Hanadirella: a new problematic arthropod(?) from the Lower Ordovician (Llanvirn) Tabuk Formation, central Saudi Arabia

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The new genus *Hanadirella* - with the type species *H. bramkampi* - from the Lower Ordovician (Llanvirn) of central Saudi Arabia represents a segmented organism which appears to have an arthropod affinity. The problematic genus is oval hat-shaped, less than 1 mm in diameter. Its affinity and palaeoecology are discussed.

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Introduction

This paper presents the first record of a problematic fossil described here as an arthropod exoskeleton of some sort, possibly a crustacean carapace(?). They are oval, convexo-concave, hat-shaped bodies, less than 1 mm in diameter. These fossils have been collected during the search for trilobites in the Hanadir Shales Member of the Tabuk Formation, at Al-Hanadir (43°27′20″E, 26°25′50″N), c. 53 km NW of Burayda, Al-Qasim Province (Fig. 1.).

The lithostratigraphy of the Tabuk Formation has been described by Thralls & Hasson (1956), Steineke et al. (1958), Helal (1964, 1968), Powers et al. (1966), and McClure (1978). According to Powers et al., the Tabuk Formation (Lower Ordovician to

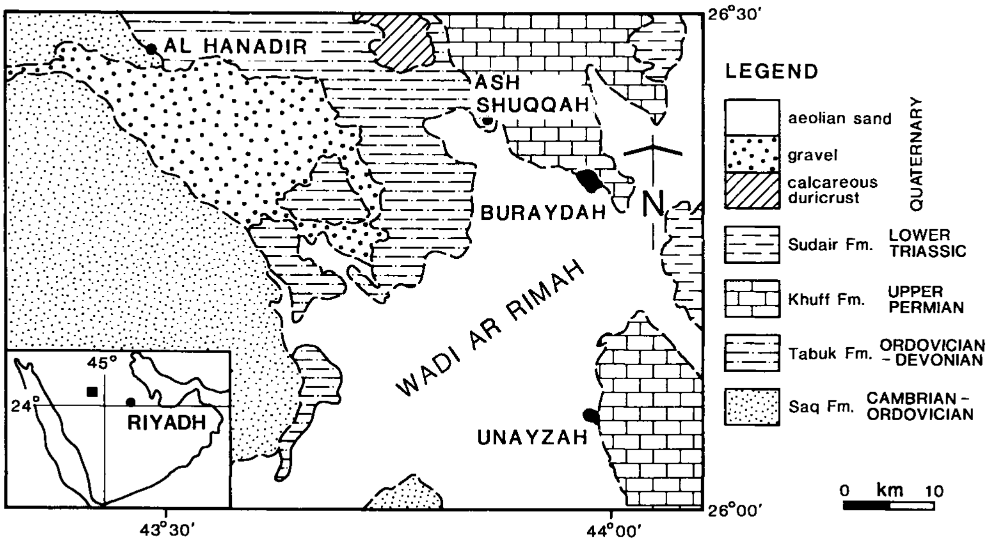

Fig. 1. Location and geological map of Jabal Al-Hanadir, Qasim Province, Kingdom of Saudi Arabia (modified after Bramkamp et al., 1963; compare also El-Khayal & Romano, 1985, fig. 1).

Lower Devonian) rests conformably but with a sharp contact on the sandstones of the Saq Formation which is of possible Cambrian to Early Ordovician age. Helal (1964), however, regards the contact as being disconformable. The writer has noticed that at 1.5 m below the base of the Hanadir Member (Fig. 2) a thin (20 cm) conglomerate bed with sandstone boulders up to 30 cm in length occurs, containing abundant fragments and broken valves of inarticulate lingulacean brachiopods in the matrix. This bed is overlain by fine-grained sandstones with *Cruziana* (*C.* cf. *furcifera, C. huberi* and *C. goldfussi*) and numerous traces resembling *Arthrophycus* (Powers et al., 1966). Helal (1968) suggests a possible Arenig age for this unit. The association of lithofacies and trace fossils resembles the Lower Ordovician pebbly channel facies of Jordan described by Selley (1970). Beds containing lingulacean debris are found at a similar horizon in central Portugal and Brittany, where they occur at the top of the Armorican Quartzites (El-Khayal & Romano, 1985). The Hanadir Shales form the basal unit of the Tabuk Formation and vary in thickness from 12.2 to 68.5 m (Powers et al., 1966, p. D112-113). At Al-Hanadir they are at least 23 m thick. The upper boundary is formed by the base of a 2 m thick sandstone bed, shown in Fig. 2, which belongs to the overlying sandstone unit (Unit 2 of Powers et al., 1966). There is, however, a gap in the exposure in the lower part of the sequence. The Hanadir Member consists mainly of pale buff to greenish brown shale, occasionally gypsiferous and limonitic, with thin beds of siltstone, fine ferruginous sandstone and calcareous conglomerate. The 2 m thick sandstone bed overlying the Hanadir Shales Member has a conglomeratic base with abundant fossil debris dominated by lingulaceans.

