Upper Triassic Ammonites from Okinawa-jima Part Ⅰ : Paleontological Study of the Ryukyu Islands-Ⅱ

Ishibashi, Takeshi
Faculty of Science, Kyushu University

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Upper Triassic Ammonites from Okinawa-jima Part I

(Paleontological Study of the Ryukyu Islands-II*)

By

Takeshi ISHIBASHI

Abstract

Twelve species of the Upper Triassic ammonites obtained from the Nakijin Formation of Okinawa-jima are systematically described on the basis of numerous specimens. Many of them are referred to the known species and are mostly of the Tethys and the North Pacific elements, with the closest similarity to those of the European Alps and Himalayas. For the Triassic in Japan they are entirely new. In the formation two ammonoid zones are recognized, of which the lower, the *Sirenites* cf. *nanseni* zone, is assigned to the Lower Carnian and the upper, the *Juvavites* (*J.*) cf. *kellyi* zone, to the Upper Carnian.

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* I: KOBAYASHI and ISHIBASHI (1970).

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Introduction

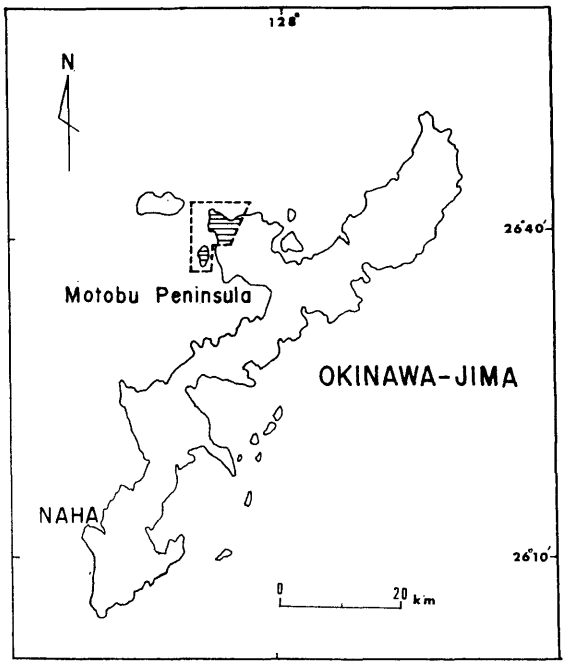
The Upper Triassic marine sediments are known from various parts of the world, and a great deal of study has been done on them both from the stratigraphical and paleontological sides. The comprehensive monographic works on the contained ammonoid faunas were accomplished by DITTMAR, MOJSISOVICS, DIENER, GEMMELLARO, ARTHABER, WELTER, SMITH and others before 1930, and thereafter refined and detailed informations on the stratigraphic sequences of the Triassic sediments in various areas and reliable material for accurate zoning and interregional correlation have been accumulated to a considerable extent. A remarkable improvement has recently been accomplished by TOZER (1961, 1962, 1967) on the basis of the newly investigated ammonite sequences in Canada.

In Japan the Upper Triassic ammonites are poorer than the Lower and Middle Triassic ones, because the Upper Triassic strata are represented dominantly by nonmarine or near shore sediments.

The stratigraphy of the Nakijin Formation was previously described (ISHIBASHI, 1969). This formation distributes in the Motobu Peninsula and annexed islet of Okinawa-jima (Fig. 1) and consists mainly of bedded limestone in which occur numerous cephalopods, halobiids (KOBAYASHI and ISHIBASHI, 1970) and others.

The ammonites obtained from the Nakijin Formation constitute the richest assemblage among the Upper Triassic ammonoid faunas hitherto known in the Japanese Islands and many of them are identified with or probably referable to the known species from other parts of the world. Thus they are very important for the interregional correlation and biogeographical consideration as well as for the biostratigraphy of the Triassic sediments of the Japanese Islands.

As noted in the stratigraphic description, the ammonites of the Nakijin Formation have been found from seven of the ten fossiliferous horizons. The lower two horizons are characterized by species of the Trachyceratidae and the upper five horizons by those of the Tropitidae, Choristoceratidae, Tropiceltitidae and Haloritidae. Thus specific assemblage of ammonites indicates that the



Text-figure 1. Locality map of the Triassic strata distributing in Okinawa-jima.

Nakijin Formation comprises at least two zones. The lower zone is designated here as the *Sirenites* cf. *nanseni* zone and the upper as the *Juvavites* (*J.*) cf. *kellyi* zone. In this paper the following selected species* from the two zones are described and some remarks are given on their affinities and the interregional correlation.

Discotropites cf. *plinii* (MOJSISOVICS)
Discotropites quinquepunctatus (MOJSISOVSCS)
Discotropites sp.
Hoplotropites cf. *arionis* (MOJSISOVICS)
Hoplotropites cf. *georgii* (MOJSISOVICS)
Hannaoceras (*Hannaoceras*) *henseli* (OPPEL)
Arietoceltites arietitoides (DIENER)
Arnioceltites cf. *arietitiformis* (MOJSISOVICS)
Jovites cf. *dacus* (MOJSISOVICS)
Juvavites (*Juvavites*) cf. *kellyi* SMITH
Sirenites cf. *nanseni* TOZER
Thisbites sp. A

For the taxonomy of ammonoid families I follow the scheme proposed by KUMMEL in "Treatise on Invertebrate Paleontology, Part L, Mollusca 4" in MOORE (Ed. 1957). Identification is entirely based on external characters. All the

* Results of paleontological studies of the other cephalopods will be published elsewhere as a separate paper.

described specimens are registered and kept in the Department of Geology, Kyushu University.

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The Ammonoid Zones of the Upper Triassic Carnian Series

The zoning of the Triassic strata on the basis of ammonoid was first introduced by MOJSISOVICS et al. (1895) in the European Alps but their zones did not in some parts accord with the real stratigraphic sequence, because of the structural complexities. The zonal subdivisions by subsequent authors (e.g., SPATH, 1934; KUMMEL, 1957; REESIDE et al., 1957) were not always founded on the stratigraphically successive sequence of a single area, but were established by the compilation of reliable data from various regions of the world, with detailed descriptions of biostratigraphic sequence and paleontological monographs of the contained ammonoids.

With regard to the Upper Triassic ammonoid zones, SILBERLING (1956) discussed the *Trachyceras* subzone of the *Tropites subbullatus* zone introduced by SMITH (1927) for the Upper Triassic Hosselkus limestones, and he renamed the *Tropites dilleri* subzone instead of the *Trachyceras* subzone. He (1959) revised the species group of *Tropites* of SMITH and classified them into five species, each of which has a restricted stratigraphical range. He assigned the *Juvavites* subzone of SMITH (1927) to his *Tropites welleri* subzone. Recently the *Tropites dilleri* and *T. welleri* subzones were elevated to the full zonal level in North America by TOZER (1967) and SILBERLING and TOZER (1968). They discriminated five ammonoid zones in the Carnian Series (Table 1).

The Triassic strata of the Japanese Islands are tectonically much disturbed, and the sequence is incomplete in most of the developed areas. Since ammonites occur very sparsely in them, the biostratigraphic subdivision of the Upper Triassic of Japan has been established mainly on the basis of bivalves. The lower unit of the Upper Triassic is called the Sakawan (ICHIKAWA, 1950), which

Table 1. Carnian ammonid zones by authors.

Stage	Substage	Mojsisovics, Waagen and Diener (1895)	North American Smith (1927)		"European Standard" Spath (1934) Kummel (1957)		North American Tozer (1967)
Norian	Lower	*Sagenites giebeli*	"Coral zone"		*Discophyllites patens*		*Mojsisovicsites kerri*
Carnian	Upper	*Tropites subbullatus*	*Tropites subbullatus*	*Juvavites* subzone	Tropitan	*Tropites subbullatus*	*Klamathites macrolobutus*
					Carnitan	*Carnites floridus*	*Tropites welleri*
				Trachyceras subzone			*Tropites dilleri*
	Lower	*Trachyceras aonoides*			Trachyceratan	*Trachyceras aonoides*	*Sirenites nanseni*
		Trachyceras aon	"*Dawsonites* zone"			*Trachyceras aon*	*Trachyceras obesum*
Lad.	Up.	*Protrachyceras archelaus*	"*Daonella* zone"		*Protrachyceras archelaus*		*Paratrachyceras sutherlandi*

is almost equivalent in age to the Carnian, and is typically distributed in the Outer Zone of Southwest Japan.

