The weathering of granitic rocks in the Sør-Rondane Mountains, East Antarctica

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Abstract

Weathering processes in hyper-arid and hypothermal environments are key to our understanding of geomorphological processes and landscape evolution in Antarctica. A number of studies have focused on the weathering of basaltic rocks in Antarctica; however, the nature of the weathering of granitic rocks, a common rock type on Earth, has received less attention and remains unclear. This study uses various petrological techniques to analyze the physical and chemical weathering of granitic rocks obtained from Dronning Maud Land in East Antarctica. Loss on ignition (LOI) values and the major element composition obtained from the crust and core of the rock samples indicate that the production of hydrous clay minerals in this area is very limited. Examination under a microscope, together with laser-Raman microspectroscopy, of thin sections from the crust and core of the samples indicate that goethite grains form mainly in veins within the crust, which is consistent with the contrasts seen in the Fe^{3+}/Fe^{2+} and color strength index (CSI) values obtained from the core and crust. A negative correlation between rock hardness and degree of weathering, as measured from the crust of the samples, indicates that the weathered samples are softer than the core. This indicates that cracking and subsequent vein formation cause a reduction in the hardness of the crust and a increase in staining by the formation of goethite grains that develop in the veins. Furthermore, electron probe microanalyzer (EPMA) analysis indicates that the original Fe–Ti oxide grains are altered by weathering, changing to hematite or a non-stoichiometric Fe–Ti compound associated with ilmenite grains in the case of a greater degree of weathering. These findings reveal that the weathering of granitic rocks in a hyper-arid and hypothermal environment is controlled mainly by oxidation, including iron hydroxide formation in veins formed by frost shattering and/or salt fretting, and Fe–Ti oxide alteration in the rock interior. Importantly, these physical and chemical weathering processes are unlikely to require a liquid water supply from the environment (snow and vapor), and the restricted supply of liquid water and salt is the most probable reason for the extremely slow weathering rates in the Sør-Rondane Mountains, East Antarctica. We therefore conclude that the weathering process observed in this area is a typical feature of granitic rocks under hyper-arid and hypothermal conditions. In situ color measurements essentially express the amount of iron hydroxide on the rock surface; thus, in situ and satellite measurements of the color of exposed rocks in Antarctica can potentially provide quantitative information regarding the degree of weathering.

Keywords: weathering, oxidation, hyper-arid environment, hypothermal environment