

The formation and disappearance of the Jaydar Landslide Lake in south of Lorestan province

A. Nooryazdan¹, M. H. Ghobadi*²

Abstract:

Landslide-dammed lakes are geological phenomenon that, despite of their beauties, can be studied as a geologic hazard. Seymareh rock avalanche has created at least three dams and lake landslides in southwest Iran. The Jaydar dam is a horseshoe-shaped landslide dam that is composed from large rocky blocks. The Jaydar debris dam length is more than 11,000 m and average height is 140 m from its bedrock. This dam is formed on the Kashkan River in south of Poldokhtar city and between the Sarab Jahangir and Baghe Jaydar villages. Due to the geometry dimensions and stability of the dam until now, it could be the oldest and the largest rocky landslide dam in Iran. The Jaydar Lake is the 2-nd landslide lake in region, has a length of 36,000 m and an area of 65 Km². The Jaydar Lake has expanded from the south of Poldokhtar city to the Jolgeh Khalaj village on the Poldokhtar-Khorramabad road. The Present Researches show, that the formation and disappearance of The Jaydar Lake are in ۳ stages. 1. Seymareh rock avalanche and formation the Jaydar landslide dam. 2. The blockage of Kashkan River route and Formation of a lake and filling up to 740 meters above sea level (m.a.s.l). 3. Lake drainage through a valley (spillway) on bedrock in the northwest of the lake. Results showed that using GPR with 10 MHz antenna showed that the water of the lake was raised from 640 to 740 m.a.s.l. The obtained radargrams show that has been done more than 70 m of sedimentation on the Jaydar Lake. Field evidence showed that there was a hydraulic connection between the Jaydar Lake and the larger lake (Seymareh Lake in west of the study area). The water of Jaydar Lake has been permanently drained to the Seymareh Lake by a solution valley at more than 740 m.a.s.l. The study shows that the drying time of the Jaydar Lake was delayed after the failure of the Seymareh landslide dam. it seems gravel and sand rich mains in east and Karkheh River path are formed after drainage the Seymareh and Jaydar Lakes. At present, there is a sedimentary zone in the Jaydar Lake place that due to some physicochemical properties is susceptible to some geological hazards such as Gully erosion and Badland areas.

Keywords: *Jaydar Lake, Landslide dam, Erosion spillway, Seymareh rock avalanche.*

1. PhD Student, Department of Engineering Geology, Bu Ali Sina University.
2. Professor, Department of Engineering Geology, Bu Ali Sina University,
* Corresponding Author

Extended Abstract:

1. Introduction

The formation of dams on the major rivers due to great landslide is an important geological hazard and a considerable geomorphic process in mountain areas (Evans et al. 2011; Fan et al. 2012a, 2012 b). River damming mostly outcome in extra-large impoundments that, in some historical cases, the volume of the reservoir of dam is larger than reservoirs made by humans (Evans, 2007). These are necessary for create landslide dams conditions, such as height, slope and discontinuities (layering, fault and joint), and triggers factors (rainfall, melting and earthquake) (Korup, 2002). There are more than 24 landslide dams in Zagros and Central Alborz (Ghobadi and Ahmadzadeh, ۲۰۱۳). But few studies have been done on these dams. After the occurrence of rock avalanche Seymareh at 11,000 years ago (Watson and Wright, 1969) in South of Poldokhtar in SW Iran, Was created 3 landslide dams and permanent lakes. The largest lake, which is called Seymareh, was length about 51 km and formed on the Seymareh River. Due to the failure of this dam, changes have been made that its effects are seen in the Mazhin plain in the downstream regions. The Gory Balamak Lake as the smallest lake in the area was formed on the Mirabad seasonal river. Since the old road of Poldokhtar-Andimashk passes across this lake, in the time of the flood, the road was blocked by the lake water. Thus, in the summer of 1994, transportation ministry of Lorestan province by creating a canal in the western part of the lake causes the discharge of the lake and its permanent drying (quotes from the people of Mirabad village). In this study, how to the formation and decline of the Jaydar Lake as the second largest lake in the region, which is formed along the Kashkan River route, as well as its effects in the geomorphologic region, have been evaluated.

2.General Characteristics of the Area

The study area is located in the south of Lorestan Province at latitude of 47° 37' to 49° 39' N and longitude 33° 05' to 33° 09' E in South-West of Iran. The average height of the area is 683 m.a.s.l. The annual average precipitation and annual evapotranspiration are 360 and 2920 mm, respectively and the climate of the study area is semi-arid. The area has very warm summers (Max. daily July temperature 47 C°) and cold winters (Min. daily January 0 C°).

3.Materials and methods

In this study, in order to precisely understand the stages of lake formation, using the IRS-P5 satellite imagery and the ENVI and ARC GIS software, the digital elevation model of the site was prepared with a precision of 2.5 m. Using a DEM, has been prepared a longitudinal profile with a length of 10,000 m from the dam site construction to the town of Poldokhtar. Using the geophysical method of ground penetration radar (GPR) are estimated position and depth of the bedrock and index morphological landforms before the formation of the lake. Using field visits, in-situ measurements and expert judgments have been investigated formation and decline of the Jaydar Lake. In this study, it was not possible to prepare a DEM with a precision of 2.5 m in the whole region.

