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Glaciations of Mongolia

Sodnom Khishigsuren, Bayasgalan A.

Mongolian University of Science and Technology,
Baga toiruu 34, Ulaanbaatar-46/520, Mongolia

1. Introduction

The main aim of this paper is to generalize study results of the Mongolian glaciations. Quaternary glaciations in Mongolia still extend within the latitudes 50°50'-46°50'N and longitudes 87°40'- 100°50'E which are high mountain areas of Mongol- Altai, Khangai, and Khuvsgul in western and northwestern parts of Mongolia. According to Baast (1998) the country has 41 mountains with 262 glaciers, at the altitudes between 2800 and 4374 m a.s.l. The glaciated area covers 659 km^2 of firn and ice masses. There are 36 active glaciers within this area; with their total area of 451 km^2. The largest/longest glacier is Khuiten valley glacier has a surface area of 43 km^2 area and 11 km long, which is located to the east of Khuiten Mountain (4374 m a.s.l.). Morphologically, the glaciations in Mongolia are mountain and mixture type - 87%, valley type - 9.2%, flat-top type - 3.8%. Rock glaciers existed on the northern side of the Mongol-Altai and southern side of Khentii uplift (Bogd uul), but they are non active now. Mongolian glaciers are deepfreeze cold glaciers; an average equilibrium-line-altitude (ELA) based on 262 glaciers gives a value of 3000 m. The traces of glaciations such as all type of moraine and glacial relief of middle and upper Pleistocene were remained left not only on the above mentioned areas nor in the Khentii Mountain which locate in the central and north-central part of Mongolia. Glacier sediments which situated in river valley and river terraces represent by deposits with different thick of clast materials of all sizes (glacial till) that comprise big well-rounded boulders (glacial erratics).

According to Kadota (2007) during the period from the 1940s to 2000 or from 1968 to 2000, the glaciers in Tavan Bogd, Kharkhiraa, Turgen, Tsambagarav regions lost 10.2%, 19.3%, 28.0%, and 28.8% of their area respectively. The climatic condition is very important for the Mongolian glaciers. According to the information of "Institute of meteorology and hydrology" mean average air temperature of Mongolia will increase from 1.8°C to 2.8°C, and rainfall measure have a possibility to increase 20-40% than the present time in the first half of the XXI century. Accordingly, it will show that the decrease of the glaciations and glacier retreats in the Mongolia will continue in the future.

2. Distribution of glaciations and glaciers

Mongolia is a large, sparsely inhabited country sandwiched between Russia and China in central Asia. Quaternary glaciations still exist within the 50°50'- 46° 50' latitude and 87°40'- 100°50' longitude which are high mountain areas of Mongolia. There are 4 main centers of Quaternary glaciations and traces in the Mongolia. 1) High mountain ridge of the Mongol-Altai (with altitudes up to 4374 m a.s.l.) in the western part; 2) Khangai upland (with altitudes up to 4031 m a.s.l) in the central part; 3) Mountain ridge near Khuvsgul (with altitudes up to 3193 m a.s.l.) in the northern part; 4) Central Khentii upland (with altitudes up to 2800 m a.s.l.) in the western part of territory (Fig. 1). Modern glaciations are present mostly in the Mongol-Altai of Mongolia. The largest/longest glacier, Khuiten valley glacier has a surface area of 43 km^2 in area

