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Early Permian (Asselian) ammonoids from the Taishaku Limestone, Akiyoshi Belt, Southwest Japan

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Abstract. **An ammonoid fauna comprising eight species belonging to seven genera (*Agathiceras*, *Neoglaphyrites*, *Emilites*, *Somoholites*, *Marathonites*, *Eoasianites* and *Metapronorites*) is described from the Uyamano Formation (Taishaku Limestone) at Miharanoro in the Akiyoshi Belt, Southwest Japan. The fauna includes two new species: *Neoglaphyrites discoidalis* and *Somoholites miharanoroensis*. The genera *Emilites*, *Somoholites*, *Marathonites*, and *Metapronorites* are described from Japan for the first time. From the coexisting interval of these seven genera, the age of the Miharanoro fauna is between the Kasimovian and Asselian, being very probably Asselian because some species show close resemblance to those known from Asselian strata. This is the most diverse early Permian ammonoid fauna ever known from Japan.**

Key words: **Akiyoshi Belt, Asselian, Miharanoro, Permian ammonoid, Taishaku Limestone, Uyamano Formation**

Introduction

Early Permian ammonoids are rare in the Japanese Islands and only nine genera have been reported from the South Kitakami Belt of Northeast Japan and from the Hida-gaien and Akiyoshi belts of Southwest Japan (Ehiro, 2010). The lower Permian of the South Kitakami Belt yields *Agathiceras* cf. *brouweri* Smith, *Agathiceras* sp. and *Artinskia* sp. (Koizumi, 1975; Ehiro, 1995), and the Hida-gaien Belt contains *Propopanoceras* sp. (Nishida and Niko, 1989). The Permian strata of these two belts are composed of shallow marine terrigenous and calcareous deposits. Eight early Permian ammonoid genera are known from the Akiyoshi Belt, including the seamount limestones (Akiyoshi and Taishaku limestones). The Akiyoshi Limestone yields *Paraperrinites* cf. *subcumminsi* (Haniel) and *Stacheoceras* sp. (Nishida *et al.*, 2002). The most diverse early Permian ammonoid fauna is from the Uyamano Formation of the Taishaku Limestone exposed at Miharanoro, Tojo-cho, Shobara City, Hiroshima Prefecture. The Miharanoro fauna is made up of 11 species belonging to 6 genera (Hayasaka and Nishikawa, 1962): *Agathiceras anceps*? Gemmellaro, *A.* cf. *suessi* Gemmellaro, *A. sundaicum* Haniel, *A.* cf. *sundaicum* Haniel, *A. tornatum* Gemmellaro, *Popanoceras bowmani* (Böse), *Peritrochia*? sp., *Waagenoceras*? sp., *Pseudogastrioceras abichianum* (Möller), *Pseudogastrioceras*? sp. and *Adrianites*? sp. These specimens, however, have not yet been described and these six genera are now understood to have different stratigraphic ranges. At least those specimens referred to *Waagenoceras* and *Pseudogastrioceras* should belong to other genera because these genera are limited in age to the middle Permian and late Permian, respectively (Ehiro, 2010).

We examined 35 ammonoid specimens collected from Miharanoro, including those studied by Hayasaka and Nishikawa (1962), and distinguished the following 7 genera: *Agathiceras*, *Neoglaphyrites*, *Emilites*, *Somoholites*, *Marathonites*, *Eoasianites* (Goniatitida) and *Metapronorites* (Prolecanitida). This paper describes the Miharanoro species, including two new species, and discusses the age of the fauna.

Geologic setting of the ammonoid locality

The Taishaku Limestone (Group) is exposed in northeastern Hiroshima Prefecture (Figure 1A). It is a seamount-reef complex deposited in the open waters of the Panthalassic Ocean and accreted to the eastern margin of

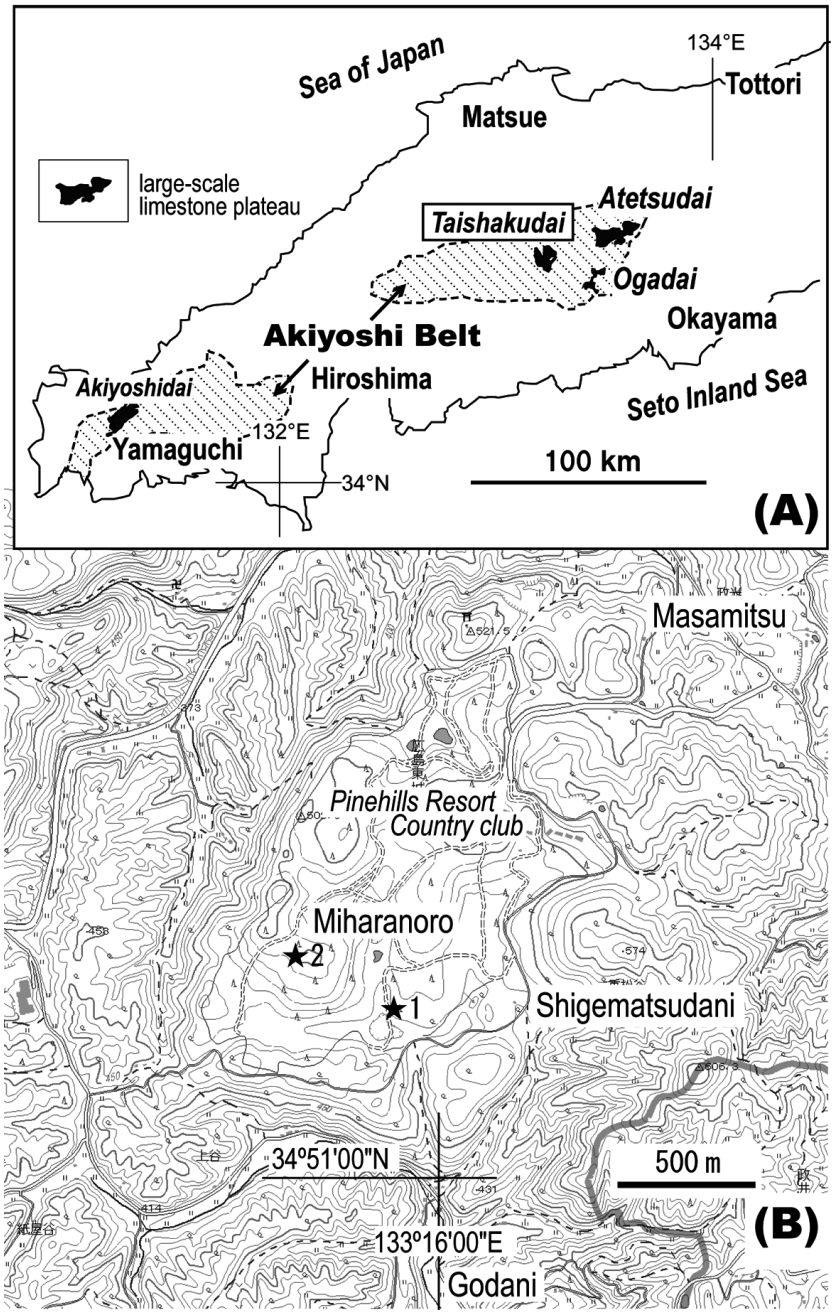

Figure 1. Index map depicting large limestone bodies (limestone plateaus) in the Akiyoshi Belt, Chugoku district, Southwest Japan (A) and map showing the fossil localities (stars) at Miharanoro (B). The base map of B is part of the "Tojo" 1:25,000 topographic map published by the Geographical Survey Institute of Japan. Longitude and latitude are from the International Terrestrial Reference Frame.

the paleo-Asian continent in the middle to late Permian (e.g. Hase *et al.*, 1974; Sano and Kanmera, 1988; Sano *et al.*, 2000). The Taishaku Limestone comprises the Carboniferous Dangyokei and Eimyoji formations and the Permian Uyamano Formation, in ascending order (Hase *et al.*, 1974). The ages of these formations were determined based primarily on their foraminiferal fauna (e.g. Hase *et al.*, 1974; Okimura, 1987).

