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GEOLOGY

Linear Weathering Crust of the Fedorova–Pana Layered Complex in the Northeastern Baltic Shield

V. Ya. Evzerov, P. V. Pripachkin, and K. O. Dudkin

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The remains of kaolin and hydromica weathering crusts were distinguished in the overburden of the Baltic Shield [1]. The kaolin crust, which presumably dominated in the past, formed under warm humid conditions during the Upper Triassic–Lower Jurassic [1, 2]. In the Lower and Middle Jurassic, products of the kaolin weathering were transported from the northeastern Baltic Shield to the South Barents depression [3]. Remains of the weathering crust extend linearly along weakened zones. The areal hydromica weathering crust was formed in uplifted areas under moderate climatic conditions during the Miocene–Lower Pliocene [1]. It is composed of clayey–sandy or clayey–crumbly rocks. In the Pliocene, the weathering crust was also significantly eroded due to uplift of this region.

We studied the weathering crust formed after the Early Proterozoic Fedorova–Pana layered peridotite–pyroxenite–gabbronorite complex (FPC) located in the central part of the Kola Peninsula. Together with other intrusions (Mt. General'skaya and Monchegorsk), this complex forms the Kola platinum group metal (PGM) belt [4]. The FPC consists of three large (Fedorova Tundra, Western Pana, and Eastern Pana) intrusions crosscut by faults in several tectonic blocks (Fig. 1).

The hydromica weathering crust was previously found within the FPC beneath the glacial sheet moraine. The clayey–crumbly weathering products of gabbronorites extend along the northern slope of the Pany Hills from Mt. Kamennik to Mt. Peshempakhk over a distance of more than 15 km. They occur as spots up to 700 m wide on low-angle (1°–3°) slopes [5]. The 0.5-m-thick upper layer consists of clayey–sandy rocks containing 10.9–13.9% particles less than 0.01 mm in size. They are underlain by gruss up to 8 m thick. The clay fraction consists of hydromica, vermiculite, metahalloysite, and subordinate amphibole [1].

Detailed geological–geophysical prospecting for PGM mineralization on the southern slope of Mt. Peshempakhk revealed a zone of high electroconductivity. In plan view, this zone is concordant with magmatic layering and characterized by the H-type three-layered geoelectric section, which corresponds to a thick overburden (up to 40–50 m). It is 2 km long and from 100–200 to 500 m thick (Fig. 2a). Two boreholes recovered the weathering crust (20–25 m thick) beneath the glacial sheet moraine within this zone. The weathering crust is composed of light or dark gray loam with relicts of altered bedrocks, which retained the structural pattern of the initial rock. It was formed on gabbronorites altered into chlorite–amphibole schists. The content of <0.01 mm particles in the weathering profile of both boreholes varies from 32 to 57%. This value is several times higher than the content in the previously found weathering products of the FPC. Figure 2b shows the grain size distribution in the weathered material from borehole P-209.

The mineral composition of <0.002 mm particles was determined mainly by X-ray diffraction analysis of air-dry glycerin-saturated oriented specimens heated at 400°C. If it was difficult to obtain the oriented samples, we analyzed powder diffraction patterns. The results indicate that pelite particles consist of chlorite with an admixture of illite, amphibole, and feldspar. Samples 1 and 2 from borehole P-209 contain kaolinite. In the oriented specimens, chlorite is identified from basal reflections 13.8–14.2 Å (001), 7.0–7.3 Å (002), 4.7–4.75 Å (003), 3.52–3.56 Å (004), 2.81–2.83 Å (005), and 2.33 Å (006). Their position does not change during glycerin saturation and after heating at 400°C. In sample 4 (borehole P-209), the first-order reflection shifted toward the low-angle region after glycerin saturation, indicating the presence of a swelling component. The intensity of basal reflections of chlorite does not change across the borehole P-211 profile, whereas the intensity of the first-order reflections in the upper

