EFFECT OF SLIDE MASSES ON GROUND WATER OCCURRENCE IN SOME AREAS OF SHARAZOOR PLAIN /NE IRAQ

Salahalddin Saeed Ali
Faculty of Geology, College of Science, University of Sulaimaniya- Iraq,
salahsulus@yahoo.com

Abstract: Baranan Mountain is about 200m higher than the surrounding Sharazoor plain, which is located at south and southwest of Sulaimaniya City, northeastern Iraq. Structurally the mountain is a homocline, along its scarp slope (slide scar) and for more than 20 km huge limestone blocks are slid possibly at Holocene, from the upper part of the scarp and many of them reached the Sharazoor plain. Some of the blocks are brecciated to masses of slide debris during sliding while others remained as intact blocks. Some of the blocks are weighted to be more than 800 million tones and commonly associated with existence of small springs. Field study showed that the blocks are underlain by impervious shale and marl and consequently about 20 springs in the area emerges at the frontal line of the masses in the contact between the masses and underlying impervious strata. Both the blocks and the masses have fissured and intergranular porosity respectively, which comprise shallow aquifers with highly variable discharge of the related springs ranging from 0.3-12 l/s. Chemical analysis of six water samples is carried out which, showed that the aquifer is limestone, reflecting the characteristic of Sinjar limestone Formation, and to some extent the underlying Kolosh Formation.

Keywords: Groundwater, flow diversion, karstic aquifer, slide

INTRODUCTION

The studied area located at northeastern Iraq, about 25km to the south and southwest of Sulaimaniya city (Fig.1). The area includes the western part of the Sharazoor plain and an elongate high ridge (or mountain), which is locally called Baranan Mountain. The ridge has Northwest-Southeast trending and extends between Darbandikhan and Dokan dams at the Southeast and Northwest of the studied area respectively. The mountain has many local names such as Shaffa Rash, Zirgoez, Bakr Agha and Tasluja mountains.

Structurally the mountain is a homoclinal ridge (called Baranan homocline) and its strata dipping 25° toward Southwest. The whole area of western part of the Sharazoor plain is located between Goizha anticline and the homocline (Fig. 1). The plain is dissected longitudinally by Tanjero stream, nearly parallel to the homocline.

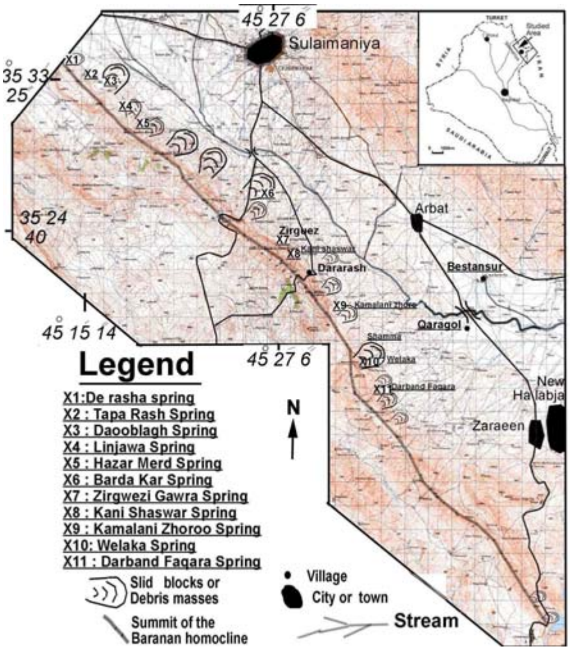

Fig. 1 Location map of the studied area showing slid block and debris masses

GEOLOGICAL SETTING

The studied area is located within the High Folded Zones near the boundary between Low and High Folded Zones (Buday, 1980). In this area, the strata of homocline dips at 25° toward Southwest, the dip amount and direction nearly equal to that of the slope (back slope). While the scarp slope forms a high cliff, which has in most places about 70° of slope. The cliff is looking over the Sharazoor plain and Sulaimaniya city. Along its elongation many Tertiary units are exposed (Kolosh, Sinjar, Gercus and Pila Spi Forma-tions, Fig .4A) from the bottom to the top of the cliff. These formations have the thickness of 1000, 120, 70 and 60 meters respectively. Kolosh Formation cropped out at an area extending from the base of the cliff to the right bank of the stream which covered sporadically by huge masses of thick to massive bedded limestone and occasionally brecciated (Fig. 3). The blocks belong to Eocene Sinjar Formation and detached from the cliff and slid from the slope onto the plain, now they can be seen rested on southern boundary of Sharazoor plain on Kolosh Formation. Karim and Ali (2004) studied in detail condition of sliding of the blocks and they mentioned that, some of these blocks are far than three kilometers from the cliff. They have sporadic distribution some of them weighted more than 800 million tones (from Tasluja, at northwest to Zarayn town).

