

RECENT PEDOGENESIS AND NEOTECTONICS AFFECTING ARCHAEOLOGICAL SITES IN NORTH YEMEN

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ABSTRACT. – A holocene pedogenetic phase identified in the central highlands of North Yemen, as well as a renewal of very recent neotectonic movements, are related to the history of different archaeological sites found in the area, ranging in age from the lower Neolithic to the Sabean period.

RÉSUMÉ. – Mise en relation d'une pédogénèse de l'Holocène reconnue dans les hautes plaines du Yemen Nord, à l'Est de Sanaa, et d'une activité néotectonique très récente avec l'histoire de nombreux sites archéologiques reconnus dans la même région dont les datations s'échelonnent du Néolithique ancien à la période Sabéenne.

A series of settlements ranging in age from the lower Neolithic to the Sabean period has been found by the Italian Archaeological Mission (1) working in the drainage basin of Wadi Dhanah south-east of Sana (Yemen Arab Republic) (fig. 1). The sedimentary series brought to light by erosion of several wadi tributaries can be correlated with depositional sequences found in central-south Arabia (2). The identification of a pedogenetic phase extending over the entire area of Khawlan, as well as evidence of a renewal of neotectonic movements which tend to rejuvenate the relief, emphasizes the role of environmental parameters in the cultural development of the region.

The Wadi Dhanah catchment basin extends for more than 8 000 sq.km, with an overall difference in height of about 1 500 m, through the crystalline and metamorphic rocks of the basement complex, excluding the headwaters of the 1st and 2nd order tributaries. These cut through the calcareous-marls and arenaceous sediments of the Amran Series in the westernmost stretch and the volcanic rocks of the Trap Series (e.g., going southward, Wadi Yana'im, Wadi Miswar and the upper stretch of Wadi Hababid, Wadi Na'mah, Wadi Naysan and Wadi Haykan).

Generally speaking, the dissection pattern is therefore of dendritic type but in places becomes sub-parallel or even parallel, because of the structural control of some of the faults and fracture systems which are the tectonics over the whole of Yemen. The predominating directions are those of the Red Sea (north-northwest and northwest) characterized by heaves and those of the Gulf of Aden (northeast-east), often emphasized by throws ("horst und gra-

ben" tectonics) (3). The watercourses generally flow parallel to one of these directions and then abruptly change direction to follow the conjugate trend, roughly at right angles to the first.

A series of sedimentological analyses was carried out on naturally exposed sections along the wadis ath-Thayyilah and Nagid al-Abyad, both of which are tributaries of Wadi Dhanah (fig. 2). The same analysis was applied to the archaeological stratigraphies of Gabal Qutran and Al Masannah (4). The field and laboratory analyses enabled us to reconstruct a type sedimentary series whose components consist of poorly sorted mixtures of clay, silt, sand and gravel-sized particles. Their textural characteristics show them to be colluvial or limited-transport alluvial sediments. In fact, the action of the *widian* also plays an important role in the filling and flooding; eluvial deposits come from the weathering of the bedrock *in situ*; and the fine sands are mainly transported by the wind. Within this sedimentary series, a more humid period is marked by the presence of a palaeosol whose pedogenetic process affected a vast area, even going beyond the Dhanah basin (5). The series includes four distinct complexes representing different periods of sedimentation or pedogenesis connected to particular environmental situations :

I. Basal conglomerate deriving from the "basement complex", which indicates high-energy transport during a period of relatively high rainfall. The cemented edges could indicate an increase in aridity subsequent to the settling of the deposit. The maximum thickness observed was two metres.

(1) de MAIGRET, 1980, 1981, 1982; de MAIGRET, 1984.

(2) AL-SAYARI and ZOTL, 1978; JADO and ZOTL, 1984; GARRARD, 1971; Mc LURE, 1976.

(3) LIPPARINI, 1955; CHIESA *et al.* 1983; EL -SHATOURY, 1976.

(4) de MAIGRET, 1984.

(5) GARRARD, 1971.

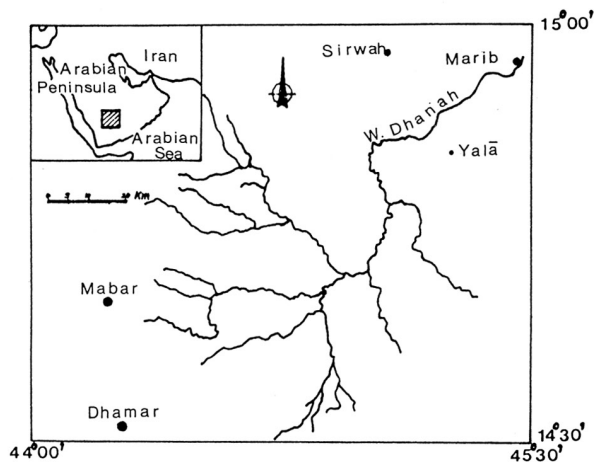


FIG. 1. - Location map of the area investigated.

