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Late Ordovician scolecodonts from the Qusaiba-1 core hole, central Saudi Arabia, and their paleogeographical affinities

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ABSTRACT

This paper reports the discovery of Late Ordovician scolecodonts from the Qusaiba-1 core hole, central Saudi Arabia. The collection of about 100 relatively well preserved diagnostic jaws represents one of the richest jawed polychaete faunas from the Gondwanan realm and the first description of scolecodonts from the Arabian Peninsula. Scolecodonts were most diverse and abundant in the Quwarah Member and basal Sarah Formation, corresponding to the *Ancyrochitina merga* and *Tanuchitina elongata* chitinozoan zones (latest Katian to early Hirnantian). The polychaete assemblage contains up to 15 apparatus-based species and is dominated by the globally distributed genera *Kettnerites*, *Oenonites* and *Atraktoprion*, and a new genus of probable ramphoprionid affinity. Additionally, *Skalenoprion* and *Kalloprion*? are recorded, both for the first time from Gondwana. Characteristic of the assemblage is very low frequency of taxa with placognath-type jaws. Comparing the Qusaiba-1 assemblage with coeval faunas of Baltica and Laurentia revealed that northern Gondwana was more similar to mid-continent Laurentia than Baltica. High proportion of paulinitids, ramphoprionids and atraktoprionids, and scarcity of placognaths is typical of both northern Gondwana and Laurentia. The Baltic faunas, in contrast, had several endemic genera particularly among placognaths, whereas paulinitids and ramphoprionids were rare. This anomalous biogeographic pattern, diverging from that of most other fossil groups, cannot be fully explained without additional first-hand data from the Middle and early Late Ordovician of Gondwana and Laurentia.

1. Introduction

Scolecodonts are the jaws of polychaete annelids, a group of soft-bodied worms that appeared in the Cambrian and flourish in present-day oceans. Unlike the body fossils of polychaetes, which are extremely rare, the organic-walled scolecodonts are common and diverse in Paleozoic marine sediments. They are frequently recovered from palynological samples together with chitinozoans and acritarchs. Although scolecodonts are known since 1850s, it was only in 1960s when the apparatus-based classification and acid extraction technique were widely adopted (Kielan-Jaworowska, 1966) and scolecodonts turned useful proxies for studying ecology, distribution and diversification of extinct polychaetes. Since then the collections and number of publications on scolecodonts have considerably increased (Hints and Eriksson, 2007a).

The main diversification episode of jaw-bearing polychaetes occurred during the Ordovician Period, when most families and genera characteristic of the Paleozoic first appeared. In spite of the fact that Ordovician scolecodonts are better known than those of any other time period, they have been thoroughly studied only in the Baltic area and partly in Laurentia, whereas data from the other regions and continents are very limited (for overview see Hints et al., 2004; Hints and Eriksson, 2007a). In particular, the Ordovician polychaete faunas of the entire Gondwanan realm have remained poorly known. This, indeed, has limited our understanding of paleobiogeographical patterns as well as stratigraphical distribution and diversification of fossil jaw-bearing polychaetes. Hints and Eriksson (2007b) therefore concluded that more first-hand data from Gondwana are essential for improving the global biogeographic assessment.

A recent study of chitinozoans from the Qusaiba-1 shallow core, central Saudi Arabia (see Paris et al., 2015a–in this volume) revealed the occurrence of well-preserved scolecodonts in a number of Late Ordovician samples. Investigation of this material commenced in the frame of the French–Estonian collaboration project in 2007–2008, when the chitinozoan slides were examined and additional scolecodonts were picked from the palynological residues in the Rennes University, France. Although the obtained collection is small, especially when compared to data available from Baltica and Laurentia, it constitutes the richest scolecodont assemblage so far from the Ordovician of

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Gondwana, being also the first report of scolecodonts from the Arabian Peninsula. Preliminary results of this study were presented at the CIMP sponsored session at the 12th International Palynological Congress in Bonn (Hints et al., 2008). The aim of this paper is to describe this material in closer detail and discuss its paleobiogeographical significance.

2. Locality and stratigraphy

The Arabian Peninsula constituted the western part of the Gondwana supercontinent during the Ordovician and Silurian (Cocks and Torsvik, 2004). The Qusaiba-1 shallow core hole was drilled near the deserted Qusaiba village, ca. 75 km NNW of Buraydah, Al-Qassim Province, central Saudi Arabia (Fig. 1), with the aim of obtaining unweathered samples for palynology and a continuous stratigraphic record of Late Ordovician and early Silurian strata. Full details of the sedimentology and stratigraphy of the Qusaiba-1 section are provided by Melvin (2014–in this volume) and Paris et al. (2015a,b–in this volume); therefore only a brief description is given herein.

The Ordovician and lowermost Silurian succession of the Qusaiba-1 section is composed of shales, siltstones and sandstones. The shallow core hole with a total depth of 551.0 ft (ca. 168 m) went through the shales of the Qusaiba Member, Qalibah Formation, for 257 ft (ca. 78 m) and penetrated the underlying Ordovician strata for 294 ft (ca. 90 m). The local Upper Ordovician succession includes the glacially related sediments of the Sarah Formation (from bottom to top: Sarah Sandstone, Baq'a Shale and Baq'a Sandstone), and the alternating shales and sandstones of the Quwarah Member in the upper part of the Qasim Formation (Fig. 2).

