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Geological Layers as Indicator of Tombs' Location (West Thebes – Upper Egypt)

Egypt is a place with permanent archaeological activity. The examination of tombs, in view of the abundance of relics, is one of the most exciting parts of archaeological work, the tomb of Tutanhamon (KV62) being a special example. Geological research conducted in the area in the years 1980–2005 permitted the author to examine many various geological layers in the vicinity of different kinds of graves and tombs. Particular observations were also provided by the search for of the Herhor's tomb, conducted by Prof. Andrzej Niwiński's mission in Deir el-Bahari.[1]

This experience encouraged the author to present some comments concerning the relations between different kinds of tombs and surrounding sediments.

GEOLOGICAL STRUCTURE OF RESEARCH AREA

Most of the tombs are located in the Theban limestones or marls. In this connection the geological profile of rocks from that area must be discussed.

The Theban limestones constitute a thick, reaching 290 m down, rock complex (Lower Eocene). Its lower part, in which the exploration of Herhor's tomb was conducted, is 120 m thick. It is represented by the light limestones containing numerous flint horizons. The upper part of the limestones convert systematically into the marl limestones, also containing a discontinuous flint concretions. This part is 75 m thick. Above the lower part there are the organogenic, mostly nummulit, 35-m-thick limestones. The uppermost part of the Theban *ǧabal* is represented by a 30-m-thick silificated limestone complex.

Underneath the Theban limestones there are 57-m-thick Esna shales which are divided into three parts. The lowest part, *c.* 15 m thick, is represented by the gray-greenish shales containing the anhydrite and ferruginous concretions. The middle part is 20 m thick. It consists of the shales interbedded with the calcareous marls and laminas made of iron minerals. The highest part of the Esna shales lies directly underneath the Theban limestones and is a 25-m-thick sequence of marls, limestone layers with gypsum veins and ferruginous concretions. These kinds of layers are situated e.g. directly behind the Hatshepsut Temple.

Stratigraphically there are the oligocene conglomerates, represented by the puddingstones made of flint pebbles cemented by a calcareous binder. In some places they are even several meters thick.

Alluvial deposits (which are now wet valleys), together with the slope cones evolued both at the bottom of the rock cliffs and close to the entrances to the tombs, are the youngest sediments in the presented area. These slope cones are the subject of this paper.

The slope cones formed at the bottom of the rocky cliffs make up the current sedimentation/erosion environment. The sedimentation there is mostly an effect of the erosion of the rock wall situated above the slope cone. Dominant gravitational erosion manifests itself in the movement of the rocky material on a very steep slope of the slope cone. The mate-

[1] Cf. A. Niwiński, Czekając na Herhora... Odkrywanie tajemnic Teb Stubramnych, czyli szkice z dziejów archeologii Egiptu, Warszawa 2003, pp. 434–535; Id. *et al.*, Deir el-Bahari. Cliff Mission, 2000, *PAM* XII, 2001, pp. 221–236.

rial creep was supported by a tectonical shock which cannot be observed in that type of deposit. Considering the material movement it is necessary to examine the influence of the possible precipitation on the material migration on the slope of the slope cone. Even though the current precipitations are rare now, in the past, especially at the end of the Pleistocene, they occurred in that area rather abundantly.[2]

The technique of identification of the features of the slope cone is a basis to distinguish the interesting phenomena of human activity. In particular it permits to establish a sequence of the discussed phenomena close to the archeological sites and tombs.

The research of the stratigraphy of a classical, natural slope cone in test is complicated. This is a result of the superposition of the natural phenomena. Near the gravitational sedimentation connected with the falling off of the rocky material from the Theban limestone wall, the results of the eolian sedimentation can often be observed. Material which was blown and settled in the slope cone may come from both the top and the bottom. The eolian deposits are in that case documented mostly by quartz sand impurity. These features were used for research of the profiles of the slope cones located close to the tombs' entrances.

The whole rock formation mentioned above is cut by many cracks connected with the tectonical systems of the Red Sea area.[3]

An example of the geological profile of the natural slope cone situated close to the east wall of the Theban limestone, above the Hatshepsut Temple is as follows. The Theban limestone debris is composed mainly of a rocky material. Even though the material is diversified, it is always represented by the more or less isometric-dimension chips. Thin interbeddings of grey, powdery-silty impurities are also recognized in the deposits of the slope cone.

