The characteristics of soils at the steppe of Kherlen River basin, Mongolia

ASANO Maki[1], TAMURA Kenji[1], MAEJIMA Yuji[2], MATSUZAKI Hiroyuki[3] and HIGASHI Teruo[1]

[1] Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Japan
[2] National Institute for Agro-Environmental Sciences, Tsukuba, Japan
[3] Research Center for Nuclear Science and Technology, University of Tokyo, Tokyo, Japan

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I Introduction

The changes in human activity and climatic conditions would cause the desertification in northeast Mongolia. To prevent the desertification and conserve the glassland, the knowledge of soil cheracteristics are essential.

In soils of arid and semi-arid regions, calcic horizon (Bk horizon) is common. It was show that the depth of Bk horizon is related to annual precipitation (Arkley, 1963). However, the studies about the generation time of Bk horizons were reprted only in the limited areas, such as a southern and the northern part United States. Although the basic data is insufficient, it is increasing importance to clarify the process and rate of pedgenic calcium carbonate accumulation from the viewpoint of a cycle of the carbon in terrestrial ecosystem.

The objective of this study is 1) to clarify the characteristic of the soils at the steppe of Kherlen River basin 2) to obtain the value of $\delta^{13}C$ and $\Delta^{14}C$ of pedogenic calcium carbonate in Bk horizons by the AMS (Accelerator Mass Spectrometry) method and to calculate the rate of pedogenic calcium carbonate accumulation.

II Materials and methods

1. Study area

Fig. 1 showed the soil survey and sampling site. Five soil profiles were surveyed, consisting Baganuur (BGN), Jagalthaan (JGH), KherlenBayan-Ulaan (KBU), Underhan (UDH) and Darhan (DH). Those site are located the steppe of Kherlen River basin, and AWS site of the RAISE project.

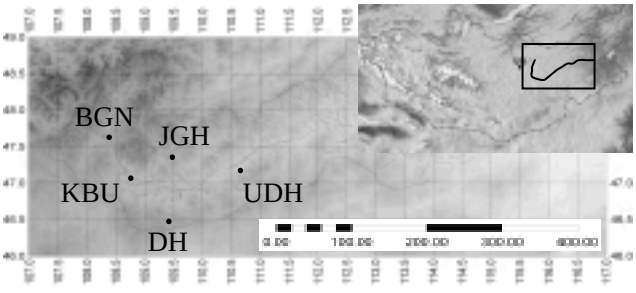
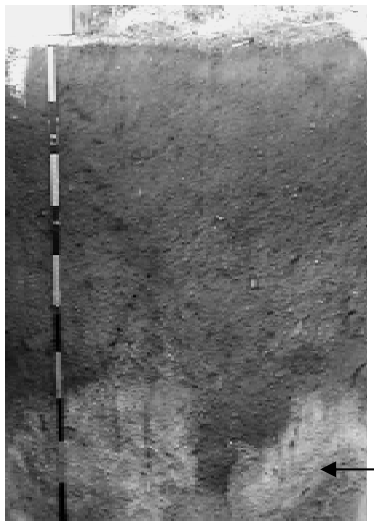


Fig. 1 Location of Soil survey and soil sampling points.

2. Soil survey

Five soil profiles were investigated and described according to Hand book of Soil Survey (Japanese Society of Pedology, 1997). Classification of soils was followed after WRB (FAO, ISRIC, ISSS, 1998). Fig. 2 showed a representative soil profile at KBU.



Accumulation of calcium carbonate (calcic holizon: Bk)

Fig. 2 Soil profile of KBU.

3. Soil sampling

Soil samples for physical measurement, chemical and isotope analysis were taken from each horizon of the five soil profiles.

Soil samples for chemical and isotope analysis were air-dried, and sieved through 2 mm. The sub samples of finery ground samples were reground to pass through 0.5 mm and 0.2 mm mesh sieve.

Undisturbed soil core samples for physical measurement were sampled by sylindrial core (100 ml) sampler.

4. Chemical analysis

pH(H_2O), pH(KCl) (glass electorode method), EC (platinum electorode method), Soil organic carbon and inorganic carbon contents (measured by wet combustion method (Kosaka *et al.*, 1959; Clark and Ogg, 1942)), Total nitrogen contents (determined by NC-analyzer using SUMIGRAPH NC-900, Sumika Chemical Analysis Service, Tokyo), Water

soluble cation of Ca^{2+}, Na^{+}, Mg^{2+}, K^{+} (determined by Atomic Absorption Spectrophotometry using AA-6200, SHIMADZU Co., Kyoto), Water soluble anions of SO_4^{2-}, Cl^{-}, PO_4^{-}, NO_3^{-} (determined by Ion chromatography (YOKOGAWA IC7000 SERIES II), Exchangeable bases of Ca^{2+}, Na^{+}, Mg^{2+}, K^{+} (determined by Atomic absorption Spectrophotometry using AA-6200, SHIMADZU Co., Kyoto) on the extract with 1 mol L^{-1} CH_3COONH_4, CEC (measured by the method of Schollenberger (Committee of Soil Environment Analysis, 1997).

5. Physical measurement

Three phase ratio and saturated hydraulic conductivity were determined by the core method.

