AN INTERSTRATIFIED ILLITE/SMECTITE MINERAL VEIN FOUND IN CHAOTIC ROCK FROM THE NIKORO GROUP IN THE ACCRETIONARY TOKORO BELT, NORTHEASTERN HOKKAIDO, JAPAN

HIROYUKI MAEDA* and MASANORI KOHNO*

*Sapporo Technology Professional Training College, 5-1-8-7, Nakanuma-Nishi, Higashi-ku, Sapporo 007-0895, Japan
Graduate School of Engineering, Tottori University, Tottori 680-8552, Japan

(Received January 24, 2015. Accepted April 17, 2015)

ABSTRACT

Interstratified illite/smectite mineral was found as a clay vein in the Toyomi landslide-prone area in Kitami City, northeastern Hokkaido, Japan. The white with a slight green tint drusy interstratified illite/smectite mineral vein was observed in chaotic rock of the Nikoro Group in the accretionary Tokoro Belt. The interstratified illite/smectite mineral is associated with calcite, quartz, and chlorite. The mode of occurrence and mineral assemblage indicate that the interstratified illite/smectite mineral precipitated directly from the hydrothermal solution having a near neutral pH.

Key words: Interstratified illite/smectite mineral vein, Hydrothermal origin, Greenstone landslide area, Nikoro Group, Tokoro Belt

INTRODUCTION

Interstratified illite/smectite mineral is the commonest interstratified clay minerals, and because the smectite-to-illite conversion occurs during diagenesis (Weaver, 1989; Inoue, 1991; Frey and Robinson, 1999; Maeda et al., 2009) of pelitic sediments and its reverse during weathering this may indeed be one of the most abundant clay mineral types in lithosphere (Newman and Brown, 1987). The mineral also occurs during hydrothermal alteration in submarine or subaerial hydrothermal system (Inoue et al., 1984; Zeng et al., 1996; Utada et al., 1999).

Interstratified illite/smectite mineral was found as a white with a slight green tint drusy clay vein within chaotic rock from the Toyomi landslide-prone area of Kitami City in the Nikoro Group of the accretionary Tokoro Belt, northeastern Hokkaido, Japan (Fig. 1).

The existence of swelling clay minerals in slip surface clays in landslides is one of the main causes of reactivation-type landslides (Maeda, 2004). Although DZLs (diagenetic zone landslides) and HAZLs (hydrothermal alteration zone landslides), based on a new geological landslide classification (Maeda, 2006, 2008, 2014), have soft or hard bedrock, and are induced by earthquakes, they operate by the swelling of clay minerals in slip surface clays, as well as a rise in underground water pressure during heavy rains, long spells of rainy weather or the spring thaw (Maeda, 2002a, b). Studies on clay minerals from MBL (metamorphic belt landslide) areas consisting primarily of hard bedrock are not few, although there are fragmentarily reported those of the Sambagawa Belt (Maeda and Hiura, 2002; Miyahara et al., 2005a), the Mikabu Belt (Miyahara et al., 2005a), the Chichibu Belt (Maeda and Hiura, 2002; Miyahara et al., 2005a, b), and the Shimanto Belt (Maeda and Hiura, 2002) in Shikoku island and the Tokoro Belt (Okazaki et al., 2006; Maeda et al., 2015) in Hokkaido island, Japan.

According to Maeda et al. (2015), the Toyomi Slide occurred at the Toyomi landslide-prone area in Tanno Town, Kitami City (Fig. 1), and the total rainfall came to 246 millimeters analyzed by the Nikoroyama radar-AMEDAS, induced by a cyclonic heavy rain October 7 to 9, 2006. This slide deposits covered the prefectural road No. 655 (Nikura-Tanno Line). A scale of the slide has approximately 20 m in width, approximately 45 m in total length, and 2 to 3 m in thickness of the slide body (Fig. 1). This slide is a debris slide occurred on an approximately 20 cm-thick slip surface clay between moderately weathered greenstone and debris of strongly weathered greenstone based on the slide body. The fault gouge in the non-landslide area of this area has approximately 20 cm
in thickness and the continuity, and consists predominantly of smectite and interstratified chlorite/smectite minerals, with lesser chlorite, albite, quartz, and calcite. In contrast, the slip surface clay of this slide has approximately 20 cm in thickness and the continuity, and consists dominantly of smectite and interstratified chlorite/smectite minerals, with lesser chlorite, actinolite, albite, quartz, calcite, and dolomite. A similarity of the mode of occurrence and clay mineral composition between the fault gouge and the slip surface clay suggests that the slip surface clay was one of the fault gouges. A slip surface, which strikes N30°E and dips 27°SE, in the slip surface clay found in the upper part of this slide body indicates a dip slope structure, whereas a fault plane, which strikes N80°E and dips 40°NW, in the fault gouge found in the non-landslide area indicates a reverse-dip slope structure. Therefore, the slope of greenstones, which have fault gouges of a dip slope structure, has a high risk of an occurrence of a slide or collapse, because a swelling clay mineral-bearing fault gouge was a slip surface clay of the 2006 Toyomi Slide.

