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Palynological Tracers of Sea-Ice Cover Extent During The Latest Ordovician On The North African Margin

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The presence of a large continental ice sheet developed on Gondwana during the latest Ordovician, caused major global crisis among paleoecosystems in relation to drastic climatic and oceanographic changes. The effects of this major climatic event on the evolution of the main pelagics and benthics fauna, have been abundantly discussed in the last past years. The short-lived Hirnantian glacioeustatic interval (1Myr or less, Brenchley et al., 1995) marked about 60% loss of total genera (Sepkoski, 1996). This icehouse climate is also responsible for significative changes on the evolution of the plankton and the distribution of related microfossil assemblages, from pre-glacial to post-glacial episodes. It has been clearly identified by us on different upper Ordovician sections from various paleogeographic location. On the north Gondwanan margin the sections close to the inlandsis in the Algerian Sahara or the Anti-Atlas in Morocco, mainly exposed the demise of the glaciation (deglaciation). The sections in outer position, in the Armorican Massif or the central part of the Bohemian Massif, less influenced by emersion/erosion related to glacio-eustatic sea-level fall, generally have preserved glacial material. The global results on these sections have been presented in the thesis of Bourahrouh (2002) and in the paper of Paris et al. (2000), and three main periods have been distinguished: a pre-glacial period (Caradoc-Asghill proparte) showing a good abundance and diversity of chitinozoa and acritarchs ; a glacial period (Hirnantian pro-parte) including the melting of the ice, with a significative drop in the populations of chitinozoa and other palynomorphs, but also the development of specific strategies of some micro-algae to environmental stress ; a post-glacial period (late Hirnantian-early Rhuddanian) corresponding to a slow recovery with concomitant climatic restoration. The most interesting conclusion is that despite the harsh environmental conditions related to the glaciation (low light intensities, low temperature, low salinity), a specialised community of acritarchs and prasinophytes has developed and adapted to live. This paper is concerned with detailed analysis of this sympagic microflora (indirectely measured on the microfossil assemblages recovered in the sediments), its species composition and succession, for a better evaluation of ecophysiological adaptations of these microfossils. It is also possible to rely the palynological signal: 1.) to the history of the late glacial paleoclimate and paleoceanographic record in a regional context; 2.) to the paleogeographic reconstitution of the north gondwanan margin; 3.) to the timing of the deglaciation events.

The interval of glacial activity and deglaciation during the Hirnantian is well documented on the north African Margin, by spreading of ice-rafted diamictites sequences. The upper Ordovician part in well NL-2 located in the norheastern part of the Algerian Sahara, allowed a fine sampling of the youngest Ordovician sequences, referred to the *Tanuchitina elongata* and *Spinachitina*

oulebsiri biozones, equivalent to the *Glyptograptus persculptus* graptolite zone. It has been selected to evaluate the survival strategies of phytoplanktonic populations of prasinophycean algae and cyst-forming acritarchs to sea-ice covers. Establishing a comparison with dinoflagellates (cf. de Vernal, A., Hillaire-Marcel, C., 2000), it is postulated that the sea-ice cover was a determinant factor to influence light penetration, photosynthesis, composition and distribution of microfossil assembages.

The results demonstrate that the effects of the glaciation did not correspond exactly to a cataclysmic event, because the palynomorphs did not show really accelerated rates of extinction, in the inhospitable environment. It could also be noted that the origins of the Silurian communities are rooted in the upper Ordovician prior to the glaciation, with appearance of forms « ahead of time » that diversified later in the Silurian. Nevertheless, this extreme climatic regime of the late Ordovician introduces reduction in the number of taxa and there are few FADs than LADs associated to this period. The changeover is marked by: quite complete extinction of the characteristic large *Baltisphaeridium, Ordovicidium, Orthosphaeridium, Peteinosphaeridium* etc.; opportunistic evolution of *Cymbosphaeridium*, some *Beromia* or *Saharidia*, and continuity of the ubiquitous *Evittia, Leprotolypa, Oppilatala, Tunisphaeridium, Tylotopalla*; occurrence of tolerant forms to stressed conditions (« extremophiles »), e.g. the morphologically simple micrhystrids, netromorphs, veryhachids and sphaeromorphic acritarchs. The palynological record documents interesting data on the autecology of acritarchs, with specific populations possibly including heterotrophic species (e.g. the producers of *Veryhachium*). The success of other taxonomic groups such as the netromorphs could also be related to an adaptation to live on the bottom or in interstitial sediments (quite comparable to pennate diatoms communities in more recent and actual sediments).

Modifications in abundance and diversity of the microfossil assemblages, in the percentages of reworked elements and of amorphic organic matter are interpreted in this core and other sections as evidence of a series of advances and retreats of the continental ice, of important changes of sea-surface conditions, of differences in the rate of melting of the icebergs during the deglaciation, as well as postglacial isostatic rebounds. These studies demonstrates that major applications can be drawn from the use of the evolution of palynomorph groups and phytoplanktonic responses, to discuss the deglaciation history and sedimentary environment in a broader context.

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