The ammonoid specimens described here were collected from Miharanoro, Tojo-cho, on the eastern end of Shobara City, Hiroshima Prefecture (Figure 1B, loc. 1). Miharanoro is a limestone plateau, *ca.* 1 × 2 km in

dimension, occupied by limestones belonging to the Eimyoji and Uyamano formations. The limestones distributed in Miharanoro are massive and the geologic structure is not clear. According to Niko and Ozawa (1997), six fusulinoidean zones are recognized in these limestones: the *Triticites ozawai–Carbonoschwagerina morikawai* Zone, *Triticites contractus* Zone, *Pseudoschwagerina muongthensis* Zone, *Pseudoschwagerina miharanoensis* Zone, *Pseudofusulina vulgaris* Zone and *Pseudoschwagerina kraffti* Zone in ascending order. Although the precise fusulinoidean distribution and geologic map of this district have not yet been described, age-diagnostic fusulinoidean faunas are known from two localities (Niko and Ozawa, 1997): one is located in the south–central part of the plateau (Fig. 1B, loc. 1) and the other is in the southwestern part (Fig. 1B, loc. 2). The former coincides with the locality where the ammonoid fossils were collected and is included in the *Pseudoschwagerina miharanoensis* Zone (late Asselian) of the Uyamano Formation. A bactritid cephalopod, *Aktastioceras nishikawai* Niko, Nishida and Hamada, was described from this locality (Niko *et al.*, 1993). The other locality yields fusulinoideans of the *Triticites contractus* Zone (late Gzhelian to early Asselian) in association with some cephalopod fossils: four orthocerids, namely, *Michelinoceras*? sp., *Bogoslovskya miharanoroensis* Niko and Ozawa, *Geisonocerina*? sp. and *Lopingoceras hayasakai* Niko and Ozawa, two nautilids, *Parachouteauoceras bingoense* Niko and Ozawa and *P.*? sp., and a bactritid, *Bactrites* sp. (Niko and Ozawa, 1997).

Ammonoid fauna of Miharanoro

About 60 ammonoid specimens were collected from Miharanoro in association with some orthocerid nautiloids and brachiopods by one of the authors (I.N.). Those studied by Hayasaka and Nishikawa (1962) are all included in this collection. Because the preservation of the specimens is generally not very good and some specimens are small and/or fragmentary, only 35 of these specimens were examined for identification. The Miharanoro fauna consists of 8 species belonging to 7 genera: *Agathiceras* sp. (14 specimens), *Neoglaphyrites discoidalis* sp. nov. (2), *Emilites* cf. *prosperus* Ruzhentsev (3), *Somoholites miharanoroensis* sp. nov. (4), *Marathonites* cf. *jpsmithi* Böse (4), *Eoasianites* cf. *subhanieli* Ruzhentsev (1), *Metapronorites* cf. *timorensis* (Haniel) (6) and *Metapronorites* sp. (1). They belong to the order Goniatitida, except for *Metapronorites* (Prolecanitida).

Hayasaka and Nishikawa (1962) published a provisional report with no descriptions. Because very few of their specimens have labels with specific names, their reports of certain species of *Agathiceras*, *Popanoceras bowmani*, *Peritrochia*? sp., *Pseudogastrioceras*? sp. and *Adrianites*? sp. could not be confirmed. In this paper, among the specimens with attached labels, *Agathiceras sundaicum* (one specimen) and *A.* cf. *sundaicum* (one specimen) were treated as *Agathiceras* sp., but "*Agathiceras anceps*?" (one specimen) was identified as *Somoholites miharanoroensis* sp. nov.; both species include additional unlabeled specimens. The single specimen referred to *Waagenoceras*? sp. was excluded from this examination because it is poorly preserved and no sutures can be observed. Hayasaka and Nishikawa's (1962) "*Pseudogastrioceras abichianum*" (one specimen) and an additional specimen are newly assigned to *Neoglaphyrites discoidalis* sp. nov.

All of the genera to which the Miharanoro specimens belong are widely distributed in the Urals–Arctic Canada region, southwestern North America and Tethys Province (South China, Pamirs, and/or Timor) (Korn and Ilg, 2007; Kullmann *et al.*, 2007; Furnish *et al.*, 2009). They are rather rare in strata originating from the Panthalassic region and only *Agathiceras*, *Neoglaphyrites* and *Eoasianites* are known from the Carboniferous strata of the Akiyoshi Belt (Kato and Nakamura, 1962; Nishida, 1971; Nishida and Kyuma, 1982) and North Kitakami Belt (Ehiro *et al.*, 2010) of Japan. The genera *Emilites*, *Somoholites*, *Marathonites* and *Metapronorites* are described from Japan for the first time.

As shown in Figure 2, all the ranges of these seven genera cross the Carboniferous/Permian boundary and some have rather long ranges (Korn and Ilg, 2007; Kullmann *et al.*, 2007). From the coexisting interval of these genera, the age of the Miharanoro fauna is considered to be between the Kasimovian and the Asselian. At the species level, *Agathiceras* sp. from Miharanoro somewhat resembles the Asselian species *A. vulgatum* Ruzhentsev from the Pamirs (Ruzhentsev, 1978). Specimens of *Emilites* are very similar to *E. prosperus* Ruzhentsev from the Asselian of the Pamirs (Ruzhentsev, 1978) and Guangxi, China (Zhou, 1987). *Somoholites miharanoroensis* is a new species, but similar to *S. shikhanensis* Ruzhentsev from the Sakmarian of the South Urals (Ruzhentsev, 1938). *Marathonites* specimens are referred to *M. jpsmithi* Böse from the Gzhelian strata of Texas (Böse, 1919). Specimen of *Eoasianites* resembles *E. subhanieli* Ruzhentsev from the Asselian of the South Urals (Ruzhentsev, 1933; Maksimova, 1948) and Guangxi, South China (Zhou, 1987). Those of *Metapronorites* are comparable to *M. timorensis* (Haniel) from the early Permian of Timor (Haniel, 1915; Smith, 1927) and the Asselian of the South Urals (Ruzhentsev, 1949, 1978) and Guangxi, South China (Zhou, 1987). From these data, the age of the Miharanoro fauna is highly likely to be Asselian. This conclusion is consistent with