In addition to the present sliding, the area around the plain contains many sliding masses. For example, at northwestern end of the studied area Hamasur (1999) and Karim et al. (2000), studied in detail large slide at the northeastern side of Charmaga valley. Jassim, et al (1975, p.144) showed, at the southeastern end of the area, rockslide of Pila Spi Formation on Kolosh Formation.

HYDROGEOLOGICAL CONDITION OF THE STUDIED AREA

Originally the plain, in the studied area, without the slid bocks is nearly water barren. This is because of the following two points:

Firstly the surface of the plain is covered to the depth of about 300m, by impervious bed of either Paleocene Kolosh or Maastrichtian - Tanjero Formations. These formations are consisted of very thick succession of sandstone, siltstone and marl, which alternate rhythmically as southwest, low dipping strata (Buday, 1980, Al-Rawi, 1981, Jaza, 1992, Karim, 2004). These two formations have the characteristics of either aquitard (where deformed) or aquiclude (where ″fresh″). Well drilled in the studied area in these formations yield no water except where faulted or intensively brecciated.

Secondly, the strata of the homocline are dipping away from the plain toward southwest. This is directed the groundwater in the same direction away from the plain (Fig. 3A and Fig. 4B). Because of this characteristic, the area to the southwest of the homocline (area of the dip slope) has sufficient opportunity to have large springs such as Sarzal spring and artesian wells such as Swarawa artesian well (Stevanović, personal communication). In contrast to this, the area located to the northeast of the homocline is nearly water barren. But due to slid masses, enough groundwater is now available for domestic uses in addition to livestock and cultivation uses.

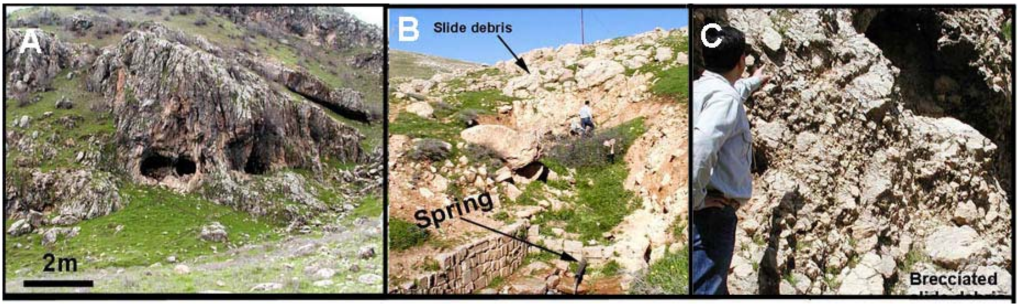

Fig. 2 A: Outlet of two caves (ancient spring mouth) in front of large limestone block at 200m south Dar Barola Village. Now the related spring is locating 30m down the caves(located at lower left corner out side the photo). B: A small spring, located at the west of De Rasha village, which exists in front of slide debris. C: Close up photo of brecciated limestone (slide debris) which forms, in many cases, aquifer of small yield

.

A CONCEPTUAL MODEL FOR SLIDE MASSES AND RELATED SPRINGS

The collected field data and observations are used for construction of a conceptual model, which consists of few steps, as following:

PARTIAL DIVERGENT OF GROUND WATER BY SCARP UNDER CUTTING

Before sliding the base (toe) of the homoclinal scarp was removed and the slope steepened gradually by the effect of vertical and lateral erosions of the soft marl. The erosion is accredited to two agents. The first one can be attributed to the Tanjero stream, which is a longitudinal (subsequent) stream and cross the plain almost parallel to the homocline ridge (Fig. 1). The second agent is occurrence of sapping at the contact between permeable (limestone) and impermeable (marl) units. Pitter (1986) described the sapping at the base of permeable beds by seepage of groundwater. He added that a horizon of the clay rich cohesive unit (top of Kolosh Formation) beneath the zone of seepage might become a lubricated surface that serve as the sliding plane for overlying unit.

The above case is most possibly what happened at the contact between Kolosh and Sinjar Formations, which is responsible for the undermining of the homoclinal scarp. This undermining caused partial divergent of ground water toward northwest and assisted subsequent sliding of the part of the homoclinal scarp. The sapping and seepage of water is now obvious from existence of few caves (Fig. 2A) and small springs. These caves exist at the contact between the two formations as a karstic features formed by solution of the Sinjar limestone.

