

Field and laboratory experiments of granodiorite weathering: quantitative separation of chemical and physical weathering rates

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To study the rate and feature of granitic rock weathering, field weathering experiments using granodiorite tablets (3.5 cm in diameter, 1.1 cm in height, 30 g) were conducted over ten years at a catchment of Abukuma mountain district, Japan. The tablets were placed at three positions having different weathering condition: on the ground, water-unsaturated grus layer, and water-saturated grus layer. The tablets were collected regularly, brought back to the laboratory and weighed, and re-excavated at the field site. The weight of the tablets linearly decreased with elapsed weathering time, and the rates were $3.6\text{E-}5$ wt%/day for on the ground, $6.0\text{E-}5$ wt%/day for water-unsaturated layer and $1.2\text{E-}3$ wt%/day for water-saturated layer. Only minor change of the tablet surface was detected after ten years of weathering on the ground and at the water-unsaturated layer. In contrast, the edges of the tablets were remarkably eroded at the water-saturated layer. In addition, biotite grains were significantly eroded while the erosions of quartz, K-feldspar, plagioclase, and hornblende were minor/moderate. The average rate of the erosion of biotite for in-depth direction from the tablet surface is estimated to be about 0.1 mm/year based on the measurement of the roughness of weathered tablet's surface using 3D scanner. The weathering of granodiorite is inferred to proceed by initial dissolution of mineral grain boundary (chemical process) and subsequent detachment of the mineral grain (physical process). To evaluate the rate of chemical process (dissolution) without any contribution of physical process, dissolution rate of the granodiorite tablet was measured by laboratory experiment using a flow through reactor at 20 degree C and pH=6-7. The obtained dissolution rate was $1\text{E-}5$ wt%/day, which is more than 100 times smaller than that obtained from the field experiment at the water-saturated layer. This result demonstrates that the contribution of physical process, in granodiorite weathering at the water-saturated layer, is very large compared to chemical process, and the ratio of weight loss between the two processes is estimated to be chemical : physical = 1 : 100.