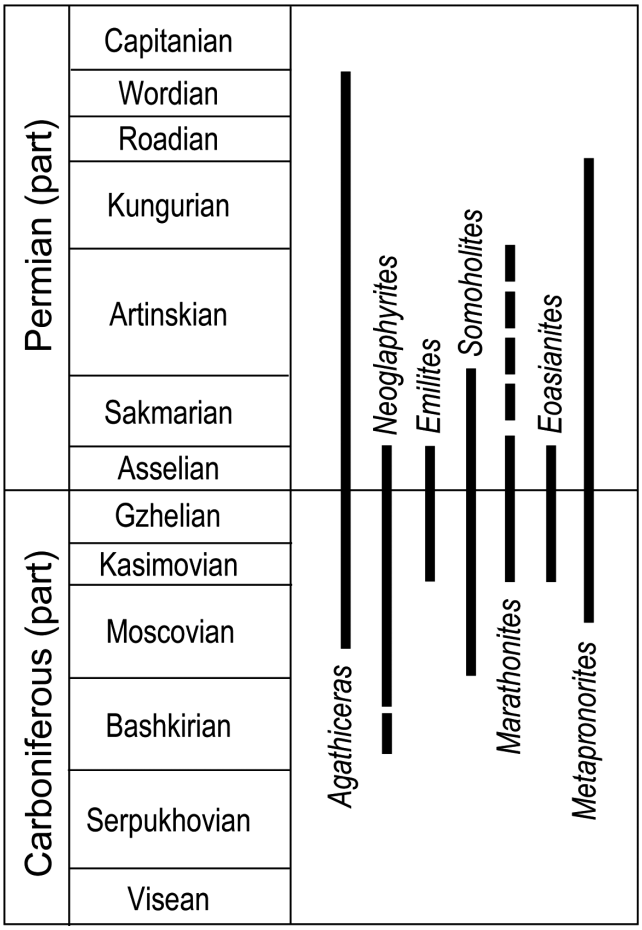

Figure 2. Stratigraphic distribution of the ammonoid genera known from the Uyamano Formation (Taishaku Limestone) at Miharanoro.

the fusulinoidean-based age by Niko and Ozawa (1997).

Systematic description

Specimens described here were all collected from the lower part of the Uyamano Formation (*Pseudoschwagerina miharanoensis* Zone; late Asselian) at Miharanoro (34°51'20"N, 133°15'53"E), Tojo-cho, Shobara City, Hiroshima Prefecture. They are kept in the Tohoku University Museum. Morphological terminology basically follows Arkell (1957) and the classification of taxonomic ranks higher than genus follows Furnish *et al.* (2009). The following abbreviations are used in the descriptions: *D* = diameter, *H* = height of whorl, *W* = width of whorl, *UD* = diameter of umbilicus.

Order Goniatitida Hyatt, 1884
Superfamily Agathiceratoidea von Arthaber, 1911
Family Agathiceratidae von Arthaber, 1911

Table 1. Dimensions of *Agathiceras* sp. *D*, diameter; *H*, height of whorl; *W*, width of whorl; *UD*, diameter of umbilicus; E, preserved end; E–α°, "at α° adapical from E". Measurements with asterisks are rounded numbers or estimates.

Catalog number	E–α°	*D*	*H*	*W*	*UD*	*H*/*D*	*W*/*D*	*UD*/*D*
111375	E	48.5*	28.0*	22.2	3?	0.58*	0.46*	—
111376	E	46.5*	28.5*	23.0*	—	0.61*	0.49*	—
111377	E	> 45	26.0*	17.0*	—	—	—	—
111378	E	28.0*	16.0*	15.0*	1?	0.57*	0.54*	—
111379	E–90°	24.0*	14.0*	14.5*	—	0.58*	0.60*	—
111380	E	27.5*	16.0*	16.5*	—	0.58*	0.60*	—
111381	E	26.5*	14.0	14.3	—	0.53	0.54	—
	E–90°	21.3	12.1	13.0	—	0.57	0.61	—
111382	E	28?	14.3	17.8	—	0.51?	0.64?	—
111383	E–90°	20.0*	11.0*	14.0*	—	0.77	0.64	—
111384	E	26.5	14.2	16.0	—	0.54	0.6	—
111385	E	14.8	9.5*	9.3	—	0.64	0.63	—
111386	E–90°	23.0	15.0*	15.1	—	0.65	0.66	—
111387	E	19.0	10.5*	11.8	—	0.55	0.62	—
111388	E	23.0*	10.5*	12.4	—	0.46	0.54	—

Genus ***Agathiceras*** Gemmellaro, 1887

Type species.—Agathiceras suessi Gemmellaro, 1887

Agathiceras sp.

Figures 3.1–3.14

Materials.—Fourteen specimens: IGPS coll. cat. nos. 111375–111388.

Description.—Fourteen small to moderately large (*D* = 14.8–48.5 mm) specimens, including fragmentary ones, are available (Table 1). The conch is ellipsoidal in cross section, with broadly rounded venter and convex sides. The umbilicus is very small with a rounded umbilical shoulder, but its diameter was not precisely measured because of poor preservation. The conch dimensions and ratios are shown in Table 1. *W*/*D* becomes smaller (0.64–0.46) with growth (*D* = *ca.* 20–48 mm). The shell surface bears prominent longitudinal lirae, numbering 56–60 or more from one umbilicus to the other. A constriction was not observed.

The external suture consists of a broad ventral lobe, which is subdivided into two bluntly pointed symmetrical prongs by a high (nearly equal to or slightly lower

