

First record of Hyolithids in the Cambrian of Kerman Region (Central Iran)

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The Cambrian sediments from the Central Zone of Iran, exposed along the Kuhbanan region, northwest Kerman, southeast Iran, are studied. 175 m thick succession, lithologically constituted of gray, thin to thick bedded limestone, shale and sandstone is examined. Study of the primitive small shelly fauna present in this section revealed tracts of organisms belonging to family hyolithids, genus *Triplicatella* for the first time from this region.

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INTRODUCTION

Hyolithids, globally known as an extinct group of Palaeozoic bilaterians marine animals with a conical shaped calcareous exoskeleton, are very important early Palaeozoic component of the Cambrian Evolutionary Fauna (Sepkoski, 1981). This group consists of morphologically two distinct subgroups, i.e. Hyolithida and Orthothecida, which are usually treated as orders (Runnegar *et al.*, 1975; Marek and Yochelson, 1976; Malinky and Yochelson, 2007). Study of the Kuhbanan Formation in the Central Zone of Iran contributes to our understanding of Cambrian animals and their interactions. Hyolithids found in the basal part of the Kuhbanan Formation are focus of the present paper.

The Cambrian outcrops are widely distributed in Central Zone of Iran and well exposed through the north part of the Kerman region in southeastern Iran. The Cambrian System of this area includes thick deposits consisting of the Dahu and Kuhbanan Formations (Aghanabati, 2004). The Dahu Formation, which belongs to the lower Cambrian, is composed of red to brown sandstone, dolomite and limestone. The Kuhbanan Formation exposed near the Kuhbanan city is mainly composed of trilobite-bearing limestone, sandstone, and shale. The Trilobite fauna along with remains of brachiopods, bivalves and gastropods are the most common invertebrate fossils within the Cambrian strata. Trilobite assemblage indicated late Early Cambrian to Middle- early Late Cambrian time interval for the deposition of the Kuhbanan Formation (Ameri and Zamani, 2013).

GEOLOGICAL SETTING

Some parts from north, northwest, central, and southeast of Kerman are located in the Central Iran structural zone. Central-East Iranian Micro-continent (CEIM) (Takin, 1972; Stocklin, 1974), together with central Iran and the Alborz Mountains, forms the Iran Plate which occupies a structural key position in the Middle Eastern Tethys (Sengor *et al.*, 1988; Sengor, 1990). The CEIM consists of north-south oriented structural three units i.e., the Lut, Tabas, and Yazd blocks. From a tectonic point of view, this region is located in the Central zone of Iran in the southeastern part of the structural and geographic framework of Iran divisions (Stocklin, 1968). Kerman region is bounded by Nayband fault to the east and to the Kuhbanan fault zone (with north-south trend) to the west. Tectonically, the area is part of a foreland basin filled dominantly with a thick sequence of clastic and carbonate sediments.

175 m thick studied section (31° 25' 26'' N and 56° 16' 76'' E) is located 2 km north of the Kuhbanan city and 200 km northwest of Kerman (Fig. 1). Red siliciclastic rocks of the Dahu Formation are covered by the basal white quartzite of the Kuhbanan Formation (Fig. 1) and are in unconformable contact. The Kuhbanan Formation is conformably overlain by the Devonian deposits of the Bahram Formation with a sharp faulted contact (Fig. 1d). The Kuhbanan section mainly constituted of thick-bedded, white quartzite with ripple marks and chert pebbles; red to brown, medium to coarse-grained sandstone, grey to brown dolomite also with chert grains,

