Journal of Earth Sciences and Geotechnical Engineering, vol. 4, no. 2, 2014, 23-32
ISSN: 1792-9040 (print), 1792-9660 (online)
Scienpress Ltd, 2014

Effect of the Sun Radiation on the Asymmetry of Valleysin Iraqi Zagros Mountain Belt (Kurdistan Region)

Kamal H. Karim[1], VaroujanSissakian[2], Nadhir Al-Ansari[3] and Sven Knutsson[4]

Abstract

The geomorphological feature of the valley's asymmetry is described in the Western Zagros in Iraqi Kurdistan; in terms of facing of the valley sides relative to the position of the sun. The asymmetry is represented by steeper northwest facing valley sides; as compared to the southeast facing sides. This feature shows clear valley's asymmetry in cross section is a new geomorphological characteristic for the Western Zagros Mountain Belt.

The asymmetry of valleys, in the present study, is proved to exist in different rock types and areas, which is developed by more chemical weathering of one facing sides relative to the other side. The weathering is attributed to the remaining of the moisture for longer time than the southeastern sides, which are stroke by sun radiation for longer time and are dried more rapidly.

A simple method was established for indicating the steeper side of the valleys. The method consists of drawing two parallel lines across the photo of the valley, then connecting the bottom of the valley with the left and right deflection points on the inter-valleys ridges by lines. Finally the angles between the lower horiozontal line and inclined lines are measured, which indicates the asymmetry of the valleys.

Keywords: Asymmetric valley, Sun radiation, Geomorphology, Zagros, Iraqi Kurdistan

1 Introduction

The Western Zagros Mountain Belt extends NW – SE for more than one thousand kilometers along northeastern part of Iraq and extends into the western part of Iran; being parallel to the International borders of the two countries (Fig. 1). The width of the belt is about 100 km and consists of several series of high mountains, elevation of which extends, in some place, more than 3000 m above sea level (a.s.l.). Off the borders and to the southeast and northeast, their elevations decrease gradually and change to low elevation

---

[1]University of Sulaimani, Iraqi Kurdistan Region, Sulaimainayh.
[2]Consultant Geologists, Iraqi Kurdistan Region, Erbil, Ainkawa.
[3&4]Lulea University, Lulea, Sweden.

hills inside the two countries. Both sides of these ranges are dissected by thousands of small and large valleys and geographically, these valleys are trending southwest and northeast across southeastern and northwestern side of the ranges, respectively.

The Iraqi Kurdistan Region has a distinct continental interior climate of the Mediterranean type with hot and dry summer, while the winter is cold and wet. The hottest months are June, July and August, while the coldest months are December, January and February [1,2]. During the summer, the region falls under the influence of the Mediterranean anticyclones and sub-tropical high pressure belts. In the winter, the region is invaded by Mediterranean cyclones moving east to northeast through the region. In addition, the Arabian Sea cyclones move northwards in this season and pass over the Arabian Gulf carrying a high amount of moisture, which causes a lot of precipitation in the region. The region is also exposed to the influence of very cold polar air masses migrating with the polar jet streams downward to the gulf. The autumn and spring are very short with mild temperatures [3]. The mean annual precipitation in the region is about 500 mm, which occurs mainly during winter and spring and it is exceptional to have rainfall between June and September. As it is clarified hereinafter, this climate has influenced; mainly on the asymmetry of the valleys.

The aim of this study is to give short scientific characteristic of the valley's symmetries and to measure the asymmetry using a new method. Moreover, to introduce a new process that may be responsible for the development of the asymmetrical valleys in the Iraqi Kurdistan Region.

2 Methodology

The already existing literature, the valley's asymmetry is mainly described in North America and Germany (see as an example [6, 7, 8, 9, 10, and 11]). They all attributed the valley's asymmetry to either stream shifting by alluvial deposits on the base of south facing sides or to pre-glacial Pleistocene weathering, besides to the position of initial stream among nearby ones.

