Petroleum Res. J. Vol. 12 (2000); P. 39–46, 10 Figs.

Groundwater Recharge in Jabal al Haruj and Vicinity, Central Libya

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تغذية المياه الجوفية بجبل الهروج والمناطق المجاورة، وسط ليبيا

المبروك أبوسريويل

تفيد الدراسات الحقلية أن منطقة جبل الهروج تعرضت حديثاً إلى عدة رخات قوية من الأمطار وأن جزءاً منها قد وجد طريقه للخزان الجوفي العلوي، ونظراً لنمو الأعشاب والأشجار ببطون الوديان بالهروج وتواجد بعض الحيوانات الثدية آكلة الحشائش به فإنه بالإمكان القول وبدرجة عالية من الثقة أن منطقة الهروج تلعب دوراً هاماً في تغذية الخزانات العلوية بالمنطقة المجاورة له، إلا أن هذه التغذية لا تكفي بالضرورة لمتطلبات الزراعة المروية على نطاق واسع. كما أن تعرض مناطق غات والسرير وشرقي جبل الحساونة إلى هطول أمطار غزيرة أحياناً، توحي بأن الخزان الجوفي العلوي، لتلك المناطق قد لا يعتبر بالضرورة غير متجدد.

تحوي الهروج أدلة على تساكن الإنسان القديم به ووجود بحيرات قديمة بالمناطق المجاورة له ترجع نشأتها إلى جريان المياه من مرتفعات الهروج إبان تعرض هذه المنطقة وشرقي الصحراء الكبرى إلى مناخ مطير ورطب. كما يعتقد أن الهروج يمثل أحد منابع نهر قديم موجود أثاره بالسرير حالياً، كما يستدل من تواجد صخور البيوميس الموجود حالياً بالسرير أن هذه المنطقة قد عبرها نهر قديم نبع أحد فروعه من جبل تيبيستي المصدر الوحيد لتلك الصخور البركانية.

Abstract: *Field observations suggest that Al Haruj area is subjected recently to periodic heavy showers and parts of the surface water are diverted from surface to underground routes. The presence of herbivores animals and the wide spread of vegetations in wadi beds, is suggestive, with a high degree of confidence, that Al Haruj region is certainly acting as a recharge zone to the local basal aquifer and subsequently to the interconnected aquifers. The present recharge in Al Haruj and adjacent areas will always be essentially smaller than major extraction demand for irrigation purposes. Periodic heavy showers on Ghat Oasis, As Sarir and East Al Hassawinah areas can tentatively suggest that the groundwater of the upper aquifer of these areas cannot be considered as a fossil water.*

The area contains evidence of in-situ prehistoric sites and eviron palaeolakes. It is thought that surface water was formed locally in the surrounding of the present discharge areas, mostly during a time when a more humid climate prevailed all over the Al Haruj, and the East Sahara. The palaeoriver in As Sarir is thought to have been originated mostly from the eastern slopes of Al Haruj. Pumice rock fragments, found in As Sarir area, are taken to indicate that these rock fragments, were associated with discharge areas from Tibisti massif, the source of this type of volcanic rocks.

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INTRODUCTION

Jabal Al Haruj al Aswad is situated in central Libya. The highest elevation lies approximately 700 m above the surrounding terrain. The catchments consist largely of Tertiary and Quaternary basaltic lava flows. These flows cover an area of approximately 42,500 km^2. Scattered outcrops of Tertiary sediments occur mostly in the southern parts of Al Haruj area. Climatic records and hydrogeological data of the area do not exist (Pallas, 1980) and the palaeoclimatology of al Haruj area has not been studied. The northern and central parts of the area were dealt with by Woller (1984), Vesely (1985) and Busrewill and Swaisi (1993) as part of the programme of regional mapping of Libya.

The winter is typically Saharan: warm in winter (very cold at night with occasional frost, and warm during the day), and hot in summer, with a few gheblis (sand storms). Perennial shrublets are *Rus tripertata, Acacia tortillas* and *Ziziphus lotus*. The annuals (herbs and grasses) provide a ground cover over the pre-existing landscape of lava flows, but barren ground is widespread when the area was cursed by droughts.

