

# The Altai Mountain Soils of Mongolia

## (In case study of Harhira Turgen mountains)

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### 1. Introduction

Mountain area occupied big territory of Mongolia specially western and north-central part of the country. This is main important pasture resource of country, which on agriculture dominated nomadic husbandry. But, the mountain soils of Mongolia still not sufficient studied, especially high mountain areas. Only few materials published on the russian and mongolian languages [Bespalov 1952, Ogorodnicov1980, Maximovich Nogina1984, Batkhisig 2000, 2003, Dorjgotov 2003]. This is some characteristics of mountain soils mostly from Hangai and south-west part of Mongol Altai mountain regions. The classification of high mountain soils not completely developed [“The soils of Mongolia“ 1984, Mongolian National Atlas, chapter of “The soils“ 1990].

On this paper presented result of mountain soil study, morphological, physical-chemical properties, specific of soil forming process in case of Harhira Turgen massif of Altai mountains of western Mongolia.

Mongolia is Central Asian country with extra continental climate conditions. According to soil geographical regions whole Mongolia including south side Russian East Siberia distinguished as „Central Asian soil bioclimatic phacia“ [Nogina 1984]. One hand high elevation (average elevation Mongolia 1580m a.s.l) dissected relief feature other hand influence of extra continental climate, long cold season, short vegetation period formed specific nature conditions, geography, soil and plant cover. There are short distances changes of nature zones from desert to steppe, mountain forest and meadow. Many of scientists noticed about complicated soil covers

of Mongolia due of surface and climate condition. The soils characterized by short profiles with stony fragments, miceller form of carbonate and paleocryomorphic pedogenic features.

### 2. Study area and methods

The study area Harhira Turgen massifs belong to the Mongol Altai range mountain systems located in the northern part (fig.1). North-eastern side located big depression-without outlet salted Uvs Lake Basine. Lowest point of western Mongolia is Uvs lake with elevations 759 m a.s.l. Lake surrounded by desert, desert-steppe and sand fields. From semidesert areas of depression up to mountains distributed mountain dry-steppe, meadow steppe, forest, high mountain meadow, and glaciated nival zone. The elevations of mountains up to 4000 m a.s.l (peak Turgen 3978m a.s.l) top with glaciers. The mountains tops with several level of planation surfaces. Intermountain high elevated biggest depression Olon Nuur situated in western side of Harhira Turgen massifs in altitude about 2600m a.s.l. There is many small lakes and bog, meadows with permafrost. The slope exposition differences very clear, north slopes usually more steep some areas with forestry and south slope gentle without forest. This is evidence of more water erosion and solifluction activity in north slopes. Mountain top and steep slopes usually with rock debris.

Base rock of mountain is mostly Paleozoic granite, metamorphic schist and conglomerate Vend-Cambrian, Devonian age. Parent soil sediment is gravel stone, loam

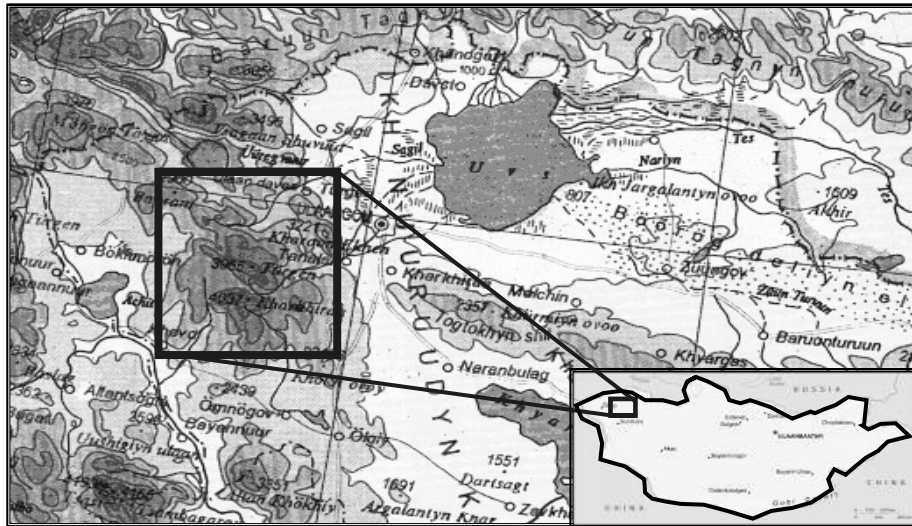


Fig. 1. Study area

silt, in the foot slope and intermountain valleys more fine material and silt. In the south slopes of Harhiraa mountain upstream of Namiriin river below 2600m a.s.l occurred moraine gravel boulders filled by aeolian like fine sand, coarse silt sediments. This sediment usually without carbonate or deep leached.

Climate of study area like as whole Mongolia characterized by extracontinentality, with long cold winter (January -20-30), short summer (July +20+25 ° C T) and also days amplitude of air temperature big. Mean annual precipitation around 100-250mm, up to 70-80% of precipitations in the June-August months. Soil developing period is short, most times in frozen conditions, very short (1-2 week) transit period between warm and cold season. In the mountain areas according to elevations increased precipitation (Fig.2). The summer air temperature in high areas colder, but in the winter marked climate inversion up to 2000-2500 m a.s.l. Comparing to central part of Mongol Altai mountain systems, the Harhiraa Turgen mountain area had more humid influence by the high latitude position. Meadow and forestry north slopes is one is indicator of such humid influence.

