International Journal of Geography and Geology
ISSN(e): 2305-7041/ISSN(p): 2306-9872

URL: www.pakinsight.com

GEOMORPHOLOGY OF THE PIRAMAGROON–KANIKHAN VALLEY, SULAIMANI GOVERNORATE, KURDISTAN REGION, NORTH IRAQ

Kamal Haji Karim Ahmad[1†] --- Azhar Bety[2]--- Polla Azad Khanaqa[3]
[1, 2]Department Geology, University of Sulaimani, Kurdistan Region, Iraq
[3]Kurdistan Institutions for Strategic Studies and Scientific Research, Kurdistan Region, Iraq

ABSTRACT

Piramagroon-Kani Khan (PK) valley runs parallel to Pira Magrun and Surdash anticlines almost in NW- SE trend and merges with the Lesser Zab River 9 kms southeast of Dokan town. The valley runs within the soft rocks of Shiranish, Tanjero and Kolosh formations. The valley bottom is gently sloping plain which divided longitudinally by Charmaga stream into two asymmetrical parts (northeast and southwest parts). The northeast part is wider than the other one mostly covered by Recent and Pleistocene coarse alluvium with a thickness of 1-20meters. The southwestern part is relatively narrow and mainly covered by slide debris and dislocated blocks of Sinjar Formation. Northern eastern side is formed by differential erosion and its slope is the dip slope since it nearly coincides with the dip of the strata of the Kometan and Qamchuqa Formations. The southwestern side is scarp slope which has lesser elevation and formed mainly by sliding processes and manly covered by slide debris. The surface of this part has hilly and hummocky topography. The alluviums are belonging to debris flow and river bed deposits. According to age of deposition, the alluvium is grouped in two types which are Holocene (Recent) and Pleistocene types. The first type has mainly caliber of gravels and sand which deposited on the valley bottom plains and suitable for cultivating. The second type has coarser grain sizes which consist of a mixture of blocks, boulder and graves. This type exists either on the hills or it form as isolated plateaus that about 30 high from the surrounding. Now, only as a small or large pachy remnant on the top of ridges and hills or exist as small plateaus which are transformed these elevated lands due to inversion of topography by erosion and weathering.

Keywords: Mass wasting, Slide, Inversion of topography, Geomorphology, Kurdistan region, Piramagroon anticline, Sulaimani governorate.

Contribution/ Originality

This study is one of very few studies which have investigated Piramagroon-Kani Khan valley by using a new methodology for studding the geology and geomorphology of the valley. The study includes field documentations of the geomorphological features and mass wasting activities which are analyzed by stereo nets and GIS maps. These activities are accurately mapped, defined and linked either with geology or climate.

† Corresponding author
DOI: 10.18488/journal.10/2015.4.12/10.12.183.195
ISSN(e): 2305-7041/ISSN(p): 2306-9872

1. INTRODUCTION

The Pira Magrun-Kani Khan (Piramagroon-Kanikhan) (P K) is located about 30 km to the west of in Sulaimani City in Sulaimani Governorate, north Iraq. It runs along (and parallel to) Pirmagroon and Sara mountains which coincides with the main regional trend of the anticlines and mountain range of Zagros Belt (Fig.1 and 2A). Technically, it is located in the High Folded Zone of Buday (1980); Buday and Jassim (1987); Jassim and Goff (2006) (Fig.1). Geomorphologically it located in the Western Zagros high mountain ranges and ethnically the area is located within Kurdistan Region and populated by Kurdish people who are mainly engaged in cultivation activities.

The valley is one of the largest valleys in Dokan and Sulaimani area and has a width, length and depth of 2 km, 20 km and 500 m respectively. The valley includes Piramagroon town and more than 10 villages. These villages such as Kani Miran, Kani Hanjir, Awalan, Shurnakh, Kalabashi, Suse, Dara Tu, Pirkandi, Kotal and Qara Chatan. The study of the valley is important due to continuous increase and extension industrial and orbanization activities of the Sulaimani city to its eastern part. At present, it contains many small refineries and warehouse store. The geomoprphological study of the valley is very helpful for understating of the geohazard and differentiation of the mass wasting activities, which is relatively rapid. Recently Sissakian et al. (2015b) have studied the valley geomorphologically and chronologically and presented many good ideas about the valley. The present one is a complementary to the latter study and introduced new ideas about development and classification of the geomoprphologic features in the valley depending on utilizing new techniques.

1.1. Aim

The study is aimed to analyze and characterize the geomorphologic features and the processes of their generation which has great role in the development of the valley. The types and magnitudes of the mass wasting are indicated and linked with stratigraphy of the valley with their possible thread of slides on human life in the area.

1.2. Materials and Methodology

The study treats with the geomorphologic features of the PK valleys which have about 60 square kilometers of surface area. It depends on the field mapping of the features and dislocated rock blocks in addition to using of topographic map and Google Earth. For slope classification Arc Map GIS V. 9.3 is used to produce slope map and the ITC system is depended on for slope classification of the study area. The DEM (Digital Elevation Model) is used to derive topographic features in 3D contour line which shows slope, hill shade and some case shows trace of large mass wasting. On these maps the classification of the landforms are indicated and the stereonet is used for analysis of sliding, creeping and rock falls for predicting geohazard of the area.

