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2006

## The character and genesis of pedogenic calcrete in southern Australia

Paul Grevenitz  
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The Character and Genesis of  
Pedogenic Calcrete in  
Southern Australia

*\*A thesis submitted in fulfilment of the  
requirements for the award of the degree*

DOCTOR OF PHILOSOPHY

from

UNIVERSITY OF WOLLONGONG

by

Paul Grevenitz BSc (Hons)

School of Earth and Environmental Sciences

March 2006

### ***Certification***

I, Paul Grevenitz, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Earth and Environmental Sciences, University of Wollongong, is wholly my own work except where otherwise acknowledged. The document has not been submitted for qualifications at any other academic institution.

Paul Grevenitz  
March 2006

## **Abstract**

Pedogenic calcrete profiles from temperate, semi-arid and arid regions of southern Australia show a diversity of forms, both in large-scale structure and texture determined in the field, and microstructures as determined by thin-section and scanning electron microscopy. Accumulations of microcrystalline calcite with varying degrees of cementation are typical of the majority of samples regardless of texture or form. Calcified filaments are prevalent at a micro-scale in the upper sections of most profiles, occurring as laminated coatings and channel infillings in hardpan calcrete, pisoliths and nodules. Organic matter occurring as filamentous and dendritic masses is commonly found associated with the calcified filaments and the formation and growth of the filaments are considered to cause the brecciated and pisolitic textures common in mature pedogenic calcrete.

Rhizogenic calcrete occurs in various host materials as taproot fragments with either dense grey micritic cement and microspar crystals which are larger adjacent to enclosed quartz grains, mottled dense micritic and microsparitic calcrete or alveolar-like fabrics. Root-formed channels are also prevalent in many indurated nodular and hardpan samples. Discrete and incipient calcrete nodules containing alveolar fabrics and microcodium grains and platy pedogenic calcrete containing fenestral microfabric were also observed. Needle-fibre calcite is present as the dominant component in some profiles, occurring as discontinuous semi-indurated channel fillings and sheets. The morphology of their occurrence suggests rhizogenic influence in their formation.

The collected samples are analysed for stable carbon and oxygen isotopic composition in order to determine if there are detectable differences across regions of different climate and host material. Many samples show within-sample variability with biogenic or rhizogenic features co-existing with micritic overgrowths and cements. In order to examine the relationship between pedogenic calcrete type and method of formation, carbon and oxygen isotopic measurements were taken from numerous sub samples within each sample to determine the extent of variation in isotopic composition within individual samples. The total spread of values is -1.0 to -12.5‰ and 2.0 to -10‰ (standard delta notation versus PDB) for carbon and oxygen isotopic composition, respectively, for all samples with large sample variation and positive co-

variation as displayed by multiple sample aliquots commonly observed. The results suggest within-sample variation caused by different and coexisting cement types, with contribution of heavy carbon by calcified filaments and carbonate precipitated through carbon dioxide degassing, and light carbon contributed by rhizogenic influences. The positive co-variation in carbon and oxygen is not depth related and indicates a simple mixing line between two end-members with differing isotopic compositions, possibly due to concomitant evaporative enrichment and carbon dioxide degassing in different carbonate cement phases. Soil organic matter carbon analysed for isotopic composition shows relative little variation across the climatic zones and no correlation with coexisting carbonate carbon isotopic composition.

Selected pedogenic calcrete samples developed in soils overlying radiogenic basement rocks from sites in arid and semi-arid western South Australia and Western Australia are analysed for  $^{87}\text{Sr}/^{86}\text{Sr}$  in order to evaluate the contribution of calcium derived from silicate weathering to pedogenic calcrete. Fresh parent materials collected at the sites show  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios ranging from 0.7100 to 0.7993 and pedogenic calcrete  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios ranging from 0.7106 to 0.7198. Samples from sites in coastal and inland South Australia have  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios close to marine values (0.8093) indicating low calcium contribution from bedrock. Samples from Western Australia have variable and higher  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios indicating considerable calcium input for parent material and bedrock.

Whole rock pedogenic calcrete and host material sampled in profiles were analysed by X-ray diffraction to determine mineralogical composition and then determine relative changes in carbonate composition within the profile. Samples were further analysed by instrumental neutron activation analysis for a suite of major and trace elements and subjected to a variety of statistical tests to determine the phase relationships of the elements to each other and, in particular, calcium within the pedogenic calcrete profile. Most elements are found to be associated with residual phases such as clay, feldspar and iron oxide correlation to calcium, in some samples, and therefore are of possible interest in geochemical exploration as pathfinder elements in the search for buried ore deposits.

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