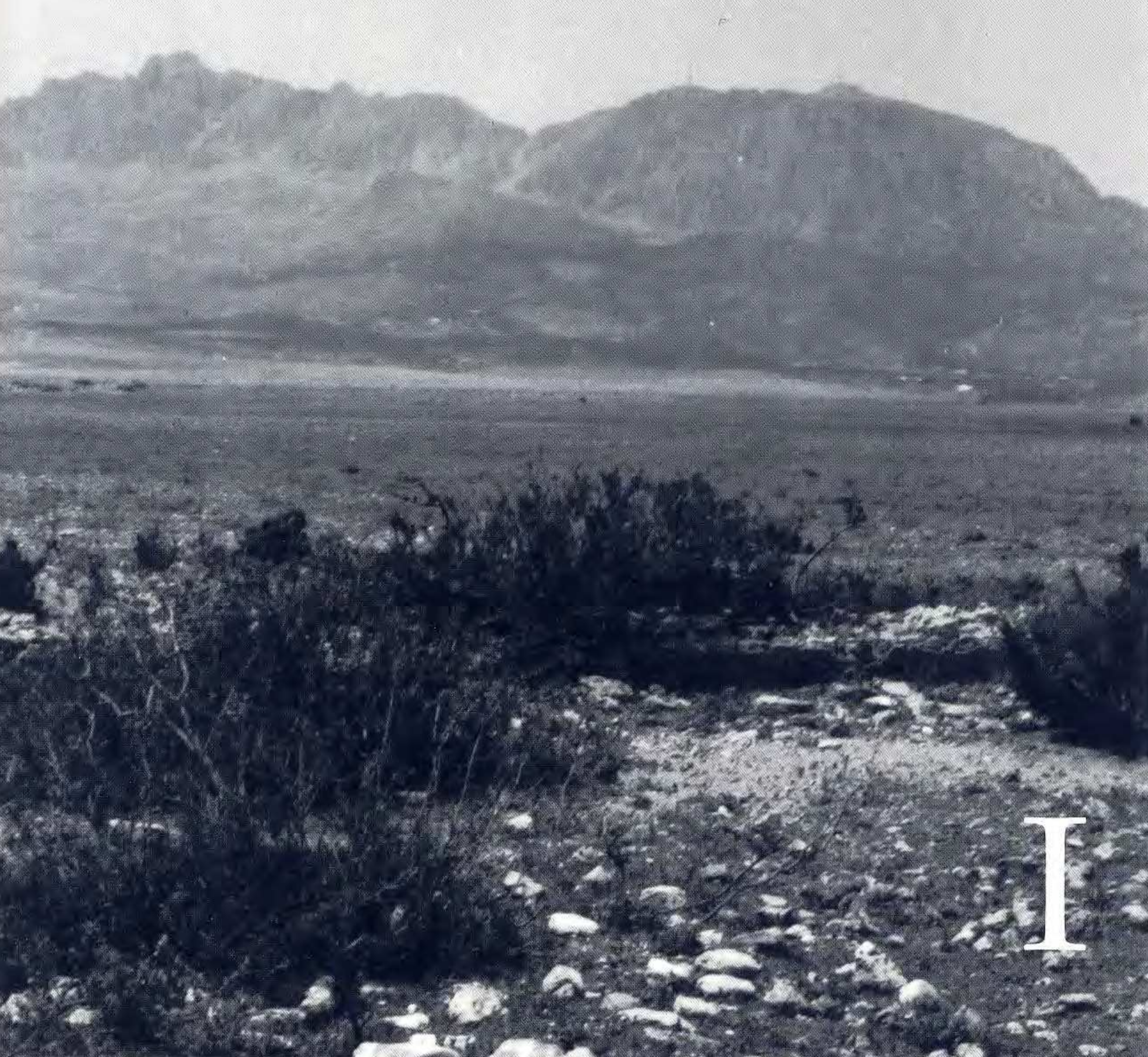
Africa Proconsularis

Regional Studies in the Segermes Valley of Northern Tunesia



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Regional Studies in the Segermes Valley of Northern Tunesia

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Geology and the Development of the Cultural Landscape

by Eberhard Zangger

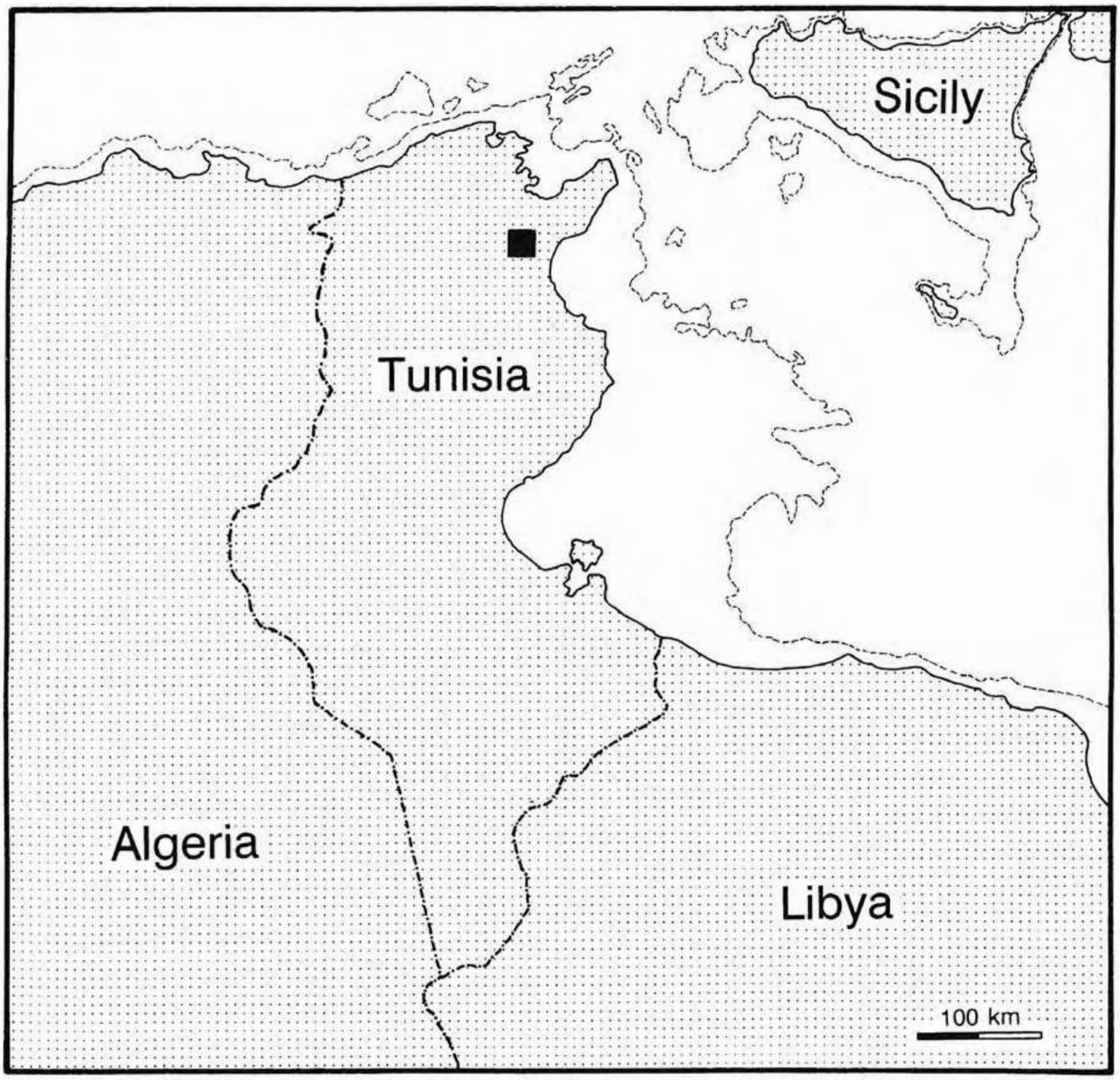


Figure 1: Location of field area in northeastern Tunisia. The dashed line indicates the 120 m bathymetric contour (after Shackleton et al. 1984) which is eqivalent to the shoreline at 18,000 BP.

Introduction

Largely due to its geographic location northern Tunisia has played a special role in the cultural history of the Mediterranean. Bounded by sea, desert, and mountains, Tunisia forms a segregated stronghold over the central Mediterranean. Nevertheless, distances to other countries are short: Sicily is only sixty miles away (Fig. 1), and freight transport between Tunisia and Rome by sea is effortless. In the Iron Age, when the whole Mediterranean came within easy reach and long distance trade became normal, an increasing demand for port cities in the central Mediterranean developed. At that time, the favourable geographic position of Tunisia as a base for trade and military action, was first recognized by the Phoenicians who established Carthage. The city, among other cities, developed an increasing sovereignty and at times dominated the Western Mediterranean. After the destruction of Carthage in 146 BC, Tunisia was subjugated and later became one of the major grain supplying areas of the Roman empire[1]. The Roman control of Tunisia succeeded by Vandal and Byzantine supremacy continued for almost a millennium, outlasting the empire itself. It was replaced by Arabic dominion in the late 7th century AD, and was colonized by France in the late 19th century, from which Tunisia acquired independence in 1956.

