# FINGERPRINTING AUSTRALIA'S RIVERS USING CLAYS AND THE APPLICATION FOR THE MARINE RECORD OF RAPID CLIMATE CHANGE

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The weathering and erosion of continental rocks provides a reservoir of terrigenous minerals, which are easily transported and eventually end up in the surrounding oceans. Clay minerals constitute a major part of these weathering products. They reach the surrounding oceans incorporated in aeolian dust or in the suspended loads of rivers discharging into the sea. As clay minerals in ocean sediments are almost exclusively derived from continental erosion, they provide a link between land and ocean, and can be used to assess climate-related processes on land, such as intensity of weathering and the mode and intensity of transport processes. A prerequisite is the detailed knowledge of the provenance of individual clay mineral groups. In practical terms, that is the composition of dust blown out to sea, or the clay mineral composition of the suspended load of individual rivers discharging into the investigation area. Once the river load has entered the ocean it can be picked up by currents and carried a considerable distance out to sea. Thus, if a source of clay minerals such as a river is sufficiently recognizable and unique in its clay mineral composition, conclusions on the relative fluctuations of its discharge can be drawn, which in turn are related to climate changes in the drainage area. Additionally, if the pattern of clay minerals on the seafloor is known in sufficient detail, and if it can be related to current patterns, deviations in the clay pattern in sediment cores through time allows the reconstruction of the intensity and direction of palaeocurrents.

Successful palaeooceanographic and palaeoclimatic studies have been carried out in a number of ocean-wide as well as regional studies (Petschick *et al.* 1996, Diekmann *et al*. 1996, Gingele *et al*. 1996: Gingele & Leipe 2001), although for practical reasons the method is limited to the 4 main clay mineral groups smectite, kaolinite, illite and chlorite.

For the Australian continent and the surrounding oceans, studies have concentrated on the identification of dust in marine sediments. 2 major trajectories of dust transport into the Indian Ocean and the Tasman Sea were identified (Bowler 1976) and the concept of an intensified “Glacial Dustplume”, with kaolinite as a characteristic mineral, was established. No comprehensive information on the contribution of Australian rivers to ocean sediment was available. Consequently, an intensive sampling program was carried out in 2000/2001, collecting fine-grained sediment from more than 30 rivers around Australia and assessing the clay mineral composition of each river (Figure 1).

Surprisingly each river showed quite unique clay mineral patterns, although some originated in similar geological settings and climatic boundary conditions. Some of the river signals were so unique that they could be traced a long way out into the ocean. Two examples are the Victoria and Ord Rivers, which provide smectite-rich clays to the Bonaparte Gulf, and the chlorite-rich De Grey and Fortescue rivers, which drain the Pilbara and flood episodically. Nevertheless, their chlorite-rich suspensions can be traced in shelf and upper slope sediments. Picked up by the Leeuwin Current and carried past the Northwest Cape (Gingele *et al.* 2001) chlorite can be traced in a band in upper slope sediments for a considerable distance. Based on data from surface sediments, variations in the intensity and the path of the Leeuwin Current, and climate change on the adjacent Australian continent, have been reconstructed from sediment cores offshore NW Australia (Gingele *et al.* 2002).

More recently, a detailed regional study (AUSCAN) has commenced, aiming at reconstructing rapid climate change, palaeodrainage and sea level fluctuations in the Murray-Darling Basin and the Lacepede Shelf. The study is based on high-resolution sediment cores from the Murray Canyon area, south of Kangaroo Island. To evaluate the clay minerals in the core, the Murray and Darling Rivers and their tributaries have been sampled in detail and analysed for clay mineral composition (Figure 2). The Murray-Darling Basin drains about 1/7 of Australia and stretches over different climatic zones, weathering regimes and bedrock geology. Consequently some variability was expected in the clay mineral assemblages of the different rivers and tributaries. The Darling River and its northern tributaries are rich in smectite, whereas the upper Murray and its tributaries are richer in illite/mica, reflecting more physical weathering in Australian Alps. Kaolinite contents are similar in the Darling and Murray catchments and chlorite is patchy and very low, and can be neglected. Both rivers

*In:* Roach I.C. ed. 2003. *Advances in Regolith*, pp. 140-143. CRC LEME.

join and a mixed clay mineral signal enters the ocean. Nevertheless, the knowledge of the material in the source area can be used to interpret potential changes in the composition of the river load near the mouth and consequently in the sediment cores.

