INVESTIGATIONS OF FERRICRETES AND WEATHERED ZONES IN PARTS OF SOUTHERN AND SOUTHEASTERN AUSTRALIA - A REASSESSMENT OF THE 'LATERITE' CONCEPT

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ABSTRACT

A review of the local literature on materials described as 'lateritic' in southern South Australia reveals much confusion about the identification, nature, age and formation of 'laterite'. However, the pedogenic model of the 'normal laterite profile' (Stephens, 1946), with genetically associated horizons of 'laterite', mottled and pallid zones, has dominated interpretations of 'lateritic' materials. According to this model 'laterite' developed on 'peneplain' surfaces in the Tertiary, under humid tropical climates, both through downward leaching and upward movement of dissolved iron and aluminium oxides, by capillarity and associated fluctuating water tables. There have been few attempts to apply alternative models of 'laterite' formation, such as those involving landscape downwasting.

This thesis investigates 'laterite' (here termed 'ferricrete'), and weathered, mottled and bleached zones of the regolith, by utilising a multi-faceted approach that involved field investigations of the relationships of these to each other, to geology, geomorphology, topography, pedology, and where possible, to hydrology. Laboratory work on samples of the ferricretes and associated materials was undertaken to determine their chemical and mineralogical compositions and micromorphological characteristics.

The major area of study has been the South Mount Lofty Ranges, both on the mainland and Kangaroo Island, where three major types of ferricretes were identified, namely, ferricreted bedrock, ferricreted sediments, which include both clastic quartzose sediments and organic materials (vesicular ferricrete), and ferricretes of complex sedimentary and pedogenic origins. Among the complex types several varieties have been noted that include pisolitic, nodular, slabby and vermiform ferricretes. Laboratory analyses of these different varieties of ferricretes allow them to be distinguished on the combined bases of bulk chemical and mineralogical composition and degree of aluminium substitution in the crystal structure of goethite, which is the most common iron oxide in the ferricretes studied. These factors probably reflect environmental conditions during their formation and subsequent transformations. These findings are generally supported by micromorphological and limited microprobe studies as well as by considerations of synthesis experiments on the pathways of formation of iron and aluminium oxides as reported in the literature.

Ferricretes in the areas studied all appear to be younger than the immediately underlying 'companion materials' of Stephens (1971), rather than being of the same age and monogenetically related to them. Diverse forms of ferricrete appear to have developed in different environments through the operation of a range of processes. For example, some ferricretes have formed by the *in situ* weathering transformation of pre-existing minerals such as siderite, pyrite and glauconite to secondary iron oxides such as goethite, hematite and lepidocrocite. Some other ferricretes developed as a result of the accumulation and iron oxide cementation of iron-rich materials such as pisoliths and fragments of mottles, transported into relatively low topographic points. Other types have formed by the precipitation of ferrous iron from solutions, dominantly forming goethite, filling voids or replacing interclast clays in pre-existing porous clastic and/or organic sediments. Such ferricretes formed in localities such as low angle valley sides, valley bottoms and swamp, lacustrine or peritidal environments.

So-called 'laterite profiles' are typically incomplete vertically, and there is no convincing evidence for the former existence of extensive and continuous ferricretes over 'peneplained' surfaces in the regions studied. Here, weathering and erosion appear to have affected a landscape of greater relief than the equivalent modern landscape, with salients of resistant bedrock protruding above differentially weathered and ferruginised undulating landsurfaces. Some profiles are actually sedimentary sequences, which might simulate the 'normal laterite profile', and some include calcareous horizons and channel fill deposits that demonstrate multigenetic origins for the profiles. Many profiles lack ferricrete crusts, and this was widely interpreted in the past as evidence for truncation of the profile, but the view expressed here is that the crust may never have been present. Under some conditions, lags of hardened mottles accumulated at the surface during landscape downwasting and have been indurated to form a ferricrete younger than the underlying weathered and mottled material. Many alleged fossil bleached sandy 'lateritic' A-horizons are actually modern soils or the result of aeolian activity.

Chemical analyses of both surface and sub-surface samples of mottled zone materials suggest that the mottles developed by the weathering of bedrock under the influence of ground water, leading to the release of iron from the bedrock and its concentration as hematite in mottles, probably via the mineral, ferrihydrite. Some borehole data suggest that weathering has led to the detailed and local concentration of iron oxides, but has not resulted in massive vertical translocations of iron oxides.

There is limited evidence for the *in situ* formation of pisoliths in the study area; the majority of them are interpreted to have developed by the breakdown, transport and pedogenetic modification of former ferricretes and/or ferruginous mottles. Even where there is evidence of sub-surface *in situ* pisolith formation, pisoliths at the surface have distinctively different physical, mineralogical and chemical characteristics. Bushfires are important in influencing these changes.

Evidence from the Mount Lofty Ranges suggests that there are similar types of ferricretes on both upland and lower level surfaces. Particularly on the latter they can be dated relatively with respect to rocks and sediments of known ages. In some cases the occurrence of ferricretes has facilitated better palaeogeographic reconstructions as some represent iron oxide-impregnated sandy Tertiary shoreline sediments, preserved well above the level of the associated submarine fossiliferous limestones. Consequently, the locations of these palaeoshorelines can be determined more precisely. Rocks and sediments ranging in age from the Precambrian to the Holocene display different degrees of weathering and ferruginisation, suggesting iron mobilisation and precipitation over immense periods of geological time up to and including the present. These data confirm the interpretation of weathered zones and ferricretes as complex polygenetic features, developed and modified over long spans of time, and cannot simply be interpreted in terms of inheritance from discrete ancient weathering events of short duration. Consequently it is impossible to generalise with respect to a particular time of 'lateritisation', or to associate ferricretes unequivocally with past humid tropical climates. The character of any ferricrete reflects the integrated effects of continual weathering and erosional processes, active to the present day, so that the preservation of ancient pristine ferricretes in the current landscape is unlikely.

The findings generated from investigations in the Mount Lofty Ranges were tested and extended by studies on Eyre Peninsula, the western Otway Basin, the North Sydney area and in the Telford Basin of the Flinders Ranges. In many cases re-interpretations of previous studies by other workers in these areas have been made.