Journal of Social Issues & Humanities, Volume 1, Issue 4, September 2013
ISSN 2345-2633

Geomorphological mapping of processes and forms in Haj Ali Gholi playa, Central Iran

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Abstract— Geomorphic mapping is a map design technique that defines, delimits and locates landforms. It combines a description of surface relief and its origin, relative age, and the environmental conditions in which it formed. This type of mapping is used to locate and differentiate among relief forms related to geologic structure, internal dynamics of the lithosphere, and landforms shaped by external processes governed by the bio-climate environment. The research attempts to distinguish the geomorphic units of Haj Ali Gholi playa, and plots its geomorphological map using method of geomorphic processes and forms study. The results show that the basin is a geomorphic landscape located in dry-lands, and is formed from three units of Mountains, Glacis and Playa. The units are included various land-forms, land-views and land-features. Using recognitions of them, we can evaluate the opportunities and threats of the area, and can identify the problems of environmental management in the study area. Also, geomorphological map of study area is presented that have high importance in the applied geomorphology such as environmental management and planning.

Index Terms— process, form, geomorphological map, Haj Ali Gholi playa.

1 Introduction

DRYLANDS cover more than 41% of the world's land surface and are home to some of the most unique biological and cultural diversity on the planet (IUCN). Playas are ubiquitous features in arid and semi-arid areas of the earth. The main requirement for the occurrence of such a system is that evaporation exceeds precipitation (Hardie et al., 1978; Langbein, 1961). Geologically, they provide information about sedimentary history, depositional environment, paleo-climate indicators, and economically valuable evaporate minerals and brines (Yechieli and Wood, 2002). Playas are proposed to be discharging, intercontinental basins remaining dry for at least three-quarters of the year with evaporates likely to be present (Briere, 2000). Playas, because of their special geographical conditions and record temperature and humidity changes, are one of valuable natural resources that have the capable of decoding the past evolution. So that can be found the environmental changes using accurate and continuous study of the Playa behavior. Thus, geomorphological mapping of drylands, especially playas, can be benefit for environmental management and planning of the regions.

Maps can be thought as a frontier or a meeting point at which geomorphologists, geologists and other professionals share their different knowledge of the territory and plan together a sustainable use of the environment. Maps are one of the most appropriate and synthetic ways of showing the distribution of landforms, surface and near-surface deposits, the processes that act on landforms and the time of their action. Geomorphological maps are one of most important end products of investigations made by geomorphologists on the territory. Furthermore they are of great usefulness to many other professionals dealing with the landscape and landforms like engineers, urban planners, soil and forest scientists, agronomists, land conservationists, etc. As stated by Cooke et al. (1982) different geomorphologists have worked on a variety of problems in contrasting terrain and morphoclimatic conditions and several mapping systems have been set up. Nevertheless attempts to produce a unified system do not seem to have been widely adopted so far (www.geomorph.org/wg/wgagm).

Mapping forms and deposits, and inferring processes, of a landscape is a very complex exercise (Demek, 1982). Its difficulty lies, on the one hand, in the challenge of identifying the processes themselves, their spatial and temporal extent and the underlying base rocks and the implementation of effective cartographic representation. General geomorphological maps are often driven by the need to understand the evolution of a portion of the landscape and a need to forecast future evolutionary trends. They have thus become a major research instrument in their own right (Hayden, 1986). Applied geomorphological mapping has to consider the evolution of the area under investigation, even if the specific objectives are more limited (Paron and Smith, 2008).

The aim of the study is the mapping of forms and processes in Haj Ali Gholi playa using geomorphological mapping method and GIS technique.

2 Study Area

The study area is the Haj Ali Gholi playa in Semnan Province, Central Iran, which is ranged from longitudes 53°15′ to 56°E and latitudes 35°15′ to 37°N (Fig. 1). This playa is a tectonic and sedimentary hole, which is influenced by different geomorphic and climatic morphogenesis processes. The shortage of vegetation and moisture are lead to the domination of

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wind processes over other processes in the basin (Mousavi et al., 2010). Thus several types of wind erosion landforms are observed in the region. Study area, with an approximate area of 18070.918 km2, is located between Toroud-Chah-Shirin Horst having 2319m elevation, and Alborz Mountains having 3884m elevation. Its general slope is to the center of playa with elevation 1028m. There are 16 seasonal streams in the basin that origin from Alborz Mountains and terminate to the playa center mostly. The most important of them are Cheshme-Ali and Cal-Shour rivers (Katebi, 2001). Center of the playa is terminal basin of runoffs that is converted to a lagoon or temporary lake, if annual rainfalls be sufficient.

