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Sedimentary Environments Can Be Changed by Geotechnology (Case Study: A Morphotectonic Idea for Design of Extensive Artificial Bay on the Iranian Plateau)

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Abstract

Iranian Plateau between the Lesser Caucasus-Alborz Mountains on the north and Zagros-Makran Ranges on the south has several inter-mountainous depressions which were filled by Quaternary deposits. Geologic evidence implied that, the last marine conditions in some depressions such as the Dasht-e Kavir, Dasht-e Lut and Jazmourian basins, had been changed to land conditions in middle Miocene. Based on shape and elevation of the Dasht-e Kavir, Dasht-e Lut and Jazmourian plains related to sea level and geomorphology of Iranian plateau, three semi-connective artificial lakes can be constructed upon the mentioned plains by consideration of many geologic and geotechnical parameters. These artificial lakes can feed by pumping of water from Oman Sea and form a triple artificial bay which they must be connected together by two gated straits. Therefore, a possible morphotectonic idea with many advantages has suggested that it can be present as an international geotechnologic design. This design has the important environmental impacts which can be changed desert to lake sedimentary basins.

Keywords

Environments, Geotechnology, Artificial Bay, Sedimentary Basin, Quaternary Deposits, Central Iran

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1. Introduction

Geotechnology is a branch of engineering and science that is concerned with construction in or on the ground. It deals with the study of subsurface conditions and materials through soil and rock mechanics, of the stability of slopes, seismicity and etc.

Five thousand years ago, the craters of extinct volcanoes in Arabia were used as reservoirs by farmers for their irrigation water [1]. Artificial lakes or man-made dating to the 5th century BC have been found in ancient Greece [2]. In this study, a morphotectonic idea with many advantages has suggested that it can be present as an international geotechnologic design. This design has the important environmental impacts which can be changed desert to lake sedimentary basins.

2. Materials and Methods

2.1. Microclimate

Iran is the eighteenth largest country in the world, with an area of 1,648,195 km^2. Its area roughly equals that of the United Kingdom, France, Spain, and Germany combined. Iran lies between latitudes 24˚ and 40˚N, and longitudes 44˚ and 64˚E. Its borders are with Azerbaijan and Armenia to the north-west; the Caspian Sea to the north; Turkmenistan to the north-east; Pakistan and Afghanistan to the east; Turkey and Iraq to the west; and finally the waters of the Persian Gulf and the Gulf of Oman to the south.

Iran consists of the Iranian Plateau with the exception of the coasts of the Caspian Sea and Khuzestan Province. It is one of the world's most mountainous countries, its landscape dominated by rugged mountain ranges that separate various basins or plateau from one another. The populous western part is the most mountainous, with ranges such as the Lesser Caucasus, Zagros and Alborz Mountains; the last contains Iran's highest point, Mount Damavand at 5671 m.

The northern part of Iran is covered by dense rain forests called North or the Jungles of Iran. The eastern part consists mostly of desert basins such as the Dasht-e Kavir or Great Kavir Basin (**Figure 1**), Iran's largest desert, in the north-central portion of the country, and the Dasht-e Lut (**Figure 2**), in the east, as well as some salt lakes. This is because the mountain ranges are too high for rain clouds to reach these regions. The only large plains are found along the coast of the Caspian Sea and at the northern end of the Persian Gulf, where Iran borders the mouth of the Arvand Rod River. Smaller, discontinuous plains are found along the remaining coast of the Persian Gulf, the Strait of Hormuz and the Gulf of Oman.

Iran's climate ranges from arid or semiarid, to subtropical along the Caspian coast and the northern forests. On the northern edge of the country (the Caspian coastal plain) temperatures rarely fall below freezing and the

Figure 1. A northward view from the northern border of Dasht-e Kavir.

Figure 2. A northward view from the southern border of Dasht-e Lut.

area remains humid for the rest of the year. Summer temperatures rarely exceed 29˚C. Annual precipitation is 680 mm in the eastern part of the plain and more than 1700 mm in the western part.