Nakazawa (1957, p. 58) proposed to introduce the Arakuran (Lower Carnian or Ladino-Carnian) below the Sakawan stage. The former is based on the Arakura Formation in the Maizuru area of the Inner Zone of Southwest Japan, which contains *"Monophyllites" arakurensis* Nakazawa.*

Review of Japanese Carnian Ammonites

In the Upper Triassic of Japan only eight species of ammonites were described from the Carnian of Shikoku and Maizuru, Southwest Japan.

Shimizu (1930) described two species of *Paratrachyceras, P.* cf. *hofmanni* (Boeckh) and *P.* sp. nov. ?, from the Kochigatani Group in Shikoku. *Paratrachyceras hofmanni* is known from the *P. aonoides* zone of the European Standard in Hungary. *Thisbites orientalus*** described by Shimizu (1930) from Zohoin, Shikoku, was referred to the *Paratrachyceras aon* zone, the Lower Carnian.

Shimizu (1931) also described two Carnian species of *Proarcestes* from Shikoku; one is *Proarcestes* aff. *hanieli* Welter from Uwonashi, Ehime Prefec-

* Bando (1961, p. 331) stated that this species might belong to *Mojsivarites* because of more complicated sutures.

** See p. 217.

ture. *P. hanieli* originally reported by WELTER (1914) from Timor is referable to the Carnian, because some species allied to *P. hanieli* have been known from the Carnian of the European Alps and California. The other is *Proarcestes* aff. *bicarinatus* (MÜNSTER) from Kochigatani, Sakawa, Kochi Prefecture. *P. bicarinatus* was originally described by MÜNSTER (1841) from the Tyrolean Alps and is characteristic of the *Halobia-Tosapecten* Bed (Lower Carnian) (ICHIKAWA, 1950) which yields *Paratrachyceras* cf. *hofmanni* (BOECKH).

BANDO (1964) described *Paratrachyceras* n. sp. from the Kochigatani Group. This species is probably of the Lower Carnian *Paratrachyceras aonoides* zone.

"Monophyllites" arakurensis (1958), together with *Monophyllites* sp. and some pelecypods, from the Arakura Formation was referred by NAKAZAWA to the Lowest Carnian or Ladino-Carnian. This correlation needs more reliable evidence.

As understood from the above description, the tropitoid ammonites which are characteristic of the Upper Carnian over many Triassic regions were not previously reported from the Japanese Islands.

Systematic descriptions

Family Tropitidae MOJSISOVICS, 1875
Genus *Discotropites* HYATT and SMITH, 1905

Synonymy.—*Eutomoceras* MOJSISOVICS, 1879, non HYATT, 1877.

Type-species.—*Ammonites sandlingensis* HAUER, 1849.

Remarks.—The species which should belong to *Discotropites* HYATT and SMITH, 1905, were once assigned to *Eutomoceras* by MOJSISOVICS (1893), SMITH (1904) and GEMMELLARO (1904). This generic name is a homonym of *Eutomoceras* HYATT, 1877. The latter was established with the type-species, *Eutomoceras laubei* MEEK, which shows ceratitic septa, and evidently belongs to the family Ceratitidae.

Discotropites was classified artificially into two groups, the *punctati* and the *striati*, by MOJSISOVICS (1893). Thereafter, SMITH (1927), on the basis of the morphological features, classified the genus into the following three groups on the basis of the Californian specimens.

I. Group of *Discotropites sandlingensis* (HAUER): With fine spirals, sharp ribs, and no knots on the ribs.

II. Group of *Discotropites theron* (DITTMAR): With fine spirals, sharp ribs, and rudimentary fine knots on the ribs where they are crossed by the spiral lines.

III. Group of *Discotropites mojsvarensis* SMITH: With fine spirals, stronger ribs, and distinct knots on the ribs crossed by the spirals.

The group of *D. mojsvarensis* has strong ribs like those of *Tropites* or *Trachyceras* and the spiral knots of the group are generally more conspicuous than those of the other groups. In view of the generic diagnosis by HYATT and SMITH (1905), the group of *D. mojsvarensis* should be separated from other

groups. In my opinion the former should receive a new generic name and the latter is *Discotropites* in a revised sense. The group of *D. sandlingensis* of SMITH (1927) corresponds to the *striati* of MOJSISOVICS (1893) and that of *D. theron* to the *punctati*.

Of these species obtained from Okinawa, *Discotropites* cf. *plinii* (MOJSISOVICS) belongs to the *striati* group, while *D. quinquepunctatus* and *D.* sp. are referred to the *punctati* group.

In *Discotropites* two kinds of characteristic features are recognized with regard to the ornamentation. One is the flattened broad ribs, without spiral knots, separated by sharply incised interspaces and the other is rounded, falcoid ribs with distinct knots. The former is found in the *striati* group and the other in the *punctati* group. In addition to the fine spiral lines which are discernible on the flank of almost all the known species, several rows of distinct knots or clavi develop in the species of the latter group, such as *D. punctatus* (MOJSISOVICS), *D. sengeli* (MOJSISOVICS) and *D. laurae* (MOJSISOVICS).

The shell-size seems to be generally larger in the *striati* group than in the *punctati*. There is, however, an exception in this respect, since an example of *D. punctatus* (MOJSISOVICS) (1893, pl. 197, fig. 7) is moderately large.

Discotropites is widely distributed in the Upper Carnian, occurring in the Hallstatt limestone of Austria, and correlative zones of Sicily, Timor, Tonkin in Viet-Nam, Alaska, California and Okinawa.

Discotropites sp. cf. *D. plinii* (MOJSISOVICS)

Pl. 26, Figs. 1–5

Compare.—

1893. *Eutomoceras plinii* MOJSISOVICS; *Abhandl. Geol. Reichsanst., Wien,* **6**, (2), p. 289, pl. 130, figs. 2–6.
1908. *Eutomoceras* aff. *plinii* MOJSISOVICS; DIENER, *Palaeont. Indica,* [15], **5**, (3), p. 84.
1914. *Discotropites* cf. *plinii* (MOJSISOVICS); WELTER, *Paläont. von Timor,* p. 121, pl. 20, fig. 22.
1916. *Discotropites* cf. *plinii* (MOJSISOVICS); DIENER, *Glasn. Zemalj. Muz. Bosni Hercegovini V,* **28**, p. 393.
1921. *Discotropites plinii* (MOJSISOVICS); DIENER, *Denkschr. Akad. Wiss. Wien,* **97**, p. 507.

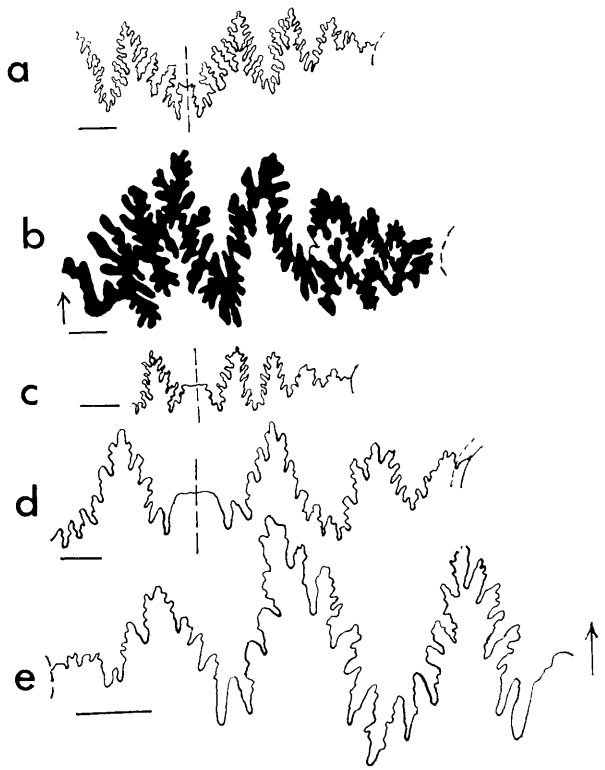
Material.—The specimens at hand are composed of moderately large but incomplete ones (GK.F 381–382) and three fragmentary pieces of the ventral part (GK.F 383–385). The whorl diameter of GK.F 381 is about 140 mm and that of GK.F 382 is 115 mm.

