such a genesis, the mentioned oolites could be considered, after Peryt (1983), oncolitic corpuscles.

Tab. 1 Chemical and mineralogical compositions of some samples from Repedea Oolites (from Kalmár, 1991)

Chemical composition (%)		Mineralogical compounds (normative calculation) (%)		Trace elements (ppm)	
SiO_2	21.70 - 43.31	Calcite	46.86 - 83.94	Zn	< 800
TiO_2	traces - 0.12	Dolomite	0.62 - 14.86	Ba	100 - 300
Al_2O_3	0.13 - 4.25	Quartz	11.14 - 34.58	Sr	100 - 700
Fe_2O_3	0.17 - 2.30	Kaolinite	0.72 - 15.22	Cr	< 35
FeO	0.14 - 0.57	Albite	0.52 - 4.67	Ni	< 5
MnO	0.05 - 0.13	Orthoclase	0.50 - 2.31	V	< 5
MgO	traces - 3.00	Titanite	0 - 0.21	Pb	3 - 100
CaO	17.97 - 41.44	Rutile	0 - 0.10	Ag	< 0.2
Na_2O	0.04 - 0.50	Apatite	0 - 0.91	Sn	< 5
K_2O	0.09 - 0.40	Pyrite	0 - 0.48	B	3 - 50
P_2O_5	0.03 - 0.09	Goethite	0 - 2.32	Li	< 31
S	traces - 0.90	Pyrolusite	0 - 0.23	Rb	3 - 40
		Hematite	0 - 1.40	Y	5 - 45
		Magnetite	0 - 0.83		
		Rodocrosite	0 - 0.69		

The laboratory experiments performed in order to generate oolites proved that, indeed, the organic component is essential for the formation of oolites (with radial texture) in calm waters, but not for the oolites developed in tumultuous waters, which would inorganically precipitate.

Initially, they appear in a plastic state, being exposed to the lithification processes; by impact, the two oolitic corpuscles can fuse, continuing to develop together; as the lithification process is previous to the ram process, there will also be generated tepee-type deformations, with the overflow of the unconsolidated sands in the fracture areas of the calcareous layers.

b. Badenian, algal limestone of the Vărăria-Miorcani type

This type of calcareous rock rarely appears in the masonry of Golia and it is represented by bio-built, detritic limestones, of the *Lithotamnium* limestone type (photo 3).

This kind of limestone presents an organogenous depositional structure and is recognized by the abundance and the nature of the bioclasts.

The most frequent are the algal laminite-type structures and the coralgal-type structures.

Photo 3 Vărăria-Miorcani quarry with Badenian algal limestones (photo: P. Ţibuleac).

The laminite-type structures are characterized by parallelism and the alternation of millimetric laminae of different colours, which are generated by algal accretion.

The skeletal space is often porous and filled with different bioclasts, with peloids or carbonatic silt.

Generally, these limestones have a fine-granular texture.

The algal thalluses appear as unicellular or multicellular fragments, sometimes ramified. Between petrographic compounds there is a microcrystalline to cryptocrystalline cement, of the basal type, which fills the empty spaces. Frequently, there are limonitization or alteration processes of the carbonates. The cellular walls of the thalluses include aragonite, and the thalluses are filled with microsparitic calcite.

2. Alteration processes of the limestones

The main carbonate minerals present in these limestones are: calcite, present in the cortex of the oolites and in intraclasts, as well as the micritic cement, and then aragonite, present in the bioclasts from the limestones, especially in the fragments of shells and algal thalluses. It is well known that, upon contact with water, the carbonates dissociate into CO_3^{2-} anion and Ca^{2+} cation.

The dissociation speed is influenced by the composition of the waters, by CO_2 pressure from the atmosphere and by temperature.

The calcium carbonate, from the calcite and the aragonite, dissociates according to the following reaction:

$$CaCO_3 \rightarrow Ca^{2+} + CO_3^{2-}$$

The carbonate ion (CO_3^{2-}), being unstable, reacts with the water ionization products, forming carbonic acid.

$$CO_3^{2-} + 2H^+ \rightarrow H_2CO_3$$

The tendency of CO_3^{2-} to react with water in order to form the stable carbon complex HCO_3^- controls the solubility of the carbonates.

The aggressive character of the natural waters (from precipitations) is much higher when the amount of CO_2 increases, especially due to the intense contamination. The solubility of $CaCO_3$ in natural waters takes place according to the reaction:

$$CaCO_3 + CO_2\ (gas) + H_2O \rightarrow Ca^{2+} + 2HCO_3^-$$

The presence of other salts in the water, with ions common to the carbonates, reduces the resistance of limestones to alteration. Moreover, due to the fact that they have weakly bounded structural compounds, the appearance and the growing process of crystals in the affected areas determine the cracking process, as a result of the induced tensions. The calcareous rocks exposed to an urban atmosphere which includes sulphur, nitrogen and carbon oxides can be much more affected because these oxides could be transformed into acids. Therefore, calcium carbonate will disintegrate, resulting in evolutive processes with material loss. At the contact with soil, the blocks from the calcareous rocks adsorb soluble salts from it, and the processes of segregation and osmosis will create efflorescences and damp areas which will activate a decreasing of rock strength.

