KARSTIC PHENOMENA IN THE NAMAKABROUD AREA OF NORTHERN IRAN

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ABSTRACT

This paper describes the Madouban Mountain karst area in northern Iran. The geomorphology of the area is examined. Karst landforms are found to be strongly influenced by lithological variations, joint and fault patterns and the effects of dolomitization. Karst development has taken place in the Lar and Tizkuh Formations of Upper Jurassic and Lower Cretaceous age respectively. Their stratigraphy is discussed.

Karst development is characterized by the presence of caves and dolines and many springs are found in the northern foothills.

To investigate the presence of percolation zones and solution cavities, geological mapping is combined with geomorphological and structural analysis. Geophysical techniques (Schlumberger method) are applied to identify the presence of solution cavities and permeable zones. Our study enables us to describe the patterns and directions of underground drainage and makes a

INTRODUCTION

Madouban Mountain is located near the town of Namakabroud (36°40'N, 51°17'E). The town is found in Mazadaran Province and is located 12 km to the west of the coastal city of Chalus (Figure 1) on the Namakabroud Plain. The plain separates the northern slopes of Madouban Mountain from the Caspian Sea. The town relies on numerous wells for its water supply but excessive pumping has caused salinity problems. Springs in the foothills of Mandouban Mountain provide a source of groundwater for the coastal plain.

STRATIGRAPHY

Geological mapping has shown that the main outcrops of the area are limestones of the Lar Formation (Upper Jurassic) and Tizkuh Formation (Lower Cretaceous) (Figure 2). The two formations are difficult to distinguish because they are rather similar and the thick forest makes field mapping difficult. The Lar Formation consists of an alternation of white, pink, cream and buff coloured layers. It is divided into five sub-units whose characteristics are shown in Table 1. The following biofacies are found in the Lar Formation: *Nautiloculina* sp., lituolids, miliolids, *Oolitica* sp., *Pseudocyclammina* sp., *Cristellaria* sp., *Haplophragmium* sp., texturalids, gastropods, pelecypod fragments, *Salpingoporella* sp., *Acicularia* sp.,valvulinids, *Cylindroporella* sp., ostracods,bryozoa, crinoids, echinoid spines and *Dasycladacea* algae.


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Saied Hakimi Asiabar delivering his paper.

Sub-unit	Texture (Folk-Dunham)	Weathered Colour	Fresh Colour	Allochems
1	Biosparite (Bioclastic Lime Grainstone)	Black purple	Pinkish grey	Oolith, Pellet, Intraclast
2	Biosparite (Bioclastic Lime Grainstone)	Greenish grey	Creamy grey	Oolith, Pellet,
3	Algal & Gastropod Biosparite (Algal & Gastropod bio-clastic Lime Grainstone)	Greenish grey	Pinkish red	Oolith, Pellet, Intraclast
4	Biosparite (Bioclastic Lime Grainstone)	Greenish grey	Grey	Oolith, Intraclast
5	Biosparite (Bioclastic Lime Grainstone)	Pink to red	Pinkish grey	Oolith, Intraclast

Table 1: Characteristics of sub-units of the Lar Formation in the Namakabroud area.

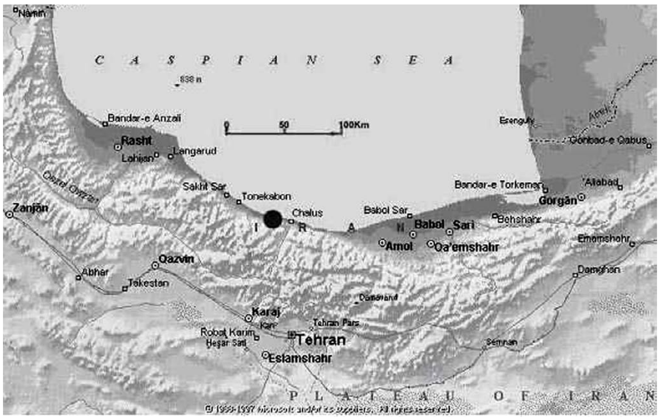

Figure 1: Locality map with dot indicating the location of the Namakabroud area.

