Neogene submarine relief and Troodos uplift in southeastern Cyprus

W. Schirmer
Department of Geology HHUniversity, Universitaetsstr. 1, D-40225 Duesseldorf

Abstract

In the Choirokoitia (engl.: Khirokitia) area of southeastern Cyprus there occurs within the hemipelagic Miocene Pachna Formation a local coarse-detritic channel facies of terrigenous source. These channels together with their surrounding pelitic beds were formerly interpreted to be deeply incised into the Pachna beds and to be of Late Pliocene age. From this a rapid Late Pliocene uplift of the Troodos hinterland was postulated. This paper will explain how the so-called deeply incised channel consists of numerous flat channels all lying in superposition with each corresponding to the lateral pelitic shallow basin facies. Therefore, a rapid Troodos uplift is not necessary. From the study of the Choirokoitia area and the southern adjoining Amala Mountains it follows that all sedimentary units of the Choirokoitia Site occur within a tight stratigraphical connection with lateral facies transitions within the higher Pachna Formation. The whole rock complex is covered by the gypsum of the Messinian Kalavasos Formation. Consequently, the age of the channel system has to be Miocene.

Introduction

The Neogene development of Cyprus is determined by the uplift of the central island Troodos ophiolite complex. All stratigraphical units of its sedimentary cover reflect the movements of this ophiolite complex. The uplift is due to a generally northerly subduction of the African Plate below the Turkish Plate along the Cyprean Arc together with Cyprus at its southern rim (Kempler and Ben-Avraham 1987). The current subduction activity was initiated (Eaton and Robertson, 1993) in the early Miocene. Since that time the development of Cyprus and its adjacent marine border is controlled by sedimentary transport off the uplifting ophiolite area. The following text deals with the question of uplift rate during the later Miocene to later Pliocene at the southeastern border of the Troodos ophiolite complex (Fig. 1).

The problem

Bagnall (1960) has mapped and carefully described the Miocene beds of the Amala Mountain area of southeastern Cyprus. He presents the following strata subdivision:

Pliocene

unconformity

Miocene: Dhali Group

Koronia Limestone + Gypsum Deposits

Pachna Formation:

Limestone-Shale Member with *Discospirina* band

Fragmental Limestone Member

Wavy-bedded Limestone Member

Xenophontos *et al.* (1987) describe within the Fragmental Limestone Member of the Pachna Formation near Choirokoitia a 20 m thick channel fill with coarse material from Lefkara beds and Troodos igneous rocks. Such a submarine relief suggests strong uplift movements of the Choirokoitia area during that time.

Houghton *et al.* (1990) assign the same channel to "uppermost Pliocene age" due to a coccolith flora. Moreover, this channel is much wider and deeper in dimensions than that described by Xenophontos *et al.*, (1987), for the flora dated has been sampled from silt within, as well as below, the cobble-filled channel. Thus they infer a steep-sided submarine gully of Late Pliocene age cut into the Middle/Upper Miocene Pachna beds. This gully formation implies an unusual rapid Late Pliocene Troodos uplift.

The results of field work carried out between 1992 and 1994 and given in this paper show that first there does not exist a 20 m deep or even deeper channel system. Second the cobble and silt beds, assigned as being of Late Pliocene age, are not younger than the *Discospirina* Beds of Middle/Upper Miocene age. Thus the consequences for a rapid Troodos uplift in the Late Pliocene cannot be based on the Choirokoitia channel occurences.

The Choirokoitia Site

Near Choirokoitia the Maroni River (or Potamos tou Agiou Mina) offers along its course a few high and steep-cut slopes with similar exposures (Fig. 2). Bagnall (1960) describes one at the "north bank of the Maroni River 200 yards northeast of Chirokitia village", with its top ending in the "Katselia area" ("Katsella" after the topographical map 1:5000 of 1977). This is undoubtedly the eastern slope of the Maroni valley 350 m northeast of the church of Choirokoitia. Bagnall records inter alia seven conglomerate layers each with a thickness ranging from 0.6 up to 3 m. The polymictic conglomerates contain

From Panayides, I., Xenophontos, C. and Malpas, J., (eds), 2000, Proceedings of the Third International Conference on the Geology of the Eastern Mediterranean.