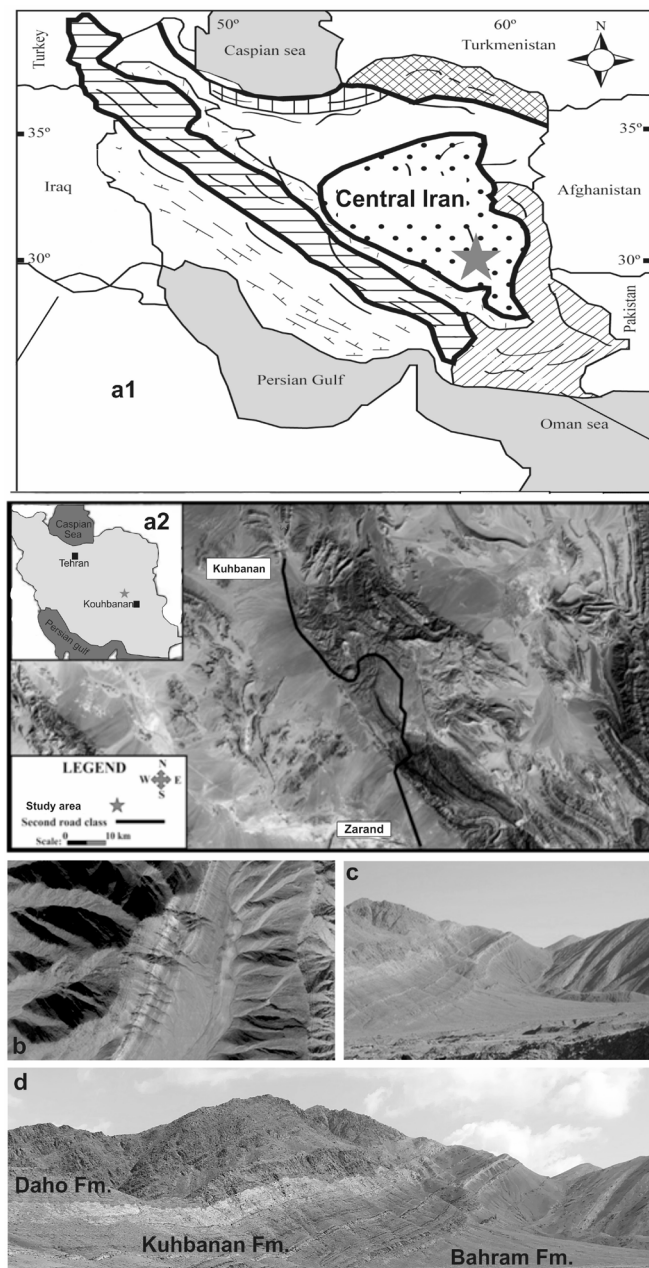


Fig. 1, a-b: Satellite photograph and access roads of the studied section. **c-d:** Outcrop at Kuhbanan region with sequence of lithostratigraphic units from Daho Fm. to Devonian deposits.

brown to black thin to thick bedded limestone, and reddish interbedded marly limestone. In the basal part of studied section, trilobites, brachiopods, bivalves and gastropods are present in 20-15 meter section from the base.

MATERIALS AND METHODS

Brownish limestone and lime marls of the Kuhbanan Formation are fossiliferous. Loose conchs and opercula constitute the hyolithid skeletal elements belonging to a single hyolithid species. Trilobites associated to these individuals indicate the *Redlichia noetlingi* biozone assigned to late Early Cambrian to early Middle Cambrian in age (Ameri

and Zamani, 2015). Specimens examined and digitally photographed are housed in the Geological Department of Shiraz Islamic Azad University, Iran.

SYSTEMATICS

Class **Hyoilitha** Marek, 1963
Order **Orthothecida** Marek, 1966
Family **Triplicatellidae** Lio *et al.* 2020
Genus **Triplicatella** Conway Morris in Bengtson *et al.* 1990

***Triplicatella* sp.**
 (Figs. 2, a-d)

The original shape of the hyoliths from the Kuhbanan Formation are slightly distorted and fragmented due to compression, and some of the specimens are preserved as flattened conchs, while a few are three-dimensionally preserved due to infilling. Studied hyolithids are referred to order Orthothecida due to quadrate - triangular conch, simple aperture without ligula, flat aperture, and absence of Helens.

Description: Ninety-seven monospecies tubular shells, rapidly expanding and small, convex, oval, and subtriangular in outline. Length ranging from 0.8 to 1.7 mm and width ranging from 0.2 to 0.5 mm. Specimens are mineralized, elongate, narrow, cone-shaped, and gently curved conch with cap-shaped and convex operculum without cardinal processes. The external surface of conch consists of fine and concentric growth lines. Conch and operculum are sometimes displaced and found in isolation forms. It lacks Helens, and internal morphology is not known.

Occurrence: Central Iran Zone, north Kerman Province, Kuhbanan Formation.

Age: late Early Cambrian.

DISCUSSION

Despite significant interest in the Kuhbanan deposits in recent years, hyoliths occurring in this formation were not studied so far. Three-dimensionally preserved guts of animals are found in the Cambrian of Central Iran Zone. Hyoliths of the Kuhbanan Formation stratigraphically sits over *Redlichia noetlingi* biozone and therefore, correlated with late Early Cambrian to early Middle Cambrian in age (Ameri and Zamani, 2015). The most of hyolithids are found in the clusters with conchs and mostly disarticulated opercula. No other remains of identifiable skeletal fossils are found in these clusters. Lio *et al.* (2020) mentioned that in some clusters *Triplicatella* shows a preferential orientation with some individuals buried at slightly different depths in the sediment, sometimes partly overlapping each other, which probably indicate concentration of organisms on the seafloor. Moreover, distinct ornamentation, low degree of fragmentation, fracturing and abrasion suggest that these animals were rapidly buried *in situ* and experienced minimal transportation before the deposition (Hou *et al.*, 2004).

