

# Mud Diapirism on the Gorgan, North Iran

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## Abstract

The several mud volcanoes have been exposed at the Gorgan area in the north Iran. The Garniarig-Tapeh is the biggest mud volcano and the investigation of its tectonic geomorphology is the main aim in this paper. Also, we have determined tectonic and geologic setting of Naft-Lije mud volcanoes and several Salses as the exposed mud diapirs at Gorgan on the northern margin of Iran. These mud volcanoes have been formed during quaternary of as a shield shape hill or pool on the flat plain in coastal region SE Caspian Sea. There are flat area and several mud volcanoes that they have been triggered by buoyant driving mechanisms, have been appeared during dormant periods of mud volcanoes activity. This mechanism has been developed in neotectonic regime by convergent setting between The Cimmerian and Eurasian plates. Finally, the main characteristics of the Gorgan area have presented.

## Keywords

Garniarig-Tapeh, Mud, Volcano, Gorgan, Iran

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## 1. Introduction

Iran country has composed from the several physiographic-tectonic provinces. Each physiographic-tectonic province has a same structural trend and dominant mechanism of deformation, because these have related to tectonic settings, magmatic histories, stratigraphic variations and deformational models of crust. Mud volcanoes have been found in the some parts of Iran. These parts are very important from the occurrence of petroleum point of view. The most mud volcanoes have been occurred along convergent plate margins where fluid-rich sediment is accumulated in deep-sea trenches at high rates. Such deposits then enter the subduction factory, where liquids and volatiles are released due to increasing compaction stress and temperature.

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The mud diapirism is very common in convergent tectonic settings that are marked by compressive forces. As for the first, tectonic activity is an additional trigger to the buoyant driving mechanism. Fluid for mud volcanism is supplied from various sources, including meteoric and volcanic waters, pore water expulsion, hot springs, mineral dehydration reactions, and gas hydrate destabilization [1]. The questions are why and how mud-volcanoes form provokes a lively discussion. Many researchers have worked in different areas and postulated usually a variety of geologic; tectonic; geochemical and hydrogeological reasons.