Field investigations was conducted in year 1995-1997. On this papers represented 14 soil profiles from

Has and Hutul area of Harhiraa Turgen mountains. Compiled soil map of Harhiraa Turgen mountains in scale 1:500 000. Following soil characteristics analyzed: organic carbon (humus)-by Turin method (oxidation by bichromat potassium-sulfur acid),  $\text{CaCO}_3$ - calcimetric, pH (1:2.5), texture-pipette method, exchangeable cations - by Trilon B tetrimetric,  $\text{F}_2\text{O}_3$  -Tamm extraction.

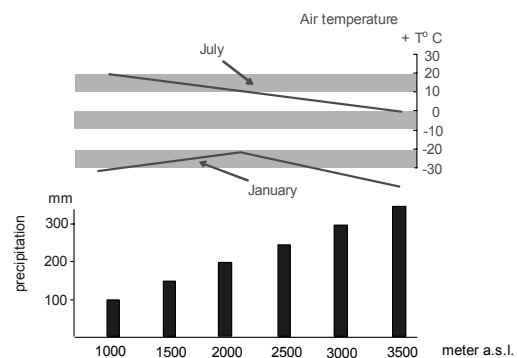


Fig. 2. Mean annual precipitation and average air temperature of July, January months in different elevations of Uvs lake basin and Harhiraa Turgen mountain area.

### 3. Mountain soils

The Harhiraa Turgen mountain regions situated just boundary positions between subarid and subhumid horizontal zonation of soils and plant cover. Morphological feature of mountain is like as Mongol Altai type with steep slopes high elevations but in climate of this area have more humid influence from north-west side. Mountain soils have very clear exposition differences and horizontal zonation. Turgen mountains with forestry north slopes more subhumid than Harhiraa regions. But in the soil geographical regions of Mongolia this area belong to the subarid zonation like whole Mongol Altai mountain systems. Subarid horizontal zonation is usually without forest.

**North slope soils:**

- B-Mountain meadow, mountain boggy-meadow.
- D-Mountain derno-taiga, mountain chernozem.
- F-Mountain meadow chernozem,
- G-Mountain dark kastanozem
- L-Mountain kastanozem.

**South slope soils:**

- A-Mountain meadow, Mountain meadow steppe.
- C-Mountain steppe, (raw humus)
- E-Mountain dark kastanozem, mountain kastanozem.
- H-Mountain kastanozem, Kastanozem.

There area vertical distribution of soils in north

and south slopes according by elevations shown in the Figure 3. Slope exposition differences very clear. The soil boundary transition depending from slope steepness. General distribution of soils shown in Fig.4. and soil covers in Figs. 5 and 6.

The rock weathering, humus forming, soil erosion and accumulation is typical soil process in mountain areas. But, intensively character peculiarity of this process is caused by micro relief and microclimate conditions of territory. Relief and climate is main factor of soil forming process in mountain areas. Mongolia specially mountain areas have very short vegetation periods (90-70days in year). So, biological activity of decay and humus accumulation is weak. Permafrost and glaciers melting water is becoming one is additional source of moisture of ground and soils specially north slopes. Slope steepness directly influenced soil erosion and accumulation activity and water regime. Also vegetation cover, parent rock, permafrost and paleogeographical history have influence of soils features.

We defined 4 different areas of distribution of mountain soils in due of geomorphological positions.

1. Planation surface.
2. North slope.
3. South slope.
4. Valley bottom meadow.

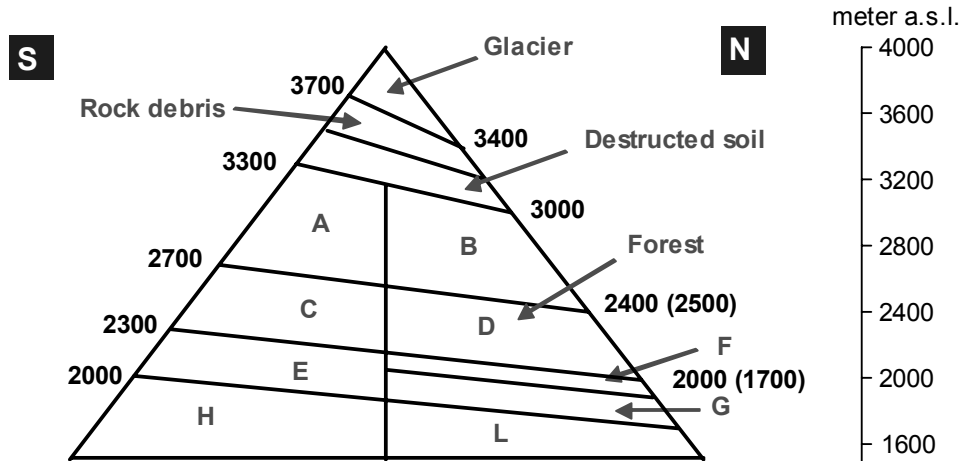


Fig. 3. Schema of horizontal distribution of mountain soils in Harhiraa Turgen mountain area (Mongol Altai).

