

Identifying a Reference Frame for Calculating Mass Change during Weathering: A Review and Case Study Utilizing the C# Program Assessing Element Immobility

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The first step in calculating elemental and bulk mass changes that occur during the transformation of plutonic rock to saprock involves the determination of a reference frame, i.e., an immobile element whose mass was conserved during the alteration process. Statistical procedures for identifying immobile elements have been available since 1990, but have not generally been applied. We therefore developed the C# program, Assessing Element Immobility (AEI) that allows for rapid and efficient assessment of a reference frame. Following discussion of the general mathematical and statistical procedures implemented in AEI, we utilize it in a case study involving 3 sites in an ~30 m thick section of regolith. ZR I is located near the base of the regolith, while ZR II and ZR III are located at depths of ~20 m and ~5 m respectively. At each site previous workers collected and chemically analyzed a number of samples from saprock and adjacent unweathered corestones. In addition, XRD work showed that from ZR I to ZR II to ZR III biotite was altered to vermiculite, vermiculite + kaolinite, and vermiculite + mixed-layer biotite/vermiculite + kaolinite respectively. At ZR III the most dominant clay mineral is kaolinite. AEI selected a reference frame of Al, Na, Fe, Mg, Ti, and P for ZR I, Si, Al, Fe, Mn, Mg, Ti, and P for ZR II, and Mg and Mn for ZR III. Using this set of reference frame elements revealed the following statistically significant losses of K mass; ~14-16 % at ZR I, ~27-31% at ZR II, and ~32-33% at ZR III. In addition, at ZR III, the statistically significant loss of ~35-36% P and ~6% Ca mass is attributed to the dissolution of apatite, while small, ~4-5%, additions of Si, Al, Fe, and Ti mass are likely the result of the translocation of kaolinite and small bits of unaltered hornblende and opaque material into the crack system at this site. In short, AEI recognized a reference frame that produced estimates of elemental and bulk mass change that are reasonable and supported by a range of other data and observations.