To the west, settlements in the Zagros basin experience lower temperatures, severe winters with below zero average daily temperatures and heavy snowfall. The eastern and central basins are arid, with less than 200 mm of rain, and have occasional deserts. Average summer temperatures exceed 38˚C. The coastal plains of the Persian Gulf and Gulf of Oman in southern Iran have mild winters, and very humid and hot summers. The annual precipitation ranges from 135 to 355 mm.

2.2. Tectonics of Central Iran

Central Iran, during the Paleozoic Era, had the form of a plateau, and then during the Mesozoic and Cenozoic Eras, was transformed to a highly active region; in which sedimentation was accompanied by volcanic activity with associated penetration of intrusive bodies. Central Iran basins are located in the eastern part of the Iranian plateau [3]. The plateau is one of two main plateau in the Alpine-Himalayan collision system [4] [5], the other being Tibet [6]. It extends from eastern Anatolia to eastern Iran, and typically has elevations until 2 km above mean sea level.

The basement of the plateau consists of microcontinents that were accreted to each other and Eurasia by the Late Cretaceous or early Tertiary [7], interspersed with zones of Ophiolite and mélanges. Volcanism of late Cretaceous—early Miocene age in Central Iran represent Andean type magmatism in southern Eurasia during the Neo-Tethyan subduction. Volcanic and turbidite successions up to 5 km thick represent Eocene back-arc extension across Central Iran, the Alborz and the Lesser Caucasus regions, north of the Neo-Tethyan subduction zone, and prior to Arabia-Eurasia collision [8]. This succession is commonly overlain in Central Iran by terrestrial clastics, evaporites and volcanics of the Lower Red Formation; of Oligocene age [9]. Marine deposition resumed across much of Central Iran with the carbonates of the largely lower Miocene Qom Formation, similar lower Miocene marine strata were deposited across much of Anatolia and the Lesser Caucasus [10]. The Qom Formation pinched out in the north against the southern side of the Alborz and in the south along a line parallel to and 100 km northeast of the Zagros suture—indicating sub-aerial relief both north and south of the marine basin. The end of marine sedimentation may have been diachronous: the Qom Formation is overlain by middle Miocene terrestrial clastics of the Upper Red Formation [11].

Based on [12], the collision of Arabia and Eurasia was preceded by 175 Million years ago of subduction of Neo-Tethyan oceanic lithosphere. Associated magmatic activity includes Jurassic plutons in the Sanandaj-Sirjan zone of southern Iran, limited Cretaceous magmatism in the Alborz Mountains of northern Iran, and widespread Eocene volcanism across central Iran.

Metamorphic core complexes of Eocene age have recently been recognized in widely separated parts of Iran, suggesting that Tertiary volcanism was related to extension. Geochemical data indicate that Eocene volcanism was typical of continental arcs and was followed by less voluminous Oligocene basaltic volcanism of the type often associated with back-arc basins. This set of observations suggests that mid-Mesozoic plutons in southern Iran are the remnants of an original volcanic arc that was only weakly developed because of slow subduction rate.

Magmatic activity largely ceased in central Iran during the Cretaceous and shifted to the north, suggesting a period of flat slab subduction. Subsequent slab-rollback during the Eocene extended the overriding plate, forming metamorphic core complexes and inducing pressure-release melting of partially hydrated lithospheric mantle and upwelling of asthenosphere.

Also, based on previous work on the salt diapirism [13]-[22] and neotectonics regime in Iran [23], Zagros in south Iran is the most active zone [24]-[38]. Then, Alborz in north Iran [39]-[70] and Central Iran [70]-[81] have been situated in the next orders.

