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Research Article

SPREADING SEDIMENTARY FACIES IN KHAMNEH ALLUVIAL FAN, EAST AZERBAIJAN, IRAN

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ABSTRACT
Khamneh alluvial fan is one of several alluvial fans of the southern hillside of Misho Mountain in North West of Tabriz, East Azerbaijan and north west of Iran. The general slope of this district is from north to south. Khamneh alluvial fan is consisting of conical or infundibular sediments that in southern hillside of Misho Mount from mountain side to the plains the thickness of its sediments is decreased and the extent of which is added. In sediments of Khamneh alluvial fan 10 sedimentary facies have been identified, including four gravel facies (Gms-Gm-Gt-Gp), four sand facies (St-Sh-Sp-Sl) and two muddy facies (Fsc-Fm). Based on the lateral extension of the facies four zones are determined: sand zone in proximal region, gravel zone in medial region, and mud and salt zones in distal region. Also, the vertical extension of the facies and the sedimentary cycles which are the result of it are indicative of general regression of alluvial fan towards the plains, active mountain front and tectonic uplift during quaternary.

Keywords: *Alluvial Fan, Sedimentary Facies, Quaternary, Alluvium, Misho Mountain, Khamneh, East Azerbaijan, Iran*

INTRODUCTION
The area that has been studied is located in northwest of Tabriz, East Azerbaijan province and north west of Iran. It is limited to eastern longitude 46˚30´45˝ and northern latitude 38˚30´. Mountain Misho is spread in a vast area of upstream and is like Horst east-west mountain range that is controlled by two faults on its both sides. General slope of the district is from north to south, so that the study area is limited from the north to the foothills of Misho and Daryan town, from east side to Shabestar town, from southern hillside with steep slope to the catchment area of Urmiya lake and salt marsh of Sharafkhaneh port and Shandabad village and from west to Khamneh town, Tasouj and Kouzehkanan (Mokhtari, 2002). Quaternary sediments are found frequently in the area so that Khamneh town is located on the quaternary sediments. Also quaternary sediments are widely spread in east and west sides of Khamneh town. In the northern region of the stratigraphic units related to Miocene, conglomerate, marn, shale and sandstone facies are outcropped. The highest point in the area is Alamdar Mount which is 3135 meters high in the North West of the region and the lowest point is 1275 meters from the sea on the eastern edge of the lake (Figure 1).

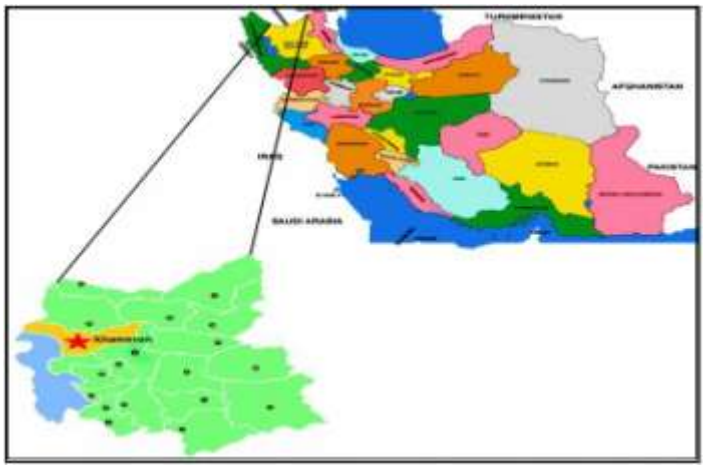

Figure 1: Geographical location of the study area (Shown with ★)

MATERIALS AND METHODS

Research Method

After preliminary visits based on the geological map 1:100,000 of Marand (Asadi and Mirzai, 1994) excavation and field sampling was conducted in various parts of the Khamneh alluvial fan. Clastic facies forming alluviums of Khamneh alluvial fan were identified. Differentiation of facies was accomplished on the surface of the alluvial fan based on identified sedimentary structures, textures, internal model of channel and channel margin deposits, by Miall (1996) method, during which all faciesthat were formed according to material and environment were coded. Also by methods of Tucker, 1988 and Folk, 1974we sampled and photographed the identified sedimentary facies of the area and after granulometry tests, statistical parameters of computation (Cheel, 2005) were used in analysis of the sedimentation condition and environment along the coded facies.

