GEOGRAPHY AND TOURISM, Vol. 3, No. 1 (2015), 39-47, Semi-Annual Journal,
ISSN 2449-9706, DOI: 10.5281/zenodo.19969

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The origin of the Great Lakes Basin, Western Mongolia: not the super flooding, but glaciated super valley

Abstract. Research on Morphology and genesis of the Great Lakes Basin in western Mongolia were taken relatively rarely in recent years. The present study combines the results of previous work with modern analysis of photographs and satellite images. The theory of Pleistocene glaciation which took vast areas of the northern hemisphere became the basis of the new approach. Glaciation covered the area from northwestern Mongolia to Mongolian Altai, Khangai and Khuvsgul mountain ranges. At that time, the ice sheet has also taken the Great Lakes basin area, which was characterized by morphology inherited from the Mesozoic era. Today, the Great Lakes Basin is like a large valley transformed by the ice sheet where "knock and lochan" topography (scoured region) and rock drumlins lie in its central part. Huge meltwater flow formed Sharga sub-basin as a super kettle hole by erosion and formed a large basin or big lakes in Lake Valley.
Key words: Great Lakes Basin, Pleistocene global glaciation, "knock and lochan" topography, rock drumlin, glaciated super valley, Sharga basin, Lake Valley

Introduction

Basin of Great Lakes is located along longitudinal direction in western Mongolia, surrounded with Tagna mountain range to north, Mongolian Altay mountain range to west, Khangay - to east and Gobi Altay - to south. The length of basin is from 600 to 650 km and width is to 200-250 km in the north side, narrowing from 60 to 100 km in the south. Eastern border of the basin is not clearly defined and usually is determined by Zavkhan fault zone which was explained by neotectonic movement to present day.

For the geological investigation of basin, more than 60 years including 25 years of joint Mongolian - Russian research and 20 years of Mongolian – Western countries of research can be found in numerous publications. During the past 20 years, several scholars have resulted to interpret it as an island arc terrane (Badarch et al., 2002), composite terrane (Tomortogoo, 2012) and a district with Devonian aged continental crust (Byamba, 2009). The present development of basin is inherited from Mesozoic era and small parts within basin, for example, Zereg sub-basin formed between intracontinental transpressions (Howard et al., 2003).

Research for morphology and the origin of the Basin of Great Lakes, Western Mongolia, are very few (Murzayev, 1948; Selivanov, 1972; Schmidt, 1974; Devyatkin, 1978; Murzayeva, 1982), and particularly in recent years there are none.

Geomorphological description of the Great Lakes Basin

The Basin of Great Lakes is divided into 4 sub-basins including Uvs, Khyargas, Khar Us (with Zereg sub-ba-

sin) and Sharga, comparing with morphological difference (Turischev, 1973; Murzayeva, 1982).

In all of sub-basins, plains of various genesis are wide developed on Paleozoic, Mesozoic and Cenozoic deposits. Island and residual mountains and hills also formed within plains. On the east side of the basin, large aeolian massives can be observed (Fig.1).