2.3. Bedrocks of Central Iran Basins

Volcanic and turbidities successions of Eocene, Lower Red, Qom and Upper Red Formations are common bedrocks in central Iran basins [82]. This succession is commonly overlain in the Dasht-e Kavir basin by Quaternary terrestrial clastics. But in the Jazmourian (**Figure 3**) and Dasht-e Lut basins, a volcanic and turbidities succession of Eocene is commonly overlain by Quaternary terrestrial clastics. It means that, the last marine conditions in the Dasht-e Kavir (A in **Figure 4**), Dasht-e Lut (B in **Figure 4**) and Jazmourian basins (C in **Figure 4**) has been overlain by these alluvium deposits (Quaternary terrestrial clastics).

Figure 3. An eastward view from Jazmourian basin.

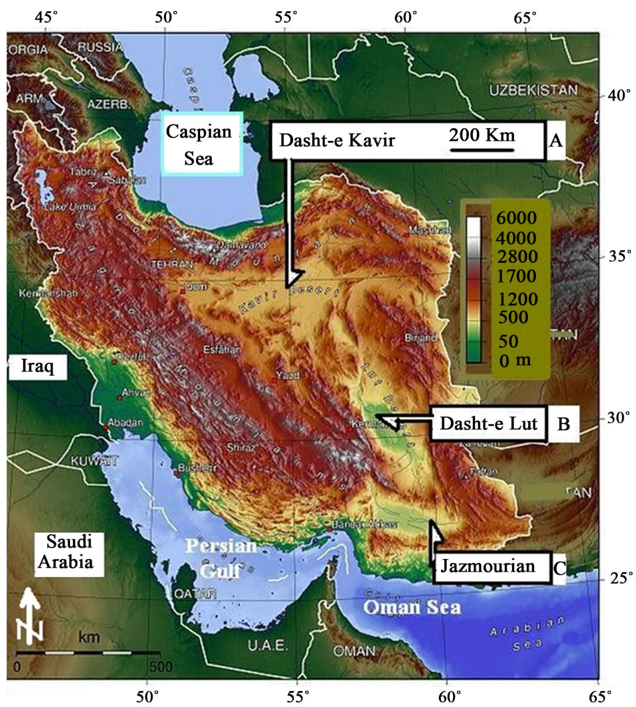

Figure 4. Geographical distribution of three main recent basins in Iran, modified from http://www.worldofmaps.net.

There is much geologic evidence for existence of epicontinental seas in the last million years. These epicontinental seas were covering the basins on Iran plateau, but they have divided to the several sub-basins by the more uplifting and folding of surrounding areas. Finally, they filled by evaporates and clastic deposits and some separated lakes such as Urmieh and Qum salt lakes have formed in Quaternary period.

An abundance of extensive basins, between individual mountain ranges, is among the outstanding characteristics of Central Iran. The structural plains either are formed over the basins of volcanic basement rocks or are in alignment with the synclines structures and grabens. The mountain ranges, which are extended at this region, are divided by closed and open depressions and plains, at various areas, in different dimensions and forms. A dry bio-climate is prevalent on these plains, so they are called desert plains.

2.4. Seismicity

Seismotectonics-geologic hazards zoning map of Iran [83] is based on deterministic seismic hazards evaluation using the seismicity records, structural trends, tectonic settings, fault ruptures and neotectonics activities in Iran.

It contains the earthquake hazards parameters such as b value and Mmax for the nineteen seismotectonic provinces. Zagros and Alborz have deep earthquakes that it is indicator for existence of thick-skinned tectonics.

The most part of study area has situated in Jazmourian, Lut and Great Kavir-Taibad provinces; Dominant structural trend in Jazmourian province is E-W. From tectonics point of view, it contains a fore arc basin (Jazmourian plain) that has been continued to Mashkel plain in Pakistan. Focal mechanisms of many earthquakes are reversed and thrusted and sometimes normal (in related to bending of subducting oceanic lithosphere) such as NW Saravan with 69 Km focal depth (Ms = 5.2, 2009) and SE Khash with 82 Km focal depth (Ms = 7.7, 2013). Jazmourian province has moderate earthquakes with middle frequency, medium repeat time and down to 150 Km focal depth. Intensity of earthquakes is in middle levels by very deep hypocenters.