MAIN DIVERGENT OF GROUND WATER BY SLIDING

The erosion by stream and sapping by seepage have localized the zone of sliding and subsequent emergence of the springs due to divergent of groundwater northeastward. It is obvious that the limestone is slid as separate blocks either toward northeast or north (Fig. 1). These blocks are juxtaposed against the impermeable marl due to the sliding from the over hanged cliff of the homocline (Fig. 3 and Fig. 4).

This type of juxtaposition of permeable and impermeable rocks are well documented by Potter, et al (2002), they described, how faulting resulted in the juxtaposition of stratigraphic units with contrasting hydrologic properties, which caused groundwater discharge. Now the blocks and debris masses exist as separate aquifers and the springs are located at the trace of the frontal line of them (Fig. 2B and Table 1). The morphology of the blocks most possibly highly modified by weathering and erosion, one can see many blocks dissected by small valley streams. The average volume of each individual aquifer is at the range of 0.3-0.6 km^3, some of which is brecciated and has interparticle porosity (Fig. 2C) while others are remained apparently as intact blocks. Close inspection of these blocks show remnant of fracturing which now exist as open fissures forming fissured aquifers. The springs mainly have low discharge; this is possibly returned to the differential settlement of the blocks according to their weight. These settlements generate local storage and seepage. Another reason for generation of local aquifer and seepage is possible presences of local grooves parallel to the direction of the siding of the blocks. These grooves formed when the relatively hard and intact blocks of limestone are slid over the soft marl of Kolosh Formation. It is worth to mention that sliding is not the only mean of diverging, in rare cases deeply penetrated valleys into homocline divert groundwater direction northeastward also, and the Zirgoez valley is the only example in the studied area.

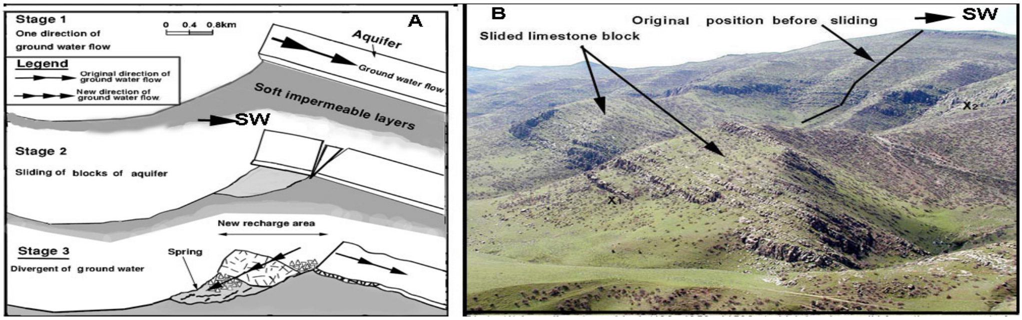

*Fig. 3 A: A conceptual model for divergent of the groundwater flow which is resulted from sliding of large blocks of an aquifers. B: Large slid limestone block (100m*250m*1500m), the original position is shown by solid black line. It is located at the southeastern part of studied area. The X1 and X2 indicate the distant displacement of the same bed.*