The present note describes the mode of occurrence and paragenesis of an interstratified illite/smectite mineral and presents X-ray powder diffraction (XRD) data, in addition to a discussion on the genesis of the interstratified illite/smectite mineral.

GEOLOGIC SETTING

The geology of the Toyomi landslide-prone area belongs to the Tokoro Belt (Suzuki, 1963), based on Mesozoic geologic structures (Kiminami et al., 1986), and consists primarily of the Middle Jurassic—Upper Cretaceous Nikoro Group (Research Group of the Tokoro Belt, 1984; Sakakibara et al., 1986; Sakakibara et al., 1993), which is an accretionary prism, Paleozoic pumice flow deposits, Paleozoic-Holocene ancient landslide deposits, and Holocene alluvial fan and river deposits. Bedrock of ancient and recent landslides in this area is primarily composed of the Nikoro Group greenstones, which were changed from basaltic pillow lava, massive lava, and hyaloclastite by low-grade regional metamorphism, with lesser red chert. Mineral composition of greenstones in this area consists primarily of albite and chlorite, with lesser quartz and actinolite (Maeda et al., 2015), and these minerals are the metamorphic origin. Many calcite or dolomite veinlets (Maeda et al., 2015) or laumontite networks (Maeda, 1995; Maeda and Kohno, in contribution) were commonly observed in greenstones. These carbonate minerals and zeolite are fissure-filling minerals of the hydrothermal origin. Consequently, greenstones were suffered by hydrothermal alteration. Although greenstones are hard rocks, the place of greenstones forms an intermediate slope between a gentle slope and a steep slope, caused by hydrothermal alteration and weathering. The landslide deposits are primarily composed of weathered rock, debris, and earth of greenstone and red chert.

METHODS AND EQUIPMENT

Sample

Sample studied is a white with a slight green tint drusy clay vein collected at depths of from 20.8 to 20.9 m in core of No. H22B-4 vertical borehole excavated in the middle part of an ancient landslide in the Toyomi landslide-prone area (Fig. 1).

Methods

The whole-rock mineralogy of the white with a slight green tint drusy clay vein was determined primarily by X-ray powder diffraction (XRD). Clay minerals in the vein were identified from the diffraction patterns of unoriented and untreated, oriented and untreated, and ethylene glycol-treated oriented samples. XRD was performed using a Rigaku RINT-2000 type diffractometer (30 kV, 20 mA) equipped with a Cu tube, an Ni filter, a 0.3-mm receiving slit, and 1° divergence and scattering slits.

RESULTS AND DISCUSSIONS

Interstratified illite/smectite mineral was found as a white with a slight green tint drusy clay vein (Figs. 2 and 3) in chaotic rock consisting primarily of greenstone and red chert of the Nikoro Group in the Toyomi landslide-prone area. The interstratified illite/smectite mineral vein was approximately 10 cm in width and the dip of the mineral vein was approximately 40° (Fig. 3). XRD patterns of the interstratified illite/smectite mineral vein are shown in Fig. 4. Mineral composition of the interstratified illite/smectite mineral vein is pri-
Interstratified illite/smectite mineral vein found in chaotic rock of the Nikoro Group in the accretionary Tokoro Belt, northeastern Hokkaido, Japan

Interstratified illite/smectite mineral vein

LEGEND

- Embankment
- Debris or strongly weathered greenstone
- Interstratified illite/smectite mineral vein
- Moderately weathered greenstone
- Moderately weathered chaotic rock
- Weakly weathered greenstone

Fig. 2. Borehole log of No. H22B-4 drilling core.

Fig. 3. A mode of occurrence of the interstratified illite/smectite mineral vein in the chaotic rock from 20.8 to 20.9 m depth of the borehole No. H22B-4.