Geology of the Area

Mount Misho is spread in a vast area of upstream and is like Horst east-west mountain range that is controlled by two faults on its both sides. In this region the central core of the Misho mountainis composed by very thick sediments of Kahar and Precambrian. Kahar is folded by Katanga wrinkles and is altered about green schist and in special circumstances of Paleozoic sedimentary basins, clastic deposits with great thickness are accumulated on it.With the significant lake of Caledonian drought causing movements, the progressive Permian deposits of Permian sea is consist of red and white grit facies. In addition to the orogeny effects of the Cimmerian (Glennie, 2000), graben creation of fault activities highlights the restart of the sedimentation cycleand advancement of upper Cretaceous sea. Between the borders of Miocene and Pliocene deposits another slope is apparent which is dependent on Pasadonianorogeny. The last tectonic event in this region, like in other parts of Iran, was Pasadonian phase, which after this tectonic event all the movements happened as drought causing and caused settlement of the Quaternary sediments in east, west and somewhat south of the region (Berbrian, 1981).

Sedimentary Facieses of Khamneh Alluvial Fan

In study of the sedimentary facies of Khamneh alluvial fan 10 sedimentary facies have been identified which include four gravel facies (Gms-Gm-Gt-Gp) and four sand facies (St-Sh-Sp-Sl) and two small-grained facies (Fsc-Fm).The identified facies were named and coded based on (Miall, 1996) segmentation:

GmsFacies (Gravel with Masivelayering and Abundant Matrix):

This facies indicates thick layers that are masive and have scattered components (Miall, 2006) and because of its proximity to the origin, it is wholly angled and includes very large to very small gravels which are often very poorly sorted. In this facies, fine-grained sand and muddy sediments have filled the space among gravel grains (Rust, 1978). This facies is composed by debris actions with high viscosity and high power of environment (Figure 3).

GmFacies (Gravel with Masive and Semi-Horizontal Layering with Poor Matrix):

This facies represents layers that the main part of it is made of gravels and most of the space among them is composed of fine-grained particles. This facies is poorly sorted and also reflects the high energy of the environment at the time of deposition (Mahari and Lasemi, 1998). So the layers are in pile situation due to their formation in high energy and turbulent activity conditions (Miall, 1977). Spreading of its sediments is wide and plate form (Figure 3).

GtFacies (Gravel with Diagonal Lens Shaped Layering Form):

In this kind of facies the surface of the lower layer is lens shaped. Sediments of this facies are in diagonal lens shaped layering form because of gravel dams' movements towards downstream side. Dominant grains of this facies varies from granular grains to pebbles (Grabau, 1904). This facies is relatively well sorted and its sediments have been deposited during high flow and energy conditions. Geometric shape of it and its spreading is lens and wedge shaped (Figure 3).

GpFacies (Gravel with Diagonal Flat Layering):

In this facies, its upper and lower surface is flat, and gravel particles' roundness varies from semi-rounded to semi-angled. Geometric shape of this facies is tabular and its slope is about 20 degrees. This facies is

composed in high energy and flow situation and is influenced by active falling and sliding processes in the channel. The sediments are fairly well sorted (Miall, 1977). The amount of mud in these sediments is very few (Figure 3).

St Facies (Sand with Diagonal Lens Shaped Layering Form):

This facies is located as lateral and intermittent with other sand and gravel facies. It is relatively well sorted (Walker, 1984), the contact of sediments in this facies with upper and lower units is quantized.Geometric shape, vertical and lateral variations and series thickness show that deposition has taken place in a sub-channel with lower flow (Figure 3). The presence of this facies in a lithological unit represents order and preferential tranquility (Tuker, 1988).

SpFacies (Gravel, with Diagonal Flat Layering):

In this facies the upper and lower surfaces are almost flat and the probability of erosion is very negligible. These sediments are the result of deposition in flows that have very weak carrying power. Mainly this facies is identified in downstream parts of the channel that indicates reduction of the flow strength of the environment (Figure 3). In terms of the geometrical shape and spreading, the facies is tabular (Reading, 1996).

ShFacies (Sand, with horizontal layering):

This facies has parallel and flat layering. It is formed with horizontal layering at high speed and few water. Thus the formation of this facies can be attributed to the high speed of the water flow (Mahari and Lasemi, 1998). Sediments are fairly well sorted (Figure 3). In these sediments erosion is not seen but the horizontal layering (Miall, 1977) is clearly seen.