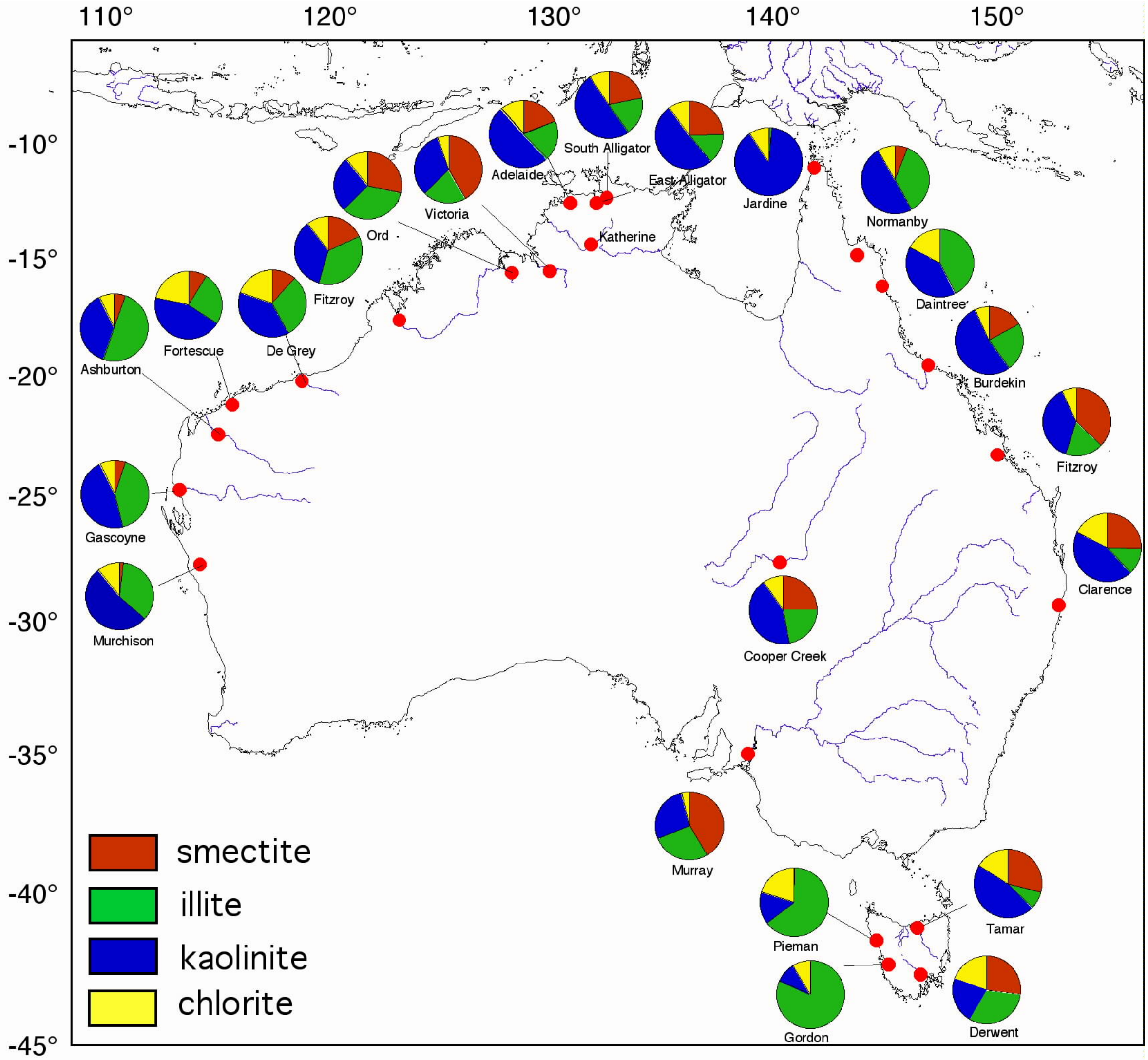


**Figure 1:** Clay mineral composition in sediments from selected Australian rivers. Each river has a unique clay mineral signature. The clay mineral suites show considerable differences, even in small, limited areas such as Tasmania, making it possible to investigate the contribution and propagation of individual point sources to ocean sediments.

Sediment core MD03-2607 was recovered from a gentle slope in the Murray Canyons area at 830 m water depth and covers the last 175,000 years. A stratigraphy was established based on τηε δ1$^{8}$O-record of the planktonic foraminifera *Globigerina bulloides* compared to the SPECMAP-stack.

