

PEDOGENIC CARBONATES, STRONTIUM ISOTOPES AND THEIR RELATIONSHIP WITH AUSTRALIAN DUST PROCESSES

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Approximately 21% of the Australian land surface is covered by pedogenic carbonates (Figure 1) that have formed in soils, saprolite, sediments and similar regolith materials (Chen *et al.* 2002). These carbonates are abundant in much of the semi-arid and arid regions of Australia and are a significant continental sink for calcium (Ca). The Ca may be derived from either *in situ* weathering of bedrock or external atmospheric sources. Identifying the relative mixtures of these two end-member components has important implications for understanding the behaviour of Ca in the continental weathering cycle.

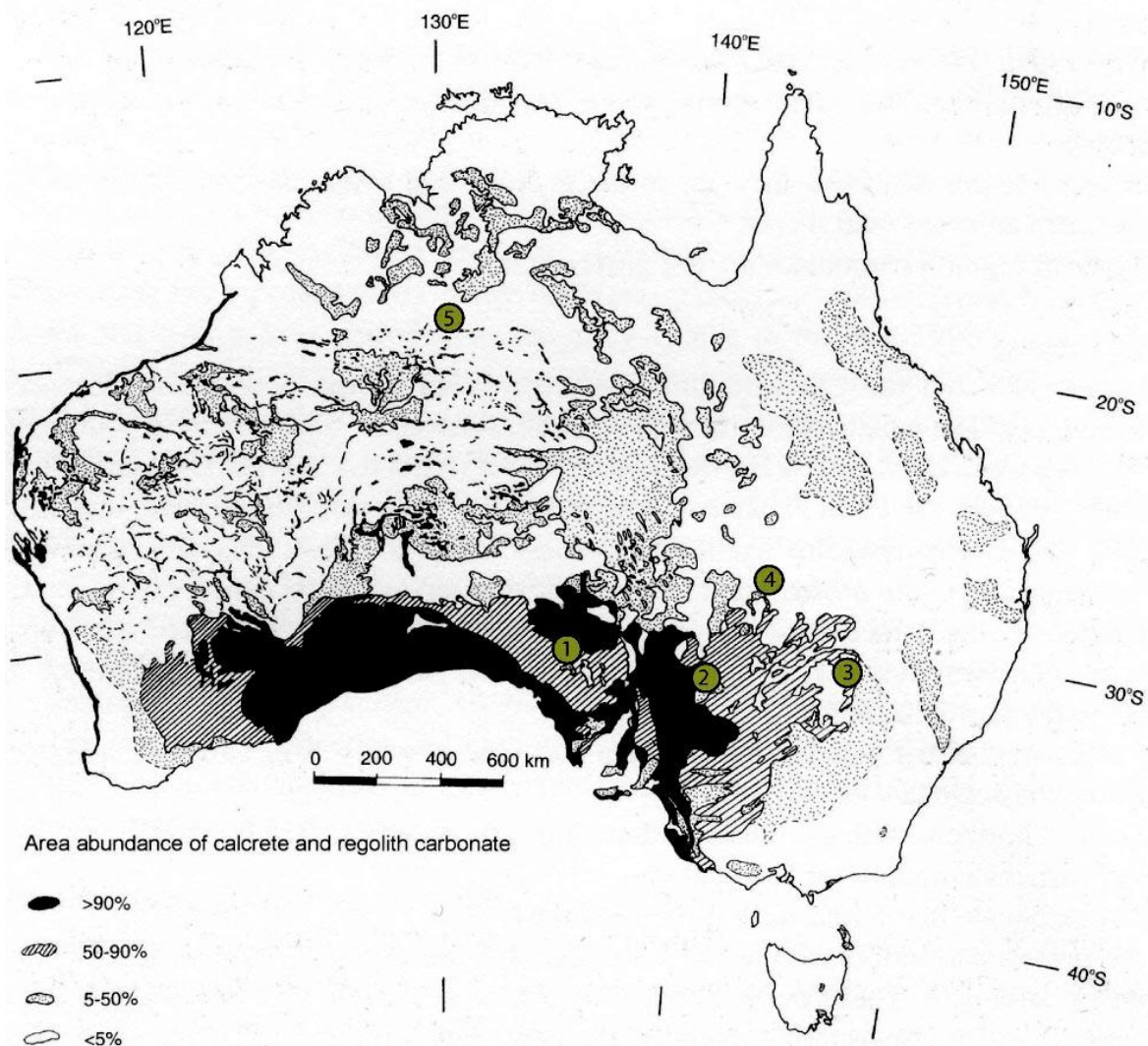


Figure 1: Location map and interpretive distribution of regolith carbonates, adapted from Chen *et al.* (2002). 1. Tunkillia, 2. Olary, 3. Cobar, 4. Tibooburra and 5. Tanami.