SlFacies (Sand, with Diagonal Layering and Slope of Less Than 10 Degrees):

In this facies the upper and lower surfaces are flat and the geometrical shape of its sediments is tabular. The sediments of this facies are deposited in a low-energy environment with less flow. So the more sediments are fine-grained and far from the origin of the deposition environment, the more energy of the environment is reduced (Miall, 2006). These sediments are deposited in a low slope (Figure 3).

FscFacies (Silt and Clay and Some Fine-Grained Sand, with a Masive Layering):

Presence of this facies in the area indicates that the sediments are deposited in low-energy condition and in the margin of the channel. Such facies can be deposited on the flood plains or in an abandoned channels (Mahari and Lasemi, 1998). This facies is formed when silt and clay sediments are more than sand sediments in deposition place (Grabau, 1904). The facies is well sorted (Figure 3).

FmFacies (Silt and Clay, with Masiveand Sometimes Horizontal Layering):

This facies is determined by yellow to orange color mud with massive and sometimes horizontal layering. The sediments of this facies are deposited in a low-energy environment and have a slow deposition. The amount of the silt and clay sediments should be high in the place so that the deposition takes place for this facies (Mahari, 2009). These sediments are well sorted (Figure 3). Also, this facies is deposited in margin and around the channel (Miall, 2006).

Zoning of Khamnehalluvial Fan:

Khamnehalluvial fan is diagnosed on sedimentary facies and also based on granulometry of the sampled alluvium (Tuker, 1988 and Folk, 1974)it is zoningin three regions: proximal or upstream, medial and distal or downstream.

A. Proximal Region of Khamnehalluvial Fan:

Figure 3 indicates proximal region and represents that the origin is close to a sedimentary environment so that the lower layer is formed by Gmsfacies. It displays that the energy of the environment is high and slope of the area is increased. Also the viscosity of the region is high and the amount of the matrix in the place is increased (Miall, 1977). Gmfacies is located on Gmsfacies and the presence of this facies in the region indicates that at the time of formation the energy of the environment was high and the slope of the region was up (Figure 3). Gmsfacies is formed on Gmfacies again. It means that at the time of formation the viscosity of the environment was increased and the energy and the slope of the environment was high. Generally, this picture indicates that the sediments of the proximal region are formed in high energy and

upper slope (figure 3) and because the flow of the formation place was high, sediments were formed with pile layering (Miall, 1996). Proximal region is specified with gravel zone at the beginning part of the alluvial fan in the zoning map of Khamneh alluvial fan (Figure 2).

B. Medial Region of Khamneh alluvial Fan:

This picture Figure 3 is about medial region and represents that the origin is a little far from the sedimentary environment. As it is shown in this figure, the lower layer in this region is formed by Fmfacies with low thickness. It shows that at first the energy of the environment was low and the slope of the area was decreased (Figure 3). But with the sudden increase in energy of the environment, Gmsfacies begins to form and the presence of this facies in the region means that the slope of the environment has increased suddenly so Sh facies with considerable thickness is formed on the Gmsfacies. This indicates that the energy of the environment is high yet but the depth of the water has decreased. Then Gmfacies is deposited on Sh facies with low thickness and it means that the slope of the environment has increased and the amount of the gravels has increased too. Inside the Gm facies there is Fsc facies with very low thickness (Miall, 1977). Generally this picture shows that, if compared with the proximal region, the energy of the environment in this region and the slope has decreased and this makes the sand sediments in the region to increase (Figure 3). Madial region is shown with sand zone at the middle of the alluvial fan on the zoning map (Figure2).

C. Distal Region of Khamneh alluvial Fan:

Picture Figure 3 is about distal region which indicates that the origin is far from the sedimentary environment. As it is shown, Fscfacies is formed with high thickness in the region and it represents that at the time of the formation, the energy of the environment and the slope was low and the amount of the silt and clay sediments were very high in the region (Miall, 1977). Inside this facies, there were Sp and St facieses among the layers (Figure 3). The presence of Spfacies inside it shows that the slope of the formation place has increased a little and this is an important indicator of the downstream sediments of the channel.* St facies is formed in the upper part of the Fsc facies that indicates the flow has changed and the end of this facies is lens shaped (Figure 3).Gmsfacies has started to form on it that displays the slope and energy of the environment suddenly has increased (Miall, 1996). Generally this picture indicates that as we are close to the end of the fan, the energy and the slope of the environment is reduced and the extent of the alluvial fan is increased. Distal region is shown with clay zone and some parts of salt zone on the zoning map of the Khamnehalluvial fan (Figure 3).