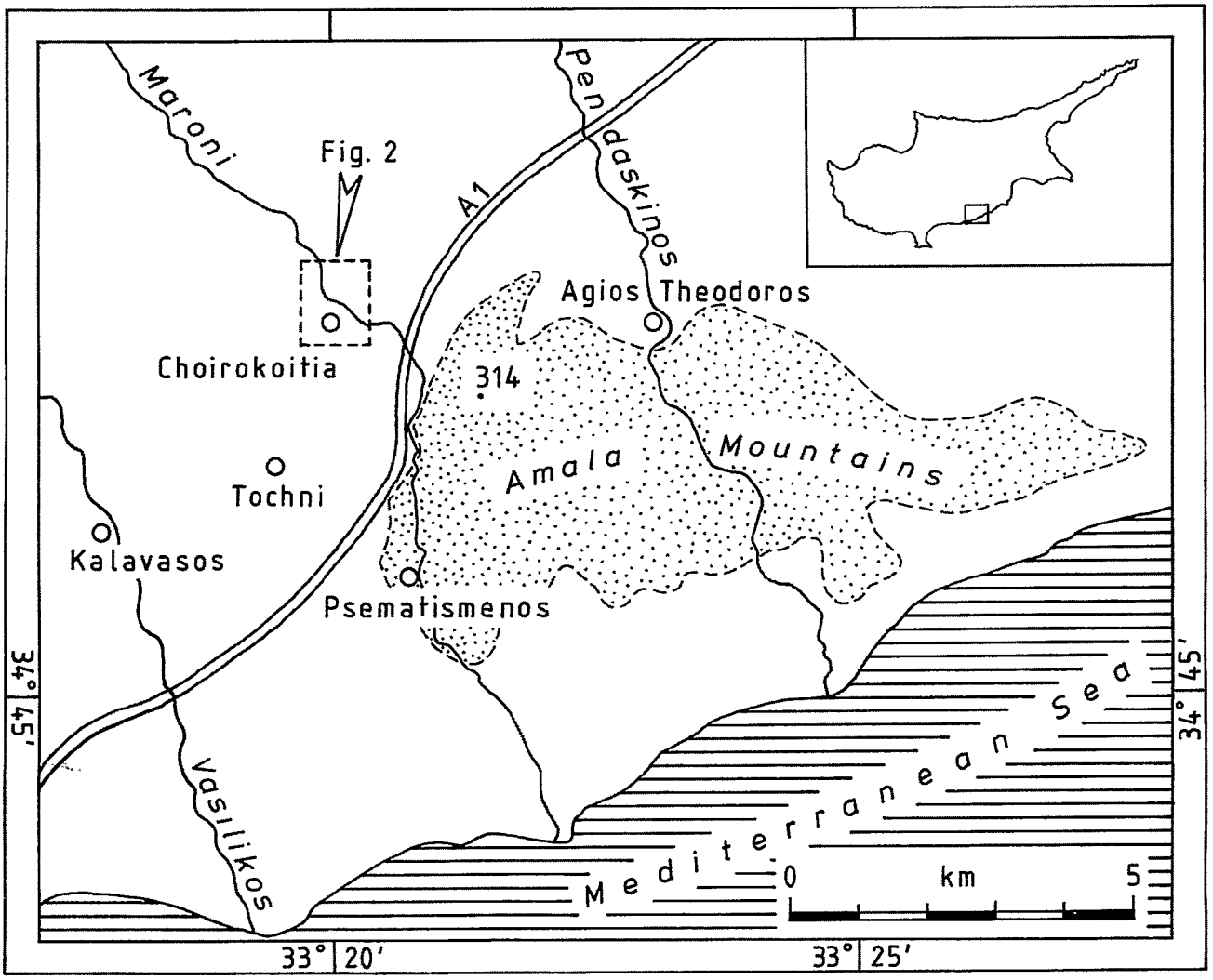

Figure 1. Location of the investigations: The Amala Mountains and Choirokoitia in the southeast of Cyprus

"diabase, basalt, andesite, chalk, chert and reef limestone fragments", some blocks "up to 6 feet in length". "Two of the thicker conglomerates are...almost entirely formed by large, well rounded boulders of algal and coral limestone associated with only small amounts of angular blocks of Lapithos chalk" [nowadays called Lefkara chalk].