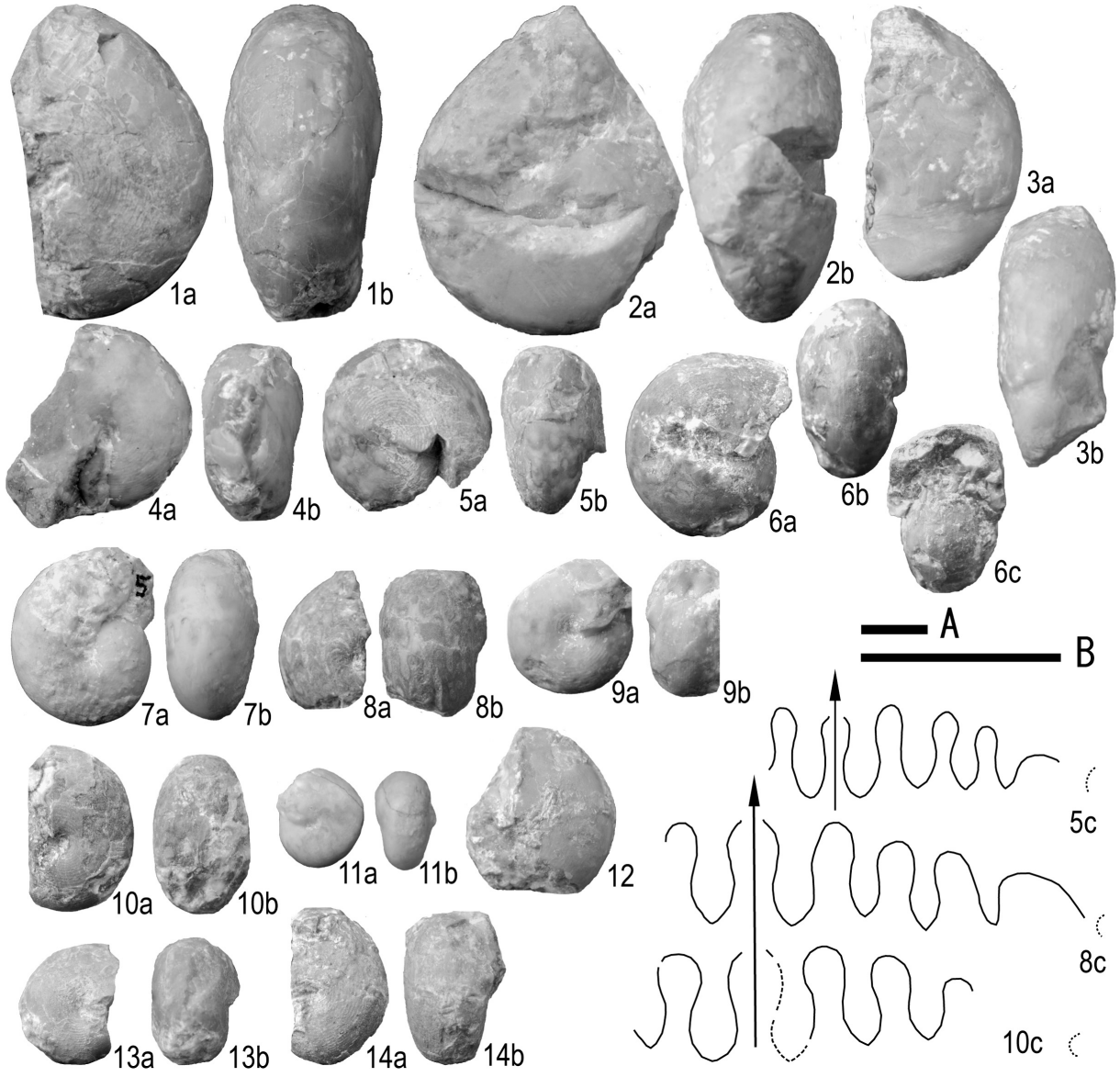

Figure 3. *Agathiceras* sp. from the Uyamano Formation of the Taishaku Limestone. **1,** IGPS coll. cat. no. 111375, lateral (1a) and ventral (1b) views; **2,** IGPS coll. cat. no. 111376, lateral (2a) and ventral (2b) views; **3,** IGPS coll. cat. no. 111377, lateral (3a) and ventral (3b) views; **4,** IGPS coll. cat. no. 111378, lateral (4a) and ventral (4b) views; **5,** IGPS coll. cat. no. 111379, lateral (5a) and ventral (5b) views, and external suture line (5c); **6,** IGPS coll. cat. no. 111380, lateral (6a) and ventral (6b and 6c) views; **7,** IGPS coll. cat. no. 111381, lateral (7a) and ventral (7b) views; **8,** IGPS coll. cat. no. 111382, lateral (8a) and ventral (8b) views and external suture line (8c); **9,** IGPS coll. cat. no. 111383, lateral (9a) and ventral (9b) views; **10,** IGPS coll. cat. no. 111384, lateral (10a) and ventral (10b) views and external suture line (10c); **11,** IGPS coll. cat. no. 111385, lateral (11a) and ventral (11b) views; **12,** IGPS coll. cat. no. 111386, lateral view; **13,** IGPS coll. cat. no. 111387, lateral (13a) and ventral (13b) views; **14,** IGPS coll. cat. no. 111388, lateral (14a) and ventral (14b) views. Scale bars: 1 cm; A for shells, B for suture lines.

than the first lateral saddle) median saddle and three bluntly pointed lateral lobes (Figs. 3.5c, 3.8c, 3.10c). The rounded lateral saddles and lateral lobes diminish in size toward the umbilicus.

Comparison.—The Miharanoro *Agathiceras* specimens are not preserved well enough to make a definite specific identification, but they somewhat resemble *Agathiceras vulgatum* Ruzhentsev (Ruzhentsev, 1978, p. 42, pl. 3, fig. 5a–b, text-fig. 4) from the Asselian strata of the Pamirs in having a slightly compressed shell with broadly rounded venter and convex sides and a high median saddle of the ventral lobe and pointed lateral

lobes. The present specimens, however, have more closely spaced lirae than the latter, which has 55 lirae from one umbilicus to the other.

Superfamily Thalassoceratoidea Hyatt, 1900
Family Bisatoceratidae Miller and Furnish, in Miller, Furnish, and Schindewolf, 1957
Genus ***Neoglaphyrites*** Ruzhentsev, 1938

Type species.—*Glaphyrites* (*Neoglaphyrites*) *bashkiricus* Ruzhentsev, 1938

Neoglaphyrites discoidalis sp. nov.

Figures 4.1–4.2

Etymology.—Named after its thickly discoidal shell form.

Materials.—Two specimens: IGPS coll. cat. nos. 111389 (holotype) and 111390.

Diagnosis.—A species of *Neoglaphyrites* with a slightly compressed, discoidal conch, small umbilicus, and a narrow, curved first lateral saddle.

Description.—Two small phragmocones, 30–40 mm in diameter at the preserved ends, were examined (Table 2). The conch is thickly discoidal and slightly compressed (W/D = 0.45–0.50). The maximum width is at the umbilical shoulder (Fig. 4.1c) and the sides converge on the rounded venter, which has broadly rounded ventrolateral shoulders. The umbilicus is small (UD/D = 0.13–0.14) with an angular umbilical shoulder and steep wall. No visible ornamentation is observed on the shell surface.

The external suture is characterized by a broad ventral lobe subdivided into two bluntly pointed asymmetrical prongs by a moderately high (about two-thirds the height of the first lateral saddle) and narrow median saddle (Figs. 4.1d, 4.2c). The widths of the prongs of the ventral lobe and the first lateral lobe are nearly equal. The sides of the ventral lobe are divergent and the rounded, narrow, high first lateral saddle is curved. The first lateral lobe is acute and pointed at the base. The second lateral saddle is broadly rounded. The V-shaped umbilical lobe is on the umbilical wall.

Table 2. Dimensions of *Neoglaphyrites discoidalis* sp. nov. For abbreviations, see Table 1.

Catalog number	E–α°	*D*	*H*	*W*	*UD*	*H*/*D*	*W*/*D*	*UD*/*D*
111389 (holotype)	E	29.5*	15.0*	13.4	4.2	0.51	0.45	0.14
111390	E–90	31.0*	16.0*	15.7	4.0?	0.52	0.51	0.13?

Comparison.—*Neoglaphyrites discoidalis* is distinguished from other species of *Neoglaphyrites* by having a slightly compressed shell form and a narrow and curved first external lateral saddle of the suture. The Japanese Carboniferous species *N. japonicus* Nishida and Kyuma (Nishida and Kyuma, 1982, p. 35, text-fig. 10, pl. 7, figs. 1–7) resembles the present species in its shell shape, but differs distinctly in the shape of the first lateral saddle and having considerably narrower prongs on the ventral lobe and a wider first lateral saddle.

Superfamily Adrianitoidea Schindewolf, 1931
Family Adrianitidae Schindewolf, 1931
Subfamily Adrianitinae Schindewolf, 1931
Genus ***Emilites*** Ruzhentsev, 1938

Type species.—*Paralegoceras incertum* Böse, 1919

Emilites cf. ***prosperus*** Ruzhentsev, 1978

Figures 4.3–4.5

Cf. —
Emilites prosperus Ruzhentsev, 1978, p. 51, pl. 4, figs. 7–8.
Emilites cf. *prosperus* Ruzhentsev, Zhou, 1987, p. 137, pl. 4, figs. 1–3, text-fig. 54.

