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SOIL GEOCHEMISTRY ON HILLSLOPE

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Abstract

This study reveals Soil geochemistry of Mt.Ovoot in the northeast of Khangai Mountain Range, Mongolia. This work is mainly focused on natural processes of sediment transportation through surface and subsurface flows in Mt.Ovoot based on movement of microelements with in soil profiles along the mountain slopes and sediment analyses of particle sizes and shapes. The main purpose is (1) to synthesize previous researches on landscape development in Mongolia, (2) to determine the chemical and physical properties of soils, and (3) analyzing hill slope process soil geochemistry and explain process. During the measurement, two gullies were observed on the lower slope, which occupy area of 9.6 hectares. Movement of the microelements and sediment analyses show intensive slope processes in the Mt.Ovoot. Each surface soil on upper slope contains microelements less than those on lower slope of the mountain, where sediments have been more round and finer. Besides, trace elements of hill slope geochemistry analyzed that modified by anthropogenic towards the hill slope in Mt. Ovoot.

Key words*:* Landscape, Microelements, Sediments, Mt. Ovoot, Soil geochemistry

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Introduction

Mongolia is located in the center of the Asian continent. Geographical location of Mongolia influences differently on the climate system, natural condition and landscape types, therefore its geomorphological setting, soil distribution, chemical and physical properties of soil types are different. Mongolian landscape has been responsible to comprehensive geological processes, which sets the present landscape condition (Tsegmid, 1969). Although there are some studies related to soil pollution by microelements (Some Issues of Mongolian Geo-Ecology, 2000), they have not been involved in landscape evolution as well as geomorphological processes like this study.

Geochemistry in soil science differs from the classical geochemistry of rock formations because soil differs fundamentally from weathered rock (Singer et.al, 1991).

Soils are open, multi-component biogeochemical systems that undergo biological, chemical, and physical transformations leading to a characteristic morphological feature-soil horizons-which reflect that unique influences of percolating water and living organisms acting over millennia. Soil geochemistry demonstrated, which included natural process, transportation of hill slope micro elements movement and define geochemical activity in mountain.

Notable among the major elements is the strong enrichment of C and N in soils relative to crustal rocks, whereas Ca, Na and Mg show significant depletion (Singer et.al, 1991). The major elements C, N, P and S also are macronutrients meaning they are essential to the life cycles of organisms and absorbed by them in significant amounts (Singer et.al, 1991).

In this study, determined soil geochemistry on hill slope in Mt. Ovoot, Khangai Mountain Range and imply that transportations and distributions of microelements in soils, and particle size and shape of sediments within soil profiles determine landscape evolution of the Mt.Ovoot in the northeast of Khangai Mountain Range.

