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Chemical Weathering of Basaltic Lava Flows Suffering Extreme Climatic Conditions: The Water Geochemistry Record

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Rock weathering depends on many factors such as climate, relief, lithology, tectonics, vegetation. It also controls both the Earth's surface morphology and the chemical composition of waters flowing towards the ocean. While numerous studies have focussed on basalt weathering processes that change rock mineralogy and chemistry, the chemistry of waters involved in the weathering process and carrying the erosion products to the ocean has received far less attention.

Mount Cameroon belongs to the Cameroon Line in Africa, an intraplate volcanic alignment extending from the Gulf of Guinea into the African continent. Its activity started 11Ma ago and still persists leading to the deposition of tephra and massive basaltic lava flows. Recent and well dated volcanic activity occurred in particular between years 1815 and 1999. Mount Cameroon is therefore an ideal target to study weathering processes and the consequences on the chemical composition of related waters. Because the lithology is simple and rock types are almost exclusively basalts, the influence of factors other than lithology and such as climate and/or vegetative cover can be evaluated. Furthermore, the volcano location - in a humid tropical area - implies both abundant rainfalls and luxuriant vegetation. These two factors should favour rapid alteration of the basaltic rocks.

Springs, streams and rivers were sampled at Mount Cameroon, during both the dry and the rainy season in December 1996 and March 1997, respectively. Springs were sampled at high altitude seeping from unweathered and fractured lava flows, while other waters were collected at lower altitudes on older flows. Rivers flowing around the volcano were also sampled.

The aim was through major-, trace-element concentration as well as Sr and U isotope composition data to assess the climatic influence on the chemical characteristics of Mount Cameroon surface waters by (i) defining and interpreting the chemistry of waters, (ii) establishing the source of dissolved constituents. As a consequence the relative mobility of elements might be appreciated and compared to what happened to the source rocks involving both fresh lavas and soils developed onto.

As shown in this study, meteoric waters are extremely dilute and should therefore respond readily to the substratum weathering. Studying surface waters in such an extreme rainfall area should therefore help constrain processes of solute acquisition and saturation states relative to primary and secondary minerals. More important, mass transfer through water/rock ratio and weathering rates could be estimated as well as the possible emphasizing effects of the vegetation and differential climatic conditions (rainfall, elevation...) on the chemical weathering of basalt and transfer to solution.

Major ions chemistry shows a strong negative correlation with the samples altitude as evidenced by chloride data exhibiting content as low as 4 micromole/l for one of the highest sample (CM 20) while the lowest sampling altitude correspond to Cl content as high as 130 micromole/l (CM 30).This reflects both the effect of the contribution of seawater in the rainfall at low altitude and the dilution coming from the predominance of rainwater at higher altitudes. Alkalinity data exhibit a comparable trend with a significant increase in alkalinity as altitude decreases, suggesting a longer interaction time between percolating waters and lavas at low altitudes. Sr isotopic compositions of all types of waters are buffered by drained bedrocks (except one sample contaminated by seawater), i.e. basalt and associated soils, (from 0.703310 to 0.703353 and 0.703303 to 0.703790, respectively) and have therefore mainly to be input to basalt/meteoric water interaction and subsequent solute acquisition by meteoric waters. Samples collected during the dry season have very coherent $^{87}Sr/^{86}Sr$ ratios (0.703397 to 0.703550) while samples recovered during the rainy season display a larger spread, particularly at low altitudes (0.703443 to 0.704049). Compared to Sr isotope ratios, the U activity ratios are much more variable with values ranging from 1.04 to 1.4, depending on the water altitude. Low ($^{234}U/^{238}U$) activity ratios are observed in high altitude springs, and water samples from high and intermediate altitudes define a good positive correlation in

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the ($^{234}U/^{238}U$) vs. U/Sr diagram. Samples from lower altitude plot out of this trend. This variability could be related to mixings between different water sources and/or to a higher contribution from surficial soil horizons and weathered profiles at low altitudes.