Graptolites from the Hanadir Shales have been known since 1947 and were later identified by Ross Jr as *Didymograptus protobifidus* (see Powers et al., 1966, p. D25). According to McClure (1978) the graptolites indicate the Upper Llanvirn *murchisoni* Zone, which is confirmed by the trilobites, and rich chitinozoan and acritarch assemblages. Khashogi (1979) concluded that the *murchisoni* Zone was indicated by assemblages

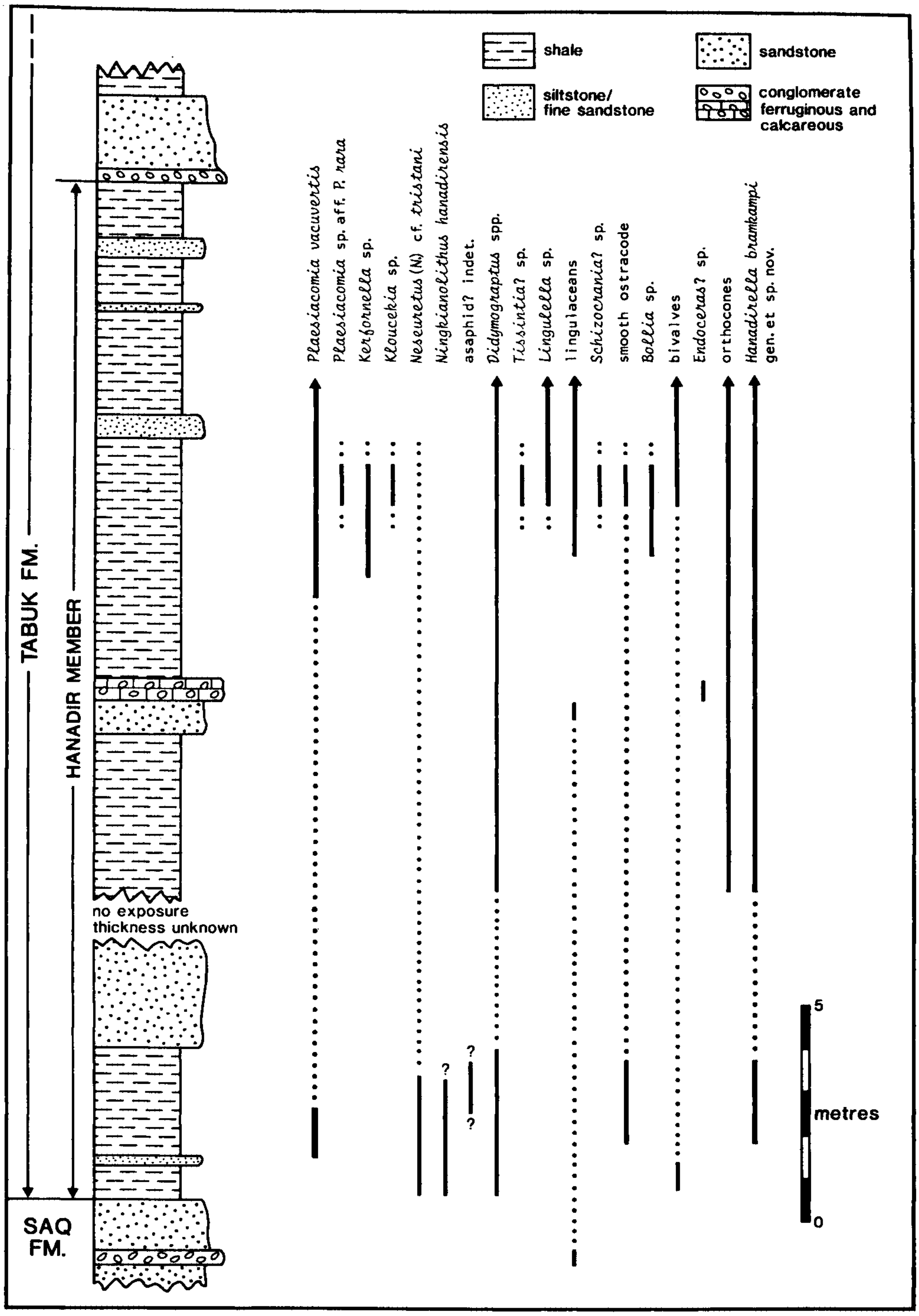

Fig. 2. Stratigraphic section and ranges of fossils found at Al-Hanadir (modified after El-Khayal & Romano, 1985, fig. 2).

occurring 1.5-2.0 m above the base. The most recent reference to the graptolite fauna is by Fortey & Morris (1982, p. 680). They list *D. murchisoni, D.* cf. *geminus, D. artus* and *D.* cf. *spinulosus* and concluded that a late Llanvirn age is likely. Forty and Morris also figured *Neseuretus (N.) tristani* from the graptolite-bearing sequence and recorded associated inarticulate brachiopods (*Schizocrania?, Monobolina, Lingulella*) as well as the bivalve *Glyptarca* cf. *narajoana* (de Verneuil & Barrande, 1855). El-Khayal and Romano (1985) have indicated that the Hanadir Shales contain a more diverse trilobite fauna than was originally thought and provided additional information on the faunal affinities and provincialism of the faunas. So in addition to the previously mentioned *Plaesiacomia vacuvertis* and *Neseuretus (Neseuretus) tristani* the following have been recognized: *Neseuretus (Neseuretus)* cf. *tristani, Plaesiacomia* aff. *P. rara, Kerfornella* sp., *Kloucekia* sp., *Ningkianolithus hanadirensis,* and asaphid indet. The fauna also includes graptolites, brachiopods, bivalves, ostracodes, and orthocones.

Hanadirella bramkampi sp. nov. was found in beds associated with indeterminate ostracodes, *Plaesiacomia vacuvertis, Plaesiacomia* aff. *P. rara,* a meraspid trilobite, a small bivalve, and one problematic form.

