Reconstruction of 2.5 Ga weathering of Pronto granite

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Introduction and results

We still have inconsistent conclusions regarding O_2 evolution in the Precambrian. The weathering processes in the Precambrian remain unknown because paleosols were altered chemically and mineralogically by later diagenesis and metamorphism. We examined chlorites in Pronto, Canada to reconstruct the processes of 2.5 Ga weathering and subsequent alteration for a better understanding of O_2 evolution in the Precambrian.

The chlorites were from fresh, slightly weathered, and intermediately weathered granites in Pronto. In the parent granite, biotite was completely altered to chlorite that is not interstratified with biotite as observed by high-resolution transmission electron microscopy (HRTEM). In the slightly weathered granite where chlorite was texturally the same as chlorite in the parent granite, we found biotite layers were inserted in some chlorite grains. In the intermediately weathered granite where chlorite was mostly replaced by sericite, chlorite grains of a few tens of micrometers in size, cut by sericite, were found in the sericite matrix. HRTEM revealed that the chlorite was interstratified with biotite. The biotite layers interstratified with chlorite were increased in number towards the top of the weathering profile. The stacking sequence of the chlorites indicated they were the same in origin.

Discussion and conclusions

Our results indicate that the above microstructural changes of chlorite can not be explained by chloritization after weathering as widely believed. Interstratified biotite/vermiculite and chlorite/vermiculite are usually formed by biotite and chlorite weathering, respectively. In both the cases, Fe(II) as well as Mg are probably consumed to form vermiculite under an anoxic condition. Vermiculite can be converted to biotite in K-bearing hydrothermal solution. These clearly elucidate how the microstructural changes of chlorite occurred: chloritization of biotite of the parent granite occurred prior to weathering. Chlorite was dissolved releasing Mg and Fe(II) in ground water during anoxic weathering and vermiculite was formed by using part of the released Mg and Fe(II). Vermiculite in chlorite were altered to biotite during K-metasomatism (hydrothermal alteration) that also formed sericite.

Detection of frictional heating of fault motion by zircon fission track thermochronology

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Quantitative assessment of heat generation and transfer along faults during or associated with fault movement is of primary importance in understanding the dynamics and geohistory of faulting. Fission track (FT) method is effective in the detection of paleothermal anomaly of deformed and altered fault rocks because temperature is the only environmental factor to cause track fading (Fleischer et al., 1965; Yamada et al., in prep). In particular, zircon FT system is suited to analyze the seismogenic zones of continental crust, the temperature of which ranges ˜100-350 ºC. Annealing kinetics of zircon FTs were given by fitting models to laboratory annealing data (Yamada et al., 1995; Tagami et al., 1998). The extrapolation of the kinetics to geological time scale was validated by analyzing rocks that experienced natural long-term annealing (Tagami et al., 1998). On the other hand, the temperature-time condition of frictional heating is ˜1000 ºC for several seconds, for which condition we also need to extrapolate the kinetics determined for the time range of ˜10^{-1}-10^{4} hours. Therefore, we designed a new series of laboratory annealing experiments on zircon FTs to determine the kinetic model for very short-term heating. We will report the result of zircon FT annealing experiments at 550-1100 ºC for 1-3600 sec.

As an example of detecting frictional heating in nature, we analyzed zircon separates from pseudotachylyte layers collected at Hirabayashi trench along the fault. Preliminary ages of the layers are ˜52 Ma, significantly younger than those of surrounding rocks.

References

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