RECENT SURFACE DRAINAGE

Drainage developed on lava flow surfaces shows systematic change with increasing flow age. Field and remote sensing data show drainage frequency increases as flows become progressively older. The most common type of drainage pattern in the older lava flows is dendritic. This type of drainage pattern is very well developed on phase two lava flows (Busrewil and Swaisi, 1993). The other type of drainage is the radial drainage pattern. It consists of wadis flowing away from the central area of Al Haruj to the north, east and south directions. The drainage in the more recent lava flows is entirely internal and no system is recognizable. Here, rainfall usually finds its way to underground routes through existing lava ridges (Fig. 1) and joints. The most important drainage channels in the area are Wadis Bu al Hidan, Sayyad, Maayder, al Had, Bil Qaraf, Aj Jidari, al Baqar, Bu Shubayrim, al Mrar, Waddan and al Atheb

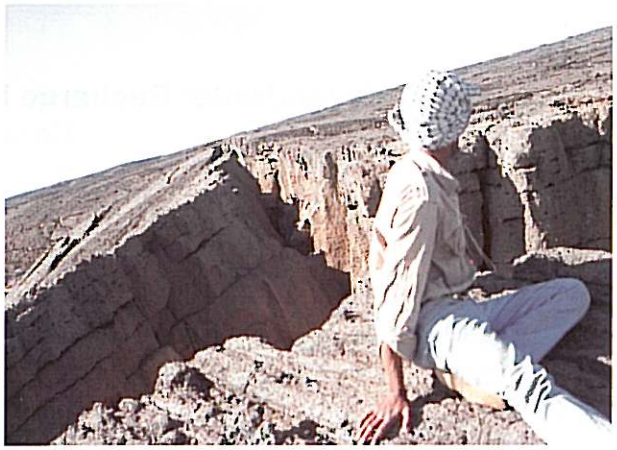

Fig. 1. This photograph, taken in Al Mashaqaq, exhibits a typical lava ridge in phase six lava field, east of Al Fuqaha. Similar features are common in phase five lava flows.

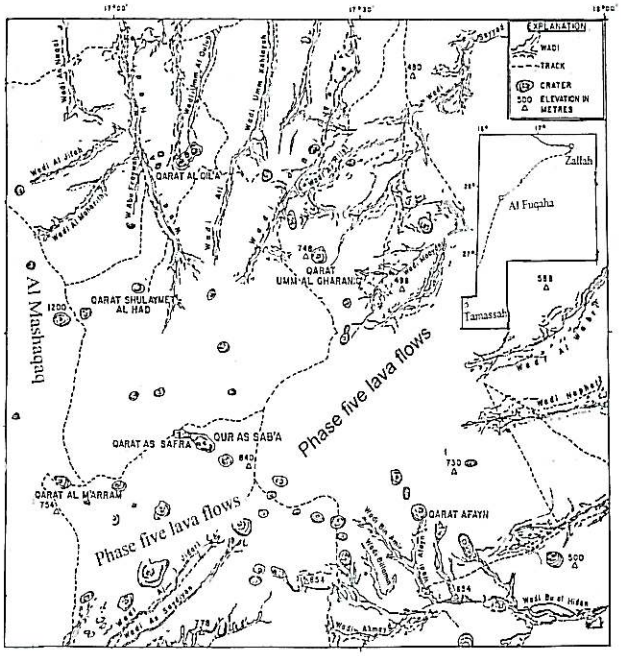

Fig. 2. Drainage pattern in central jabal Al Haruj al Aswad.

(Fig. 2). The present day Sebchas in Tamassah and Hatiyat Meduin in Zallah Oasis may constitute discharge areas.

The arrangement and distribution of the above mentioned wadis suggest that rainfall increases with increasing in elevation from the periphery to the upper Jabal area, decreasing outwards towards low areas. The lack of any prominent drainage system along the west side of Al Haruj is related to topographic relief which might have been related to a basement high and the outpouring of the more recent lava flows.

PALAEODRAINAGE

Interpretation of Landsat images revealed the presence of streams originating at the surface of lava flows on the north, east, south-east and south-western side of Al Haruj. It also points to the existence of margins of possibly huge palaeolakes NE of Tamassah and SE of Waw al Kabir. Traces of the shoreline can still be recognized east of Tamassah (Fig. 3), but sand sheet had obliterated traces of wadi lines in much of the area SE of Waw al Kabir. The presence of ash within the latter