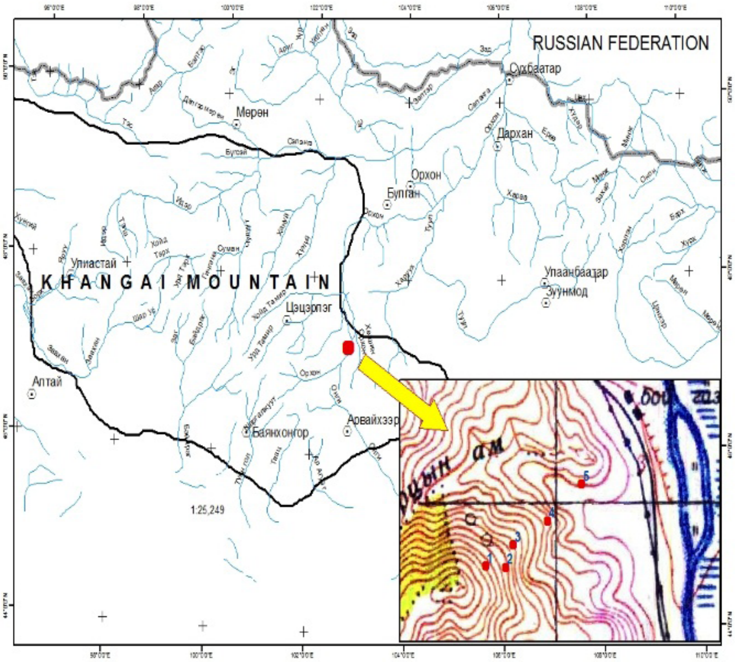

Fig 1. Site description

Mt.Ovoot (102°46'E, 47°12'N) is located at 1800-1900 m above sea level in the northeast of Khangai Mountain Range, about 5-6 km northwest of Kharkhorin in Uvurkhangai (Figure 1). Landscape of the Khangai Mountain Range is different from most of landscape and geomorphology in Mongolia (Samiya, 2009). The Khangai Mountain Range clearly shows a kind of weathering intensity for landscape evolution (Samiya, 2009).

Figure 1 Location of Mt.Ovoot in the northeast of Khangai Mountain Range

Tectonic movements played an important role in formation of Khangai province for relief. However, its current state is much influenced by external factors. The Khangai Mountain Range is dominated by granites of upper-middle Cambrian, lower and middle Devon, upper Stone age, Permian, upper Triassic-lower Juriassic periods and the rocks of granite types of granite-diorite, granite-cienite, adamellite, and plagio granite. Moreover, the rocks, e.g. metamorphic shale and sands, and basaltic rocks are abundant (Dashjamts et al, 2010). The average annual precipitation is about 80-100 mm in Khangai Mountain Range (Dash, 2010).

Khangai range topography, climate and soil resources due to its development, quality and productivity at each of the surface irregularities. Highlands mini-mountain range, ridges, hills and extensive mountain valley in the forest-steppe and steppe grasslands and mountain dark brown and brown soil, and the small river floodplain, meadows, wetlands and meadow alluvial soils are dominated (Samiya, 2009). The Mt. Ovoot dominated soil is mountain brown soil. The brown soils are spread across Old Orkhon River valley and Balgasiin plain which is 1400-1440 meters above sea level (Dash, 2010). Mt. Ovoot high mountain alpine taiga and permafrost from the turf and peat soil in the middle of the top rock, especially back in the forest covered with gray, dark soil prevails. Mountain hillside often spread poorly developed soils, while the top of the slopes around mid-mountain slopes of brown and especially small stone covered surface and from the party slipping dark soil accumulated in the soil. Mt. Ovoot some place of south of the border pale brown soils were occur.

Materials and Method. This study adopted random sampling methods depending on several main factors, such as landform, slope, elevation along the mountain slopes, in order to estimate landscape evolution. Soil samplings were carried out in November. 15 soil samples are taken from upper slope, middle slope, and lower slope of Mt.Ovoot. Also there have been two gullies in this slope of the mountain. It includes six vertical soil profiles from the slopes of the mountain, and the deepest profile is 50 cm depth. Each layer of soil profiles is analyzed for chemical and physical properties. Research method of soil chemical and physical properties including of microelements and sediment particles is based on its goals of hill slope processes due to soil erosion and landform evolution (Orkhonselenge, 2006).

Laboratory analysis: Soil samples accumulated from field site are dried in a certain temperature, and are prepared for the analyses of water content, and chemical and physical property (Baatar, 2003). In soil laboratory of the Institute of Geography, MAS, analyses were done for soil humus by Turine method, heavy metals spectrometric method, soil mechanic compounds by Kachenski method, respectively. And, soil particle sizes, shapes and chemical compositions were detected in deposits a laboratory of Field Research Center (FRC). The transportations and distributions of microelements such as Ni, Fe, Mn, Cd, Pb and Co are the main identification keys to soil horizontation, which is used as an effective indicator for vertical and lateral through flow movement on hill slopes, and the geochemical activities chemical microelements are compared by Clark concentration of chemical elements on landscapes (Orkhonselenge, 2006). In this study, the microelements such as lead (Pb), Zincium (Zn), Nickelium (Ni), Cadmium (Cd) and Chrome (Cr) are analyzed.