3. Aspects of restoration and preservation of stone buildings

Restoration and preservation efforts, as far as architectonic monuments built in stone (limestones, calcareous sandstones, sandstones, etc.) are concerned already, have a considerable history, exceeding one hundred years. Throughout this period, there were numerous successes, but some of these achievements are less significant.

For the modern preservation and restoration techniques, as well as for the special materials used in this sense, numerous works were published by different specialists, such as chemists, geologists, and especially architects. The necessity of a collaboration between so many specialists in the process of restoration and preservation of art monuments is primordial for the finding of adequate solutions for the keeping of their initial characteristics.

In the restoration and preservation process, the methods evolved from the simplest, which implies the execution of a copy of the original (the original work of art being sent in museums to be submitted to some complex procedures), to more complex methods. The latter represent the usage of hydroisolation substances (to eliminate unwanted substances), thermic treatment methods, as well as chemical methods, with acrylic esters.

Special attention must be paid to the mortar used in the restoration and preservation process. This must be similar to that used in the initial construction process. Another type of mortar can also be accepted, provided that it has technical characteristics compatible to the construction stone.

From the present study, the few analytical approaches on the samples yielded from the masonry of Golia Monastery represent the first steps in the restoration of the stone from the architectural art work.

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CAPTION OF PLATES

PLATE I

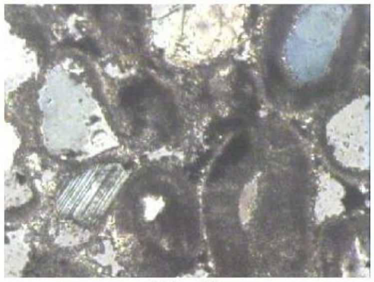
1, 2, 3, 8 – Oolitic limestone, type Scheia
4, 5 – Altered oolitic limestone
6, 7 –Algal limestone, type Vărăria

PLATE II

1, 2 –Oolitic limestone, type Şcheia
3 –Altered oolitic limestone
4, 5, 6, 7, 8 –Altered algal limestone

PLATE III

1, 5 –Altered algal limestone
2, 4 –Algal limestone
3 –Oolitic limestone
6, 7, 8 –Very altered algal limestone



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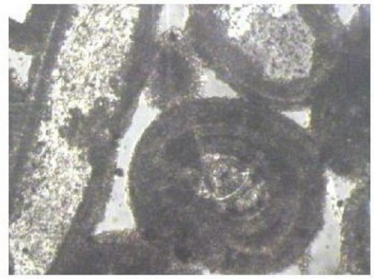

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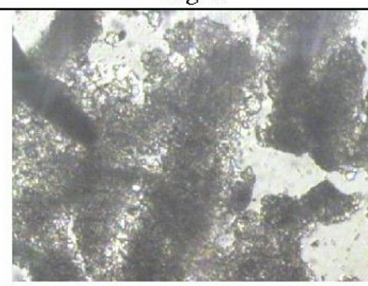

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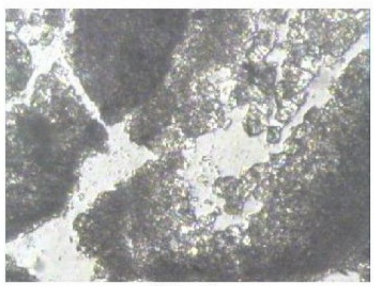

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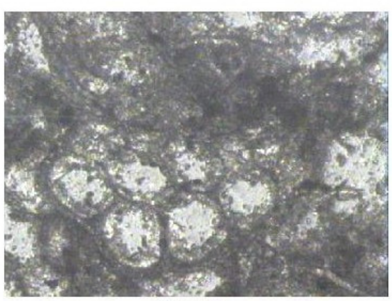

