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Barefoot in Ethiopia: Identifying potential minerals and environmental factors contributing to podoconiosis

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Podoconiosis (non-filarial elephantiasis) is a non-communicable, yet entirely preventable, disease that is endemic in tropical regions[1]. It is a chronic, debilitating disorder that occurs after prolonged barefoot exposure to irritant red clay soils derived from volcanic deposits[2]. Podoconiosis affects some of the world's poorest populations, its occurrence contributes to economic burden[3] and social stigmatisation, and the World Health Organisation recently designated it as a Neglected Tropical Disease.

Podoconiosis is highly prevalent in Ethiopia where it is known to affect up to 1 million people, and it is thought that approximately 11 million people (18 % of the population) reside in endemic areas. Previous work by Price et al. showed that colloid-sized particles (Al, Si, Mg, Fe) were found in the tissues of individuals living on red clay soils in Ethiopia[4], and electron microscopy identified stacked kaolinite in macrophage phagosomes[5]. Frommel et al identified raised levels of Zr and Be in a limited number of soil samples from an endemic area in southern Ethiopia compared with a neighbouring non-endemic area[6].

Our team of geochemists, geologists, medical doctors and epidemiologists has developed a new, inter-disciplinary field approach that combines geological and epidemiological sampling principles to allow soil and rock sampling based both on disease status and topographic factors. This approach was piloted in East Gojjam zone, north-western Ethiopia plateau in Oct-Dec 2011: an ideal place to investigate the transition from podoconiosis endemic to non-endemic area. In brief, traverses were selected according to both disease distribution and known geological variation, and soil samples were taken at predetermined intervals governed by altitude and distance. Traverse sampling was accompanied by soil sampling from plots of case and control households within areas of high and intermediate disease endemicity, and by sampling from vertical rock sections. Traverse soils have been fully characterised, to determine their mineralogy, including minor and major elemental composition, crystalline and amorphous components and particle size in order to identify a geological signature that may be typical in the soils where disease is endemic. The samples have also been tested in vitro using the haemolysis assay, which is an effective preliminary screening test for particulate toxicity.

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) imaging showed that many of the particles are fine to ultrafine in size. Particle size analysis, using laser diffractometry confirmed a large proportion of particles within the fine fraction (i.e. <2.5 μm in diameter). Mineralogical and chemical characterisation demonstrated that the soils from podoconiosis-endemic areas have elevated levels of titanium, quartz and are predominantly clay-rich, predominantly kaolinite and smectite. The haemolysis assay suggests differences in particulate toxicity between endemic and non-endemic soils.

Our research indicates that fine clay minerals could potentially play an important role in disease initiation. Although these studies are still preliminary, they have already challenged the few pre-existing hypotheses surrounding the etiology of podoconiosis. Our continued study of the geological characteristics that may be linked to podoconiosis, combined with parallel studies into the genetic susceptibility[7], will increase both awareness of the disease and the likelihood of prevention.

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