Work presented here uses strontium (Sr) isotopes ($^{87}\text{Sr}/^{86}\text{Sr}$ ratios) as a tracer for the Ca to identify these sources. This technique has been utilised by researchers in other arid/semi-arid regions including Chiquet *et al.* (1999) in Spain and Naiman *et al.* (2000) and Van Der Hoven & Quade (2002) in the southwest United States). In order to identify the source region of the Sr it is necessary to know the values of signature Sr ratios of end-member components. The Sr isotope ratio for modern oceans is 0.70918, while bedrock ratios depend on the age and type of bedrock. However, with much of the bedrock in Australia being Archaean to Proterozoic in age, values of 0.8 or above are common. This project proposes to identify the sources of Ca in

pedogenic carbonates throughout the Australian arid zone.

The component of interest in pedogenic carbonates is the Ca and Sr of the carbonate minerals and labile fraction, i.e., the cations adsorbed to organic matter or clay surfaces. This component is extracted with a weak acetic acid solution. The remaining residue consists of minerals that are not as susceptible to chemical weathering. These minerals will over time contribute cations to the labile fraction as they are weathered.

The idea of an aeolian source of Ca in southern Australia was first hypothesised by Crocker (1946). He suggested that wind erosion of the southern Australia continental shelf, which was exposed during times of low eustatic sea level, and the reworking of coastal calcareous dunes, was the source of the calcareous material common throughout South Australia. The continental shelf along southern Australia is the world's largest region of cool-water carbonates (James *et al.* 1994), which makes it a viable source area and supports Crocker's hypothesis.

The importance of dust transportation and deposition has been recognised by many researchers. Subsequent to Crocker's hypothesis on the source of calcareous material in south Australia, clayey and calcareous material was described and given the name *parna*, because it did not fit the true definition of loess, by Butler (1956). Butler describes parna as being a major component in the soils of south-eastern Australia. In more recent times considerable work has been undertaken on the sources, sediment loads, travel paths and content of dust in Australia (see Knight *et al.* 1995, McTainsh *et al.* 1998, Hesse & McTainsh 2003, Hesse *et al.* 2004). In contrast to parna described by Butler (1956), McTainsh & Duhaylungsod (1989) describe the principal component of Australian dust and dust deposits as silt sized quartz that is a very well sorted population with a clear modality not found in other soils.

The soils of south-eastern Australia show the strongest evidence of dust deposits (Hesse & McTainsh 2003). This fits in well with the southern dust path recognised by Bowler (1976) (Figure 2). However, despite dust raising and dust storms, no dust deposits have been positively identified in the Northern Territory (Hesse & McTainsh 2003). A large part of dust deposited is later removed by further dust transport or fluvial activity resulting in great variability in the dust deposit thickness over a region (Hesse & McTainsh 2003). Two modern source areas, the Lake Eyre Basin and the western sector of the Murray Darling Basin have been suggested by Hesse & McTainsh (2003).