Xenophontos *et al.* (1987) describe not the same section but one lying exactly on the opposite side to that of Bagnall within the Maroni valley. Though they put their "spectacular cliff" on the north bank of the river, their photo, plate D2 on p. 122, proves to be the section on the southwest bank of the Maroni River 250 m northeast of the church of Choirokoitia. They record the same facts as Bagnall but they place the group of conglomerate layers in a "some 20 m thick" channel deposit. Likewise in the paper of Houghton *et al.* (1990) the same channel deposit is recorded as "c. 20 metres thick and c. 30 metres wide".

This cliff is called the Choirokoitia Site in this text. It is situated 250 m northeast of the church (UTM grid 307.5/511) on the western wall of the Maroni valley immediately below the village (Fig. 2).

Indeed, at first glance the cliff presents the conglomerate layers as belonging to one fill and one deep channel (Fig. 3a). However, actually there are at least ten single channels well separated from each other and situated almost in superposition (Fig. 3b) and, what is essential there, their thicknesses range from only 0.7 m - 10 m.

It exhibits a succession of channels embedded into a monotonous, thin-bedded, grey, pelitic-arenitic sequence of silty marlstones that are alternating with small calcarenite beds. The channel fill displays from base to top the following sequence (Fig. 3a, b):

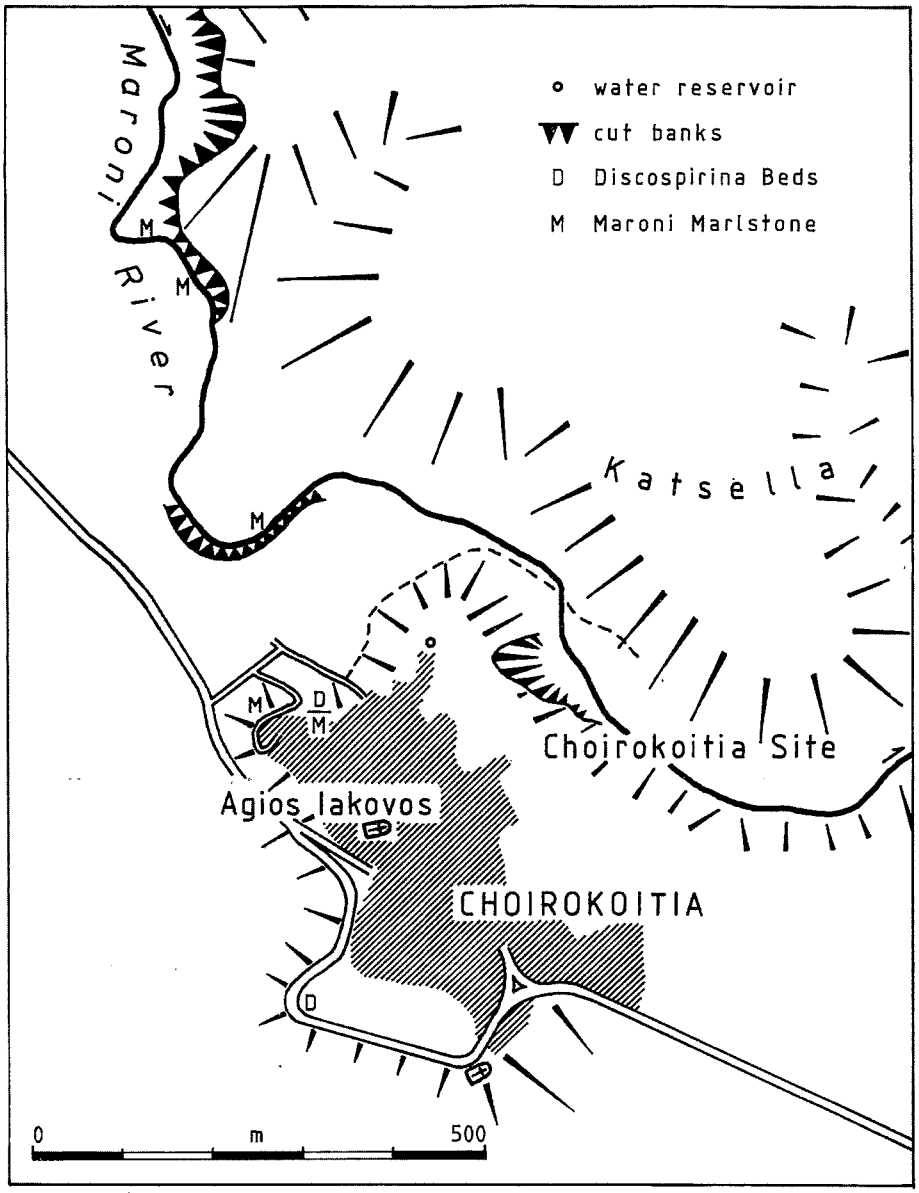

Figure 2. The local situation of the surroundings of Choirokoitia (Engl.: Khirokitia). For location see inset in Figure 1.

Channel 1

It is the lowest channel visible at the exposed wall (Fig. 4). Perhaps there are older channels below covered by the debris at the foot of the steep wall. This channel is situated below the lowest easily visible boulder-filled channel. The material of its fill resembles more the pelitic-arenitic outside-channel facies. Therefore, channel 1 is more easily recognizable by standing immediately before the wall.

Its maximum thickness above the talus debris is 1.7 m, 0.7 m of which have been preserved below channel 2. The fill consists of small calcarenite beds and marlstones with distinct trough-bedding. Gravel of reworked marlstone, Troodos ophiolite rocks, chert and Lefkara limestone, the latter up to 0.6 m in diameter occur occasionally. The channel top is formed by calcarenitic to marly beds up to 20 cm thick.

Channel 2