Cultural climaxes are often reflected in constructive and destructive responses in landscape evolution. The major cultural episodes of Punic, Roman, Islamic and French dominion of Tunisia therefore may have led to significant landscape changes. At the same time Tunisia embraces two very different climate regimes, the semi-humid Atlas mountain range in the North (precipitation > 700 mm/year) and the Sahara desert in the South (precipitation < 100 mm/year). The radical climatic changes during the last 20,000 years must have shifted the boundary between these two zones, and, if as is claimed by some authors[2], climate is the main controlling factor of soil erosion, then such shifts should be preserved in the Holocene depositional record. Hence, whatever the principal causes of Holocene landscape instability and soil erosion might have been, because of its well-defined cultural history and contrasting climate, Tunisia could provide the answer to the enigma.

Objectives

This geoarchaeological study of the eastern Segermes valley in Tunisia was carried out to determine the Late Quaternary stratigraphy, the Holocene depositional rate, the extent of environmental changes and their driving force, phases of soil instability and the past and present soil quality.

The evolution of the Tunisian landscape becomes especially important for an archaeological survey which concentrates on the countryside and not on the cities. Recent large scale erosion combined with redeposition of eroded material in topographically lower areas could have destroyed some archaeological sites, buried others, thereby distorting the archaeological record at the present surface.

This paper provides an introduction to the regional geologic history of Tunisia and the forming of the modern landscape with some emphasis on the origin and provenance of ore and building stone resources in the field area. Most new data are presented in the sections entitled *Quaternary Deposits* and *Soils and Holocene Depositional History*. The observations

1. Van Zeist & Bottema 1983
2. E.g. Vita-Finzi 1969, Bintliff 1977, Hassan 1985, 63

are analyzed and discussed in *Late Quaternary Landscape Evolution*. Finally, a detailed discussion will compare the new findings with analogous studies elsewhere in North Africa and aim to develop a generally applicable concept for the recent landscape evolution of Tunisia.

Physiography

The mountains and plateaus in North Tunisia are controlled by Mediterranean climate resulting in cool moist winters and hot dry summers, while fully arid conditions in the south dominate the Sahara desert. The Segermes valley (Lat. 40°40', Long. 10°20') lies in the east of the Dorsale, the easternmost part of the Atlas, close to the boundary between the temperate north and the dry south (Fig. 1). The field area is limited to the eastern part of the Segermes valley, 10-20 km west of the coastal village of Bou Ficha and extending ca. 15 km N-S (Fig. 2). Undulating hills, a few hundred meters high, enclose the valley, which is at the height of 45 m where it exits to the coastal plain.

Several important ephemeral streams cross the survey area on their 25 km path to the coast (Fig. 2). During floods from mid-September to October the streams spill over their banks leaving behind overbank loams and crevasse splay deposits several feet thick. Events like this require bulldozers to clean the roads. Apart from excessive husbandry carried out between the Segermes valley and the Sahara desert, agricultural use is generally moderate and includes mostly cereal fields and widely spaced olive orchards.

Regional Geologic History

The continent of Africa consists of a consolidated plate which has formed over 250 million years ago in the Precambrian and Palaeozoic era and which has not significantly changed in shape since (Fig. 3). The generally low and uniform relief of North Africa is due to the age of the plate. During the Mesozoic the African continent and Eurasia moved apart yielding space for the Tethys Sea, a predecessor of the Mediterranean Sea, to form between the continents. In the Jurassic and Cretaceous, North Africa was situated on the southwestern border of the Tethys which then covered the present Middle East and parts of North Africa where it laid down substantial marine sediments[3]. These Jurassic and Cretaceous deposits now serve as crude petroleum reservoirs. In the Tertiary the African plate moved northwards and collided with the Eurasian plate thereby causing the Alpine orogenesis during which the Mesozoic sediments in the Maghrib were folded and faulted.

The following description of the bedrock geology of the field area is based largely on the geologic map of Bou Ficha[4]. The oldest rocks found in the Bou Ficha area date back to the Triassic and occur near Hammam Djedidi in a 550 m by 80 m diapir (Fig. 2). The tectonic contacts of this diapir formed a mineralized breccia which, due to hydrothermal water, became enriched in lead, zinc, barium, strontium and fluorine. These deposits are mined today in Hammam Djedidi and Hammam Zriba. It is said that when the mine in Hammam Djedidi was founded during the French occupation, tunnels from a previous exploitation were discovered and attributed to Roman mining activities.

Jurassic and Cretaceous deposits occur near Hammam Djedidi and Hammam Zriba. The Jurassic sediments are massive, grey to red quartzitic limestones with foraminifers indicating a marine origin. The Cretaceous is represented in a several 100 m thick lithologically monotonous limestone which is sterile in the lower part and contains marine fossils in the upper part.

All building stones used in Roman constructions in the survey area are derived from Tertiary rocks (Fig. 2). The Tertiary sequence begins with Paleocene marine marls, 17-30 m thick, olive green to black in colour. During the Lower Eocene the marl was replaced by thickly bedded, quartzitic limestone, 120-190 m thick. In a quarry near Djeradou, just south of the survey area (Fig. 2), this Lower Eocene limestone is still mined today to produce grit for roads. The Roman orthostones in the southern half of the survey area are made of

3. Smith & Woodcock 1982
4. Johan & Krivy 1965

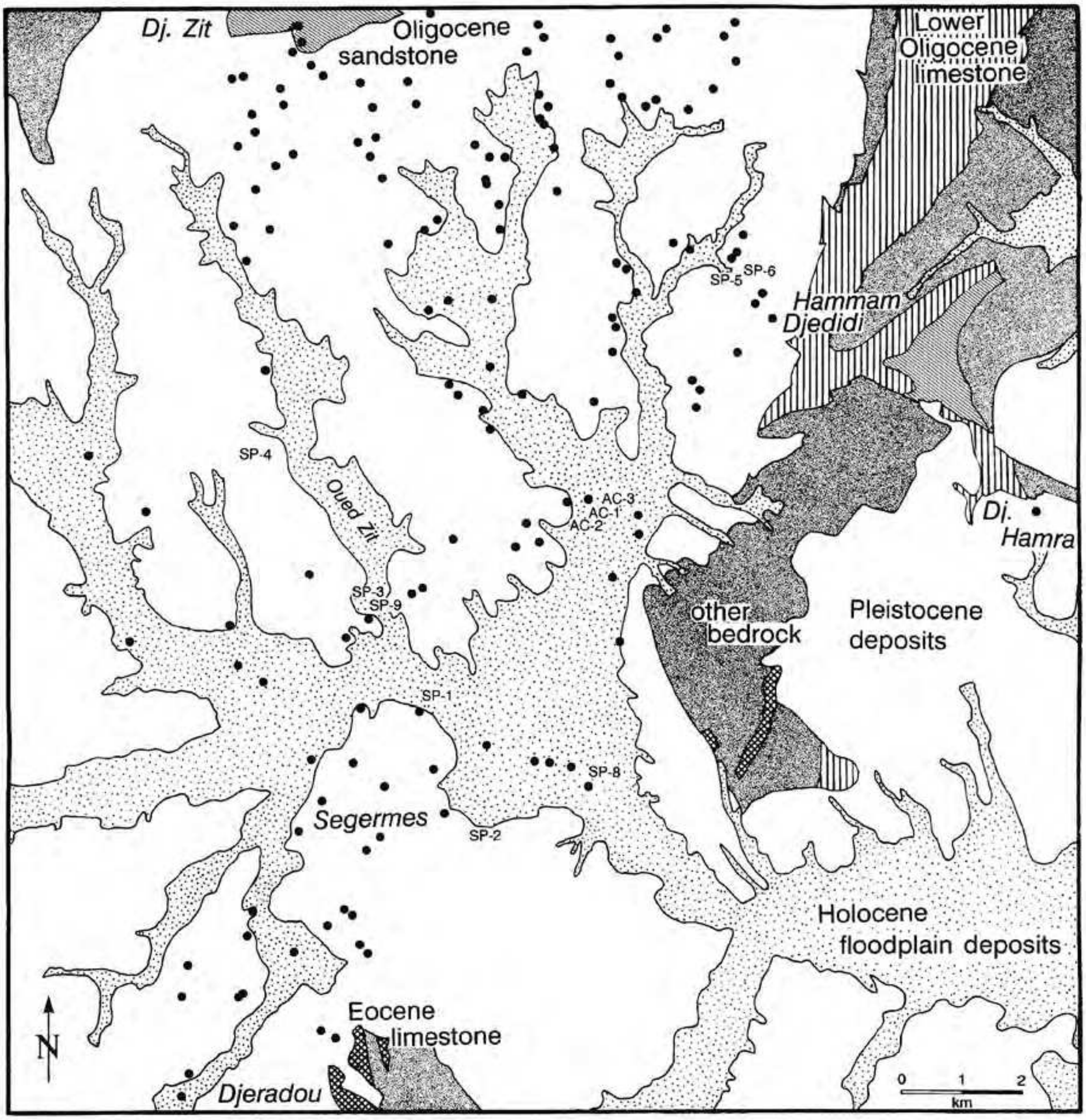


Figure 2: Geologic map of the field area (after Johan & Krivy 1965). Bedrock formations used for Roman building stones are labelled individually. The black dots indicate Roman findspots. The location of soil profiles described during the geoarchaeological fieldwork are labelled SP, auger cores are designated AC.

this limestone and were probably taken from the area near Djeradou as well. The rock has the advantage of being thickly layered with the bedding providing parallel surfaces 15-50 cm apart so that square blocks are easily and quickly hewn. However, because of its bedding, the Lower Eocene limestone cannot be used for the production of massive olive mills or counterweights.