4.Geology

Regarding field observations, from the point of view of geology, in the Jaydar Lake location have the most outcrops the Asmari (Limestone), the Gachsaran (Gypsum and marl) formations (Oli.-Mio.), landslide-dammed lake deposits and landslide materials (Quaternary). Also, on the road of

Khorrarnabad-Poldokhtar (between the Jolagh Khalaj and the GolGol villages), There are outcrop of the Upper Cretaceous contains Sarvak, Gurpi and Ilam formations.

5. Hydrodynamic conditions

In study area; the main drainage system is the Kashkan River. To Jaydar Lake, several sub-rivers such as Gol Gol, Khers Dar and Morani are connected to the Kashkan River. In Jaydar plain are 6 active piezometers. In this study, groundwater levels have been measured several times. The results show that the average level of groundwater is about 20 meters above the ground. Also, according to the groundwater level map, the prevailing groundwater flow is east to west.

6. How to formation of Jaydar lake

Based on field observations, the study of the boundaries of the expansion sediments of the old the Jaydar Lake, how to contact this sediments with bedrock and Quaternary sediments including colluvium material, can be formed and the deterioration of the Jaydar Lake divided into 3 stages.

6-1. First stage: Create a landslide dam

Seymareh landslide (Seymareh Rock Avalanche) (SRA) has occurred due to separation of the layers of the Asmari Formation with a thickness of more than 300 m and a length of more than 15,000 m in the North limb of the Kabir Kuh anticline (Harrison and Falcon 1934, 1936, 1937, 1938; Oberlander 1965; Watson and Wright 1969; Ambersayes and Melville, 1982). As a result of this event, sliding materials have covered an area of 166 Km² (Harrison and Falcon, 1938), 270 Km² (Watson and Wright, 1969) up to 200 Km² (Shoaei, 2014). The volume of landslide material Seymareh is estimated from 32,000 to 24,000 Mm³ (Shoaei and Ghayoumian, 2000), 38000 Mm³ (Shoaei, 2014, Roberts and Evans, 2013) and 44,000 Mm³ (Roberts and Evans, 2013). The Jaydar landslide dam has blocking the Kashkan River and formed a landslide lake. The main location of the dam construction is 8 km SW of Poldokhtar city. It seems that the maximum height of the Jaydar dam (which is now eroded) is 50 m (Shoaei, 2014). Field investigations and the results of geophysical data indicate the Jaydar dam height is greater than the amounts mentioned in previous studies. Accordingly, the Jaydar dam is a horseshoe rock fill dam that its length and width is more than 11000 and 2000 m, respectively. Results of geophysical data and field observations show that the average height of the dam is about 140 m from the its bedrock.

6-2. Second stage: Landslide lake formation

After filling the reservoir, all Terrain area is covered by lake water up to 740 m.a.s.l. Also, more than 75 percent of the reservoir volume of lake with a total area of 46.77 Km² was located in south of Poldokhtar city (The Jaydar plain). According to maps of lake water up to 740 m.a.s.l are estimated more than 3860 Mm³.

6-3. Third Stage: The reason for the drain of the Jaydar Lake

In this study, two matter related to the drying of the Jaydar lake have been investigated. 1- The time of filling the reservoir of the dam from sediments (Dam longevity) 2- Investigating the stability of the Jaydar and Seymareh dams. using selected sections in different of the Jaydar and Seymareh Lakes, parts average sediment thickness is estimated to be 30 and 60 m respectively (Shoaei, 2014). Due to the hydro- morphologic conditions, the Longevity of the Jaydar and Seymareh dams is estimated to be 325 and 935 years after formation (Shoaei, 2014). However, as noted the thickness

of sediments in the Jaydar and Seymareh lakes is 70 and 120 m, respectively. Also, the area of the Jaydar and Seymareh lakes is 65 and 215 km², respectively.

According to the hydraulic connection between the lakes of the Jaydar and Seymareh dams, in this study has been to compare the relative time drain the lakes. Since the Seymareh Dam is failure, its exact location is unclear. Between the two possible locations for the formation of the Seymareh dam, the options of the west Godarnamak village and the east of saffron plain have a length less than 3000 and 1500 m respectively. As well as field surveys show that a lot of body volume of the dam's right abutment (the connect to the Kabir Kuh anticline limb) is made up of debris material. The catchment area of the Seymareh dam is 3 times of the Jaydar Dam and location of the Seymareh Lake is a syncline axis, so the area of the Seymareh Lake is about 2.3 times of the Jaydar Lake. Field studies shown that the right abutment of the Seymareh dam with low resistance materials (debris flows of soft Pabdeh and Gurpi Formations) had been capability rupture by the force of water seepage. Considering the above factors, it seems that the Seymareh dam is completely disrupted before the dam is fully drained. With the drainage of the Seymareh Lake and the increase of the hydraulic gradient, the volume of water passage from the Jaydar Lake spillway has increased. As a result, a part of the lake sediments in the route of the spillway, was washed out and transferred from the lake. The spillway of the Jaydar Lake is located on the Gachsaran Formation. Due to the high solubility of this formation, over time the dimensions of the spillway increased and increased the volume of water passing through it.