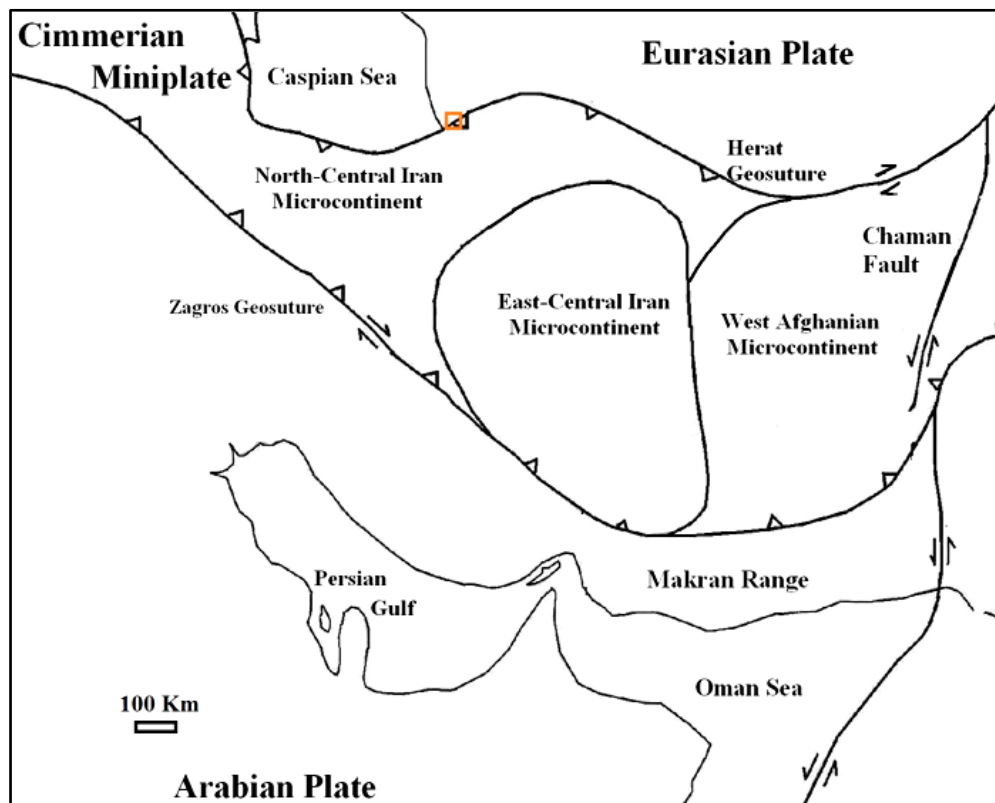
## 2. Materials and Methods

The high sediment accumulation rate at passive continental margins and the lateral tectonic compression at active continental margins can be consider as the main reasons for space distribution of mud diapirs that formed by density inversion, faulting, fluid migration. In addition, it is obvious that plastic clay layers must be presented for mud volcanoes to form. In some regions, submarine mud volcanoes form in areas characterized by a spatial combination of rapid sediment accumulation and lateral tectonic compression [2].

Characteristics of mud diapirs in the Gorganregion in the northern part of Iran are the main aim in this research. This area is located on convergent tectonic setting between Cimmerian and oceanic part of Eurasian plate (**Figure 1**).

Previous research on Iran's tectonic setting [4]-[6], salt diapirism [7]-[16], Seismotectonics [17]-[20] have shown that the Zagros belt is the most active zone in Iran [21]-[34]. Alborz belt in north Iran [35]-[66] and Central Iran [67]-[81] have been situated in the next orders. The study area is located on the south Caspian foreland basin.

Dominant structural trend in South Caspian foreland basin province is NW-SE. From tectonics view, it contains the northern foreland basin of West-Central Alborz and lesser Caucasus hinterland in the south margin of Eurasian plate since late Eocene. Although, median part of South Caspian and Black sea basin has uplifted by collision between Eurasian and Cimmerian plates. There are several Mud volcanoes along the coastal part of Gorganarea. The biggest one is Garniarig-Tapeh Mud volcano (**Figure 2**).