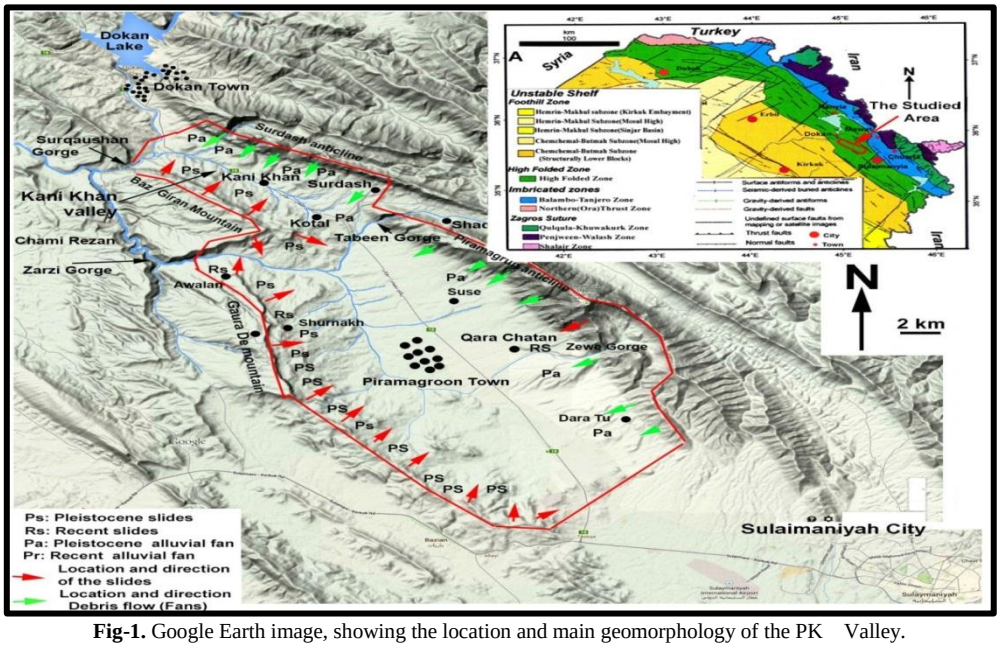

Fig-1. Google Earth image, showing the location and main geomorphology of the PK Valley.

2. GEOMORPHOLOGY OF THE VALLEY

The southern and northern part of the area consists of low and high mountainous terrain respectively. The valley enclosed between low elevation mountains, at the south such as Qshlakh, Baranan, Bazgiran and Qawrade Mountains and high mountains at its north and northeast. Among these high mountains are Daban and Sara, at the north and Piramagrun, at northeast and has about 2400 m of elevation above mean sea level.

The valley is trending northwest–southeast and elongate parallel to southwestern sides of the above latter mountains as a strike valley which is a developed by vertical erosion and mass wasting processes and it can be called subsequent valley too. Three factors have imprinted its present shape (Fig.1, 2A and 2B).1- The valley has scored vertically inside the soft formation such as Shiranish, Tanjero and Kolosh Formations therefore are elongated parallel to the strike of the above formations. 2 – The alluvial deposits and slide debris are limited the further vertical scoring therefore, the lateral erosion and mass wasting has widen the valley.3-`The erosion resistant limestone layers of Kometan and Qamchuqa Formations limit the northern and northeastern extend of the valley. All the beds (strata) of the above formations are dipping toward southwest and the amount of the dip variable and ranges between 15 to 45degrees. The dips are increasing progressively from southwest to northeast trend along which the strata of Eocene to Early Cretaceous Formations are exposed respectively (Fig.2A and 2B). The low and high dips degrees are belonging to the strata that are located on the outer limb and in the core of the anticlines respectively.

The valley located and developed on southwestern limb of the Pira Magrun (at the northeast) and Sara (at northwest of the valley) anticlines. The differential erosion is main factor on the northeastern side of the valley while the mass wasting is common on the southwestern side of the

valley and is one of the factors that were scored the valley during Quaternary. The most significant geomorphological features in the studied area are: 1-Valley bottom, 2-Valley streams 3-valley sides, 4- Gorges.

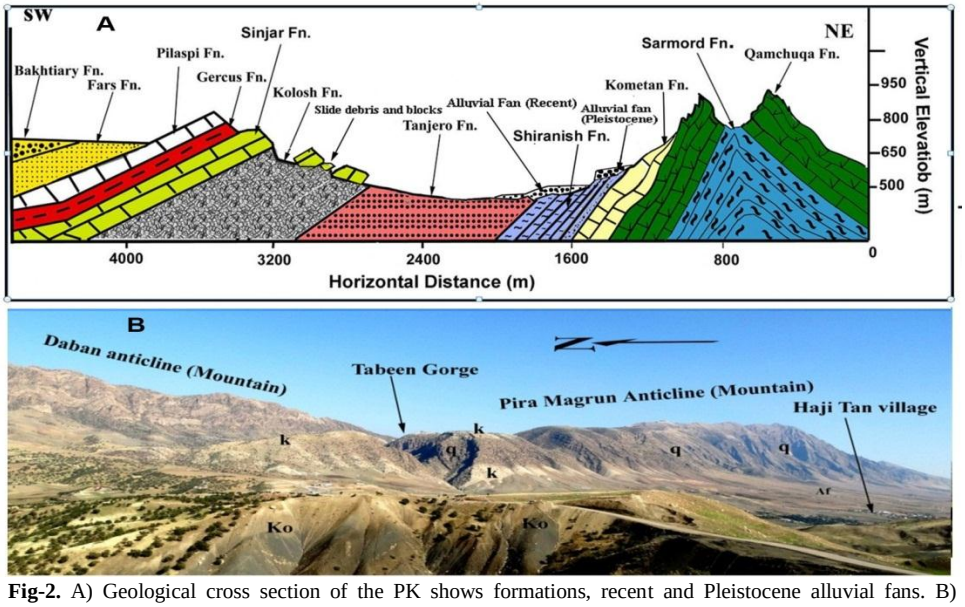

Fig-2. A) Geological cross section of the PK shows formations, recent and Pleistocene alluvial fans. B) Central part of the Pira Magrun-Kani Khan valley with the exposed Formations along crest and limb of Piramagroon anticline. k: Kometan Formation, q: Qamchuqa Formation, Ko: Kolosh Formation, Af: alluvial Fan sediments.