Description.—Shell involute, discoidal; whorl strongly compressed, slightly convex, high; outer whorl completely embracing the inner whorl and deeply indented to one-third of its height by the latter; umbilicus very narrow, occluded; umbilical shoulder and precise diameter not observed; venter narrow and acute, capped with a high hollow, ruonded keel; width of keel about 1.8 mm (GK.F 384) and 1.5 mm (GK.F 385); surface with numerous radial, gently sinuous and

broadly flattened ribs; ribs mostly single but some of them dichotomous, broader than the intercostal space (0.8 mm), broadest just below ventral part, projected in the ventrolateral part; spiral lines which cross the ribs not distinctly observed except for the weak and fine ones in one specimen (GK.F 383); spiral knots absent; umbilical knots not clearly discernible; suture lines unpreserved.

Remarks.—Discotropites plinii was originally described by MOJSISOVICS (1893) from the Hallstatt limestone of Austria. Of the syntype described by MOJSISOVICS (1893) the one illustrated in pl. 130, fig. 6 is here designated as the lectotype of *D. plinii*.

He stated that this species was accompanied by *Trachyceras austriacum* MOJSISOVICS and *Lobites ellipticus* HAUER from the Lower Carnian. WELTER (1914) described *D.* cf. *plinii* with a text-figure of suture line from the Lower Carnian of Timor. Thereafter DIENER (1921, p. 507) mentioned that "Diese die Julischen Unterstufe (Schichten mit *Lobites ellipticus* und mit *Trachyceras austriacum*) am Feuerkogel bekannte Art in der Sammlung Dr. HEINRICH's durch vier Exemplare aus *Subbullatus*-Schichten der gleichen Lokalität vertreten".



Text-figure 2. Suturelines of some species of *Discotropites*.

a. *Discotropites plinii*; MOJSISOVICS, 1893, pl. 130, fig. 6.
b. *Discotropites* cf. *plinii*; WELTER, 1914, pl. 20, fig. 22.
c. *Discotropites theron*; MOJSISOVICS, 1893, pl. 130, fig, 8c.
d. *Discotropites sandlingensis*; MOJSISOVICS, 1893, pl. 130, fig. 12.
e. *Discotropites empedoclis*; SMITH, 1927, pl. 11, fig. 4.
Length of bar is 0.5 mm.

The suture-lines of *Discotropites plinii* or *D.* cf. *plinii* described by MOJSISOVICS and WELTER are shown in Text-figure 2, with those of some allied species. The suture of *D. plinii* belongs to the most developed type. Unfortunately the suture is not preserved in the specimens from Okinawa.

In *D. plinii* the umbilical knots and spiral lines are considered to have been reduced. In the present specimens the spiral lines are not clearly observable.

As the specimens of GK.F 381 and GK.F 382 are incompletely preserved, the essential characters are observable. In the fragments (GK.F 383–385) the ventral part is well preserved. These specimens are comparable with *Discotropites plinii* (MOJSISOVICS) by the characteristics of the venter as well as those in lateral view. *Discotropites empedoclis* originally described by GEMMELLARO (1904, p. 86, pl. 15, fig. 17) is larger than any other species of *Discotropites* from Sicily. GEMMELLARO mentioned that *D. empedoclis* was very similar to *D. plinii* of the Alps but the former had the more advanced form of suture than that of the latter. But there is no figure of suture line in his paper.

Though SMITH (1927) described that *D. empedoclis* (GEMMELLARO) might be only a variety of *D. theron* (DITTMAR), *Discotropites empedoclis* described by SMITH (1927, p. 40, pl. 11, figs. 1–4, in figs. 1–7) is quite similar to *D. plinii* described by MOJSISOVICS (1893) in various respects. I consider that *D. empedoclis* from California is more intimate to *D. plinii* than to *D. theron.*

Discotropites plinii occurred together with many species reported from the Upper Carnian of other Triassic regions. According to this evidence and DIENER's statement, *Discotropites plinii* (MOJSISOVICS) indicates the *Tropites subbullatus* zone (*s. l.*) of the Upper Carnian.

Occurrence.—Locality* 1 (Ya) on the western coast of Yamakawa, Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Black bedded argillaceous limestone and calcareous tuffite of the Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Discotropites quinquepunctatus (MOJSISOVICS)

Pl. 26, Figs. 6–9

Synonymy.—

1893. *Eutomoceras quinuepunctatum* MOJSISOVICS; *Abhandl. Geol. Reichsanst.*, **6**, (2), p. 293, pl. 131, figs. 12 and 15.
1904. *Eutomoceras quinquepunctatum* MOJSISOVICS; GEMMELLARO, *Giornale Sci. Nat. Econ. Palermo* **24**, p. 94, pl. 8, figs. 15–16.
1969. *Discotropites quinquepunctatus* (MOJSISOVICS); ISHIBASHI, *Mem. Fac. Sci., Kyushu Univ.*, [D Geol.], **19**, (3), p. 377, 378.

Material.—Four specimens (GK.F 386–389) from Okinawa are concerned with the description below.

Description.—Shell small for the genus, laterally compressed, involute, discoidal; outer whorl completely embracing inner whorls, with a closed umbilicus and flattened sides; ribs rounded in younger stages and gradually flattened with

* See ISHIBASHI (1969).

age, bifurcate, gently sinuous, projected on the venter; fine clavi arranged in five rows, of which the fifth (i.e. the outermost) clavi remarkably developed.

Remarks.—Of the syntypes described by MOJSISOVICS (1893) the one illustrated as fig. 12 on pl. 131 is here designated as the lectotype. It was collected from the Hallstatt limestone, Austria. *Discotropites quinquepunctatus* illustrated by GEMMELLARO (1904, pl. 8, figs. 15–16) is a small specimen and a part of whorl, but ventral keel and tubercles on ribs are well preserved.

The specimens at hand are rather well preserved, although they are secondarily compressed. On the basis of observed characteristics, they are almost certainly identified with *D. quinquepunctatus* (MOJSISOVICS).

Discotropites quinquepunctatus is classified in the group of *punctati* by MOJSISOVICS. This group is characterized by the spiral knots or clavi on the ribs. *D. quinquepunctatus,* among others, has very strong clavi at the ventrolateral row, while *D. sengeli* (MOJSISOVICS) has stronger ribs and stronger clavi even other parts of the flank and in addition secondary, faint clavi between the rows of stronger clavi (MOJSISOVICS, 1893, p. 294, pl. 131, fig. 14).

Discotropites quinquepunctatus is rather similar to *D. laurae* (MOJSISOVICS) in various respects, but in the latter species only the clavi of the outermost row is distinct and those of other rows are much weakened.

Occurrence.—Locality 1 (Ya), the same bed as *Discotropites* cf. *plinii* (MOJSISOVICS), Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Discotropites sp. indet
Pl. 26, Fig. 10

Descriptive remarks.—An examined specimen (GK.F 390) is a part of shell from umbilicus to venter.

The sculptures such as ribs, keel, clavi and spiral lines are well preserved. The ribs are low, rounded and flexiradiate. Strong clavi are arranged in four rows on the ribs and weak ones are found between them. Judging from these observed characters, the specimen at hand evidently belongs to the *punctati* group. Possibly it could be referable to *D. sengeli* (MOJSISOVICS, 1893: SMITH, 1927, p. 42, pl. 10, figs. 15–19).

Because the umbilical part and the greater part of the whorl are not presented, the specific identification is impossible at present.

Occurrence.—Locality 1 (Ya), Upper Member of the Nakijin Formation. This specimen occurred with the preceding two species from the same horizon: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Genus *Hoplotropites* SPATH, 1929

Synonymy.—*Margarites* MOJSISOVICS, 1889, non GRAY, 1847.

Type-species.—*Ammonites jokelyi* HAUER, 1855.

Remarks.—The genus *Hoplotropites* was established by SPATH (1929) based

on the type-species, *Ammonites jokelyi* HAUER, 1855 (p. 151, pl. 4, figs. 1, 2 and 7). This genus had been described under the name *Margarites*, MOJSISOVICS, 1889, which was a homonym of a gastropod genus (GRAY, 1847). *Hoplotropites* has a ventral keel, with a shallow furrow on either side, beautiful spines or tubercles on the flank and a wide umbilicus.

Many species of *Hoplotropites* were described by MOJSISOVICS (1893) from the *Tropites subbullatus* zone and the *Lobites ellipticus* zone of the Alps in Austria, but DIENER (1921) clarified that the specimens from the latter zone were collected actually from the *Tropites subbullatus* zone by HEINRICH. GEMMELLARO (1904) also described some new species from Sicily.

Hoplotropites is similar to *Metasibirites* of Metasibiritidae and *Distichites* of Dischitidae in the shell ornamentaton. However, the *Metasibirites* has rounded, arched venter, bifurcating ribs, and *Distichites* is distinguished from the former in possessing a median furrow on the venter.

