

strength and ENSO-like climate variability. Despite proximity to corrosive Antarctic water masses, sufficient  $\text{CaCO}_3$  in Palmer Deep sediments exists to provide a high-quality stable isotopic record (especially in the late Holocene). Coherence of benthic foraminifer  $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ , sedimentologic, and  $\text{CaCO}_3$  fluctuations suggests that rapid (<20 yr) Palmer Deep bottom water temperature fluctuations of 1-1.5°C are associated with competitive interactions between two dominant oceanographic/ climatic states. An abrupt shift from a warmer, stable Upper Circumpolar Deep Water (UCDW) state to a cooler, variable Shelf Water state occurred at ~3.6 ka. Palmer Deep bottom waters oscillated between UCDW and shelf water-dominated states between ~3.6 and 0.05 ka. Cool shelf water intervals correlate with Neoglacial events, the most recent and largest being the Little Ice Age (LIA; ~0.7-0.2 ka). Similarities between Palmer Deep and global Holocene records and the rapidity of inferred bottom water fluctuations suggest that western Antarctic Peninsula shelf hydrography has not been controlled by thermohaline reorganizations, but by variable strength and/ or position of the Southern Hemisphere westerly wind field. We suggest that these atmospheric perturbations may have originated in the low latitude tropical Pacific.

### THE OLDEST BURROWS

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The Neoproterozoic Doushantuo Formation (565 to 555 Ma), south China, contains a remarkable array of exquisitely preserved microbial fossils found in phosphate-rich chert. Aside from uncommon macroscopic carbonaceous compressions of algal origins, microscopic fossils abound. The microfossil assemblage includes coccoids (unicellular and pluricellular examples), filaments, and a variety of spinose acritarchs. Microscopic examples of animals have also been discovered: possible sponges, tabulate corals, and embryos of cnidarians and bilaterians.

We here report submillimeter, slightly curved, cylindrical structures, oriented within 40° of bedding, 200 to 400 mm in diameter, with internal, paraboloid-shaped laminae, preserved in chert nodules. These structures are interpreted as back-filled burrows that were most likely produced by a worm-like coelomate. The advent of burrowing (peristalsis) is an evolutionary milestone in metazoan evolution. The coelom, which acts as a hydrostatic skeleton, conferred new opportunities on animals: it permitted development and control of complex muscles that facilitated active movement that included coordinated, fast swimming and burrowing. An animal without a hydrostatic skeleton can only glide across the surface of a substrate or live between sediment grains. The earliest coelomates would certainly

have been soft-bodied and difficult to fossilize. However, one can infer their existence by the trace fossils they might have left behind. The Doushantuo Formation's burrows represent such trace fossils.

The nature and significance of the Doushantuo Formation's fossils clearly place this formation into the ranks of such exceptional deposits as the Burgess Shale and Chengjiang Lagerstätte. The fossils of the Doushantuo Formation add to the growing body of data on the complexity of microbial life before the appearance of macroscopic, multicellular animal life. We now add the Doushantuo Formation's burrows, which provide the oldest compelling evidence of coelomates in the fossil record.

### AN UNUSUALLY LARGE CERVICAL RIB OF APATOSAURUS FROM THE MORRISON FORMATION OF OKLAHOMA, WITH COMMENTS ON THE CERVICAL MUSCULATURE OF SAUROPODS

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OMNH 01368 is a disarticulated cervical rib of a large sauropod from Stovall's Quarry 1 in the Morrison Formation of the Oklahoma panhandle. The specimen lacks an anterior projection and is therefore referable to *Apatosaurus louisae*. The specimen is unusually large, and indicates an animal approximately half again as large as CM 3018, the holotype of *A. louisae*. Furthermore, the articular surfaces of OMNH 01368 are unfused, indicating that the animal was not yet skeletally mature. Other elements from the quarry also pertain to one or more exceptionally large individuals of *Apatosaurus*, and have previously been referred to *A. excelsus* on the basis of size. To date, no locality has produced more than one species of *Apatosaurus*, and the identification of OMNH 01368 suggests that all of the *Apatosaurus* material from Stovall's quarries should be referred to *A. louisae*.

OMNH 01368 and CM 3018 are also alike in having bony tubercles that project from the ventral edges of the cervical ribs. These tubercles resemble the carotid tubercles of avian cervical vertebrae, which are attachment sites for the ventral neck muscles of birds. Similar tubercles are absent in the cervical ribs of other sauropods. However, all other sauropods have anterior projections of the cervical ribs that may have served to anchor the same muscles.

### "MIDDLE TRIASSIC RHYNCHOSAURS" AND "LATE TRIASSIC RHYNCHOSAURS" INDICATE AGE—DON'T THEY?

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Rhynchosaurs (Reptilia: Archosauromorpha) are common components in Middle and Late Triassic terrestrial faunas containing mammal ancestors and some of the earliest