2.1. Valley Bottom

The valley bottom constitutes most surface area of the PK valley and it consist of the wide and gently sloping (1-3/100) plain which fertile and extensively cultivated. The bottom is divided by Charmaga stream into two asymmetrical northeastern and southwestern parts. The former is wider and slopes toward the southwest. It is located at the foot of Pira Magrun, Surdash, Sara Mountains and the Dokan town and Sulaimani main road that pass through this part (Fig.1).

This part contains series of coalescing alluvial fans along the lower slope of above mountains and forms a pediment. These fan-shaped depositional terrain formed form spreading of the sediments over the plain that is located below the valley mouth. The spreading is due to confining of sediments within narrow, steep and deep seasonal valley stream, when the confining and flow velocity decrease on the gentle plain the sediment are deposited as fan-shaped sheets.The southwestern part of the valley bottom is narrow and has steeper slope than the former part and experienced extensive sliding processes (Fig.2A). Both parts are dissected shallowly by tens of consequent and obsequent emepheral streams.

2.2. Alluvial Fans

Chronologically the alluvial fans are divided in to two types of Pleistocene and recent (Holocene) while descriptively they divided into coarse and fine sediments fans.

2.2.1. Pleistocene Alluvial Fans

On the northeastern part of the valley bottom and this type of fans can be seen in most place and they extend from center of the valley to the lower slope northern. They can be seen obviously around Qamachuqa village and to the south of Zewe Gorge. They now can be seen either as separate gently dipping plateaus or as mesa which cover the hill tops which have an elevation of about 20 meter from the surrounding plain and now they can be seen on the Shiranish, Tanjero

and Kolosh Formation, (Fig.2A). The surface areas of the remnants of plateaus are no more than one square km and its surface is not suitable for cultivation due to rocky surface. These old remnants are very obvious around Qamchuqa and Dar Baru villages in addition to south of Zewe Gorge.

These plateaus are remnants of the ancient (Quaternary fans) and they located at higher elevation than the recent fans. These fans are represented now by gently dipping thick beds of limestone conglomerate which is about 10 m thick (Fig.3A, 3B, 4A and 4B). They dip angle is nearly equal to the local slope angle of the valley bottom which about 3-12 degrees. The thickness of the fan thins toward the lower valley slope. The clasts are sized 2-200 cm in diameters and mostly subrounded and badly sorted which bounded (lithified) by calcitic materials. These fans show different degrees of weathering and lithification by surface and groundwater. In some place, the weathering and lithification is so intense that they classified descriptively as calcrete (Sissakian *et al.*, 2015a; 2015b). These author cited that the calcrete was covered the whole area during Pleistocene and attributed their deposition to wet phase.

2.2.2. Relief Inversion (Reciprocal) of Topography

According to Pain and Oilier (1995) Inversion of relief occurs when materials on valley floors are, or become, more resistant to erosion than the adjacent valley slopes. They added that when erosion proceeds, the valley floor becomes a ridge (or hill) bounded by newly formed valleys on each side.

In the PK valley, the resting of the Pleistocene on hills and ridges or their occurrence as plateaus are attributed to relief inversion. Very coarse alluvial sediments are deposited during very heavy floods in the valley bottoms as wedge- shaped or fan-shaped sediments. Subsequent smaller floods could not remove these coarse and erosion resistance sediment so they score the soft sediment of the valley sides and transformed them to low land. In the PK valley, many smaller valleys are formed during Pleistocene in the Kolosh, Tanjero and Shiranish Formation, which filled with alluvial and later had changed to hills by stream shifting toward softer sediment of the latter formations (Fig.3 and 4). The reciprocal of relief is not related to the PK valley only but it is extensive in whole Kurdistan Region and Northern Iraq. In all places only the thickest and coarsest part of the Pleistocene and Recent fans are remained after weathering, mass wasting and erosion.

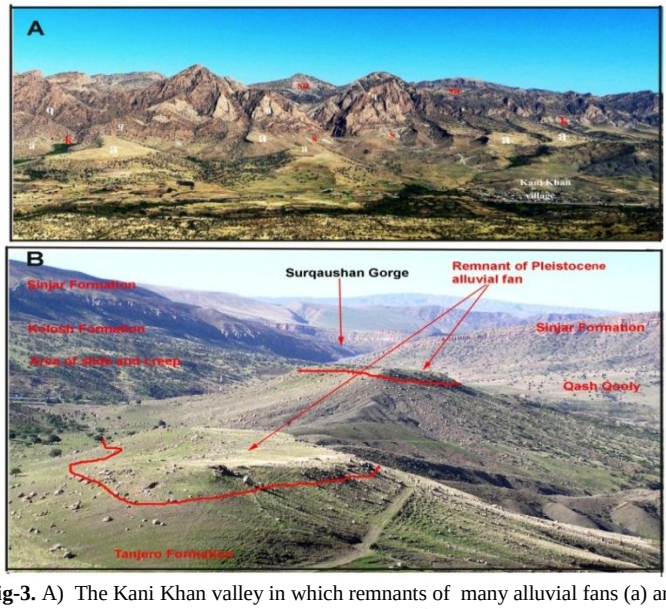

Fig-3. A) The Kani Khan valley in which remnants of many alluvial fans (a) are indicated and Daban mountain on which the formations (sa: Sarmord, k: Kometan, q: Qamchuqa, s: Shiranish) are shown. The Jasana Gorge is located In the middle of the photo. B) Remnant of Pleistocene alluvial fan on Kolosh Formation in the west of Qamchuqa Village, the large blocks of the Pleistocene alluvium can be seen which are derived from Qamchuqa Formation.