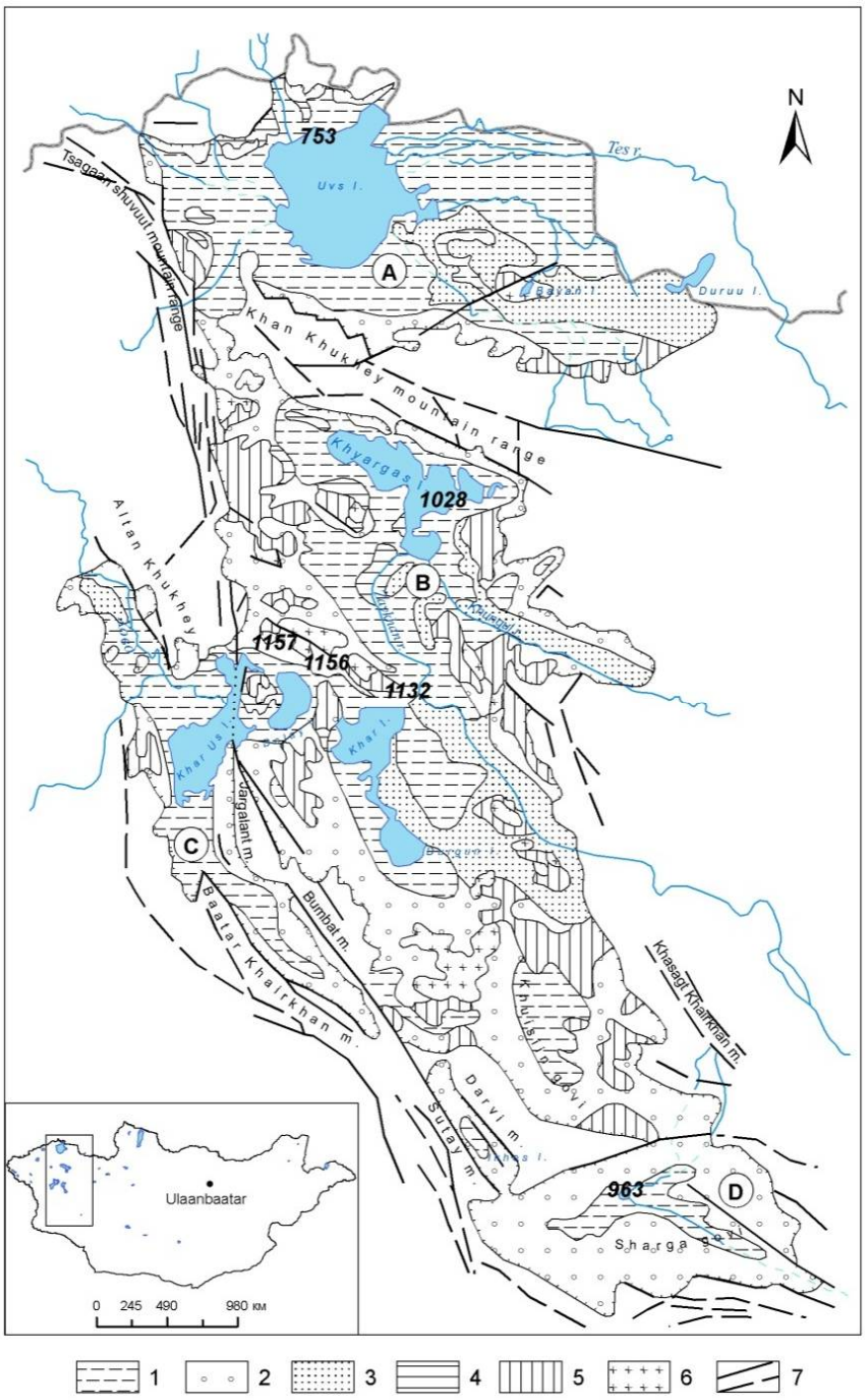

Fig.1. Location and schematic geomorphological map of the Great Lakes Basin, Western Mongolia: 1 – lake – deltaic plain, 2 – proluvial plain, 3 – aeolian massive, 4 – abrasion plain, 5 – piedmont plain, 6 – island mountains, 7 – fault lines.
Modified after V.E. Murzayeva (1982, 1987)

Methods and data sources

The main base of the new theory is the Pleistocene Last Glacial Maximum distribution. Many scholars proved that the global glaciation covered many areas of the Northern Hemisphere during Pleistocene (Leverett, 1929; Miller, 1964; Richmond & Fullerton, 1986). Ice sheets covered most of the northern parts of North America, Europe and Asia continents and extended to about 45 degrees north latitude and were from 1,5 – 2,5 to 3 - 4 km thick (Richmond & Fullerton, 1986; Kim Seong Joong et al., 2007).

Example of basin that formed during this glaciation is the Great Lakes Basin in North America. Scholars studied the origin of it for more than 100 years and finally explained it at the end of 1980's, often using the satellite imagery (Shepard, 1937; Richmond, Fullerton, 1986; Zuzek et al., 2003).

In this paper, a new approach to the origin of the Great Lakes Basin, Western Mongolia, is presented, combining a previous research materials, their results, and interpreting the digital photos.

Results

Numerous landforms in the Great Lakes Basin were formed by neotectonics and large meltwater flooding coming from the mountain glaciation that covered surrounding mountain ranges as stated in previous research (Murzayev, 1948, 1958; Selivanov, 1959, 1972; Schmidt, 1974; Devyatkin, 1968, 1978; Murzayeva, 1982).

Glacial meltwater flooding may form valleys and other landforms within valleys. An example of it is the Chuja river valley in Gorny Altay, Russia (Baker et al., 1993). But morphology and landforms in the Great Lakes Basin, Western Mongolia, didn't get the opportunity to be developed by the glaciofluvial erosion.

