ATMOSPHERIC COMPOSITION AND CLIMATE IN THE EARLY PRECAMBRIAN: A COMPARATIVE ANALYSIS OF WEATHERING PROFILES AND GEOCHEMICAL SIMULATIONS

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ABSTRACT: The nature of subaerial weathering depends on environmental conditions. Thus the mineralogy and bulk composition of preserved Precambrian weathering profiles may be a source of information about the atmospheric composition and climate specifics. This investigation aims to research chemical weathering processes that took place on the surface of the early Earth and to reconstruct possible environmental conditions that persist during such phenomena.

Weathering processes on the Earth's surface occur at low temperature. Therefore, they are characterized by incompleteness of chemical reactions. For simulation of chemical weathering, a numerical approach is attempted here. Thermodynamic calculations that accounts for mineral dissolution kinetics were implement on the basis of a code for thermodynamic simulations GEOCHEQ. The iterative lixiviation of basalt by rainfall at Precambrian surface conditions is modeled as a system that includes the following elements: O-H-K-Mg-Ca-Al-C-Si-P-Na-Fe. We used a sample of Archean basalts as a weathering protolith analogue. It is composed of 41.4 wt.% plagioclase, 31 wt.% chlorite, 21.3 wt.% pyroxene, 4.3 wt.% microcline, 1 wt.% quartz, and 1 wt.% magnetite,

A series of simulations considering CO_2 and CH_4-rich atmospheres were performed. Some scenarios envisage carbon dioxide partial pressures varying from $4 \cdot 10^{-4}$ up to 10 bar; another with methane partial pressures around 1 bar. The influence of temperature and water-rock ratio during the weathering was also evaluated. Surface temperatures employed in the modeling comprised steps of 25°C, 50°C and 75°C. Water precipitation involved steps of 400, 1000 and 4000 mm per year.

The results yielded from the modeling were compared with the composition of Paleoproterozoic and Neoarchean weathering profiles formed between 2.2 - 2.78 Ga.

Modeling shows that the final weathering profiles consist mostly of clay minerals (Na and Ca-montmorillonites; K,Na and Mg-nontronites, illite). The only exception is a scenario of weathering under a CO_2-rich atmosphere at 10 bar. In this case the residue consists of quartz mostly. Carbonate minerals (dolomite or calcite) may deposit in the course of the initial stage of weathering under all environmental conditions tested**.** Their formation is limited by the concentration of Mg and Ca in solution and the water-rock ratio during rock dissolution. Carbonates are rather stable at low water-rock ratio (or under dry climatic conditions). In all scenarios at 25°C they dissolve completely and are removed from the substrate at the final stage of the weathering profile formation. The stability of calcite increases as temperature rises and it is preserved as a residue at 75°C.

The evolution of the bulk composition of the approached Precambrian weathering profiles suggests a concentration of Si, Al, K and a reduction of Ca, Na, Mg and partly Fe. The analysis of simulated data indicates that the weathering of these samples took place due to low rainfall rates and low temperatures under a CO_2-rich atmosphere.

KEYWORDS: PRECAMBRIAN, WEATHERING, ATMOSPHERIC COMPOSITION