

Biogenic phosphate pollution inducing eutrophication as a catalyst for the decline of obolid-dominated brachiopod communities in the Early Tremadocian of East Baltica

Lars Holmer^{1*}, Mansoureh Ghobadipour², Leonid Popov² and José Javier Álvaro Blasco³

¹ Uppsala University, Earth Sciences - Palaeobiology, Earth Sciences, Sweden

² Department of Natural Sciences National Museum Wales Cardiff CF10 3NP United Kingdom

³ Facultad de Ciencias Geológicas C/ José Antonio Novais, 12 Ciudad Universitaria 28040, Madrid

* Corresponding author, lars.holmer@pal.uu.se



During the late Furongian - early Tremadocian (*Cordylodus andresi* to *Cordylodus angulatus* zones), the Baltoscandian epicratonic basin displayed environmental heterogeneity. The basin included a black shale depocentre (Alum Shale Formation), bordered in North Estonia by coastal plains and shoal complexes featuring extensive brachiopod shell accumulations (Kallavere Formation). Since the mid Cambrian to the Tremadocian, the costal planes and shoals of the inland Baltoscandian Basin were inhabited by low diversity benthic communities dominated by a single or few linguliform brachiopod species of the genera *Obolus*, *Oepikites*, *Schmidtites* and *Ungula*, characterised by organophosphatic shell mineralisation. Abundance of *Skolithos* trace fossils was also characteristic. These obolid dominant communities were adapted to the life on soft,

mobile substrates affected by storms and tidal currents. Before expansion of bivalve and gastropod molluscs in the Ordovician, these habitats were marginal for almost all early Palaeozoic benthic animals. The gradual proliferation of these brachiopod dominant faunas through the Furongian reached its peak during in the latest Furongian (*Cordylodus andresi* and *Cordylodus proavus* zones), when bioclastic material produced by costal brachiopod communities invariably present in siliciclastic sediments deposited nearshore. It was a major source of biogenic phosphate accumulation in Furongian shoal complexes, which produced economically significant phosphorite ore deposits. The geological scale of bioaccumulation processes at that time can be illustrated by the fact that proven P₂O₅ reserves exceeding 27 million tons were reported just for the Toolse phosphorite ore deposit. These figures represent only a fraction of biogenic phosphates produced at the late Furongian time. The repetitive early Tremadocian (*Cordylodus lindstromi* and *Cordylodus angulatus* zones) marine transgressions coeval with the geographical expansion of the Alum Shale accumulation resulted in the collapse of shallow marine biota in the Baltoscandian basin. Due to extremely low net deposition rates, extensive Furongian obolid shelly substrates remained exposed to the redox environments in sediment/water interface. They were a major source of constant influx of phosphate nutrients into the water column resulting in widespread coastal eutrophication, which likely led to a significant seasonal enrichment of the water column with nutrients, linked to fluctuations in dissolved oxygen. The presence of substantial amounts of dissolved phosphate in the water during this period was evidenced by the deposition of concretions and crusts of chemogenic phosphorites outlining the periphery of the black shale depocentre. Simple shallow ecosystems with obolids on the top of a very short trophic chain and virtual lack of predation led to uncontrollable proliferation of the obolid-dominated nearshore communities and probably contributed to the extinction.

Keywords: late Furongian - early Tremadocian, East Baltica, phosphorites, brachiopods.