TRACING EARLY TERRESTRIALIZATION IN THE ORDOVICIAN-SILURIAN DIRK HARTOG GROUP, SOUTHERN CARNARVON BASIN

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The exact timing of the colonization of the continental realm by plants remains relatively poorly constrained. Yet incipient terrestrialization would have had significant effects on subsequent biotic and Earth system evolution by affecting nutrient fluxes, carbon reservoirs and the rate of photosynthesis. To date, the oldest embryophyte traces are documented by cryptospores with vascular plant affinity that stem from 470 Ma sediments in Argentina (Rubinstein et al., 2010), giving rise to the hypothesis that embryophytes evolved on Gondwana and spread from there on out onto other continents (Wellman, 2010).

Deep branching plants, i.e. hornworts, liverworts and mosses, do not possess recalcitrant tissues that would leave fossil evidence in the rock record. Thus apart from rare palynomorphs, biomarkers might be the only option to add valuable information about the timing and extent of early plant colonization of early Paleozoic continents. This approach is, however, limited by the fact that most diagnostic terpenoid plant biomarkers derive from Gymnosperms and Angiosperms that only evolved during the Carboniferous and Cretaceous, respectively.

We here analyzed shales, mud- and dolostones from the Coburn-1 drill core (Southern Carnarvon Basin, Western Australia) that are thermally well preserved (T_{MAX} <430°C) and which were deposited across late Ordovician through Silurian times (ca. 435–410 Ma) in equatorial latitudes. The shallow marine depositional environment experienced periodic atmospheric exposure and likely accommodated not only sporadic fluxes of coarse fluviatile or deltaic clastics, but also any terrigenous organic matter, thereby offering an opportunity to enhance our knowledge of early plants in Australia. Although palynomorphs are rare in Coburn-1, both cryptospores and spores show evidence for early plant input to the sequence that we studied in this project (Yasin and Mory, 1999). Samples were solvent extracted and fractionated extracts were analyzed by GC-MS and GC-MS/MS.

In parallel to the palynological data, our results show some distinct patterns in the biomarker composition of the samples, such as unusually high relative abundances of C_{19} and C_{20} tricyclic terpanes and the (co-)occurrence of trimethylated naphthalene (1,2,7-TMN) and phenanthrene (1,2,8-TMP) species. The relative abundance of hopanoids is high throughout the sampled section of the core, with hopanes outweighing the abundance of steranes, whose C_{27}–C_{29} pattern remains relatively unchanged throughout the profile section. No unambiguous higher plant indicators, such as strong odd-even-predominance of long chain n-alkanes, or specific biomarkers like retene—which was previously reported from Silurian deposits (e.g. Romero-Sarmiento et al., 2010)—were observed. However, we do find anomalously elevated abundances of 1,2,8-TMP and 1,2,7-TMN amongst aromatic hydrocarbons. Although no direct biosynthetic source of these compounds is known, such elevated abundances were previously reported from Late Paleozoic terrigenous organic matter (Armstroff et al., 2006). Liverworts have been shown to biosynthesis a wide range of molecules (Asakawa et al., 2013), including manool and manoyl oxide (Matsuo et al., 1972).
Both of these compounds can be converted to, amongst others, 1,2,8-TMP upon dehydrogenation (Hanson, 2001). This suggests that these trimethylated polyaromatic compounds may indeed be useful markers for tracing the incipient terrestrialization of the Earth System. By finding these markers in the samples sequence in Coburn-1, we contribute to the understanding of the terrestrialization of early embryophytes on the Australian continent during the early Paleozoic.

References