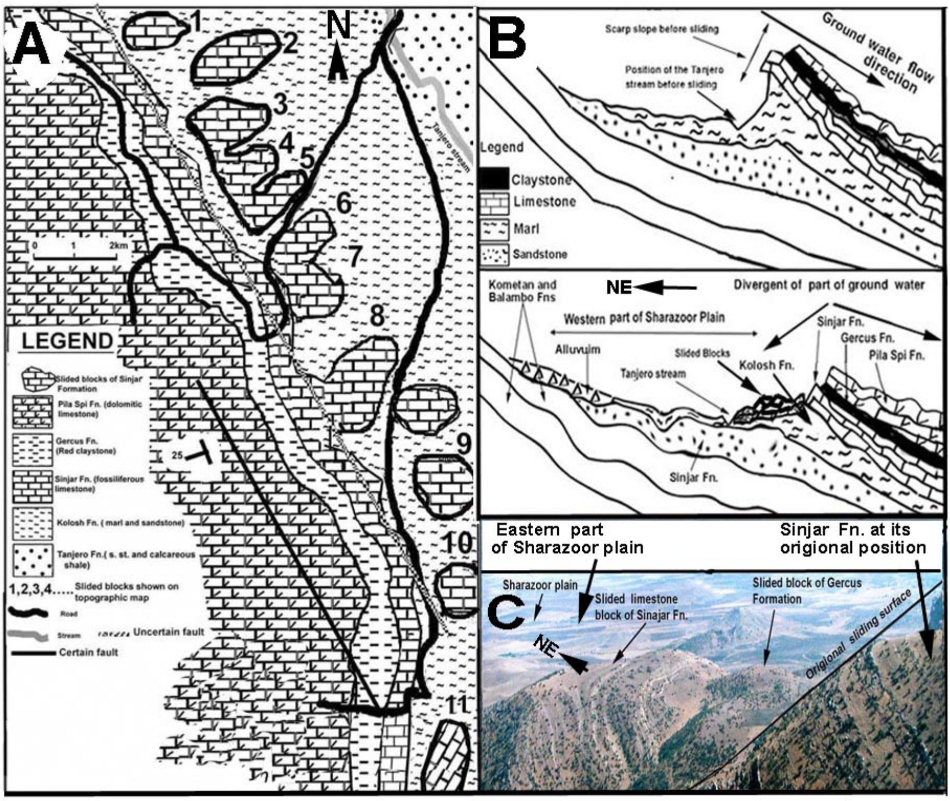

*Fig. 4 A: Geological map of the central part of the studied area. B: Practical field example for conceptual model showing divergent of groundwater rout C: Large slid limestone block of Sinjar Formation (1km * 0.7 km *0.1km) at the west of Glazarda village. Modified from (Karim and Al,i 2004)*

CHEMICAL CHARACTERISTICS OF WATER SAMPLES

Chemical analysis of water samples Table 2, that shows the major ions concentration calcium, magnesium and bicarbonate are the dominant ions. Although the Sinjar Formation is mainly composed of more than 80% of $CaCO_3$ (Surdashy, 1988), but high Mg values have been detected. This deviation from hydrostratigraphy of the aquifer is reflecting the general stratigraphy of the area where the pure limestone aquifer of Sinjar Formation is underlain and overlain by relatively Mg-rich rock units of Kolosh and Pila Spi Formations. Kolosh Formation contains basic igneous rock fragments in the sandstone portion, while the marl and shale beds contain illite and chlorite minerals. These constitutions suppose to contaminate the water of Sinjar aquifer. The similar is for Pila Spi Formation.

Table 1. Location and hydrogeological attribute of some spring along the frontal parts of the slid masses

No	Spring Name &Location	Lat.	Long.	Elevat	Q_{max} l/s	$Q_{av.}$ l/s	Q_{min} l/s	Catchment area (km^2)	Type of Aquifer
1	Tapa Rash	35º 33.2̀49″	45° 14.9́ 14″	817	1	0.6	0.2	0.5	Slid mass and debris
2	Daoblagh	35º 32̀ 80″	45° 15.9́ 13″	810	1	0.4	0.2	0.5	Slid mass and debris
3	Qazan	35º 32̀ 04″	45° 16.9́ 94″	821	10	5	3	4	Same
4	Linjawa	35º31.2 3″	45° 18.1́ 44″	870	12	20	6	3	Same
5	Daragha	35° 28́ 46″	45° 24 3́6.8″	974	5	2	0.2	1.5	Slid mass and debris
6	Kani Shaswar	35° 24′42″	45° 28́ 48″	819	4	1	0.2	1.5	Slid mass and debris with alluvium
7	Dara rash	35° 23′20″	45° 28́ 40″	700	6	3	1	4	Slid masses
8	Zirgoezi Gawra	35° 24′40″	45° 27́ 5.7″	800	10	5	3	8	Slid mass and debris
9	Barda kar	35° 13′40″	45° 37́ 15″	800	5	2	0.7	2	Slid mass and debris
10	Darband Faqara	35° 18′00″	45° 32́ 50″	850	6	2	0.6	2	Slid mass and debris
11	Kani Hanjeer	35° 15́ 20″	45° 36́ 00″	1225	3	1	0.1	4	Slid mass and debris
12	Kani tu	35 °14́ 20″	45° 36́ 25″	1350	4	2	1	4	Slid mass and debris
13	Kamalani Khuwaroo	35° 21́ 50″	45° 31́ 00″	780	3	1	0.2	2	Slid mass and debris

Table 2. Chemical analysis of six water samples taken from some springs along the frontal area of the slide masses.

