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## Early Neoproterozoic origin of the metazoan clade recorded in carbonate rock texture: REPLY

**REPLY:** doi: 10.1130/G30484Y.1

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We (Neuweiler et al., 2009) used scanning electron microscopic, fluorescence spectroscopic, fluorescence microscopic, and thin-section analytical work from modern, Cretaceous, Silurian, and early Neoproterozoic reefal material to make a geological case for an early Neoproterozoic origin of animals. In a modern analogue for ancient petrographic textures, degradative calcification of the extracellular collagenous matrix (ECM) of a modern siliceous sponge can be directly observed (Neuweiler et al., 2007). Attributes of the resultant fabric match those of abundant calcified sponge material of the Phanerozoic, and offer an explanation for a number of distinct taphonomic details. Most important among these are: 1) preservation of fragments of calcified siliceous sponges in sediment matrix; 2) preservation of non-rigid spicular architectures; 3) replication of the sponge canal system; 4) local enrichment of water-soluble organic matter trapped by newly formed minerals; 5) local presence of secondary voids that include examples of stromatactis; and 6) origin of the polymud fabric as commonly observed in Phanerozoic sponge-rich carbonate mounds (Lees and Miller, 1985, 1995; Desrochers et al., 2007).

Planavsky (2009) presents no new data or observations that would call the above into question, nor does he faithfully represent the content of Neuweiler et al. (2009) in his introductory statements. Furthermore, he intends to demonstrate that the polymud fabric can also be found in modern, non-metazoan bioherms. Unfortunately, Planavsky addresses only voids in place of the full set of petrographic attributes that was originally used to establish the concept (Lees and Miller, 1985). By definition, polymuds are not just mixtures of carbonate mud generations; they are highly structured, showing successive geopetal relationships (Lees and Miller, 1995, p. 210). The polymud fabric applies only to microcrystalline facies; it typically consists of three-dimensionally labyrinthine patches of authigenic microcrystalline carbonate of variable density (Lees and Miller, 1995, their figure 13). The associated marine cement-filled voids, which petrographically correspond to stromatactis, are a network of very early collapse structures (Bourque and Boulvain, 1993).

Planavsky's (2009) Figure 1 shows subspherical voids in a deposit dominated by calcified cyanobacteria. The voids lack internal sediment, and have outer boundaries that exhibit evidence of dissolution that took place before the precipitation of a microcrystalline to microsparitic cement. These are either solution-enhanced primary framework voids, or cavities that formed by entrapment of gas bubbles followed by solution enlargement. Planavsky's Figure 1 does not display a polymud fabric. Planavsky's Figure 2 shows subspherical voids among microbial clots. The voids lack successive generations of infiltrated sediment; their outer boundaries exhibit evidence of dissolution (purely chemical or due to bioexcavation). With caution, this might be a remodeled Bahamian microbialite, but no polymud features are evident.

We (Neuweiler et al., 2009) explicitly state that because of the absence of a preserved canal system, early Neoproterozoic polymuds cannot be directly attributed to the sponge taxon. Sponges are derived members of the metazoan clade; their origin and diversification are recorded

in much younger rocks, starting roughly at the Cryogenian-Ediacaran transition (McCaffrey et al., 1994; Love et al., 2009). We are much more cautious than is implied by Planavsky (2009), in not fully ruling out alternative explanations for Neoproterozoic polymuds, and in pointing out that existing knowledge does not allow an exclusive link between an early Neoproterozoic polymud texture (Turner et al., 2000) and degradative ECM calcification. We illustrated the striking similarity between sponge-related Phanerozoic polymud fabrics and Neoproterozoic polymuds, to suggest the possibility of a connection between the two based on the known taphonomy of ECM, and to encourage further research into the possibility that carbonate microstructures may record the early stages of metazoan evolution.

In conclusion, Planavsky's (2009) argument does not address the essence of the polymud—secondary void—internal sediment argument, and the evidence he presents does not support his contention that polymud fabrics, including their characteristic voids, are present in modern bioherms that lack metazoans. Furthermore, the presence of a specific petrographic texture in a relatively small area is not sufficient evidence upon which to make far-reaching inferences regarding algal diversification, globally decreasing carbonate saturation state, or a globally increasing concentration in atmospheric oxygen. Earliest animals likewise respired via diffusion, probably supported by local conditions of flushing oxygenated waters, a scenario that is in accord with the Little Dal cyanobacterial reef environment.

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