Acknowledgments

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Palaeontology

Hanadirella gen. nov.

Type species — *Hanadirella bramkampi* gen. et sp. nov.

Derivatio nominis — The genus name *Hanadirella* is derived from the Jabal Hanadir, the type locality of the Hanadir Shales Member of the Tabuk Formation.

Diagnosis — For the diagnosis and description see the diagnosis and description of *H. bramkampi*.

Hanadirella bramkampi gen. et sp. nov.
Fig. 3; Pls 1-4.

Derivatio nominis — The species is named after the outstanding American geologist R.A. Bramkamp, a pioneer worker who contributed much to the geology of Saudi Arabia.

Plate 1

A photograph of a slab of Hanadir Shale showing hundreds of specimens of *Hanadirella bramkampi* gen. et sp. nov. associated with *Didymograptus murchisoni*; specimen KSU-OTH 100, × 4.

Type specimen — External mould, KSU-OTH 101 (Pl. 3, figs. 1-2).
Type locality — Al-Hanadir (coord. 43°27'20"E, 26°25'50"N), c. 53 km NW of Burayda, Al-Qasim Province, Saudi Arabia (see Fig. 1).
Type horizon — Shale beds below sandstone layer in upper part of the Tabuk Formation (see Fig. 2).
Diagnosis — Very thin, small carapaces, circular to ovoid in outline, less than 1 mm in diameter and less than 0.2 mm in height. Grooves give the carapace a segmented appearance. Considered to have originally been composed of $CaCO_3$ and to be of crustacean affinity.

Material — More than one thousand specimens preserved as internal and external moulds are kept in the collection of the Geology Department, King Saud University, Riyadh, Saudi Arabia. Topotype material is kept at the Rijksmuseum van Geologie en Mineralogie (National Museum of Geology and Mineralogy), The Netherlands, registered under the numbers RGM 343 098, 343 099.