The clay minerals in these veins are primarily composed of interstratified illite/smectite and calcite (Fig. 4A), with lesser quartz (Fig. 4A) and chlorite (Fig. 4B, C). These minerals are clearly hydrothermal vein minerals on the basis of a macroscopic observation. Based on oriented ethylene glycol XRD data (Fig. 4C and Table 1) and Watanabe (1988), the smectite-layer content and Reichweite of the interstratified illite/smectite mineral are approximately between 15 and 20 % and g = 2, respectively. The mode of occurrence and mineral assemblage of interstratified illite/smectite mineral-calcite-quartz-chlorite indicate that the interstratified illite/smectite mineral precipitated directly from the hydrothermal solution having a near neutral pH.

As described previously, this clay vein has approximately 10 cm-width and 40°-incline, whereas a slip surface clay, which is a fault gouge origin, of the 2006 Toyomi Slide has approximately 20 cm-thickness and 27°-incline. The modes of occurrence have some similarities between the clay vein and the slip surface clay. Also, the interstratified illite/smectite mineral vein consists primarily of interstratified illite/smectite minerals and calcite, with lesser quartz and chlorite, whereas the slip surface clay consists primarily of smectite and interstratified chlorite/smectite minerals, with lesser chlorite, actinolite, albite, quartz, calcite, and dolomite. The clay vein and the slip surface clay are rich in swelling clay minerals. The greenstone landslide, therefore, is closely related to the presence of swelling clay mineral-bearing clay vein such as this interstratified illite/smectite mineral vein or fault gouge and its dip slope structure.

ACKNOWLEDGMENTS

We gratefully acknowledge the help of the Dr. Naya, H. and M. Uematsu, S. of the Main Office of Meiji Consultants Co. Ltd., which supplied the drilling core samples. We would also like to thank an anonymous reviewer and Dr. Jige, M. of an associate editor of Clay Science for constructive reviews.
H. Maeda et al.

**Fig. 4.** XRD patterns of the interstratified illite/smectite mineral vein from 20.8 to 20.9 m depth of the borehole No. H22B-4 (A: Unoriented and untreated sample, B: Oriented and untreated sample, C: Ethylene glycol-treated sample).

**Table 1.** X-ray data for the interstratified illite/smectite mineral vein within the chaotic rock of the Nikoro Group in the Tokoro Belt, northeastern Hokkaido, Japan

<table>
<thead>
<tr>
<th>Unoriented and untreated</th>
<th>Oriented and untreated</th>
<th>Treated with ethylene glycol</th>
</tr>
</thead>
<tbody>
<tr>
<td>d (nm)</td>
<td>Intensity</td>
<td>d (nm)</td>
</tr>
<tr>
<td>1.15</td>
<td>16 VB</td>
<td>1.45</td>
</tr>
<tr>
<td>1.09</td>
<td>Chl</td>
<td>0.719</td>
</tr>
<tr>
<td>0.502</td>
<td>36 B</td>
<td>0.498</td>
</tr>
<tr>
<td>0.450</td>
<td>100 S</td>
<td>0.385</td>
</tr>
<tr>
<td>0.436</td>
<td>8 VB</td>
<td>0.332</td>
</tr>
<tr>
<td>0.427</td>
<td>Qz</td>
<td>0.354</td>
</tr>
<tr>
<td>0.385</td>
<td>Cal</td>
<td>0.354</td>
</tr>
<tr>
<td>0.365</td>
<td>20 VB</td>
<td>0.332</td>
</tr>
<tr>
<td>0.335</td>
<td>Qz</td>
<td>0.304</td>
</tr>
<tr>
<td>0.304</td>
<td>Cal</td>
<td>0.304</td>
</tr>
<tr>
<td>0.284</td>
<td>Cal</td>
<td>0.284</td>
</tr>
<tr>
<td>0.258</td>
<td>64 B</td>
<td>0.294</td>
</tr>
<tr>
<td>0.249</td>
<td>Cal</td>
<td>0.249</td>
</tr>
<tr>
<td>0.240</td>
<td>16 B</td>
<td>0.228</td>
</tr>
<tr>
<td>0.228</td>
<td>Cal</td>
<td>0.228</td>
</tr>
</tbody>
</table>

S: sharp peak, B: broad peak, VB: very broad peak.
Abbreviations: Cal = calcite, Chl = chlorite, Qz = quartz.
REFERENCES


