AGSO Journal of Australian Geology & Geophysics, 16 (3), 323–324

Discussion: Landscape evolution and tectonics in southeastern Australia (Ollier & Pain 1994)

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Ollier & Pain (1994) have put forward an interesting and thought-provoking synthesis of Late Mesozoic and Tertiary landscape evolution in southeastern Australia. However, their interpretation of landscape evolution is presented "as a brief outline, without reference to sources" of evidence (p. 335). This is unfortunate, because, as a consequence, their paper sometimes lacks justifications for their conclusions. To convince the reader, their interpretation requires evidence from detailed studies of the highlands, like those of Young (1978, 1989), Bishop (1988), Gale (1992), and Nott (1992). These studies are "mostly confined to small areas" (p. 335) and Ollier & Pain maintain that "their relevance to the broader picture is not demonstrated." However, the "broader picture" of the whole landscape can only be built up from detailed studies of individual small areas; without them, a general explanation of the landscape evolution of southeastern Australia cannot be derived with any confidence.

Because of this lack of evidence in Ollier & Pain's paper, some parts of their model are unclear. We would like to concentrate on four aspects which we think are in need of amplification or revaluation.

1. Drainage reorganisation

Ollier & Pain have proposed that numerous river diversions accompanied the development of particular divides. However, detailed evidence for the diversions, e.g. palaeocurrent directions based on crossbedding measurements, or gradients calculated using the elevation of valley remnants or gravels, is apparently lacking. Thus, although much of Ollier & Pain's model may be correct, it is difficult to evaluate in detail. In particular, we believe that there are viable alternatives to some of their proposals.

It is unlikely that the western part of the Otway Basin was the source of the Early Cretaceous volcanolithic sediments of the Eromanga Basin (p. 337). Palaeocurrents in the central Otway Basin are predominantly towards the west and southwest (data from Drossos 1989), indicating that the sediments in this basin were derived from active volcanoes along the convergent margin to the east (Veevers 1984). Volcanolithic strata in the Eromanga Basin may also have been derived from the east; the line of active volcanoes in the Early Cretaceous extended northwards from east of Victoria well into Queensland (Veevers 1984).

Ollier & Pain also state (p. 335) that rivers flowing northwards from the Victoria Divide into the Eromanga Basin were diverted westwards at the beginning of the Tertiary by the uplift of the Canobolas Divide. However, there is considerable evidence that rivers were flowing westwards before this. In particular, the Ceduna Depocentre within the Eucla Basin contains over 3 km of Late Jurassic–Early Cretaceous sediments and 8 km of Late Cretaceous strata; delta foresets indicate that sediment supply was from the northeast (Fraser & Tilbury 1979; Veevers 1984). This huge volume of material (0.95 x 106 kms) was most probably brought into the Ceduna Depocentre by the ancestral Murray–Darling system, although an additional supply of sediment from the Eromanga Basin to the northeast cannot be ruled out (Veevers 1984). In any case, it is clear that major west or southwest-flowing river systems were in existence in the Cretaceous. The Canobolas Divide may indeed have been uplifted at the beginning of the Tertiary, at the same time as the Flinders Ranges (Wellman & Greenhalgh 1988); the latter uplift cut off sediment supply to the Ceduna Depocentre, which received only a small amount of detritus through the Cainozoic.

2. Miocene uplift

Ollier & Pain proposed that a "major uplift of the Gippsland–Snowy Mountains block took place in Miocene times" (p. 342), with "up to a kilometre" of throw along the Long Plain Fault, "leaving the 22 Ma Kiandra Flow hanging on the edge of the fault scarp" (p. 339). Although it is very likely that major movement has occurred along the Long Plain Fault, dating of this is problematic, and the significance of the Kiandra Flow is uncertain. The age of the basalt is well established (Wellman & McDougall 1974), but there is no detailed documentation showing that it has been displaced by faulting. On the downthrown side of the fault there is a nearby outcrop of basalt at Shannon's Flat, but this is of slightly different age (18 Ma; Ollier & Taylor 1988), and there is no evidence that it represents the same flow as the Kiandra basalt.

Studies on the middle and lower reaches of the Snowy, Buchan and Murrindal Rivers have shown that there has been only 200 m of incision by these rivers since the Eocene (Webb et al. 1991; Webb et al. 1992; Li 1995). Thus, there was no large-scale regional uplift of this part of the Gippsland–Snowy Mountains block in the Miocene; any major fault movement at this time, if it occurred, must have been confined to the New South Wales part of the southeastern highlands.

3. Comparison of volumes of eroded material and deposited sediment

Ollier & Pain (pp. 337, 338) calculated the volume of material eroded to create the Great Escarpment between Newcastle and Eden, and the volume of sediment on the continental shelf in this region. They found approximately the same answer for both calculations (3400 km^3), but additional factors mean that these estimates must be revised.

Firstly, the volume of material eroded ("a triangular prism of length 550 km, width 50 km and height 0.5 km") is 6800 km^3. Secondly, the calculation of sediment volume ignored porosity. The maximum thickness of the sediment on the continental shelf is 500 m (the vertical exaggeration on Fig. 4 in Ollier & Pain is x 200). Sands and shales at the base of this sediment column will have a porosity of 35–50 per cent (Sclater & Christie 1980; Baldwin & Butler 1985); porosities of newly deposited sediments on the sea floor may be over 80 per cent (Hamilton 1971). Thus, of the calculated sediment volume on the continental shelf (3400 km^3), about half to one-third represents water-filled porosity.

There is, therefore, a major mismatch between the material eroded (6800 km^3) and the sediment deposited (1700–2300 km^3). A small proportion of the material eroded will have been lost in solution, and some sediment will have been transported down the continental slope to be deposited on the

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floor of the Tasman Sea. The latter amount is likely to be proportionally minor, as there are no major submarine canyons between Newcastle and Eden (Davies 1975), and Tertiary strata on the floor of the Tasman Sea are thin and often biogenic (Kennett et al. 1975).

The lack of correspondence between the two calculated figures suggests that either the eroded volume has been overstated or the volume of sediment on the continental shelf cannot be used as an accurate guide to the amount of onshore erosion.

4. The timing and scale of palaeoplain downwarping

There is some confusion regarding the timing and scale of the palaeoplain downwarping that led to the formation of the coastal plain and Great Escarpment. Ollier & Pain (p. 340) propose that "the palaeoplain, complete with its silcretes, basalts and lateritic weathering profiles, was gently downwarped". This clearly indicates that the downwarping was post-Miocene, as the basalts are Miocene in age. However, their Figure 3 and the discussion on p. 337 imply that downwarping was associated with the rifting that formed the Tasman Sea; this began in the Late Cretaceous (Veevers 1984). The latter timing is also indicated by the statement that the Great Divide, which was created by downwarping of the palaeoplain sloping down from the Tasman Divide (see their Figure 5), was "in existence by the Cretaceous" (p. 343).

Although none of the four points discussed above necessarily invalidates Ollier & Pain's model, either entirely or in part, they do require re-evaluation and amplification of some components of the model. It is clear that much work still remains to be done in understanding the geomorphic history of southeastern Australia, and a consistent hypothesis to explain all aspects of the landscape evolution has yet to be developed.

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