The Lower Oligocene, on the other hand, appears in a massive limestone which could be used to manufacture large millstones. One olive mill, made of this rock, 70 cm high, 110 cm wide and weighing ca. 770 kg, was found at a site in square K16. The limestone has an exceedingly rich marine fossil fauna including abundant large shells of *Pecten arcuatus* (Fig. 3), allowing rapid identification on archaeological sites. During the geoarchaeological fieldwork an abandoned quarry of the *Pecten*-limestone was discovered at Djebel Hamra (Figs. 4-6). Near the quarry is an extensive Roman village with hundreds of upright standing orthostones, hewn of the same rock, providing a date for the mining activity. The Pecten-limestone also crops out in the NE-corner of the Segermes valley near Hammam Djedidi, but it was not used for orthostones in that area. The large quarry at Djebel Hamra is located at the farthest eastern exposure of

Era	Period	Epoch	Ma	Deposits	Tectonic Events
Cenozoic	Quaternary	Holocene Pleistocene	0.01 1.64	alluviations lake deposits	
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	65	massive limestone bedded limestone marine marl	collision of African and Eurasian Plate, Alpidian orogenesis
Mesozoic	Cretaceous		146	limestone	development of Tethys
	Jurassic		208	quartzitic limestone	
	Triassic		245	magmatic diapir	
Paleozoic			570		consolidation of African Plate
Precambrian					

Figure 3: Geologic timetable showing the periods mentioned in the text and the formations represented in the Bou Ficha area. Ma marks the lower boundary of each period in million years.

the *Pecten*-limestone, the mining was thus more oriented towards the sea than towards the land. In a time of strong demand for millstones and counterweights the massive limestone must have been appreciated as a precious raw material and was possibly used for trade via sea routes.

The Roman building materials in the northern half of the survey area consist entirely of a coarse, yellow to light brown, Upper Oligocene sandstone of terrestrial origin. This often conglomeratic deposit occurs only near Djebel Zit and in the mountains between Hammam Djedidi and Djebel Hamra. The Roman settlement at Djebel Zit could therefore have been a mining town like Djebel Hamra, notwithstanding the fact that quarries are no longer readily visible in the area.

Quaternary Deposits and Soils

The Pleistocene shoreline in North Africa, having fluctuated during the ice ages, regressed from its Tertiary inland position to a low sea level at 18,000 b.p. (Fig. 1) leaving Sicily and Tunisia separated only by a narrow channel[5]. Thus, the Pleistocene sediments of North Africa originated in terrestrial and lacustrine environments. According to Johan & Krivy (1965) over 700 m thick lacustrine deposits were deposited discordantly onto folded Mesozoic rocks after the termination of the Alpidian orogenesis during the Lower Pleistocene (Villafranchien). These grey, lithologically diversified, lacustrine clays are covered by yellow to red Upper Pleistocene (Sicilien) sand which is interlayered with marl, clay and scattered pebbles. Frequently occurring land snails (*Helicides*) are evidence of a terrestrial origin.

Where the Pleistocene deposits had been exposed for a long time mature soils formed on their surface. Enrichment of iron oxides and clay produced fat, red soil B horizons while precipitation of pedogenic carbonate resulted in solid subsurface caliche horizons. Such mature soils usually require a few ten thousand years of surface stability to form (Fig. 7). They cover roughly 70% of the surface in the Segermes valley (Fig. 2). Some Pleistocene soils are truncated: their soil A horizons have been washed away (SP-6, Fig. 8, Table 6), B horizons have disappeared or shifted into C horizons (SP-2, Fig. 8, Table 2) and at some places the whole soil above the indurated K horizon has been eroded. The exposed pedogenic calcite nodules are often recorded as Pleistocene gravel deposits on the geologic map. In conclusion, the Pleistocene soils provide a stable, arable platform for agriculture, which has been slightly eroded in the recent past.

5. Shackleton et al. 1984

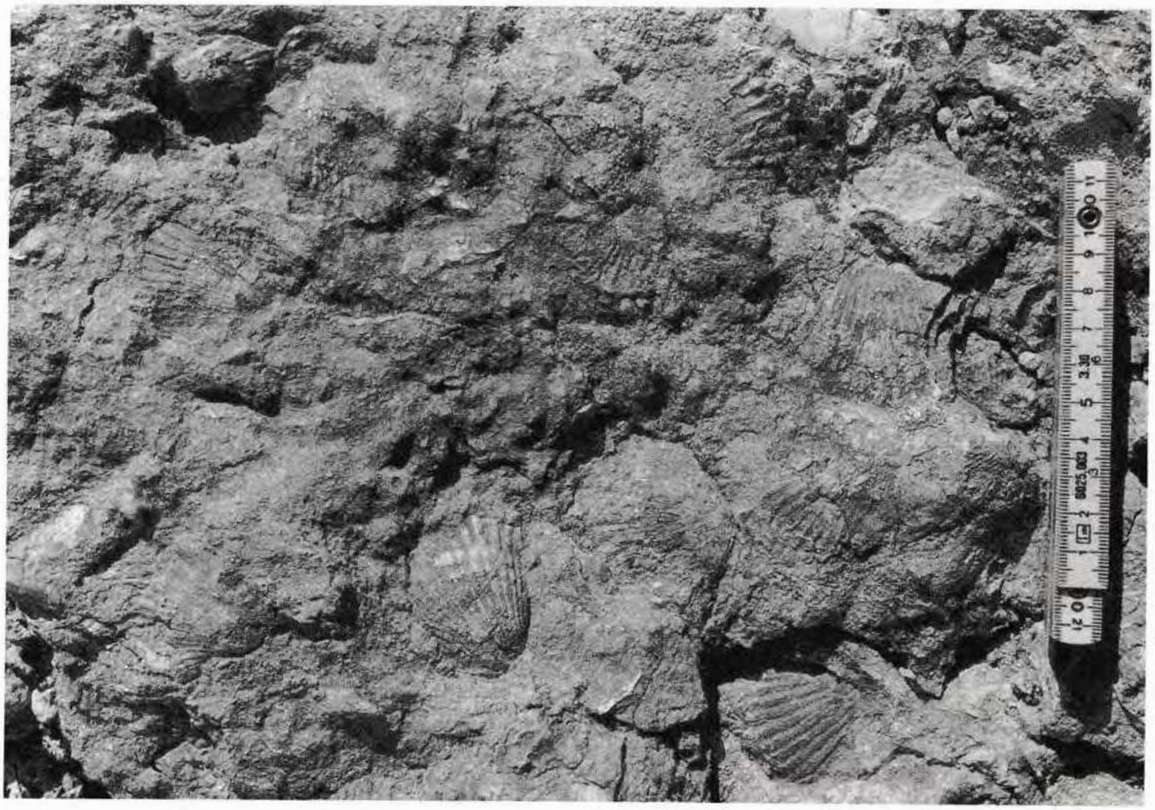


Figure 4: The Lower Oligocene limestone crops out near Djebel Hamra and contains large marine shells of Pecten arcuata. Because of its massiveness this rock has been used for Roman olive millstones.

Figure 5: This photograph shows a section of the Roman quarry near Djebel Hamra where the massive Lower Oligocene limestone was mined. Chissel marks are still preserved to the left and right of the 1 m scale.

Figure 6: Another section of the Roman quarry near Djebel Hamra. The blocks were extracted along a ca. 1 km long quarry face.

Figure 7: Mature Pleistocene soils require many thousand years of landscape stability to form. Since they cover roughly 70% of the field area, the overall soil quality of the Bou Ficha region has not changed dramatically during the Holocene. A 1.8 m exposure on the left side of the photograph was used to describe soil profile number 2. The white caliche horizon consisting of almost 100% of pedogenic calcium carbonate stands out, it is covered by a black 50 cm thick, fertile A horizon.