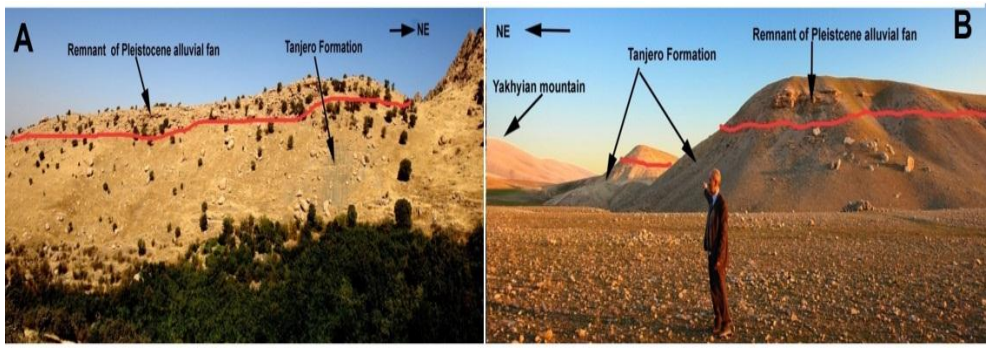

Fig-4. A) very coarse grain (boulder and block conglomerate) of remanent of the Pleistocene alluvial fan directly to the west of Old Qamchuqa village near Dokan village. B) Medim grained coarse grain Pleistocene remnant of alluvial fan to the 2k to the south of Darbaro village about 7 km to the northest of Tasluja cement factory.

2.2.3. Recent Alluvial Fan

These fans are larger but with lesser thickness and smaller grain sizes as compared to the Pleistocene ones. They cover most of the surface of the valley floor and in most cases, the clasts are not bounded (not lithified) and the caliber is smaller which range from 2- 30 cm in diameters. Lithologically, the clasts belong to Kometan and Qamchuqa Formations. These fans mainly occur on the northeastern part of the valley bottom. As mentioned before, this part contain of a series of coalescing alluvial fans along the front of Pira Magrun, Surdash and Sara anticlines that form a pediment. These fan-shaped depositional terrains are formed from the setting of sediment within a stream onto flat land at the foot of a mountain.

2.3. Valley Streams

The valley bottom and it's both sides are dissected by tens of small emepheral streams traversally and each stream flow in its related valley. The valley which located on the northeastern side are consequent type which have courses tend toward regional slope while those on the southeastern are obsequent type which flow opposite to the regional slope of the area. Their wide head are located near the peak of the mountain such as Piramagroon, Sara and Chaqzh while their mouth is located near the foot of these mountains and these mouths are narrow and occur as small gorges. PK valley, as whole is a strike valley and developed by erosion and mass wasting on the soft rocks of Shiranish (marl), Tanjero (sandstone and marl) and Kolosh (marl and sandstone) formations (Fig.2A).

2.4. Valley Sides

2.4.1. Northestern Side

On the digital elevation map (DEM), this side is red in color whicvh indicater of steep slope and high elevation of about 1400 m above the PK valley bottom (Fig.6). Genetically, the PK valley has two different sides. the north eastern side is high and consists of exposed hard rocks of Kometan and Qamchuqa Formations. This side is corepond to the southwestern side of the Pira Magrun, Surdash and Sara mountains (or anticlines). This side has slopes nearly equal to dip of the strata of the aforementioned formations, therfore it can be called dip slope (Fig.5). The side is developed by removal of the soft formation while the hard ones are moslty remained. The sediments of the valley bottom (fans) are deriverd from the strata of the latter formations. On this side only one slide is recorded which is Qarachattan slide tha t studied by Karim *et al.* (2000).

2.4.2. Southwestern Side

This side has low elevation of about 500 m above the valley bottom and form the northeastern side of Chaqzh and Gaura De mountains.This side is mainly consist of soft rocks of Kolosh and Gercus formation and the only hard rock on this side is Sinjar Formation. Due to this softness, the erosion is rapid by which the underneath of the hard rocks are romoved and remain without support which help sliding of large blocks of Sinjar Formation. Therefore, the upper slope of this

side now is consist slide scar while the lower slope consists of slide debris which gave the side homocky and rolling shape. On the digital elevation map (DEM), the upper slope appear as narrow belt which is classified as steep slope (21-55 degrees) accodring to ITC system of slope classification (Table 1 and fig.6). Ouside this valley and on southern boundary of Shararazor plain, Karim and Ali (2004) and Ali (2005) described in detail the mechanism of sliding and it role in valley development.

Table-1. The classification of the slope of the area according to ITC system

Description	Slope	Description	Slope
Flat-Almost Flat	0 - 2	Moderately Steep	14 - 20
Gently Sloping	3 - 7	Steep	21 – 55
Sloping	8 - 13	Very Steep	56 – 89

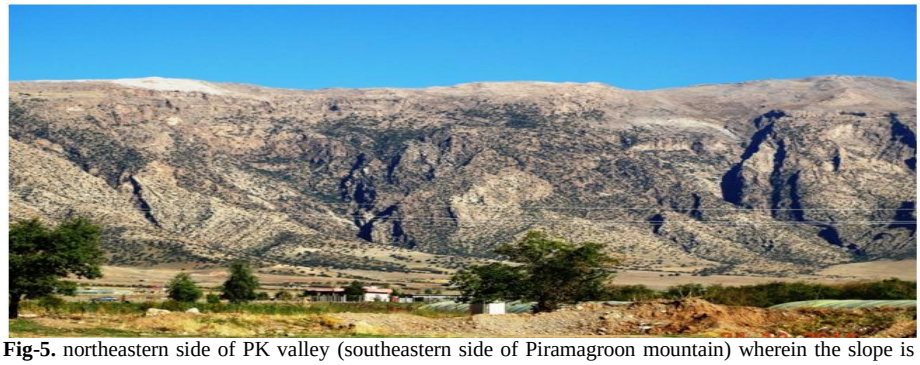

Fig-5. northeastern side of PK valley (southeastern side of Piramagroon mountain) wherein the slope is nearly equal to dip of strata of Qamchuqa Formation (dolomitic limestone), three consequent valleys can be seen (the photo looks northeast)

2.5. Gorges

A gorge is a narrow and steep-sided part of valleys which consist of rocky walls which is located between hills or mountains. In most cases, the gorges are corsponds to valley mouths.,three gores open into PK valley and two leave it from the northern and southern boundaries respectively. The former ones are Qamchuqa, Jasana, Tabeen and Zewe which are connectiong small valley to the studied area while the latter ones are Zarzi and Surqawshan gorges which are discharge the runoff out the valley. The outlet of the Piramagroon valley consists of two gorges which discharges the surface runoff and rivers that are pass through of the valley. These gorges developed in hard and massive limestone or dolomite rocks whereat there are no masswasting and only vertical erosion prvaled by running water.