Hoplotropites sp. cf. *H. arionis* (MOJSISOVICS)

Pl. 27, Figs. 1–3

Compare.—

1893. *Margarites arionis* MOJSISOVICS; *Abhandl. Geol. Reichsanst.*, **6**, (2), p. 300, pl. 117, figs. 7–8.
1915. *Margarites arionis* MOJSISOVICS; HEINRICH, *Mitteil. Geol. Ges. Wien*, 8, p. 246.
1921. *Margarites arionis* MOJSISOVICS; DIENER, *Denkschr. Akad. Wiss. Wien*, **97**, p. 508.

Material.—Three specimens which were once compared to *Hoplotropites jokelyi* are here reexamined. GK.F 393 (Pl. 27, Fig. 3) is an immature shell, GK.F 392 (Pl. 27, Fig. 2) is better preserved, showing various characteristics, and GK.F 391 (Pl. 27, Fig. 1) is a fragment of a larger shell.

Description.—Shell evolute, with two rows of tubercles on the flank; outer whorl embracing the inner one above the outer row of tubercles; outer tubercles of the inner whorl in contact with the umbilical wall; umbilicus broad; tubercles stronger on the ventrolateral shoulder than at the umbilical shoulder; ventrolateral ones appearing at earlier growth-stage in the immature shell; ribs not distinct, but somewhat rounded mould discernible between ventral and umbilical tubercles.

Remarks.—Of the two specimens of *Hoplotropites arionis* illustrated by MOJSISOVICS (1893, p. 300, pl. 117, figs. 7–8) the larger one (pl. 117, fig. 8) is designated here as the lectotype, although the smaller one may be the immature shell of the same species.

Hoplotropites arionis is characterized by the ventrolateral spinose tubercles which are stronger and more numerous than the peri-umbilical ones. The tubercles are poorly developed in other species of the same genus.

The specimens from Okinawa are almost identifiable with the lectotype described by MOJSISOVICS (1893), although they are secondarily compressed and the sutures are not visible in them.

Occurrence.—Locality 1 (Ya), Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Black argillaceous limestone, Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Hoplotropites sp. cf. *H. georgii* (MOJSISOVICS)
Pl. 27, Fig. 4

Compare.—
1893. *Margarites georgii* MOJSISOVICS; *Abhandl. Geol. Reichsanst.*, 6, (2), p. 309, pl. 119, fig. 9.

Material.—Only a fragmentary specimen (GK.F 394) is examined here.

Descriptive remarks.—The holotype was described by MOJSISOVICS (1893) from the vicinity of Sandling in Austria.

The specimen from Okinawa is poorly preserved and fragmentary. It is a part of the last volution with a keel. The ornamentation evidently shows that this specimen belongs to the genus *Hoplotropites*. Tubercles are composed of hollow spines, but the spines are broken at the base and appear as rounded nodes in the present specimen. Ribs on the ventrolateral part are curved in crescent-shape, running through the base of the spines, and gradually vanish as they approach to the keel. The keel is narrow, entire and bordered on either side by distinct furrows.

Hoplotropites georgii belongs to the group of the *H. unispinosi* (MOJSISOVICS, 1893). *Margarites georgii* reported by DIENER (1906, p. 143, pl. 3, fig. 8) from the *Tropites*-limestone of Byans, Himalaya, closely resembles *H. petersi* (MOJSISOVICS, 1893).

DIENER stated "the presence of short external ribs originating in parts from the marginal spines, ...". These paired ribs are not clearly confirmed in the specimen from Okinawa.

Occurrence.—Locality 1 (Ya), Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Black argillaceous limestone, Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Family Choristoceratidae HYATT, 1900
Genus *Hannaoceras* TOMLIN, 1931
Subgenus *Hannaoceras* TOMLIN, 1931

Synonymy.—*Polycyclus* MOJSISOVICS, 1893, non LAMARCK, 1815; *Smithoceras* HANNA, 1924, non DIENER, 1907; *Polyshinctoceras* SPATH, 1934.

Type-species.—*Ammonites nasturtium* DITTMAR, 1866.

Remarks.—The type-species of *Hannaoceras* was described from the neighbourhood of Sandling, Austria, by DITTMAR (1866, p. 358, pl. 14, figs. 24–37).

While almost all the species of this genus were described under the generic name of *Polycyclus* before 1927, this name, unfortunately, had been already used by LAMARCK (1815) for Tunicata. Likewise *Smithoceras* HANNA, 1924 is homonymous with DIENER's (1907). After several changes, *Hannaoceras* of the

present usage was established by TOMLIN (1931).

SPATH (1951, p. 85) proposed a new subgenus *Sympolycyclus* under *Hannaoceras,* with the type-species *Polycyclus nodifer* HYATT and SMITH (1905, p. 201, pl. 38, figs. 1–8), which is very evolute and has a shallow ventral groove. The subgenus *Hannaoceras* (*Hannaoceras*) is evolute, with a widely opened umbilicus, compressed to depressed and has no ventral furrow. The ribs are radial, rounded, gradually widen outward, separated by narrow intercostal spaces, and pass over venter.

The immature shell of the type-species, *Ammonites nasturtium,* is depressed and involute. It is different from other species in the sculpture of ribs, and resembles the globose *Leconteiceras,* as has already been pointed out by SPATH (1951, p. 85).

Hannaoceras (*Hannaoceras*) *henseli* (OPPEL)
Pl. 27, Figs. 5–22

Synonymy.—

1865. *Ammonites henseli* OPPEL; *Paläont. Mitteil. Mus. Staates,* 4, p. 132, pl 41, fig. 3.
1866. *Ammonites henseli* OPPEL; DITTMAR, *Geol. Paläont. Beiträge,* in BENECKE, 1, p. 375, pl. 16, figs. 16–20.
1879. *Choristoceras henseli* (OPPEL); BRANCA, *Palaeontographica,* **26**, p. 42, pl. 5, fig. 7.
1893. *Polycyclus henseli* (OPPEL); MOJSISOVICS, *Abhandl. Geol. Reichsanst.,* 6, (2), p. 536, pl. 132, figs. 7–23.
1906. *Polycyclus henseli* (OPPEL); ARTHABER, *Lethaea Mesozoica,* 1, (3), pl. 45, fig. 4.
1915. *Polycyclus henseli* (OPPEL); HEINRICH, *Mitteil. Geol. Ges. Wien,* 8, p. 246.
1920. *Polycyclus henseli* (OPPEL); DIENER, *Sitzungsber. Akad. Wiss., Wien,* **129**, p. 614.
1925. *Polycyclus henseli* (OPPEL); DIENER, *Leitfossilien der Trias,* p. 92, pl. 16, fig. 3 (copy from MOJSISOVICS, 1893, pl. 132, figs. 20b, 21).
1928. *Polycyclus henseli* (OPPEL); KUTASSY, *Zentralbl. Min. Geol. Paläont.,* (B), p. 324.
1962. *Hannaoceras* sp.; TOZER, *Geol. Surv. Canada, Paper* 62–19, p. 18, pl. 8, fig. 5.
1965. *Hannaoceras* sp.; CARLISLE and SUSUKI, *Canadian Jour. Earth Sci.,* 2, p. 475, pl. 4, figs. 35–38, pl. 5, figs. 44–45.
1969. *Hannaoceras* (*Hannaoceras*) *henseli* (OPPEL); ISHIBASHI, *Mem. Fac. Sci., Kyushu Univ.,* [D Geol.], **19**, (3), pp.377, 379.

Material.—Twenty specimens (GK.F 395–414) are examined.

Description.—Shell evolute, laterally compressed, discoidal; whorl gradually embracing the one-third or one-fourth of the inner whorl and increasing slowly in height; umbilicus wide and shallow; ribs simple, strong, rounded, rectiradiate, becoming stouter outward, separated by narrow and uniform interspaces, passing over the venter; venter rounded, without furrow and tubercles.

Remarks.—The holotype is the specimen illustrated by OPPEL (1865, p. 132, pl. 14, fig. 3).

The specimens at hand are more or less deformed. The ventral part is shown

only by a fragmentary specimen (Pl. 27, Fig. 22). The irregular scratch on the last specimen is obviously secondary.

Two varieties were distinguished by MOJSISOVICS (1893, p. 536), but they can be considered to be settled within the range of individual variation.