According to Melvin (2014–in this volume) the Quwarah Member was deposited in a proximal pro-delta to distal delta front. This member ends with a prograding shoreface sequence unconformably overlain by the Sarah Formation, which begins with a basal disrupted facies (glaciotectonic unit) corresponding to the lower part of the Sarah Sandstone Member. The main sandy part of the Sarah Sandstone Member represents gravity flow deposits. The Baq'a Shale Member begins with stratified diamictites, interpreted as resulting from the final melting of the Gondwana ice sheets. The Sarah Formation ends with the Baq'a Sandstone Member representing delta-front sandy deposits abruptly overlain by high energy fluvial sediments (Melvin, 2014–in this volume). This fluvial sequence is likely related to the post glacial isostatic uplift described by Melvin and Miller (2009).

Chitinozoan biostratigraphy implies that the Katian–Hirnantian boundary lies within the uppermost Quwarah Member, coinciding with *Ancyrochitina merga* and *Tanuchitina elongata* chitinozoan biozones. The Sarah Formation represents the Hirnantian. The basal part of the Qusaiba Member is referred to the earliest Rhuddanian, whereas the main part of the latter member corresponds to the mid Aeronian (Paris et al., 2015b–in this volume).

3. Material and methods

For organic-walled microfossils only shales and siltstones were sampled. The bulk samples, 8–60 g in size, were provided to FP for chitinozoan study by the Saudi Arabian Oil Company (Saudi Aramco). On average 6–10 g of each sample was processed for palynomorph extraction using standard HCl and HF treatment in the palynological laboratory of Rennes University. Microfossils, mostly chitinozoans, were hand-picked and mounted on permanent palynological slides. The remaining sample residues were kept in distilled water for future analysis. For full methodological details see Paris (1981) and Paris et al. (2015a–in this volume).

In search for scolecodonts, chitinozoan slides from 20 samples were examined and 14 of them turned productive. The jaws mounted on slides were photographed under a Leica optical microscope in Rennes University. Additionally the residues of six samples were re-picked for scolecodonts under a stereo-microscope. Scolecodonts were common or abundant only in three of the residues studied. Altogether the collection contains ca. 100 individual diagnostic jaws, a few fused jaws and one jaw apparatus, not counting fragments and various non-diagnostic smaller elements (the total number of scolecodonts is about 200).

The picked specimens were stored in glycerine and studied according to the methods described by Hints (1998). Scolecodonts were photographed using a Nikon AZ-100 optical microscope equipped

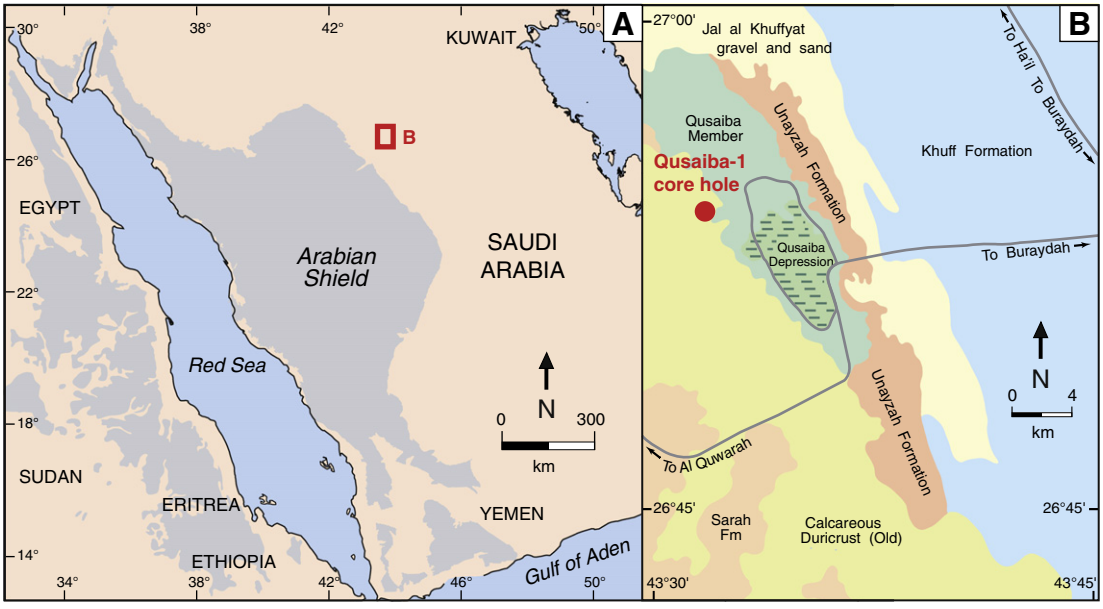

Fig. 1. Location maps for the Qusaiba-1 core hole. (A) Map of the Arabian Peninsula showing the location of the north-western part of the Buraydah quadrangle in Qasim region, central Saudi Arabia (red box). (B) Geological sketch map of the north-western part of the Buraydah quadrangle, showing location of the Qusaiba-1 core hole. Modified after Zalasiewicz et al. (2007).