Hypsometric features of Mongolia become lower to south gradually, but elevation for the Great Lakes Basin is lowered to the north, oppositely. Uvs lake located in the Uvs sub-basin is the lowest (759 m) and Khyargas lake in the same sub-basin is located higher than the previous (1028 m a.s.l.). Khar Us, Dalay and Khar lakes within Khar Us sub-basin are located at even higher elevations: 1157 m, 1156 m, 1132 m a.s.l., respectively. The trend in the position of successive lakes on increasingly higher locations continues to the south. For example, Zereg sub-basin – 1091 m and Khuisiin govi – 1220 m a.s.l.. However, elevation became low to approximately 963 m a.s.l. in the southeastern side of the Sharga sub-basin sharply (see Fig.1). This elevation feature has not been identified until now.

Late Pleistocene glaciation occurred in the northwest part of Mongolia and spread out to Mongolian Altay, Khangay and Khuvsgul mountain range. At the same times, the ice sheet transformed the vast basin, the general shape of which was inherited from the Mesosoic era.

Contemporary relief of the Basin of Great Lakes, is a super-trough or glaciated super valley that was shaped by glacial erosion.

Among a group of landforms formed by the glacier and which can be found within the basin, are rock drumlins and also 'knock and lochan' topography which are described below.

Fig. 2. Rock drumlins in the central part of basin. Khovd province, Mongolia. (photograph by G. Nyamdavaa)

Pediments located at the edge of the basin, are also sorrounding the inselbergs in the central part of Kyargas and Khar Us sub-basins. These landforms developed on the Cambrian volcanic rocks and Paleozoic granitoids. Pediments developed at elevation of 1400-1500 m a.s.l. on the east side of the basin, at 1600-1700 m on the west side (at the foot of Mongolian Altay) and at 1800 m on the south (Jargalant mountain range, Dariv mountain range). Two small pediments are distinguished to the west of Khyargas and Khar Us lakes.

Between pediments, on the wide areas observed in all sub-basins, rock drumlins can be found. These features are approximately 30 to 80-100 m high and 5 to 10-15 km long. Blocks of various, weathered types of rocks are widespread between drumlins (see Fig. 2).

Also island mountains and hills wide developed in the basin, mostly on Cambrian volcanics and intrusive rocks as well as on Devonian volcanic rocks. These are approximately 100-300 m high. Most island mountains and hills are asymmetric along the longitudinal axis (north to south), with a gentle slope facing the glaciation (north) and steeper slope on the opposite side (see Fig. 3, 4). This feature is very characteristic for roche moutonnée.

The biggest feature is a glacial depression with a small height differences produced by the areal glacial scouring characterized by 'knock and lochan' topography which is particularly evident in the central part of the basin, in areas surrounding Khar Us, Khar and Dalay lakes. 'Knock and lochan' topography is a glacially-scoured lowland area which displays alternating roches moutonnées (cnoc: a small rock hill in Gaelic) and eroded hollows (Linton, 1963). There are not any drumlins and scoured areas present towards the south of the lakes mentioned above.

Fig. 3. Glacial island hill (roche moutonnée), Khovd province, Mongolia. (photograph by G. Nyamdavaa)

4. Glacial island hill (roche moutonnée), Khovd province, Mongolia. (photograph by G. Nyamdavaa)

Another glacial erosion product (?) of the ice sheet can be found in the Khan Khukhey mountain range which is split by a longitudinal valley up to 1400m wide and to hundreds of kilometres long, and is stretching from Uvs sub-basin to Khyargas sub-basin.

In the south of Khar Us lake, a transverse dam was determined which separates Zereg sub-basin. Zereg sub-basin is dry with salt bottom (solonchak) and seasonal, ephemeral lakes. Rounded

mounds approximately 2-10 m high can be found to the north of Zereg solonchak. Mounds contain gypsiferous clay. Therefore, the ice-marginal zone may be to the north of Zereg sub-basin, because the clayey mounds mentioned above are definitely not of a glacial origin.

If the sub-basins to the north of Zereg solonchak were transformed by the ice-sheet, where all the meltwaters were able to make their route?