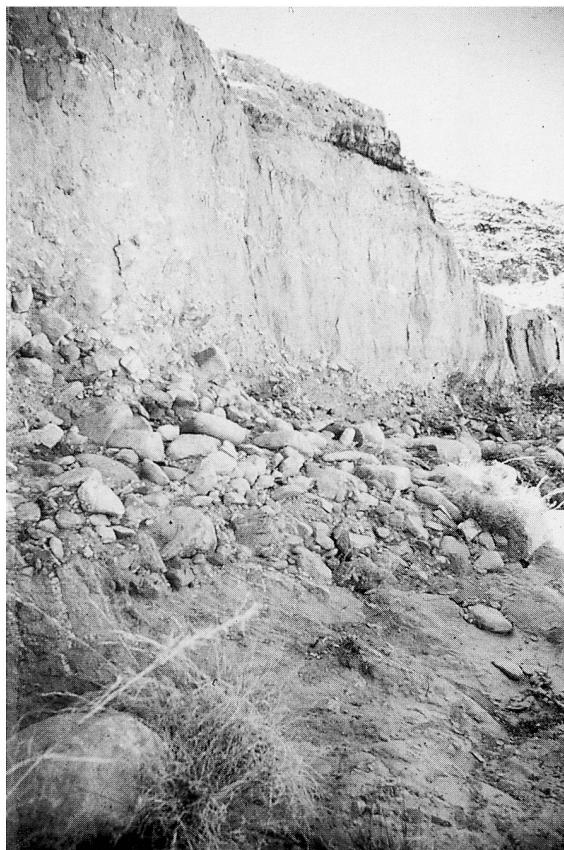


FIG. 2. - Natural section along Wadi ath-Thayyilah showing the palaeosol in the sedimentary sequence.

Ia. Layers predominantly of sand, silt and clay. The granulometric curves show a certain sorting of the sandy fraction and seem to indicate a fluvial type of deposit. The coarse fraction is mainly represented. Organic matter is practically absent. The grains of quartz, ranging from angular to sub-angular, suggest local origin with medium-low transportation energy. These sediments are partly alluvial, probably transported for a short stretch by currents of no great strength, and partly colluvial, from the slopes, and were accumulated in semi-arid conditions. There is also an eolian component (some polished grains are present). The maximum thickness is two and a half metres.

Ib. Light grey deposit of travertine type, at times powdery and weathered. The vacuolar structure is not greatly developed but there are traces of vegetable organisms. The visible thickness is about 1.2 m. The fact that this deposit is not found in all the sections may be explained by horizontal variations of *facies* derived from the presence of zones of episodic flooding. This would imply the alteration of wet and dry periods with extensive evaporation of episodic or seasonal nature, with salt deposition in calm and shallow waters. In general, a semi-arid environment is indicated.

III. this level is very dark grey, rich in organic matter and vegetable remains. The silt-clay component predominates. The level has many fissures and is divided into prismatic elements, whose surface is covered with a whitish patina. While the upper limit is clear, the lower is indistinct (fading gradually to light grey) down the section. It would seem to be an accumulation horizon indicative of a palaeosol. The pedogenesis from which the soil originated, developed on an alluvial sand layer. The discovery of conifer pollens and fungi in this level is evidence that arboreal forest vegetation existed in the Dhanah basin. The pedogenetic process indicates a period of marked humidity favouring the development of abundant spontaneous vegetation. The clear limit with the next upper level seems to indicate removal of the eluvial horizon from the pedological profile, as a result of intense aeolian activity.

IV. Sandy-silty colluvium with pebble levels and eolian sand, indicating an environment which was increasingly arid with conditions of slope instability, brought about by reduced or absent vegetal cover and by thermoclastic weathering of rocky masses (fig. 3).

In an archaeological sounding performed in the site of Nagid al-Abyad the last two levels were found associated with either Neolithic artifacts (III) or Bronze Age structures (IV). In addition a partly cemented base conglomerate or remarkable thickness is present at Wadi Hababid. A conglomerate is also found at the base of sandy sediments in Wadi Qawqah. In the last two cases, the upper levels may have been subsequently removed.