Results and Discussion. Bedrock, time, climate and slope type are major controllers for the landscape development, and which is defined by several properties including soil texture, soil moisture, particle size and shapes, and movements of microelements (Orkhonselenge, 2006). Soil texture in each layer of all soil profiles consists of sands. Movements of microelements are very active from upper slope to lower slope in Mt.Ovoot. Microelements are varied for each layer within soil profiles and each slope of the mountain. Zn, Cr, Pb, Ni, Cd are determined for four profiles of the slopes, and compared with for the global Clark concentration of microelements determined by Kabata-Pendias (Figure 2).

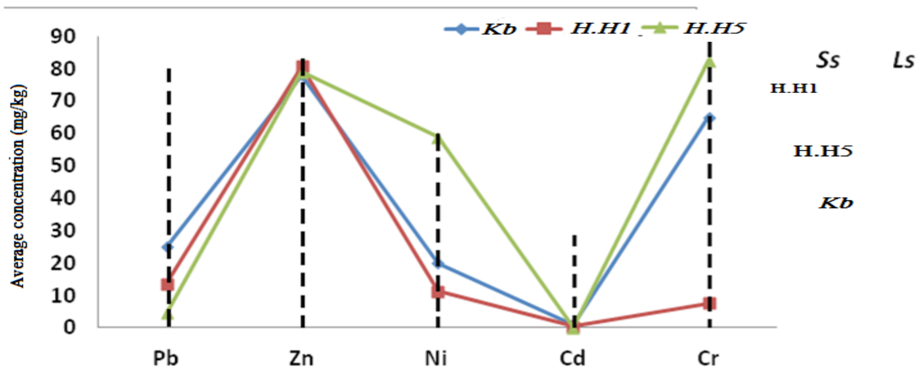

Figure 2. Average concentrations of microelements in the soils (*H.H1, H.H5*) in Mt.Ovoot compared with global average by Kabata Pendias (*Kb*)

Figure 3 shows that movements of microelements are high in the mountains slopes. The microelements Pb, Ni, Zn, Cd and Cr are higher than the global Clark concentrations on the lower slope. Pb and Cd are concentrated at higher levels on the lower slope than on upper slope. This high concentration indicates active soil erosion there.

In the soils, particle size and shape are determined particle size distributions of each profile are differentiated in upper and lower slopes (Figure 3).