Porosity of the beds has been affected in various ways by open space infilling, cementation, dolomitization, recrystallization, the development of vughs, fissures and solution cavities.

Sub-units 4 and 5 of the Lar Formation and the *Orbitulina* grey, thick-bedded limestone sub-unit of the Tizkuh Formation show more evidence of solutional processes than the other sub-units.

GEOMORPHOLOGY AND HYDROLOGY

The study area can be divided into two parts (Figure 3):

- The Namakabroud coastal plain adjacent to the Caspian Sea.
- The Madouban Mountain area to the south which forms part of the central Alborz mountain belt and has a topographic gradient of between 28 and 32 degrees. The uppermost parts have a subdued topography and are characterized by numerous dolines (Figure 4).

Uplift along the Namakabroud thrust fault has created a topographic contrast between the coastal plain and Mandouban Mountain. This thickly forested mountain is located between the Namakabroud and Sardabroud Rivers. The rivers are strongly incised and provide good exposures of the Lar and Tizkuh Formations. There is little outcrop of bedrock in the forested areas.

Mass movement and solutional processes have shaped the local topography. The largest collapse doline on the northern flank of Madouban mountain is u-shaped and is about 600 m long and 250 m wide. Dive-Hamman collapse doline is the deepest surface collapse feature. It is 100 m deep and 80 m in diameter and has near-vertical walls. It is located towards the western end of the mountain. Dolines may show slickensided walls and contain many fresh tree trunks suggesting that collapse has been recent and is actively continuing.

This is also supported by ongoing collapses of both

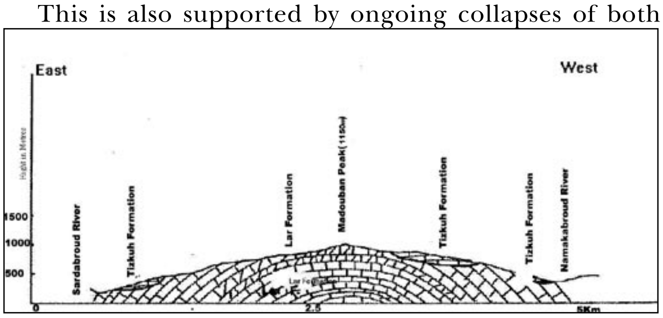

Figure 2: Geological E-W cross-section with limestones of the Lar Formation (Upper Jurassic) and Tizkuh Formation (Lower

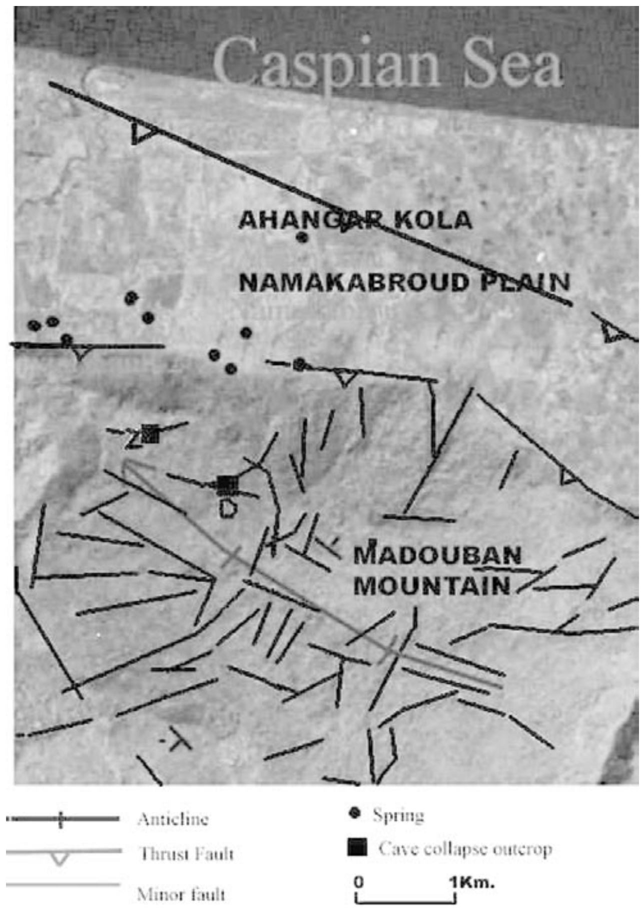

Figure 3: Aerial view of Caspian coastal plain and Alborz Mountain Range

bedrock and soils. Zang-e-Tool and Sisara Caves are found near the mountain crest and provide good examples of cave development.