Holocene Depositional History

The oued floodplains comprise roughly 65 km^2 or 20% of the eastern Segermes valley and are mainly depositional environments (Fig. 2). The perpetual threat of devastating floods prohibits any agriculture leaving the wide plains to become covered by impenetrable shrub. Gully erosion and debris flows, often facilitated by poor land management,

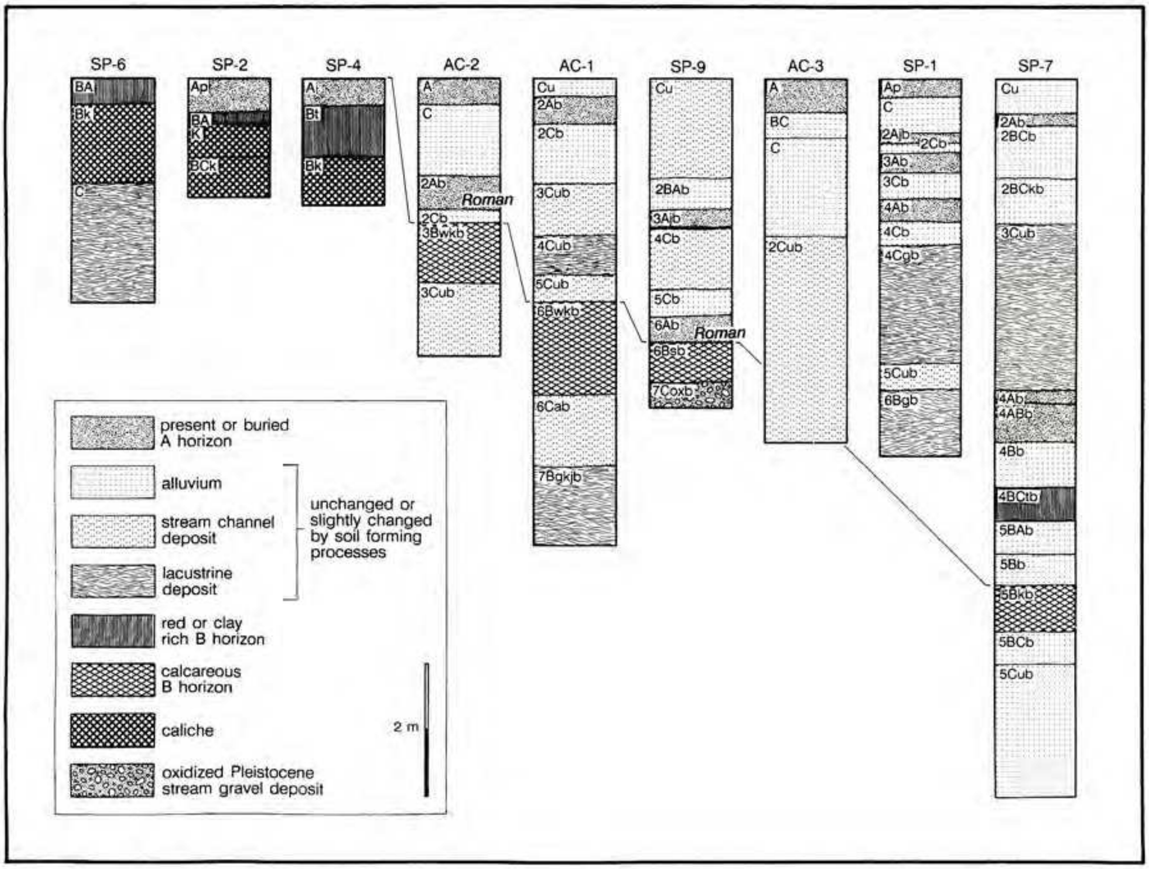


Figure 8: This diagram presents the soil stratigraphy of most auger cores and natural exposures examined in the Bou Ficha area. The columns are aligned according to the thickness of the Holocene deposits. The diagonal line connects the upper boundary of an early to middle Holocene soil which presented a stable surface in Roman time. Apart from this unit, all Holocene deposits are of post-Roman age providing evidence of how little landscape change occurred until the end of the Roman period. The soil nomenklature follows Birkeland 1984.

occur along the streams (Fig. 9). A few kilometres northwest of the archaeological survey area, gully erosion has become enhanced by tectonic uplift of the northern Segermes valley rim, resulting in an 11 m deep canyon (Fig. 10, Table 7).

The stream incision often reaches down to the harder Pleistocene surface, so that the entire Holocene depositional sequence, consisting of overbank alluvium, stream channel deposits and reduced subaqueous deposits, becomes exposed in the oued banks (Fig. 11). The buff alluvia are made up of well sorted homogenous silt, they are the most extensive Holocene sediments often reaching several meters in thickness. White, thinly layered, cross-bedded stream channel deposits are exposed in the stream banks where oued meanders have crossed previous courses. The stream channel deposits are made up of extremely well sorted sand, often resembling aeolian sediments (Fig. 11). Reduced subaqueous sediments formed in small ponds in the river beds are frequently intercalated with the stream channel deposits (Fig. 11). Small amounts of plant material, suitable for radiocarbon accelerator analysis, have been preserved in the anaerobic gley environment of these thinly laminated clays.

Figure 8 gives an impression of the Holocene depositional history of the Segermes valley. It consists of 6 soil profiles and 3 auger cores arranged by increasing depth to the Pleistocene surface. Three soil profiles (SP-2, SP-4, SP-6) from the margins of the floodplain (Fig. 2) showed no Holocene sediments at all. The Pleistocene age of these soils is indicated by their intense red colour (5YR – 7.5YR), thick clay films and mature Bk and K horizons – these soil characteristics require many thousands if not ten-thousands of years to develop.

A different paleosol, not as old and mature as the Pleistocene ones, was found in auger core 1, taken near the Roman site K15-1, 2.2 m of Holocene alluvium covered another paleosol which is not nearly as old and well developed as the Pleistocene paleosols. It dis-

Figure 9: Beginning gully erosion in an olive orchard. Note the wide spacing of the olive trees probably chosen to use the field for cereal cultivation too.

Figure 10: An ephemeral stream produced this 11 m deep ravine NE of the survey area (SP-7, Fig. 7, Table 7). The incision marks an east-west striking fault along which the northern rim of the Segermes valley is being uplifted.

tinctly differs from both, Pleistocene paleosols and Holocene alluvium, by way of its dark brown colour (10YR4/4) and calcareous B horizon which must have needed a few thousand years to form. This relative position in the sequence between Quaternary soils and

Figure 11: This photograph of Oued Zit in May shows how three different Holocene deposits form today. During the dry period a wetland develops in the stream bed (left) producing dark, fine grained, reduced, lacustrine deposits. In the autumn, when the amount of water and suspended sediment increases, thinly laminated, fine grained, well sorted, sandy stream channel deposits accumulate in the ravines (right). If the water level swells further the stream will spill over its banks and deposit silty floodplain alluvium (visible in the stream banks).

post-Roman alluvium makes a mid-Holocene age for this soil most likely. It was also found in the adjacent auger core 2 and can be correlated with mature Bs and Bk horizons in SP-7 and SP-9 (Fig. 8). The stratigraphy above this early Holocene soil consists entirely of alluvium, channel sands and lacustrine clay which cannot be correlated from place to place because they occur only locally (Fig. 8). Due to their limited age these deposits are unchanged or only slightly altered by soil forming processes. Several A horizons in the Holocene sequences indicate intermittent deposition.

A few auger cores (AC-1 to AC-4) were taken near two Roman sites (K15-1 and O15-1) in the floodplain to determine whether these sites had been established on alluvium and thus to ascertain whether the alluvium was pre- or post-Roman. Three auger cores were aligned in a cross-section near the K15 site (Fig. 12; core AC-1 was placed 110 m 128° SE of site). The cored stratigraphy (Fig. 8, 12) consisted mostly of alluvia and stream channel deposits with some lacustrine interlayers. The mid-Holocene paleosol discribed above was found in two auger cores. Sherds, charcoal and opus caementicium pieces in AC-2 mark the Roman surface in 1.7-1.8 m depth. Accordingly, the settlement had been established on the edge of the floodplain on top of the mid-Holocene paleosol; the margins of the site extended toward more recent stream channel deposits which covered the paleosol in the deeper parts of the oued. In post-Roman time the lower parts of the Roman site became buried by ca. 2 m of alluvium.

Soil profile 8 near the large but poorly preserved site O15-1 was combined with an auger core (AC-4) to investigate the stratigraphy below the current escarpment (Table 8). A simple twofold sequence consisting of 1.5 m of alluvium and 2.6 m of lake deposits was found with an underlying gravel horizon inhibiting further augering. Charcoal and sherds retrieved from the gravel layer implied that it could be correlated with the neighbouring site. If the site was established before the deposition of the lacustrine sediments parts of it could have been inundated by the lake. However, the site might also have been contemporary to the lake in which case it would be important to determine its function.