During the field research it was found that in geological profiles of the slope cone deposits placed close to the tombs calcareous chips of different sizes are present. The studies of the graining of spalling material from such a slope cone were conducted on

[2] M. PAWLIKOWSKI, Ekspertyza w sprawie zagrożenia świątyni w dolinie Deir el Bahari. *Materiały Instytutu Geologii i Surowców Minereralnych AGH*, Kraków 1987 [= Ekspertyza]; ID., Geomorphology and geology of investigated area, in: B. GINTER, J.K. KOZŁOWSKI, Predynastic settlement near Armant, *SAGA* 4, 1994 [= Geomorphology], pp. 3–6.

[3] R. SAID, The Geology of Egypt^2, New York 1963, 377 pp.; B. GINTER, J.K. KOZŁOWSKI, M. PAWLIKOWSKI, Results of field researches between Qurna and Armant, Upper Egypt, *MDAIK* 31, 1976, pp. 230–256; IID., Investigations into Site MA 6/83 and MA 21/83 in the region of Qurna-Armant in Upper Egypt, *MDAIK* 43, 1987, pp. 45–66; B. GINTER, J.K. KOZŁOWSKI, M. LITYŃSKA, M. PAWLIKOWSKI, Field report from the excavation of the site MA 21/83 and MA 21a/83 near Armant in Upper Egypt in 1986, *MDAIK* 44, 1988, pp. 86–104; PAWLIKOWSKI, Ekspertyza, *passim*; ID., Geomorphology; *passim*; ID., The investigation of rocks present under and above the Hatshepsut temple – Deir Bahari – Upper Egypt. Auxiliary sciences in archaeology, preservation of relicts and environmental engeneering, CD No. 2, 2007 – M PAWLIKOWSKI (ed.); M. PAWLIKOWSKI, M. WASILEWSKI, Some remarks on jointing in the Theban limestones in the region of Deir el-Bahari, Egypt, *Geologia* 30/1, 2004, pp. 47–56; M. PAWLIKOWSKI, A. TAJDUŚ, T. MIKOŚ, J. CHMURA, Wstępne wyniki badań wybranych grobów w rejonie Teb Zachodnich (Górny Egipt) z punktu widzenia prac górniczych (in press); S. YEHIAR, Contribution to the geology of Gebel Gurnah, Luxor, Nile Valley, *Bull. Geol. Surv. Egypt*, 1987, pp. 1–33; A. DRĄGOWSKI, R. KACZYŃSKI, J. WRÓBLEWSKI, Engineering geological problems related to the reconstruction of the Hatshepsut temple in Deir el Bahari, in: P.G. MARIONS, G.C. KOUKIS (eds.) The Engineering Geology of Ancient Works, Monuments and Historical Sites. Preservation and Protection, Vol. 1, Athens 1988, pp. 161–168.

50 chips sampled from the profile in the direction from the top of the material to its bottom. The studies included measurements of length, width, and thickness of these chips, separately counting natural spalls from the calcareous chips. It was found that there is only one level with deposits with significant amounts of the calcareous chips.

From a mineralogical point of view it may be said that the directions of the exfoliations on the surface of those chips are often compatible with the directions of the best cleavage of limestone; the direction being compatible with the rock bedding. The exfoliations perpendicular to the beddings were not observed.

Precise recognition of the calcareous chips, appearing e.g. in the slope cone, needs a systematic and detailed research by the specialists.

THE RESULTS OF A MINERALOGICAL RESEARCH OF THE LIMESTONE AND CALCAREOUS CHIPS

On a base of the mineralogical research conducted at polarized light, it can be said that all samples of the Theban limestone have a parallel texture of which was caused by recrystalization, diagenesis of calcite, and the presence of a very thin, almost parallel trail of silty material. The directional recrystalization of calcite is a result of the diagenetic effect. Both factors have a principal influence on the directional cleavage of limestone, which results in a very good cleavage in both directions, compatible with limestone trailing, silty minerals, and calcite crystal elongation.

These directions are compatible with the directions of the limestone bedding and determine the advantageous features of the rocks from a mining works point of view. This chip technique was used during the hewing of the tombs.

