

## Geological Processes of Sand dune Development in Sadegh Abad Near Bafq, Central Iran and Its Geotourism Attraction

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### Abstract

*Bafq is one of the main cities of Yazd Province, located at SE of Yazd City, with deserts and eolian processes. The most important external agents of desert development in this area are arid lands, lack of vegetation and wind. Geological setting, petrology and wind erosion, which has been forming Sadegh Abad sand dune, near Bafq, are discussed here. Mounds, ridges and low hills of loose windblown sand with star dunes in center and crescentic dunes in border are created a nice view for Geotourism in Sadegh Abad. Winds with highest speed principally blowing from N and NW of sand dune. Changing speed and direction of wind in different seasons has created dunes with variety of morphology in this area. The heavy minerals such as olivine, pyroxene and hornblende which originally are highly spherulitic and unstable formed in short term processes, are gathered along more stable minerals such as calcite, dolomite and feldspar which in a long term processes became well rounded in Sadegh Abad sand dune. The drainage system comes from east and north east of the sand dune. This system brings altered metamorphic and carbonate rocks toward Darreh Anjir desert and collects them at north part of the sand dune, not far from it. Then, the N and NW direction winds are carrying them to the dunes. So the grains transported in a turbulent flow before moving by wind.*

**Key Words:** *Geology, Sand dune, Sadghabad, Bafq, Geotourism, Desert, Wind erosion, Petrology*

### 1-Introduction

Wind erosion is widespread in this area and sand dunes are attractions of the weathering and wind erosion. Continental isolation and climate zone deserts are the mostly types of deserts in Iran. They include 61 percent of desert lands, 24 percent sandy places and 15 percent sand dunes. In this research, we did geological and petrological investigation in Sadegh Abad sand dune. The study aims are explanation the geological processes has been forming sand dunes in Sadegh Abad and their mineralogical contents, external agents that created the morphology of them and finally expressing their Attraction force for geotourism.

### 2- Geographical Situation

The study area lies in the north of Sadegh Abad, a small village of Bafq district, limited by coordinates: 31°44'-31°46'N and 55°17'-55°19'E. The sand dune height is from 3 up to 100 m in central part and 15km<sup>2</sup>, situated at 18km NW of Bafq along the road to Hasan Abad village (Fig1). Due to the general conditions of the desert and the lack of any kind of surface stream, Bafq region does not have a satisfactory supply of drinking water. (Semsar Yazdi, A., Labbaf

Khaneiki, M., 2006). The study area is located in the eastern border of Darre Anjir desert (Fig2).

### **3- Geological Setting**

The study area is a part of central Iran. The Central Iranian Terrane as a fragment of Gondwana with a Precambrian basement is surrounded by fold-and-thrust belts, within the Alpine-Himalayan Orogenic System of Western Asia with three major crustal domains, Lut, Tabas and Yazd blocks. (Ramazani, J. and Tucker, R.D., 2003, Fig 3). All of these blocks with arid climate lie on desert belts. The central plateau of Iran surrounded high mountain systems along its margins. Several lesser chains enclose extensive deserts, like Lut and Darreh Anjir mainly salt flats, sand dune and sand sheet. Physiographic-geomorphologic studies show the collaborative effect of wind and water action in forming the Lut mega yardangs. (Alavi Panah, S.K. et al. 2007 after Bobek, H., 1969). Darreh Anjir is the largest salt flat in Yazd and Sadegh Abad sand dune located in its western border (Fig 2). Bafq Precambrian basement comprises high to low grade metamorphic rocks such as schist, gneiss, amphibolite, quartzite and marble and low grade slaty shale, quartzitic sandstone, greywacke and phyllite. (Haghipour, A., 1977). Darreh Anjir has formed a playa in west of Sadegh Abad with a desert lake on it as shown in fig 2. In the east of sand dune tectonic movements let to develop a broad pediment. The front mountains has formed the Metalogenic belt of Bafq- Saghand. This belt consists of the major iron mines like Choghart, Sechahoon and Chadormalu (Fig 4). Drainage lines within these mountains are capable to come down from autochthonous slope. The lower flat pediments facilitate transportation and denudational processes. The altered rocks come down by flood and stream via natural slopes and are deposited in lowered part of pediments. Later, prevailing wind moves the sands particle in order to forming Sadegh Abad sand dune.

### **4- Materials and Methods**

The following Materials for this research were employed: Topographical map with scale of 1:250000, Geological map with a scale of 1:100000, Satellite images (Aster), Mineralogical analyses methods (XRF & XRD), thin sections. WRplot software used to determine wind speed based on data since 1996 to 2005. Research methods were determined based on field investigation, geological and topographical maps, and satellite images. Finally, Sand dune types and external agents controlling characteristic and the sand source were determined based on the models related to the wind direction, geomorphology, geology processes and petrological studies.