7. Conclusion

Seymareh rock avalanche in SW of Iran has caused the formation of at least 3 landslide dams' names the Jaydar, Seymareh and the Gori Balmak. The results of this study show the Jaydar dams are a horseshoe shape dam. The length and width of the landslide dam is 11,000 and 2,000 m respectively. The dam on the Kashkan River has created a lake with a length of 36000 m and a total area of 65 Km². The application of the ground penetration radar (GPR) showed that the average depth of lake sediments is 70 m. Also, the combination of geophysical data, field studies and in situ measurements showed that the average height of the dam is more than 140 m. Field surveys showed that the body of the lake dam is often composed of large blocks of Asmari Formation, and this dam is never unbroken and it can be considered the largest and most stable landslide dam in Iran. The studies showed that the Jaydar reservoir of the dam, up to 740 m.a.s.l, had a capacity of more than 3860 Mm³. It seems that the Jaydar Lake is filled at least 2 years after formation. It can be said that the Jaydar dam has not been failure and has stable itself. The water of the Jaydar Lake was gradually drained by a spillway into the Seymareh lake location at a maximum height of 700 m.a.s.l s. l (40 m. below the water level of the Jaydar Lake). The results of this study show that the length of the Seymareh Dam is 1/3 of the Jaydar dam and Seymareh Lake area is 2.3 times the Jaydar Lake. The results of this study showed that a lot of part of the body of the Seymareh dam formed from debris of Pabdeh-Gurpi soft formations. Therefore, the failure of the Seymareh dam before the complete discharge of the Jaydar Lake is definitive. Due to the failure of the Seymareh landslide dam and drainage of the Jaydar lake, a part of the sediments in the location of Seymareh lake, also a part of the Jaydar lake sediments have been transferred from the its location and have been deposited in SE of the study area. At the location of the spread of The Jaydar Lake has been formed, a flat sedimentary zone. In some places, due to some physical and chemical properties, there are signs of morphological changes, including gully erosion and the creation of badland areas.

References

- Evans S.G. and Delaney K.B. (2015). The 2000 Yigong landslide (Tibetan Plateau), rockslide- dammed lake and outburst flood: Review, remote sensing analysis, and process modelling. *Journal of Geomorphology* 246:377-399.
- Evans, S.G., Delaney, K.B., Hermanns, R.L., Strom, A.L., Scarascia and Mugnozza, G., 2011. The formation and behavior of natural and artificial rockslide dams; implications for engineering performance and hazard management. In: Evans, S.G., et al. (Eds.), *Natural and Artificial Rockslide Dams. Lecture Notes in the Earth Sciences* vol.133. Springer, Heidelberg, pp.1-75.
- Evans, S.G., Guthrie, R.H., Roberts, N.J., Bishop, N.F., 2007. The disastrous February 17, 2006 rockslide-debris avalanche on Leyte Island, Philippines: a catastrophic Landslide in tropical mountain terrain. *Nat. Hazards Earth Syst. Science* 7, 89-101.
- Fan, X., van Westen, C.J., Korup, O., Gorum, T., Dai, F., 2012b. Analysis of Landslide dams induced by the 2008 Wenchuan earthquake. *J. Asian Earth Science* 57, 25-37.
- Fan, X., van Westen, C.J., Korup, O., Gorum, T., Xu, Q., Dai, F., Huang, R., Wang, G., 2012a. Transient water and sediment storage of the decaying Landslide dams induced by the 2008 Wenchuan earthquake, China. *Geomorphology* 171-172, 58-68.
- Harrison, J. V and Falcon, N.L., 1938. An ancient landslip at saidmareh in southwest Iran. *The geographical journal*, 46, 296-309.
- Harrison, J.V and Falcon, N.L., 1937. The saidmarreh landslip, Southwest Iran. *The geographical journal*, 89(1), 42-47.
- Harrison, J.V. & Falcon, N.L., 1934. Collapse structures. *The Geological Magazine*, 71, 529-539.
- Harrison, J.V. & Falcon, N.L., 1936. Gravity collapse structures and mountain ranges as exemplified in southwestern Iran. *Quarterly Journal of the Geological Society*, 92, 91-102.
- Korup, O., 2002. Recent research on Landslide dams – a Literature review with special attention to New Zealand. *Progress in physical Geography* 26, 206-235.
- Roberts, N.J. and Evans S.G., 2013. The gigantic seymareh (saydmareh) rock avalanche, Zagros Fold-Thrust Belt, Iran. *Journal of the Geological Society*, 170(4) 685-700.
- Shoaei Z., 2014. Mechanism of the giant seimareh landslide, Iran, and the longevity of its landslide dams. *Environment Earth science*, 72:2411.
- Watson, R.A. and Wright, H.E., Jr., 1969. The Saidmareh Landslide, Iran, *Geology Society of America Special Paper* 123, pp. 115-139.