It is the channel below the big Lefkara chalk boulder within the cliff. Its thickness ranges up to 2.0 m. The fine-clastic outside-channel facies that corresponds to the channel facies has a thickness of 1.35 m. The main channel fill is coarse clasts up to 40 cm in dia., consisting of Troodos ophiolite rocks, Lefkara chalk and corals in a coarse-sandy, pebbly matrix. The roundness varies from excellent to bad. The channel fill is covered by a grey-green marlstone layer of max. 25 cm thickness containing a slight amount of gravel above the channel axis. Beyond the channel it forms a 12 cm thick prominent band within the grey-green marlstone facies. This layer dips down from beyond the channel into it (Fig. 4). The dipping is not only an effect of stronger compaction within the big channel complex but it also marks the primary channel form.

Figure 3a. General view of the Choirokoitia Site.

Channel 3

It is the channel with the big Lefkara chalk boulder. This boulder is 2.0 m vertical and 2.3 m horizontal in size, somewhat more than the thickness of the whole channel fill which reaches up to 1.5 m. The correponding sandy marl facies beyond the channel comes up to 0.8 m. On the stoss side of the boulder (right side at the cliff) a lag facies has been deposited with rudites up to 50 cm in dia. mainly consisting of coral and algal chunks. On the lee side (left side) a sand bar has been left by the current.

A fine-clastic layer up to 0.6 m tops this third channel fill forming a conspicuous groove in the cliff. Again, this fine layer has been deposited outside as well as inside the channel, dipping towards the channel and wedging out towards the channel axis due to later erosion during the formation of the base of channel 4.

Channel 4

This channel, up to 3.1 m thick, is very rich in rudites. They consist of large coral and algal heads in addition to white Lefkara chalk and dark Troodos ophiolite boulders. As in the lower channels a marlstone layer from outside the channel extends from the left side some meters over the channel fill.

Channel 5

It is the channel with the hole of *Corvus monedula* (Cypr.: Koliós, Engl.: Jackdaw). The coarse-clastic channel fill rises up to 5.5 m. The channel axis lies above the left rim of channel 4. The channel fill is conspicuously cemented thus forming the hardest bastion within the cliff with a vegetated roof. Its bluff contains the crevise with the jackdow hole.

The fill consists of thick-bedded conglomerate; the clasts are on average 20 cm across and at maximum 1 m. Troodos ophiolite rudites come up to 30 cm in diameter. Coral cobbles are frequent. The matrix is fine- to medium-sandy. Carbonateous cementation is conspicuous. The fine-clastic top separating channels 5 and 6 may be 2m in thickness.

