matters arising

Origin of the Metazoa

THE recent article by LaBarbera[1], in which the late Precambrian appearance of multicellular organisms is related to the development of shallow-water marine environments late in the Proterozoic, requires some examination of the evidence from which his conclusions have been drawn. LaBarbera bases his arguments on Hargraves'[2] model for the evolution of the Earth through the Precambrian. Hargraves' model has been shown by Windley[3] to be totally incompatible with the geological evidence as it relates to processes taking place on the Earth's surface.

LaBarbera's statement that "during the first three-quarters of the Precambrian ..., shallow water environments (defined here as less than 200 m depth) were very rare, and those that did exist were the result of volcanic or dynamic mountain-building processes and were geologically transitory" cannot stand unchallenged.

While it can be argued that, apart from the 3,000 Myr Pongola sequence[4], most shallow-water environments recognised in Archaean sediments[5–9] may have been geologically transitory, it cannot reasonably be disputed that from about 2,500 Myr ago, shallow-water environments occurred frequently, were developed extensively and were geologically persistent. Examples are too numerous to list here[10], but a few outstanding and clearly documented cases from the Early and Middle Proterozoic from widely separated areas are the sediments of the Athapuscow Aulacogen[11] and Kilohigok Basin[12] of Canada, the Transvaal Basin of South Africa[13], and the Nabberu[14] and McArthur Basins[15,16] of Australia. All the major Proterozoic basins contain stromatolitic carbonate sediments, most of which are interpreted as being of shallow-water marine origin[17]. Thus LaBarbera's comment that the shallow-water fossils "are restricted to a surprisingly few localities" cannot be sustained. Furthermore, these basins frequently contain additional sedimentological evidence which, taken together, indicates deposition in shallow-water environments; for example, numerous breaks in sedimentation, with desiccation, formation of evaporites[15], oolitic, pisolitic and intraclastic beds, and tidal channel and associated continental marginal deposits. In fact, in the Proterozoic record, it is deep-water sediments that are rare, and not shallow-water ones.

A further point which must be challenged is LaBarbera's contention that early life evolved in deep-water environments, and that its most primitive manifestations must have been planktic. However, the assemblages[18] which he quotes as being the "fossil record for most of the Precambrian" are all associated with stromatolitic carbonates, and they are all benthic. The organisms lived at the sediment–water interface, or just below it, and trapped or precipitated carbonate sediments by their metabolic activities. Some of the described microfossils may have had a planktic phase in their life cycle, or isolated species (for example, *Eosphaera*[19] from the Gunflint Iron Formation, Canada) may have lived in surface waters—but in all cases, the water depth was shallow to very shallow. Clear evidence for oceanic microplankton appears only in the latest Precambrian.

Two recently described assemblages from Middle Proterozoic shales[20,21] contain large spheres that may be planktic; but petrographic and palaeogeographic studies show these shales to be products of shallow-water environments. It should be added, however, that oceanic plankton has poor preservation potential in deep water unless it has very chemically resistant walls[22].

Thus the major point that LaBarbera had hoped to demonstrate for the evolution of multicellular organisms is geologically untenable. A number of other recent models[23–27] are more compatible with the geological evidence.

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LABARBERA REPLIES—Muir, Walter and Jackson (and others[1]) have apparently misinterpreted the purpose of my article[2] despite the explicit statement in the first paragraph that it was an "attempt to evaluate some of the implications of Hargraves' model of the geophysical evolution of the Earth during the Precambrian for the evolution of the metazoan phyla". The statement cited by Muir *et al.* concerning the existence of shallow-water environments through much of the Precambrian was not my conclusion, although failure to quote the entire sentence from my article makes it sound as though it were (missing from their quote is the phrase, "The primary implication of Hargraves' model is that . . .").

Muir *et al.* take two other quotes out of context, and by doing so change their original meanings. The complete relevant section reads, "The fossil record for most

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