A key locality for an understanding of the

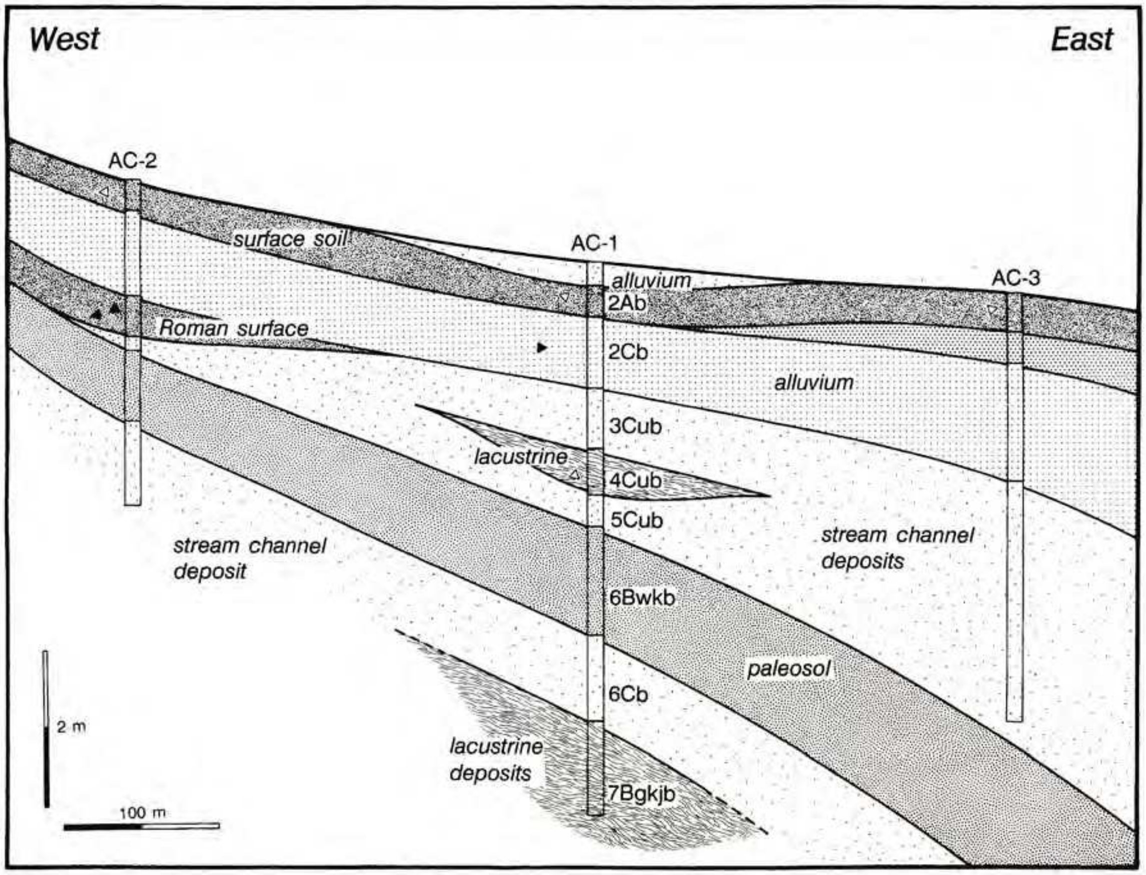


Figure 12: An auger core cross-section was produced in the vicinity of a large Roman site K15-1 to determine whether the settlement had been established on alluvial deposits. The Roman paleo-surface, indicated by sherds, charcoal, and cement pieces, was found in 1.5-2.0 depth in AC-2. The site had been established on an early to middle Holocene paleosol, but its outer area continued onto younger stream channel deposits. After the Roman period the lower parts of the site were buried by 1.5 m of alluvium. Empty triangels indicate undiagnostic pot sherds, full traingles mark the places were datable sherds were found.

Holocene environmental history was discovered in L12, where a Roman mausoleum (L12-2) which had been buried under 5 m of alluvium, became exposed in the banks of Oued Zit (Fig. 14, 15). The mausoleum consisted of two parallel 50 cm thick walls 2 m apart. The base of the grave was ca. 40 cm below the bottom of the stream bed and its walls had remained to a height of 1.4 m. The bottom of the walls was made of square hewn blocks, the upper 40 cm consisted of smaller boulders. The construction was enforced by opus caementicium, thus providing a Roman date even before ceramics from the site were examined. An archaeological team cleared the stratigraphy in and around the grave and produced another profile 120 m downstream where a burnt horizon had appeared in the bank. Two soil descriptions, one of the profile above the grave (SP-3) and one where the burnt layer was found (SP-9) are combined in Figure 14 with a sketch provided by the excavating archaeologist and a sketch of the stratigraphy in the river bank.

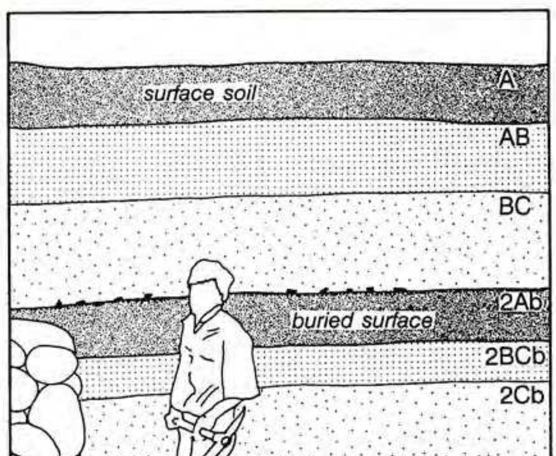


Figure 13: A buried Roman check dam was found in H17 providing evidence for the efforts made to stabilize the soil. The 1 m thick and 1.5 m high wall was founded on coarse stream gravel deposits. The first alluviation in this area sufficed to bury the entire wall. Large charcoal pieces on the former surface of this alluvium record a local fire somewhere in the vicinity. Later in time, this area was buried by 1.2 m of alluvium.

The lowest unit of the profile, a well-sorted stream channel gravel, was excavated in SP-9 at 4.6 – 5.0 m. This deposit stands out, because of its bright spotted colour (red, yellow and white) which originates from post-depositional movement of sesquioxides and unambiguously indicates a Pleistocene age. The upper boundary of the gravel was approximately level with the oued bottom showing once again that stream incision reaches down to the indurated Pleistocene surface but no further.

The Pleistocene stream gravel deposit is covered by a one meter thick overbank loam on which a mature paleosol developed. The characteristics of this paleosol are very similar to the one found in the auger core cross-section in Figure 12. Both record a few thousand years of landscape stability and both provided the surface during Roman times. The foundations of the mausoleum were laid one metre deep into this soil. A plaster of well rounded pebbles and many large pottery fragments were exposed in a depression of the paleosol's surface a few meters downstream of the grave (Fig. 14). These, as well as all other sherds found inside the grave and within the buried surface of the paleosol date to the 5th-6th century AD.

After that time the whole area including the mausoleum became buried by 3.5 m of unstratified alluvium. The lack of stratification and soil A horizons indicates that the alluvium was deposited in a short time, possibly in one season or even one single event. A large number of sherds, including African Red Slipped Ware, apparently emanated from the site uphill of the stream. This pottery, too, was dated Late Roman with the latest phases of the 7th century missing.

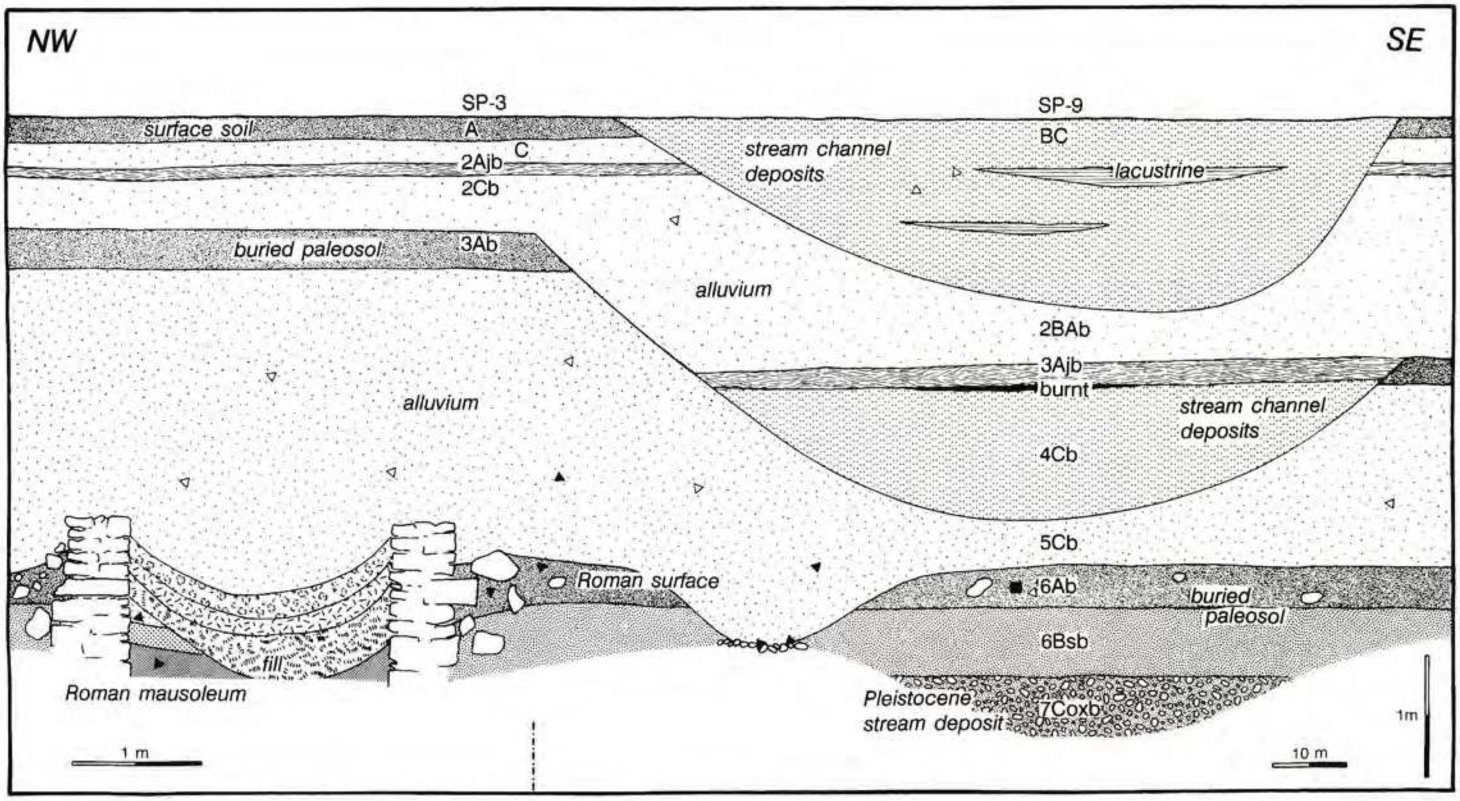
Landscape stability returned to the area after the first major alluviation allowing a soil A horizon to form (Fig. 14, unit 3, Fig. 15). Oued Zit then changed its path cutting into the alluvium. When the river had abandoned this bed it became gradually filled with stream channel deposits (unit 4, Fig. 14) until it was roughly level with the alluvium. At that time a local fire in the river bed produced a burnt horizon. Landscape stability continued for a while providing the time for the A horizon on the alluvium to mature and a juvenile A horizon to form on the stream channel deposits (unit 3, Fig. 14). Then the whole area became again buried by a second alluviation 0.5-1.5 m thick (unit 2, Fig. 14). A short period of equilibrium allowed just enough time for the development of a juvenile A horizon, before yet another alluvium was deposited, this one being only 30 cm thick. Oued Zit once again chose a path across the profile incising the most recent alluvium about 1.5 m deep. Its bed became filled with stream channel deposits and lacustrine clays which formed in small ponds in the river bed. Finally, the present river cut into the whole sequence down to the surface of the Pleistocene.