The Altai mountain soils of Mongolia (In case study of Harhira Turgen mountains)

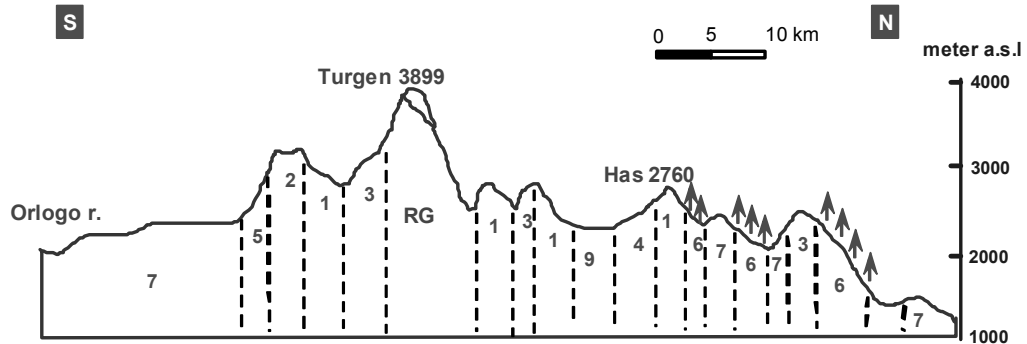


Fig. 4. Soil-geomorphologic transect of Harhira Turgen mountains. Soils: 1-Mountain meadow, 2-Mountain meadow-boggy, 3-Mountain meadow-steppe, 4-High mountain steppe, 5-Mountain dry-steppe raw humus, 6-Mountain demo-taiga, 7-Mountain dark kastanozem, 8-Mountain meadow chernozem, 9-Meadow cryomorph, RG-Rock debris and Glaciers.

**Legend of soil map of Harhira Turgen mountains**

<b>High mountain soil</b>	
	Mm Mountain meadow
	Mm Mms Mountain meadow with Mountain meadow-steppe
	Mms Mountain meadow-steppe
	Mms Mk3 Mountain meadow-steppe with Mountain dark Kastanozem
	Mb Mountain boggy cryomorph
	Mb Mmb Mountain boggy cryomorph with meadow cryomorph
	Hms High mountain steppe
	Msr High mountain steppe raw humus
<b>Mountain forest soils</b>	
	MTd Mountain demo-taiga
<b>Mountain steppe soils</b>	
	Mch Mountain chernozem
	MCh Mk3 Mountain chernozem with Mountain dark Kastanozem
	Mk3 Mountain dark Kastanozem
	Mk3 MmCh Mountain dark Kastanozem with Mountain Chernozem
	Mk2 K3 Mountain Kastanozem with dark Kastanozem
	Mk2 Mountain Kastanozem
<b>Intermountain plain area soils</b>	
	K3 Mk3 Dark Kastanozem with Mountain dark Kastanozem
	K2 Kastanozem
	K2 K1 Kastanozem with light Kastanozem
	K2 Skm Kastanozem with Solonchaks
	Bds Brown desert-steppe
<b>Hydromorphic soils</b>	
	Mbs Bds Meadow brown saliferous with gobi brown
	Sa Sairic (fan) gravel stony soil
	Al Mk Alluvial sod-meadow with meadow Kastanozem
<b>Rock debris and glaciers</b>	
	Rm Rock debris with destructed meadow soils
	R Rock debris with destructed soils
	G Glaciers
	Lake