Materials.—Three specimens: IGPS coll. cat. nos. 111391–111393.

Description.—Three small specimens, two of which are fragmentary, were examined. The conch is spherical with an almost closed umbilicus. At the preserved end, the umbilical shoulder forms a low umbilical ridge; therefore, the maximum width is at the umbilical shoulder. The diameter of no. 111391 is *ca.* 17 mm at the preserved end. At a diameter of 16.1 mm, the corresponding height and width are 9.0 and 14.5 (estimated), respectively. No. 111392 exceeds 20 mm in diameter, and at a height of 10.5 mm the corresponding width is 14.5 mm. The shell surface bears faint growth lines and fine spiral lirae.

The suture is only preserved in no. 111391 (Fig. 4.3d). The wide ventral lobe is subdivided into two bluntly pointed symmetrical prongs by a moderately high median saddle. The first lateral lobe is broad and bluntly pointed at the base. The wide umbilical lobe has two denticulations on the lateral side. The lateral and umbilical saddles are rounded.

Comparison.—The present species is very similar to *Emilites prosperus* Ruzhentsev (Ruzhentsev, 1978, p. 51, pl. 4, figs. 7, 8; Zhou, 1987, p. 137, pl. 4, figs. 1–3, text-fig. 5) in its shell shape and sutural trace, but differs in having a low but obvious umbilical ridge. It also some-

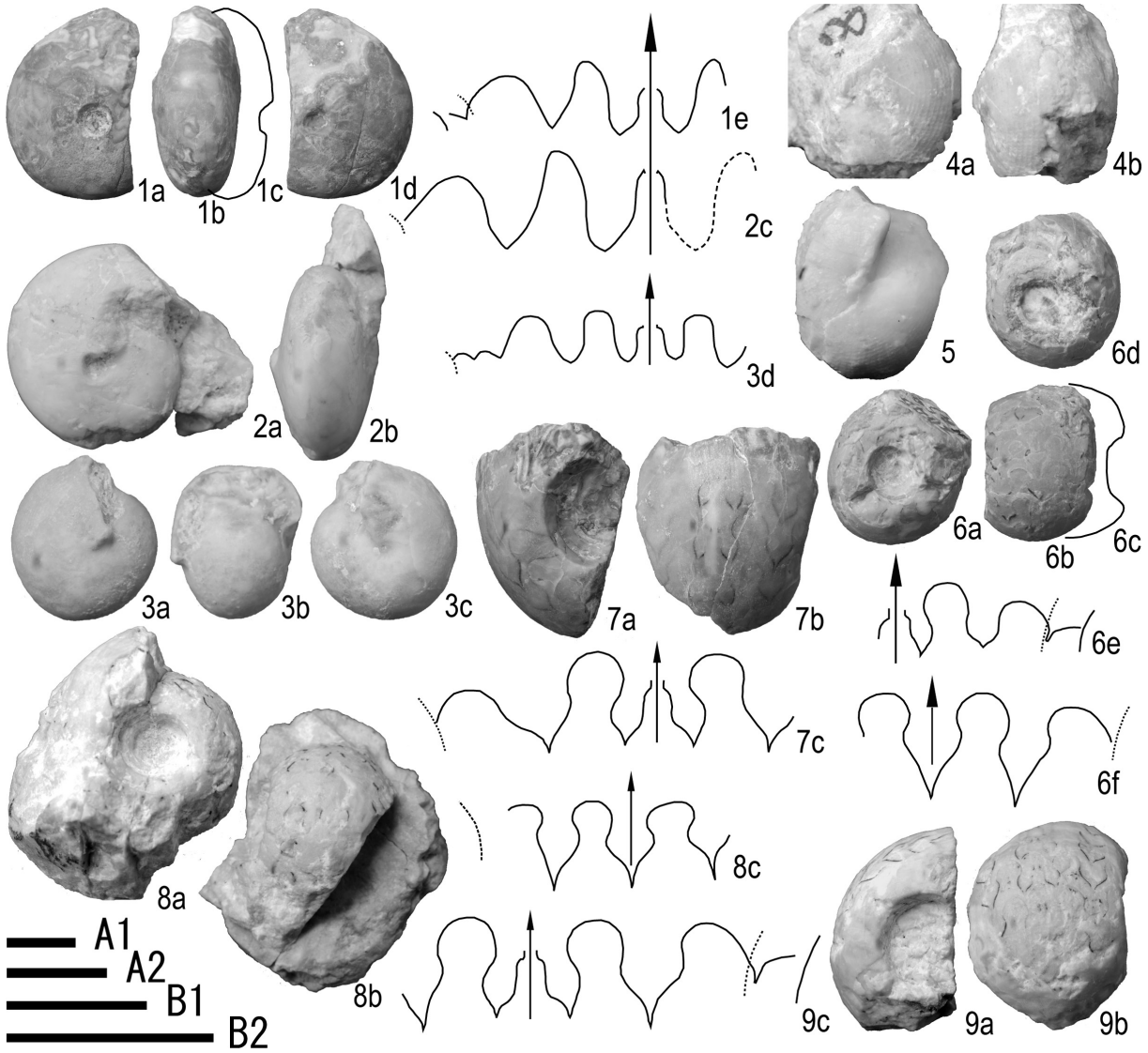

Figure 4. *Neoglaphyrites*, *Emilites*, and *Somoholites* from the Uyamano Formation of the Taishaku Limestone. **1, 2,** *Neoglaphyrites discoidalis* sp. nov.; 1, IGPS coll. cat. no. 111389 (holotype), lateral (1a and 1d) and ventral (1b) views, cross section (1c) and external suture line (1e); 2, IGPS coll. cat. no. 111390, lateral (2a) and ventral (2b) views and external suture line (2c); **3–5,** *Emilites* cf. *prosperus* Ruzhentsev; 3, IGPS coll. cat. no. 111391, lateral (3a and 3c) and ventral (3b) views and external suture line (3d); 4, IGPS coll. cat. no. 111392, lateral (4a) and ventral (4b) views; 5, IGPS coll. cat. no. 111393, lateral view; **6–9,** *Somoholites miharanoroensis* sp. nov.; 6, IGPS coll. cat. no. 111394 (holotype), lateral (6a and 6d) and ventral (6b) views, cross section (6c) and external (6e) and internal (6f) suture lines; 7, IGPS coll. cat. no. 111395 lateral (7a) and ventral (7b) views and external suture line (7c); 8, IGPS coll. cat. no. 111396 lateral (8a) and ventral (8b) views and internal suture line (8c); 9, IGPS coll. cat. no. 111397 lateral (9a) and ventral (9b) views and external suture line (9c). Scale bars: 1 cm; A for shells (A2 for fig. 3a–c, A1 for others), B for suture lines (B2 for fig. 3d, B1 for others).

what resembles *E. bennisoni* Mapes and Boardman (Mapes and Boardman, 1988, p. 73, figs. 5-2, 6-14, 6-16, 6-17) in shell proportions, but the latter is clearly distinguished from the present species by having an acute second lateral saddle.

Superfamily Shumarditoidea Plummer and Scott, 1937
Family Somoholitidae Ruzhentsev, 1938

Genus ***Somoholites*** Ruzhentsev, 1938

Type species.—*Gastrioceras beluensis* Haniel, 1915

Somoholites miharanoroensis sp. nov.