Late Quaternary Landscape Evolution

The excellent exposures in the eastern valley combined with the soil descriptions, the auger cores and the wealth of archaeological data provided by the Danish survey, allow an accurate reconstruction of the Late-Quaternary landscape evolution. The large number of sherds found in the Holocene deposits and the relative ages provided by the paleosols suffice to determine the time when landscape changes occured. The buried monuments especially, provide precise minimum dates for underlying deposits as well as maximum dates for superjacent ones.

The Sahara and North Africa in general saw far-reaching ecologic fluctuations during the last 1.5 million years including times when Lake Chad exceeded the size of the present Caspian Sea[6]. The ecology varied so drastically in time and space, that so far no explanation for this diversity could be provided. A more humid period 50,000 – 20,000 bp seems to have been followed by semiarid conditions 20,000 – 14,000 b.p.[7]. According to Brunnacker (1973, 1974) the climax of the last glacials was accompanied by dry climate in Tunisia with local loess deposition; only transitional phases displayed moister, pluvial conditions. During these times of increased rainfall, perennial high energy rivers carried much coarser sediments than the modern

6. For literature see Lamb 1982: 116; Nilsson 1983: 342; Williams & Faure 1980
7. Nilsson 1983: 342; Sonntag et al. 1980; Rossignol-Strick & Duzer 1979



oueds. A remnant of such Pleistocene stream gravel deposits was exposed at the base of SP-9 (unit 7, Fig. 14). These braided rivers also laid out the wide floodplains which are today reused by ephemeral streams.

Cave paintings from Tassili in the Central Sahara show lions, hippos, rhinoceroses, crocodiles, trees and boats. These pictures were drawn 4000 – 3000 BC when the monsoons brought more rainfall to the Sahara turning today's desert into a habitable steppe[8]. Between about 3000 and 2500 BC the north African climate became dryer because the storms coming from the Atlantic moved farther north. At 3000 BC Lake Chad still had a water level 30-40 m higher than today[9].

According to Chavaillon (1963, 1964) and Alimen (1965), who were not able to detect a straightforward relation between landscape stability and pluvial and arid phases, alluviations are most likely to occur during transitions between wet and dry stages. Such a transition at 3000 – 2500 BC apparently caused a general landscape instability resulting in the deposition of a roughly 1 m thick alluvium (unit 6, Fig. 14). Right after the alluviation, stability returned for a few thousand years allowing a deep soil to form on the surface. The alluvium and paleosol are consistently thick in the Segermes valley (AC-1, AC-2, SP-7, SP-9) and similar mature soils of mid-Holocene age have been found elsewhere in North Africa[10]. Their high clay, organic matter and phosphorus contents have been attributed to high levels of biological activity and moist conditions[11].

The landscape remained stable all the way through the Roman period. Uneroded Pleistocene red beds on the undulating hills and the mid-Holocene soil in the valleys provided rich arable land in an unusually balanced environment. Today's twofold landscape division of arable Pleistocene soils (70%) and desolated Holocene floodplains (20%) was not applicable in Roman times. Floodplains did not exist or were much smaller and thus there was no need to distinguish fertile Pleistocene from fertile mid-Holocene soil. We

Figure 14: A Roman mausoleum buried under 3.5 m of alluvium became semi-exposed in the bank of Oued Zit. Its walls were founded about 1 m deep in a mid-Holocene paleosol which had provided the Roman surface. The pottery associated with the mausoleum and the paleosol dates to the 5th and 6th century AD. Empty triangels indicate undiagnostic pot sherds, full triangles mark datable sherds. During the 6th cent. the mausoleum and the paleosol were buried by alluvia and stream channel deposits. Two horizontal scales are combined in this figure to show the monument in relation to the geologic profile.

8. Pearce 1989, 73
9. Lamb 1982, 116
10. Dorsett et al. 1984, Gilbertson, Hayes & Barker 1984; Gale, Gilbertson & Hunt 1986
11. Barker et al. 1983, 80; Gilbertson & Hunt 1988, 96

Figure 15: Photograph of the Roman mausoleum in L12 after it had been cleaned by an archaeological team. The hewn block in the front was reused as a foundation stone. A buried soil A horizon appears as a dark band 1 m below the surface.

therefore can assume that the whole area was uniformly used for agriculture.

Many Roman farms were established on hill tops, because they provided an advantageous view of a wide area. Combining the site distribution map with the geologic map reveals (Fig. 2), however, that a number of settlements were also placed in today's floodplains. According to the auger cores in K15 and O15 these sites rest on buried paleosols and their margins are covered by modern alluvium. More Roman settlements might be concealed farther down in the floodplain under thick alluvium.

As mentioned above, site O15-1, located at the lowest place of the Segermes valley where Oued R'mel is narrowest, became partly buried by lake sediments. The river was possibly dammed to produce this reservoir artificially. A simple lifting mechanism at the lake could have supplied Segermes with water that would otherwise be lost to the sea. Remnants of an aqueduct running westwards from O15 to Segermes have been reported by the archaeologists; a check dam to control a stream was found in H17 (Fig. 13). It is known that the Romans employed a highly sophisticated and effective water distribution system securing both water supply and the stability of the landscape. Numerous examples of check dams are described from Tripolitana[12]. The Roman control of the landscape was so effective, that not a single alluviation occurred during that time, despite the extensive agricultural use of the landscape. And the Roman land management continued in Vandal and Byzantine times.

When the Byzantine control of Tunisia came to an end during the 7th century AD the way of life became determined by semi-nomadic pastoralism and patch cultivation; erosion control measures were abandoned and the land management system collapsed entirely[13]. Pope & van Andel (1984, 297) have pointed out that terrace negligence with continued land use leads to maximum soil erosion. In Tunisia – similar conditions prevailed, masses of good soil, sufficient to bury the Roman mausoleum L12-2 3.5 m deep, were eroded and redeposited in a short time (unit 5, Fig. 14). A large number of sherds

12. Vita-Finzi 1960; Gale, Gilbertson & Hunt 1986
13. Barker & Jones 1982, 3; Vita-Finzi 1960

Figure 16: Overgrazing leaves depleted vegetation consisting of large trees and shrub.

collected from the alluvium provide a reliable maximum age for the deposition (middle of the 7th century AD). Of course, the deposition could have occurred long after the seventh century AD, but the lack of Hellenistic pottery most likely indicates a deposition before that period. The sequence of events described above for the mausoleum site illustrates the subsequent instability of the landscape.

In conclusion, the Late Quaternary landscape evolution of the eastern Segermes valley is characterized by long lasting stability interrupted only by a single regionally occurring alluviation in the mid-Holocene. With the abandonment of the land management in the 7th century, the landscape stability collapsed resulting in soil erosion and deposition of alluvia many times thicker than those of the mid-Holocene. Ever since then the landscape has not regained its balance.

The general agricultural productivity of the country suffered severely from the post-Roman soil erosion. One quarter of formerly arable ground turned into wasteland in the form of floodplains. If the Holocene alluvia uniformly covered the whole floodplain, every vertical meter of post-Roman deposit would represent 25 cm of soil loss. The truncated Pleistocene paleosols, however, indicate that the total soil loss was only ca. 20 – 30 cm, which would still suffice to provide 500,000,000 m^3 of mud. Nevertheless, enough of the fertile A horizons on Pleistocene surfaces have been preserved and even the floodplain alluvium, although less fertile than a mature soil, is perfectly suitable for agriculture.

Discussion

Due to its distinct cultural history and its drought-prone, fragile climate, the Tunisian environment serves as an excellent tool to determine whether climate or man are the dominant controlling agencies of Holocene soil stability. Until twenty years ago most scholars favoured human impact as the most important cause of soil erosion. Vita-Finzi (1960) himself wrote: »*The deduced sequence of post-Roman changes* (in Tripolitana) *resembles that described in other parts of N-Africa, notably*

Figure 17: In this area west of Djebel Hamra the vegetation is much less exploited by husbandry than in the Segermes valley. Complete removal of the herds would probably result in a dense vegetations and stable soils within a matter of decades.