**Figure 1.** Tectonic framework map of Iran and study area (Red rectangle), modified from [3].

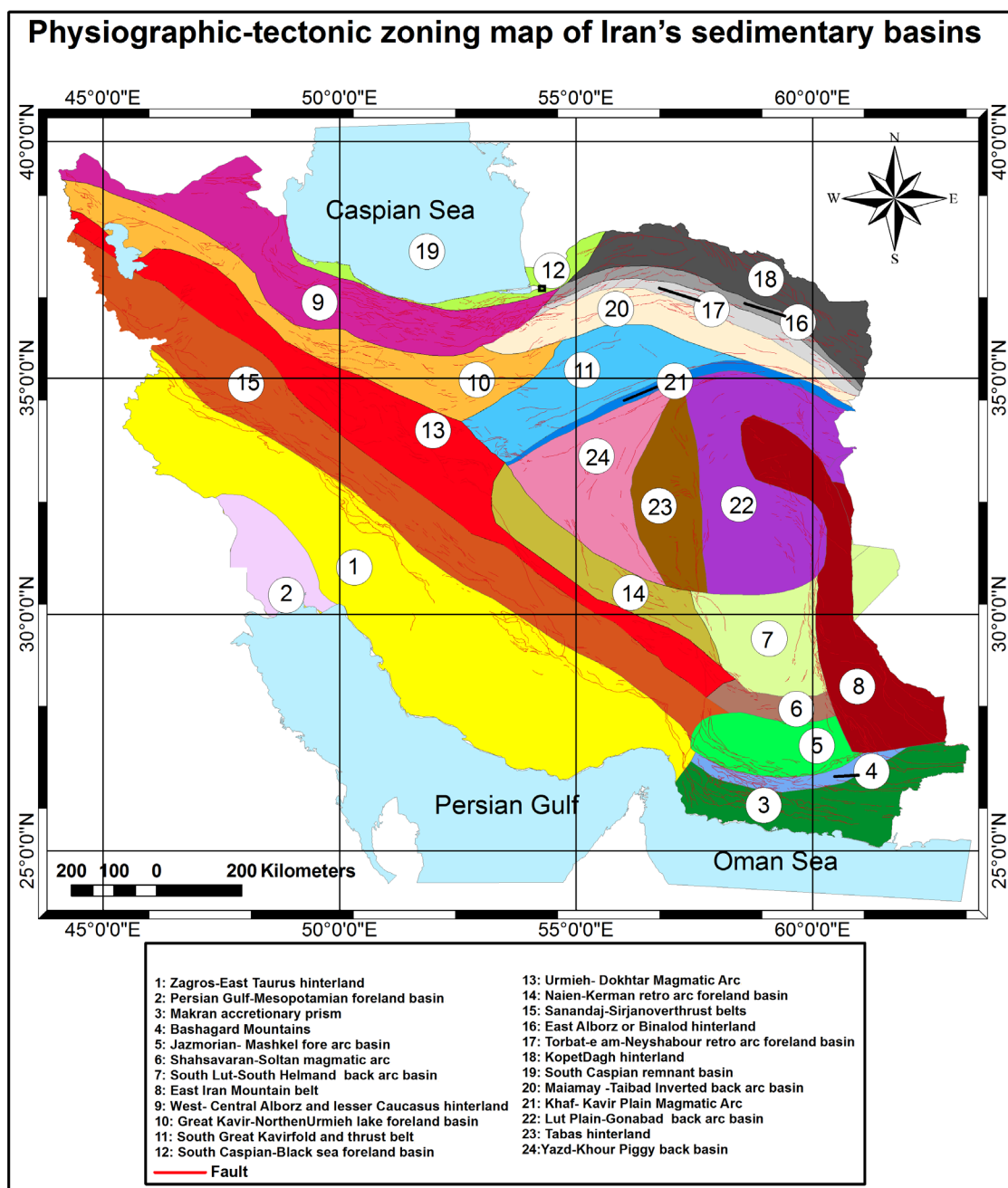
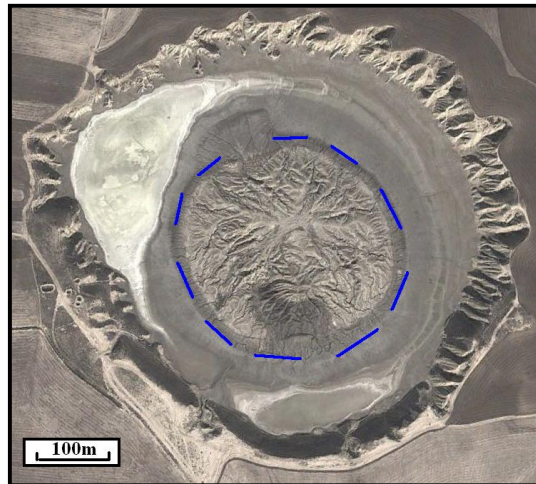


Figure 2. Physiographic-tectonic zoning map of Iran's sedimentary basins and study area (Black rectangle) modified from [3].

### 3. Results and Discussion

Based on our investigation, the Garniarig-Tapeh mud volcano has a shield shape with a height of near 25 meters and a diameter of near 650 meters. It has formed on the flat quaternary plain in the coastal region (Figure 3) of the Caspian Sea. Also, there are several salt lakes or small mud craters which have been filled with water (Figure 4 & Figure 5). These features have appeared during dormant periods of mud volcanoes.