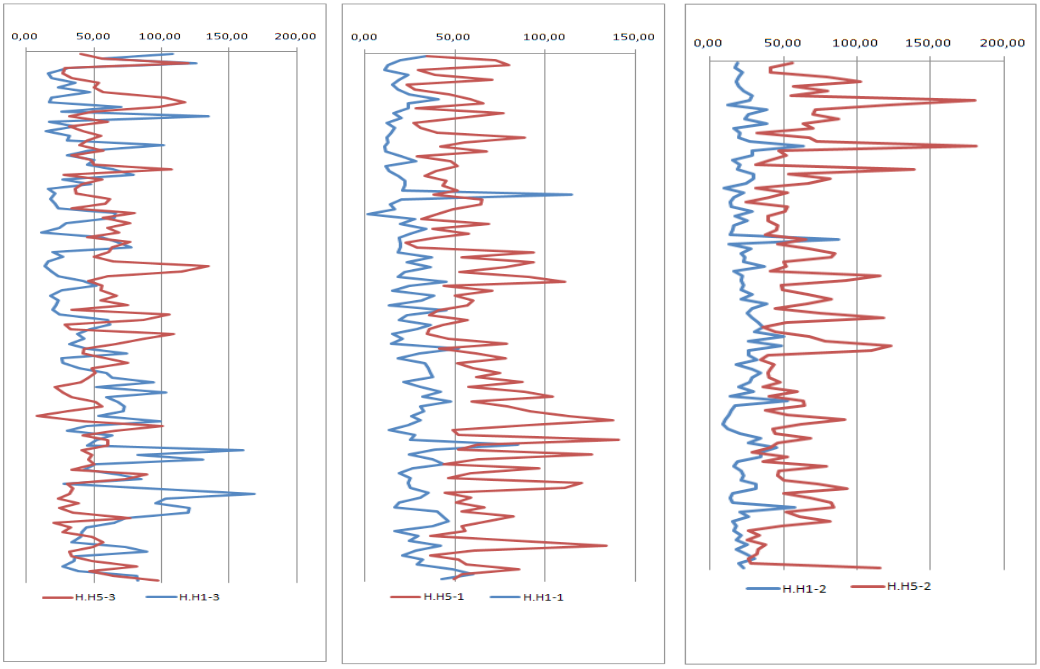

Figure 3 Relationship of grain sizes between upper and lower slopes

Figure 4 shows particle size is finer on upper slope (H.H1) than those on lower slope (H.H5). Particle shape is actually comprised two independent geometric concepts (Beehag et al., 2000). Two concepts term roundness and sphericity to quantitatively describe the shape of sedimentary particles (Beehag et al., 2000). Roundness is a measure of angularity of the corners regardless of particle shape. Sphericity is a measure of the degree to which the shape of a particle approaches that of a sphere (Beehag et al., 2000). It results particle sphericity is high in all profiles, and it is less than 1. For roundness of particles are angular to sub-angular from upper slope to lower slope, where high sphericity shows that weathering processes is intensive.

Weathering intensity in soil depths along the mountain slopes was detected with chemical compositions. Elements such as Fe, Al, Ca, Mg, Na and K indicate that mobile chemical elements are important in landscape evolution Ca, Mg and Na are found in the lowest parts of the mountain due to very soluble chloride compounds From those elements, the most abundant is Fe with an highest percent of 85 and average is 68.4 in the Mt.Ovoot. It suggested that iron and aluminum released by weathering deposit at the site where they do not form very soluble. In all vertical soils, Si is the most abundant element. In addition, concentration of K is varied in the soils, and Mg and Ca are increased from upper slope to lower slope (Table 1).

Table 1. Concentration of the elements in soil profiles along the hillslope in Baga artsin am along in mountain Ovoot (%)

Profile	Depth,(cm)	Al	Si	K	Fe	Br	Mg	Ca	Na	Ti	Tm	Rb	Ta
		Brown soil at 1688 m a.s.l (profile number H.H4)											
A	0-1	18.2	62.3	10.4	72.8	23.1	4	22	-	21	-	-	-
AB	2-17	17.4	63.2	16	66	28	9.8	13.5	-	15	26.5	-	-
	Mean	17.8	62.75	13.2	69.4	25.5	6.9	17.7	-	18	26.5	-	-
		Brown soil at 1589 m a.s.l (profile number H.H5)											
A	0-10	15.8	67	12.3	73.7	27.7	3.3	7.7	-	-	-	-	-
E	10-28	14.4	72.7	6.2	79.7	18.56	8.06	8.2	-	8.9	-	-	100
B1	28-40	11.2	42.7	9	69.5	25.9	10	51	-	10	-	-	25
B2	40↓	14.8	49.9	19.6	75.4	29	10.6	60	-	7.3	-	-	29.7
		Mountain chernozem soil at 1831m a.s.l (profile number: H.H1)											
A	0-2	13.5	43.5	14.3	57.6	19.8	3.4	13.7	5.1	3.7	-	-	-
A_0	2-8	15.3	45.7	20.3	65.8	20.5	3.1	17.8	6.3	15.4	30	100	-
A_{0c}	8-15	16.5	64.1	17.5	74.4	24.8	-	16.3	-	-	-	100	81.9
	Mean	15.1	51.1	17.3	69.7	21.7	3.25	15.9	5.7	9.55	30	100	81.9
		Dark brown soil at 1772m a.s.l (profile number: H.H2)											
A	0-2	16.8	61.1	14.9	74.6	21.2	-	15.1	8.3	50	-	-	-
Ac	2-10	15.6	58.5	17.7	82.9	25.8	5.1	17.7	6.9	48.5	-	100	-
	Mean	16.2	59.8	16.3	78.75	23.5	5.1	16.4	1.7	49.25	-	-	-
		Brown soil at 1734 m a.s.l (profile number: H.H3)											
A	0-1	18.6	68.9	22.8	82.8	22.5	-	20	6.4	27.4	-	-	-
Ac	2-1	23.1	65.02	16.6	100	42.8	-	32.7	-	72.8	-	-	-
	Mean	20.85	67.5	19.7	91.4	62.8	-	26.35	64	50.1	-	-	-