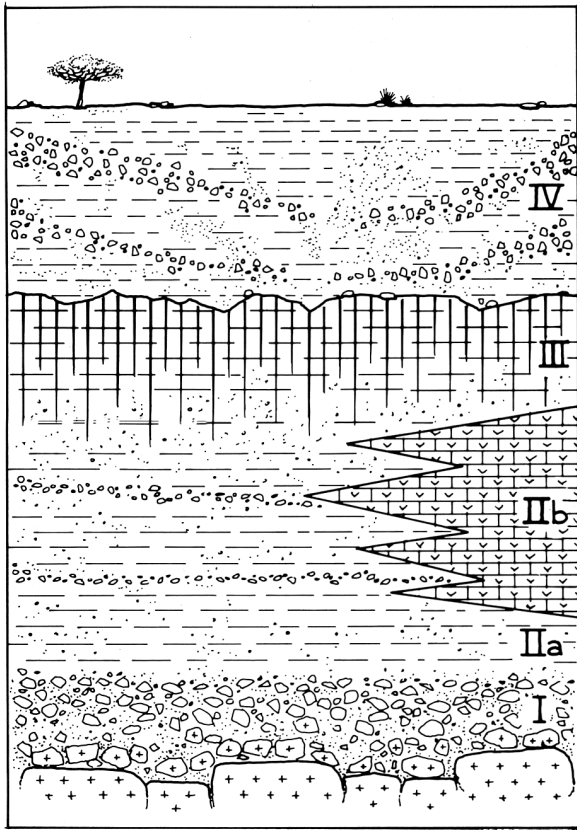


FIG. 3. - Typical sedimentary series of the Wadi Dhanah basin.

C14 dating on organic matter from two palaeosol samples, collected along the upper course respectively of Wadi ath-Thayyilah and one of its left tributaries, provided values of 5750 ± 500 B.P. (large error is due to small quantity of available material) and 6595 ± 75 B.P. (Rome University's Carbon 14 Dating Laboratory). It seems evident that dates apply to the soil-forming interval (during which organic matter was provided by vegetal cover), because this period is included between two arid phases. These dates fall in one of the more important humid Holocene phases dating from around 9000 to 6000 B.P. recorded in central-south Arabia : 6100 ± 70 B.P. for lake Mundafan (6), 6685 ± 50 B.P. for the palaeosol of the "Jubba basin" (7), 7000 to 6500 B.P. for the "Spring Formation" of 'Ain Qannas (8), 8450 ± 175 B.P. and 5070 ± 220 B.P. for two organic horizons containing *Melanoides Tuberculata* from lacustrine levels of the Bahrain Islands (9). Another date for the aceramic Neolithic of Rub'al-Khali is 5090 B.P. (10).

The Neolithic site of Gabal Qutran, in the Wadi Dhanah basin, shows a sedimentary series indicating a climatic sequence from a humid to an increasingly arid phase. It includes a lower complex more silty

- (6) Mc LURE, 1976.
- (7) GARRARD, 1971.
- (8) *Ibid.*
- (9) LARSEN, 1983.
- (10) FIELD, 1960.



FIG. 4. - Gawf valley : under arid conditions exploitation of groundwater resources and management of surface run-off are basic requirements for site development. The sabean town of Baraqis is a typical example, with its wells, earth dams and networks of irrigation channels.



FIG. 5. – Basalt sill of middle holocene age along Wadi Hababid, interbedded with sub-horizontal marly limestone (Amran Series), uplifted and then cut by erosion.

and clayey, very compact and dark grey in colour, with high organic content, and an upper loose sandy-gravelly level, with abundant rounded and polished quartz grains, produced by intensive aeolian action. The archaeological evidences testify a shift from permanent settlement to sporadic occupation (11).

The same sequence has been observed in the excavation of the Neolithic site of *WTH iii*, near Wadi Nagid al-Abyad. The sites of al Masannah, Wadi Yana'im and Ar-Raqlah, of the Yemeni Bronze Age and dating from 2150 to 1750 B.C. (12), show characteristics that are typical of a definitely more arid environment both in sedimentological (abundance of eolian quartz grains) and faunal (capro-ovines and gazelles) contexts.

Once this new climatic phase had begun, any real change in drainage pattern and water resources has to be attributed to neotectonic movements and, in particular, differential uplift of the Dhanah basin by block faulting. In fact in the whole area no other proofs were found of subsequent humid periods over the described palaeosol, covered everywhere by coluvial sediments. Furthermore in the Arabian Peninsula after the Mid-Holocene Pluvial a climatic trend towards increasing aridity with only light humid fluctuations is recognizable (13). Lastly the base level of the Dhanah basin, which is endoreic, cannot