Figures 4.6–4.9

Etymology.—After the geographic place name where

the specimens were collected.

Materials.—Four specimens: IGPS coll. cat. nos. 111394 (holotype) and 111395–111397.

Diagnosis.—A species of *Somoholites* with a small umbilicus and highly asymmetric prongs on the ventral lobe.

Description.—Four phragmocones are available. The conch is thickly discoidal (*W*/*D* = 0.73–0.77; Table 3). The venter is broadly rounded with rounded, ventrolateral shoulders. It is moderately evolute and the umbilicus has a somewhat sharp shoulder and steep wall (Fig. 4.6c). *UD*/*D* becomes smaller as it grows and ranges from 0.37 (at *D* = 21.2 mm) to 0.33 (at *D* = ca. 34). The conch dimensions and ratios are shown in Table 3. Specimen no. 111396 is probably more than 40 mm in diameter, estimated from the preserved part, and its phragmocone is more than 35 mm in diameter because the mold of the internal suture of the succeeding volution, preserved on the shell surface, is *ca.* 30 mm in diameter. No. 111395 is a fragmentary phragmocone whose diameter is more than 30 mm. The shell surface is not always preserved in detail, but has some weak constrictions and in some specimens, for example, in the holotype, faint growth lines and longitudinal lirae are observed.

The suture is typical for the genus and characterized by sharply attenuated external (Figs. 4.6d, 4.7c, 4.8c, 4.9c) and internal (Fig. 4.6e) lobes that possess prominent lateral pouches. The ventral lobe is considerably wider than the first lateral saddle and narrows upward. It is subdivided into two highly asymmetric prongs. The narrow median saddle of the ventral lobe is about three-fourths the height of the lateral saddle. The first lateral lobe and the first lateral saddle are approximately the same width. The umbilical lobe is funnel-shaped, lying on the umbilical wall near the umbilical shoulder. The crests of all external and internal saddles are rounded.

Comparison.—The species from Miharanoro is very similar to *Somoholites shikhanensis* Ruzhentsev (Ruzhentsev, 1938, pl. 7, figs. 3–4, text-fig. 17a–b; *Eoasianites shikhanensis*: Miller and Furnish, 1940, p. 542, text-fig. 7C; Ruzhentsev, 1951, p. 128, pl. 9, fig. 3) from the Sakmarian strata of the South Urals in general shell shape and with nearly the same ratios in *W*/*D* and *UD*/*D*. They are also closely related in the general shape of the suture, but this species differs from the Uralian species in having highly asymmetric prongs on the ventral lobe. *S. miharanoroensis* sp. nov. somewhat resembles *S. beluensis* (Haniel) (*Gastrioceras beluense*: Haniel, 1915, p. 54, pl. 48, fig. 1; *Eoasianites beluensis*: Ruzhentsev, 1936, p. 1082, text-fig. 4d; Ruzhentsev, 1938, p. 281, pl. 7 figs. 1–2, text-fig. 17c; *E. beluensis*: Miller and Furnish, 1940, p. 542, text-fig. 7A; Ruzhentsev, 1951, p. 130, pl. 9, fig. 4; Popov, 1958, p. 145, pl. 1, fig. 4; Saunders, 1971, p. 105, pl. 2, figs. 2–4, 6, 9, 11, text-fig. 3b–e; Boardman *et al.*, 1994, p. 51, fig. 23) from the Sakmarian strata of Timor and the South Urals in shell shape, but is distinguished by having a slightly wider conch and highly asymmetric prongs on the ventral lobe. In having highly asymmetric prongs on the ventral lobe, this species is somewhat similar to *S. merriami* (Miller and Furnish) from the Pennsylvanian strata of Oregon, U.S.A. (*Eoasianites merriami*: Miller and Furnish, 1940, p. 542, pl. 65, figs. 1–2, text-fig. 7b; *Neoshumardites merriami*: Nassichuk *et al.*, 1965, p. 15, text-fig. 2a) and the Moscovian strata of Oklahoma, U.S.A. (Saunders, 1971, p. 109, pl. 23, figs. 11–12, text-fig. 3a) and Arctic Canada (Nassichuk, 1975, p. 117, pl. 12, figs. 1, 5). *S. merriami*, however, differs from this species in having a wider umbilicus.

Table 3. Dimensions of *Somoholites miharanoroensis* sp. nov. For abbreviations, see Table 1.

Catalog number	E–α°	*D*	*H*	*W*	*UD*	*H*/*D*	*W*/*D*	*UD*/*D*
111394 (holotype)	E	21.2	7.7	16.4	7.8	0.36	0.77	0.37
111396	E–270°	30.0	14.0*	22.5*	10.0	0.47	0.75	0.35
111397	E	34.0*	11.0*	24.0*	11.3	0.32	0.71	0.33

Superfamily Marathonitoidea Ruzhentsev, 1938
Family Marathonitidae Ruzhentsev, 1938
Genus ***Marathonites*** Böse, 1919

Type species.—*Marathonites jpsmithi* Böse, 1919

Marathonites cf. ***jpsmithi*** Böse

Figures 5.1–5.4

Cf. —

Marathonites j.p. smithi Böse, 1919, p. 135, pl. 6, figs. 77–89; Smith, 1929, p. 77, figs. C1–12.

Marathonites jpsmithi Böse. Glenister and Furnish, 1988, p. 62, text-fig. 3A; Boardman *et al.*, 1994, p. 61, pl. 2, figs. 1.

Marathonites smithi Böse, Bogoslovskaya, 1990, p. 81, text-fig. 1.

Materials.—Four specimens: IGPS coll. cat. nos. 111398–111401.

Description.—Four small specimens, with a maximum diameter of ca. 30 mm, were examined (Table 4). The body chamber reaches almost one volution in the largest specimen. The conch is subspherical with nearly parallel