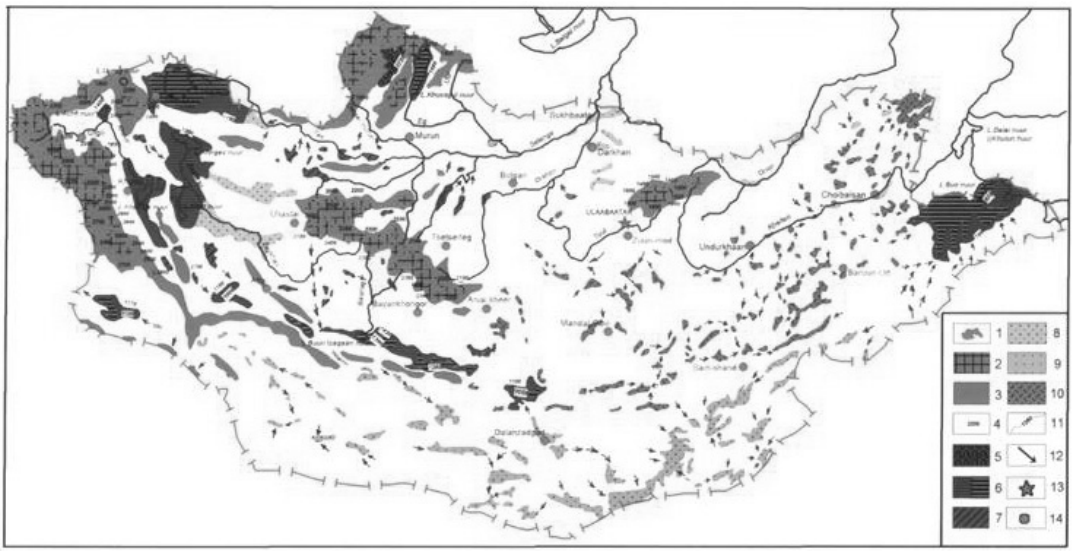

Fig. 5. Scheme of Middle to Upper Pleistocene glaciations paleogeography in Mongolia (modified after Devyatkin and Murzaev). 1) glacier-accumulation relief area; 2) glacier-erosion relief area; 3) passive glaciation area (field firn and cap); 4) End moraine absolute altitude; 5) glacier lake; 6) fluvial lake; a) Middle Pleistocene; b) Upper Pleistocene; 7) fluvial lake of Middle to Upper Pleistocene; 8) sandy materials accumulated area of high terrace; 9) temporary lake of Gobi area; 10) temporary lake of steppe; 11) level of pluvial lake (absolute altitude); 12) remnants of river set and flow directions; 13) capital city; 14) animag center

and 11 km long according to Kadota (2007) which is located on the Khuiten Mountain in Mongol-Altai. In addition, two small firn fields are present on Otgon Tenger uul (4031 m a.s.l.) in western Khangai and on Khordil-Sardig uul of the so called Great Soyan mountain, which belong to the Khuvsgul lake catchment basin, to the north of country.

According to Baast (1998) the country has 41 mountains with 262 glaciers, at the altitudes between 2800 and 4374 m a.s.l. The glaciated area is 659 km^2 with all surface firn and ice masses which is determined using the aerophoto map and large scale topomap. Approximately 62% of the glaciers are small, with a total surface area of 54 km^2, which is only 8% of the total glaciated area. There are 36 active glaciers with area, exceeding 4 km^2 and their total area is 451 km^2. There are only 14 glaciers with area, exceeding 10 km^2 in Mongolia but their total surface area represents more than half the total glaciated surface area of the country.

3. Characteristics and morphological type of glacier

Mongolian glaciers are deepfreeze cold glaciers, which exist under influence of the perhaps with the strongest continental climatic condition in the world. The borehole temperature below 5m was about -18°C, and the annual mean accumulation rate was 250 mm w.e., these values being derived from 10 m deep ice-core drilling at the summit (4000 m a.s.l.) of Tsast uul ice cap (located to the west of Tsambagarav) in June 1991 (Schotterer and others, 1997). According to Baast (1998) calculation on average equilibrium-line-altitude (ELA)

based on 262 glaciers gives a value of 3000 m.

Morphology of Quaternary glaciations in Mongolia was determined by the oroclimatic features of the territory. Morphologically the glaciations in Mongolia comprise mainly mountain type (Munkh Khairkhan)-87%, valley type (Tsagaan gol-Khuiten, Aleksandr) -9.2%, flat-top-type (glaciers of Tsambagarav) glacier -3.8%. There have rock glaciers in the north side of the Mongol Altai and southern side Khentii uplift (Bogd uul) but they are non active now.

