Havara on Cyprus - a surficial calcareous deposit

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Havara, talus, colluvial deposit, kafkalla, caliche, fossil soils, \(^{14}C\) data, Middle Würmian, Cyprus

Abstract: Havara is a local name of a surficial, soft, porous, white to buff, carbonaceous, clastic rock of Quaternary age widely spread in Cyprus. Its grain size varies from predominant silt to pebbles. It is bound to Quaternary age widely spread in Cyprus. Its grain size porous, white to buff, carbonaceous, clastic rock of soils to 31.970 and 27.440 a BP, i.e. Middle Würmian 4. Similar rhythmicity is known from loess sequences in Central Europe, thus giving evidence that the climatic rhythmicity worldwide known is likewise reflected within the debris processes of the eastern Mediterranean. The rhythmic interbedding of havara with soil formations gives evidence of less vegetated landscapes during main phases of havara formation. In contrast to havara, kafkalla is the result of soil formation processes. Descendent, ascendent and lateral intrasol lime transport forms hard crusting of the surface (caliche).

[Kavara auf Zypern - eine terrestrische kalkige Deckschicht]


Introduction

Havara is one of the most widely spread surficial deposits in Cyprus. It occurs predominantly in the limestone areas of Cyprus outside of the Troodos ophiolite area. It is a white to buff, fine, chalky, porous silty powder, which is always mixed with rounded or angular heterolithic bigger clasts although limestone predominates. Havara is used in Cyprus for road metal. Its silt with rock fragments is mixed with water and is spread on top of the surface of roads. During rains it does not turn into slurry - due to its only small content of clay
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minerals. The CaCO₃ content of havara, based on eight samples geographically spread over Cyprus, varies from 75-91% (PANTAZIS 1973: 21).

The origin of havara in Cyprus has been subject of a prolonged discussion. BELLAMY & JUKES-BROWNE (1905: 44) described it as "a calcareous tufa combined with fine pebbles to make a material known as 'khavara', the local term for gravel". Hence, BELLAMY & JUKES-BROWNE interpret havara as a sedimentary deposit. Later workers confused havara with kafkalla, the local name for caliche, e.g. BEAR (1960a: 12): "In many places it is difficult to distinguish" Koronia reef limestone "from havara (calcrete)". WILSON (1957: 26) states: "A secondary surface limestone or havara forms a crust". Other workers separated havara and kafkalla lithologically, but interpreted them as having the same origin - the evaporation of calcium carbonate (BEAR 1960b: 42, GASS 1960: 59).

PANTAZIS (1973) analyzed havara samples from different sites in Cyprus in detail and concluded in concurrence with the earlier workers BELLAMY & JUKES-BROWNE (1905) that havara was a sedimentary deposit, a "terrestrial (fresh water) deposit" (PANTAZIS 1973: 39). However, PANTAZIS does not discuss his assertion that havara is a fresh-water deposit. - See Addendum.

In this paper the results of recent studies of numerous outcrops of havara in the southern and western circum-Troodos area are described.

1 Occurrence of havara

1.1 The depositional environments of havara

Havara is a terrestrial deposit forming the surficial mantle of limestone-marl areas. It occurs at least in the following geomorphic situations:

a) Slope debris: Along the toes of slopes in limestone uplands havara can accumulate up to a few meters in thickness. In this environment it displays a disordered mixture of limestone fragments and sand-silt components. In some sections, indistinct and discontinuous bedding can be found. The bigger fragments show a slope parallel orientation, sometimes with imbrication dipping upslope.

An example of slope-debris havara is described in the Kalavasós Márkou section below.

b) Debris cones. At the toe of slope concavities, the exit of dales or small valleys thick debris cones form large aprons consisting through and through of havara. In the debris cones havara displays better bedding, caused by an alternation of stone-free to stone-rich havara. Stone-rich havara exhibits good imbrication of flattened rock fragments dipping upslope. In vicinity to river terraces the rock fragments are also rounded to gravel. Most of the havara exploited in Cyprus comes from debris cones.

c) Surficial veneer. In many places the havara simply occurs as a surface veneer on horizontal or gently inclined geomorphic surfaces. In this type of occurrence the silty-sandy grain size of havara is dominant with rock fragments or gravel being subordinate.