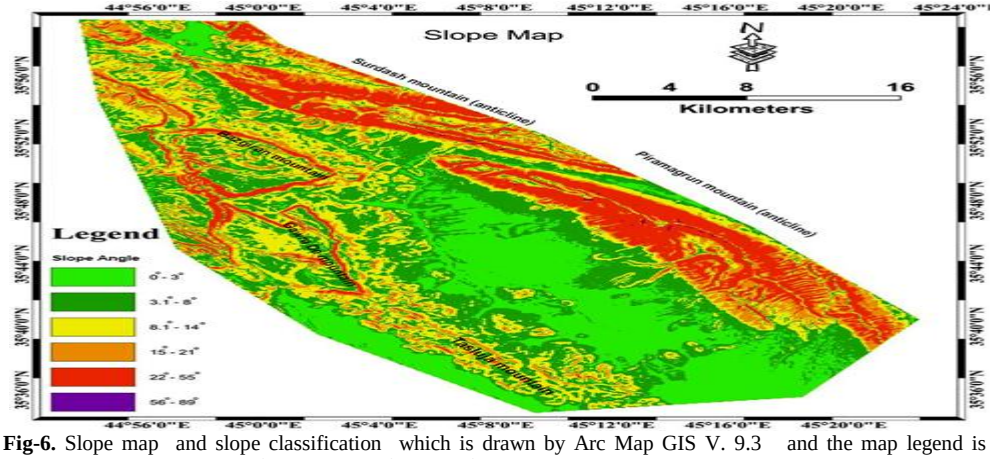

Fig-6. Slope map and slope classification which is drawn by Arc Map GIS V. 9.3 and the map legend is depended on the ITC system for slope classification of the study area

3. STRATIGRAPHY

3.1. Qamchuqa Formation (Early Cretaceous)

The formation builds up of alternation of lagoonal and reefal successions which are thickly and thinly bedded respectively. The latter succession is massive and very hard which is made up of dark brown dolomite while the other one is well bedded and consists of light grey (white weathering) limestone. The formation is a good source for supplying the coarse particles of the sediments of the alluvial fan and river beds; the thickness of the formation ranges from (600) m. The role of this formation is the greatest in shaping the Piramagroon valley since it forms the highest part of the northeastern side which called Pira Magrun (or Piramagroon), Sara and Surdash mountains (Fig.1, 3A, and 5).

3-2. Kometan Formation (Early Cretaceous)

The formation consists of thinly and well bedded white limestone which is relatively hard and slightly marly. The formation is a good source for supplying the fine and medium sized particles of the sediments to the alluvial fans. In the studied area, the thickness of the formation ranges from 75–125 m. it is exposed in the lower part of the northeastern side and its role is minor as compared to the previous formation. Due to its calcitic composition which is easily dissolved in weak acid, there for its clasts are absent in alluvial fans where it is dissolved by moisture.

3.3. Shiranish Formation (Campanian)

The formation consists of thinly well bedded blue marl and marly limestone. It is located in the valley floor and mostly covered by alluvium .The thickness of the formation ranges from (200–220) m.

3.4. Tanjero Formation (Maastrichtian)

It consists of two main parts; the lower one constitutes thick alternation of sandstone with interbeds of calcareous shale with rare lenses of conglomerate. The upper part consists of light blue or light grey marl. The formation is covered mainly by alluvium and its out crops are extending along the central line of valley axis. The thickness of the formation is about 600m.

3.5. Kolosh Formation (Paleocene)

The formation consists of black to grey fine clastics with local lenses of conglomerate. The thickness of the formation ranges from (400-500) m when the repetition by deformation is excluded. This formation has the softer lithology than other formations and mostly exposed on the southeastern side of the valley. Due to the softness, the blocks of the Sinjar Formation are slipped on Kolosh Formation along the southeastern side. Due to the sliding, the surface of formation appears as rolling and hummocky land (Fig.10).

3.6. Sinjar Formation

This formation consists of thick succession of massive bedded fossilliferous limestone. It is hard and coherent with a thickness of about 60 meters and it is used widely as a raw material for Portland cement production in the studied area. This formation is directly related to the sliding processes in the studied area. This is due to fact that nearly all slipped masses are made up of large blocks of this formation. As mentioned before, it is underlain by Kolosh Formation which is soft and incompetent there rapidly weathered and overlying Sinjar Formation become unsupported so is slipped toward the lower topography (Fig.7 and 8) .

