UC **SANTA BARBARA**

Department of Earth Science

Speakers Club

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Complex life in the 'Boring Billion'

Dr. Heda Agić
Department of Earth Sciences
UC Santa Barbara

The evolution of Eukaryota, one of the three domains of life, characterized by a complex cell with a nucleus, represents a major transition in the history of life on Earth. Palaeontological record and molecular clock estimates indicate that this step took place by the late Paleoproterozoic Era, around 1.6 billion years ago. Although the microbial eukaryotes expanded at this time, the fossil record shows c. 600-million-year delay until the appearance of multicellularity (seen in the red algae), and even further lag until the evolution of macroscopic forms such as animals, plants, and fungi.

This period of ostensible evolutionary and environmental stability from the Mesoproterozoic to the late Neoproterozoic glaciations and the subsequent appearance of the Ediacara biota is often termed the "Boring Billion". Anoxic conditions and nutrient limitation prevalent around this time have been often invoked to have acted as a brake on the diversification of eukaryotic lineages. Recent palaeontological, sedimentological, and geochemical investigations of the "Boring Billion" units, allow us to examine the possible drivers and constraints of the evolution of early eukaryotes, and if their fossil record represents a true evolutionary stasis, response to challenging environmental conditions, or sampling biases.

In this talk, I will present data from two case studies, from the siliciclastics of the early Mesoproterozoic Ruyang Group in northern China and the late Mesoproterozoic Bylot Supergroup in Arctic Canada. These successions contain rocks deposited under various conditions with diverse assemblages of organic-walled microfossils. In addition to studying the fossils' morphological complexity, I will examine trends in eukaryote species richness and abundance in relation to offshore and nearshore settings, as well as variations in water column redox recorded by iron speciation and trace metal enrichment analyses. These results suggest that microbial eukaryotes were abundant throughout water column, but preferred shallow environments, and that the distribution of oxygen per se may not have controlled the distribution of eukaryotes.

Reproductive strategies of Cambrian molluscs

and mollusc-like problematic fossils

Dr. John Moore
Department of Earth Sciences
UC Santa Barbara

Modern marine invertebrates make use of a variety of different ecological strategies during their development from fertilized egg to adult: in some the first free-living stage is a juvenile similar to a miniature adult, but many others have a swimming larva phase in their life cycle. Some larvae feed on plankton to gain the energy needed to grow and develop into juveniles, while others do not feed and instead depend upon yolk and other substances provided in the egg. These different developmental strategies record varying levels of parental investment, and in turn they result in differing abilities of a species to disperse to new areas. While larvae themselves are rarely preserved in the fossil record, the accretionary growth characteristic of molluscs can preserve a record of embryonic and larval stages into adult shells, allowing insights into the life history and larval ecology of extinct animals. Very few examples are known from the earliest molluscs in the Cambrian, however, because of the loss of detail during recrystallization of their aragonitic shells: only a few definite examples are known, and much of the literature is based on indirect inferences from internal molds. I report on material from the latest Dyeran (traditional "Lower" Cambrian) Combined Metals Member of the Pioche Formation from several sections in the Pioche–Caliente region, southeastern Nevada. While many samples from this unit produced phosphatic internal molds following acid maceration, a few also yielded specimens with a delicate phosphatic layer preserving the outer surface of the shell, including details of ornamentation and growth lines. These fossils demonstrate that pelagiellids, a group of coiled molluscs widespread in the Cambrian, had a very tiny larval shell, ca. 85 μm tall, without clear evidence for a plankton-feeding stage, showing that their larvae settled on to the seafloor at a smaller size than is known from any other mollusc. Larval shells are also present in co-occurring hyoliths, a group of problematic fossils with a tall conical shell covered by a door-like operculum; they may or may not be related to molluscs. Their larval shells are larger, 200–250 μm tall, consistent with a non-feeding larval strategy; it seems that their shell may have formed later in development than did their opercula.