Hannaoceras (*Hannaoceras*) *henseli* has been reported by many authors from various regions of the world. DIENER (1906a) reported a small specimens from Kalapani of Himalaya. He distinctly mentioned that his specimen agreed perfectly and in every respect with the description and figures given by DITTMAR (1866) and MOJSISOVICS (1893). As is shown in the illustration, DIENER's specimen (pl. 7, fig. 12) has angulated, bifurcating ribs instead of simple, rounded ones. The ventrolateral shoulder is almost rectangular as mentioned by DIENER. These facts seem to suggest that his specimen belongs to *Helictites* and not to *Hannaoceras*.

SMITH (1927) also reported *Polycyclus henseli* from the Upper Hosselkus limestone, California. He described that his figured specimen (pl. 57, fig. 29) had no ventral furrow, but a distinct ventral furrow is recognized in the figure and the whorl is extremely evolute. These characters are commonly observed in *Choristoceras* or *Hannaoceras* (*Sympolycyclus*) but not in *Hannaoceras* (*Hannaoceras*).

JOHNSTON (1941) described *Hannaoceras newpassense* from the New Pass Range, Nevada. The ribs of *H. newpassense* are slender than those of *Hannaoceras* (*H.*) *henseli* and bent slightly forward on the venter. *H. newpassense* was associated with many Lower Carnian species which referred to *Joannites* zone (*Trachyceras obesum* zone, TOZER, 1967).

CARLISLE and SUSUKI (1965) described an indeterminable species of *Hannaoceras*. In spites of their brief description, the illustrated specimens (pl. 4, fig. 35–38; pl. 5, figs. 44–45) are very similar to the variety *directa* of *Hannaoceras* (*H.*) *henseli* illustrated by MOJSISOVICS (1893, pl. 132, figs. 7–10). Tentatively these specimens are listed here under *Hannaoceras* (*H.*) *henseli*.

Occurrence.—Locality 1 (Ya), Kamimotobu-son, Motobu Peninsula, Okinawajima. Black argillaceous limestone, Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Family Tropiceltitidae SPATH, 1951
Genus *Arietoceltites* DIENER, 1916

Type-species.—*Tropiceltites arietitoides* DIENER, 1906.

Remarks.—The genus *Arietoceltites* was proposed by DIENER (1916b), with the type-species, *Tropiceltites arietitoides* DIENER (1906a, p. 156, pl. 3, fig. 12), from the Himalayan region, but he did not give the generic diagnosis. This species was unfortunately missed in the Fossilium Catalogue by DIENER (1915).

This genus is characterized by the evolute and discoidal shell; strong, concave and radial ribs; a pointed keel on the venter with a wide and deep furrow on either side. *Tropiceltites* (*Arnioceltites*) *multispiratus* MOJSISOVICS (1893, p. 388, pl. 121, fig. 44), from the Austrian Alps, was referred to *Arietoceltites*

by SPATH (1951, p. 95). KUMMEL (1957) also accepted SPATH's opinion. *Arietoceltites multispiratus* is smaller, devoid of deep ventral furrows and provided with tubercles on ribs of inner whorls. Only two species are known at present.

Arietoceltites arietitoides (DIENER)
Pl. 28, Figs. 1–6

Synonymy.—

1906. *Tropiceltites arietitoides* DIENER; *Palaeont. Indica,* [15], 5, (1), p. 156, pl. 3, fig. 12.
1966. *Arietoceltites arietitoides* (DIENER); KUMMEL, *Breviora, Mus. Comp. Zool., Harvard Univ.,* (248), p. 3, figs. 1a–b.
1969. *Arietoceltites arietitoides* (DIENER); ISHIBASHI, *Mem. Fac. Sci., Kyushu Univ.,* [D Geol.], 19, (3), pp. 377, 379.

Material.—Six specimens (GK.F 415–420) from Okinawa are concerned with the present description.

Description.—Shell rather evolute, discoidal, flattened; whorl gradually increasing its height; outer whorl indented at about one-third height by inner whorl; umbilicus widely opened; surface with considerably strong, concave, rather crescent shaped radial ribs on the main part of the flank, which show falciform bending at the ventrolateral shoulder with much weakening; intercostal species wide on the main part of the flank and narrowed on the ventral part; venter with a distinct keel.

Remarks.—The holotype, from Kalapani, Himalaya, described by DIENER (1906a) is a half whorl including the umbilical area, but the ornamentation is well preserved. It has a sharply pointed keel, with a wide and deep furrow on either side.

The specimens at hand are secondarily compressed and somewhat weathered. The ventral keel is recognized, but the furrows bordering the keel are indistinct owing to the secondary deformation. The characteristic ornamentation and the shell-form in lateral view are well preserved, which enable me to identify the specimens with the same species as the holotype.

Arietoceltites arietitoides is similar to such species as *Arnioceltites gschwandtneri,* (MOJSISOVICS, 1893, p. 387, pl. 128, fig. 3) and *A. linarius,* (MOJSISOVICS, 1893, p. 387, pl. 129, fig. 3). They have strong and sharp ribs on the whole part of the whorl, without weakening at the ventrolateral part.

According to DIENER (1906a), all of the fossil species including the holotype from the *Tropites*-limestone of Kalapani are a mixed fauna of Carnian and Norian. He (1912, p. 150) concluded that the mixed fauna was Norian in age. KUMMEL (1966) described *Arietoceltites arietitoides* from Hindubagh region in West Pakistan, from where DIENER (1906b) previously reported some ammonites, *Halorites* aff. *subcatenato* MOJSISOVICS, *Paratibetites* aff. *tornquisti* MOJSISOVICS, *Celtites* sp. (group of *acuteplicati* ?), *Dittmarites* or *Distichites* ? sp., *Rhacophyllites vredenburgi* DIENER and a pelecypod, *Monotis salinaira* SCHLOTHEIM.

Some of those specimens were collected by VREDENBERG (1904) from transported boulders within the Triassic outcrop area. It seems to me that DIENER (1906b, p. 21) and KUMMEL (1966, p. 2) did not set down the geologic age of the Triassic sediment in Hindubagh, Pakistan, but HAAS (1969) defined the geologic age of *A. arietitoides* illustrated by KUMMEL as Norian.

In Okinawa *A. arietitoides* is accompanied with the Carnian ammonite fauna and evidently belongs to the *Juvavites* (*J.*) cf. *kellyi* zone. Though this species may be found in Norian in Himalayan regions, it is necessary to reexamine the mixed fauna of Kalapani and the detailed stratigraphic study of the Triassic sediment in Hindubagh.

DIENER (1906a) pointed out that this species was apparently similar to a species of Lower Jurassic *Arietites*, but they are of entirely different stocks of much separated ages. The similarity is an example of homeomorphy.

Occurrence.—Locality 1 (Ya), Yamakawa, Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Black limestone of the Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Genus *Arnioceltites* MOJSISOVICS, 1893

Type-species.—*Tropiceltites* (*Arnioceltites*) *laevis* MOJSISOVICS (designated by SPATH, 1951).

Remarks.—MOJSISOVICS (1893) described many species from the Hallstatt limestone, in which three subgroups were distinguished; a) *costati*, b) *laeves* and c) *arietitiformes*. For the latter two groups subgenus *Arnioceltites* was proposed by him.

Subsequently DIENER (1906a) designated *Ammonites caducus* DITTMAR (1866, p. 361, pl. 14, figs. 14–15) as the type species of *Arnioceltites*. SPATH (1951) stated that "The creation of *Arietoceltites* by DIENER (1906a), with *Tropiceltites arietitoides* DIENER (1906a) as the type-species, seem to settle the point in favour of *T. laevis* MOJSISOVICS (1893) as the type-species of *Arnioceltites*". *Ammonites caducus* DITTMAR is not evidently a representative of the MOJSISOVICS' two groups of *laeves* and *arietitiformes*. This species is referred to the group of *Styrites tropitiformes* because of absence of distinct ribs. For the above reason I support the opinion of SPATH (1951) that *Arnioceltites laevis* is the type-species of *Arnioceltites*.

Arnioceltites sp. cf. *A. arietitiformis* (MOJSISOVICS)

Pl. 28, Figs. 7–10

Compare.—

1893. *Tropiceltites* (*Arnioceltites*) *arietitiformis* MOJSISOVICS; *Abhandl. Geol. Reichsanst.*, **6**, (2), p. 384, pl. 121, figs. 39–40.

1893. *Tropiceltites* (*Arnioceltites*) sp. ind. ex. aff. *arietitiformis* MOJSISOVICS; *Iibd.*, p. 386, pl. 121, fig. 41.