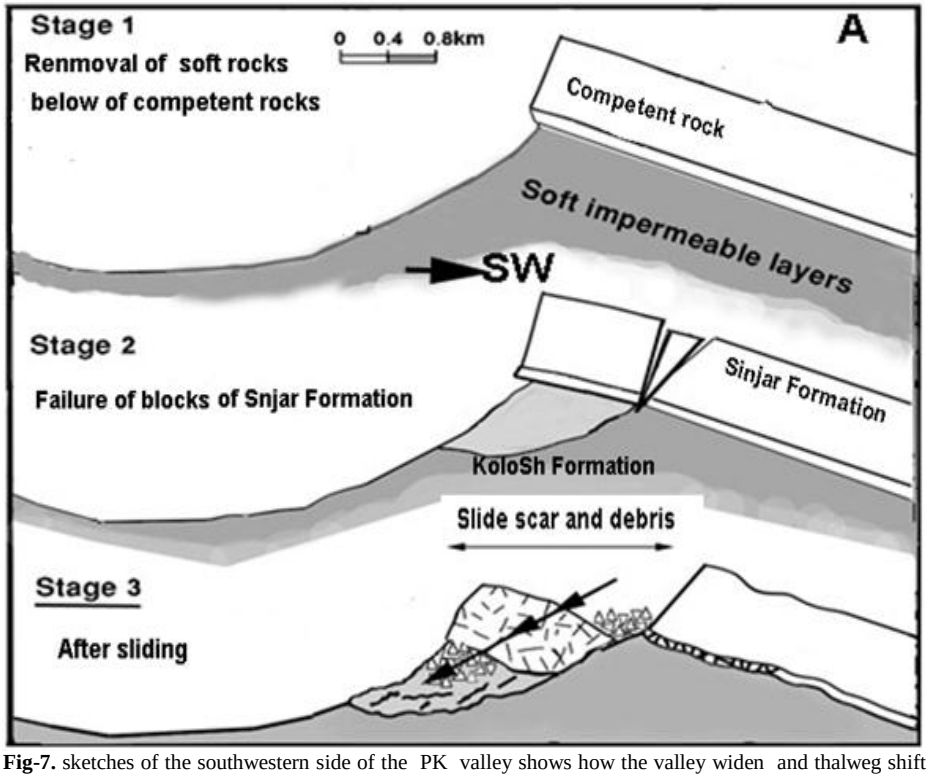

Fig-7. sketches of the southwestern side of the PK valley shows how the valley widen and thalweg shift southward by sliding (modified from Ali (2005).

4. ANALYSIS OF SLIDE IN THE VALLEY

As mentioned before the southwestern side of the valley is characterized by presence of extensive slides (Fig.7, 8 and table 2). These slides are important geomorphologic feature of the PK valley sides and have noticeable vulnerability on the human activities. The slides are active till now which will affect the stability of the large urban structures that will build on this side.

These slides are analyzed (classified) historically, genetically and geometrically. Historically they are of two groups, the first one are those that are slid during recent time (Holocene) while the second group are those which dislocated during Pleistocene (Fig.8 and 10). These two groups ate differentiated on the bases of the modification of the slide scar by weathering .The latter group is more wide spread than the former one due to wet and cold climate during Pleistocene (www.wikipedia.com/Pleistocene). The cold climate had prevented evaporation and consequently, the land becomes more saturated with water and seepage was dominated. These saturation and seepage are important for sliding of the bocks of the Sinjar Formation due to slippery nature of Kolosh Formation and its ease of erosion. The scars of the first one are not modified by weathering

and they are relatively fresh with no corrosion rills and pits while those of Pleistocene contain these features.

4.1. Stereonet Analysis

The valley contain tens of the large slides some of which are shown in the table (2) and all these slides can be seen on the Google earth on the southwestern side. The slope of this side consists of two segments, the first one is forming a steep slope which in some case form vertical cliffs and it located near the peak of the Gaura De and Bazgiran mountains (or ridges) (Fig.1 and 8A). The slope angle of this part is slightly variable from place to another but their mean values are 45 degrees which is valid for Qazan, Shurnakh, Kani Miran and Awalan, Kani Hanjir slides. On the DEM this slope is appear in red colour as narrow strip (Fig.6).

It is possible that the upper slope was steeper during Pleistocene than present due to more undercutting of the cliffs by more wetter climate. The sliding of this part is mostly plane sliding which is occurring on discontinuities surfaces of tension fractures (Fig.13). The sliding direction is nearly coincides with direction of slope ± 13 due to local variation of local slope and type of discontinuities and weight of block. The lower segment has same direction but the slope angle is gentler than the upper one and its mean value is less than 8 degrees. Most observations showed that the slides on these segments are creep which transformed the areas to rolling and hummocky land.

Table-2. Locations and data attitude of the major slides in the PK valley

No.	Location name	GPS location	Angle of lower slope face	Angle of upper slope face	Sliding direction	Estimated weight of slipped block in tons	Age of sliding	photo
1	Qazan village	35 42 08.08 N 45 05 16.31 E	9	60	22	400	Pleistocene	See Google earth
2	Shurnakh village	35 45 42.53 N 45 02 42,.70 E	15	65	52	150	Pleistocene	See fig.10A
3	2km West of Qubah village	35 43 54.29 N 45 03 53.74 E	12	60	71	100	Pleistocene	See Google earth
4	1k east of Asia Cell Tower	35 44 32.90N 45 02 56.84E	7	40	44	50	Pleistocene	See Google earth
5	1k east of Gawra De village	35 41 55.43 N 45 02 29.43E	30	70	120	10000 tons	Recent	See fig.8A
6	Kani Hanjir bedding plane slide	35 47 42.41N 45 01 18.27E	7	80cliff	350	20	Recent	See fig.8B
7	Awalan	35 47 55.13N 45 00 20.18E	4	60	311	50	Pleistocene	See Google Earth
8	Kani Miran	35 50 42.80 N 45 02 24.33E	6	22	19	300	Pleistocene	See fig.10B
9	Qara Chatan	35 44 27.04N 45 12 01.49 E	5	30	245	200	Pleistocene	See Google earth

The frontal part of the slide debris shows upward bulging of the ground. Hamasur (1992) calculated internal friction angles of limestone of Sinjar Formation and marl of Kolosh Formation of the Basara Dam site. In the present study, the friction angle of former Formation (33^{o}) is browsed from latter author while that of Kolosh Formation is not used due to fact that he measured them from fresh sample taken from wells. Contrary, the surficial outcrops of Kolosh formation (on which blocks of Sinjar Formation slipped) in PK valley is converted to loose black calcareous soil which is slightly organic. According to (http://www.geotechdata.info/parameter/angle-of-

friction.html) the internal friction of these oils may be less than 20 degrees. Moreover than that the friction angle of water- saturated and weathered outcrop of Kolosh Formation may be decrease to less than 10 degrees (Fig.9). Especially that the southwestern side of the valley facing north and northwest which is less subjected to sun radiation than northeastern side. Therefore, according to Karim *et al.* (2014) the former side is more exposed to chemical weathering and preserve moisture for longer time than the latter side