This study depends mainly on field investigations; for checking the degree of the valley's asymmetry in different regions and rocks (formations). Tens of valleys were inspected to deduce if the previous ideas are applicable in the Western Zagros Region, or otherwise. The authors of previous ideas had mentioned in the previous studies, and those which contradict the recently introduced idea are discussed latter on.

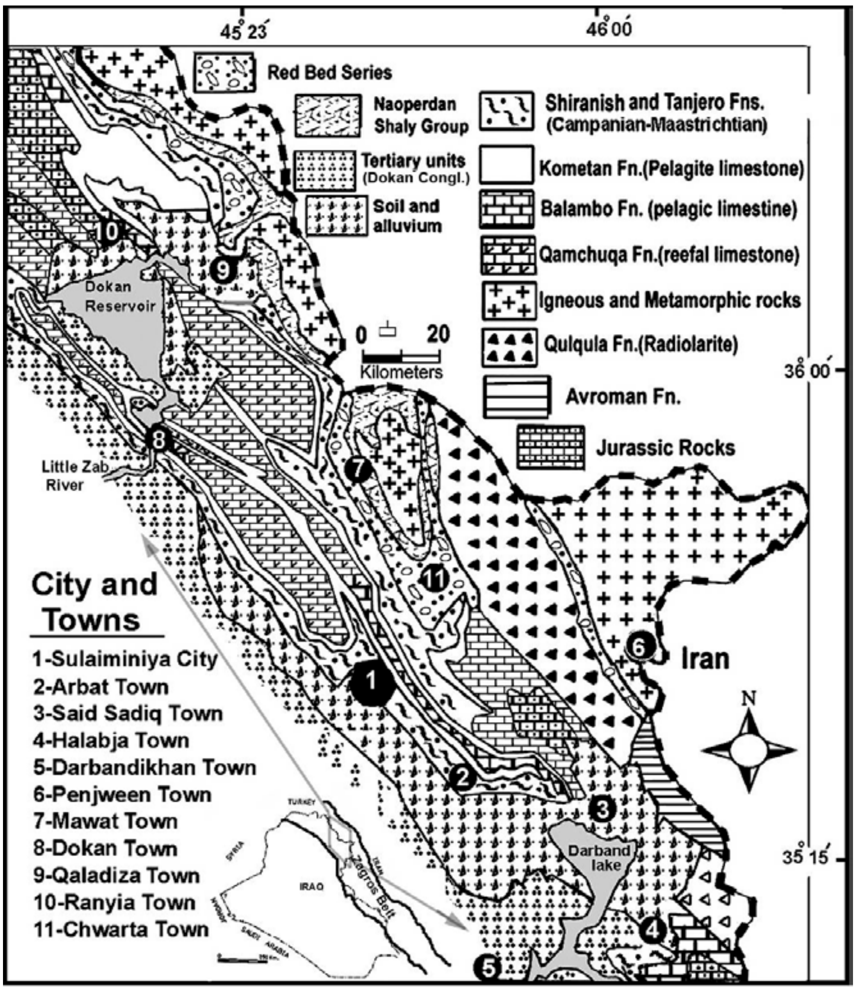

Figure 1: Geological map of Northeastern Iraq (after [4] modified by [5])

For calculating of the degree of the valley's asymmetry, a simple method was established by the authors, which depends on field photographs, topographic maps, and images of the Google Earth. The method includes the following stages.

1-A series of adjacent valleys were photographed. The direction of the photograph must be normal to the valley. If Google Earth image was used, then the valleys must be brought to the center of the PC.

2-Two parallel lines, with suitable spacing, were drawn along the middle part of the valleys (red lines in the Fig.2).

3-The valley bottom (center of the channels stream) were indicated on the lower red line, while the deflection point on the inter-valley ridges (or crest) were indicated on the upper red line.

4-The points on each valley channel (on the lower red line) were connected, by a line, with the two ridges crest points, on the upper red lines, of the opposite valley sides (black lines in Fig. 2).

5-Then stage 4 was repeated for all the studied valleys.