1904. *Tropiceltites* (*Arnioceltites*) nov. sp. ind. aff. *arietitiformis* MOJSISOVICS; GEMMELLARO, *Giornale, Sci. Nat. Econ. Palermo* 24, p. 21, pl. 22, figs. 14–15.

Material.—Four specimens before me are examined (GK.F 421–424).

Description.—Shell very evolute, compressed, discoidal; whorl very slowly increasing its height; outer whorl overlapping only the ventral part of the inner one; umbilicus widely opened, occupying about a half of the entire shell diameter; venter provided with a rounded, smooth keel bordered by a deep furrow on either side; ribs rectiradiate on the flank, moderately elevated, rather narrow, regular in distance, separated by the interspaces somewhat broader than the ribs themselves and projected on the venter fading away as they approach to the furrow.

Remarks.—MOJSISOVICS (1893) established this species on several syntypes, of which illustrated one (pl. 121, fig. 39) is here designated as the lectotype.

The specimens from Okinawa-jima are considerably larger in size than the syntypes and the other species of the same genus. *Arnioceltites arietitiformis* is very similar to *A. minimus* (HAUER) and *A. gschwandtneri* (MOSISOVICS) from the neighbourhood of Sandling, Austria. Of these species the first has a rounded ventral keel and distinct ventral furrows, elevated and rather narrow ribs which are straight on the flank and abruptly bent at the ventrolateral shoulder, whereas the latter two have crescent ribs with narrower intercostal spaces.

The specimens from Okinawa are probably identified with *A. arietitiformis* because of the identify or close similarity in general characters, particularly in the mode of ribbing and character of the venter, but they are somewhat deformed. They have more numerous ribs and are larger than the illustrated specimens of MOJSISOVICS'.

Unnamed species allied to *A. arietitiformis* were reported from the same locality with the syntypes by MOJSISOVICS (1893) and from Sicily by GEMMELLARO (1904). They are too small to be exactly compared. The specimens from the Alps came from the Zone of *Lobites ellipticus*. They are probably of lower horizon than those from Okinawa.

Occurrence.—Locality 1 (Ya), Yamakawa, Kamimotobu-son, Okinawa-jima. Black argillaceous limestone, Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Family Haloritidae MOJSISOVICS, 1893
Subfamily Haloritinae MOJSISOVICS, 1893
Genus *Jovites* MOJSISOVICS, 1893

Type-species.—*Tropites dacus* MOJSISOVICS, 1875.

Remarsk.—*Jovites* was at first introduced by MOJSISOVICS (1893) as a subgenus of *Halorites*, but it was soon ranked at generic level by himself (1896). Afterwards, DIENER (1921) treated it as a subgenus of *Halorites*, whereas SMITH (1927) established *Bacchites* as a subgenus of *Jovites*, with the type-species, *Juvanites* (*Anatomites*) *bachus* MOJSISOVICS, 1893. As KUMMEL (1957) shows, *Jovites*, *Halorites*, *Hemerites* and *Bacchites* are accepted as independent genera.

Jovites resembles *Halorites* and *Bacchites* in general characters. *Jovites* has a generally subglobose shell, broader, more rounded and weaker ribs which pass over the venter. There is a faint, narrow keel-like elevation on the venter

instead of a strong keel and furrows. No tubercles are developed on the ribs as in *Halorites* and *Hemerites*.

SMITH (1927) described that "Surface with rather fine radial ribs that alternate on the venter, at the thread like central keel ridge". He illustrated only one species from the Hosselkus limestone, Block Mountain, California, under the name of *Jovites pacificus* SMITH (1927, p. 53, pl. 13, figs. 11–13), which is probably an inflated species of *Juvavites* as TOZER (1961) pointed out, because it has a narrow umbilicus and many fine, strong and radial ribs.

Almost all the species of *Jovites* have been reported from the Upper Carnian of the Alps (MOJSISOVICS, 1893) and Sicily (GEMMELLARO, 1904), Greece (FRENCH, 1907; RENZ, 1910), Himalaya (MOJSISOVICS, 1896; DIENER, 1908), Timor (WELTER, 1914) and the Canadian arctic region (TOZER, 1961). Only *Jovites mercedis* (MOJSISOVICS) (1893, p. 55, pl. 85, figs. 1–5) is known from the Norian of the Alps.

Jovites sp. cf. *J. dacus* (MOJSISOVICS)
Pl. 28, Figs. 11–13

Compare.—

1875. *Tropites dacus* MOJSISOVICS; *Verhadnl. Geol. Reichsanst.*, **1**, p. 142.
1893. *Halorites (Jovites) dacus* (MOJSISOVICS); MOJSISOVICS, *Abhandl. Geol. Reichsanst.*, **6**, (2), p. 49, pl. 84, figs. 1–8.
1896. *Jovites* cf. *dacus* (MOJSISOVICS); MOJSISOVICS, *Denkschr. Akad. Wiss. Wien*, **63**, p. 590.
1899. *Jovites* cf. *dacus* (MOJSISOVICS); MOJSISOVICS, *Palaeont. Indica*, [15], **3**, (1), p. 19.
1907. *Jovites dacus* (MOJSISOVICS); FRECH, *Neues Jahrb. Miner.*, [Fest Bd.], p. 31, pl. 6, fig. 1.
1910. *Jovites dacus* var. *apollinis* (MOJSISOVICS); RENZ, *Palaeontographica*, 58, p. 81, pl. 6, fig. 9.
1914. *Jovites* cf. *dacus* (MOJSISOVICS); WELTER, *Paläontologie von Timor*, **1**, p. 47, pl. 5, figs. 8–9.
1915. *Jovites dacus* (MOJSISOVICS); HEINRICH, *Mitteil. Geol. Ges. Wien*, 8, p. 246.
1921. *Halorites (Jovites) dacus* var. *umbilicata* (MOJSISOVICS); DIENER, *Denkschr. Akad. Wiss. Wien*, **97**, *p.* 467, pl. 1, fig. 1, text-fig. 1.
1925. *Jovites dacus* (MOJSISOVICS); DIENER, in GÜRICH, *Leitfossilien*, 4, p. 63, pl. 14, fig. 6, (copy from MOJSISOVICS, 1893, pl. 84, fig. 5).

Materials.—Three specimens were examined at present. Two (GK.F 425, 426) of them show whorls in lateral view, the rest (GK.F 427) is a fragmentary ventral part.

Description.—Shell sphaerocone, subglobose, laterally convex; outer whorl completely embracing the inner one; body-whorl somewhat excentric and contracted; aperture with a zigzag shaped lappet and a moderately projected rostrum; venter rounded with a thready and fine elevation in the middle; radial ribs narrow and crowded on the inner whorl, moderately broad and less crowded on the outer whorl, rounded and branching on the flank, showing alternating disposition on both sides of the keel-like ventral thread; fine striae discernible near the aperture.

Remarks.—*Jovites dacus* was originally reported as *Tropites* without illustration by MOJSISOVICS (1875) from Siebenbürgen, Rumania (then Austria). Unfortunately the original description is inaccessible to me at present, so I have to refrain from discussion about the original type.

MOJSISOVICS (1893) described again *Jovites dacus* with well preserved specimens from the limestone at Kovács-Patak, Balán, in Siebenbürgen and Sandling in Austria. The former was the same locality with the type specimen and the specimens from this locality were monographed (MOJSISOVICS, 1893, p. 49, pl. 84, figs. 1–3). They are slightly deformed and have a rather stronger keel-like elevation on the venter than the specimens from Okinawa.

DIENER (1921) replaced *Jovites* to the subgeneric rank and described a variety of this species from the Alps, but it is specifically identical with MOJSISOVICS' specimens from the Alps and the present specimens from Okinawa.

Occurrence.—Locality 1 (Ya), Yamakawa, Kamimotobu-son, Moto Peninsula, Okinawa-jima. Black argillaceous limestone, Upper Member of the Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Genus *Juvavites* MOJSISOVICS, 1879
Subgenus *Juvavites* MOJSISOVICS, 1879

Type-species.—*Ammonites ehrichi* HAUER, 1855.

Remarks.—The genus *Juvavites* was established by MOJSISOVICS (1893, p. 74), who included subgenera, *Juvavites, Anatomites* and *Dimorphites*. The latter two subgenera were ranked up to independent genera by KUMMEL (1957), but other authors treated them as subgenera of *Juvavites*. Furthermore, the subgenera *Griesbachites* (MOJSISOVICS, 1896), *Molengaaffites* and *Malayites* (WELTER, 1914) were proposed, but they are treated as independent genera.