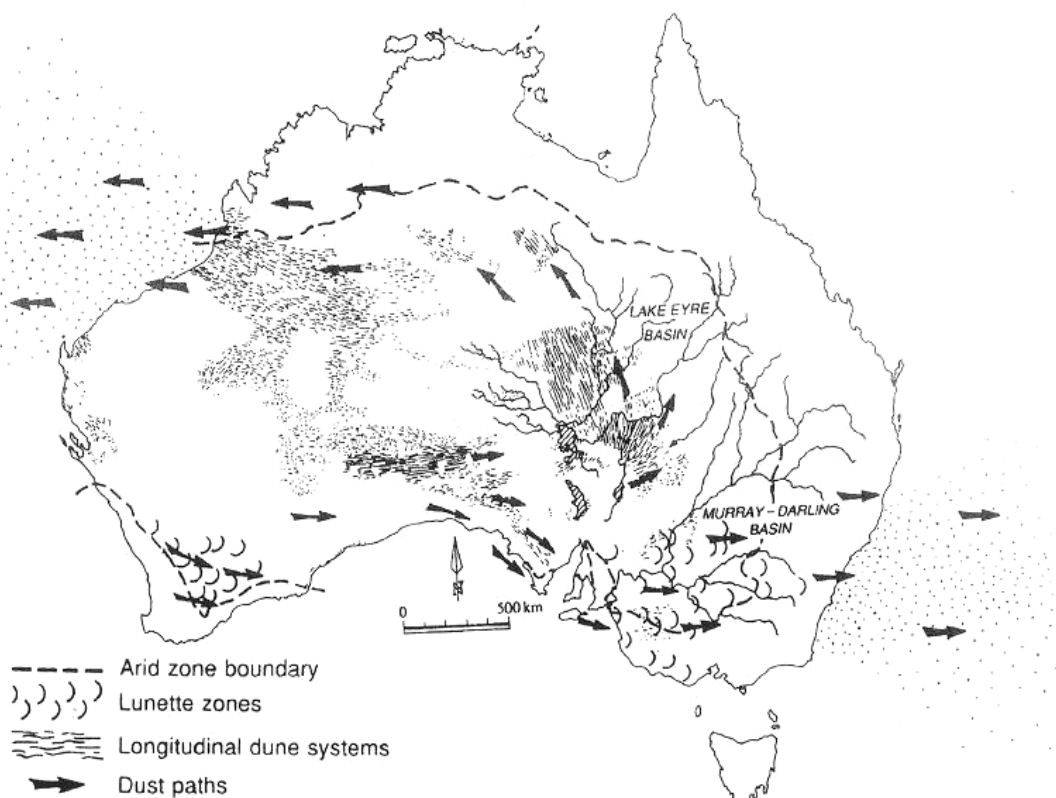


Figure 2: Australian dust paths, modified by Hesse & McTainsh (2003) after Bowler (1976).

Analysis of the Sr isotope ratios from pedogenic carbonates collected from the Tunkillia region in the central Gawler Craton, Olary region in the southern Curnamona province, Tibooburra and Cobar (NSW) (Figure 1) all show a dominant marine input with average ratios of 0.7113, 0.7151, 0.7145 and 0.7136 respectively. Apart from Tunkillia, which is located closest to the continental shelf, Olary, Tibooburra and Cobar are all very similar suggesting that a plateau may be reached once a certain distance is reached from the coastal source area.

Samples have also been analysed from the Tanami region in the Northern Territory (Figure 1). The average ratios for this area are significantly higher at 0.7292, however, this is still relatively low compared with typical Precambrian bedrock values of 0.8 or above. The difference between this region and those in the south may be due to a larger influence from *in situ* bedrock rather than an aeolian source, or differences in climatic conditions that have resulted in a different carbonate formation process. Further analysis of Sr isotopes of bedrocks and pedogenic carbonates in and near the Tanami area will assist in providing answers to this problem.

Along with the regional analyses, two profiles have also been sampled from the White Dam prospect in the Curnamona province. The Sr isotope ratios through these profiles show values that are consistent with a largely marine signature until the saprolite is reached. In one profile this is at a depth of ca. 2 m and includes a potential palaeosurface, which, significantly, has no influence on the ratios. We infer that either the amount of Ca released from the bedrock is insignificant or Ca that is released from silicate weathering is being removed from the system before it is incorporated into carbonate. In either case, the bedrock Sr is in such a small quantity compared with the aeolian Sr that it does not have a measurable effect on the Sr isotope ratio. Once Ca is deposited on the surface it is quickly mobilised, most likely through dissolution by rainwater, and transported through the profile where it is precipitated as the water is evaporated. This is likely to be a continual process and explains the uniformity of the Sr isotope ratios throughout the profile. The other point that becomes clear is that Ca from the weathered saprolite remains within the saprolite and has very little influence in the overlying pedogenic carbonates.

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