The clay mineral records of kaolinite and smectite correlate with glacial-interglacial climate fluctuations, whereas illite is non-conclusive at a first glance. Smectite clearly increases in cold isotope stages and substages. As the river is the only substantial source of smectite, the fluctuations mirror a changing sea level and thus the proximity of the river mouth. Smectite contents, similar to those recorded near the river mouth today, are only reached in isotope stages 2 and 6, when sea level was below –120 m and the river mouth within 15 km of the core site. During warm stages and high sea levels, hardly any smectite reaches the core site, as the river mouth is more than 200 km away. The dominant mineral then is kaolinite, which is a characteristic mineral of aeolian dust. The kaolinite contents in the core are always well above any concentrations recorded in river sediments, thus attributing to a continuous supply of aeolian kaolinite. Kaolinite contents peak during warm periods, when sea levels are high and the overall terrigenous input is low. An increase in aeolian supply, as implied by the concept of a “Glacial Dustplume”, cannot be verified, because during glacials the proximity of the river mouth drowns the core site in fluvial sediment. Unusually high kaolinite contents are observed in the penultimate glacial, stage 6. As the other fluvial proxies smectite and clay/silt-ratio attest to the dominance of fluvial input during that time, we must assume a change in the clay mineral composition of the river load. We assume that a kaolinite-smectite-rich tributary joined the lower Murray River on the dry shelf during that glacial and was not available or took a separate course in the last glacial, stage 2. A possible candidate would be the "Palaeo-River Vincent" as described by Sprigg (1947), draining the Gulf of St. Vincent during low sealevels.

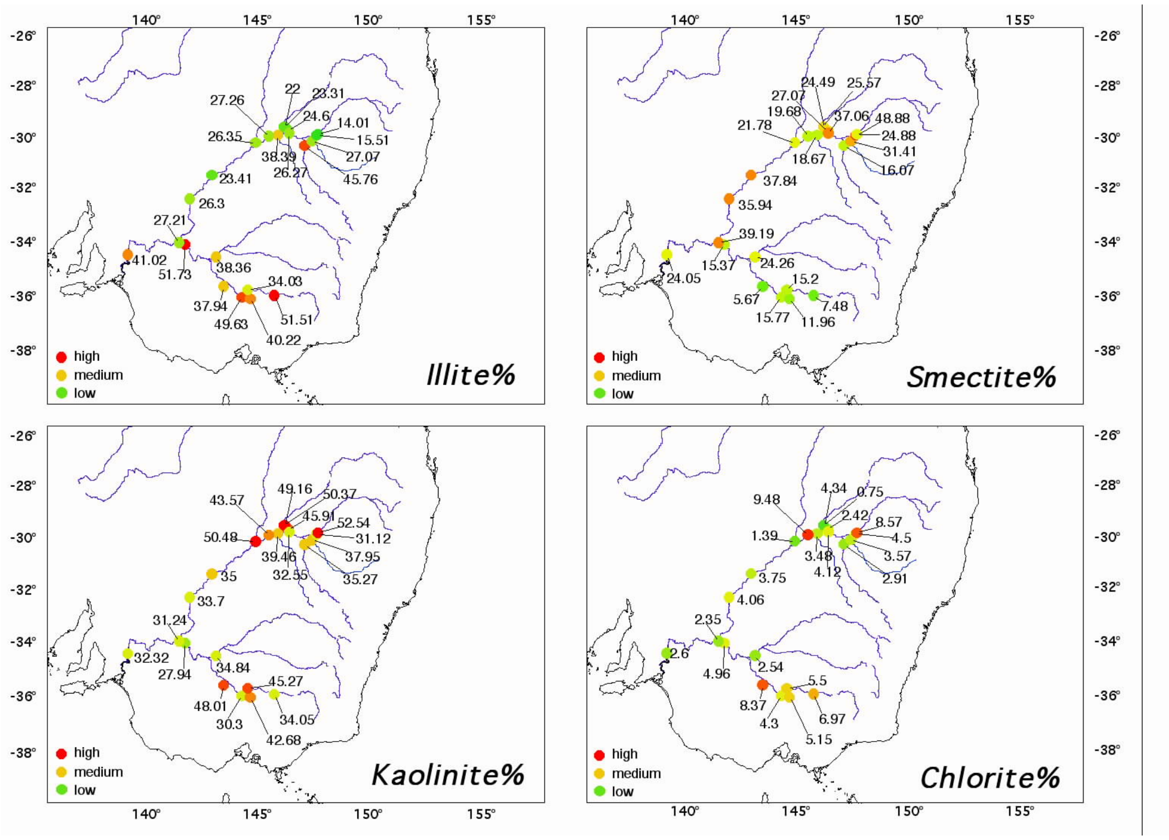


**Figure 2:** Clay mineral composition in 22 samples from rivers within the Murray-Darling Basin. Illite is more prominent in rivers draining the Australian high country, whereas smectite mainly originates in the northeastern Darling catchment. Kaolinite is more evenly distributed and chlorite is very low in concentrations and patchy.