The microscope research of six limestone chip samples were conducted with the same technique as the one used for the limestones coming from the stone wall. Different kinds of textures and structures were observed in microscope pictures. The most interesting are chips and chiplike forms: their structures show similarity to the limestones from the examined profile. Among all the examined forms, chips with structures similar to the Theban limestone structure, as observed in the microscope pictures, seem to be the most interesting. They are similarly based on trailing limestone silty material. In the other case, chips contain elongated calcite crystals, resulting from the recrystalization of the rock, which underline the parallelism of the limestone texture.

CONTEMPORARY TECHNIQUES OF THEBAN LIMESTONE EXCAVATION

The observations of the contemporary techniques of the Theban limestone excavation are very useful in understanding the methods of drilling and hewing of the passageways and the tomb chambers in the pharaohs' times. These techniques were known during the exploration work including, among other things, big Theban limestone blocks splitting.

The macroscopic observation of the Theban limestone *in situ* shows that it has a very good cleavage (flexibility to crack), compatible with the direction of its bedding. It can be easily seen in some of the cracked calcareous blocks in a form of parallel slits system. This feature, i.e. facility of separation is used until now, e.g. for crushing of the large blocks. Workers, using wedge and hammer and natural cleavage of the limestone, are able to split several cubic meters of calcareous blocks into the small, easy for transportation blocks within just a few hours. Similar chips diversified in size, often bigger than 0.5 m, were products of such kind of activity. Successive research proved that these chips have many morphological features similar to the ancient chips found in the slope cones located close to the tombs.

Observation of the contemporary stonework suggests that the progress in excavation (represented by the speed of drilling) of the passageways or tomb chambers with use of the chip technique could be considerable. The hewing of the tomb passageways in calcareous wall was started probably in the direction parallel to the limestone bedding, particularly in places where the limestones were disturbed by the tectonical foults. In these places rocks were loosened in a natural way, what facilitated exploitation and made it faster. Opened tombs, partly located just in the slit zones and tectonical cracks, are the evidence of this kind of procedure.

The drilling was conducted from the top to the bottom; partial drilling only profiled passageways and then continued deeper into the massif. During the progress of the mining work, chips that were formed were removed systematically. Surfaces of the passageways and chambers could be hewn in with use of the exfoliation techniques, which can be easily observed in various unfinished tombs. After drilling passageways and chambers, their walls were smoothened. Traces of those grindings can be still seen on the walls of the tombs in many places. Decoration of the walls was the next step.

Observations show that the tombs were drilled in all kinds of rocks described above.

SLOPE CONES WITH ANTHROPOGENIC MATERIAL

The knowledge of the geological profile sequences of the youngest deposits and of the techniques of the tombs' drilling are based on their exploration. The skill of interpreting sedimentation structures of the slope cones formed close to the entrance to the tomb is especially important. These slope cones are partly anthropogenic occurring material. They consist partly of stones from the drilling of the tomb.

During it was found the research of the tombs in Thebes West that, from a mining and geological points of view, the tombs were made by hewing with use of the picks made of flint.[4] After removal of the large blocks, the walls of the passageways and chambers were smoothened by splitting of the calcareous chips. These chips have various sizes and their common feature is a flat shape and a presence of an extrusion butt – a fat shoulder in place of impact that produced the chip.

The excavated materials were dumped at the entrance to the tomb. After burial the tomb and its closest surroundings were backfilled and camouflaged.

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[4] B. Drobniewicz *et al.*, Site no 16/74 Deir el Bahari, *Prace Archeologiczne* 24, 1977, *passim*.

The research conducted shows that ancient miners hewing tombs in those days had a wide knowledge of geology as well as of physical features of the rocks.

Most of the theban tombs were located at the contact point Esna shale–limestone. In such case, after drilling through the limestones, tombs were drilled in the soft shales and limestone was used as a ceiling for the tomb passageways and chambers. Royal tombs, completely drilled in the limestones are exceptions. Schematized diagrams showing main kinds of theban tombs are shown on **Figs. 1, 3** and **5**.

The decoration of the walls of the royal tombs was possible due to the location of these tombs in limestones. In tombs drilled first in limestones and then into shales, decoration could only survive in parts hewn in limestones. Shales are unstable and the walls drilled in shales were easily destroyed.

An additional feature distinguishing the material coming from the tombs is its formation in stone cones. Esna shales in its natural form lie horizontally or in an orientation close to horizontal. Shales removed during the drilling of the tombs are present as variable, sometimes even sharp angle layers.