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*Geological Institute, Kola Scientific Center,
Russian Academy of Sciences, ul. Fersmana 14, Apatity,
Murmansk oblast, 184209 Russia;
e-mail: yevzerov@geoksc.apatity.ru*

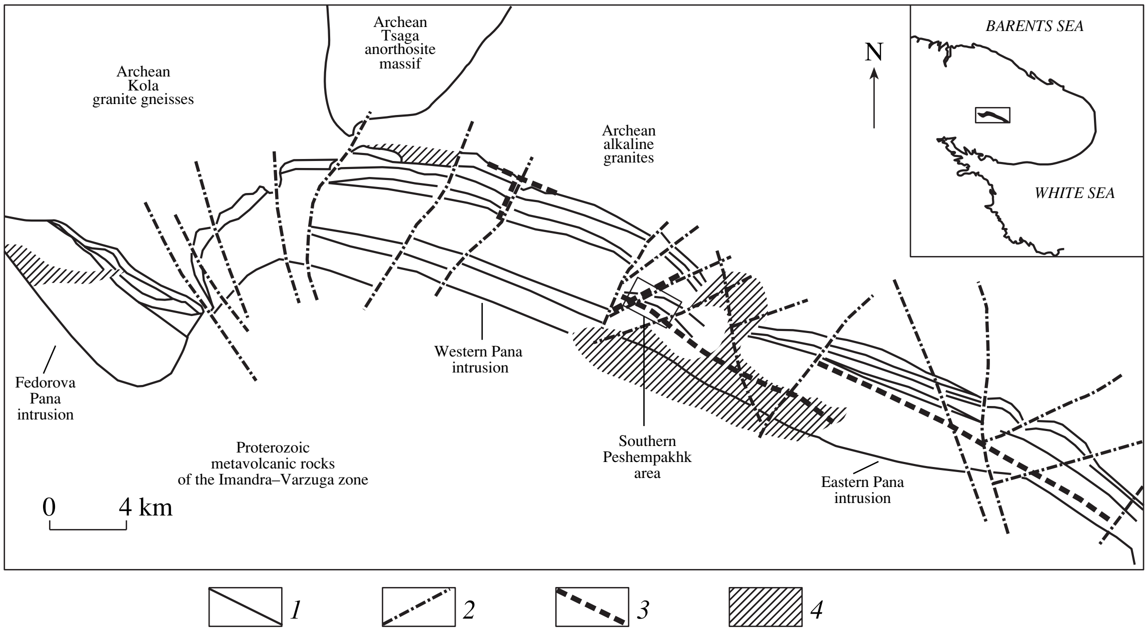

Fig. 1. General geological map of the Fedorova–Pana layered intrusive complex. (*1*) Geological boundaries of intrusive rocks and magmatic layering; (*2*) faults; (*3*) inferred linear weathering crust (based on airborne geophysical data); (*4*) areal development of Quaternary sediments within the complex.