6. Isotopic analysis

Radio carbon and stable carbon analysis of soil carbonate samples were carried out by Accelerator Mass Spectrometry (AMS), using 5MV Tandem van de Graaff electrostatic accelerater (National Electrostatics Corporation) in Micro Analysis Laboratory, Tandem accelerator, The Univ. Tokyo.

The soil samples of Bk horizon (Fig.2) in each five profile were reacted with 85% H_3PO_4 under vacuum to release CO_2. Then reduced to graphite with H_2 and its ^{14}C / ^{12}C ratio was measured by AMS.

$$\delta^{13}C\ (‰) = \{(^{13}C / {}^{12}C)_{sample} / (^{13}C / {}^{12}C)_{PDB} - 1\} \times 10^3 \quad (1)$$

$$\Delta^{14}C\ (‰) = \{(^{14}C / {}^{12}C)_{sample(-25)} / (^{14}C / {}^{12}C)_{STD} \times 2\hat{}\ ((t - 1950) / 5730) - 1\} \times 10^3 \quad (2)$$

$\delta^{13}C$ STD: the PDB standard, $\Delta^{14}C$ STD:NIST HOX II (1950),

radiocarbon age

$$= -8033 \ln [(^{14}C / {}^{12}C)_{sample(-25)} / (^{14}C / {}^{12}C)_{STD(-25)}] \quad (3)$$

III Results

The chemical and physical properties at the soil surface of the investigation area were considered to be uniform if geographical feature was a flat side. However, in the Bk horizons, difference was remarkable in pH, EC, water-soluble cation and anion, and exchangeable base especially. Water soluble ions of soils showed higher content at site with lower precipitation.

The rate of pedgenic calcium carbonate accumulation was calculated 1.10 g m^{-2} yr^{-1} from the relationships between the radiocarbon age and the contents of $CaCO_3$ in the Bk horizons (Fig. 3). The $\Delta^{14}C$ ratio was high in the upper part in Bk horizon at the site with high amount of precipitation. In contrast, the $\Delta^{14}C$ ratio was lower the upper part of Bk horizon at the site with lower amount of precipitation. The $\delta^{13}C$ ratio show difference of CO_2 sources, they shows difference of water movement in soils each site (Fig. 4).

Fig.5 shows the characteristics of soil at the steppe of Kherlen River basin.

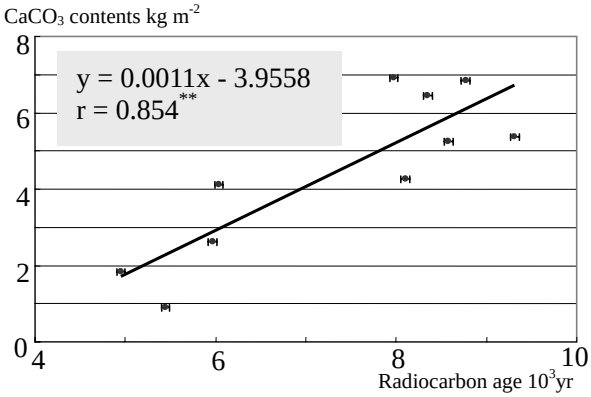


Fig. 3 The relationships between $CaCO^3$ contents and Radiocarbon age of pedogenic calcium carbonate in Bk horizons.

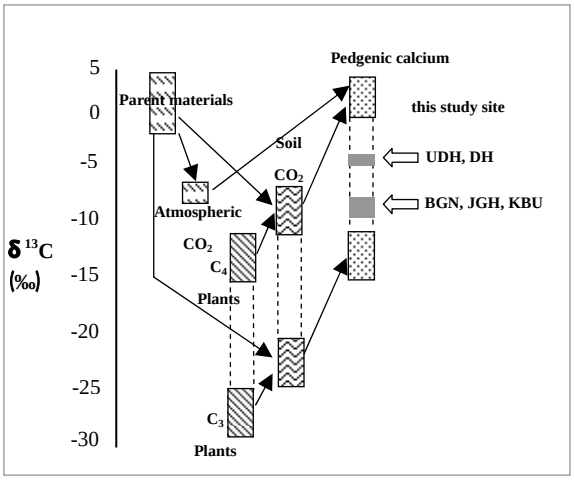


Fig. 4 The stable carbon isotope ratios of different components of terrestrial ecosystems (Nordt *et al.*, 1996).

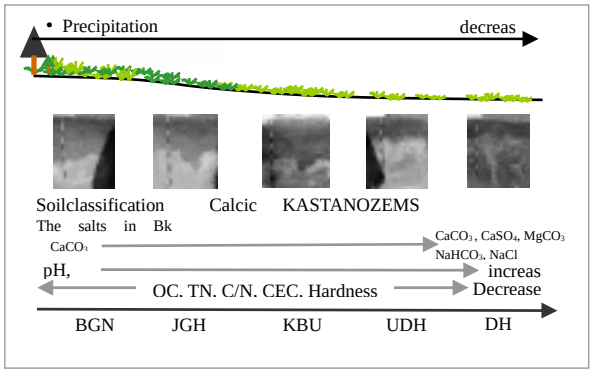


Fig. 5 The characteristics of soil at the steppe of Kherlen River basin.

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FAO, ISRIC, ISSS, World reference base for soil resources, 1998.

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