### **5- Morphology**

Dunes, as fixed, covered by vegetation that has taken root and prevented further shifting of the sand (Strahler, A. H. & Strahler, A. N., 1992). Sadegh Abad sand dunes are fixed. They have no sufficient vegetation but relative humidity and their high elevation made them inactive, however multi direction winds bring sands continually, increases sand elevation and there is not noticeable transgression. Based on satellite images and field investigation there are three major dunes in the area: seif, barchanoid ridge and star dune. Seif dunes in Sadegh Abad as the first dune will be change eventually to asymmetrical ones because of wind regime

and then under influence of NW to SE wind, transformed to transverse dunes (Fig4a). These dunes principally are found in N and NW parts. Barchanoid ridge dominated the area, pressed each other to form a special kind of dunes named reversing dunes (Fig 4b, c). Winds of different directions transformed the dunes and have wrinkled them. (Fig4d). Dominate winds of three directions maked star dunes in central peak of study area with three or more arms and each corresponds to a wind direction. Star dunes do not migrate but grow vertically so they have the highest altitude in the area (Fig 4e, f). The study of wind rose diagrams indicates predominance of N direction wind till NW and S direction wind till SE Winds with highest speed (more than 11Knot) principally blowing from N and NW. The wind direction in spring and summer is rather from south (Fig 5).

The autumn and winter winds often blowed from north. The relation between geological conditions and dunes' morphology, investigated by Nishimori, H., Tanaka, H., 2003. The results indicated transverse dunes formed in one direction wind. Seif dunes in two and star dunes formed when wind is blowing in three direction.

### **6-Petrography and Origin of Sand Dune**

The size grain of sands in Sadegh Abad change between 0.1- 0.35mm as fine to medium fine sand. The petrographic and microscopic studies indicates that most grains composed of iron oxides like hematite and magnetite. Other major phases contained of calcite, dolomite, albite, orthoclase and quartz indicated by XRD analysis and microscopic study. Also the mafic minerals like olivin, pyroxen, garnet and amphibole have seen under polarizing light (Fig 6a, b, c, d). Epidot has a predominate view in thin section. Montmorillonite and hornblende as minor phases have reported. Quartz grains not in abundant, are commonly worn out with uniform extinction in the studied dune sands indicates that they have considerable mineralogic maturity. This suggests that the major part of these sands passed through several sedimentary cycles rather than derived directly from igneous and metamorphic rocks (Rushdi B.A., 2009, after Ehlers and Blatt, 1982; Carozzi, 1993). This confirms the binary origin (moving by water and wind) in Sadegh Abad sand dune. The carbonate grains are dull and some crusts of them resulting of dissolution have seen. The usual multiple twining in calcite and dolomite crystals are not seen here. Feldspars are represented by plagioclases and orthoclase with multiple and simple twining. The garnet crystals having well shape and euhehedral crystals (fig 6b). These crystals based on chemical composition through X-rey florescence seem to be a garnet of almandine type. Garnet is common in a great variety of metemorphic rockes so presentation of it in Sadegh Abad sand dune indicates the matomorphic rocks located in the NE parts, as Chadormalu iron mine (Fig3), could be one of the Sands sources. Commonly seen iron oxides and north direction wind, confirm this idea as well and suggests derivation from the same source and their passage through the same sedimentary history. Some olivin crystals altered to iddingsite through their crackes. The present of epidote is markedly and they are the most colorful crystals in crossed polar view (Fig6d). We do not examine the average percentage distribution of opaque and non-opaque minerals from all direction in this research. The sand grains classified as shown to well rounded and well sorted. This rounding degree gives us the clue to a long time transporting. In the other hand, unstable minerals such as olivine, pyroxene and hornblende as well less stable minerals like epidote and garnet, will not survive for a long time in the weathering and transportation cycles. At a glance should say

it depends on different distance of source rocks to the sand dune. The metamorphic rocks consist of such heavy minerals are closer to sand dune and their high sphericity depends on their original shape, not to rounding by long transportation. Based on petrographic study such as partial dissolution and non-transparent grains especially in carbonate crystals, likely they transported by two agents and before moving by wind, transported in a turbulent flow. The Sadegh Abad sand dune based on geological map (geological survey of Iran, 2005) belongs to quaternary age.

### **7- Geotourism Attraction**

A huge hill of sand dancing in wind below the sunrays joint to silence and peace of desert is the things you can see in Sadegh Abad sand dune. Attractive view, available road and close to Bafq (only 18Km) are the benefits of this place as a national natural landmark. Hiking, climbing and playing on the sands is enjoyable for everybody. Except hot months (June, July and August) sand temperature is suitable for a bare foot. The sand size is fine enough to give a feeling of joy. The temperature of sands usually is higher than air temperatures. Therefore, in a paucity cold weather touching warm sand is pleasurable. We suggest this place as a geo site. These sand dunes have ability to become a Geopark with big Darreh Anjir desert beside them, which has a nice desert lake full of salt within. It may design hang-gliding, landing, sand boarding and launching zones over there. A visitor center established can help visitors a little bit more about the area and learning about the geology of sand dune.

