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Applications of molecular analysis for the study of early land plant evolution during the upper Silurian – Lower Devonian: borehole M.G.1, Ghadamis Basin, southern Tunisia, North Africa

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The development of land plants during the Ordovician to Devonian time is essentially documented by rare macro and micro remains such as cuticles and sporomorphs. This period is a key interval for the development of life on emerged lands – the so – called terrestrialization process, which includes the origin of land plant and their progressive spread on the continents. It is well known that many biomarkers (such as cadalene, retene, among others) can provide important information on the evolution of major plant groups. Nevertheless, no land-plant biomarker studies have been carried out on sediments older than Middle Devonian so far.

We performed molecular biomarker analyses on a Siluro-Devonian clastic sequence (borehole MG-1, southern Tunisia), known to contain abundant and well-preserved plant remains (miospores and phytodebris:[1]). Our aim is to identify possible land plant biomarkers in Ordovician – Devonian sediments and relate these biomarkers to specific kind of plants.

All samples were studied by Rock-Eval pyrolysis and biomarker analysis. The Rock-Eval results show that most of the samples are in the type II-III organic matter indicating a mixture of organic matter of terrestrial and marine origin. In general, we detected n-alkanes with a number of carbon atoms lower than twenty in all the aliphatic fractions. These n-alkanes are considered of algal origin. However, most samples also show long n-alkanes which could indicate a land plant origin. In addition to short-chain alkanes, hopanes and terpanes indicates a bacterial/algal origin for the organic matter. This result is consistent with both the marine depositional setting and the palynofacies of the studied samples where amorphous organic matter and marine palynomorphs such as Tasmanites algae can be observed. An algal contribution is also visible in the aromatic fraction, where series of isohexylalkylbenzenes and aryl isoprenoids from C13 to C20 have been identified. The occurrence of both series in the Silurian more marine part of the section is consistent with the abundance of algal organic matter in the palynofacies spectrum.

On the other hand, the aromatic fractions also contain land plant biomarkers such as cadalene, retene, tetrahydroretene and isohexylalkylnapthalene. Cadalene is derived from cadinenes and cadinols synthesized by most land plants and in particular bryophytes [2]. Bryophytes are among the earliest plants that developed on land, and the presence of cadalene in the studied sediments is consistent with the occurrence of abundant bryophyte-derived cryptospores in the palynological spectrum. Additionally, several isohexylalkyl-naphthalenes have been detected in all the samples. This class of biomarkers is supposed to derive from higher plant diterpenoids [3]. The observed increase of the relative proportion of land plant biomarkers takes place in conjunction with a progressive lithological transition from upper Silurian marine sandstones and mudstones (Acacus Formation) to Lower Devonian continental sandstones and mudstones (Tadrart Formation), richer in land plants remains.

The occurrence of retene in the studied samples raises questions: retene has generally been associated with conifer inputs [4], however this plant type was not present during the Silurian – Devonian period. Several explanations are possible. Retene can be produced by maturation of algal organic matter [5], it may therefore derive from an algal source in our samples. Alternatively, since retene is produced by diagenesis of abietic acid,

which is a major constituent of conifers resins, we propose that the first land plants in early Silurian could have already possessed the biosynthesis of abietic acid. This is a viable hypothesis, considering that the biochemistry of land plants is highly similar. This hypothesis is also supported by the fact that retene shows a general correlation with the other land plant biomarkers and with the abundance of trilete spores and cryptospores in the palynofacies of all sampling levels.

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