THE DYNAMICS OF SOILS IN NORTH QUEENSLAND: RATES OF MIXING BY TERMITES DETERMINED BY SINGLE GRAIN LUMINESCENCE DATING

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INTRODUCTION

Charles Darwin drew attention to the role of earthworms in the formation of the upper, organic-rich horizons of soils. He concluded (Darwin 1837) that progressive slow burial of objects, originally at the surface, could be explained by *'the large quantity of fine earth continually brought up to the surface by worms in the form of castings'*. Darwin (1881) calculated rates of surface accumulation by weighing worm casts that accumulated in small areas (typically about 1 m^2) over a year, and also by measuring the burial depth of objects, originally at the surface, over periods of up to 30 years. Calculated rates of surface accumulation were 2-5 mm/year.

Since that time, the role of soil biota in soil mixing has become well established, particularly the role of termites (e.g. Lee & Wood 1971). Mixing, or turnover of soils by biota (usually referred to as bioturbation) plays a key role in nutrient cycling. Coventry *et al.* (1988) estimated that rates of surface soil accumulation, averaged over the building and erosion of one generation of termite mounds in the Charters Towers area of north Queensland, were in the range of 0.018 to 0.025 mm/year. Somewhat higher rates (0.05-0.4 mm/year) were reported by Lee & Wood (1971) and Williams (1968), from sites in the Northern Territory. In this study we use Optically Stimulated Luminescence (OSL) dating of individual quartz grains to determine long-term rates of soil mixing, principally by termites, near Hughenden in north Queensland.

FIELD AREA

Soils were located on a series of basaltic lava flows in the Sturgeon Volcanic Province, near Hughenden, where flow ages are established up to 6 Ma by whole-rock K/Ar dating. Present-day climate in the field area is semi-arid tropical. Mean annual rainfall is between 500 and 550 mm, with 80% falling in the summer monsoon months (October to March). Mean annual temperatures are in the range 23-25°C. Regional vegetation, which has been partially cleared for cattle grazing, is an open savanna woodland dominated by *Eucalyptus* and *Acacia* trees with a ground cover of tussock grasses.

Two broad groups of soils were studied: Black soils (Vertisols), dominated by smectite clays, which occur in areas of impeded drainage and show evidence of shrink-swell activity; and red soils (Lithic and Oxic Ustropepts), dominated by kaolinite clays, that are typical of well drained sites and are extensively colonised by mound-building termites. Pillans (1997) calculated long term rates of soil formation of 0.30 m/Ma for the red soils. Paleomagnetic data show that lower parts of some of the red soil profiles have reversed polarity; indicating that termite activity is depth-limited (about 60-80 cm). In contrast, the black soils have normal polarity throughout, with shrink-swell mixing extending to the base of the profile. The soils contain allochthonous quartz sand grains derived from adjacent Mesozoic sedimentary rocks.

RESULTS

In four red soil profiles and one black soil profile, mean luminescence ages of quartz grains increase with depth (up to 44.7 ka in the red soils and 11.3 ka in the black soil at 80 cm depth); standard deviation of mean age also increases with depth.

In the simplest (Darwinian) model of bioturbation, soil particles are brought to the surface by termites to construct mounds, which are subsequently eroded and the material spread evenly across the surface. Exposure at the surface resets the luminescence signal in individual grains, which then undergo slow, progressive burial by later mound-derived material (Figure 1). The results of a Monte Carlo simulation model of bioturbation will be discussed in the light of our OSL data.

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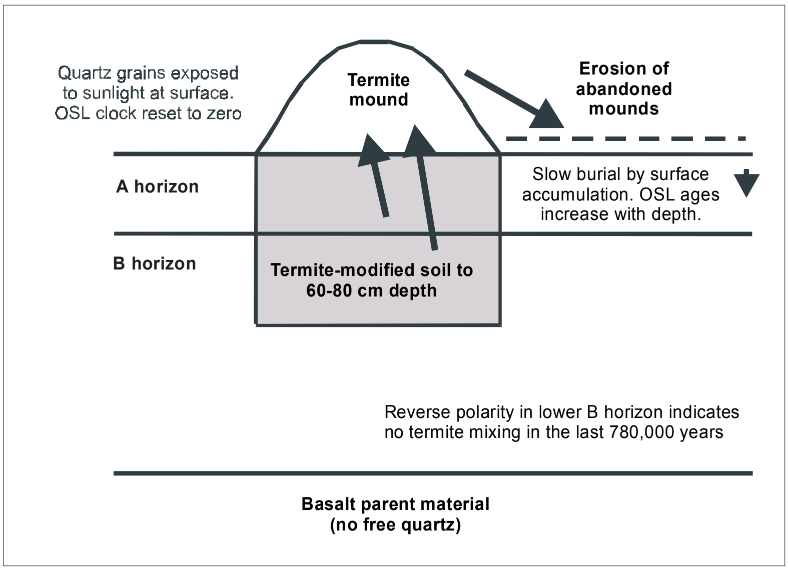

Figure 1: Mixing by termites in basaltic soils of the Hughenden area, North Queensland

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