Fig. 5. Legend of soil map

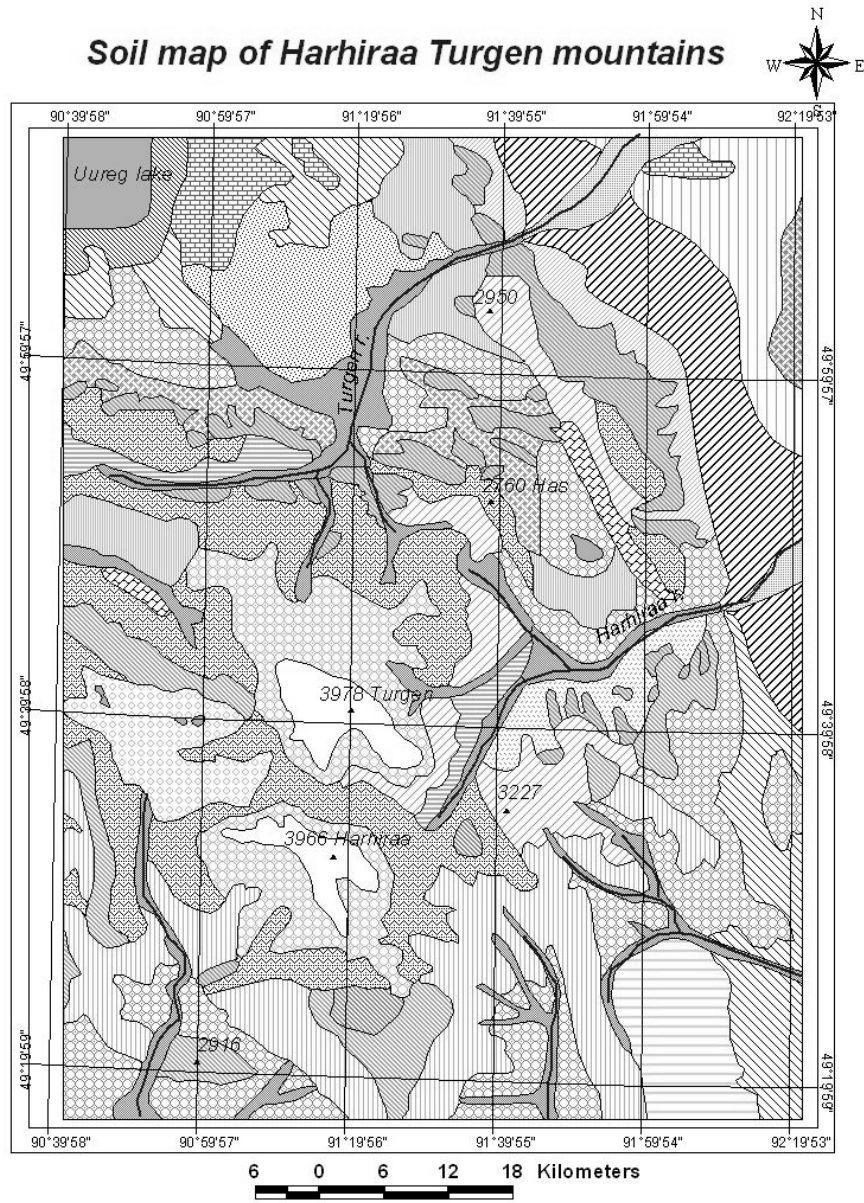


Fig. 6. Soil map

**Planation surface soils.** High part of mountains beginning around 2500-2700m a.s.l different level of planation surfaces. The planation surface area have more moisture conditions. Under mountain meadow grass vegetations formed mountain meadow-boggy, meadow and meadow steppe soils. With undrained small depressions usually meadow-boggy soils on the permafrost.

**High mountain meadow steppe soil.** One is most typical soil of high mountain area. This soil transit positions between Mountain meadow and mountain steppe soils. Result of global warming and retreat of glaciers, occurred steppization of meadow area.

*Profile No.4.* On the top of Has mountains. 2760m a.s.l. Even plato, with paleo polygonal frozen structures. Polygons diameter 1-1.5m, boundary fissures filled by stones, centre small depressions. High mountain meadow grass-forbs with lichen. (*Carex melanantha*, *C.macrogyna*, *Kobresia bellardii*, *Cetraria sp.*, *Cladonia sp.*).

Organic (O) accumulation horizon (0 - 6 cm), dark coloured, undecayed plant residues and roots, silt. Humus (A) horizon (6 -15sm), dark brown, grass roots, clay silt, stone (10-20%), boundary sharp by color. Silt accumulation and parent rock stones (BC) transit horizons from 15sm to 30sm, yellowish dark brown colored silt stony (40-50%) metamorphic schist.

Soil rich with undecayed organic content, shallow humus layers, not clear motley gleyzation and permafrost, because polygon fissure is becoming good drainage. In down of profiles very little carbonate content (Table 1). Exchangeable cations not so high 8-4 meq/100g of soil, because soil reaction is neutral. In high elevations more precipitation in summer season, so this time soil with active leaching regimes marked movement of iron oxide  $Fe_2O_3$  up to 2,5%.

**Mountain meadow-boggy soil.** On the planation surfaces of mountains distributed many areas with boggy soils which not indicated on the Soil maps of Mongolia (scale 1:1 000 000). Soil scientists which was investigated

mountain soils of Mongolia not characterized and mentioned about mountain boggy soils. But some parts of mountains big area occupied by boggy soils, for example: Olon nuur. The mountain boggy soil is not typical for subarid horizontal zonality. One is additional source of water is permafrost and glacier.

2800 m a.s.l . Mountain boggy on the permafrost, *Carex (C.macrogyna, C.orbicularis)* and moss, plant cover 90-100%, relief with small mound.

*Profile No.14.* Harhira mountain, 4-5km east side from Harhira peak glaciers top plato depression with small lakes Hutuliin nuur surrounded by small hills with tuff basaltic rocks.

Organic accumulation (O, 0-10 sm) horizon, dark greyish colored, grass moss root mass, silty. Humus and transit horizon (ABg, 10-17sm) grey dark, with gleyd motley stain, stone fine sand silt. From 17sm buried organic layer (Ab, 17-23) dark greyish, few stone silt, boundary sharp by colour. Down greyish yellow, gravel sandy, transit horizon up to permafrost (60sm). Soils very wet up 20sm filled by water. The mountain boggy soils has accumulation of organic residues, peat. In reduction conditions very active gleyzation process. Soil reaction weak acid (Table 1). Exchangeable calcium reach 29.4-20,4 (meq/100g of soil) possible migration of Ca surrounding tuff basaltic rocks hills and accumulation in the depressions.