1.2 The Kalavasós Márkou Site

The site is a slope-cut behind the house of Charálampos Varêlla in Kalavasós 150 m south of the church (arrow in Fig.1). It lies 30 m above the valley bottom at the first flattening of the slope toe. The full place name of this slope is Spilios tou Papá Márikou, the caves of Father Márikou. Here the name is abbreviated to Márkou. A section from this site (see Fig.2) is described as follows:

<table>
<thead>
<tr>
<th>cm</th>
<th>soil symbol</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Ah</td>
<td>Havara: loam, silty, porous, often powdery, medium- to coarse-stony, rare boulders, scarce small ophiolite pebbles; loose, grey, humic, not stratified, perforated by burrows. - Anthropogene colluvium with autochthonous surface soil</td>
</tr>
<tr>
<td>80</td>
<td>C</td>
<td>Havara: silt, yellow-white, medium- to coarse-stony, scarce boulders; alternating with irregular, less stony layers; inconspicuous bedding. 20 cm above the lower contact a 20 cm long humus-charcoal streak. Radiocarbon age of the charcoal: Hv 19 672: 27 440 ± 1 600 a BP</td>
</tr>
<tr>
<td>20</td>
<td>fAh</td>
<td>Upper Tsiâko Soil*: silt, yellowish grey-brown, porous, medium-stony, scarce coarse- to boulder-stony, very rare ophiolite pebbles, locally humic</td>
</tr>
</tbody>
</table>

1) This paper is based on a former unpublished report of T. M. PANTAZIS: A study of some havara and kafkalla samples of Cyprus. - 32 p., 1 map; Nicosia (Ministry of Agriculture) 1961.

2) deutsch: Márikou

3) Soil symbols after FAO (1990). Additionally, M horizon (AG Boden 1994: 102) as migrated soil material is added
The Lower and Upper Tsiáko Soils merge lip (Fig. 2). The soils have fewer coarse clasts than the havara and are also enriched in humus. The soils represent distinct quiescence phases of slope erosion activity. The baked soil slab in the Gondéssa Soil is possibly indicative of human occupation.

2 Origin of havara

The occurrence of havara as slope debris, debris cones and surficial veneer as described above provides evidence of the differing origin of havara. The bulk of the havara has a colluvial respectively deluvial\(^5\) origin. Hill wash processes transport the fines and some of the coarse clasts that occur downslope. In places, the fragments occur as distinct beds well-stratified into coarser and finer layers, the coarser layers occasionally being imbricated; this form of stratification occurs typically in debris cones. In other places, stratification is absent and the coarse and fine material is unsorted.

At the toe of steep slopes there can be rock fragments originating from rock falls producing a lithologic result of isolated large rock fragments within pure fine havara beds.

The large amount of rock fragments, often up to some decimeters in diameter, cannot solely be explained by hillwash and rock fall processes, because there are many areas where rockfall can be excluded. Therefore, it is argued, that soil creep processes play a major role in the formation of these poorly sorted deposits.

Where deposits of fine havara are found they lack any stratification and exhibit porosity and other characteristics similar to loess. This suggests the idea of an eolian origin. On the other hand, however, secondary recrystallisation of the lime within in the havara may have destroyed primary laminations. Little eolian component might occur. However, big dust storms, as they occur in cold and or warm arid areas, can be excluded as trigger for havara deposition. Otherwise white havara should cover the dark, widely exposed ophiolite rocks, at least those adjacent to the limy or marly areas, but this is not the case.

3 Climatic background of the havara formation

Colluvial processes on slopes of notable amount - as they occur in havara piles - as well as eolian processes and solifluction need a landscape less vegetated than today. Additionally these processes need a certain periodical frost scattering thus supplying the slopes with scree to be transported down slope. The requirement for frost activity in Cyprus uplands means a climate colder than today.