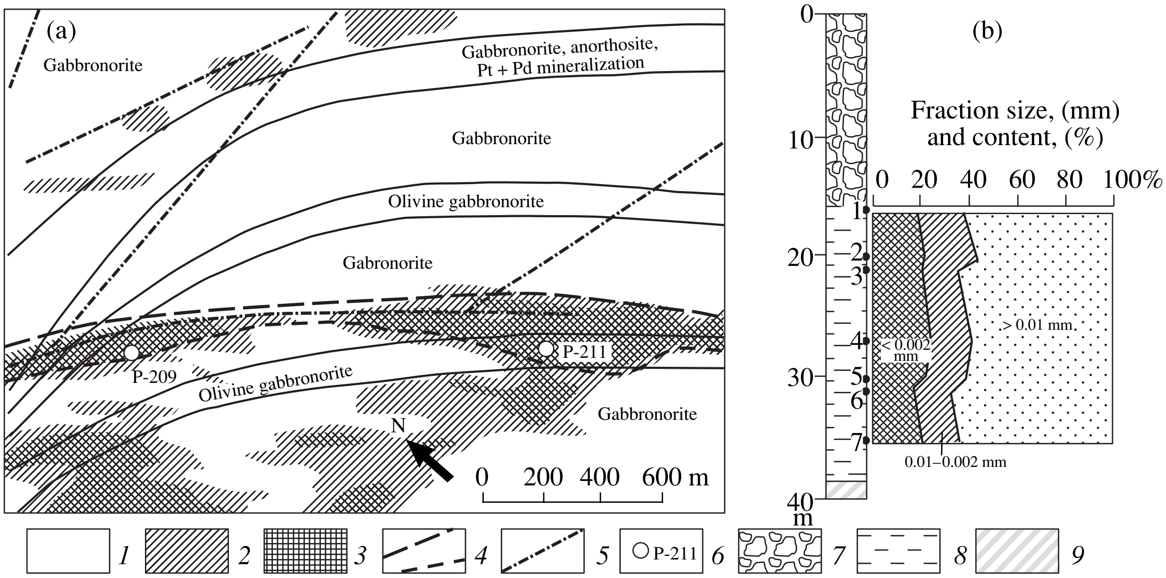

Fig. 2. Geological–geophysical scheme of (a) the southern Peshempakhk area and (b) cross section of borehole P-209. (a) Specific resistance: (*1*) >7000 Ωm, (*2*) 3500–7000 Ωm, (*3*) <3500 Ωm; (*4*) boundaries of the conductive zone nearly concordant with magmatic layering; (*5*) faults (based on magnetic survey and drilling data); (*6*) boreholes and their numbers; (*7*) moraine, (*8*) weathering crust; (*9*) amphibole–chlorite–clinozoisite schists formed after gabbronorite. (1–7) Sample numbers.

part of borehole P-209 (samples 1 and 2) decreases with respect to other basal reflections. This is related to partial breakdown of chlorite into kaolinite, whose basal reflections virtually coincide with those of chlorite beginning from its second-order reflections. Kaolinite was identified from the X-ray powder diffraction pattern of <0.002 mm particles of sample 1 after their dissolution in hot 10% HCl. These particles almost completely consist of kaolinite with subordinate amphibole and feldspars, the typical reflections of which are presented below.

Illite in the XRD pattern of an oriented sample is represented by reflections 9.9 Å (001), 4.95–5.01 Å (002), 3.33–3.34 Å (003), 2.50 Å (004), and 2.0 Å (005). Their position is preserved regardless of treatment of specimens. Amphibole was identified from reflections 8.35–8.4, 3.26, 3.10–3.11, 2.92–2.93, 2.70–2.71, and 2.37–2.38 Å. Feldspars were recognized from reflections 4.02, 3.75, 3.18–3.19, and 2.54–2.55 Å.

In terms of granular and mineral composition of pelitic particles, the studied weathering products are very close to those from the hydrochlorite zone of the kaolinite weathering crust of chlorite schists near the Titan station, where <0.01 mm particles account for 26.1–42.90%, and hydrochlorite is the major mineral of the pelitic fraction [6]. The hydrochlorite zone is replaced upsection by a kaolinite zone, in which approximately 70% of the particles are less than 0.01 mm, with kaolinite as the major mineral of the clay fraction [6].

As was shown above, the upper part of the borehole P-209 profile also demonstrates the transition to the kaolinite zone. However, its products have not yet been found, possibly because of erosion soon after their formation.

Based on airborne magnetic and EM survey, the linear zone of low resistance and magnetization recovered by drilling extends for at least 12 km. The other analogous zone within the Eastern Pana intrusion extends for approximately 15 km. In addition, the study region incorporates areas with a thick overburden having the characteristic H-type three-layered geoelectric section. Such areas are confined to faults of different directions. Our study showed that the typical kaolin can be found within the indicated zones. Such kaolin has already been discovered in some areas of the eastern Baltic Shield [1]. In other words, the overburden confined to tectonic zones deserves purposeful study, because kaolin could be of practical interest as a raw mineral for the production of ceramics and as a filler for production of high-quality paper in the case of the mining of platinum and palladium deposits.

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