4. Glaciation age and their sediments

According to the Mongolian and Russian scientists, two to three main Pleistocene glaciations occurred in the mountains of Mongolia. The Pleistocene stratigraphy of Mongolia was established by Russian scientists and for the Middle and Upper Pleistocene the local names from the Siberian stratigraphy were used. According to this stratigraphy the last glaciation is divided into glacial periods, the Sartan Glaciation (corresponding to the Late late Weichselian in Central Europe) and the early Zyrianka Glaciation (early Weichselian), interrupted by Karginsky Interstadial (Lehmkuhl, 2001). According to Devjatkin (1981) the beginning of the Sartan Glaciation dates to 32±6 ka (TL) and 35.3 ±0.6 ka (radiocarbon). Middle Pleistocene glaciations are more than the Upper Pleistocene glaciations. Their remnants represent by the glacier deposits which are near glacier area and near the modern glaciers.

The ice-free areas within the mountains have several Pleistocene terraces along the main rivers, periglacial block fields and solifluction debris, alluvial gravel fan deposit, sand, aeolian sandy loess-like deposits. The 50-60 m glacier sediments of Middle Pleistocene glaciers in Mongol Altai consist of grayish-brown moraine-sandy silts and clay materials with big boulders (from 2 m up to 15 m to 20 m in diameter) of well-rounded and medium-rounded granite and smaller boulders of gneiss-hornfels, effusive rock, green-schist, greywacke sandstone. Remnants of glaciations in southwest and central part of Khangai Mountains represent by moraine type brown grey colored clay materials and rare sands, pebbles, cobbles and boulders. The well-rounded boulders which have glacier shading on theirs face are especially granite and effusive rocks and they consist of 30-50% of the total mass. The average size of the boulders is 0.1-0.3 m; a maximum size is 1-1.5 m in the Khangai. Thick of this deposit is from 2-5 m up to 20m.

Glacier sediments developed all of the high areas near Khuvsgul. Brown moraine sediments of 30-60 m thick consist of silt materials which comprised of boulders with size from 0.4 to 5 m in diameter near the Darkhad and Khuvsgul basin. Sometimes thick of this deposit is 100 m in west and south of Khuvsgul Lake.

Upper Pleistocene glacier sediments developed near the river valleys in Mongol-Altai Mountain. The moraine deposit accumulate in Khovd, Tsagaan Shiveet, Bairam area (from 25 m up to 30 m thick), in Ikh Bogd, Baga Bogd, Bayan Tsagan of Gobi-Altai area (from 5-6 up to 18-20 m thick), in south of the Khovd area (until 70 m), Kharkhiraa and Baga Gol area (from 15 up to 40 m thick). Almost all of the deposits consist of sand, clay and silt with many pebble, cobble, boulder and sometimes boulders with 5m in diameter. It is different by the bad-rounded boulders, rock debris from Middle Pleistocene glacier deposits.

The glacier sediment compositions of the Upper Pleistocene are similar to the Middle Pleistocene in Khangai region. Upper Pleistocene brown colored moraine deposits are from 20-25 m (southwest side) up to 70-100 m (some lateral moraine) thick in central part of Khangai Mountain. It composite of 3-5% clay, 10-15% silt, sand 10-30%, 40-70 granule, pebble, cobble, boulder in total mass. Composition of little fraction consists of quartz and feldspar, granule, pebble, cobble are very different, boulders consists of well-rounded granite, effusive rocks in size up to 1-2m. Glacier deposits near Khuvsgul are almost same with Khangai area. Thick of this deposit is up to

50-200 m in end dam, up to 200-300 m in lateral. Well-rounded boulders of from 0.1 up to 2-3 m size consist of metamorphosed schist and granite, rare marble and marbled limestone.

Glacier deposits in Khentii area developed near the high mountain and in valley of river Tuul, Kherlen, Onon. Khentii glacier deposits (from some m up to 100 m) represent by silty and sandy materials with boulders and rock debris.

Modern glacier sediments spread by high mountain of Mongol-Altai, Khangai, Munkh Saridag. They represented by end and firn moraines of small thick consist of rock debris and boulder materials with insignificant bad-rounded pebble and coarse grained silt.

5. Climatic conditions, resent glacier variations and future climatic changes

The climate of Mongolia is continental and semi-arid because the location of the central Asian territory. The Climatic condition of glaciers in Mongolia are characterized by high temperature ranges with winter temperature below -20°C to − 30°C summer temperatures up to more than 20°C. Annual precipitation near glaciers is characteristically around or below 700 mm. The climatic condition of glacier existence would be following: 1) the annual mean air temperature below -8°C; 2) the annual rainfall is more than 380 mm; 3) at the altitudes between 2780 and 4374 m a.s.l. under the influence of glacier local climatic condition of high mountain areas (Baast, 1998).