#### 4. North slope soils

North slopes more moisture conditions than south slope, glacier, permafrost melting water becoming one is additional source of soils water. Soils cover very complicated depending of slope steepness, micro-relief, plant cover and rock materials. In field investigations we are distinguished following area of distribution of soils cover (Fig.3). Low boundary of glaciers 3400 m a.s.l , from glaciers down until 3000 m rock debris, only low parts

Table1. Chemical properties and texture of mountain soils

Profile No. Soil horizons	Depth (cm)	pH (H <sub>2</sub> O)	CaCO <sub>3</sub> %	Humus %	Exchangeable meq/100g.		Fe <sub>2</sub> O <sub>3</sub> %	Physical clay < 0.01 mm	Clay < 0.001 mm
					Ca <sup>+2</sup>	Mg <sup>+2</sup>			
PLANATION SURFACE SOILS									
4. High mountain meadow steppe. 2760m a.s.l									
AO	0-6	6.8	-	11.3	8.0	5.0	2.2	30.1	11.0
A	6-15	7.0	-	7.7	8.0	4.0	2.5	28.0	17.5
AC	15-30	6.8	0.3	2.9	6.5	3.5	2.2	40.5	12.7
14. Mountain meadow-boggy. 2790m a.s.l									
O	0-10	6.5	-	23.4*	29.4	2.5	n.d.	41.4	20.6
ABg	10-17	6.5	-	5.5	21.0	3.2	n.d.	32.2	13.5
Ab	17-23	6.8	-	5.3	20.4	1.7	n.d.	39.2	15.8
BCg	40-50	7.3	0.4	0.5	14.7	2.4	n.d.	30.4	12.3
NORTH SLOPE SOILS									
12. Mountain meadow. 2850m a.s.l									
AO	0-7	7.3	-	12.9	22.4	5.6	n.d.	34.4	14.7
A	7-12	6.0	-	9.8	19.3	4.8	n.d.	35.8	12.0
AB	12-18	6.5	-	8.9	18.3	1.7	n.d.	33.7	15.3
BC	18-30	6.5	1.13	6.5	14.2	1.8	n.d.	37.8	17.3
3. Mountain boggy-meadow. 2450m a.s.l									
O	0-10	7.0	-	27.5*	13.0	6.7	1.2	41.6	17.2
ABg	10-20	7.5	-	10.9	11.3	5.0	1.3	33.9	12.2
5. Mountain meadowish-steppe. 2400m a.s.l									
AO	0-5	7.4	-	7.3	7.0	3.0	3.5	50.1	17.2
A	5-15	7.2	-	7.8	6.8	2.2	2.8	59.8	20.7
AB	15-31	7.0	-	3.6	6.5	2.0	2.5	68.6	25.5
BC	31-50	6.9	-	3.2	5.4	1.0	0.8	54.9	23.2
6. Mountain meadow-peat. 2390m a.s.l									
O	0-7	7.0	-	15.0	6.2	3.0	3.4	47.9	21.0
A	7-20	7.3	-	14.2	6.4	3.0	3.4	57.0	25.0
AC	20-30	7.0	-	12.5	6.4	3.2	2.8	42.5	26.4
2. Mountain derno-taiga. 2260m a.s.l									
O	0-4	7.0	-	11.3	14.7	10.0	0.7	27.7	11.6
AO	4-15	7.1	-	10.5	18.0	6.5	1.3	29.3	12.3
BC	15-30	8.0	-	4.4	16.0	4.0	2.4	44.1	15.6
7. Mountain meadow chernozem. 2170m a.s.l									
AO	0-8	6.6	-	17.6	5.5	3.3	2.8	40.9	21.3
A1	8-14	6.8	-	10.3	5.6	3.3	1.4	44.6	14.5
A	14-30	7.2	-	7.1	5.0	2.8	1.4	38.3	20.6

\* - loss of ignition

around 3000 m a.s.l. with small depression with permafrost melted water areas covered by vegetations 20-40 %, mostly lichen, and very thin humus layer.

Area between 3000-2400 m a.s.l. developed mountain meadow and boggy-meadow soils. Some steep slopes with debris and rocks. On the slopes, steeper than 25-30° very fragmentary destructed soil and plant cover.

**Mountain meadow soil.** One is main type of soils in high part of mountains. Basically developed north slopes, under mountain meadow vegetations.

*Profile No.12.* Up stream part of Harhira river valley. North slope 4-5°, 2850m a.s.l. Meadow with Kobresia-carex. (*Carex melanantha*, *C.orbicularis*, *Kobresia belardii*). Plant cover 85-95%.

Organic humus horizon (AO 0-7sm) dark black colored plant roots concentration, few gravils, silt. Humus (A 7-12sm) horizon black, plant roots less than up horizon, few gravel (5-10%) silty, subangular structure. AB (12-18sm) horizon black kastanozem colored down becoming yellowish chestnut, stony(20-30%) silt. BC (18-30sm) brown kastanozem, stony(30-40%) silt. From 30 sm (C) parent rock, stones, basaltic tuff, metamorphic sheist, slate stone.