Tunisia and human agencies may be the common factor... It is tempting to explain the similarities between the post-Classical geologies of Tripolitana and other parts of North Africa by parallels in the history of human occupance.»

In 1969, however, Vita-Finzi's book »The Mediterranean Valleys» appeared introducing the simple »Older Fill/Younger Fill» concept of climate induced soil instability. Despite serious reservations by other scholars[14] this concept became widely accepted. Reexamination of the Late-Quaternary depositional history especially in Greece[15] led to the conclusion, that soil erosion and redeposition have occurred irregularly and that it was most likely caused by changes in agricultural technique[16].

The present study of the eastern Segermes valley shows two phases of soil erosion during the last ten thousand years. The first one resulted in the deposition of a 1 m thick alluvium in the mid-Holocene, the second one coincided with the collapse of the Roman/Byzantine land control in the 7th century AD and resulted in up to 4 m of alluvium. Therefore, changes in political control have had a far more important impact on the environment than the drastic climatic change at the end of last ice age.

(This article was submitted in March 1990).

14. E.g. Butzer 1969, Davidson 1971; 1980; Eisma 1978; Wagstaff 1981
15. Pope & van Andel 1984, Demitrack 1986, Finke 1988
16. Van Andel & Zangger 1990

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.00 - 0.30	Ap	10YR 3/3	dark brown	10YR 4/3	dark brown	sil	f-m abk 2	sh/ss		0.0-2.5 m alluvium
0.30 - 0.80	C	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	s	no	lo/so		^{14}C sample [N-12-SP1: 0.5m]
0.80 - 0.95	2Ajb	10YR 5/3	brown	10YR 4/3	dark brown	sil	m sbk 2	sh/s		
0.95 - 1.10	2Cb	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	s	f sbk 1	so/so		
1.10 - 1.40	3Ab	10YR 4/3	dark brown	10YR 5/4	yellowish brown	sil	c sbk 3	h/ss		
1.40 - 1.80	3Cb	10YR 4/4	dark yellowish brown	10YR 5/4	yellowish brown	s	m sbk 1	sh/so		
1.80 - 2.10	4Ab	2.5Y 4/4	olive brown	2.5Y 4/4	olive brown	sil	c sbk 2	h-vh/s		lime around roots
2.10 - 2.50	4Cb	2.5Y 4/4	olive brown	2.5Y 5/4	light olive brown	sil	c sbk 1	h/ss		0.5-3 cm thick sand layers
2.50 - 4.30	4Cgb reduced lacustr. deposits	5Y 6/1 5Y 5/1 2.5Y 6/4	gray gray light yellowish brown	2.5Y 5/2	grayish brown	C				5-10 cm thick sand layers, undiagnostic shards, abundant carbonized roots
4.30 - 4.70	5Cub stream channel deposit			10YR 6/4	light yellowish brown	f-c sand				cross bedding, laminar bedding, extremely well sorted, locally mixed with shell fragments
4.70 - 5.70	6Bgb reduced lacustr. deposits			2.5Y 4/0	dark gray	C				rich in carbonized roots and charcoal; carbonate 1sf; ^{14}C sample from 4.7-4.8 m [N-12-SP1: 4.7 m]

Table 1: Soil profile 1 (square N12) was taken from a fresh 5.7 m deep cut bank of Oued Zit (see also Fig. 8). The profile shows a sequence of stream channel and lacustrine deposits. The soil taxonomy and abbreviations are based on Birkeland 1984 and Soil Survey Staff 1975.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.5	Ap	10YR 3/2	very dark grayish brown	10YR 3/2	very dark grayish brown	sicl	m sbk 2	so/s		humus, rich fertile top soil
0.5 - 0.7	BA	10YR 4/2	dark grayish brown	10YR 4/2	dark grayish brown	sicl	c sbk 1	h/s		
0.7 - 1.2	K	10YR 6/4	light yellowish brown	7.5YR 7/4	very pale brown	sc	vc pl 1	vh/ss		laterally thinning; well preserved landsnails
1.2 - 1.8	BCk	7.5YR 5/6	strong brown	7.5YR 5/6	strong brown	c	m abk 3 - vf pr 2	h/s		

Table 2: Soil profile 2 (square P13) showing the maturest Pleistocene soil found in the eastern Segermes valley (see also Fig. 7-8). A solid calcrete horizon (K) indicates many thousand years of surface stability in this area.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.2	Aj	10YR 4/2	dark grayish brown	10YR 5/4	yellowish brown	sicl	f sbk 1	h/ss		burnt
0.2 - 0.4	C	10YR 4/3	dark brown	10YR 5/4	yellowish brown	sicl	m sbk 2	h/ss		
0.4 - 0.5	2Ab	10YR 3/2	very dark grayish brown	10YR 4/2	dark grayish brown	sil	m abk 2	vh/ss		burnt
0.5 - 0.9	2Cb	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	scl	m sbk 1	h/s		
0.9 - 1.2	3Ajb	2.5Y 5/4	light olive brown	10YR 5/2	grayish brown	sil	m sbk 1	h/ss		
1.2 - 4.3	3Cb	2.5Y 5/4	light olive brown	10YR 6/6	brownish yellow	ls	f pr 2	vh/ss		unsorted, small rounded pebbles, many sherds

Table 3: Soil profile 3 (square L12) was taken from the profile above the buried Roman mausoleum (see also Fig. 14-15). It shows three phases of alluviation interrupted by periods of stability indicated by A horizons. Many sherds from the early 7th century were found in the lowest alluvium.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.4	A	5YR 3/3	dark reddish brown	2.5YR 3/4	dark reddish brown	c	m sbk 2	vh/s		disturbed by road construction; rich in roots and organic matter
0.4 - 1.2	Bt	2.5YR 3/6	dark red	2.5YR 3/6	dark red	c	c abk 3 m pr 3	vh/vs		clay films 3kpf
1.2 - 1.9	Bk	5YR 5/6	yellowish red	5YR 5/6	yellowish red	cl	c abk 2	vh/s		nodules 3 rsc, ca. 2 cm diam.

Table 4: Soil profile 4 (square I10) represents another mature Pleistocene soil with its typical dark red color, thick clay films and calcite nodules (see also Fig. 8).

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.3	A	10YR 3/3	dark brown	10YR 3/2 mottled with 10YR 5/6	very dark grayish brown yellowish brown	l	f sbk 1	sh/s	ev	many roots in 5-10 cm; pebbles throughout section
0.3 - 0.7	AB	10YR 4/3	dark brown	10YR 4/3	dark brown	sl	m pr 1	h/s	ev	
0.7 - 1.2	BC	10YR 4/4	dark yellowish brown	10YR 5/4	yellowish brown	sl	m sbk 2	h/ss	ev	
1.2 - 1.5	2Ab	10YR 3/2	very dark grayish brown	10YR 3/2	very dark grayish brown	sl	f sbk 1	sh/so	ev	surface burnt, abundant charcoal in top layer; 1.3-2.8 m: wall
1.5 - 1.7	2BCb	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	sl	c sbk 2	h/so-ss	ev	
1.7 - 2.5	2Cb	10YR 5/4	yellowish brown	10YR 6/6	brownish yellow	ls	m sbk 1	sh/so	ev	
2.5 - 3.1	3Cub stream channel gravel			10YR 6/6 10YR 7/1	brownish yellow light gray	G			ev	sightly rounded boulders <20cm; shards in top layer, roof tiles, charcoal

Table 5: Soil profile 5 (square H17) corresponds to the section in Figure 13. A Roman check dam on the lowest deposit (stream gravel) was buried by later alluviations. Subsequently, an A horizon formed on this alluvium. A number of charcoal pieces were deposited on this surface. Afterwards, a second alluviation covered the whole profile with another 1.2 of silt.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.4	BA	7.5YR 5/6	strong brown	7.5YR 5/6	strong brown	sl	vc abk 2	h/so	ev	truncated
0.4 - 1.6	Bk	7.5YR 4/4	dark brown	7.5YR 5/6	strong brown	sl	m sbk 2	sh/ss	ev	Pleistocene paleosol; calcite nodules 3rs (<4cm)
1.6 - 3.4	C reduced lacustr. deposit	2.5Y 6/2 5Y 7/1 10YR 6/1	light brownish gray light gray light brownish gray			C	none	eh/vs	ev	tectonically disturbed; life roots on tectonic filaments; very poor clay