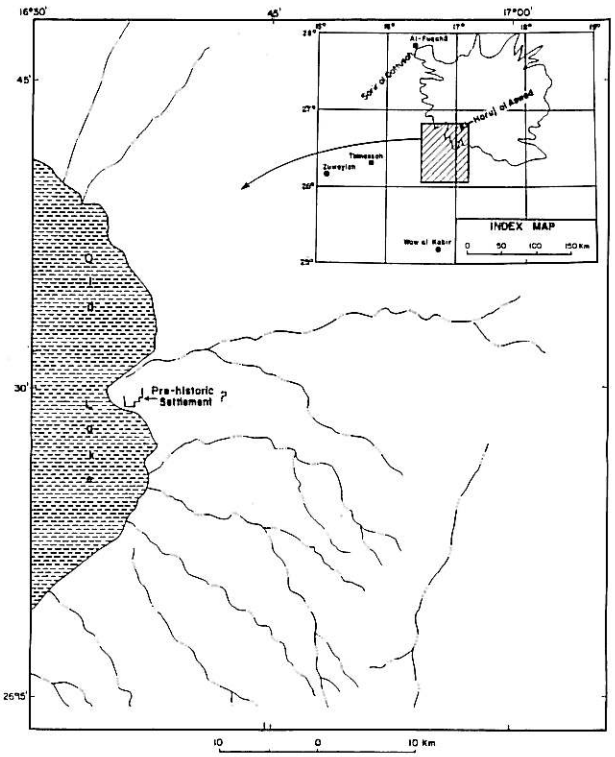

Fig. 3. Landsat interpretation of a margin of a palaeolake SW of Al Haruj (Londsat 5 TH. Band 6, 17 July, 1984).

palaeolake deposits may suggest that Waw an Namus volcano was possibly active during humid periods in late Pleistocene times. The stream at As Sarir (Ahmed, 1978), is thought to have been originated in part from the eastern slopes of Al Haruj during the pluvial time, with the present day Wadi Bu al Hidan and Wadi Bu Shobayrim representing remnants of old drainage tributaries of the streams. The surface expression of the uppermost of the prior streams died out in the sand dunes and part of the ancestral streams appear as discontinuous traces which meander across the plains toward Jalu Oasis. The proof that water courses flowed over east of Al Haruj at As Sarir and the entire length of the Libyan desert from NE Tibisti massif to the north is given by the composition of gravels at As Sarir pipe manufacture for the Great Man-made River Project. In this locality, the old drainage system is totally defunct and can be deduced only from alluvial deposits it left behind.

East of the ancestral stream and at about 3 m higher a spread of quartz pebbles and rock fragments is being quarried for aggregates. Pumice was found among other rock fragments and were interpreted to have been associated with very high discharge from the NE Tibisti massif, the source area of this type of rocks to the present day As Sarir area. The old drainage system from Al Haruj and Tibisti, may form the large scale water courses from mountainous recharge areas in Al Haruj and Tibisti to discharge areas in the Sirt Basin and finally to the Mediterranean Sea (Busrewil, 1993). Silimar conclusion was suggested by Pachur, (1996). The distribution of palaeolakes in the vincinity of Al Haruj may suggest that groundwater was collected locally in these areas during a time when a more humid climate prevailed all over the present area.

FIELD OBSERVATIONS

Meteorological records of Al Haruj *sensu strictu* do not exist. Climatic records of historical periods depend equally on indications of change rather than direct instrumental measurements. Bearing this in mind, field work coupled with intensive enquiries, were carried out for all available unpublished information, pertaining not only to Al Haruj, but also for the surrounding areas, in order to develop the regional distribution of surface waters that might afford better understanding of local conditions. These observations revealed the presence of at least two generations of perennial shrubs.

A large desiccated thorn trees and a subsequent young generation of grown plants. Ponded water in a broad shallow depression (called locally baltas, Fig. 4) was also observed. It may require several weeks or even months for these temporary water ponds to dry (Fig. 5). However, when the water has evaporated a great flat of recent mudcracks can be seen on the floors of these baltas. In addition, straw and/or mud marking the

Fig. 4. Photograph of a ponded water in Al Haruj. Ponded water in broad similar depressions is a common feature in many places of the study area (e.g. Wadi Bu Al Hidan, Qarât Shalesh, Al Badari, Qararat Sayyad ...)

Fig. 5. Photograph of a dry water pond (Grarat Alya, looking NW).

height of water can also be observed along the banks of many depressions (Fig. 6), indicating that such depressions were recently flooded by water. Elongate-shaped, interconnected, large depressions (Qararat) lying within old wadi channels are common (Fig. 7) and represent areas for herds of livestock pastoralism.