6-The angle of opposite sides (between lower red line and inclined black lines) of all valleys were measured (see red and black figures in degrees in the Fig.1). The amount of degrees may change according to the spacing of the two lines, but the ratio will not change.
7-The degree of the valley's asymmetry was estimated, which is given as a ratio; by dividing the two angles of south or southeast facing side by north or northwest facing side of each valley. The ratio of 1 means that there is no asymmetry, while ratios larger than one mean the presence of valley's asymmetry.

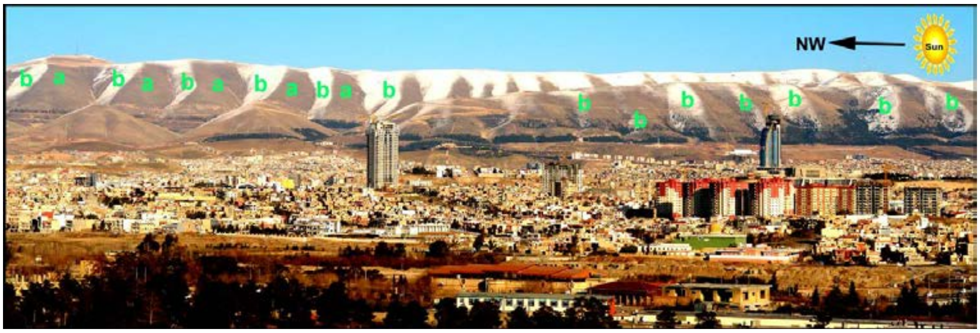

Figure 2: Method of indicating asymmetry of the valley sides, as applied to Azmir Mountain (Balambo and Kometan formations). It can be seen that northwest facing sides are steeper

3 Types of Asymmetry

In the studied area, the valley's asymmetries are divided into two types, these are mentioned hereinafter.

3.1 Longitudinal Valley Asymmetry

This type of symmetry is developed along the length of the valley, which is formed by physical (mechanical) and chemical weathering by which the valleys heads are wide and shallow, while the mouths are deep and tight (Figs. 2, 3 and 4). These two different properties of the valley's parts are due to prevalence of chemical and physical weathering, respectively. The mouth is subjected to vertical weathering – erosion of the high velocity running water with high dynamic energy, while the head is affected mainly by chemical weathering – erosion and slow flowing of water with low dynamic energy. Along the studied area and the extending ranges, the valleys are nearly arranged (existing) in regular intervals (Fig.2). This shows that nearly at each internal of 350 ^{O} there is a valley. This interval (distance) depends on the climate and lithology. It should be noted that, where the climate is wet and rainy, then the interval decreases, while the effect of the lithology is to resist the effect of the climate, and where the lithology is hard rock, then the interval increases. In the studied area, there are many areas of badlands in which the lithology is soft and there are several small valleys in distance of 100 m. These badlands are located on the Shiranish (marl), Tanjero (thin beds of sandstone and marl), Kolosh (marl) and Injana (red claystone) formations.

3.2 Traversal Valley Asymmetry

Another property of the valleys in Western Zagros Ranges of Iraqi Kurdistan is clear valley's asymmetry in cross section, which can be developed by lithological and structural contrast of the two sides of the valleys; in addition to the orientation of the topographic slope with respect to geologic structures.

This study had focused on another kind of valley's asymmetry, which is called in this study, "Traversal Valley Asymmetry". It compares between northwestern and southeastern valley sides in term of asymmetry. This type of asymmetry is regular and predicted by more steepness (or by higher relief) of the northwest facing sides than the southwest facing sides of the valleys.

This characteristic can be assigned as a recently established geomorphological or geographical feature of the area, and can be observed in the field and on Google Earth images. This study is the first one, as the authors aware, that records this phenomenon in the Western Zagros Mountains.

In this study, many mountains (anticlines) are inspected in the field such as, DarbandiBazian, Qshlagh, Azmir, Goizha, DardaKar, Greza, Kura Kazhaw, Safeen, and Bar Kew Mountains. The observation of this phenomenon is extended into other parts of Iraq and even into Iran which was noticed using Google Earth images. In the studied area, the valley's asymmetry is observed in many formation, such as Balambo and Kometan (Fig.2), Qulqula (Fig.3), Shiranish (Fig.4), Tanjero, Kometan (Fig.5 and 7), and Fatha (Fig.8) formations.