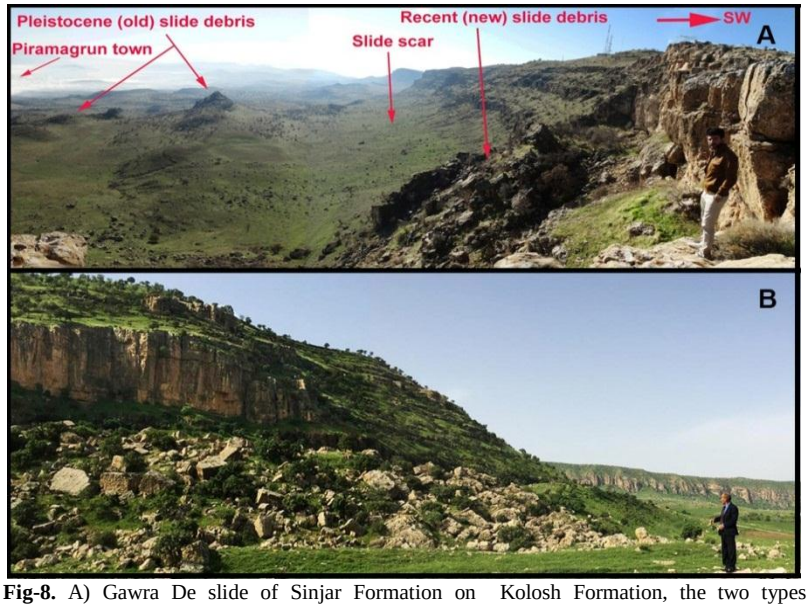

Fig-8. A) Gawra De slide of Sinjar Formation on Kolosh Formation, the two types (Pleistonene and Holocene) can be seen together. B)Kani Hanjir bedding plane sliding of Sinjar Formation on Kolosh Formation near Awalan village.

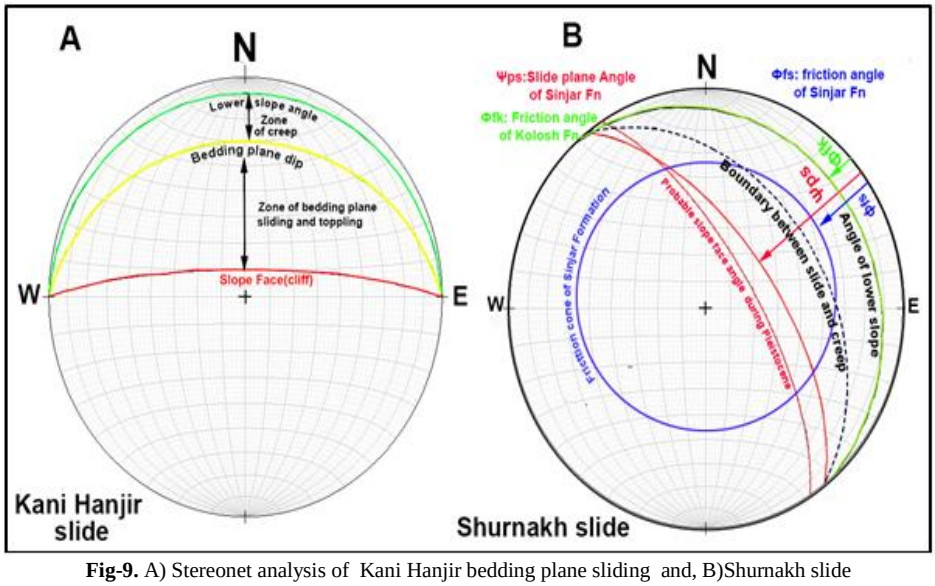

Fig-9. A) Stereonet analysis of Kani Hanjir bedding plane sliding and, B)Shurnakh slide

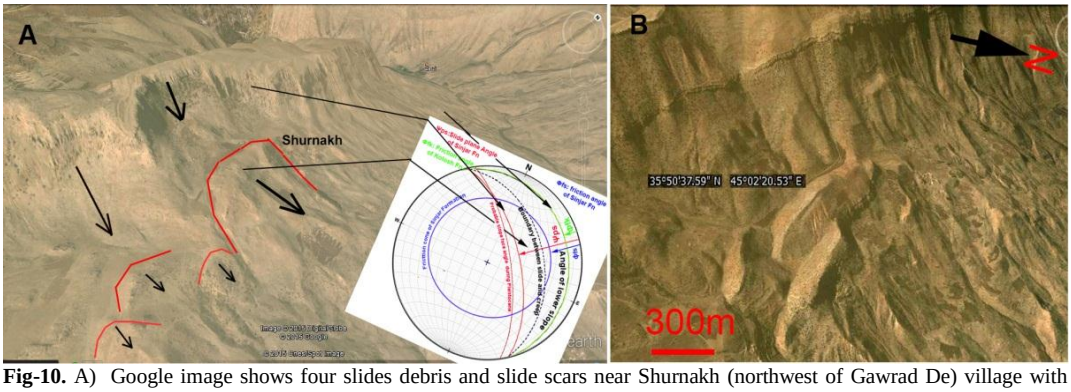

Fig-10. A) Google image shows four slides debris and slide scars near Shurnakh (northwest of Gawrad De) village with their stereonet plot. B) Kan Miran slide