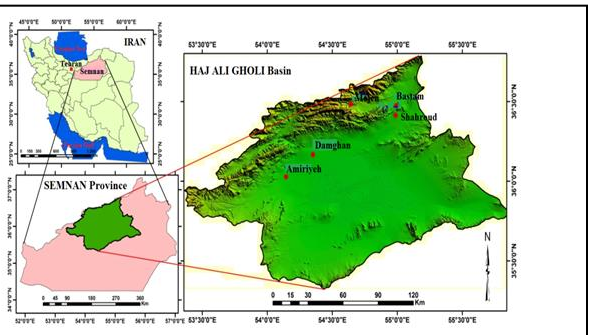

Fig. 1. Location of study area.

3 METHODOLOGY

In the study, the form and process analyses method was used to plot the geomorphological map of study area. For this purpose, topographic maps (scale 1:50000), digital elevation model, geological maps (scale 1:100000) and satellite images of Landsat (TM and ETM+) are materials. Stages of the research are as following:

- Recognition of geomorphological characteristics
- Extent determination of landforms, land-views, land-features and landscapes
- Separation of geomorphic types, units, features and forms
- Preparation of vector and raster layers of parameters
- Rawing of geomorphological map using combination of layers in Arc GIS software.

4 FINDINGS AND RESULTS

One of the most important characteristics of landscapes for separation of them is slope (amount and direction) and type of surface (convex, concave, plane). The slope value and aspect, and the surface type are determined by contours density and stream drainage pattern respectively (Ramesht, 2006). In the study area, according to slope and surface, three landscapes were recognized (figure 2). First landscape is the Mountains that have steep hillsides and divergence streams drainage. Second landscape having concave surface is the Glacis. Its slope is less than the Mountains slope, and its streams drainage patterns are parallel. This landscape includes foot-mountain plains, alluvial fans and flood plains. Third landscape is plane and flat, and has very low slope and convergent streams drainage. This landscape involves Playa, Sabkha, Playa Lake and other flat surfaces. The most important factors for identification of flat surface are elevation points, mesas and buttes features, and sinuosity contours in the Playa margin.

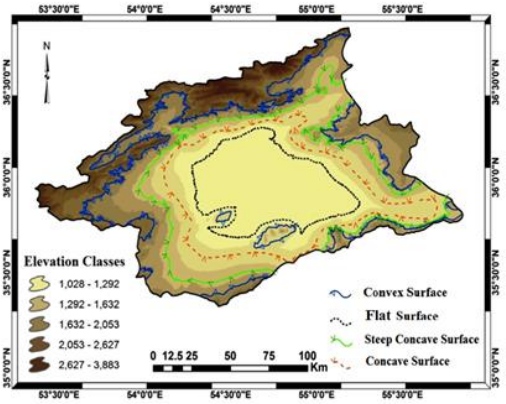

Fig. 2. landscapes of study area.

The Mountains landscape is as a belt on margin of study area that end to alluvial fans in some areas. The landscape is the most important supplier of water resources; hence it has very high role in the creation of landforms that are produced by water process. Limestone, calcareous sandstone, dolomite, conglomerate, volcanic and metamorphic materials are the most important land-features of the Mountains landscape in study area. The Glacis landscape is concave surface that is begun from foot-mountains and is terminated to the Playa margin. Erosive plains, Epandage plains, Mantled plains, alluvial fans, sand fields and Oueds are the major land-features of the Glacis landscape in study area. Landscape of Haj Ali Gholi Playa is a flat surface, with 2391 km2 area, that is composed from evaporated and siliciclastic sediments. Clay plain, wetlands and salt marsh are the most important land-features of Haj Ali Gholi Playa. Figures 3 and 4 illustrate elevation classes and slope range of study area.

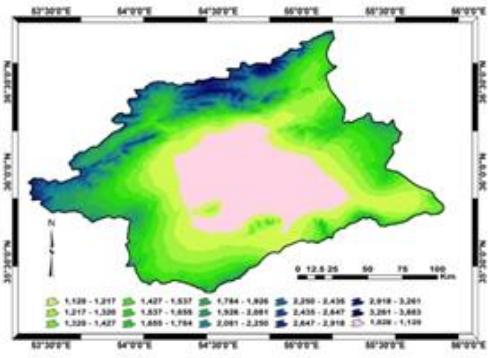

Fig. 3. Elevation classes of study area.