Channel 6

This channel, lighter in colour than those below and above, and up to 4 m in thickness has again a coarse-gravelly fill with a gradation coarsening upwards. Lefkara chalk boulders flat-ellipsoidally shaped and well imbricated range up to good 2 m. The channel is topped by a grey-green pelitic layer up to 10 cm thick exposed to a lateral extent of 5 m.

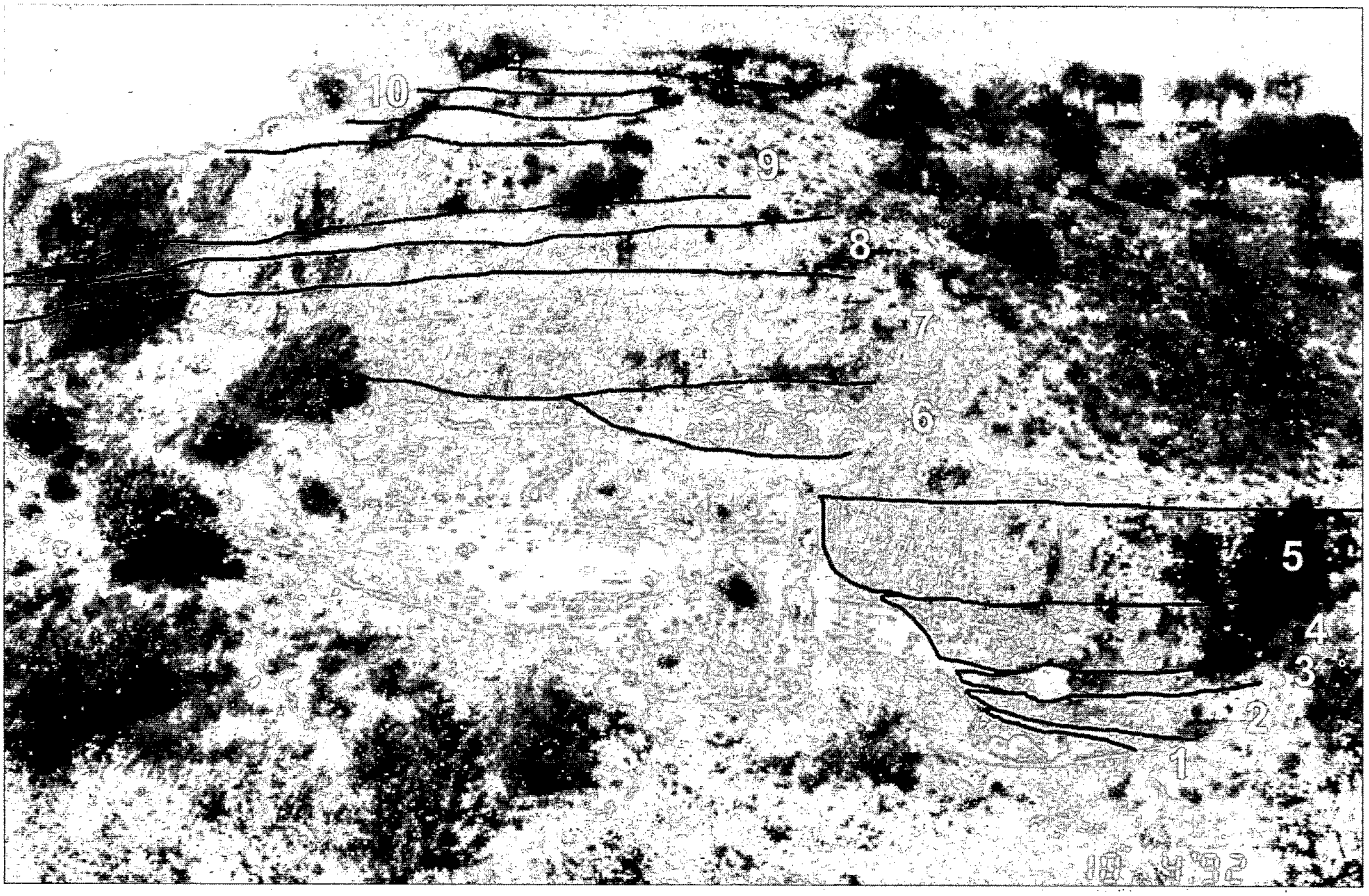

Figure 3b. The Choirokoitia Site with channel fills 1-10 (Amala Facies). On top the capping rock (Choirokoitia Limestone).