All these processes, colluvial, soil creep, rock fall and eolian, do occur, of course, nowadays in Cyprus, especially where the forested landscape has been cleared. Colluvial processes require rainfall that happens during the winter and in the Troodos area sometimes throughout the year. Moreover, colluvial processes need prevention from water seepage. This happens under conditions of extreme water supply, water-oversaturation, extreme dryness of the soil, but also permafrost. Only the former three cases are realized in present Cyprus albeit rarely. Thus, conditions

\(^5\) pronounce: Chako, deutsch: Tschako. The Tsiáko and Gondéssa Soils are named after the two dogs housed at the toe of the wall scratching that produced rockfall on the roof of their huts. Only the promise of scientific fame could convince them. The term colluvial equals the German term deluvial, also the term obluvial (Leddke in Galbas et al. 1980: 10), whilst the German kolluvial is restricted to down slope transport of soil material, mostly induced by man’s impact onto the landscape.
for recent colluvial processes are not very frequent but do exist. Furthermore, where the land is cleared on limy soft rocks, that are easily erodable, a solid kafkalla crust (caliche) prevents the soft lime material from being washed off. Thus, modern colluvial deposits concentrate preferably to ravines and along the thalweg of dry valleys.

Soil creep processes do not necessarily imply permafrost conditions as it is the case in the periglacial zone. But strong intermittent frost periods as well as water-oversaturated soil effect soil creep. However, these are rare situations in recent times.
Fig. 2: Sketch of the Kalavasós Márcou Site showing the presence of fossil soils of Middle Würmian age within the havara (silt-rich calcareous talus). Horizontal scale is approximate. wm = Middle Würmian, wu = Upper Würmian, h = Holocene

Abb. 2 Skizze des Kalavasós-Márcou-Aufschlusses mit fossilen Mittelwürm-Böden im Havara (siltreicher Kalkhangschutt). Horizontalerstreckung nicht maßstabsgetreu. wm = Mittelwürm, wu = Oberwürm, h = Holozän

and cannot give rise to major and extended soil creep masses.
Recent rockfalls have occurred where there is sheep and goat grazing on cleared slopes or by human use of the slopes. Occasionally, rockfalls augment rock debris at the toe of a slope conspicuously.

Recent eolian processes occur in Cyprus. During the wet season a certain amount of rain dust from outside Cyprus is spread over the island; the colour of this allochthonous silty dust is yellow to red brown. During dry periods, autochthonous dust can also be blown around on the island, but as rocks adjacent to limestones are free of remarkable coats of lime dust, then the amount of recent local blown lime dust has to be negligible. The modern landscape is not greatly affected by all these processes even though the forest cover has been largely removed. Otherwise, in the geomorphic context of recent slope erosion activity as shown presented by the havara exposures, the erosional debris production would have covered repeatedly the surficial kafkalla crust in such a way that there would exist a series of buried kafkalla horizons - but this is not the case.

As the landscape is now largely deforested, yet extensive active slope processes are lacking, then the landscape at times when havara formed must have been more open than today. This requires a colder climate than that today. Consequently, most of the havara must have been deposited during colder climate than that existing today.

4 Age of havara

The data gained from the Kalavasós Márcou section (Fig. 2), as well as the thick and fine-grained havara beds, deposited under scattered vegetation and increased frost activity, lead to the conclusion that most of the exposed havara is of Würmian age:

- 1,5 m kafkalla formation (displayed in Fig. 2):
  anthropogene Holocene
- 1,5 m humic soil formation:
  forested Holocene
- 2,0 m upper havara: Upper Würmian
- 4,5 m Tsiáko-Gondéssa havara: Middle Würmian

It is concluded that most of the havara is of a glacial age, and a lesser amount was produced du-

