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The role of geology and climate in soil nutrient variability - potential drivers for large ungulate migrations in the Serengeti ecosystem (Northern Tanzania, East Africa)

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The East African Serengeti ecosystem hosts a great range of mammals and one of the world's largest seasonal ungulate movements, with over 1.3 wildebeest and several hundreds of thousands of zebras and antelopes migrating through the region in a regular pattern. While climatic and biological drivers for this migration have been studied in great detail, the role of rock chemistry, weathering and resulting soil diversity as a source for nutrient provision has so far been largely neglected and needs detailed and systematic study.

Geological processes provide important controls on long-term ecosystem dynamics. Volcanic eruptions, earthquakes, and rock weathering influence soil edaphic properties, which represent the ability of soils to provide vital plant-available nutrients, which therefore control grazing patterns of herbivores, particularly during birthing and lactating seasons. Studying the geological role in providing and distributing essential nutrients is critical to understand long-term drivers and stability of animal migrations in dynamic ecosystems. We have carried out a field reconnaissance study in the Serengeti National Park, with the aim to study variations in nutrient variability in soils and vegetation in relation to the chemical composition of soil parent material, i.e. volcanic or metamorphic rocks and sediments derived from those rock units, and under consideration of climatic variations. First results show that the Serengeti ecosystem can be subdivided into three geo-edaphic subregions that correlate with seasonal wildebeest grazing habitats.

(1) The southeastern Serengeti (wet-season grazing), is characterized by soils developed on volcanic ash derived from recent eruptions of the Ol Doinjo Lengai carbonatite volcano. Here, we have identified deeper organic-rich soils with andic and vitric properties and varying amounts of carbonate concretions or near-surface calcrete horizons. High Na, K, and Ca levels of volcanic ashes suggest high levels of those elements in soils and vegetation in this region, also because the precipitation is lowest in this area.

(2) In the central Serengeti (short-term transitional grazing), soils develop on Archean basement rocks including granitic gneisses, phyllites and banded iron formations. Geochemical signatures of

these rock types suggest that soils in this region have lower levels in Ca, Mg, and plant available P, compared to the SE Serengeti, which is supported by the transitional nature of this grazing habitat.

(3) Soils in the Northern Serengeti (dry-season grazing) develop on a diverse patchwork of Archean basement rocks as well as basaltic lavas and thick fluvial deposits. North of Mara river, the Insuria fault – a large normal fault of the East African Rift - creates a wide sedimentary basin dominated by soils developed on basaltic sediments. Here, higher precipitation leads to stronger weathering and leaching of nutrient elements.

Our preliminary results suggests that geochemical variations together with continuous (syngenetic) pedogenesis through active volcanism or tectonic faulting and related fault scarp erosion created regions of high edaphic quality in the north and southeast of the Serengeti ecosystem, and that the patchy nature of soil edaphics is important to understand the underlying drivers of large scale migration of grazing animals in this region.