Table 6: Soil profile 6 (square H17) was taken 50 m upstream of SP-5. A mature soil formed here during the Pleistocene on reduced lacustrine deposits. The upper units of this soil are eroded.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.5	Cu alluvium	10YR 5/4	yellowish red	10YR 5/3	brown	clay	f sbk 2	h/vs	ev	thick dead roots
0.5 - 0.7	2Ab alluvium	10YR 3/3	dark brown	10YR 5/3	brown	sil	f sbk 2	vh/ss	ev	eroded sherds
0.7 - 1.5	2BCb	10YR 4/3	dark brown	10YR 5/4	yellowish brown	sil	f sbk 2	vh/ss	ev	alluvium 0.5-2.2 m
1.5 - 2.2	2BCkb	10YR 5/3	brown	10YR 6/3	pale brown	sil	f abk 2	h/ss	ev	carbonate 1 sf
2.2 - 4.7	3Cub reduced lacustr. deposit	2.5Y 4/2	dark grayish brown	2.5Y 5/2	grayish brown	clay	-	-/vs	ev/e	rich in fine roots
4.7 - 4.9	4Ab alluvium	10YR 5/3	brown	10YR 4/3	dark brown	sil	f sbk 1	sh/ss	e	
4.9 - 5.5	4ABb	10YR 5/3	brown	10YR 5/4	yellowish brown	sil	vf pr 1	vh/s	e	
5.5 - 6.2	4Bb	10YR 5/3	brown	10YR 5/4	yellowish brown	sicl	m abk 1	vh/s	e	
6.2 - 6.7	4BCtb	10YR 4/4	dark yellowish brown	7.5YR 5/4	brown	c	m pl 2	vh/s	es	
6.7 - 7.2	5BAb	10YR 5/4	yellowish brown	10YR 6/6	brownish yellow	sil	m sbk 2	vh/ss	es	truncated
7.2 - 7.7	5Bb	10YR 5/6	yellowish brown	7.5YR 5/8	strong brown	sl	c sbk 2	eh/ss	ev	
7.7 - 8.4	5Bkb	10YR 5/4	yellowish brown	7.5YR 5/6	strong brown	sl	none	eh/s	ev	1 rsm
8.4 - 8.9	5BCb	10YR 6/6	brownish yellow	10YR 7/6	yellow	sl	none	sh/s	ev	
8.9 -10.9	5Cub	7.5YR 5/8	strong brown	7.5YR 6/8	reddish yellow	s	none	so/so	ev	

Table 7: Soil profile 7 (square E2) shows the stratigraphy of the 11 metre deep canyon depicted in Figure 10. Despite the great depth of the section, all exposed deposits are of Holocene age.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 1.5	Cu modern alluvium	10YR 3/3	dark brown	10YR 5/3	brown	M				very few shards, some land snails
1.5 - 4.1	Cu lacustr. deposit	10YR 3/3 5Y 4/1	dark brown dark grey	mottled		clay				lacustrine character increasing with depth
4.1 - 4.3	Cu pebbles in lacustr. matrix	5Y 4/1	dark grey			gM				stream pebbles 4-5 cm; charcoal and shards; could be correlated with site O-15

Table 8: Soil profile 8 (square O15) was combined with auger core 4 to determine the stratigraphy below the current gully escarpment. The profile consists of recent alluvial and lacustrine deposits. A pebble layer in 4.3 m inhibited further augering.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 1.50	Cu stream channel deposit	10YR 5/4	yellowish brown	10YR 6/6	brownish yellow	S	laminar bedding and cross-bedding	-/so	ev	interlayered with two 10-15cm thick clay layers; some eroded shards
1.50 - 2.00	2BAb trunc. alluvium	10YR 4/2	dark grayish brown	10YR 5/3 mottled with 7.5YR 5/8	brown, mottled with strong brown	sil-M	none	-/s	ev	small charcoal pieces, unregu-larily dispersed; roots
2.00 - 2.25	3Ajb alluvium	10YR 4/2	dark grayish brown	10YR 4/2	dark grayish brown	sicl-C	none	-/vs	ev	carbonate: sf
2.25 - 2.28	burnt soil surface	10YR 2/1	black	10YR 2/1	black	sic	f sbk 2	-/s	es	extends a few meters laterally
2.28 - 2.30	oxydized soil	5YR 3/3	dark reddish brown	2.5YR 4/6	red	sic	f sbk 1	-/s	ev	caused by burning
2.30 - 3.20	4Cb stream channel deposit	2.5Y 5/4	light olive brown	10YR7/4	very pale brown	S	none	-/ss	ev	crossbedding; erosional lower boundary
3.20 - 3.60	5Cb trunc. alluvium	10YR 5/3	brown	10YR 5/6 10YR 3/1	yellowish brown very dark gray	sic	f sbk 1	-/s	ev+	mottled colour; root structures; landsnails
3.60 - 4.00	6Ab	2.5Y 5/4	light olive brown	10YR 4/3	dark brown mottled with black	sil	none	-/s	ev+	humus rich A-horizon; two undiagnostic shards; charcoal sample in 3.8m: [L-12-SP9:3.8m]
4.00 - 4.60	6Bsb	10YR 5/6	yellowish brown	10YR 6/8	brownish yellow	s	none	-/so	ev	
4.60 - 5.00	7Coxb Pleisto-cene stream deposit			10YR 8/2 10YR 6/8 2.5YR 4/6	white brownish yellow red	S	none	-/	none	well rounded pebbles up to 6 cm

Table 9: Soil profile 9 (square L12) was taken from a cut bank of Oued Zit 150 m downstream of the buried Roman mausoleum (see also Fig. 8, 14-15). This profile was cleaned by an archaeological team to investigate the burnt layer in 2.25-2.28 m. No evidence was found that the fire was attributable to human impact. Unit 6 represents the mid-Holocene soil which provided the surface in Roman times.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.3	Cu alluvium	2.5Y 4/4	olive brown	10YR 7/4	very pale brown	zS			e	
0.3 - 0.7	2Ab	10YR 4/3	dark brown	10YR 4/3	dark brown	sM				contains undiagnostic shards
0.7 - 1.6	2Cb alluvium	10YR 4/4	dark yellowish brown	10YR 5/4	yellowish brown	sM				contains shards
1.6 - 2.4	3Cub stream channel deposit	2.5Y 4/4	olive brown	2.5Y 5/4	light olive brown	mS				well sorted
2.4 - 3.0	4Cub lacustr. deposit	2.5Y 4/4	olive brown	10YR 5/4	yellowish brown (mottled)	C				few charcoal pieces; small, undiagnostic shards in 2.8 m
3.0 - 3.4	5Cub stream deposit	2.5Y 4/4	olive brown	10YR 7/4	very pale brown	mS				
3.4 - 4.8	6Bwkb juvenile paleo-sol	2.5Y 4/4	olive brown	10YR 5/3	brown	M				well consolidated; root structures; calcite nodules <5 mm
4.8 - 5.9	6Cgb stream channel deposit	10YR 3/2	very dark grayish brown	10YR 4/4	dark yellowish brown	S				groundwater at 4.8 m
5.9 - 7.1	7Bgkjb reduced lacustr. deposit	7.5YR 2/0	black	5Y 4/1 mottled	dark gray	M			ev	incipient carbonate precipitation

Table 10: Auger core 1 from the Roman site in square K15 shows the typical Holocene sequence of alluvium and stream channel deposits interrupted by some reduced lacustrine deposits (Fig. 8, 12). The paleosol in unit 6 is most likely of mid-Holocene age.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.4	A	10YR 3/3	dark brown	10YR 4/3	dark brown	l				
0.4 - 1.5	C alluvium	10YR 4/3	dark brown	10YR 6/6	brownish yellow	sM				dispersed undiagnostic shards
1.5 - 2.0	2Ab	10YR 4/4	dark yellowish brown	10YR 4/3	dark brown	sl				shards, charcoal and cement pie-ces in 1.7-1.8 m; probably Roman surface
2.0 - 2.2	2Cb alluvium	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	sM				
2.2 - 3.1	3Bwkb buried paleo-sol	10YR 4/3	dark brown	10YR 4/3 mottled	dark brown	sil				incipient nodule formation (<5mm); consolidated
3.1 - 4.2	3Cub stream channel deposit	10YR 5/6	yellowish brown	10YR 6/6	brownish yellow	S				extremely well sorted; groundwater at 4.2 m; whole collapsed

Table 11: Auger core 2 was taken 300 m west of AC-1. Sherds and cement in 1.7-1.8 m mark the Roman surface. The margins of the adjacent site (K15) must be buried by ca. 2 m of alluvium.

Depth [m]	Horizon	MUNSELL	Colour, wet	MUNSELL	Colour, dry	Text.	Structure	Consist.	HCl	Miscellaneous
0.0 - 0.2	Aj	10YR 4/2	dark grayish brown	10YR 5/4	yellowish brown	sicl	f sbk 1	h/ss		burnt
0.2 - 0.4	C	10YR 4/3	dark brown	10YR 5/4	yellowish brown	sicl	m sbk 2	h/ss		
0.4 - 0.5	2Ab	10YR 3/2	very dark grayish brown	10YR 4/2	dark grayish brown	sil	m abk 2	vh/ss		burnt
0.5 - 0.9	2Cb	10YR 5/4	yellowish brown	10YR 5/4	yellowish brown	scl	m sbk 1	h/s		
0.9 - 1.2	3Ajb	2.5Y 5/4	light olive brown	10YR 5/2	grayish brown	sil	m sbk 1	h/ss		
1.2 - 4.3	3Cb	2.5Y 5/4	light olive brown	10YR 6/6	brownish yellow	ls	f pr 2	vh/ss		unsorted, small rounded pebbles, many sherds

Table 12: Auger core 3 was aligned with AC-1 and AC-2 and located furthest to the stream. The mid-Holocene soil was not found in this core.

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