Fig. 6. This photograph was taken in the periphery of Al Mashaqaq east of Al Fuqaha. It marks the height of water in that locality.

Fig. 7. Photograph of interconnected large depression lying within Wadi an Naqai, looking north.

Enquiries to accompanist guides revealed that local rainfall, though irregular, is common. Some parts of Al Haruj, however, are either receiving very little or no rain at all in some years. Heavy showers of rain producing runoff are not uncommon. During the period December 1981 to June 1982, the south and south central parts of Al Haruj areas were subjected to three storms. One of these storms lasted for nine hours and caused runoff and hazardous driving conditions (J. Humprey of Brown and Root, London, Pers. Comm.). Widespread sheet-flooding on the plains of northern Jabal as Sawda, central Libya were reported, (Nov. 1989), to have lead to rapid groundwater recharge. Similar flooding occurred in As Sarir in Feb. 1989 (As Sarir Project Authority. Pers. Comm.). Diversion of surface water to underground routes was observed in Qararat Umm ash Shih (27° 21' N 17° 17' E), Qarat Shalesh (27° 48' 20" N 17° 15' 10" E) and al Badari (27° 39' 30" N 17° 46' E). A sinkhole along a wadi bank (Graret Umm Atheilah, 28° 03' 11" N 16° 58' 15" E) in the SW part of Sheet Zallah was visited during the fieldwork (Fig. 8). The

Fig. 8. Photograph of a sinkhole along a Wadi bank (Grarat Umm Atheilah), looking east.

guide (Hag Ruffah) mentioned that this sinkhole and Al Badari are so effective in collecting surface runoff that the water of the wadis are rarely able to cross the sinkholes. Similar sinkholes can be seen NE of Al Haruj (e.g. Al Battah, Fig. 9)

Elders in the surrounding villages retain the memory of an earlier time in which Al Haruj was heavily wooded, possibly until sixty years ago.

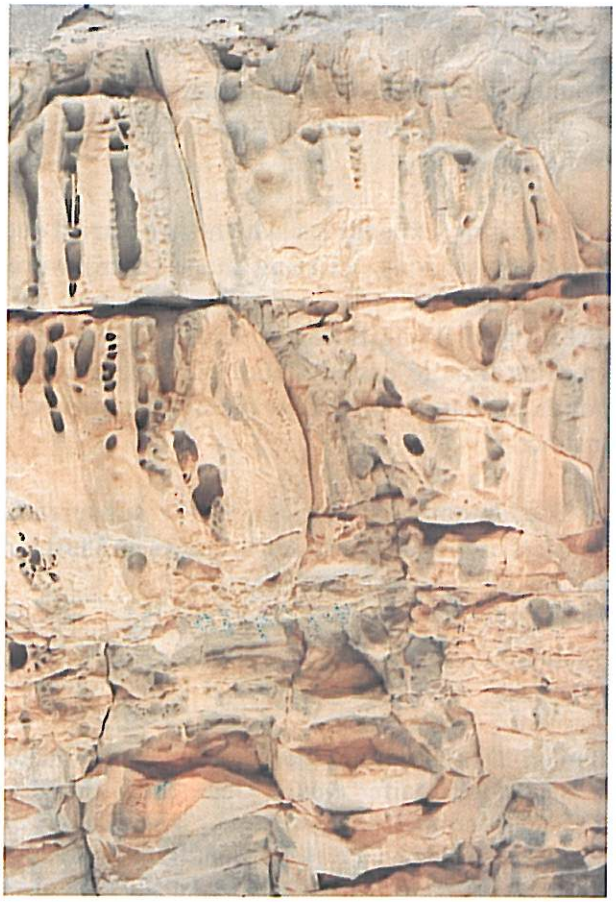

Fig. 9. Side view of the wall of one of few sinkholes along The Zallah – Tazirbu track, NE of Al Haruj. Traces of downfall water seepage (vertical groves) can still be observed and was possibly active during the pluvial time. The guide mentioned that palm trees are growing inside a near-by sinkhole. In all, drainage, around this sink hole today, is total defunct (Hammer, top left, is used for scale).

