

COMMENT: MESOZOIC ATMOSPHERIC OXYGEN

(Comment on "MAGic: A phanerozoic model for the geochemical cycling of major rock-forming components" by Rolf S. Arvidson, Fred T. Mackenzie and Michael Guidry, *American Journal of Science*, v. 306, p. 135–190.)

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Arvidson and others (2006) state (p. 170) that in the MAGic model "nor . . . is the sedimentation of organic matter tied in any quantitative manner to clastic sedimentation rate." Since the sedimentation (burial) rate of organic matter constitutes a major control on atmospheric oxygen, the purpose of this note is to provide a quantitative estimate of the role of clastic sedimentation on organic burial. As will be seen, correction for the effects of changing clastic sedimentation rate over the past 200 million years has a major effect on values calculated for organic burial rate and, very likely, the level of atmospheric oxygen.

Berner and Canfield (1989) have shown that the sedimentation rate of organic matter is linearly proportional (slope of one on a log-log plot) to total marine sedimentation rate over a range of four orders of magnitude. Their results are reproduced here as figure 1. From data presented in the GEOCARB III paper (Berner and Kothavala, 2001, table 1) the original deposition rate of sandstones and shales derived from the data of Ronov (1993), when normalized to the Miocene as the present (to avoid unusually high Plio-Pleistocene sedimentation rates due to glaciation), can be fitted to a simple cubic function for the past 550 million years. This is shown in figure 2 in terms of the dimensionless factor f_{sed} . If the relation between sedimentation rate and carbon burial rate is linear (fig. 1), then one can, as a first approximation, simply multiply the carbon burial values given by Arvidson and others by f_{sed} to get carbon burial rates corrected for changes in sedimentation rate. This is shown in figure 3 by F_{bgb} . (F_{bga} represents the uncorrected burial rates.)

Figure 3 demonstrates that the lower clastic sedimentation rates of the Mesozoic should have led to lower burial rates for organic carbon, much lower than that given by Arvidson and others (2006). Lower rates of organic carbon burial would thereby mean lesser rates of input of O_2 into the Mesozoic atmosphere than at present. Thus, it would seem reasonable that over much of Mesozoic time atmospheric O_2 values were considerably lower than those calculated by Arvidson and others (2006) and also by Bergman and others (2004). Neither study considered the effects of changes in sedimentation rate on rates of organic matter burial. Instead the models of Arvidson and others and Bergman and others assume that organic burial is controlled by the input of nutrients, mainly phosphate, to the ocean. However, nutrients control only productivity. Preservation is also necessary for burial (and O_2 production), and faster total sedimentation preserves more organic matter.

Use of a completely independent approach of calculating organic carbon burial rates from carbon (and sulfur) isotopic data (see for example, Berner, 2004, 2006; Falkowski and others, 2005) results in atmospheric O_2 levels for the Mesozoic distinctly lower than those found by Arvidson and others and Bergman and others. This agrees with the thrust of this paper.

An additional reason for believing that there were low O_2 levels during the early Mesozoic when organic burial rates were probably low, is because the