MOJSISOVICS divided the species of *Juvavites* (s. s.) into the *cotinui* and the *interrupti* group. The *continui* group as represented by the type-species, *Juvavites ehrichi* (HAUER), has a rounded venter which is crossed by ribs. In the *interrupti* group, the ribs are interrupted at the top of the venter and alternate on opposite side. These interrupted ribs make a furrow with those on the siphonal line.

A number of species has been described under *Juvavites* and *Anatomites* from the Carnian and Norian strata of representative Triassic regions, although it is necessary to reexamine them.

Juvavites sp. cf. *J.* (*Juvavites*) *kellyi* SMITH
Pl. 28, Figs. 14–16: Pl. 29, Figs. 1–14

Compare.—

1905. *Juvavites* (*J.*) *subinterruptus* MOJSISOVICS; HYATT and SMITH, *U. S. Geol. Prof. Paper,* (40), p. 46, pl. 30, figs. 1–2.
1927. *Juvavites* (*J.*) *subinterruptus* MOJSISOVICS; SMITH, *U. S. Geol. Surv. Prof. Paper,* (141), p. 55, pl. 18, figs. 1–7, pl. 30, figs. 1–2.
1927. *Juvavites* (*J.*) *kellyi* SMITH; SMITH, *ibid.*, p. 55, pl. 18, figs. 8–25.

Material.—The seventeen specimens at hand (GK.F 428–444) are more or less deformed.

Description.—Shell involute, with convex sides; outer whorl deeply embracing the inner one and indented about one-half by the latter; umbilicus very narrow; venter rounded, with a furrow on the siphonal line; radial ribs, rounded, crowded, branching in multiple way, bending forward from the umbilical margin to the venter, less raised near the umbilical margin and sometimes irregular in strength on the flank but more regular on the venter, where the ribs are interrupted and show alternating disposition on both sides of the siphonal line; a constriction-like, prorsiradiate deep furrow, accompanied with raised ribs, periodically seen on the flank, cutting apparently obliquely the ribs behind them.

Remarks.—The holotype of *Juvavites* (*J.*) *kellyi* was originally described by SMITH (1927) from the Upper Triassic Hosselkus limestone, California. This species as mentioned by him, closely resembles *Juvavites* (*J.*) *subinterruptus* MOJSISOVICS, which is associated with *Juvavites* (*J.*) *kellyi* at several localities in California. SMITH (1927) said that "*Juvavites* (*J.*) *kellyi* differs only in the general lateral compression and finer ribs. The two forms may be male and female of the same species, but the difierence is constant, and there is no intergradation, in spite of the constant association of two".

Juvavites (*J.*) *subinterruptus* MOJSISOVICS (1893, p. 90, pl. 89, fig. 13; pl. 90, figs. 2–3; pl. 126, fig. 16) may be different from the *Juvavites* (*J.*) *subinterruptus* of SMITH (1927, p. 55, pl. 18, figs. 1–7) in view of the morphological difference and stratigraphical occurrence. In the former the ribs are rather stronger on the flanks and interrupted on the venter, in the latter the ribs are broader, lower and never alternated on the venter. SMITH's *Juvavites* (*J.*) *subinterruptus* occurs with *Juvavites* (*J.*) *kellyi* in the *Tropites dilleri* zone (TOZER, 1967) of California. *Juvavites* (*J.*) *subinterruptus* MOJSISOVICS was found in the upper part of Lower Carnian (*Trachyceras aonoides* zone) of the Alps. To the best of observation, *Juvavites* (*J.*) *subinterruptus* illustrated by SMITH (1927) is indistinguishable from *Juvavites* (*J.*) *kellyi* SMITH.

Though the present specimens are slightly deformed and have a little deeper furrow on the siphonal area, they are probably identified with *Juvavites* (*J.*) *kellyi* SMITH. *Juvavites* (*J.*) *kellyi* is somewhat similar to certain species of the *Anatomites intermittentes* group, e.g., *Juvavites* (*Anatomites*) *adalberti* MOJSISOVICS (1893, pl. 93, figs. 12–14) in lateral view, but the ribs cross the venter in the latter.

Occurrence.—Locality 1 (Ya), Yamakawa, Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Black argillaceous limestone, Upper Member, Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Family Trachyceratidae HAUG, 1894
Genus *Sirenites* MOJSISOVICS, 1893

Type-species.—*Ammonites senticosus* DITTMAR, 1866.

Remarks.—The genus *Sirenites* was proposed by MOJSISOVICS (1893, p. 725),

who distinguished in it three subgenera, *Diplosirenites*, *Anasirenites* and *Sirenites* (s. s.). The last is composed of four groups represented respectively by *Sirenites senticosi*, *S. striatofalcati*, *S. pamphagus* and *S. argopautae*.

A great number of species of *Sirenites* in a broad sense has been reported from the Carnian and Norian of the Alps (DITTMAR, 1866; MOJSISOVICS, 1893; DIENER, 1920), Sicily (GEMMELLARO, 1904), Greece (FRECH, 1907; RENZ, 1910), Himalaya (MOJSISOVICS, 1896, 1899; DIENER, 1906), Timor (WELTER, 1914; DIENER, 1923), New Guinea (SKWARKO, 1967), North America (HYATT and SMITH, 1905; SMITH, 1927 in the western United States; MCLEARN, 1960 in British Columbia; TOZER, 1961 in the Arctic region of Canada) and North-East Siberia (KIPARISOVA, 1937; POPOW, 1961).

KUMMEL (1957) regarded *Anasirenites* and *Diplosirenites* as subgenera, but POPOW (1961) ranked them at the generic level. A number of genera or subgenera were furthermore separated from *Sirenites*. Hitherto known genera related to *Sirenites* are as follows, with the type-species in square branckets.

Anasirenites MOJSISOVICS, 1893; ranked at a generic level by KITTL (1900)
[*Sirenites* (*Anasirenites*) *ekkehardi* MOJSISOVICS, 1893]
Diplosirenites MOJSISOVICS, 1893: KITTL (1900)
[*Sirenites* (*Diplosirenites*) *raineri* MOJS., 1893]
Pseudosirenites ARTHABER, 1911: SPATH (1951)
[*Sirenites stachei* MOJSISOVICS, 1893]
Vredenburgites DIENER, 1916: DIENER (1916)
[*Sirenites vredenburgi* DIENER, 1906]
Welterites DIENER, 1923: DIENER (1923)
[*Welterites egregius* DIENER, 1923]
Neosirenites POPOW, 1961: POPOW (1961)
[*Sirenites irregularis* KIPARISOVA, 1937]
Striatosirenites POPOW, 1961: POPOW (1961)
[*Sirenites striatofalcatus* (HAUER), 1893]
Pamphagosirenites POPOW, 1961: POPOW (1961)
[*Sirenites pamphagus* MOJSISOVICS, 1893]
Argosirenites POPOW, 1961: POPOW (1961)
[*Sirenites argonautae* MOJSISOVICS, 1893]
Arctosirenites TOZER, 1961: TOZER (1961)
[*Arctosirenites canadensis* TOZER, 1961]

These genera are generally characterized by the multiplied ornamentation on the ventrolateral and ventral parts. The tubercles on the outer part are more numerous than those on the inner (i.e., umbilical) part of the flank. SPATH (1951, p. 44) mentioned that "they are not derived from one branch, say the genus *Protrachyceras*, ...". In fact *Sirenites costatus* was regarded by TOZER (1961) as a probable descendant of *Paratrachyceras*. If more species like *S. costatus* without lateral tubercles are discovered from the Carnian of other regions, it may be desirable to transfer than to a new subgenus or genus.

Sirenites sp. cf. *S. nanseni* TOZER
Pl. 29, Figs. 15–26

Compare.—

1961. *Sirenites nanseni* TOZER; *Geol. Surv. Canada, Mem.* **316**, p. 77, pl. 23, nos. 1a–8b; pl. 24, nos. 12a–16b.

Material.—Twelve specimens (GK.F 445–456) in the present collection are concerned with the description below.

Description.—Shell evolute, compressed with slightly convex sides; whorl gradually increasing its height; outer whorl embracing about two-third to three-fifths of the inner whorl; umbilicus of moderate width, about one-third of the whorl diameter; ribs gently flexiradiate, somewhat more elevated and thickened near the umbilical margin, bifurcating or with some intercalated shorter ones at about the middle of the flank, considerably crowded on the outer half of the whorl; numerous, equally fine tubercles on the ribs arranged in regular spiral rows.