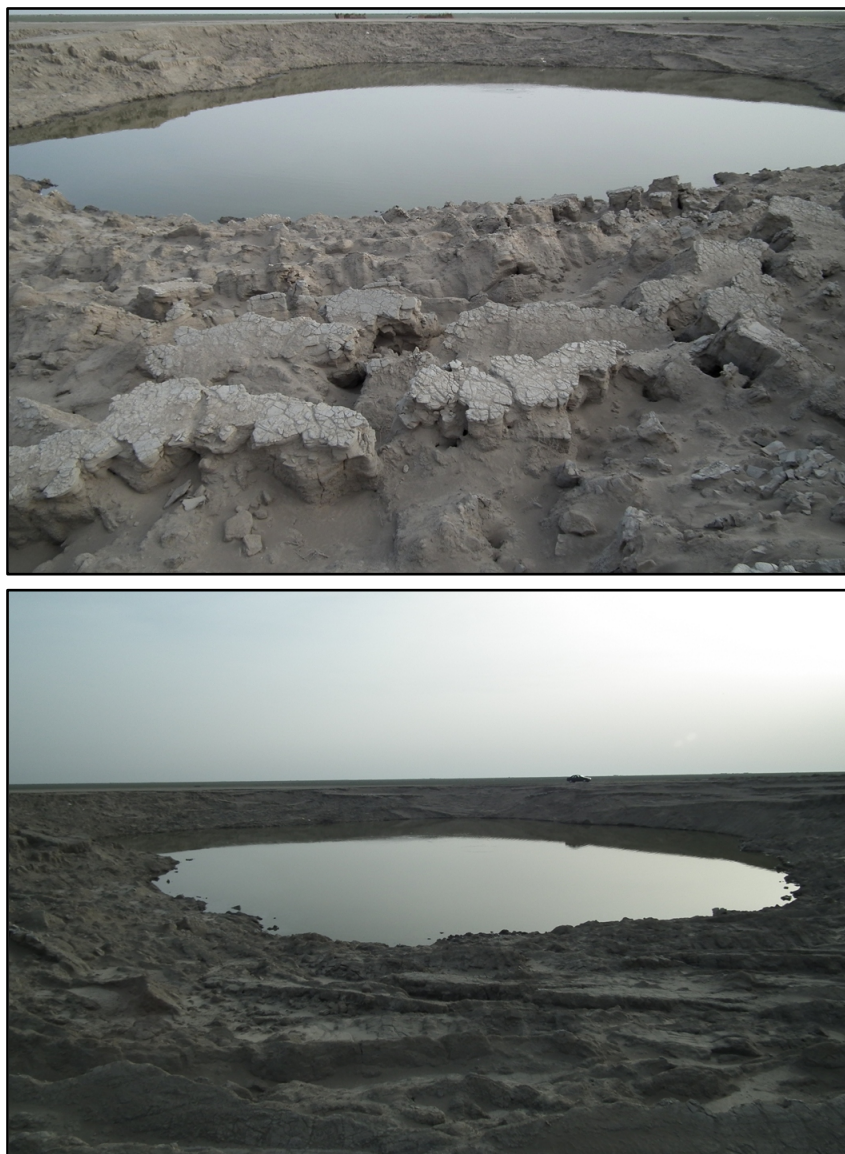
In the central part of the Garniarig-Tapeh mud volcano, radial streams have formed in a big pond that has been filled with viscous clay (Figure 3). Also, there are several mud volcanoes along the coastal region of the Caspian Sea that one of them is Naft-Lije that is found at the north of Gomish-Tapeh city (Figure 6).



**Figure 3.** Interpreted ETM+ Satellite image of the Garniarig-Tapeh Mud volcano.



**Figure 4.** Two views from a salse near to Garniarig-Tapeh mud volcano at north of Gorgan city.



**Figure 5.** Two views from another salses near to Garniarig-Tapeh mud volcanoat north of Gorgan city.

These mud volcanoes have been triggered by buoyant driving mechanisms, because there are not find geological structures such as folds and faults. This mechanism can be related to neotectonic regime of the south Caspian basin. It means that oceanic lithosphere beneath of the Caspian Sea has been sloped to the south, however it has been covered by thick sediments.

This mud diapirs has been rise from quaternary deposits and probably mud diapirism has been started since Early Pliocene, because it has covered quaternary plain. There are not the index structures in the Gorgan region. It means that mud diapirs have not been triggered by tectonic forces, in contrast of mud diapirism in Makran in the south part of Iran [82]. Also, there are several dispersed mud diapirs, but all of them are the smaller than Garniarig-Tapehdiapir.

#### 4. Conclusions

Tectonic geomorphology and origin of the exposed mud volcanoes on the Gorgan area have determinated. Mud diapirism in this zone has not been controlled by only tectonic forces, however there are an old



**Figure 6.** Interpreted ETM + Satellite image (up) and a photo from the center (down) of Naft-Lije mud volcano at North Gorgan.

suture zone between Cimmerian and Eurasian plates.

It means that buoyant driving mechanism is predominant compared with tectonic forces in the coastal parts of the Caspian Sea. Therefore, formation of the new mud volcanoes and more development of the older mud diapirs are not expected for short times. Because mud diapirism has been developed before regional shortening on the old convergent zone between Cimmerian and Eurasian plates. Also, there are several salses that have been appeared during dormant periods of mud volcanoes activity.

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