	Mean	14.5	58.7	11.7	74.5	19.04	7.99	33.7	-	8.7	-	-	51.9
		Reddish brown soil at 1516 m a.s.1 (profile number H.H6)											
A	0-10	23.9	77.6	26	81.8	31.5	12.4	4	-	-	-	100	-
AB	10-28	20	67.3	16	55	32	4	21	-	44.4	-	-	-
	Mean	21.9	72.5	21	68.4	31.75	9.2	12.5	-	44.4	-	100	-

These tables shown all microelements are distributed differently in each layers (Table 1). This is due to poorly developed soil texture consisting of high content of gravel, sand also related for low organic humus and pH. Particularly, those properties can already explain hillslope processes of mountain Ovoot. Vertical distribution of elements indicates that *Fe, Al, Ca, Mg, Na* and *K* were strongly distributed along the hillslope. Vertical distributions of these elements correspond to common variables in the soils. And summit slope and lower side slopes concentration of microelements are shown (Table 1).

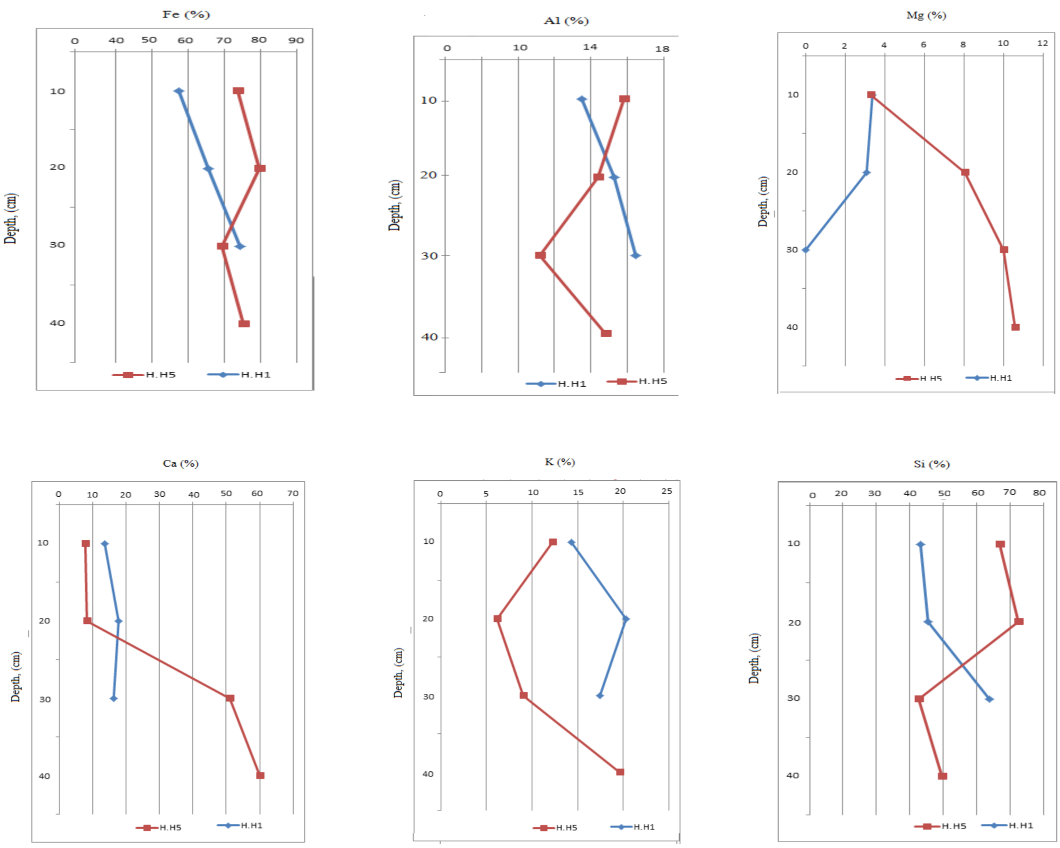

Figure 4 Vertical profiles of the *Fe, Al, Ca, Mg, Na*, *K* in the soils within the catchment