4 Discussion

The recently introduced idea about the valley's asymmetry and those ideas, which contradict this idea, are discussed hereinafter. This new idea about the valley's asymmetry is applicable only when there is a snow cover for the valleys for relevant duration, and the sun direction fits with the trend of the mountain, as described in this study

From the recently introduced idea of the present study, and through the field checking of the studied area, it was found that among the available theories of the valley's asymmetry, which most seriously contradict the current study are the ideas of two authors, they are mentioned bellow:

Figure 3: The asymmetrical valley profiles in Qulqula Radiolarian Formation in northeast of Dostadara Village (20 km to the east of Nalparez town) about 40 kms to northwest of Sulaimanyia city.The northwest facing sides are steeper and intensely vegetated.

Figure 4: An asymmetrical valley in the Chaqchaq valley within Shiranish Formation (marl and marly limestone), north of Sulaimaniyah city. It can be seen that the northwest facing side (A) has less surface area (steeper slope), more vegetation cover, and dens stream dissection than the southeast facing side (B).

Figure 5: Asymmetrical valleys along southwestern limb of Azmir and Goizha anticlines, north and northeast of Sulaimaniyah city.The northwest facing valley sides (b) keep snow for longer time than the southeast facing ones (a).

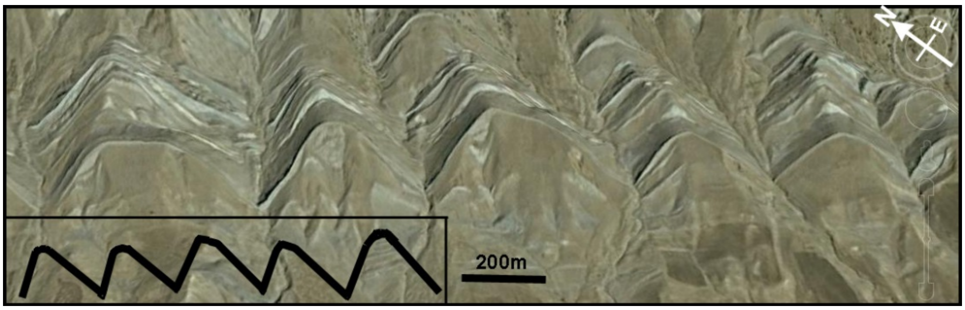

Figure 6: Google Earth image of the southeastern limb of DarbandiBazian anticlineshows many asymmetric valleys (in Fatha Formation) with saw teeth section (as shown by the drawn line at lower left corner)

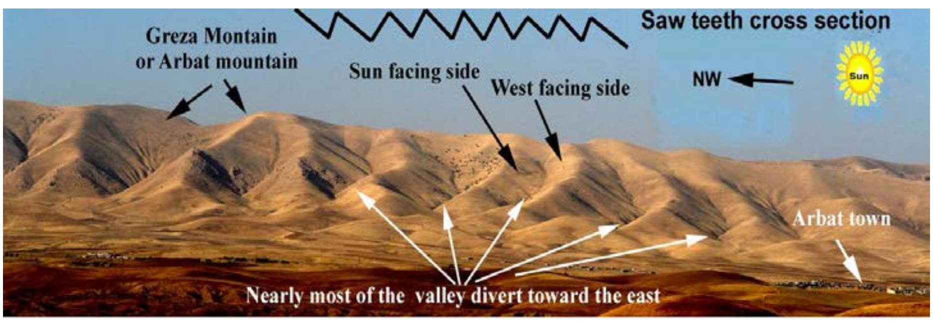

Figure 7: An asymmetrical profile of the valleys, northwest of Arbat town (30 km to the southeast of Sulaimaniyah city) in Kometan and Balambo formations. The northwest facing side has less surface area (steeper slopes) and the diverting of the valley eastwards is clear in the middle part.The cross sections of the valleys in the photo are all collectively similar to saw teeth.