### **8- Conclusion**

Wind in different direction is constantly changing both the shape and size of the dune and make the sand dune growth vertically. Barchanoid ridge and star dunes are the terminology variety of dune exists here. The star dune are in central part and three direction winds made them as highest dunes in Sadegh Abad with up to 100 meters height. The size grain of the sands in Sadegh Abad changes between 0.1-0.35mm as fine to medium fine sand. The conclusion of mineralogy not only indicates the predominate source of this sand dune but also gesture that existing sediments are rich in the relatively unstable heavy minerals. Presence of unstable minerals along more stable ones suggest several sedimentary cycles and long term geological processes with short term ones. The sources of these different minerals relative to metamorphic rocks located in superior position at east of the sand dune. Hydro-Aeolian processes are responsible to gathering this huge of sands together with very attractive view beside a great playa.

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Fig3- Metagenetic belt of Bafq- Saghand consist of main iron ore mines like Choghart, Sechahon and Chadormalu. (Torab & Lehmann, 2006- modified)

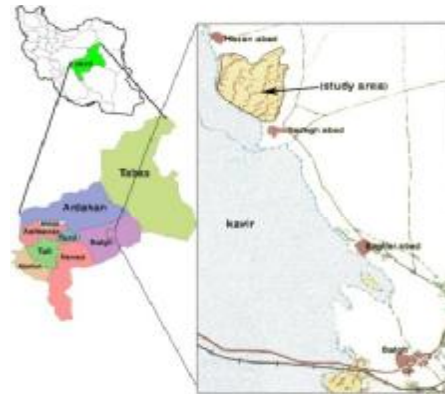
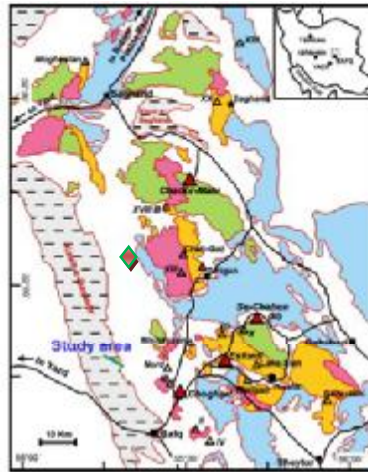


Fig 1- Geographical Situation of study area based on topographic map, scale 1:250000

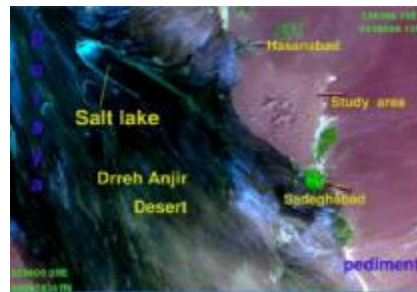
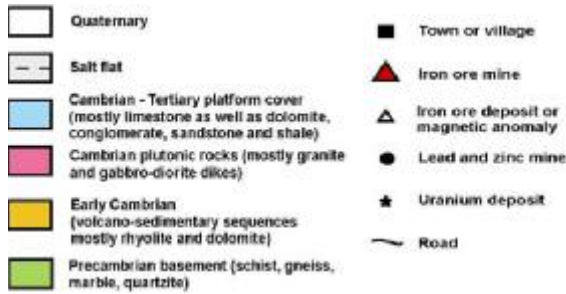


Fig 2- The study area is located in eastern border of Darreh Anjir desert



Fig6a- Olivine and pyroxene (PPL)



Fig 4- Reversing dunes



Fig 4b- Reversing dunes



Fig4a- transverse dunes

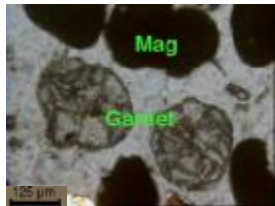


Fig6b- Garnet and magnetite. (PPL)



Fig 4f- Star dune



Fig 4e- Star dune



Fig 4d - wrinkled dune

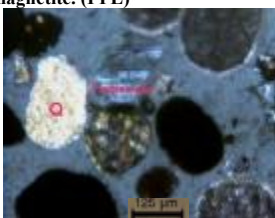


Fig6c- Plagioclase with multiple twinning (XPL)



Fig6d- Calcite, Epidote and magnetite (XPI)

Fig 5- Winds with highest speed (more than 11Knot) principally blowing from N and NW of sand dune.