Description — The carapace was very thin, circular to ovoid in outline with a c. 0.1 mm wide surrounding rim. It was supposedly composed of $CaCO_3$, which has been dissolved leaving behind only moulds of the dorsal and ventral surfaces. The dorsal surface is seen on the shale as a concave structure while the ventral surface forms a convex, circular to ovoid body. The size is less than 1 mm in diameter and less than 0.2 mm in height. Table 1 shows the length and width ratios measured from 68 specimens, preserved as external or internal moulds. The length of the external moulds ranges between 0.6 mm and 0.9 mm (most specimens: 0.7 mm), their width between 0.5 mm and 0.7 mm (most specimens: 0.5 mm). The internal moulds range between 0.6 mm and 0.8 mm in length (most specimens: 0.6 mm). The dorsal side has 6 to 9 ridges, which are seen as grooves on the external concave moulds. In latex external casts, they are seen as raised ridges, on each side of these ovoid bodies, running from the dorsal axial area to the lateral areas in a curve, then running up to the middle of the surrounding rim but they do not reach the margins. The ridges increase in length towards the posterior side attaining maximum length just after the middle and then decrease in length towards the posterior side. These ridges give the carapace a segmented appearance suggesting 6-9 segments.

There are two grooves on the anterior side of the dorsal mould running parallel to the surrounding rim. These may be the moulds of anterior eyes (Pl. 3, figs. 1, 2).

The ventral side is preserved as convex moulds, with raised ridges (see Pl. 4, fig. 1). The posterior side of the internal and external moulds shows four transverse segments which are parallel to each other and also to the posterior rounded edge. The length of these segments increases gradually towards the posterior side. There are some faint transverse furrows on the internal axial area which meet the side ridges at an acute angle (Pl. 4, fig. 2).

Table 1. The length and width of 68 specimens in mm.

Length-width	0.9-0.7	0.8-0.7	0.8-0.6	0.7-0.6	0.7-0.5	0.6-0.5
Number of external moulds	1	2	12	5	18	13
Number of internal moulds	—	1	2	—	—	14

Plate 2

Enlargement of the upper right side of the slab shown in Pl. 1 with *Hanadirella bramkampi* gen. et sp. nov. and their size relation to *Didymograptus*, × 20.

Plate 2

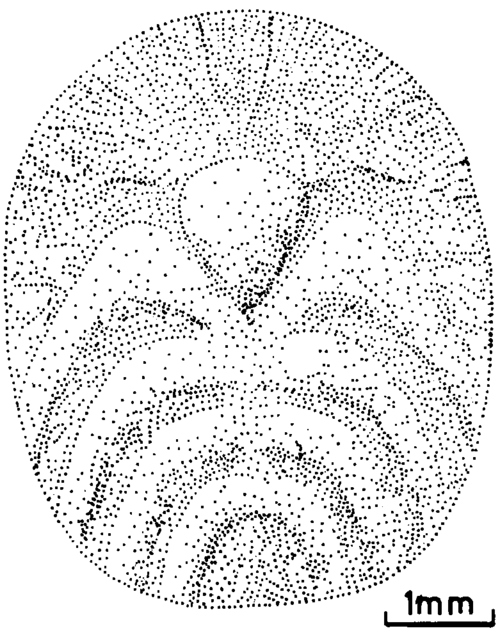

Fig. 3. *Praecambridium sigillum* Glaessner & Wade, 1966, diagrammatic reconstruction of a specimen with four segments and a triangular terminal area (after Glaessner & Wade, 1971).

Affinity

The question arises what kind of fossil *Hanadirella bramkampi* is. A graptolite affinity is ruled out by the fact that these microfossils are convexo-concave, hat-shaped, less than 1 mm in size, and the internal moulds always stand in relief and are not carbonized, but considered to have consisted of $CaCO_3$, while the graptolite remains are flat and carbonized. Similarly, gastropod affinity or the possibility of an early stage of bivalve proloculus can be dismissed.

Are they fish remains of some sort, e.g. dermal scales? By examining the photographs and reconstructions of the earliest Upper Cambrin fish *Anatolepis* from North America (Repetski, 1978), the Early Ordovician *Anatolepis* from Spitzbergen (Bockelie & Fortey, 1976), and the first Ordovician vertebrates *Arandaspis* and *Porophoraspis* from Australia (Ritchie & Gilbert-Tomlinson, 1977), it is revealed that the shape, symmetry and other characters of *Hanadirella bramkampi* differ in all aspects from the dermal scales of these early fishes.