6) SCHIRMER (1991, 1995) subdivides the Middle Würmian (MW) loess of Germany into four sections: MW 1 represents the could O-stage 4, MW 2-4 the warmer O-stage 3 with eight interstadial soils and a conspicuous intermittent cooling phase (MW 3) (see Tab. 1)
Fig. 3: Rhythmicity within the depositional sequence of havara deposits (calcareous talus) and soils in Cyprus

Abb. 3: Ablagerungsrhythmus innerhalb der Havara (Kalkhangschutt)-Boden-Folgen in Zypern

Table 1: Middle Würmian of the Central European periglacial area and Cyprus

<table>
<thead>
<tr>
<th>O-stages</th>
<th>Stage</th>
<th>Central European periglacial area</th>
<th>Cyprus (Kalavasós Márcou Site)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Upper Würmian</td>
<td>loess</td>
<td>havara</td>
</tr>
<tr>
<td>3</td>
<td>Middle Würmian</td>
<td>Kripp stadial: loess</td>
<td>Tsiako-Gondéssa soils (3 soils): calcic regosols havara</td>
</tr>
<tr>
<td>4</td>
<td>Sinzig soils 1-3: calcic cambisols</td>
<td>Remagen soils 1-5: calcic cambisols</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>stadial: loess</td>
<td></td>
</tr>
</tbody>
</table>

ring a warm climatic period. A certain share is due to reworking of the havara and redeposition under deforested Holocene conditions.

5 Rhythmicity within havara deposition

Sections through the havara show the depositional sequence schematically drawn in Fig. 3. This rhythmicity of slope development points to a climate process starting with strong erosional activity that later tapers off and is eventually totally lacking during periods of active vegetational growth with its accompanying soil formation.

6 Havara formation and climate course

The soil units within the Kalavasós Márcou section demonstrate the stadial/interstadial rhythms, known from the periglacial areas, likewise to be well developed in the eastern Mediterranean. The Middle Würmian of the Central European periglacial area is subdivided by at most eight fossil soils (SCHIRMER 1991, 1995), alternating with loess and loess derivates (Tab. 1). I am far from assuming the three Kalavasós Márcou soils to correspond to the three Sinzig Soils listed up in Tab. 1, but the Central European soil sequences provide a potential model for correlation. However, for such a correlation the Kalavasós Márcou Site is, firstly, too limited in exposure though, presumably, the rhythmical sequence continues at depth. Secondly, neither the dates of the Sinzig Soils nor that of the Tsiako-Gondéssa Soils are reliable enough to correlate both soil by soil. The only fact to follow is the Kalavasós Márcou Site to assign to the Middle Würmian 4 sensu SCHIRMER 1991, that is the upper part of O-stage 3.

In the Kalavasós Márcou section the havara takes the position of the periglacial loess, and the calcic regosols in Cyprus take the position of the calcic cambisols of the periglacial zone. The difference
between cambic soils in the loess and regosols in the havara is due to a higher clay content of the loess and a less one in the havara. The morphogenetic relationships are similar in both areas - the periglacial area of central Europe and the eastern Mediterranean:

During stadials, there were unstable conditions with slope forming processes under scattered vegetation in Cyprus, and loess-steppe with solifluction in the periglacial zone. During interstadials, stable conditions existed with a vegetation cover (?) in Cyprus, and similar stable conditions but with shrub tundra in the periglacial zone. No doubt, there was a difference in climatic conditions and vegetative zones between the periglacial area and Cyprus. However, during the course of a glacial cycle the principal geomorphic conditions and the process rhythmicity turn out to be comparable between both the eastern Mediterranean and the Central European periglacial zone.

To argue against the former opinion the debris masses to origin during strong rainfall under "pluvial" conditions, and the soils to origin under drier "interpluvial" conditions, it is pointed out that the debris deposits lack considerable shares of soil material (for example humic streaks) that is to be expected in case of strong hill wash processes under warm conditions with an extensive vegetation cover.