Similar fossils were reported in the Cambrian successions of eastern China, Germany, Italy, France and Spain (Qian *et al.*, 1979; Kerber, 1988; Elicki, 1997; Elicki *et al.*, 2003; Elicki and Pillola, 2004.). The specimens of hyolithids and

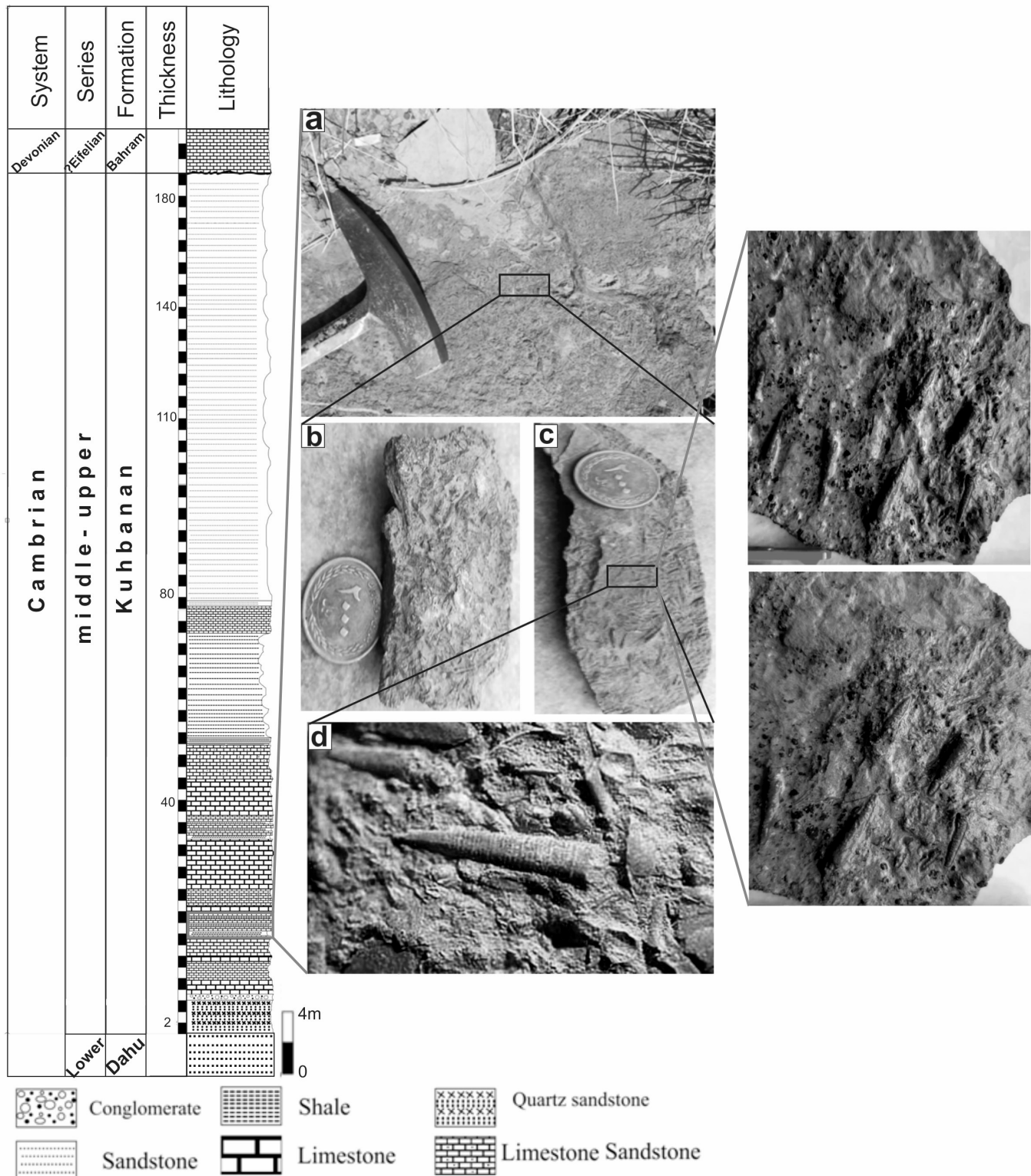


Fig. 2: Stratigraphical and lithological column of Kuhbanan Formation. **a-c:** Heliolithid samples in Kuhbanan section. **d:** Close view of heliolithid sample magnified 200X.