Plate 3

Fig. 1. A Scanning Electron Micrograph of the external mould of the holotype of *Hanadirella bramkampi* gen. et sp. nov., Hanadir Shale, Tabuk Formation, Saudi Arabia; KSU-OTH 101, × 120.

Fig. 2. A Scanning Electron Micrograph enlargement of fig. 1 showing the grooves that are left from the eyes (?) of *Hanadirella bramkampi* gen. et sp. nov.; × 275.

Plate 3

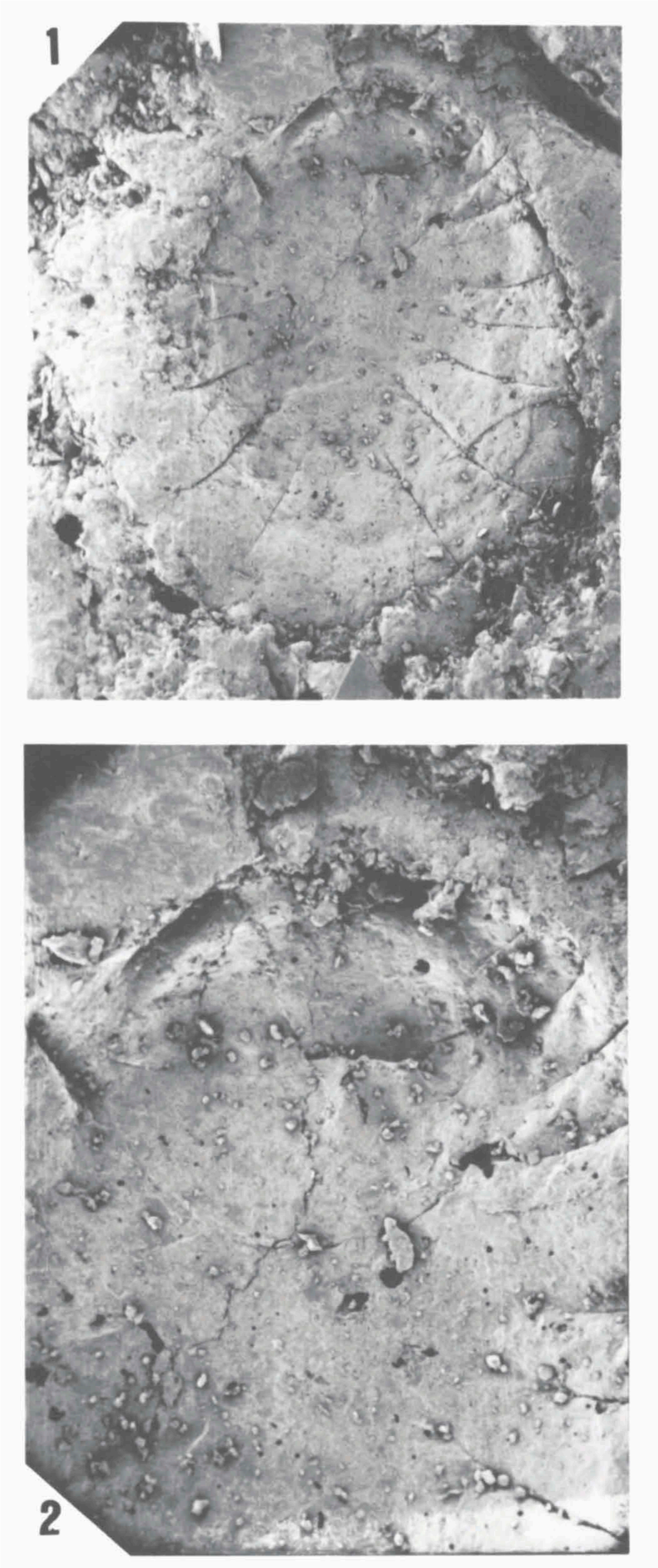

Fig. 4. *Vendia sokolovi* Keller, 1963, diagrammatic reconstruction. Five segments are shown in this interpretation of the fossil as bilaterally symmetrical with slight distortion, × 5 (after Glaessner & Wade, 1971).

There are at least two reasons against the acceptance of annelid relationships of *Hanadirella*. One is the relatively small size (less than 1 mm) of *Hanadirella*. So far such a small-sized annelid is unknown. The other reason is the absence of any lateral projections from the body which could represent parapodia.