Mountain meadow soils with good developed humus horizons, upper parts concentration of roots. Specific of mountain meadow soil is not active gleyzation because stony parent material is good drainage. Leached by carbonates, soil reaction neutral down profile weak acid. In the upper organic humus layers increased content of exchangeable Ca and Mg, this is related to the amount of organic humus content.

**Mountain boggy-meadow soil.** On the north slopes very often small depressions solifluction permafrost originally. This depressions with stagnant of waters developed boggy-meadow soils. Mountain boggy-meadow soils on the slopes not occupied big area comparing to planation surface areas.

*Profile No.3.* East-north slope of Has mountains. 2450m a.s.l. Slope with rocks. Small boggy depressions

10m long and 7m wide. Forb-carex boggy meadow.

*Carex melanantha*, *C.orbicularis*, Peat accumulation (O, 0-10sm) laeyr with greyish dark colour, concentration of roots and peats. Humus gley horizon (Abg 10-20sm) black grey, red stain, motley, roots, silt. water (after 10 min). This soils have thin organic humic layer.

On the small depressions accumulated organic materials and peat. Clear soil gleyzation process. Soil reaction is neutral.

**Mountain meadowish steppe soil.** More drained, positive part of slopes developed soils with feautres steppe soils.

*Profile No. 5.* East-north slope (8-10°) of Has mountains. 2400m a.s.l Small mound with rocky. Forb-gras mountain meadow-steppe. Soil have good developed humus horizons (31sm) with content of humus 7.8-3.6% , upper profiles with concentration of roots, humus horizons black kastanozem colored gravel stony silty, from 50smrs beginning parent rock. Between parent materials and humus horizons have transit horizons (BC) accumulations of clay particles. Soils silty humus contents penetrated by stones. On the surface of the stones covered by very clear humic clay cutans, which indicated by horizontal movement.

**Mountain meadow peat soil.** From upper boundary of distribution of forests up to 30-50m continued transit zone between forest and high mountain (alpine) meadow area. On this transit zones growing single trees and small bushes. Soils have features between mountain demotaiga and mountain meadow soils. The relief surface is different rocky up area and depressions. Small depressions with bushes developed mountain meadow peat soil.

*Profile No. 6.* Mid part of north-east slope of Has mountains, nearby profile No.5. Elevation 2390m a.s.l. steepness 8-10°. Smal depression with size 1.5 and 3.0m. Bush (*Dryas oxyodontha*), moss.

Soil have peat humus horizons with high content of humus 15-12%. Down profile humus content not so decreased. Soil reaction is neutral. Depression with bushes



Table2. Chemical properties and texture of mountain soils

Soil horizons	Depth (cm)	pH (H <sub>2</sub> O)	CaCO <sub>3</sub> %	Humus %	Exchangeable meq/100g.		Fe <sub>2</sub> O <sub>3</sub> %	Physical clay < 0.01 mm	Clay < 0.001 mm
					Ca <sup>+2</sup>	Mg <sup>+2</sup>			
<b>SOUTH SLOPE SOILS</b>									
<i>11. High mountain steppe. 2910m a.s.l</i>									
A	0-6	7.5	-	16.7	24.3	2.7	n.d.	36.3	17.6
AC	6-15	6.3	-	13.4	19.5	5.0	n.d.	45.2	22.8
<i>13. Mountain meadow-steppe. 2850m a.s.l</i>									
AO	0-4	6.3	-	16.0	17.4	2.6	n.d.	41.9	20.0
A	4-16	6.3	-	7.0	18.4	2.4	n.d.	27.9	10.2
BC	16-30	6.3	-	0.7	9.0	1.4	n.d.	26.4	12.7
<i>15. Mountain dry-steppe raw humus. 2600m a.s.l</i>									
AO	0-7	6.5	0.75	8.1	15.6	2.4	n.d.	36.1	20.5
A	7-20	6.5	0.75	4.1	13.0	2.0	n.d.	29.1	12.3
AB	20-32	7.0	1.13	3.4	14.0	1.8	n.d.	28.5	11.3
BC	40-50	7.3	1.50	0.5	17.6	1.0	n.d.	28.4	12.1
<i>8. Mountain dark kastanozem. 2230m a.s.l</i>									
A	0-8	7.0	0.14	12.7	8.2	2.0	0.7	31.0	15.1
AB	8-20	7.3	0.14	3.2	8.4	4.6	0.8	25.8	24.2
<b>VALLEY BOTTOM SOILS</b>									
<i>9. Mountain meadow frozen. 2690m a.s.l</i>									
O	0-6	7.1	-	7.19	8.2	2.8	1.4	35.3	15.4
Ag	6-20	7.0	-	6.26	8.4	5.6	1.8	42.3	15.4
BC	20-30	6.9	-	3.25	8.4	5.6	2.0	49.9	20.4
<i>1. Typical meadow stepped. 2160m a.s.l</i>									
AO	0-5	7.6	-	4.7	16.4	6.6	0.7	22.8	11.9
A	5-23	8.0	-	5.1	10.0	4.6	1.2	26.8	11.4
ABg	23-51	7.8	-	4.8	9.5	4.0	1.5	24.3	10.2
Ab	51-55	8.1	0.20	10.3	8.0	3.5	1.1	41.6	15.0
B	55-75	7.5	0.20	6.4	5.7	2.0	-	34.8	13.3
ABb	75-85	7.6	0.20	7.7	3.0	1.5	-	36.5	14.9
C	85-95	7.0	0.20	0.8	3.8	1.0	-	26.7	10.7

\* - loss of ignition

have more humid condition, so it is suitable for peat accumulation.

