**EDIACARAN TRACE FOSSIL DISTRIBUTIONS MAP BENTHIC OXYGEN OASES.** S. L. Olson[1], M. L. Droser[1], J. G. Gehling[2], and T. W. Lyons[1]. [1]Department of Earth Sciences and NASA Astrobiology Institute, University of California, Riverside, CA 92521 (solso002@ucr.edu). [2]Earth Sciences, South Australian Museum and Sprigg Geobiology Centre, University of Adelaide, North Terrace, Adelaide, South Australia 5000.

**Introduction:** *Helminthoidichnites* is a simple, meandering mm-scale furrow-and-levee trace fossil that first appears in the Ediacaran and thus reflects the activities of one of the earliest bilaterians. This trace is commonly preserved in negative relief on the top of sandstone beds. Intriguingly, *Helminthoidichnites* is also commonly preserved in negative relief on the base of thin, discontinuous sandstones that overlie textured surfaces of microbial origin. This association suggests that the *Helminthoidichnites*-creator may have depended on benthic microbial communities for either food or oxygen. The presence of *Helminthoidichnites* in negative relief on the base of these sandstone beds also indicates that the organism followed the mat surface laterally by burrowing beneath the sand post-deposition. In the absence of predation, the incentive for grazing on the mat *beneath* the sand is unclear, and penetration into sediments is otherwise uncommon among Ediacaran trace fossils.

Here, we describe the spatial distribution of *Helminthoidichnites* traces as preserved on the base of lenticular sands of the Ediacara Member of South Australia. Notably, although lateral burrow penetration distance (i.e., burrow length) can be highly variable, the thickness of the overlying sand (i.e., effective burrow 'depth') is not; *Helminthoidichnites* is exclusively observed on the base of sands that are very thin, generally limited to less than ~10 mm in vertical thickness, and is entirely precluded where sand thickness exceeds 25 mm. Meanwhile, vertical burrows are absent. We hypothesize that this systematic burrowing behavior reflects redox conditions within the sand, specifically oxygen penetration into the sediments, potentially providing insight to the oxygen demands of this ancient bilaterian as well as benthic oxygen availability in the shallow Ediacaran ocean.

**Model description:** With this scenario in mind, we use a simple numerical model to identify the primary controls on benthic oxygen fluxes within *Helminthoidichnites* burrows penetrating laterally discontinuous sands. The model considers 2-D (lateral and vertical) diffusion of oxygen and sulfide within a lenticular sand of variable thickness. This sand overlies an active microbial surface, and depending on whether the sand is sufficiently thick to smother photosynthetic activity, oxygen may be produced or consumed along the surface of the mat throughout the diurnal cycle. Where anaerobic conditions develop at the mat surface, sulfide leakage into the sand and subsequent porewater accumulation of sulfide is possible. The water column, however, is assumed to be devoid of sulfide. Meanwhile, seawater oxygen dynamics are modeled after Reinhard *et al*. [1].

**Results:** We find that near the margins of lenticular sands, oxygen concentrations in porewaters influenced by *in situ* production likely exceed the oxygen availability of ambient seawater—creating benthic, subsurface 'oxygen oases.' These refugia, which are rich in both organic substrate and oxygen, develop where benthic photosynthesis is locally enhanced because light reflection within the sand effectively amplifies incident sunlight and increases the flux of photosynthetically active radiation received by the photosynthetic community [2]. This optical effect, however, is restricted to very shallow sediments; away from the sand margins, photosynthetic rates exponentially decrease as the depth of the sand increases, and photosynthetic activity is inhibited for sand exceeding a few mm in thickness.

Oxygen concentrations far from the sand margins are ultimately controlled by the balance of oxygen diffusion from the overlying water column, aerobic respiration, and oxygen consumption through the oxidation of sulfide leaking from the underlying microbial community. In sum, the lateral transition from net photosynthesis to net respiration results in the establishment of a strong horizontal redox gradient within the sandy sediments: porewater oxygen in excess of seawater oxygen yields to anoxic and sulfidic conditions over a few cm's of horizontal distance.

Thus, our numerical results support the hypothesis that the lateral extent of *Helminthoidichnites* burrowing is limited by the local redox environment as controlled by the vertical sand thickness—implicating either inadequate oxygen availability or avoidance of toxic sulfide very near the sediment-water interface as a primary control on the behavior of early bilaterians. Ediacaran animals apparently experienced a patchy benthic redox landscape, featuring both oxygen oases and toxic sulfide accumulation in close spatial association within shallow shelf environments.

**References:** [1] Reinhard C.T. *et al*. (2016) *PNAS, 113,* 8933-8938. [2] Kuhn *et al*. (1994) *Mar. Ecol. Prog. Ser. 105*, 139-148.