Channel 7

On the steep wall this channel is a brown colour. Its thickness is up to 6 m. Its maximum incision lies just outside the edge of channel 6. Its fill exhibits predominantly well stratified calcarenite layers. Subordinate gravel concentrations show well rounded pebbles. Lefkara chalk blocks run up to 1 m across. The channel is topped by a 10 cm thick fine-grained layer forming a conspicuous groove in the cliff. On its right edge there are two little shrubs marking the groove.

Channel 8

The channel differs from channel 7 because of the grey-green colour of its gravel-rich base. The channel thickness is up to 6.9 m on the left side of the cliff. The deepest channel incision lies above a large shrub of *Pistacia lentiscus* (Cypr.: sinià, Engl.: Mastic tree). The channel fill is very rich in boulders (up to 70 cm in diameter).

It is topped by a much finer grey-green layer up to 1.2 m thick, pelitic and calcarenitic, forming a ledge in the cliff overgrown with grass and shrub. Over a small area within this fine layer a light limestone bed (c. 20 cm thick) of *Discospirina* Bed type is visible from below.

Channel 9

This, the thickest one of all these superimposed channels, runs up to 10 m. Its fill forms the roof of the ridge at the left (southern) side of the cliff. There, the cliff wall exhibits a dark colour. Towards the north even higher strata are preserved above channel 9. The deepest incision of channel 9 lies on the left side of the outcrop. Additionally, there the basal conglomerate of this channel displays its maximum thickness of 1.8 m and is thinning out towards the right side. This basal layer exhibits a carbonate-supported conglomerate composed chiefly of Troodos igneous rocks, Lefkara chalk and chert (up to 20cm in diameter). It is followed by a vivid alternation of calcarenites and carbonate-supported conglomerates with boulders up to 1m in diameter.

The channel fill is topped by soft beds, 3.40 m thick at maximum, forming a 3 m wide ledge on the cliff. As far as the rocks of the soft beds are exposed they consist of thick ophiolite-sandy calcarenite beds and fine-clastic beds ending on top with 20 cm yellow-green silt that forms a groove. They contain fine plant detritus and represent in facies and colour the type of the *Discospirina* marlstone of the adjoining area.