**Mountain demotaiga soil.** North slopes mountain between 2400-2000 m a.s.l covered by forests(Larix Sibirica). Some area with steep slopes forest beginning

from 1700m a.s.l. On the forests developed derno-taiga and mountain forest dark colored soils. In Mongolian forest regions not developed podzolic soil. Because, for the soil leaching process not enough precipitation, very short warm period, even in this time soil temperature very low by the permafrost impact.

*Profile No.2.* Northeast slope of Has mountain. 2260 m a.s.l. steepness 5-7°. Forest (*larix Sibirica*). Forb and moss.

Soil covered by trees needles and organic materials. Short organic humus horizon content of soil organics very sharp decreased by depths. From 15 sm beginning stone and gravels. On the surface of the stones clay movement. Soil reaction up part weak acid, down neutral. Without permafrost, profile was making late 24 August possible melting other wise stone gravel texture not long frozen.

**Mountain meadow chernozem.** On the north slopes down to 50-100m from forests distributed mountain chernozem and meadow chernozem soils. This area has influence of ground and surface water from forest.

*Profile N°. 7.* Has river valley. Fan slope of Has mountains. 2170m a.s.l. East-north exposition 4-6°. Meadow. (*Leumus chinensis*, *Ranunculus sp*, *Potentilla sp*).

Soil have good developed humus horizon (30sm). Upper part of profiles with root concentrations. Black kastanozem colors no motleys. Not stagnation of waters. Humus and organic content accumulated mostly from up sides by the surface water flows.

## 5. South slope soils

The south slope is more dry comparing to north slopes. Solar radiation caused more evaporation in the south slopes. In the south slopes formed mostly steppe featured soils. The soils cover also complicated by relief character, slope steepness, vegetation and rock debris. But distinguished by general distribution of soils by elevation differences. In the high elevations from 2700m a.s.l up to 3300 m a.s.l occurred mountain meadow-steppe,

meadow and steppe soils. Down to mountain slopes this soil changed to mountain dry steppe raw-humus, mountain dark kastanozem and kastanozem soils (fig.2).

**High mountain steppe soil.** This soils distributed in mountains in elevations between 3300-2700m a.s.l. mostly on the south slopes, more drained parts of relief.

*Profile No. 11.* In 5-6 km east from Harhira peak mountains. On the top of the mountains 2910m a.s.l. South exposition 2-3°. On the surface rock and stones, soils cover 40-50%. High mountain steppe. (*Cobresia sp*, *Carex sp*, *Potentilla sp*.) Lichen.

Short soil horizon (A,AC), in the 15sm beginning rock gabbro-diorit. High content of humus and organic residues.

**Mountain meadow steppe soil.** On the small depression, plain gentle slopes formed this soil.

*Profile No.13.* In 500 m south from profile No.11. South slope 3-4°. Mountain meadow steppe. Forb-Cobresia-Carex, plant cover 70-80%.

Upper 4sm of soil profiles is peaty, root plant concentration, down (4-16sm) humus horizon structured, stony, black colored with greyish shine. BC horizon (16-35sm)-brown dark colored fine sand silt, from 35sm rock stone. Soil not effervescing from 10% HCl. Comparing to mountain steppe soils, this soils have more thick horizon, distinguished transit (BC) horizon.

**Mountain dry-steppe raw humus soil.** In the central part of Mongol Altai regions described this soils N.A.Nogina and Maximovich (1984) and classified as mountain dry-steppe raw humus soil. Morphological feature of this soils very like to the dark kastanozem soils, but have more raw coarse humus content.

*Profile No.15.* Harhira mountains up stream of Orlogo river. South slope 4-6°, with moraine granite boulders. 2600m a.s.l. Mountain steppe. Forb-Cobresia-Festuca vegetation cover 60-70%. Cobresia and Festuca formed small pillow like mound with 4-7sm height and 10X20sm size. AO(0-7sm)-humus organic horizon with

root organic accumulations, A(7-20sm)-dark kastanozem with brown reddish shine, structured, fine sand texture, AB(20-32sm)-structured, stony, fine sand texture, BC(32-50sm)-moraine sand granite stone. Soil horizon boundary not so sharp, all profiles with reddish shined kastanozem colors. Not accumulation of carbonate only down part of profiles small content of carbonate. Texture of soils fine sand, aeolian like sediment with moraine granite boulders.

**Mountain kastanozem soils.** One is most distributed soils of mid elevations of mountains. This soils occur on the south slopes up to 2300m a.s.l, north slopes up to 2000m a.s.l. From up boundary to down distributed mountain dark kastanozem, m-kastanozem, m-light kastanozem soils. Lower boundary of this soils approximately boundary between mountain and plains.