be substantially influenced by causes (e.g. eustatic variations) other than tectonics. Evidence of such movements is found along Wadi Nagid al-Abyad, Wadi ath-Thayyilah, Wadi Hababid, in the area of the wadis Qawqah and Yala, in the alluvial plain in front of the Sabeen dam of Marib (14) and, finally, along the southern flank of the wide Gaw Valley (fig. 4). The evidence comes mainly in the form of active re-incision downstream of the neutral point of the equilibrium profile (where depositional processes are predominant in normal conditions) in numerous tributaries of W. Dhanah and the Dhanah itself. The erosion exposes the entire sedimentary sequence down to a basal conglomerate. Moreover in Wadi Hababid, southwest of Bayt Abu Hasim, a basalt sill outcrops interbedded with a sub-horizontal marly limestone dated to the Upper Pleistocene-Holocene (15) and is uplifted, a few hundred metres downstream, at least 60-70 m by a NW-SE fault. This Holocene very deep incision is not to be attributed solely to greater rainfall than at present, but above all to rejuvenation by neotectonic movements, which are probably still in progress (fig. 5).

Recent river capture and epigenetic valley formation are also evident, as in the new stretches of Wadi Dhanah and Wadi Yala southwest of Marib, which are cut along fault zones (16).

(11) ZARATTINI, 1984.

(12) de MAIGRET, 1984.

(13) LARSEN, 1983.

(14) MARCOLONGO and PALMIERI, 1986, 1987.

(15) GROLIER and OVERSTREET, 1978.

(16) MARCOLONGO and PALMIERI, 1986, 1987.

Protracted activity of these structural movements is indicated in the Sabean and Minean periods by the breakdown of some important hydraulic structures. For example, the retaining wall along Wadi Qawqah near Yala has been incised and the irrigation scheme around Baraqis was destroyed by an shift eastward of the palaeo-wadir Magzir (17).

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BIBLIOGRAPHY

AL-SAYARI S.S. and ZOTL J.G.

1978 *Quaternary Period in Saudi Arabia I.* Wien, New York : Springer.

CHIESA S., LA VOLPE L., LIRER L. and ORSI G.

1983 Geological and structural outline of Yemen Plateau : Yemen Arab Republic. *N. Jb. Geol. Paleont. Mh.*, II : 641-656.

EL-SHATOURY H.S.

1976 Analysis of lineaments in LANDSAT - I photographs of Yemen and their geologic significance. *Di-rasat Yamaniyyah I* : 3-14.

FIELD H.

1960 Carbon 14 date from a "Neolithic" site in the Rub 'al - Khali. *Man* 60 : 172.

(17) *Ibid.*

GARRARD A.N.

1971 Environment and settlement during the Upper Pleistocene and Holocene at Jubba in the Great Nefud, Northern Arabia. *Atlat* 5 IIIb : 137-151.

GROLIER M.J. and OVERSTREET W.C.

1978 *Geological Map of the Yemen Arab Republic, I : 500 000.* Washington : U.S. Geological Survey.

JADO A.R. and ZOTL J.G.

1984 *Quaternary Period in Saudi Arabia 2.* Wien, New York : Springer-Verlag.

LARSEN C.E.

1983 *Life and Land Use on the Bahrain Islands.* In : BUTZER K.W. and FREEMAN L.G. (eds.) Chicago : the University of Chicago Press.

LIPPARINI T.

1955 Contributi alla conoscenza geologica dello Yemen. *Boll. Serv. Geol. d'It.* 76 : 95-117.

MAIGRET A. de

1980 Prospezione archeologica nello Yemen del Nord. Notizia di una prima ricognizione. *Oriens Antiquus* 19 : 307-313.

1981 Two Prehistoric Cultures and a New Sabaeen Site in the Eastern Highlands of North Yemen. *Raidan* 4 : 191-204.

1982 Ricerche archeologiche nella Repubblica Araba Yemenita. Notizia di una seconda ricognizione. *Oriens Antiquus* 21 : 237-253.

1984 A Bronze Age for Southern Arabia. *East and West.* 34 : 75-106.

MARCOLONGO B. and PALMIERI A.M.

1986 Neo-tectonic evidences in Wadi Danah basin through geomorphological, sedimentological and archaeological observations. *Workshop on geophysics and its tectonic implications in the Arabian Peninsula and the Red Sea Region, SU/ICTP, Sana'a,* (in press).

MARCOLONGO B. and PALMIERI A.M.

1988 Environmental Modification and Settlement Conditions in the Yala Area, In : MAIGRET A. de (ed.) : *The New Sabaeen Archaeological complex in the Wadi Yala,* Rome : IsMEO XXI, 45-51.

McCLURE H.A.

1976 Radiocarbon Chronology of Late Quaternary Lakes in the Arabian Desert. *Nature* 263 : 755-756.

ZARATTINI A.

in press Neolithic settlements from North Yemen : data from field excavation. *International symposium : Late Prehistory of the Nile Basin and the Sahara.* Poznan 1984 (in press).