Channel 10

The channel deposits form a small but very solid cliff above the

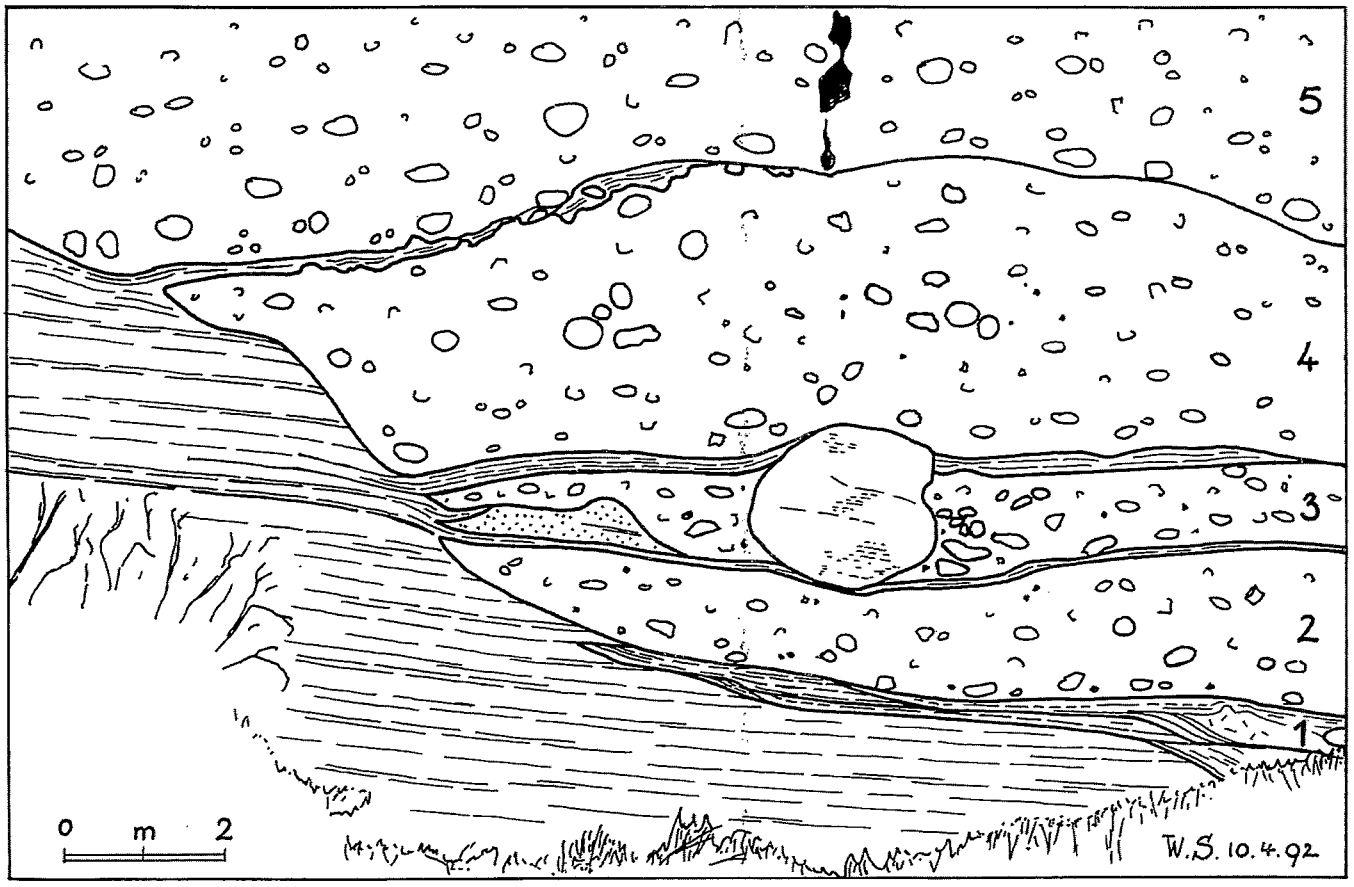

Figure 4 Choirokoitia Site. Detail of channels 1-5

ledge of the upper part of channel 9. Upon this cliff a few *Ceratonia siliqua* (Cypr.: teratsia, Engl.: carob tree) are growing, easily visible from the bottom of the valley. The channel fill is at least 1.7m thick. Its base cuts the fine-clastic top of the fill of channel 9. A deepening of 1 m along a lateral stretch of 5 m is recognizable. The fill consists of crystalline limestone, rich in fossils, containing ophiolite and Lefkara pebbles ranging from a few centimeters up to 20 cm in diameter, microgabbro pebbles strongly weathered, up to 15 cm, as well as black, bluish coated Perapedhi radiolarite.

This hard channel fill is covered above with soft rocks up to 65 cm thick forming a groove behind a 2 m wide ledge. It consists of grey-green limestone marl and pink ophiolite-conglomeratic calcarenite. In places, these soft beds are eroded by the rock capping the ridge.

Capping rock

The top of the ridge is formed by a 3 m thick recrystallized limestone, coarse-bedded, rich in cavities, with plenty of fossil moulds. It is embedded with gravel bands of Lefkara chalk up to 15cm in diameter and Troodos igneous pebbles up to 10 cm. At the southern edge there occur 10-20 cm thick smooth limestone beds rich in fossils.

Interpretation of the Choirokoitia Site section

Palaeogeographical setting

The Choirokoitia Site displays a well-stratified, marly-calcarenitic facies interfingering with a conglomeratic channel facies. The first is a marine deposit of a shallow basin. The channel facies is a linear debris supply onto the basin margin by scooping out flat channels and filling them with material supplied by erosion from a steep hinterland that could be marine, litoral as well as terrestrial.

Evaluating the material of the channel fills the occurrence of reworked coral individuals points to a shallow-marine source. The occurrence of weathered microgabbro seems to point to a terrestrial hinterland. But possibly the microgabbro weathered later, after being uplifted together with its surrounding