**Petrological and Geochemical Evidence for Polygenetic Development of Regolith at Santa Margarita Ecological Reserve, Southern California, USA**

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**Abstract**

This study combines petrological, clay mineralogical, and statistical methods to characterize a polygenetic weathering profile located in the Santa Margarita Ecological Reserve, Temecula, California. Clay mineralogical study identifies large quantities of kaolinite within saprock, and subsequent thin section analyses show minimal alteration of primary igneous minerals along with an extensive, clay-lined fracture network. Such observations imply that kaolinite was illuviated onto the walls of the fracture network, and was thus derived from an exterior source.

Non-central principal component analysis allows for the statistical modeling of compositional linear trends within the system along with the ability to calculate illuviation intensity values, $t_i$. The latter parameter describes the intensity of compositional change relative to the original parent (e.g., the composition of the fractured saprock rind compared to the corestone) as a result of the translocation of kaolinite into the system. Based on petrological and clay mineralogical observations, we model three separate linear compositional trends, in which the fractured saprock rind is derived from underlying corestone, the upper saprock is derived from the fractured saprock rind, and the overlying pebbly sandy loam is derived primarily from corestone. For each respective compositional linear trend, principal component 1 explains 98.7%, 99.4%, and 99.1% of the spread of A-CN-K data about the trend (i.e., the variance).

Elemental mobility tests identify suitable candidates for immobile reference frame elements for each of the three separate alteration trends. Mass balance calculations are used to

show the relative percent increases and decreases of each element, the amount of mass lost on ignition (LOI), and the changes in bulk mass. Bulk mass changes of 20 ± 6%, 11 ± 8%, and -28 ± 6% are calculated for the fractured saprock rind, upper saprock, and pebbly sandy loam, respectively.

These observations and data indicate that the majority of chemical changes within the fractured saprock rind and upper saprock are the direct result of kaolinite being suspended in a higher eroded-away section of regolith that was undergoing leaching and then transported downward, where it was then illuviated onto the walls of the saprock crack system. In contrast, the weak to modest alteration of plagioclase and the transformation of biotite to vermiculite cannot alone explain the abundance of kaolinite within the pebbly sandy loam. Therefore, given a colluvial origin, much if not all of the included kaolinite within the pebbly sandy loam is likely inherited from the section of the saprock that served as the partial source of detritus for the pebbly sandy loam. The mixing of translocated kaolinite with weakly altered granodioritic parent rock produces distinctive compositional linear trends in p(A)-p(CN)-p(K) space. If the presence of such material were to go undetected, an investigator might infer a much higher degree of chemical alteration than is actually present. Such errors can be avoided through the holistic petrologic, clay mineralogic, mathematic, and statistical approach exemplified by this case study.