The problematic genus *Cyclus* de Koninck, described as a crustacean shield, differs markedly from *Hanadirella* in size, ornamentation and other aspects. *Hanadirella* shows certain similarities with *Praecambridium sigillum*. Glaessner and Wade (1966, p. 623) described it as 'Oval disc-shaped bodies less than 5 mm. in length and under 4 mm. wide. One is slightly conical, rising 0.15 to 0.2 mm. above the bedding plane; the remainder are flattened. The surfaces of the casts each bear three pairs of small raised lobes and an axial lobe. These lobes are more or less confluent in the centre. The axial lobe of the best-preserved specimen bears another pair of small lobes laterally. All the paired lobes taper to pointed outer ends which are directed towards one end of the disc. This is here considered the posterior end. The axial lobe is rounded at the opposite (anterior) end'. *Praecambridium sigillum* must have been soft rather than brittle but strong enough to be preserved as external moulds in the overlying sediments much the same as *Hanadirella bramkampi*. The main differences between the two are the size and nature of segmentation. *Praecambridium* has an anterior lobe which has some characters of a glabella, and the small number (3-5) of chevron-shaped segments which decrease rapidly in size towards a minute triangular posteromedian area. In *Hanadirella* the surrounding rim and the fused segments are at the posterior side. Fig. 3 shows *Praecambridium sigillum* as illustrated by Glaessner & Wade (1971).

Vendia sokolovi Keller was figured by Menner (in Keller, 1963, pl. 18, fig. 11) as a trilobite-like organism from the Late Precambrian of the northern U.S.S.R. (Yarensk Borehole, 1552 m, Vendian, Valdai Series) and was described by Keller (1969, p. 175). The English translation given in Glaessner & Wade (1971, pp. 75-76) is as follows: 'The impression is ovoid, 14 mm long and 8 mm wide. The anterior area is undivided, half-moon shaped, and resembles remotely the head shield of a trilobite. Its sickle-shaped ends are directed obliquely backwards where they merge with the general elliptical contour. Medially a ventral ridge reaches towards the anterior pole. It is about 1 mm