STRUCTURAL GEOLOGY

The rocks of Madouban Mountain are folded into an anticline with a NW-SE trend and plunging at an angle of 12° to 15° towards N60°-65°W. On the northern flank of the mountain the strata dip at 28° to 32° to the north. The angle is similar to the surface gradient.

A variety of joint and fault sets are seen on Madouban Mountain. Joint spacing is highly variable with an average spacing of 30 to 60 cm. Joint planes are rough and because of the high rainfall generally contain some water. Analysis of aerial photographs shows the presence of three sets of joints, faults and lineaments. They are:

- Parallel to the fold axis.
- NE-SW trending lineaments perpendicular to the fold axis
- Diagonal to the fold axis.

Many sinkholes are located on lineaments and are ellipsoid in plan with the long axis parallel to the direction of lineaments.

The principal fault associated with the Namakabroud coastal plain is the deep-seated Khazar thrust fault. Resistivity data indicate that the fault passes north of the village of Ahangar Kola and is covered by sediments (Figure 3). One branch of the fault separates the coastal plain of Namakabroud from the northern flank of Madouban Mountain and trends W-E while dipping in a southerly direction (Figure

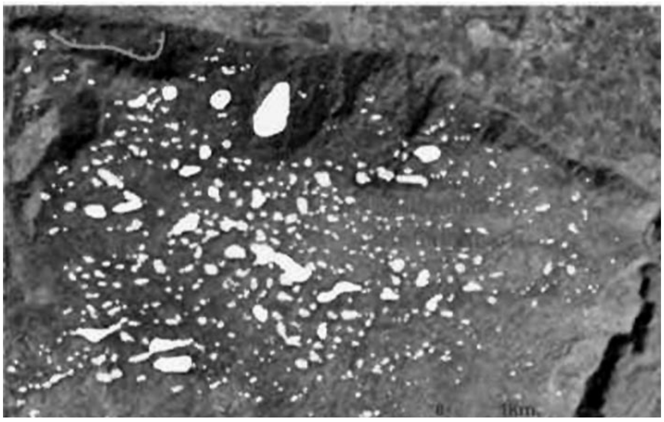

Figure 4: Karstic zone of Madouban Mountain with the Great Landslide shown in top left corner