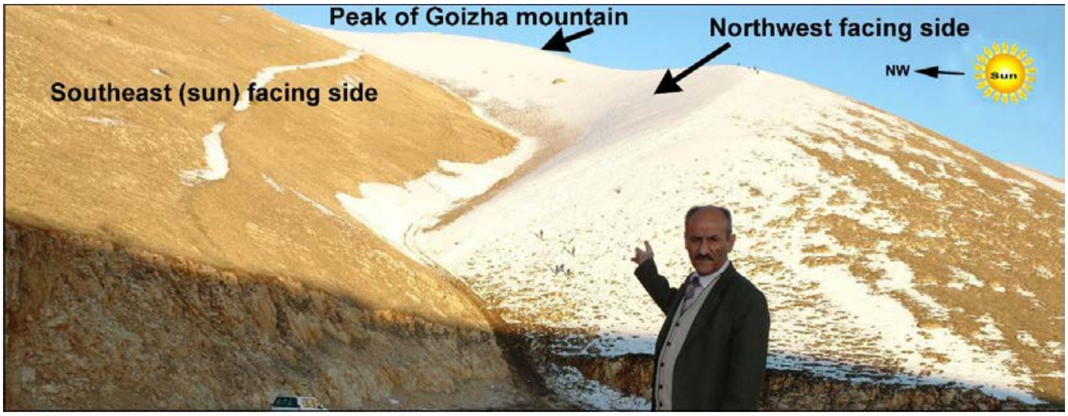

Figure 8: Southeastern limb of Goizha anticline shows a single valley with steeper northwest facing side, with more snow accumulation; as compared to the southeast (sun) facing side.

Wende [7], gave four possible causes for valley's asymmetry in the Lower Bavaria, Germany, these are:

a) The position of an initial channel in relation to its adjacent parallel or sub-parallel drainage lines.

b) Different rates of head-ward erosion of tributaries on either side of an inter-stream divide, (uneven topography) than the southeast facing ones.

c) Oblique drainage development to an initial terrain slope, and

d) Tilting of a land surface and the resulting preferential head-ward erosion of consequent running streams.

Thus, asymmetric drainage development causes differences in slope dimensions and an imbalance in run-off and sediment yield on opposite valley sides leading to the development of asymmetric valleys.

Dohrewend [11] mentioned that the mechanism of valley's asymmetry depends on the rate of deposition at positions favorable for deflection of the main valley. This rate is a function of the gradient and the sediment yield of the main valley. If the valley gradient is above the threshold for deposition, valley's asymmetry will not develop. If the gradient is below this threshold, the higher the sediment yield to the main valley the stronger the tendency for the development of valley's asymmetry. He added that that the tendency for the development of valley's asymmetry is not as strong in the areas with vegetation densities, high relief, or erosion-resistant rock types.

The idea of the first author [7], is not applicable in the studied area, as the first, second and third points can occur randomly for one valley (or channel), but not for several adjacent valleys (or channels). The fourth point is not important as valley's asymmetry is found in all types of valleys such as consequents, subsequent streams or valleys.

The idea of the second author [11] is also not valid in the studied area, as the valleys that are shown in his study are located in such slope and elevation that the deposition of the sediment is very rare or absent. Our interpretation of valley's asymmetry is related to the difference in the amount of sun radiation (heat) that is received by each side. The eastward or southeastern valley sides are suffering from more duration of daily sun radiation (about 10 hours). But, the other side (west facing side) receives less sun radiation; for few hours only (three to four hours; in afternoon, when the sun radiation is less effective) and some part of these valleys are stroked by the sun during summer season only. The northwest facing side receives less sun duration during all seasons, therefore, the moisture content (supplied by precipitation; such as rain and snow) remains in more duration than the southeast facing sides (Figs.2, 3, 4, 5, 6 and 7).

Along the Azmir, Goizha and PiraMagroon mountains, in Sulaimaniyah vicinity snow remains on northwest facing sides for three months while the other face keeps snow for few days only (Figs.5 and 8). This wet condition promotes more chemical weathering of the rocks forming these sides. The chemical decomposition of the northwest side is more intense and extends for long time as compared to other side. The moisture content of the northwestern side is more along base of the slope near the stream between the two faces. Therefore, the chemical weathering is more along the slope base and therefore, the valley stream is shifted towards the northwestern facing slope. This side has nearly two times more vegetation and soil thickness than the eastward facing side.