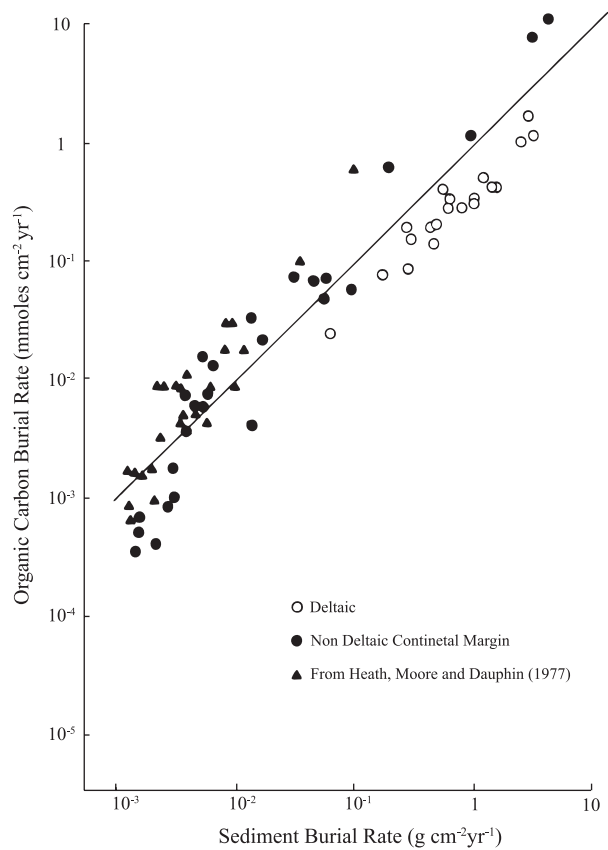


Fig. 1.

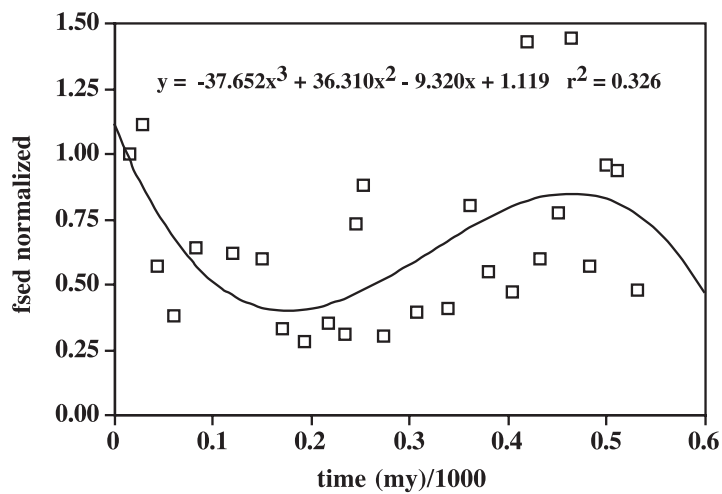


Fig. 2.

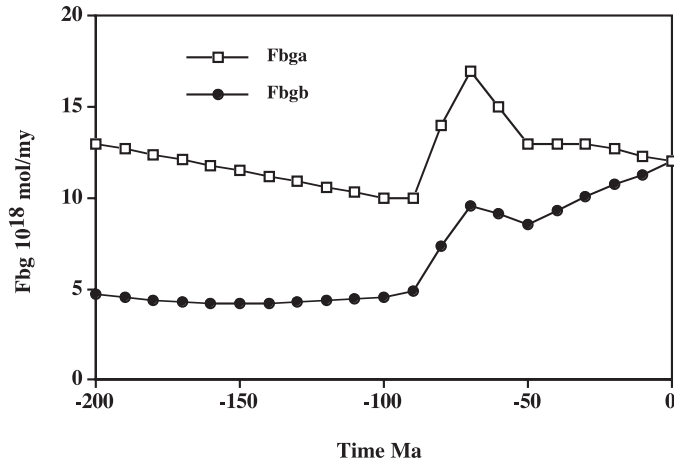


Fig. 3.

weathering of relatively young terrestrial Permo-Carboniferous rocks, which are unusually rich in organic matter, would have provided a large sink for O_2 , further adding to a drop in atmospheric O_2 . This is the concept of rapid recycling (Bernier and Canfield, 1987; Bernier, 2006) whereby immediately preceding, more superficial rocks are more likely to undergo weathering than older, more buried rocks. Although global erosion and sedimentation must be equal, this does not necessitate oxidative weathering of rocks with the same mean organic content as that of sediments being deposited (Bernier and Canfield, 1989). Otherwise, O_2 consumption would equal O_2 production and the major argument presented here would be irrelevant.

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