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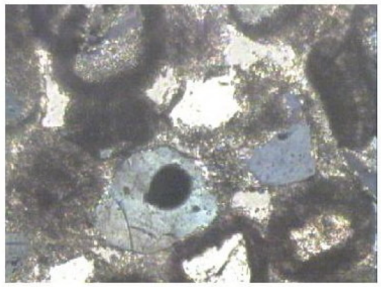
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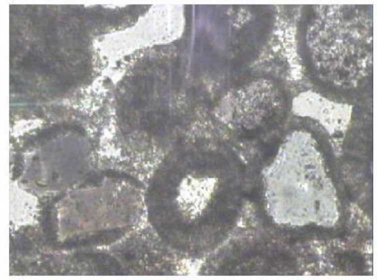
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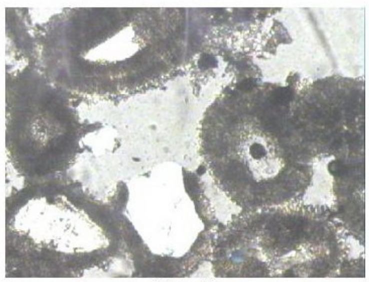
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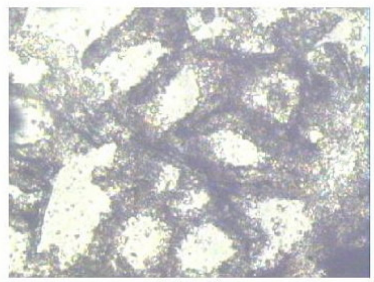
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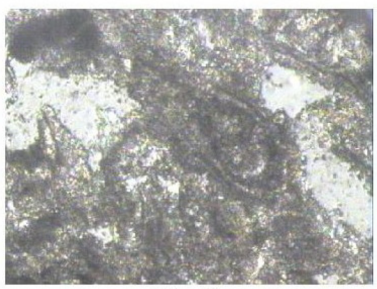
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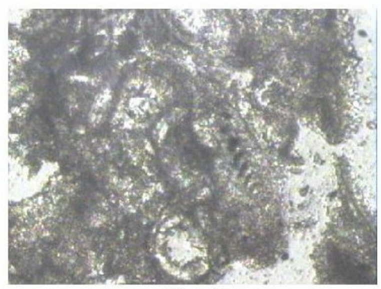
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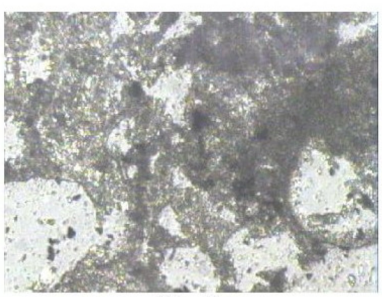
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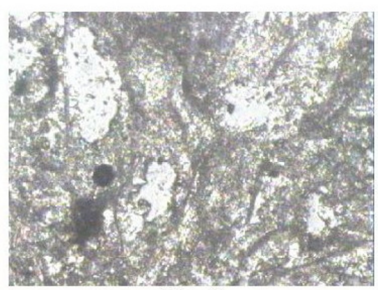
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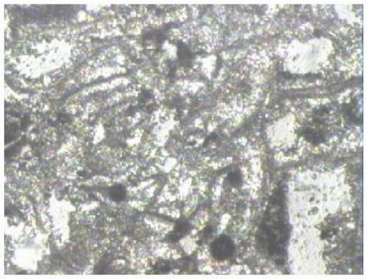
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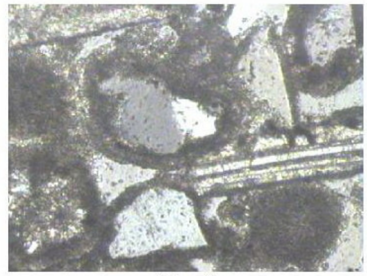
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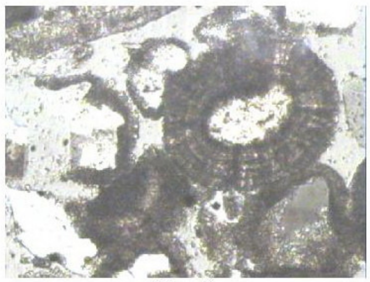
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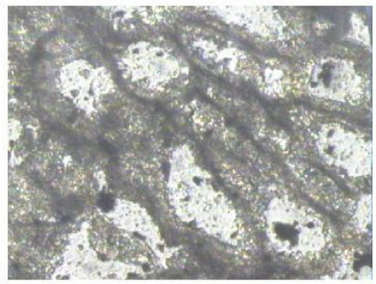
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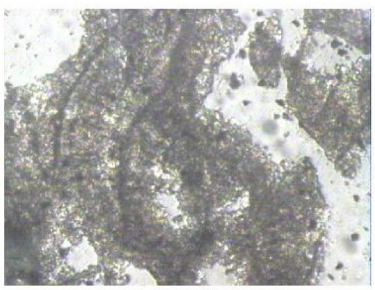
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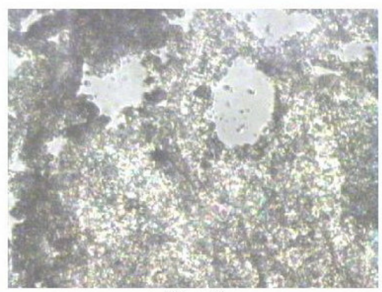
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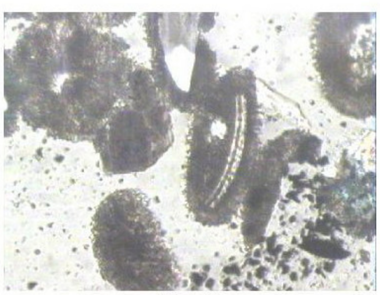
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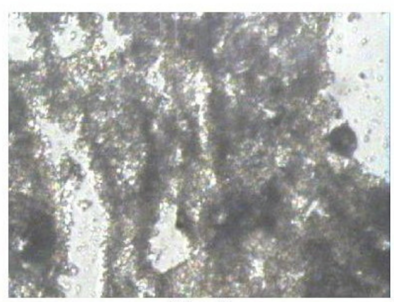
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