Spring Name	PH	Ec uc/cm	TDS mg/l	Cl^{-1} ppm epm	$CO3^{=}$ ppm epm	$HCO3^{=}$ ppm epm	K^{+1} ppm epm	$SO4^{=}$ ppm epm	Na^{+1} ppm epm	Mg^{+2} ppm epm	Ca^{+2} ppm epm
Darband Faqara	7.1	440	308	29.0	0.0	264.39	0.40	15.0	3.9	33	56.0
				0.817	0.0	4.33	0.01	0.313	0.17	2.75	2.8
Kamalani Zhoroo	7.6	470	284	53	12	210	0.52	10.0	4.0	20	44.0
				1.5	0.4	3.44	0.013	0.20	0.17	1.65	2.2
Welaka	7.9	360	240	11.0	12.0	250.0	0.31	15.0	7.0	32	52
				0.31	0.40	4.10	0.008	0.13	0.30	2.63	2.6
Daragha	7.51	440	287	24.0	5.1	228.29	0.40	14.0	4.5	19.0	63.0
				0.676	0.17	3.74	0.01	0.292	0.196	1.58	3.15
Linjawa	7.1	380	266	23.0	3.40	299.89	0.0	23.1	5.60	35.0	61.0
				0.648	0.11	4.92	0.0	0.481	0.243	2.92	3.05
Derasha	7.8	400	285	27.0	24	159.0	0.68	25.0	4.4	17	38.0
				0.76	0.8	2.6	0.17	0.52	0.19	1.4	1.9

CONCLUSIONS

1- It is possible that a large landslide, as block or debris masses, may divert the groundwater direction where the lithology and stratigraphy are comfortable.

2- It was found that many springs may be generated, where the slid blocks and debris masses rested on the impervious rocks.

3- A conceptual model is drawn to explain the phenomena of the diversion and many field examples are clarified in situ.

4- The examples include intact limestone blocks and blocks brecciated to slide debris during sliding. Some of the blocks are weighted to be more than 800 million tones.

5- Both the blocks and masses have fissured and intergranular porosity respectively. Both have characteristics of shallow aquifers with highly variable discharge of the related springs, which are ranging from 0.3-12 l/s.

6-Chemical analysis confirm karstic as the main aquifer is limestone, which reflects the characteristic of Sinjar limestone Formation, and to some extent the underlying Kolosh Formation.

REFERENCES

Al- Rawi I K, 1981: Sedimentology and Petrography of Tanjero Clastic Formation from north and northeastern Iraq. Unpublished Ph. D. Thesis, University of Baghdad, 295p

Buday T, 1980: In: Regional Geology of Iraq: Vol. 1, Stratigraphy, I.I.M Kassab and S.Z. Jassim (Eds) D. G. Geol. Surv. Min. Invest. Publ. 45p.

Buday T, Jassim S Z, 1987: The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism. I.I. Kassab and M.J. Abbas (Eds), Baghdad, 445 p

Hamasur G A, 1999: The Quantitative analysis of the Qara-Chattan rock slide from northeastern Iraq. Journal of Dohuk University, 2(4). Special issue of the First Scientific Conference of Dohuk University. pp.465-477

Jassim S Z, Al-Shaibani, S I Q, Ajina T M, 1975: Possible Middle Eocene block movements in the Darbandikhan area, Northern Iraq ; 1. Geol. Soc. Iraq. Special Issue, Pp. 139-145.

Jaza I M, 1992: Sedimentary facies analysis of the Tanjero Clastic Formation in Sulaimaniya District, northeast Iraq. Unpl. M. Sc. Thesis, Salahaddin University, 121p

Karim K H, 2004: Basin analysis of Tanjero Formation in Sulaimaniya area, NE-Iraq. Unpublished Ph.D. thesis, University of Sulaimani, 135p

Karim K H, Ali S S, 2004: Origin of dislocated limestone blocks on the slope side of Baranan (Zirgoez) Homocline: An attempt to outlook the development of western part of Sharazoor Plain. AKJ, 3(1), pp.5-20

Karim K H, Hamasur G A, Mohasmad S T, 2000: Qara-Chattan rockslide in Piramagroon anticline, Northeastern Iraq, Journal of Zankoy Sulaimani, Part A, Vol. 3 No.1

Pitter D F, 1986. Process of Geomorphology. Second Edition, WCB Publisher, 579p

Potter C J, Sweetkind, D.S. Dickerson, R.P and Killgore, M. 2002. Hydrostructural maps of the Death Valley regional flow system, Nevada and California, U.S. Department of the interior, U.S. Geological survey Report. 12p

Surdashy A M, 1988: Lithological ,facies and environmental study of Sinjar Formation in selected sections from Sulaimanyia area, Northeast of Iraq; Unpubl., M. Sc. Thesis, University of Salahaddin.NE-Iraq,170p

Van Bellen R C, Dunnington H V, Wetzel R, Morton D, 1959: Lexique Stratigraphique, Interntional. Asie, Iraq, vol. 3c. 10a, 333 p