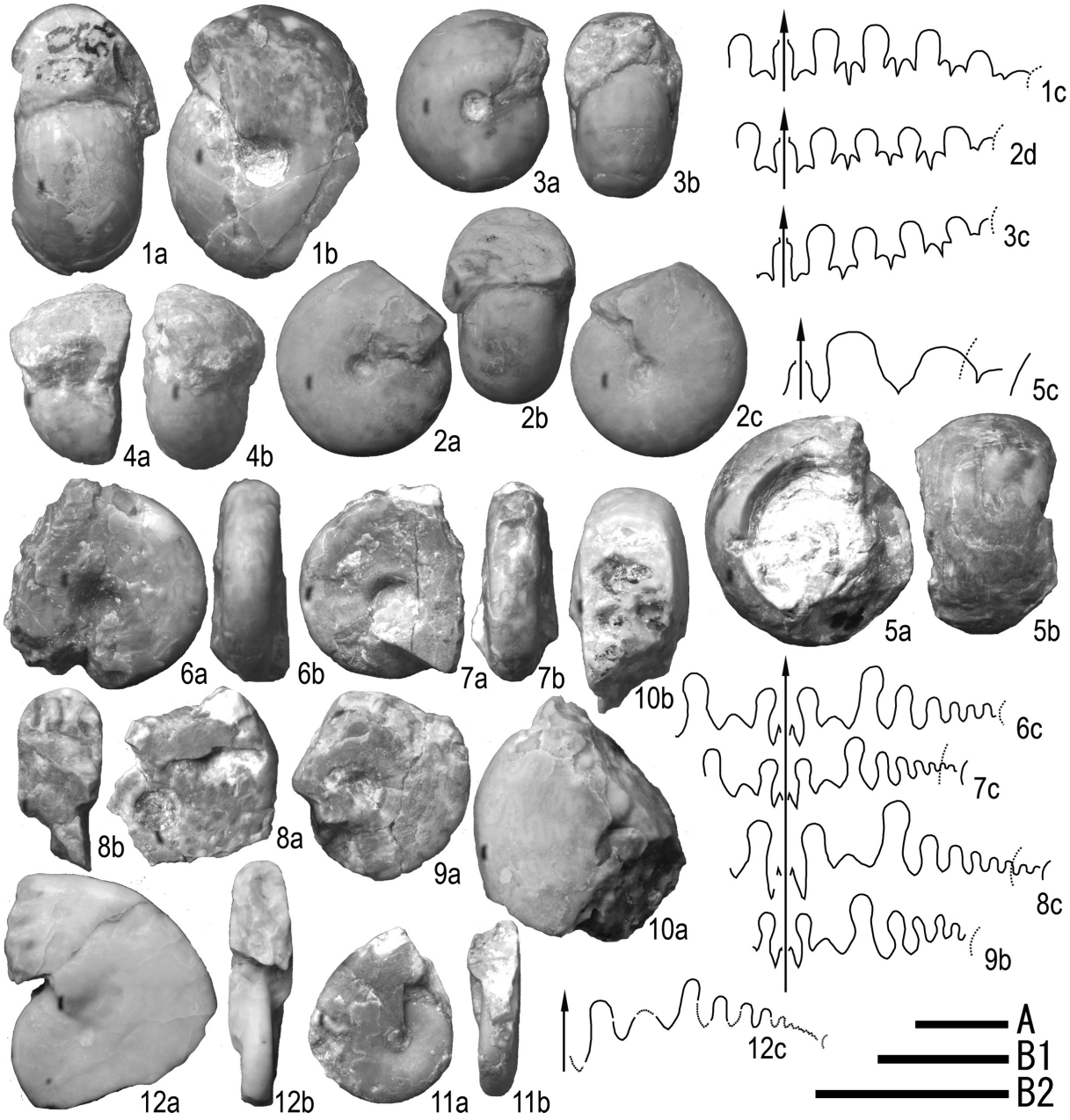

Figure 5. *Marathonites*, *Eoasianites*, and *Metapronorites* from the Uyamano Formation of the Taishaku Limestone. **1–4,** *Marathonites* cf. *jpsmithi* Böse; 1, IGPS coll. cat. no. 111398, lateral (1a) and ventral (1b) views and external suture line (1c); 2, IGPS coll. cat. no. 111399, lateral (2a and 2c) and ventral (2b) views and external suture line (2d); 3, IGPS coll. cat. no. 111400, lateral (3a) and ventral (3b) views and external suture line (3c); 4, IGPS coll. cat. no. 111401, lateral (4a) and ventral (4b) views; **5,** *Eoasianites* cf. *subhanieli* Ruzhentsev, IGPS coll. cat. no. 111402, lateral (5a) and ventral (5b) views and external suture line (5c); **6–11,** *Metapronorites* cf. *timorensis* (Haniel); 6, IGPS coll. cat. no. 111403, lateral (6a) and ventral (6b) views and external suture line (6c); 7, IGPS coll. cat. no. 111404, lateral (7a) and ventral (7b) views and external suture line (7c); 8, IGPS coll. cat. no. 111405, lateral (8a) and ventral (8b) views and external suture line (8c); 9, IGPS coll. cat. no. 111406, lateral view (9a) and external suture line (9b); 10, IGPS coll. cat. no. 111407, lateral (10a) and ventral (10b) views; 11, IGPS coll. cat. no. 111408, lateral (11a) and ventral (11b) views; **12,** *Metapronorites* sp., IGPS coll. cat. no. 111409, lateral (12a) and ventral (12b) views and external suture line (12c). Scale bars: 1 cm; A for shells, B for suture lines (B1 for fig. 12c, B2 for others).

to convex sides, a broadly rounded venter and rounded ventrolateral shoulders. The maximum width is at about one-fourth of the umbilical shoulder. The umbilicus, with a sharp shoulder and steep wall, is small. At a diameter of 20–30 mm, *W*/*D* and *UD*/*D* are 0.62–0.65 and 0.12–0.15, respectively. The shell surface is not well pre-

Table 4. Dimensions of *Marathonites* cf. *jpsmithi* Böse. For abbreviations, see Table 1.

Catalog number	E–α°	*D*	*H*	*W*	*UD*	*H*/*D*	*W*/*D*	*UD*/*D*
111398	E	29.3	14.3	19.0	4.5*	0.49	0.65	0.15
111399	E	21.0	10.0*	13.2	2.5*	0.48	0.63	0.12
111400	E	20.1	9.9	12.5	2.5*	0.49	0.62	0.12

served, but in some specimens, constrictions and faint growth lines are observable.

The wide ventral lobe is subdivided into two prongs by a moderately high median saddle (Figs. 5.1c, 5.2d, 5.3c). The median saddle, the sides of which are subparallel but slightly constricted near the base, is narrow and about three-fourths the height of the first lateral saddle. Each prong is slightly narrower than the first lateral lobe and asymmetrically bifid; the ventral branch is much longer. The first to third lateral lobes are trifid with the middle branch much longer. The fourth lateral lobe is bifid.

Comparison.—The Miharanoro species closely resembles the type species *Marathonites jpsmithi* Böse (Böse, 1919, p. 135, pl. 6, figs. 77–89; Smith, 1929, p. 77, figs. C1–12; Glenister and Furnish, 1988, p. 62, text-fig. 3A; Bogoslovskaya, 1990, p. 81, text-fig.1; Boardman *et al.*, 1994, p. 61, pl. 2, figs. 1, 3) in its general shell shape and sutural outline, but the largest specimen of Böse (Böse, 1919, pl. 6, figs. 78, 81–83), *ca.* 23 mm in maximum diameter, has a rather narrowly rounded venter, whereas Miharanoro specimens of nearly equal size have a broadly rounded venter. The bad preservation of the shell surface of the present specimens also makes it difficult to identify them at the specific level.

Superfamily Neoicoceratoidea Hyatt, 1900
Family Neoicoceratidae Hyatt, 1900
Genus ***Eoasianites*** Ruzhentsev, 1933

Type species.—*Eoasianites subhanieli* Ruzhentsev, 1933

Eoasianites cf. ***subhanieli*** Ruzhentsev

Figure 5.5

Cf. —

Eoasianites subhanieli Ruzhentsev, 1933, p. 166, pl. 4, figs. 1–2; Ruzhentsev, 1936, p. 1082, text-fig. 4e; Plummer and Scott, 1937, p. 258, text-fig. 55; Ruzhentsev, 1938, p. 274, pl. 6, figs. 1–4, text-fig. 14; Ruzhentsev, 1951, p. 110, pl. 7, figs. 1–3.

Eoasianites subhanieli morpha *alta* Maksimova, Maksimova, 1948, p. 15, pl. 2, figs. 4–6, text-figs. 10–11.

