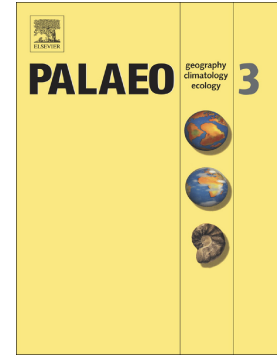


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Mohammad Ghavidel-Syooki



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Stratigraphic evidence for Hirnantian glaciation in the Alborz Mountain Ranges, northeastern Iran

Mohammad Ghavidel-Syooki

Institute of Petroleum Engineering, University of Tehran, Iran. P. O. Box
11365/4563, Tel: +982161114726, Fax: +982188632976, E-mail:
m_ghavidelsyooki@yahoo.com

Abstract

The author examined the high-latitude Hirnantian diamictites of the Ghelli Formation and the early Silurian olive-gray shales of the Niur Formation exposed in the northeastern Alborz Mountains, Iran. These 404 m thick glacial deposits can be divided into three progradational-retrogradational cycles, each potentially controlled by the regional advance and retreat of the Hirnantian ice sheet. The glaciated source area was west of the study area, in the Arabian Shield region, where numerous tunnel valleys have been reported. Time calibration was performed based on a high-quality biostratigraphic control, mainly derived from the chitinozoan biozones *Tanuchitina fistulosa*, *Acanthochitina barbata*, *Armoricochitina nigerica*, *Ancyrochitina merga*, *Tanuchitina elongata*, *Spinachitina oulebsiri*, and *Spinachitina fragilis*. The land-derived miospores present in most chitinozoan assemblages, often abundant, seem associated with global sea-level changes during the Late Ordovician glaciation. The Ghelli Formation's high abundance of terrestrial miospores and low abundance of marine palynomorphs suggests its deposition in a shallow marine environment. Additionally, rhythmic bedded tidalites of claystone and sandstone indicate the growth of early land plants producing cryptospores on adjacent flooded areas. Based on marine palynomorphs (chitinozoans and acritarchs), the northeastern Alborz Mountains glacial deposits were dated as Hirnantian; the Niur Formation was assigned to the earliest Llandovery (Rhuddanian). Glacial deposits and marine palynomorphs suggest the presence of Hirnantian ice caps in the Alborz Mountains, at the margin of the Arabian Plate, and indicate the peripheral extension of the Late Ordovician ice sheet. Several biostrome beds forming pelmatozoan-bryozoan mud-mounds, mainly comprising bryozoans, echinoderms, tentaculites, and subordinate trilobites, were found in the glacial deposits of the Ghelli Formation, suggesting carbonate deposition during the Hirnantian. These carbonate beds are not related to the Boda warming event, which happened over the Gondwana landmass in the Katian interval; the glacial deposits of the Alborz Mountain Ranges are thus not correlated to those of the Gondwana paleocontinent. Climatic amelioration is more likely than local reduction of clastic input to be responsible for the biostrome beds in the Glacial Member of the Ghelli Formation, namely a short-lived episode of global warming during the Hirnantian interval (the Milankovitch cycles). Four new chitinozoan species, namely *Armoricochitina persianense* n. sp., *Tanuchitina alborzensis* n. sp., *Spinachitina iranense* n. sp., and *Hyalochitina jajarmensis* n. sp., are described and illustrated. Biometric data are also provided for the Iranian *S. oulebsiri* and *A. nigerica*.

Keywords: Northeast Iran; diamictites; Hirnantian; chitinozoans; Gondwana.

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