The most important seismic hazards in Jazmourian province are rapid uplifting and settlement in some plains. It should be noted that low seismicity in Makran and Jazmourian provinces has been related to slow subduction rate and steeper dip of Benioff zone.

Dominant structural trend in Lut province is NW-SE. From tectonics point of view, it contains a retroarc (back arc) basin (Lut plain) that has continued to Helmand plain in Pakistan. Focal mechanisms of many earthquakes are reversed and thrusted and/or right slip in related to N-S strike slip faults such as Nayband and Nehbandan.

Lut province has low earthquakes with low frequency, medium repeat time and down to 10 Km focal depth. Intensity of earthquakes is in high levels by existence of hot igneous rocks. The most important seismic hazards in Lut province that contains Lut plain are settlement, surface faulting and volcanic hazards in southern and western part of plain.

Dominant structural trend in Great Kavir-Taibad province is NW-SE in eastern part and NE-SW in western part. From tectonics point of view, it contains the Maiamay-Taibad marginal back arc basin, south eastern part of Great Kavir-Urmieh lake foreland basin and South Great Kavir folded and thrusted belt. The latter case is result of collision between northern part of East-Central Iran miniplate and south eastern part of North-Central Iran miniplate. Focal mechanisms of many earthquakes are thrusting and dextral strike slip faulting in eastern part and sinistral strike slip faulting and thrusting in western part such as Garmsar (Ms = 5.1, 2007).

Great Kavir-Taibad province has low to moderate earthquakes with low frequency, medium repeat time and down to 10 Km focal depth. Intensity of earthquakes is in low levels. The most important seismic hazards in Great Kavir-Taibad province are settlement in some plains and surface faulting.

3. Results and Discussion

Based on geomorphology of Iranian plateau and elevation of some its plain related to sea level, three semi-connective artificial lakes can be construct by consideration of many geologic and geotechnical parameters. These artificial lakes which cover central part of Dasht-e Kavir (A in **Figure 5**), Dasht-e Lut (B in **Figure 5**) and Jazmourian (C in **Figure 5**) basins will feed by pumping of water from Oman Sea in the long periodical times.

The water pumping can be start from the west termination of Makran range (south of Minab) and thus, a triple artificial bay will be form. This bay is composed from three extensive lakes that cover recent Dasht-e Kavir, Dasht-e Lut and Jazmourian basins (**Figure 4**). The lakes must be connecting together by two gated straits.

In the other hand, seismotectonics provinces such as Jazmourian, Lut and Great Kavir-Taibad that are contain

Figure 5. Geographical position of Dasht-e Kavir (A), Dasht-e Lut (B) and Jazmourian (C) basins on the Iranian plateau modified from http://www.freeworldmaps.net.

the most part of study area have not shown high seismic hazards. Because, the most part of deformation in Iran has been concentrated in its continental crust. Lut and Great Kavir-Taibad have not got destructive earthquakes and Jazmorian has got deep earthquakes that it is indicator for slow subduction of Oman Sea.

4. Conclusions

A new morphotectonic idea for design of extensive artificial bay on the Iranian plateau was suggested in this paper. This suggestive idea has several advantages: development of marine and desert ecotourism and geotourism; change of seismicity regime from low frequency/high magnitude to high frequency/low magnitude; construction of new cities and touristic villages; construction of natural parks; construction of blocks for migrating fish and trapping them; development of agricultural activities by use of fresh water technology; change of the local climate with increasing humidity and reducing extremes of temperature in local scales.

This design has got the important environmental impacts which can be changed desert to lake sedimentary basins. Also, tectonic setting, geologic position, and seismicity regime are compatible with this suggestive idea. Finally, based on morphotectonic conditions, Dasht-e Kavir, Dasht-e Lut and Jazmourian basins are very suitable to lake formation. The lakes must be connected together by gated straits.

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