PREHISTORY SITES

Sites with inscriptions and artifacts left by prehistoric inhabitants of the area were found, including engraved figures and Neolithic stone weapons, (arrow heads). The animals depicted in the engravings are similar to mammals now living south of the Sahara, such as lions, elephants, giraffes, bubales, antelopes (Fig. 10) and deer. There are also some unidentifiable birds. Sites of

Fig. 10. Close-up view of engraved mammal taken in Ghadir ad Duwaylaa, Wadi al Had.

engraving were found in Wadi al Had (Ghadir al Duwaylaa, 27° 50' 67" N – 17° 00' 47" E; Klitzsch, 1968; Busrewil and Swaisi, 1993). Wadi an Naqai (An Naqaa al fawqiyah, 27° 58' N – 16° 57' 30" E) Qarat ar Ruwais (27° N – 17° 43' E) and Ghadir Bu Attusawir (Wadi al Mrar).

The arrow heads are widely distributed over much older and more accessible lavas and can also be found near the water pools and places where wadis broaden out. An ancient habitation site of unknown age was observed a few kilometers south of Waw al Kabir along scarp edges in the range of few hundred metres across. In addition, an ostrich's egg shell was found in a nearby wadi terrace. These observations suggest that climatic conditions allowed palaeolithic bands to roam over most of Al Haruj area and other parts of Libya. Similar occurrences of prehistoric sites have also been described from south-western Libya and northern Tibisti (Ziegert, 2000, and references cited in). The extension in time and space of these cultures over this desert area, cannot yet be concluded from the data available, and is beyond the scope of this work.

DISCUSSION

Research work on the Libyan Sahara during the past three decades by numerous geologists and geographers furnished data that this area had been subjected to heavy rains and witnessed prosperous palaeolakes during the pluvial time (El Ramly, 1980; Pachur and Braun, 1980, 1986; Petit-Maire, *et al.*, 1980). In the meantime, numerous ^{14}C measurements were carried out on carbonates or

organic matter. The ages fall mostly between 5 and 35 ka BP and on the basis of these dates several authors (Pachur, 1980; Pachur and Braun, 1986; Wright, 1986) deduced the occurrence of one or several humid episodes during Late Pleistocene and Holocene times. Similar work suggested that groundwater should be considered as a non-renewable source and should be treated as a fossil water (Burden, 1980; Klitzsch, *et al.*, 1976).

This study, based on field observations and remote sensing data supports previous conclusions that groundwater was formed locally in the surrounding of Al Haruj during a time when more humid climate prevailed all over the present desert. The area contains evidence of *in situ* prehistoric sites and environ palaeolakes. Some dendritic and meandering morphologic pattern, having on the whole, the characteristic of an extinct hydrographic system, was observed east, south-east and south-west of Al Haruj, implying the existence of palaeodrainage.

Meteorological records within Al Haruj are lacking, and striking discrepancies were observed between ^{14}C ages and Th/U ages for several Saharan localities (Szabó *et al.*, 1989; Fontes and Gasse, 1991). Enquiries from local inhabitants and field observations suggest the reconstruction of the climate over the past two hundred years in Al Haruj as follows.

1. A period from the nineteenth century until some time before 1917 in which the area experienced substantial rainfall with respect to the beginning of the present century. Ostriches, now living south in the equator, are thought to have been common in the area during the early time of this century. Remnants of their egg shells were observed west and south of Al Haruj (Kanter, 1967).

2. A marked change toward famine and droughts along the margins of Al Haruj during most of this century. It is characterized by the 1917 famine in Fezzan (Kanter, 1967) and a decrease and impoverishment of flora in surrounding areas. The last of a tame ostrich in Tobga (south of Mizdah) disappeared at the beginning of this century (Kanter, 1967). Within Al Haruj limited rainfall is envisaged, as old and preliminary topographic maps of Zallah and Tamassah (The Italian Geographic Military Institute, (1932-33)) show names and locations of a still existing Thameds, Ghodran (single Ghadir) and Geltas (places of water accumulation and ponding).

3. It is suggested that the area has experienced increased rainfall during the last two decades. This is supported by the presence of almost of a new generation of thorn bushes. Some current recharge via runoff is occurring during rainy seasons within Al Haruj. Evidence of very unusual rainfalls causing damages to livestock was observed in wadi al Atheb (26° 37' N 16° 58' E).

During my expeditions, which were carried out in spring seasons, existing maps (then) were utilized successfully in conjunction with the direction of flying flocks of sand grouse during morning time to explore place of existing water ponds as nature provided them with survival instinct.

The amount of recharge to the subsurface aquifers around Al Haruj is not known and further field work is, therefore, suggested.

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