Vertical distribution of the elements indicates that *Fe, Al, Ca, Mg, Na*, *K* were differently distributed along the hill slopes. Chemical elements are more all important in variation in soils over the slope. *Ca, Mg, Na* are found in the lowest parts of the landscapes because as compounds with chloride re very soluble. From those elements, the most abundant is *Fe* with an average percent of 85 and highest being is 68.4 in along the mountain Ovoot. It is suggested that iron and aluminum released by weathering would stay at the site of release as they do not formvery soluble. *Si* is element of chemical, which is more stable and steady for erosions. So all vertical soils samples most abundant element is *Si*. Vertical profile of H.H1 concentrations increased A layer to A_{oc}. And lower side vertical concentration of *Si* is decreased A layer to $B_{2.}$

Besides, concentration of *K* is distributed differently in catchment. Except summit slopes top soils layer is decreased by *K* concentration but, it increased to depth in soil. And lower side slopes K concentration is increased A layer to B_2. *Mg* and *Ca* concentrations are increased summit slope to lower side slope. Except that concentration of summit slopes *Mg* and *Ca* are approximately 4-12%, and in lower side slope it shown that, more than 6 times concentration within. *Na* concentration of vertical soils is distributed between 5-6% in summit slopes in humus layer, otherwise in lower side slopes *Na* concentration was 0 in all layers. It related their potential hydrogen. Present soil pH is correlated their parent rocks, climate change, plants and other related conditions. The pH is one indicator of acid or alkaline property, which it easy to define that chemical processes and chemical elements. Most of chemical reactions are belong to their *pH*. So it would be prophecy their chemical properties. Except pH of study area is 5.82 to 8.36 (Figure 4). This alteration is distributed differently in samples of hill slopes. Most of mountain pH is 5.5-7.5. If there have sub flow along to hill slopes that alkaline cation will outflow the top soils which are *Ca, Na, Mg, K*, after its resulted soil should be acidic. Also soils pH were high acidic and high alkaline it would be influenced worse for plants and organic materials. That *Ca, Na, Mg, K alkaline metals* can increase soil *pH*. So it could be alkaline soils. That high geochemical activity indicates that soils along hill slopes are highly vulnerable to erosion by sub flow and though flow, associated intensive of weathering processes along the hills slope. The microelements movements are main indicator of along hill slope processes. Mainly it related their slope gradients, side of mountain, soil chemical and physical properties one most important of geochemical activity. Generally, microelements were most highly on summit and shoulder slope those shown that related for parent rock or bedrocks. Which metals, *Cr* and *Ni* concentrations are high in lower side slope in along hill slope. This can be proven that hill slope processes are accumulated in to low side of mountain. But such as, *Pb, Cd* and *Zn* are high concentration in summit slope of mountain, it related for their bedrocks. And vertical distribution of heavy metal is distributed differently in all layers. Except *Cr* concentrations of A layers in low but, deepest of all samples *Cr* concentration is being high in along hillslope processes. Lead (*Pb*) concentration of *H.H1* or summit slope of all vertical profiles are all high than other samples and vertical profiles. *Cd* was same as concentration level is same as lead.

Conclusion

The movement of microelements within soil profiles along the mountain slopes and sediment analyses of particle sizes and shapes determine the landscape development of Mt.Ovoot in the northeast of Khangai Mountain Range, Mongolia. The particle size and shape indicate high weathering intensity from upper slope to lower slope. Movements of microelements indicate that soil particles are strongly deposited on lower slope. Landscape development in the Mt.Ovoot may be related to geomorphic factors such as steep slopes and high elevation. This factor may have caused the development of the two gullies, which occur area of 6.9 and 2.7 hectares. It implies that weathering intensity is high in Mt.Ovoot.

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