Huge meltwater discharge from the ice sheet formed Sharga sub-basin, south-eastern part of the Great Lakes Basin, as a super kettle hole by evorsion. Sharga sub-basin elevation is at 963 m a.s.l. in the central and at 1700-1800 m a.s.l. at the edge. As considered in previous research, Sharga sub-basin was formed by tectonics and consedimentation, as the Sharga fault zone appeared on the north border of the basin. Most of the area in Sharga appears to be a 30-40 km wide plain completely devoid of island mountains, hills and glacial erosional surfaces. Water from overflowing big kettle hole flowed to the southeast through Gobi Altay (between Khantayshir and Gichgene mountain range through Biger and Ulaan shal valley, fig. 5) and formed a pluvial basin or big lake in Lake Valley. Lake Valley is approximately 400 km long, 30-50 km width and contains four lakes including Boon tsagaan, Orog, Taatsiin tsagaan and Ulaan, separately. The central part of Lake Valley is lake plain and consists of lacustrine sediment. In Quaternary period, a pluvial basin or a big lake existed in the valley and it's waters flowed to the east from the lake. (Tsegmid, 1965; Nikolayeva, 1971; Devyatkin, 1981, 1982; Lehmkuhl et al, 2001, Komatsu et al., 2001). Terrace located at 1420 m elevation today consists of lacustrine sediment and indicates that the big lake was there and 4 separated lakes are what is left this day (Boon tsagaan, Orog, Ulaan and other).

In the Great Lakes Basin, glacial depositional products including moraines and tills were not described and studied in historic time and the origin of the basin was explained by flooding, but V.A.Amantov, scientist of joint Soviet – Mongolian geological expedition, made a note of the moraine ridge in Khan Khukhey mountain range (Marinov, 1954).

Furthermore, some natural dams (80-100 m high) and hills (20-50 m high), for example, 20-30 km to the west from Uvs lake and to west and north of Khyargas lake, are not made from basement rock, and the main possobillity is, that these are morain ridges.