Considering the morphological features of the natural slope sediments and the sediments from drilling of the tombs, different forms of the geological layers observed close to the tombs' entrances were distinguished. The figures of these forms, compatible with the different kinds of tombs, are shown on **Figs. 2, 4** and **6**. The thickness of slope sediments might vary from few centimeters to several meters, depending on a geomorphological and geological situation. This is the reason for the absence of the scale in these figures.

SUMMARY

All the figures shown and the results of our researches do not exhaust the subject and do not solve all the problems that researchers meet during their explorations. It is proved in the text that in the slope cones formed close to the tombs in Thebes West and the Valley of the Kings, together with the natural, isometric fragments of rocks, the calcareous chips with chiplike forms occure. The features of the slope sediments, as in the geological profiles presented above, can be used in finding of so far undiscovered tombs.

It is also important to remember that during many years of research conducted in large territories, the primary structures and layouts of the layers were often chaotically destroyed or disturbed. This made it more difficult, or sometimes even impossible, to use the discussed features in explorations. However, even in the most difficult case of disturbed geological structures, geological observations can solve many problems and clarify existing doubts.

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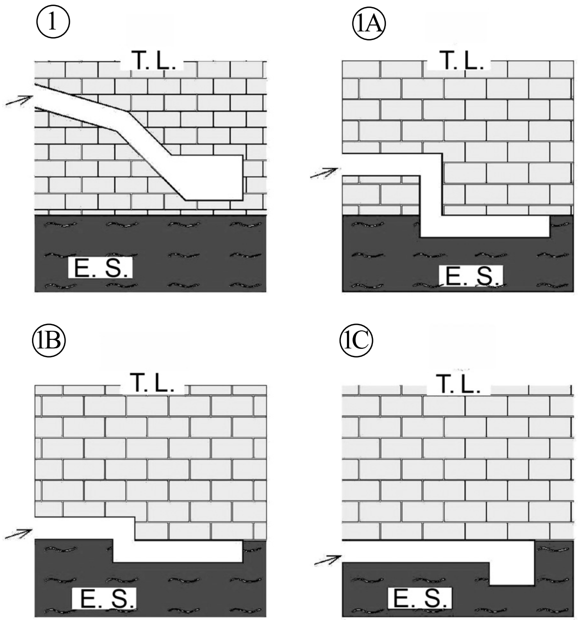
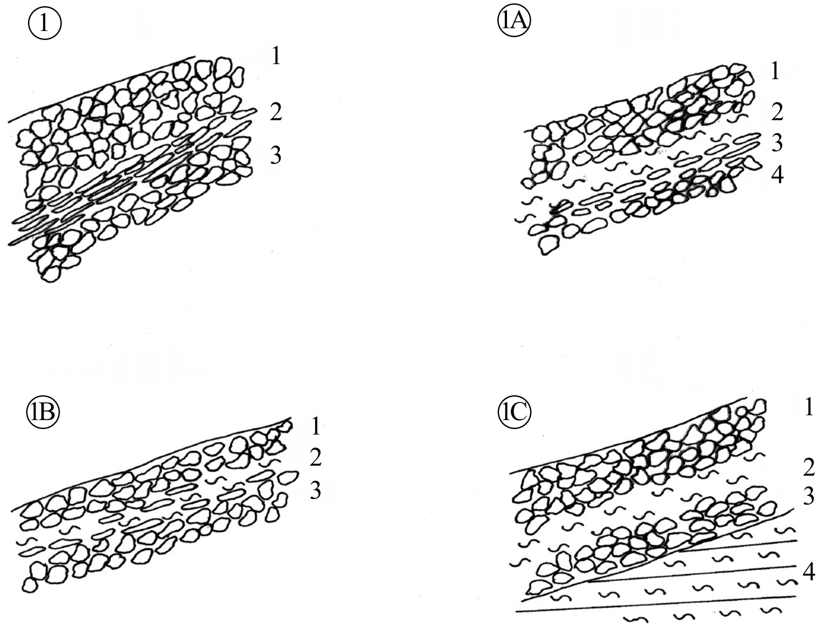
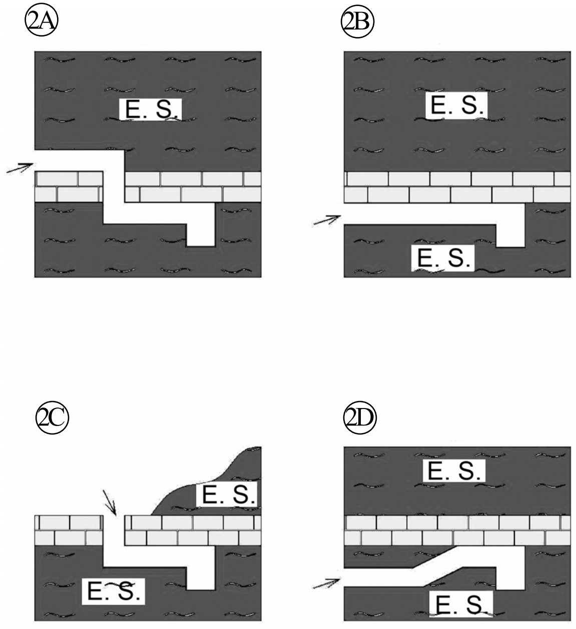