Plate 4

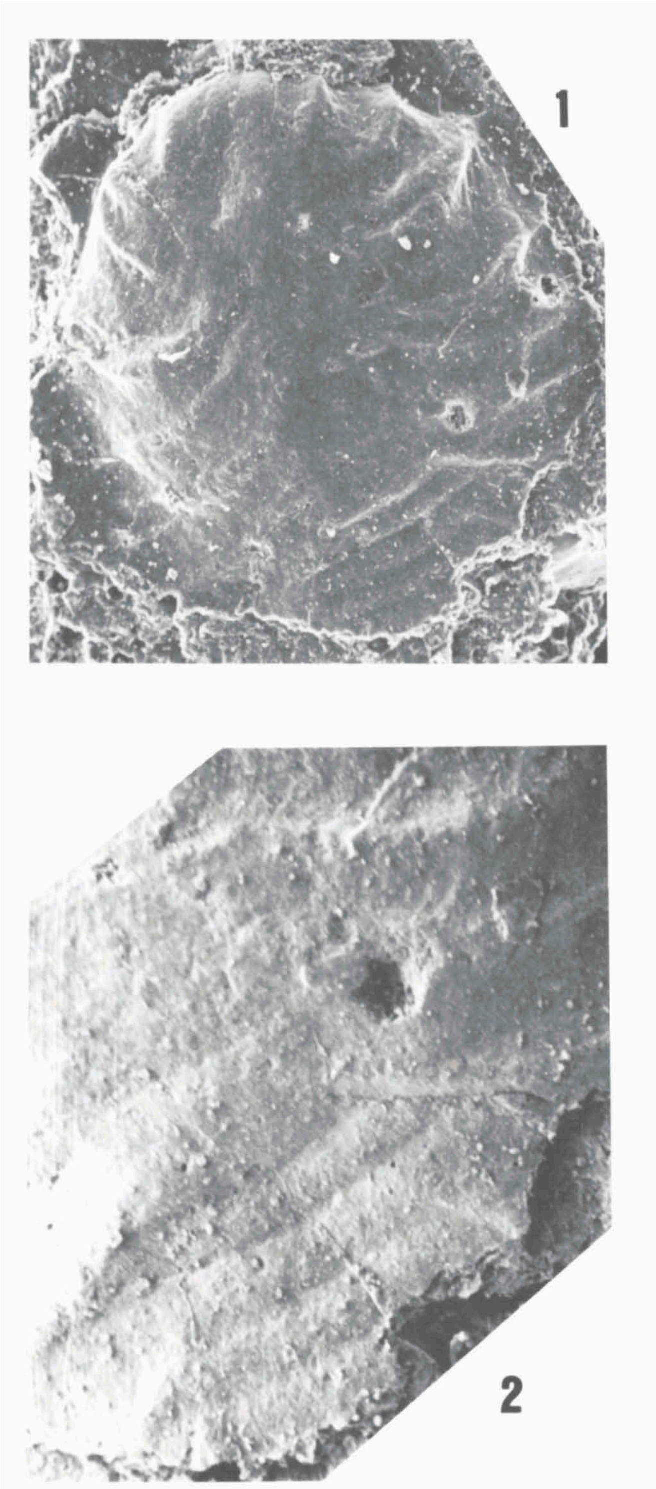

Fig. 1. A Scanning Electron Micrograph of an internal mould of *Hanadirella bramkampi* gen. et sp. nov., Hanadir Shale, Tabuk Formation, Saudi Arabia; KSU-OTH 102, × 120.
Fig. 2. A Scanning Electron Micrograph enlargement of the posterior side of fig. 1; × 200.

wide and 5 lateral branches arose from it. Their length is 3-4 mm and their width 0.8 mm. They are asymmetrically arranged in rows. A faint groove extends down the median ridge. It is very narrow where the lateral outgrowths join the ridge. The posterior portion of the animal is incompletely preserved. Apparently the median ridge ended bluntly and the lateral outgrowths exceeded it significantly in length in the posterior part of the animal.' It is clear from a comparison between *Hanadirella bramkampi* and *Vendia sokolovi* that they are not closely related and differ in many aspects except that they could both have an arthropod affinity. *Hanadirella bramkampi* is much smaller, whereas *Vendia* being 18 times longer, 10 times higher and 10 times broader than *Hanadirella.* It is also different in other details. Fig. 4 shows a diagrammatic illustration of *Vendia sokolovi* after Glaessner & Wade (1971).

A relation to a trilobite protaspis is out of the question since there is no resemblance between *Hanadirella* and protaspis larval stages of trilobites. The main difference is the absence of an axis defined by lateral furrows and divided into segmented rings. The only similarity is the size and the shape, since Whittington (1959, p. 0127) reported that protaspis is the smallest member of trilobite series and is c. 1 mm or less in length (range 0.25-1 mm), subcircular in outline, convex, and without articulation. Affinity to the Chelicerata is hard to determine in the absence of appendages in *Hanadirella* and of any knowledge of equivalent larval stages in fossil Chelicerata.

Many workers on Lower Ordovician stratigraphy and palaeontology have been consulted at the Smithsonian Institute, U.S.G.S., in Washington D.C., at the British Museum of Natural History, London and at Sheffield University, and others from Australia, New Zealand and China as well. All of these workers I have met indicated that they have never seen before these microfossils in the sediments they worked with and agreed with me that *Hanadirella bramkampi* is probably a crustacean carapace exhibiting incipient segmentation.

Palaeoecology

Hanadirella is not restricted to any particular type of sedimentary environment. I consider that its remains may have occurred in almost any kind of open marine sediment, either shallow or deep, into which they have sunk or drifted. Nevertheless, since they are very small and thin, they could easily have been dissolved. They have so far only been found in fine muds, although not in black shales, probably because they were dissolved in the acid water.

Ruedemann (1925) has pointed out that other shales than black graptolite shales exist, such as the Utica Shales, which contain benthonic organisms and a variety of animals other than graptolites. These shales probably represent depostion in quiet waters beyond the littoral zone, where muds probably were carried out by strong undertow. Powers et al. (1966) have indicated that the described Ordovician lithologic units in Saudi Arabia certainly reflect extensive shallow-water conditions in which several marine transgressions are recorded by graptolite-bearing shales.

The presence of these small crustaceans in abundance with graptolites and trilobites of different growth stages and some ostracodes, bivalves, articulate and inarticulate brachiopods indicates that they were in plume i.e. in spring time and probably upon a sudden change in the chemistry of the water died instantly and were preserved in the fine muds of the Hanadir Shales. It is also inferred that they had not drifted in from far away.

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