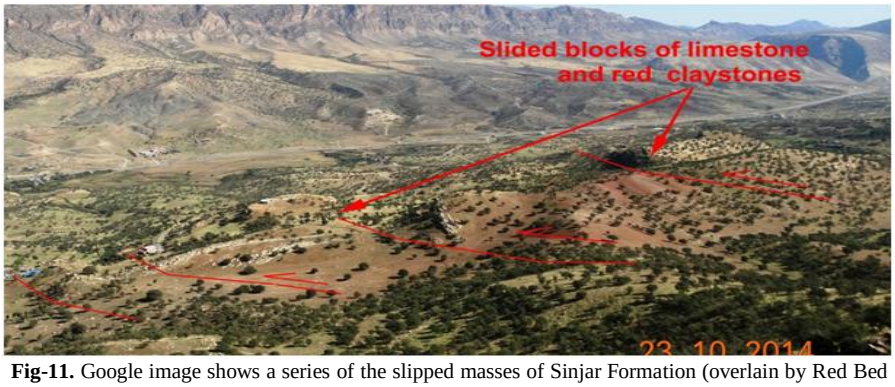

Fig-11. Google image shows a series of the slipped masses of Sinjar Formation (overlain by Red Bed Series) near Kani Miran slide (Pleistocene Slide)

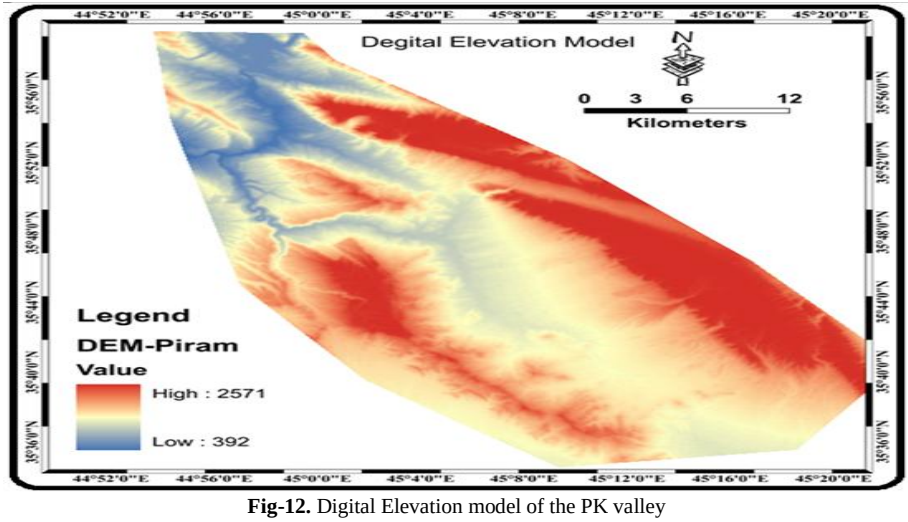

Fig-12. Digital Elevation model of the PK valley

5. CONCLUSION

1. The most prevailing mass wasting, during recent and Pleistocene are rockslides and creep which occur mainly on southeastern side of the Pira Magrun valley.
2. Most slides are occurred either on fractures planes on slope surface and only in one case bedding plain sliding is recorded

3. The occurrence of soft marl of Kolosh Formation under massive and hard limestone of Sinjar Formation is the main reason for prevailing mass wasting in the PK valley.
4. The slides and creeps are common on the upper and lower respectively.
5. The Remnants of Pleistocene and Recent alluvial fans are widespread in the valley some of which are transformed to hills or plateaus by inversion of topography due to differential.
6. The rock falls and toppling occur in the area too

REFERENCES

Ali, S.S., 2005. Effect of slide masses on ground water occurrence in some areas of Sharazoor plain /NE Iraq. Water Resources and Environmental Problems in Karst –Proceedings of International Association of Hydrogeologist. International Conference, Karst CVIJIĆ.

Buday, T., 1980. Regional geology of Iraq: Stratigraphy: I.I.M Kassab and S. Z. Jassim (Eds). Geosrcy. Min. Invest. Publ, 1: 445.

Buday, T. and S.Z. Jassim, 1987. Regional geology of Iraq: Tectonism magmatism, and metamorphism. I.I. Kassab and M.J. Abbas (Eds). Baghdad: Iraqi Geological Survey and Mineral Investigation Press.

Hamasur, G.A., 1992. The quantitative analysis of the Qara Chattan Rock Slide from Northeastern Iraq. Journal of Dohuk University, 2: 465-476.

Jassim, S.Z. and J.C. Goff, 2006. Geology of Iraq. Berno: Dolin, Prague and Moravian Museun.

Karim, K.H. and S.S. Ali, 2004. Origin of dislocated limestone blocks, on the slope side of Baranan (Zirgoez) Homocline: A key to the development to western part of Sharazoor plain. KAJ, 3(1): 46-60.

Karim, K.H., G.A. Hamasur and S.M. Tofiq, 2000. Qara-Chatan rockslide in Pira-Magroon anticline, Northeastern Iraq. Journal of Zankoy Sulaimani, Part A, 3(1): 33 – 47.

Karim, K.H., V.K. Sissakian, N. Al-Ansari and S. Knutsson, 2014. Effect of the sun radiation on the asymmetry of Valleys in Iraqi Zagros Mountain belt (Kurdistan Region). Journal of Earth Sciences and Geotechnical Engineering, Lulea University of Technology, Sweden, 4(2): 23-32.

Pain, C.F. and C.D. Oilier, 1995. Inversion of relief — a component of landscape evolution. Geomorphology, 12(2): 151–165.

Sissakian, V.K., N. Al-Ansari and S. Knutsson, 2015b. Age estimation of Qash Qooly valley in Dokan vicinity. North Iraq Using Exposure Age Determination Method Journal of Civil Engineering and Architecture, 9(3): 90-103. DOI 10.17265/1934-7359/2015.01.011.

Sissakian, V.K., H.A. Al-Mousawi, N. Al-Ansari and S. Knutsson, 2015a; 2015b. Old alluvial fan relics in North and Northeast Iraq. Journal of Earth Sciences and Geotechnical Engineering, 5(2): 45-62.