*Profile No.8.* East mountain from Has valley. Mid part of south-west slope 18-20°. Mountain steppe Artemisia-Festuca. Vegetation cover 60-70%. On the surface gravel stones. A(0-8sm)-dark kastanozem, roots, stony(20-30%) silt. AB(8-20sm)-kastanozem, stony (50-60%) silt, rock stone from 20sm. Soil profile very shallow and stony.

## 6. Valley bottom soil

Intermountain valley bottoms with meadow, bogs and steppes. Nearby river territory floodplains developed meadow and boggy frozen soils. Lower than 2000 m a.s.l part of intermountain depressions distributed dark kastanozem soils. Width of valleys different, high part of mountains becoming more wide some areas reach to 1-2km. Soils cover will vary from relief and moisture conditions.

**Mountain meadow frozen soil.** *Profile No.9.* Up stream of Turgen river U shaped valley, north side of Tsagaan Deglyi (peak Turgen). West slope 5-6°, 2690 m a.s.l Moraine boulder, rock and stones, boggy-meadow

and meadow. Soil covered by moss raw humic layer(0-6sm), down (Ag 6-20sm) humus gleyer horizon with little grey shined and small rare red stains. Soil humus and fine materials penetrated by between stones from 20sm and down. Soil course silt down increased clay content. Mobil Iron oxide increased down.

**Typical meadow stepped soil.** *Profile No.1.* Has valley bottom 2160 m a.s.l. Meadow stepped, Forb-grass Leymus chinensis, Potentilla, Carex.

Soils formed on the layered silt and sandy sediments. 0-5sm root silt, 5-23sm humus horizon, black kastanozem, fine sand and silty, 23-51sm layered silt and fine sand with small rare reddish stains, 51-55sm fossil humus horizon with high content of humus (up to 10.3%) course silt, 55-75 cm layered silt gravel fine sandy, 75-85 sm next fossil humus silt, 85-95 sm gravel sandy sediment. This soil one is example for the steppeization soils of mountain areas. Upper part soil reactions becoming weak alkaline, down profiles marked little accumulation of carbonate.

## 7. Conclusion

In result of investigations clarified vertical and horizontal distribution of soils in Harhira Turgen mountain areas with compilation of soil maps. Characterized morphological and physical-chemical properties of most typical mountain soils, specially high mountain areas. In the high part of Harhira Turgen (in altitude 2600-2800m) mountains on the planation surfaces distributed mountain boggy and boggy-meadow soils, which was in Mongol Altai regions first time characterized. On the south slopes between 2500-2700m formed specific soils with raw humus. Soil morphological feature is like as kastanozem soils but humus organic content more raw with undecayed organic contents. This is influence of long cold condition not sufficient biological active time for decay organics. High mountain soils leached by carbonate only mountain steppe soils (mountain kastanozem, mountain dry-steppe raw humus) have carbonate horizon. Mountain soils cov-

ered by thin layers with undecayed organic residues. Shallow humus horizon 15-20cm, between humus and parent rocks usually transit horizon. Short biological active period caused slow humus forming process. In the high mountain soils and mountain tundra soils marked iron oxide movement. Gleyzation process not active only indicated by weak greyish shine colours, undrainad area with boggy soils more clear gley features. Down to mountain soil profiles occurred not intensive but clear silt and clay movement, the surface of stones with clay cutans. In the Harhira Turgen mountain areas result of climate warming, and pasture degradation soil properties changing becoming more steppe features.

### References

- O.Batkishig. Mountain soils of western Mongolia. "Central Asian ecosystem" *International conference*. Sept.5-7, UB 2000, pp.25-26,
- O.Batkishig, F.Lehmkühl "Trace elements of high mountains" *Mongolian Geographical Problems*. MOGZA No.2, Ulaanbaatar 2003, pp.,
- N.D.Bespalov, "The soils of Mongolian Peoples Republic". *Academia of Science of USSR*. 1951., p78.
- D.Dorjgotov, "Soils of Mongolia". Ulaanbaatar 2003. p37-47,
- Lehmkühl F., G. Stauch & O. Batkishig (2003): Rock glacier and periglacial processes in the Mongolian Altai. – *Proceeding of the 8th International Conference on Permafrost*, 21-25 2003, Zurich, Vol. 1, Eds.:Phillips, M., S.M. Springman & L.U. Arenson, p. 639-644. Blankema, Lisse.
- "The National Atlas of Mongolian Peoples Republic". The Academia of Sc.MPR, Academia of Sc.USSR. Ulaanbaatar, Moscow 1990. p65,
- "The soil map of Mongolia, scale 1 : 1 000 000.," Ulaanbaatar 1981
- "The soils and soils cover of Mongolia". *Edited by I.P.Gerasimov, N.A.Nogina*, M, 1984. p58-63,
- Ogorodnikov "Mountain forest soils of Mongolia" Novosibirsk. 1980.
- E.M.Murzaev. "The Mongolian Peoples Republic, Physical-geographical description". M.,Geographiz, 1952. p.472,