### 7 Slope development and debris accumulation

The Kalavasós Márkou section demonstrates the main phases of debris production to be assigned to stadial phases of a glacial period. Consequently, the extended debris fans flanking the river valleys in Cyprus have to be regarded as result of stadial conditions; these conditions are characterized by less vegetation than in the Holocene. Further, it is suggested that stronger frost activity was also a major factor during glacial periods. Today, on Mount Olympos (1956 m), the highest elevation of Cyprus, frost polygons and solifluction lobes are developing in areas with scattered vegetation. Every year from end of November to the beginning of April several tens of freeze-thaw transitions occur on this summit. During Würmian stadial conditions the lower frost limit was much lower, and when combined with a lack of vegetation, then conditions of debris production would have been more intensive throughout Cyprus.

These results coincide with the conclusions of IOKIM & CHRISTANIS (1997: 102) who follow for the Greek mountains from palynological evidences an "open steppe-like vegetation" for the cold phases of the last glacial-interglacial cycle. HEMPEL (1990: 80) also found in the mountain areas of Crete and southern Greece that the main phases of debris deposition were of glacial age. He attributes, however, the bulk of debris to Saalian, rather than Würmian age.

### 8 Relationship of havara and kafkalla

Kafkalla is the local term for caliche, calcrete or petrocalcic horizon (SOIL SURVEY STAFF 1992: 20). Genetically the kafkalla horizons belong to soil formation, because there is no kafkalla deposition but rather kafkalla precipitation. The Cyprean kafkalla is an enrichment of lime within the solum that occurs in three ways:

- a) Descendent lime precipitation starting with calcaric nodules within and below the B horizon;
- b) Ascendent lime precipitation forming the calcaric crusts on top of the surface;
- c) Lateral lime precipitation by groundwater movement.

Each of these processes effects a hardening of the soil. Although all three processes interact in forming kafkalla, it is the ascendent origin that has the dominant role.

BELLAMY & JUKES-BROWNE (1905: 43) give a reasonably good description of kafkalla with an essentially correct explanation of its origin, although they term it capstone and do not use the name kafkalla.

Normally a surficial kafkalla crust is hardest at the top and merges downward into a softer material, which may resemble havara. Therefore, the delimitation of both rock types becomes difficult especially in those cases when kafkalla has been formed on top of havara. This may be a major reason for the different opinions regarding the genesis of havara and kafkalla by the authors quoted in the beginning of this paper.

Kafkalla occurs rarely prior to the Holocene. Pre-Holocene soils exhibit mostly descendent Bc horizons, and they lack the ascendent component. Therefore, it is concluded, that the dominant ascendent lime precipitation of the recent surface is mainly due to land clearance in the Holocene. Thus, kafkalla formation needs a surface free of vegetation to some extent. Kafkalla does not pass...
latterly into havara. The formation of both does not happen simultaneously in the same place - even though both need a restricted vegetation cover. During periods of havara formation evaporation was not enough to form kafkalla. Thus, kafkalla needs little vegetation and a warm climate to cause high evaporation rates. Under natural (pre-clearance) conditions on Cyprus, warm climate encourages vegetation growth, and vegetation reduces evaporation from the soil and precludes kafkalla formation. Consequently, it is concluded that land clearance under Holocene conditions was the main cause for the formation of kafkalla.

9 Acknowledgements

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10 Literature


Addendum

MRS. NERGIS AÇOÇA, Turkologist, Düsseldorf, was so kind to give me information about the REDHOUSE Turkish-English-Lexicon that lists the term havara. In the edition of 1921 (page 810) „hawwara“ is listed to have the meaning of „white flour, fine flour“. After the edition of 1968 (page 464) the term „havara“ is derived from Arabic and is provincially used for „kind of soft building stone“ and „whitewash“. These explanations of both editions match highly with the definition and description of the soft, surficial rock havara given in the foregoing text. The meaning of the 1921 edition reflects the fine, powdery consistence of the rock havara. That of the 1968 edition points to the use of the rock havara.

REDHOUSE, J. W. (1921): A Turkish and English Lexicon; Constantinople (H. Matteosian).


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