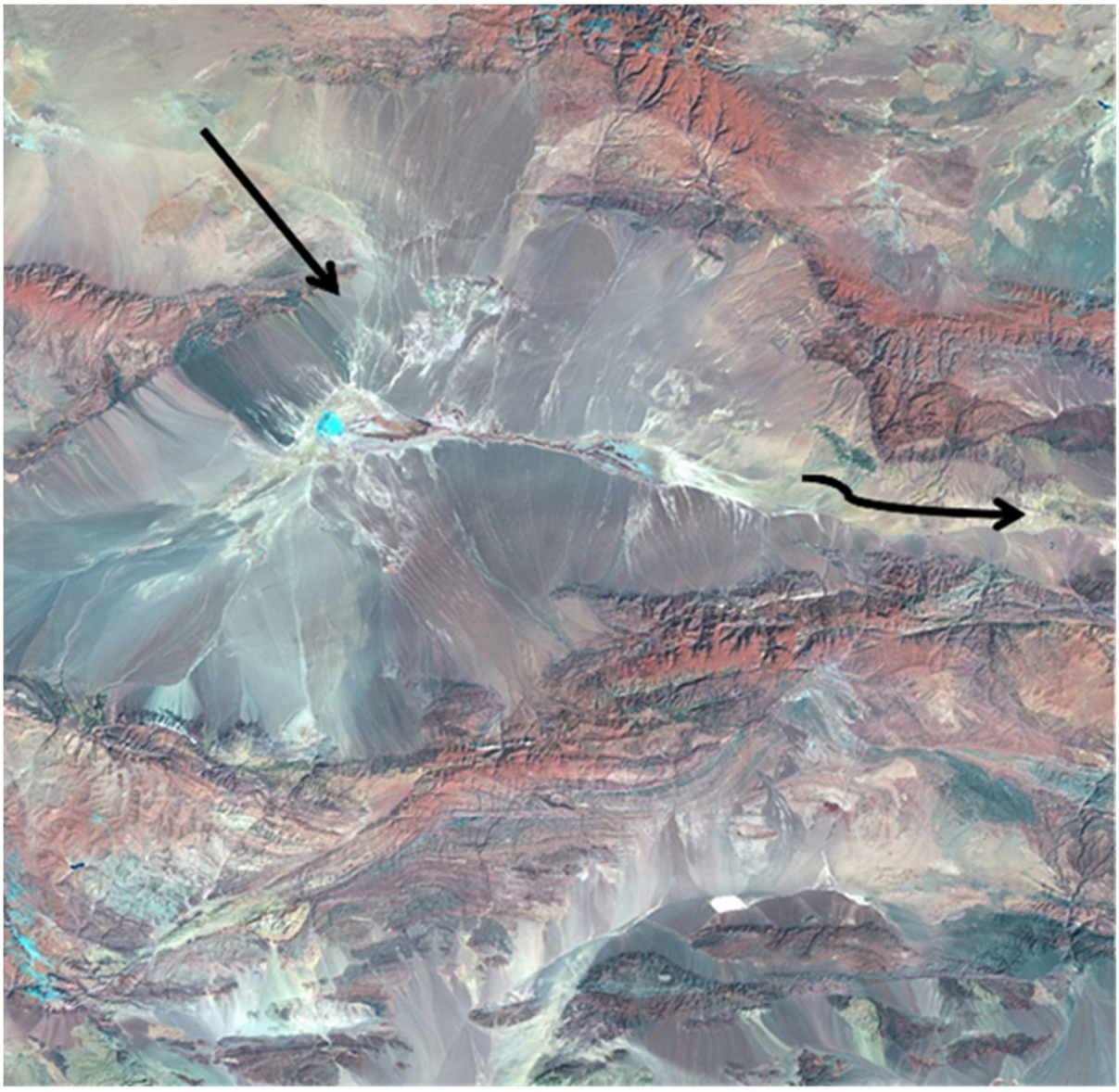

Fig. 5. Sharga sub-basin a a kettle hole formed by evorsion. Straight arrow indicates the direction of the flow that formed the sub-basin, and the curved arrow – meltwater escape route direction from the overflowing kettle.
Source: Landsat 7 ETM.

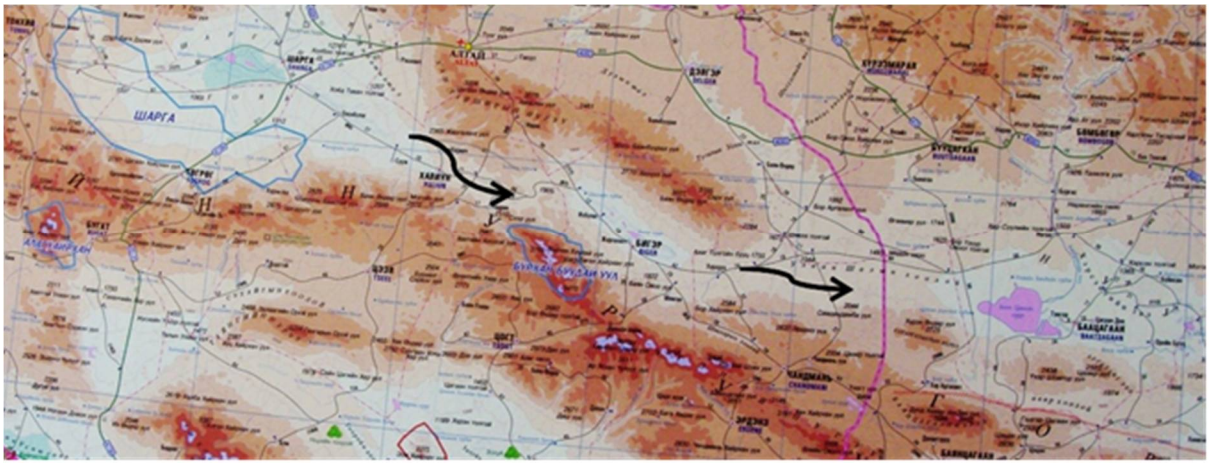

Fig. 5. Meltwater route through the Gobi Altay. Curved arrows indicate flow direction.

Conclusion

The global glaciation that covered many areas of the Northern Hemisphere during Pleistocene occurred in the northwest part of Mongolia and produced the present morphological appearance of Basin of Great Lakes as a super trough or a glaciated super valley.

'Knock and lochan' topography (scoured region), rock drumlins and island hills located in the basin are characterized by a gentle slope facing the glaciation and steeper slope on the opposite side of the longitudinal axis.

Huge meltwater discharge from the ice sheet this formed Sharga sub-basin as a super kettle hole by evorsion and and overflowing waters flowed further towards the southeast through the Gobi Altay and formed a pluvial basin or a big lake in the Lake Valley.

In the future, the presented problem needs to be investigated with more detailed research on glaciation stages, morainic deposition and neotectonic influence.

Acknowledgment

I thank Prof. G.Nyamdavaa, NUM, for the opportunity to use his photographs.

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