1. Location of tombs drilled in the Theban Limestones (1) and at the floor of the Theban limestones and Esna shales (1A–1C).

T.L. – Theban limestones
E.S. – Esna shales
arrow – tomb entrance

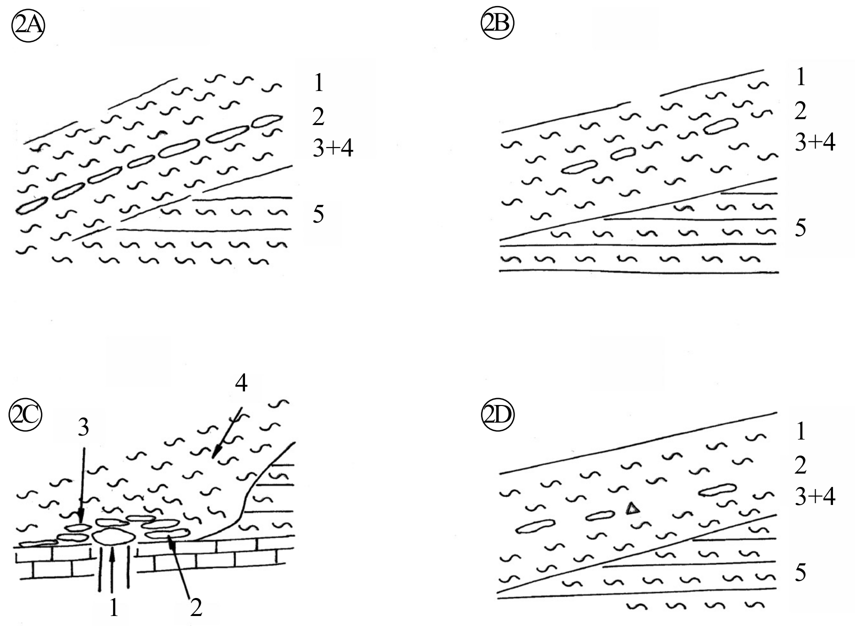


2. Geological profiles in front of the tombs shown on Fig. 1:
1: 1 – isometric debris, 2 – layer with calcareous chips from the tomb drilling, 3 – isometric debris;
1A: 1 – isometric debris, 2 – Esna shales removed during drilling of the tomb, 3 – layer with calcareous chips from tomb drilling, 4 – isometric debris;
1B: 1 – isometric debris, 2 – calcareous chips mixed with Esna shales, 3 – isometric debris;
1C: 1 – isometric debris, 2 – Esna shales removed during drilling of the tomb, 3 – isometric debris, 4 – primary, horizontally layered Esna shales.