Normal rainwater has a pH of about 5.6 (slightly acidic), which decomposes rock materials. In most cases, the northwestern side will generate further humic acid due the high vegetation and moisture content. This factor (humic acid) will increase the acidity (pH) of the moisture to be below 5.6. Thus, the high acidity (low pH) and long duration of moisture are responsible for relatively rapid chemical decomposition of the bed rocks of the northwest facing sides; as compared to southeast facing one, therefore, this side either has steeper slope or is dissected by small valleys (has high relief topography) (Fig.2). The chemical weathering of these two faces is similar to two steel boxes, one of them filled with wet clothes and the other one with dry clothes. The clothes in the wet box will decompose and disintegrate during few months while the dry one will remain fresh for several years. Due to effect the acidity, the asymmetry are clearer in limestones and thin bedded rocks than dolomites and thick bedded rocks, therefore it is clearer in Kometan Formation (thin bed of limestone) than Qamchuqa formation due to more resistance of dolomite to acid weathering.

5 Conclusion

This study has the following conclusions:

1- The valley's asymmetry is described in term of processes and geomorphological characteristic for the first time in the Western Zagros Mountain Range, Kurdistan Region, Iraq.
2- There are two types of valleys asymmetry, longitudinal and traversal.
3- Simple method is established for estimating the longitudinal valley's asymmetry.
4- The longitudinal valley's asymmetry is attributed to more moisture content (when the lithology and structure, on both sides are the same) of the northwestern facing side, which is less stroke by the sun radiation than the southeastern sides.
5- The asymmetry is more clear in limestone and thin bedded rocks than dolomite and thick bedded rocks

References

[1] Al-Ansari, N.A. and Knutsson, S., 2011, Toward Prudent management of Water Resources in Iraq, J. Advanced Science and Engineering Research, **1**(1),(2011),53-67.

[2] Al-Ansari, N.A., 2013, Management of Water Resources in Iraq: Perspectives and Prognoses, J. Engineering, **5**(8), (2013), 667-684.

[3] Stevanovic, Z. and Markovic, M., Hydrogeology of Northern Iraq, Climate, Hydrology, Geomorphology and Geology, 1, 2nd edition, FAO, 2004.

[4] Sissakian, V.K. and Fouad, S.F., Geological Map of Iraq, scale 1: 1000000, 4th edit. GEOSURV, Baghdad, Iraq, 2012.

[5] Karim, K.H., Koyi, H., Baziany, M.M. and Hessami, K., Significance of angular unconformities between Cretaceous and Tertiary strata in the northwestern segment of the Zagros Fold – Thrust Belt, Kurdistan Region, NE Iraq, Geol. Mag.,. **148**(5 – 6), (2011), 1 – 15

[6] Walker, E.H., Differential erosion on slopes of northern and southern exposure in western Wyoming (abs.): Geol. Soc. America Bull., **59**, (1948), 1360pp.

[7] Wende, R.1., Drainage and valley asymmetry in the Tertiary Hills of Lower Bavaria, Germany Geomorphology, **14**, (1995), 255 – 265.

[8] Judson, S. and Andrews, G.W., Pattern and Form of Some Valleys in the Driftless Area, Wisconsin, Jour. of Geology (The University of Chicago Press) **63**(4), (1955), 328-336.

[9] Beaty, C.B., Asymmetry of stream patterns and topography in the Bitterroot Range, Montana. Jour. Geol., **70**, (1962), 347 – 354.

[10] Kennedy, B.A., Valley-side slopes and climate, In: E. Derbyshire (Ed.), Geomorphology and Climate, Willey, London, p. 17 l – 202, 1976.

[11] Dohrewend, J.C., 1978. Systematic valley asymmetry in the central California Coast Ranges. GSA Bulletin; **89**(6), p. 891 – 900.