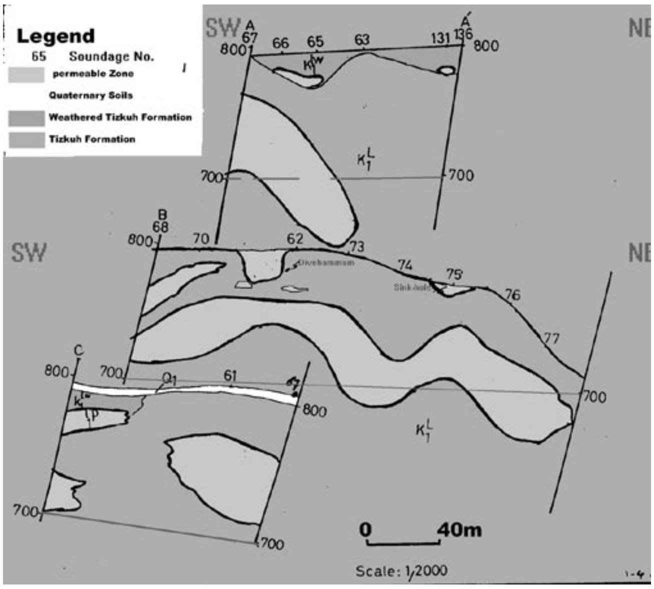

Figure 5a: Geophysical profile of Divehammam area with SW–NE trend

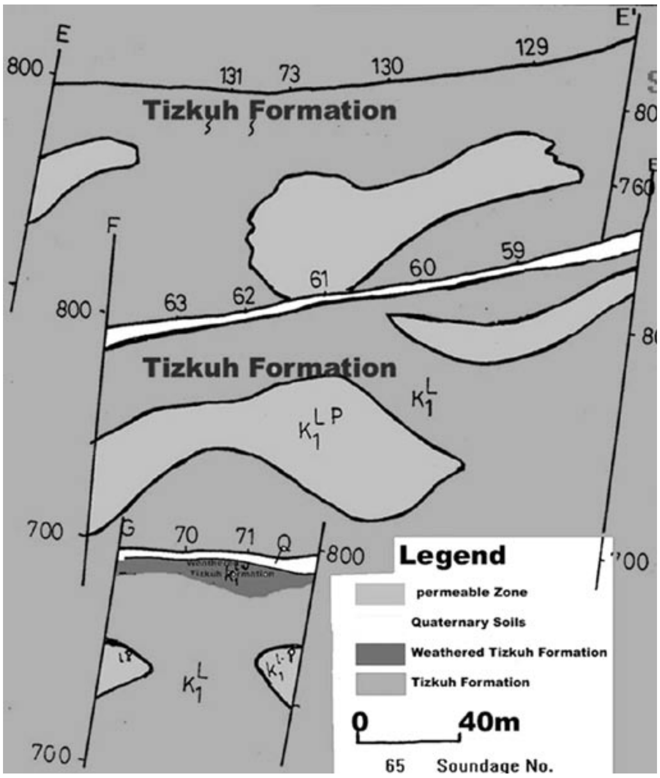

Figure 5a: Geophysical profile of Divehammam area with SE–NW trend

3). This fault is called the Namakabroud Thrust Fault and is marked by a large topographic discontinuity that follows the northern edge of the mountain coinciding approximately with the 1000 m contour.

In the western region of Madouban Mountain, near the Namakabroud River, a spectacular area of mass movement is found that is approximately 1200 m in length and 200 m in width (Figure 4). Solution processes concentrated at the western extremity of the anticlinal hinge appear to have created underground cavities that have played a major role in initiating the landslide.

GEOPHYSICAL STUDIES

Geophysical studies have been carried out to analyze the location of solution cavities and permeable zones. These methods have used resistivity measurements (Schlumberger method) based on an electrode spacing of 1000 m. Permeable zones are characterized by very low resistivity and cavities by very high resistivity.

Figures 5a and 5b show resistivity profiles around the Dive-Hamman collapse doline. Permeable zones were identified in the Lower Cretaceous *Orbitolina* limestone and units of the Upper Jurassic Lar Formation (Figure 6). Many underground cavities in Madouban Mountain show a relationship with surface collapse features.

DEVELOPMENT OF KARST PHENOMENA

The most important factors favouring karst development are the calcareous nature of the rocks making up the Lar and Tizkuh Formations and the mild and humid climate. Karst development has been initiated in beds of high primary permeability but cave enlargement has been strongly influenced by the geological structure. A large number of faults and lineaments are aligned parallel to the axial trace of the Madouban anticline and have promoted the downward penetration of seepage water.

On the crest of Madouban Mountain the more gentle topography, combined with the exposure of beds varying in primary permeability, has provided good conditions for karst development. On the northern flank of the mountain the steep topographic gradient causes rapid surface runoff and this has restricted karst development.

High up on Madouban Mountain rocks of the Tizkuh Formation have been thrust over those of the Lar Formation. Solution processes have been concentrated along the thrust plane.

The occurrence of dolines and caves along the crest of the Madouban anticline increases towards the west as the fold plunges towards the northwest. Permeable zones on the northern flank of the mountain tend to be oriented down the dip of the beds.

The directions of small surface streams on the mountain crest tend to be controlled by lithological and structural factors but terminate as stream sinks and become part of the underground drainage.

The direction of underground drainage is controlled by the NW-plunging fold axis and by the dip of the strata. This tends to concentrate spring activity in the western and northern foothills of the mountain.