Materials.—One specimen: IGPS coll. cat. no. 111402.

Description.—A small phragmocone, discoidal and evolute. The venter is broadly rounded. The umbilicus is large with a prominent umbilical shoulder and steep wall. The conch is *ca.* 25 mm in diameter and the corresponding height, width, and umbilical diameter are *ca.* 6.0, 14.3 (*W*/*D* = 0.57), and 12.4 (*UD*/*D* = 0.50), respectively. The shell surface is poorly preserved, but may be smooth except for faint growth lines.

The ventral lobe is subdivided into two bluntly pointed symmetrical prongs by a moderately high median saddle (Fig. 5.5c). The broad first lateral lobe, bluntly pointed at the base, is about equal in size to the rounded first lateral saddle. The umbilical lobe is funnel-shaped and lies on the umbilical wall.

Comparison.—This species is very similar to *Eoasianites subhanieli* Ruzhentsev (Ruzhentsev, 1933, p. 166, pl. 4, figs. 1–2; Ruzhentsev, 1936, p. 1082, text-fig. 4e; Plummer and Scott, 1937, p. 258, text-fig. 55; Ruzhentsev, 1938, p. 274, pl. 6, figs. 1–4, text-fig. 14; *E. subhanieli* morpha *alta* Maksimova: Maksimova, 1948, p. 15, pl. 2, figs. 4–6, text-figs. 10–11; Ruzhentsev, 1951, p. 110, pl. 7, figs. 1–3; Zhou, 1987, p. 141, pl. 1, figs. 12–14, text-fig. 10) in the shape of the shell, especially in having a prominent umbilical shoulder, and in the sutural trace. *W*/*D* and *UD*/*D* of *E. subhanieli* change according to shell diameter. As it grows in the range of D = 11.6–40.7 mm, *W*/*D* increases from 0.58 to 0.76, whereas *UD*/*D* decreases from 0.60 to 0.42. Those ratios in the present specimen are within this trend. However, we refrain from identifying it at the specific level because only one poorly preserved specimen is available.

Order Prolecanitida Miller and Furnish, 1954
Superfamily Medlicottitoidea Karpinskii, 1889
Family Pronoritidae Frech, 1901
Subfamily Pronoritinae Frech, 1901
Genus ***Metapronorites*** Librovich, 1938

Type species.—*Pronorites timorensis* Haniel, 1915

Metapronorites cf. ***timorensis*** (Haniel)

Figures 5.6–5.11

Cf. —

Pronorites uralensis var. *timorensis* Haniel, 1915, p. 25, pl. 46, figs. 1–5, text-fig. 2.

Pronorites timorensis Haniel. Smith, 1927, p. 13, pl. 10, figs. 1–15; Böhmers, 1936, p. 14, fig. 4.

Metapronorites timorensis (Haniel). Librovich, 1938, p. 82; Ruzhentsev, 1949, pl. 2, figs. 9–13, text-fig. 3; Nassichuk, 1975, text-fig. 22; Ruzhentsev, 1978, p. 40,

pl. 3, figs. 2–3; Zhou, 1987, p. 134, pl. 2, figs. 1–8, pl. 2, figs. 11–12, text-fig. 2.

Materials.—Six specimens: IGPS coll. cat. nos. 111403–111408.

Description.—The specimens are small and have a diameter between 15 and 22 mm (Table 5). The whorls are compressed (*W*/*D* = ca. 0.3) with nearly flattened, but slightly divergent, flanks. The venter is broadly rounded with narrowly rounded ventrolateral shoulders. The umbilicus is moderately small (*UD*/*D* = 0.21–0.24 at *D* = *ca.* 20 mm) with a rounded umbilical shoulder and steep wall. The shell surface lacks visible ornamentation.

The ventral lobe is deep, inflated, and trifid (Figs. 5.6c, 5.7c, 5.8c, 5.9b). Eight to 9 external lateral lobes are present, 2 or 3 of which are on the umbilical wall. The first lateral lobe is broad and bipartite, with a low, broad saddle about one-fourth the height of the first lateral saddle. The umbilical branch is slightly larger than the ventral one. The second and following lateral lobes are simple with a bluntly pointed or rounded base becoming progressively smaller to the umbilicus.

Comparison.—The present species is similar to the type species of *Metapronorites*, *M. timorensis* (Haniel) (Haniel, 1915, p. 25, pl. 46, figs. 1–5, text-fig. 2; Smith, 1927, p. 13, pl. 10, figs. 1–15; Ruzhentsev, 1949, text-fig. 30, pl. 2, figs. 9–13; Nassichuk, 1975, text-fig. 22; Ruzhentsev, 1978, p. 40, pl. 3, figs. 2–3; Zhou, 1987, p. 134, pl. 2, figs. 1–8, pl. 2, figs. 11–12, text-fig. 2) in having a broadly rounded venter and 8–9 external lateral lobes. The type species differs from the present species by having a rather small umbilicus and a high (about one-third the height of the first lateral saddle), acute median saddle of the first lateral lobe, although some smaller specimens with shell diameters of *ca.* 20 mm (nearly the same as the present species) have a larger umbilicus (*UD*/*D* = 0.2 or more: Haniel, 1915, p. 25, pl. XLVI (1), fig. 5; Smith, 1927, pl. X, fig. 7) and low saddle of the first lateral lobe (Smith, 1927, pl. X, fig. 8a).

Metapronorites angustus Andrianov (1985, p. 114, pl. 1, fig. 3a–b, text-fig. 27) somewhat resembles the present species in having a rounded venter and a rather large umbilicus, but the venter of the former is more rounded and the saddle of the first lateral lobe is higher and acute compared with the latter.

Table 5. Dimensions of *Metapronorites* cf. *timorensis* (Haniel). For abbreviations, see Table 1.

Catalog number	E–α°	*D*	*H*	*W*	*UD*	*H*/*D*	*W*/*D*	*UD*/*D*
111403	E–180°	21.7	11.2	6.3	4.5*	0.52	0.29	0.21
111404	E–90°	20.6	10.0*	6.8	5.0*	0.49	0.33	0.24
111405	E	?	11.8	8.6	5.0*	—	—	—
111407	E	?	14.3	10.1	5.0*	—	—	—
111408	E	16.5	8.8	4.7	2.0?	0.54	0.28	0.12?

Metapronorites sp.

Figure 5.12

Materials.—One specimen: IGPS coll. cat. no. 111409.

Descriptive remarks.—The estimated diameter of the conch reaches 28 mm. The compressed conch (*W*/*D* = *ca.* 0.25) has nearly flattened, broadly rounded flanks. The venter is broadly rounded with rounded ventrolateral shoulders. Near the preserved end (*D* = 25.6), the corresponding height, width, and umbilical diameter are 14.2, 6.3 (*W*/*D* = 0.25), and 1.8 (*UD*/*D* = 0.07), respectively. No visible ornamentation is observed on the shell surface. The suture is typical for the genus, but has more than 6 lateral lobes between the venter and the umbilical shoulder (Fig. 5.12c). Some space exists between the 6th lateral lobe and the umbilical shoulder, but the suture near the umbilicus is rather poorly preserved.

This specimen differs from other specimens of *Metapronorites* from Miharanoro (*Metapronorites* cf. *timorensis*) in having a more compressed shell and smaller umbilicus, but species level identification is difficult because of its poor preservation.

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