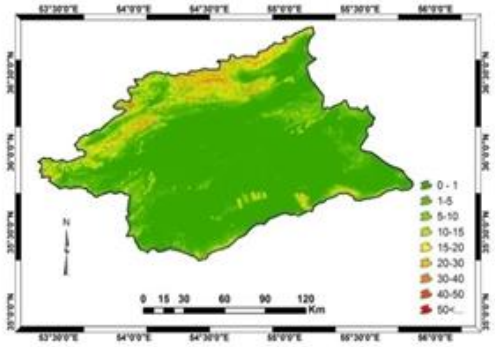

Fig. 4. Slope range in study area.

There are 3 lake terraces in the margin of Haj Ali Gholi playa that are witness of Quaternary climate change (Kerinsly, 2002; Katebi, 2001). They have been situated in elevation of 1165 m, 1138 m and 1060 m respectively. At present, playa floor has 1054 m elevation that is as a salt marsh (Fig. 5).

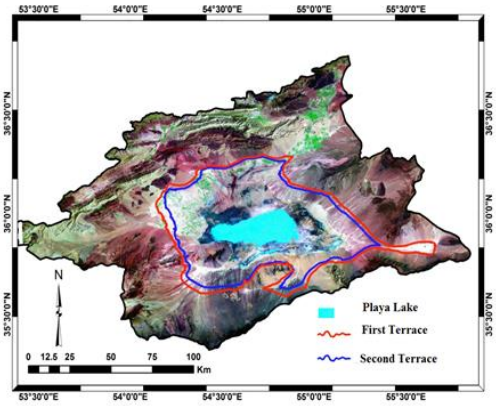

Fig. 5. Lake terraces of Haj Ali Gholi playa.

Vertical and horizontal movements of faults have formed geological evolution of the basin. The vertical movements have been caused the creation of playa and subsidence of salt marsh. Generally, the basin is the result of tectonics and faults function (Figure 6). In the next step, erosive processes have been changed the basin form, and have been created a smooth surface in the basin floor by sedimentation (Ahmad, 2008). The most important faults of study area and their function are listed in table 1.

TABLE 1
PROPERTIES OF FAULTS IN STUDY AREA (AGHANABATI, 2006; DARVISH ZADE, 2006)

Fault	Length (Km)	Direction	Moving Type	Creation Agent	Outcomes
Astane (Semnan)	190	Northeastern-Southwestern	To the left	---	-Separating of Alborz Mountains and Central Iran -Discrete of Eocene rocks in North of Semnan
Mayamy (Shahroud)	310	Eastern-Western	To the right	Alpine Folding	- Northern boundary of Ophiolite zones Mayamy - Abbas Abad -Northern border of rift Sabzevar - Shahroud
Enjilo	100	Northeastern-Southwestern	To the right	Caledonian Orogeny	-Creation of local folding -Boundary between local mountains and nearby hole -Active Tectonic
Totoud	290	Northeastern-Southwestern	To the right (Inverse)	Caledonian Orogeny	-Creation of local folding -Uplift of tectonic valleys and folds -Boundary between local mountains and nearby hole -Active Tectonic -Earthquake of years 1331, 1385 and 1389 in Torud and Reshm regions

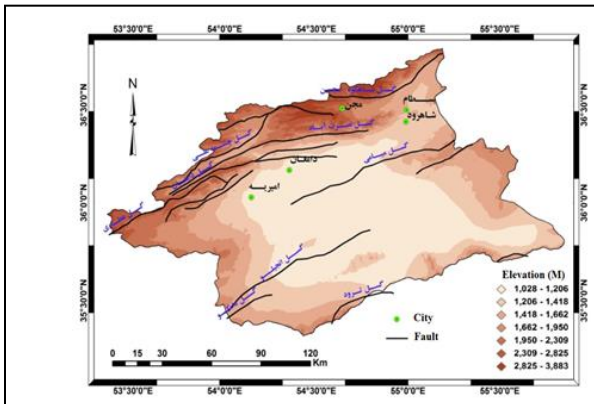

Fig. 6. Faults of study area.