CONCLUSIONS

The evolution of karst drainage in the area has been promoted by lithological variations, structural elements, the

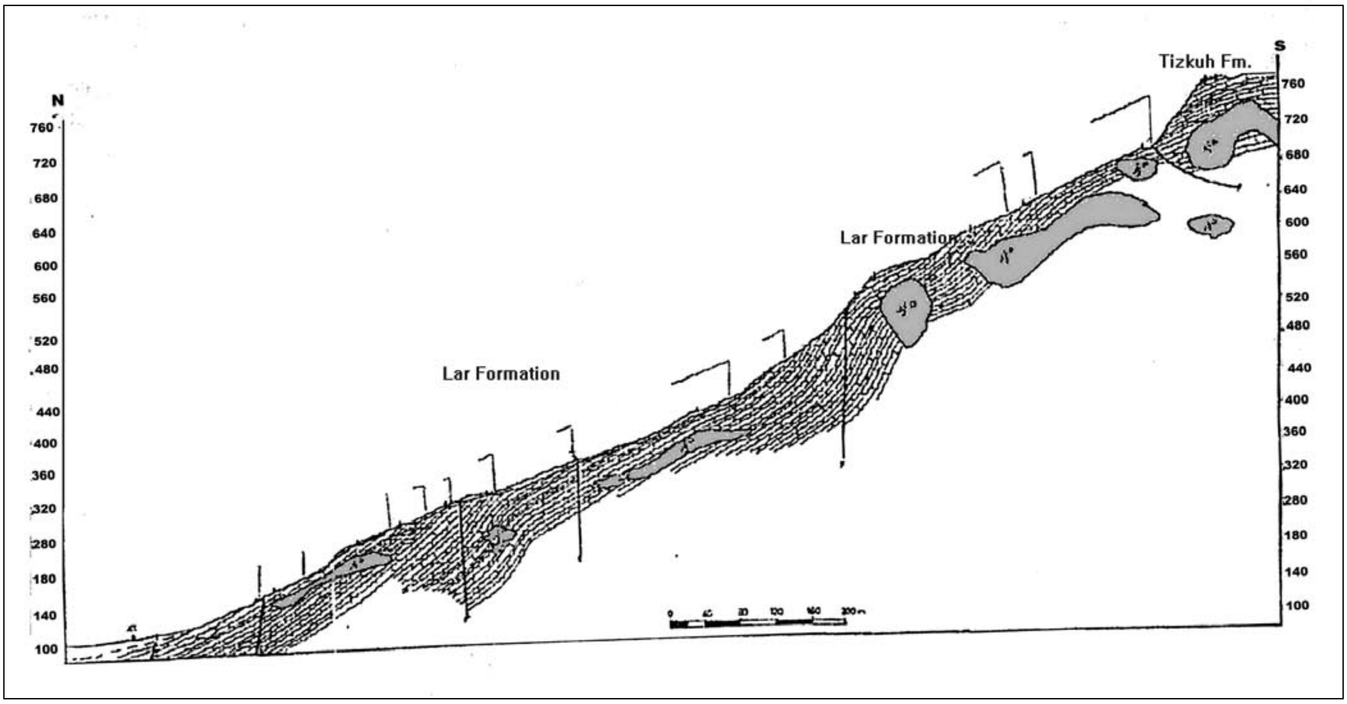

Figure 6: Structural cross-section of northern part of Madouban Mountain showing locations of geophysical traverses and permeable zones.

nature of the topography as well as climatic conditions which combine mild temperatures with humid conditions and high intensity rainfall.

The calcareous rocks of the area vary in their primary permeability. They show the combined effects of cementation, dolomitization and recrystallization followed by the development of secondary permeability due to solution processes. Solution processes have been concentrated in the thickly bedded arenaceous bioclastic limestones of the Lar Formation (Sub-units 4 and 5) and the thickly bedded *Orbitolina* limestones of the Tizkuh Formation.

Underground drainage directions have been controlled by the NW plunging fold axis and the northerly dip of the beds causing springs to be concentrated in the northern and northwestern foothills of Madouban Mountain. Surface karst development is concentrated along the crestal area of the mountain and this appears to be the principal recharge area for underground drainage.

The size and frequency of dolines is greater in the western part of the mountain crest. The Dive-Hamman collapse doline is the deepest found in the area. Other significant karst features are the extensive Zang-e-Tool and Sisara Caves. ■

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