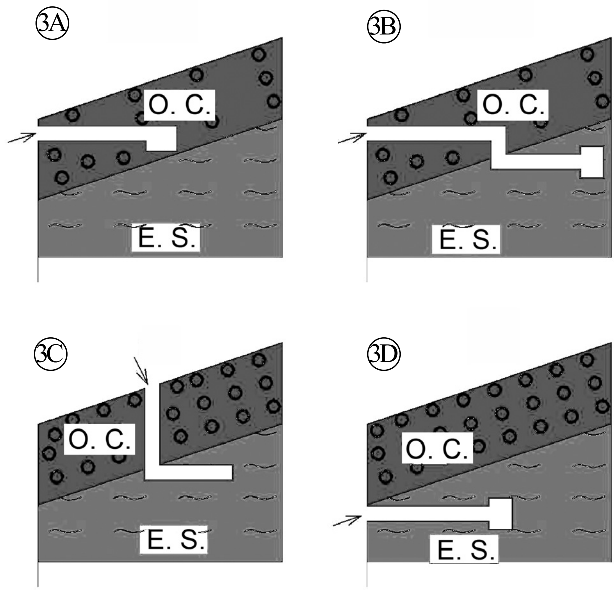


3. Location of tombs drilled in the Esna shales containing layers of the Theban limestones (2A–2C).

T.L. – Theban limestones
E.S. – Esna shales
arrow – tomb entrance

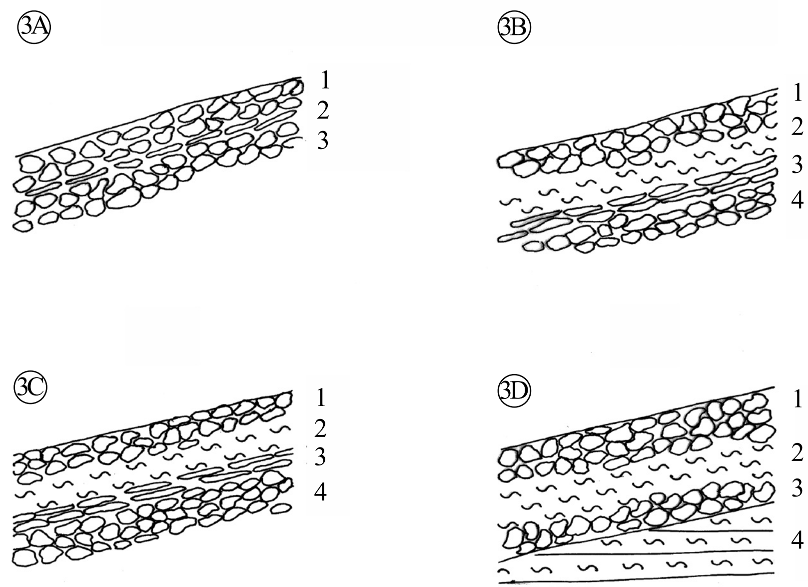


4. Geological profiles in front of tombs shown on Fig. 2:
2A: 1 – Esna shales naturally thrusted from the slope, 2 – layer of Esna shales with calcareous chips from drilling, 3+4 – shales from drilling mixed with Esna shales naturally thrusted from slope, 5 – primary, horizontally layered Esna shales;
2B: 1 – Esna shales naturally thrusted from the slope, 2 – layer of Esna shales mixed with chips from limestone drilling, 3+4 – shales from drilling mixed with Esna shales naturally thrusted from the slope, 5 – primary, horizontally layered Esna shales;
2C: 1 – the stone block covering the entrance to the tomb shaft, 2 – layer of calcareous chips from tomb drilling, 3 – layer of Esna shales from tomb drilling, 4 – Esna shales naturally thrusted from the slope, 5 – primary, horizontally layered Esna shales;
2D: 1 – Esna shales naturally thrusted from the slope, 2 – layer of Esna shales with calcareous chips from drilling, 3+4 – chips from drilling mixed with Esna shales naturally thrusted from the slope, 5 – primary, horizontally layered Esna shales.



5. Location of tombs drilled at the contact point of Oligocene conglomerates and Esna shales

O.C. – Oligocene conglomerates
E.S. – Esna shales
arrow –tomb entrance



6. Geological profiles in front tombs shown on Fig. 3:
3A: 1 – isometric debris, 2 – layer with calcareous chips and flints, 3 – isometric debris;
3B: 1 – isometric debris, 2 – layer of Esna shales from tomb drilling, 3 – layer with calcareous chips and flints, 4 – isometric debris;
3C: 1 – isometric debris, 2 – layer of Esna shales from tomb drilling, 3 – layer with calcareous chips and flints, 4 – isometric debris;
3D: 1 – isometric debris, 2 – layer of Esna shales from tomb drilling, 3 – isometric debris, 4 – primary, horizontally layered Esna shales.