Petrographic studies have been showed that sediments of Haj Ali Gholi playa aren't destructive and erosive, and/or haven't been moved to the out. Also, sedimentary layers of around area aren't observed in the Playa. It cans argument that the Playa is a tectonic hole. In addition, according to considerable sediments with thickness of 500 to 600 meters, there is this possibility that the Playa is an erosive hole (Ahmadi, 2008). The most important geological materials of study area are as Figures 7.

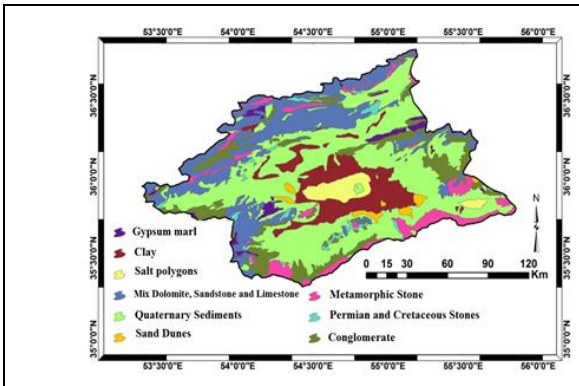

Fig. 7. Geological materials of study area.

Geomorphic processes are called as physical and chemical interactions between the Earth's surface and the natural forces acting upon it to produce landforms. The processes are determined by such natural environmental variables as geology, climate, vegetation and base level, to say nothing of human interference. The nature of the process and the rate at which it operates will be influenced by a change in any of these variables (www.eionet.europa.eu). In geomorphological maps, colors are used to symbol the geomorphic processes, for example, blue color for water processes, clear blue for glacial processes and etc. In other words, landforms and their colors show the creative processes (Ramesht, 2006). At present, morphogenesis systems, dominating on study area, are sub-glacial, fluvial, wind erosion and pedimentasion processes from mountains to playa respectively. Properties of landforms and their creative processes in study area have been presented in table 2.

TABLE 2
LANDFORMS AND PROCESSES OF STUDY AREA

Landform	Symbol	Creation Era	Process	Equilibrium
Alluvial Fan		Kata-Glacial	Concentrated runoff	No
Butte		Kata-Glacial	Concentrated runoff	No
Fault		Pre-Quaternary	Tectonic	No
Gully		Kata-Glacial	Concentrated runoff	No
Stream		Kata-Glacial	Concentrated runoff	No
Terrace		Kata-Glacial	Stagnant water	No
Clay Plain		Kata-Glacial	Stagnant water	No
Salt March		Kata-Glacial	Stagnant water	No
Sand Dunes		Kata-Glacial	Wind	No

The combination of landforms, land-views, land-features, landscapes, processes, geologic materials and geomorphic analyses in Arc GIS software were resulted to the geomorphological map of study area that has been represented in the figure following.

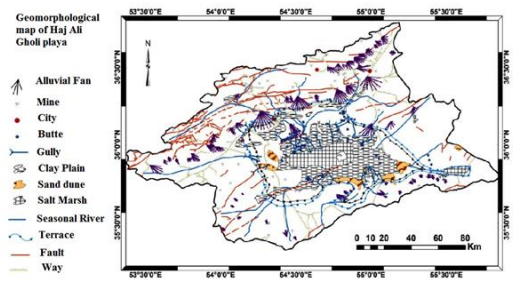

Fig. 7. Geomorphological map of study area.

Haj Ali Gholi basin is a geomorphic landscape of dry-lands that consists of Mountains, Glacis and Playa units. Limestone, calcareous sandstone, dolomite, conglomerate, volcanic and metamorphic materials are the most important land-features of the Mountains landscape. Erosive plains, Epandage plains, mantled plains, alluvial fans, sand fields and Oueds are the major land-features of the Glacis landscape. Clay plains, wetlands and salt marsh are the most important land-features of Haj Ali Gholi Playa.

Geomorphological map of study area, presented in the research, is plotting the geomorphic forms and processes of the region, and relationship among them by separation and depiction of landforms, land-views, land-features and landscapes. At present, morphogenesis systems of study area are sub-glacial, fluvial and wind processes from mountains to playa respectively. Also, prevailing erosional processes are weathering, water, wind and the human factors. Geomorphological map of the area is presented that have high importance in the applied geomorphology such as environmental management and planning, because the map includes the capabilities and limitations of geomorphic landforms, land-views and land-features.

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