The studies show that glaciations and glacier retreats have been occurring in the Central Asia within the last years. According to the study of Kadota & Davaa (2007) the glaciers of Tavan Bogd area lost 10.2% of their area during the period from the 1945 to 2000, Turgen-19.3% and Kharkhiraa-28% from 1968 to 2000, Tsambagarav-28.8% from 1948 to 1963. The glaciers in Tavan Bogd (valley type), Kharkhiraa and Turgen (mixture type = valley type + flat-top type) regions have been almost stationary since 1987/88 but Tsambagarav (flat-top-type) was no significant change since 1963. Retreats of the glaciers occurred between 1945 and 1987 in Tavan Bogd region, between 1968 and 1987/88 in Kharkhiraa and Turgen regions, mainly between 1948 and 1963 in Tsambagarav region. It was similar tendency of glacier area reduction in the Russian Altai (flat-top-type glaciers lost 16.1% of their area on average, whereas valley glaciers lost 4% of their area during 1954-98) by the study of Narozhniy and Nikitin (2003). Flat type glaciers are more sensitive to ELA change than valley-type glaciers, because even small shift in ELA affects a large area of flat-type glaciers. This implies that climatic warming, especially during the summer, raises the ELA, causing this glacier shrinkage by the study of Baast (1998) and Kadota (2007). According to the Baast (1998) measurement results of 6 glaciers in Altai Mountains, the mean extent of retreat about 4-12 km per year with a total retreats between 180-480 m between 1942 and 1996.

According to the information of “Institute of meteorology and hydrology” the mean average air temperature of Mongolia will increase from 1.8°C to 2.8°C in the first half of the XXI century. This will be increase in winter time (1.4°C - 3.6°C) will be more than summer time (1.0°C to 3.0°C). This tendency will continue 2025-2050, and will be stronger 2 repeatedly than the present time. During this period rainfall measure have a possibility to increase 20-40% than the nowadays. Calculation of the weather size will be increase until 2040 and decrease 2070. Accordingly, it will show that the decrease of the glaciations and glacier retreats in Mongolia will continue in the future.

References

Baast P. (1998) Modern glaciations and glacier hydrology in Mongolia. Abstract of the PhD thesis. UB.

Bayanmunkh B. Bayartsengel Ts. Khishigsuren S (2006) Glaciations of the Bogd Mountain, southern edge of the Khentii mountain ridge in Mongolia.

Mongolian geoscientist 29:57-60

Devyatkin E.V (1981) The Cenozoic of Inner Asia. The joint Soviet-Mongolian scientific-research geological expedition. Transactions, vol. 27: p.196

Bob carson, Karl Wegmann and Bayasgalan A. (2008) Quaternary tectonic and Geomorphic Evolution of the Deluun Nuruu, Mongolian Altai, Western Mongolia. 2008 Keck geology Consortium Research Proposal. 10p.

Kadota Ts. and Davaa G (2007) Recent glacier variations in Mongolia. Annals of Glaciology 46:185-189

Lehmkuhl Frank and Andreas Lang (2001) Geomorphological investigations and luminescence dating in the southern part of the Khangay and the Valley of the Gobi lakes (Central Mongolia). Journal of Quaternary science 16(1):69-87

Murzaev V.E. Marinov N.A., Sirnev I.P., Blagonravov B.A., Devyatkin E.V., and Silivanov E.I. (1973) Quaternary period. Geology of Mongolia, volume I:539-563

Narozhniy Yu.K. and Nikitin S.A. (2003) Recent glaciation of Altai at the beginning of the 21st century. Mater. Glyatsiol. Issled/Data Glasiol. Stud. 93-101

Schotterer U., K.Froehlich, H.W. Gaeggeler, S. Sandjordg and W. Stichler. (1997) Isotope records from Mongolian and Alpine ice cores as climate indicators. Climatic Change, 36(3-4):519-530