some other small shells, such as primitive brachiopods and primitive sponges, in the Cambrian of the Mediterranean realm are closely related. Recent palaeobiological research suggests that, the Cambrian ecosystem was flourishing at a very shallow sea (Alvaro *et al.*, 2007). The sensitivity of small

shells, such as assemblage of hyolithids, help understand the palaeoenvironmental conditions. Accumulation of hyolithid fossils in the Cambrian of different regions can help recognize similar palaeoecological conditions. Ecological sensitivity and regional changes indicate changes in the substrate fauna

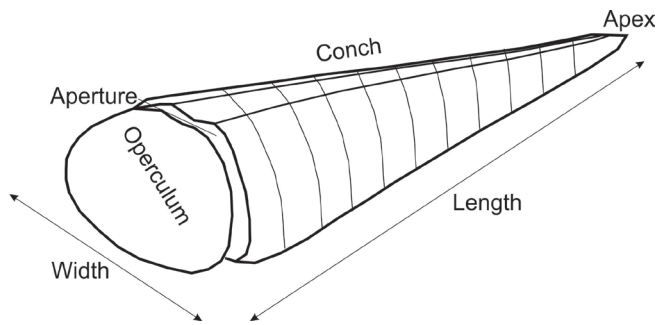


Fig 3: General morphology of hyolithides shell

as well as tectonic effects. The fossils found in Cambrian are specific to the Gondwana margins which were observed till the end of middle Cambrian (Elicki, 2005; Ruban *et al.*, 2007).

Sedimentary information shows a cross belt of diverse facies in the most parts of Europe. Alvaro *et al.* (2003) conducted studies on early Cambrian trilobites and some tiny shells. Palaeogeographic relationship between Cambrian in the Mediterranean and the Far East is more easily comparable based on trilobites as well as their tiny shells. Some taxa like gastropods and bivalves may confirm the relationship among these areas. Based on some local specimens, it is assumed that the migration of these shells was limited which is observed in certain areas of Asia. Biostratigraphy based on these tiny shells helps greatly in correlation of the strata which otherwise lack trilobite. The palaeobiogeographical model proposed by Elicki (2005) determined the position of Iran at 10 degrees on the Asian platform while the deposition was taking place during the Cambrian.

Paleobiogeography of central iran zone

The main benthic fauna in the Central Zone of Iran includes brachiopoda, ostracods, and trilobites, and it has a direct relationship with simultaneous fauna in the tropical latitudes (for example, Laurentia, Baltica and southern China) (Alvaro *et al.*, 2013). Hyolithid traces found in the Kuhbanan area are no exception. Through the lower Palaeozoic, most of Iran, including the Zagros Basin and Central Iran Zone,

was an integral part of Gondwana (Brenchli *et al.*, 1994). All these areas were affected by the cold near Antarctica currents (Brenchli *et al.*, 1994). Hirnantian was the maximum glaciation time in the heart of a longer ice age that continued until Silurian. During the ice age, cold oceanic currents (adjacent to Antarctica) flowed along the west coast of Gondwana and affected Central Iran (Alvaro *et al.*, 2013). This current caused the growth of the polar cap due to creating severe cooling. Antarctic currents weakened during global warming, and consequently, hot water benthic fauna was able to spread to temperate southern latitudes along the west coast and eventually to Central Iran Zone. Warmer climate was accompanied by the migration of various new benthic fauna. Significant warming occurred in Central Iran during lower Aeronian. The reason for this warming is the spreading of tabulate corals and roguza that were not existed in Ordovician in Iran (Qobadipour *et al.*, 2015). Therefore, the paleobiogeographic model of Iran may be designed as follows through the Cambrian.

It is interpreted that Iran was located near 0° latitude during the Cambrian. Moreover, the latest studies on the Central Iran palaeogeography based on brachiopods indicate that Iran was located on latitude near 0° during Cambrian, and its biological fauna are correlated with southeast Asia, southern China, southern Siberia, and the Baltic (Elicki, 2005; Landing, 2005). It is concluded that the existence of hyolithid in the Cambrian units of Central Iran Zone and the appearance of mentioned primitive animals in this study show that the central Iran Zone and Kerman region were located in latitude near 0°S during the Cambrian.

CONCLUSIONS

Late Early Cambrian age hyolith *Triplicatella* is reported for the first time from the Kuhbanan Formation of the Central Zone of Iran. The new material of *Triplicatella* described herein confirms that Iran was located on latitude 0° during the Cambrian and its faunal composition is correlated to Southeast Asia, southern China, southern Siberia, and the Baltic Basin.

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