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Relationships between reddening and soil magnetic properties as indices for the weathering of tropical soils

Holger Preetz (1), Jacqueline Hannam (2), and Jan Igel (1)

(1) Leibniz Institute for Applied Geophysics, Hannover, Germany (Holger.Preetz@liag-hannover.de), (2) Department of Natural Resources, School of Applied Sciences, Cranfield University, Cranfield, MK43 0AL, U.K. (j.a.hannam@cranfield.ac.uk)

Soil magnetic susceptibility is caused by the presence of ferrimagnetic Fe- and Fe-/Ti-Oxides such as magnetite, titanomagnetite and maghemite that are stable in soils and can accumulate due to their resistance to weathering. Macro-sized ferrimagnetic minerals tend to be of lithogenic provenance and weather directly from basic igneous rocks. Ultrafine grained ferrimagnetic minerals are thought to form during pedogenesis and can be identified by their superparamagnetic (SP) behaviour. Quantifying SP behaviour by measuring frequency dependent (FD) magnetic susceptibility can potentially provide a proxy for soil formation and weathering in certain environments. There are very limited magnetic measurements of tropical soils and we investigated a unique dataset of 506 samples from tropical regions. Samples included topsoils, subsoils and weathered and unweathered parent rock from lateritic soils from the entire tropical belt representing a variety of soil parent materials: ultrabasic magmatic rocks, basic and intermediate magmatic rocks, acid magmatic rocks, clay and clay slate, phyllite, sandstones. The relationship between magnetic measurements and redness rating was investigated as a potential indicator of tropical soil development, particularly lateritic processes. Soils from ultrabasic and basic parent materials showed little correlation between FD susceptibility and RR due a strong lithogenic overprint and a potential input of lithogenic SP material. This influence is likely to derive from a relative enrichment, indicated by higher magnetic values from pedogenic samples compared with unweathered parent material. The enrichment of weathering resistant ferrimagnetic iron oxides is concordant with lateritic processes for enrichment of other elements such as Al. Soils from clay and clay slate show positive correlations primarily due to diminished inputs from lithogenic sources. In this instance, RR and FD susceptibility could be used as proxies for neoformation of hematite and SP ferrimagnetic iron oxides respectively. Pedogenic hematite has been suggested to derive from the transformation of ferrimagnetic minerals, hence as hematite content increases, magnetic properties should decrease. The coexistence of hematite and ferrimagnetic minerals after such long weathering histories in the clay-derived laterites suggest other pathways may operate during tropical weathering and laterite formation. However, colour saturation may occur in the RR measurements as hematite content reaches large concentrations.