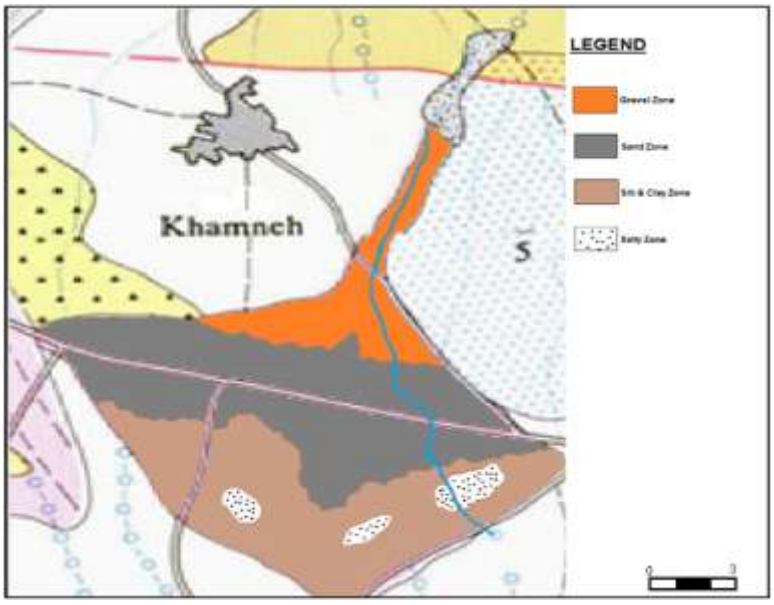

Figure 2: Zoning map of Khamneh alluvial fan

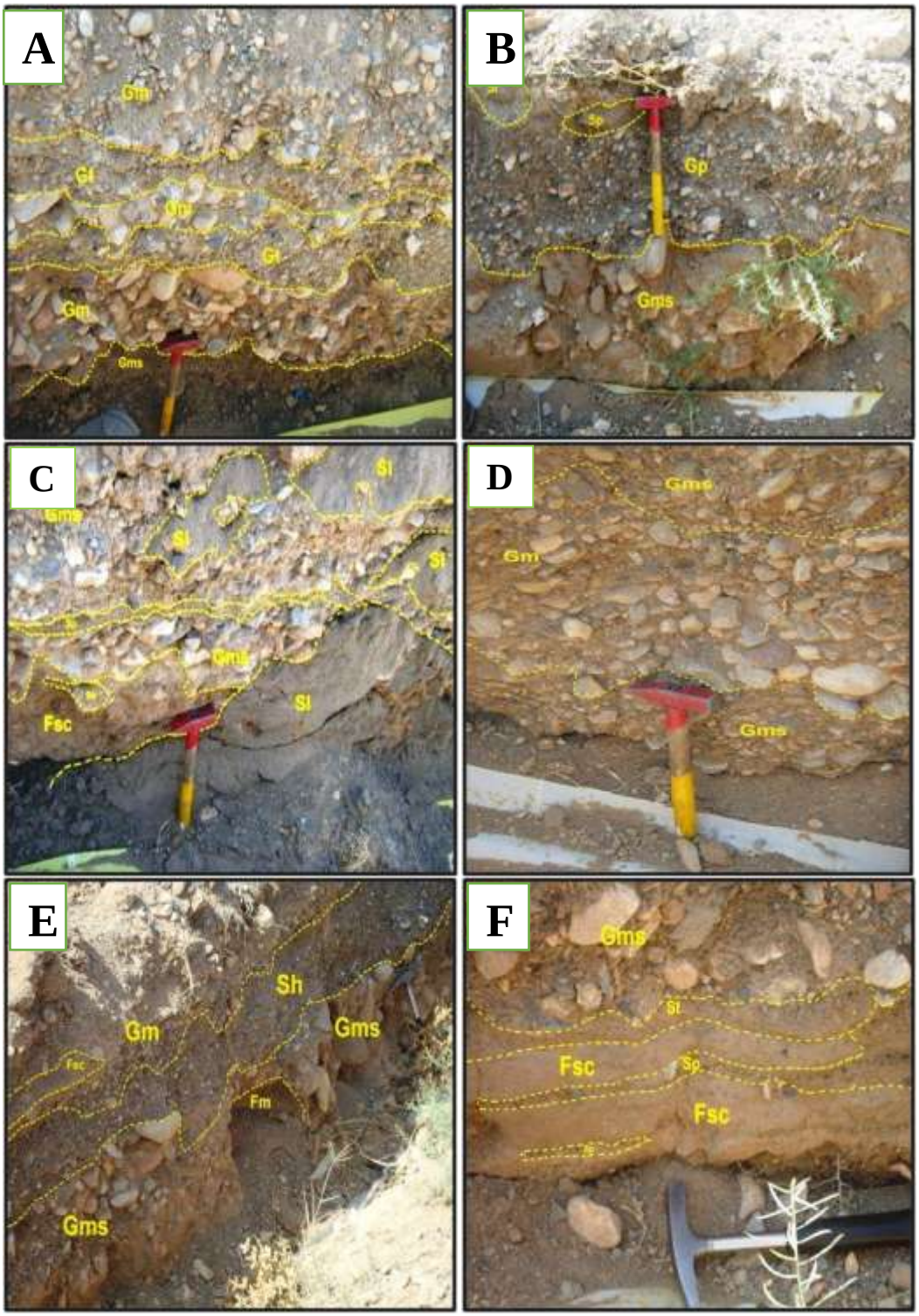

Figure 3: (A) St-Sp-Gp-Gms facies of the region. (B)Gt-Gm facies of Khamneh alluvial fan. (C) Sl-Fsc facies of Khamneh alluvial fan. (D) Facies of the proximal region. (E) Sh-Fm facies of medial region. (F) Sedimentary facies of distal region

CONCLUSIONS

The studies and analyses of the sedimentary facies of Khamnehalluvial fan has the following results:

1. Khamnehalluvial fan is located in north west of Tabriz, East Azerbaijan province and is located in the north west of Iran. It is a part of Geological Map 1:100,000 of Marand.
2. In the sediments of the Khamneh alluvial fan, we have determined 10 facies that can be categorized into 3 groups: gravel, sand and mud facies.
3. Gravel facies group includes four facies: Gms (gravel with massive layering and abundant matrix) -Gm (gravel with massive and semi-horizontal layering and poor matrix) -Gt (gravel with diagonal lens shaped layering) -Gp (gravel with diagonal flat layering).
4. Sandfacies group includes four facies: St (medium to coarse grained sand, with diagonal lens shaped layering)-Sp (medium to coarse grained sand, with diagonal flat layering) - Sh (small to coarse grained sand, with horizontal layering) - Sl (small grained sand, with diagonal layering and slope of less than 10 degrees).
5. Mudfacies group includes two small grained facies: Fsc (silt and clay with few small grained sand, with masive layering) - Fm (silt and clay, with masive layering, and mud cracks).
6. Based on the granulometry and environmental conditions, the sediments are divided into three parts:

Part one) Proximal region: In this region the energy and slope of the environment is high and the amount of gravel grains is high. Sediments are deposited with masive, flat diagonal and lens shaped diagonal layering but they are mostly with masive layering. Sediments are poorly sorted.

Part two) Medial region: In this region the energy is relatively low, and the slope of the environment is decreased. The amount of sand sediments is high and the sediments are mostly deposited with flat diagonal, lens shaped and sometimes horizontal layering, but generally they are in flat diagonal layering. The sediments are sorted poorly or relatively good.

Part three) Distal region: In this region the energy is fairly low and the slope is highly decreased. The amount of silt and clay sediments has increased and the sediments are very small grained. So it is very hard to identify the structure in this region.

7. In distal region, we can see a very small district of salt zone and it indicates that in this area because of high heat, intense evaporation has been occurred so the cement dough with evaporative dose is formed.
8. Based on the lateral extension of the main facies, four zones (sand, gravel, mud and salt zones) are determined: gravel zone matches with proximal region, sand zone matches with medial region, and mud and salt zones match with distal region.
9. With the vertical spreading and the sedimentary cycles of the facies, general regression of the alluvial fan towards the plains is clear.
10. With the general regression of the alluvial fan along quaternaryand the presence of the active faults of Misho southern fault following Tabriz fault, Khamneh-Shabestar-Sis fault, Khamneh south west fault, Daryan-Shanjan fault and Benis-Kandroud fault are active. Mishomountain and its tectonic uplift is identified which causes debris, river, wind and lake flows.

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