As illlite occurs in the same concentrations in the river load as in aeolian dust (around 40%), changes in dust and fluvial input is not reflected in the illite record of the core. However, 2 conspicuous peaks occur near the stage 6/5 and the stage 2/1 boundary. We assume that they reflect a deglacial release of physically eroded material from Alpine glaciers and permafrost areas in the upper Murray catchment area.

Further sampling and clay mineral analysis will hopefully increase the resolution, and yield an even more detailed history of rapid climate and sea level change in the Murray-Darling Basin.

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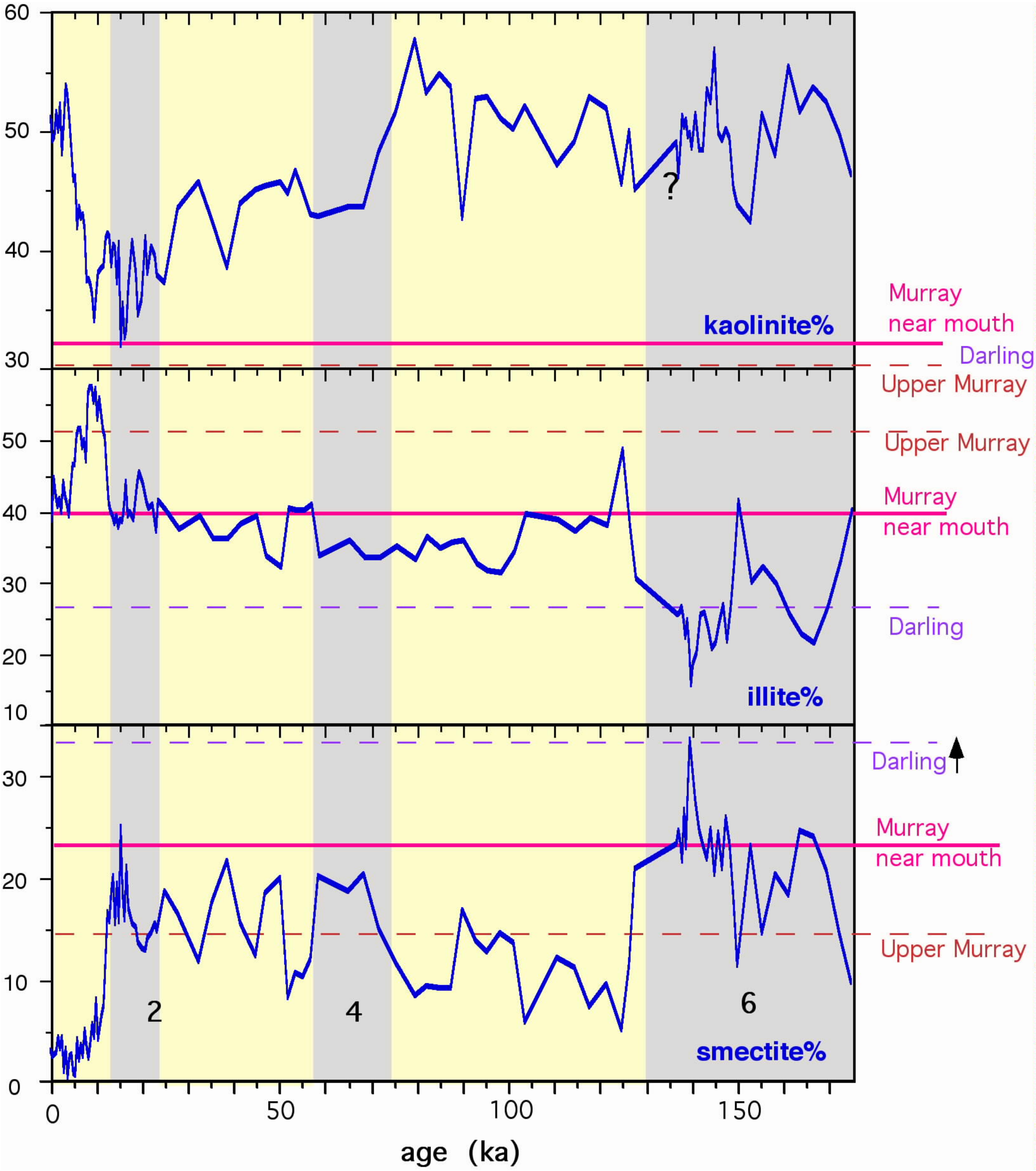


**Figure 3:** The 3 main clay minerals in core MD03-2607 from the Murray Canyons area for the last 175,000 years. Lines represent typical concentrations for the Darling and the Murray River before the confluence and for the Murray near the mouth.