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Spheroidal weathering process of granite porphyry with columnar joints to form corestones covered with rindlets

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In the southeast mountainous region of the Kii peninsula, Japan, granite porphyry shows typical spheroidal weathering, in which 0.4-1.5 m diameter of corestones are made with scale-like rindlets. The rindlets are made by the exfoliation of surface parts of a corestone by mineral-chemical alteration and crack propagation, of which processes were poorly known. We made field investigation and made analyses and measurements for mineralogy, chemistry and physical properties of rock samples and found that the oxidation of colored minerals and iron precipitation creates micro-cracks, which separates rindlets from a corestone.

Fresh granite porphyry has almost vertical columnar joints with 2-6 m intervals and is intersected near the ground surface by the sheeting joints. At the beginning of the spheroidal weathering, an oxidation front is made along joint surfaces to form a brown band. Brown bands were 2.5-5 cm thick and individual rindlets were 3.5-5 cm thick regardless of radius of corestones, which suggests that the rindlet separation occurs when a brown band thickness reaches about 5 cm. Thin-section observation and XRD analyses indicated that pyrite is depleted, chlorite is transformed into vermiculite, and iron(Ⅲ) hydroxides precipitate in the brown band. Microscopic observation of cut surfaces of rock samples impregnated with fluorescent resin showed that pores are filled with the precipitate and micro-cracks form subparallel to the oxidation front in the brown band. Cracks in the brown band or rindlets seem to converge at aggregates of iron(Ⅲ) hydroxides and vermiculite, and cracks form a network subparallel to the oxidation front with 0.5-2 cm interval at a maximum. In the brown band, P-wave velocities increased up to 10%, but tensile strengths with fracture surface parallel to the oxidation front decreased in the brown band than those of fresh rock. These physical property changes are due to pore filling and crack development in the brown band. The mass balance calculation using densities and Ti concentrations of rock samples did not detect rock volume changes in the brown band and the inner rindlets, but suggested that rock volumes increased by 20% in the outer rindlets and by 80% in the saprolite from the fresh rock. Mass balance calculation also suggested that chemical components are leached out in the brown band, the rindlets, and the saprolite in a consistent way. A corestone is thus getting smaller with the exfoliation of rindlets from brown bands, which gradually migrates inside the corestone by the oxygen diffusion, then rindlets are finally disintegrated into saprolite.

Keywords: spheroidal weathering, weathering rind, granite porphyry, crack, oxidation, P-wave velocity