Remarks.—The holotype (GSC. No. 14161) designated by TOZER (1961, pl. 23, nos. 8a, 8b) came from the Middle Shale Member, Blass Mountain Formation, between Hare and Otto Fiords, Ellesmere Island, Canada. Other examples of *Sirenites nanseni* occur, according to TOZER, at several localities in the Arctic regions of Canada.

The specimens from Okinawa are sightly deformed and weathered. Though the ventral part is not well shown in most of them, a fragmentary specimen (Pl. 29, Fig. 23) shows a shallow furrow at the middle of the venter. On account of the described characters, the specimens from Okinawa are probably identified with *Sirenites nanseni* TOZER. Some of the specimens from Okinawa seem to be slightly more evolute than the average of the latter.

The present species also resembles several species of the group of *Sirenites senticosi* described by MOJSISOVICS (1893), from the Lower Carnian of the Alps. Such species as *Sirenites vestalinae, S. hermes* and *S. sophiae* resemble the present one, but they have stronger ribs, smaller rows of tubercles and more multiplied tubercles on the ventral part.

Occurrence.—Locality 5 (HGU), the vicinity of Nagatakibaru, Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Argillaceous limestone, Upper Member, Nakijin Formation: Lower Carnian [*Sirenites* cf. *nanseni* zone].

Family Thisbitidae SPATH, 1951
Genus *Thisbites* MOJSISOVICS, 1893

Type-species.—*Ceratites* (*Thisbites*) *agricolae* MOJSISOVICS, 1893.

Remarks.—The genus *Thisbites* was originally proposed as a subgenus of *Ceratites* by MOJSISOVICS (1893). Many species have been known from the Alps (MOJSISOVICS, 1893), Sicily GEMMELLARO, 1904) and Himalaya (DIENER, 1906a), which were reported mainly from the Carnian, but one species, *Thisbites meleagri* (MOJSISOVICS), was regarded as a Norian species by KUTASSY (1933).

In Japan, SHIMIZU (1930) described a species, *Thisbites orientalus,* from Sakawa, Shikoku, but SPATH (1951, p. 80) and NAKAZAWA (1958, p. 21) expressed some doubts about the generic identification of this species.

Thisbites sp. A
Pl. 27, Figs. 23a–b

Material.—Only an external mould (GK.F 457, Pl. 27, Fig. 23a) was obtained, from which a rubber cast (GK.F 458, Pl. 27, Fig. 23b) has been taken.

Descriptive remarks.—The shell is considerably involute and laterally compressed. The whorl increases rapidly its height. The ribs are rounded, strong and bifurcated in the middle of the flank, gently flexiradiate on the main part of the flank and bent strongly forward at the ventrolateral margin, showing a sickle-shape in the lateral view. The intercostal spaces are irregular in width. The keel on the venter is rounded and strong.

Although the specimen is deformed and a part of the whorl is destroyed, it is closely similar to *Thisbites ronaldshayi* described by DIENER (1906a, p. 30, pl. 11, fig. 19) from Himalaya, which is apparently as involute as *Parathisbites,* while the species belonging to *Thisbites,* which generally show an evolute form, have been reported from other Triassic regions of the world. I hesitate to give a specific name to this specimen, until better material is obtained.

Occurrence.—Locality 2 (LYa), Yamakawa, Kamimotobu-son, Motobu Peninsula, Okinawa-jima. Calcarous siltstone, Upper Member, Nakijin Formation: Upper Carnian [*Juvavites* (*J.*) cf. *kellyi* zone].

Ammonoid faunal assemblage in Okinawa

The Triassic ammonites occur at seven horizons in the Upper Member of the Nakijin Formation. This member consists mainly of bedded limestone with subordinate amounts of greenstone, calcareous siltstone, mudstone, tuffite and chert.

In each unit of seven horizons ammonites occur abundantly and are accompanied with numerous shells of *Halobia.* Furthermore, other kinds of fossils such as other pelecypods, gastropods, nautiloids, belemnoids, bryozoans, conodonts, algae etc. are also found in the same fossiliferous unit consisting of limestone, siltstone, mudstone and tuffiite beds. The cephalopods are especially abundant in the limestone and tuffiite beds of the Horizon 1 (Ya), 3 (Aka), 8 (HNa-3) and 5 (HGU). The ammonites and other fossils found at each horizon* are as follows:

Horizon 10 (HJ): halobiids; posidoniids.
Horizon 11 (HF): *Jovites* ? sp. A, ammonoid gen. et sp. indet.; halobiids.
Horizon 1 (Ya): *Discotropites* cf. *plinii* (MOJSISOVICS), *D. quinquepunctatus* (MOJSISOVICS), *D.* sp., *Tropites* ? sp., *Hoplotropites* cf. *arionis*

* See ISHIBASHI (1969, p. 377, fig. 2) for the stratigraphic position of the numbered horizon.

(MOJSISOVICS), *H.* cf. *georgii* (MOJSISOVICS), *Hannaoceras* (*H.*) *henseli* (OPPEL), *Arietoceltites arietitoides* (DIENER), *Arnioceltites* cf. *arietitiformis* (MOJSISOVICS), *Jovites* cf. *dacus* (MOJSISOVICS), *J.* ? sp. B, *Juvavites* (*J.*) cf. *kellyi* SMITH, *Arcestes* sp. B; nautiloids; belemnoids; halobiids.

Horizon 3 (Aka): *Juvavites* sp., *Clionites* ? sp., ammonoid gen. et sp. indet.; gastropod, halobiids; algae (*Parachetites, Cayeuxia*); bryzoans; conodonts.

Horizons 2 (LYa) and 4 (To): *Thisbites* sp. A, *Parathisbites* ? sp.; halobiids; bryozoans; sponge ?; algae (Solenoporaceae, Dasycladaceae).

Horizon 8 (HNa-3): *Tropiceltites* sp., T. ? sp., *Juvavites* ? sp., *Arcestes* sp. A; halobiids; sponge ?.

Horizon 9 (HNa-P) and 12 (HMO): *Paratrachyceras* sp. B, *Thisbites* sp .B; gastropods; bryozoans; halobiids [*Halobia styriaca* (MOJSISOVICS)] *Lima* sp.; *Palaeoneilo* sp.

Horizon 5 (HGU): *Sirenites* cf. *nanseni* TOZER, *Paratrachyceras* sp. A, *Hannaoceras* ? sp.; belemnoids; halobiids; *Bositra* sp.

Correlation

Almost all the Triassic ammonites from Okinawa are identified with the species which are well known from other regions of the world.

Sirenites cf. *nanseni* from the lowest Horizon 5 (HGU) is almost identical with *S. nanseni* from Canada, although it is based on the fragmentary specimens. *Sirenites nanseni*, an index species of the *S. nanseni* zone, was originally described by TOZER (1961) from the Canadian Arctic region. This species has also been found from the northern British Columbia and California (TOZER, 1967) and is characteristic of the upper part of the Lower Carnian. *S.* cf. *nanseni* from Okinawa is accompanied with *Paratrachyceras* sp. A and *Hannaoceras* ? sp. *Paratrachyceras* is commonly known from the Lower Carnian in Japan.

Halobia styriaca (MOJSISOVICS) from the Horizon 9 (HNa-P, HMO) has been known from the Lower Carnian of the Tethys province (KOBAYASHI and ISHIBASHI, 1970). As the bed at this horizon also yields *Paratrachyceras* sp. B and *Thisbites* sp. B, it is probably referred to the upper part of Lower Carnian.

The numerous tropitid ammonites are collected from the Horizon 1 (Ya) in the upper part of the Nakijin Formation. The tropitid ammonites are good representatives of the Upper Carnian.

SMITH (1927) reported the faunas from California which are representatives of the *Tropites dilleri* and the *T. welleri* zones. The latter *welleri* zone is particularly characterized by the following species (TOZER, 1967):

Tropite welleri SMITH (as revised by SILBERLING 1959)
Discotropites theron (DITTMAR)
Discotropites mojsvarensis SMITH
Hannaoceras major (SMITH)
Juvavites subintermittens HYATT and SMITH

Juvavites knowltoni SMITH (and many other species of *Juvavites* described by SMITH, 1927)
Jovites richardsi TOZER
Hoplotropites cf. *H. auctus* (DITTMAR)

The *Tropites dilleri* zone is synonymous with the "*Trachyceras* subzone" of the *Tropites subbullatus* zone of SMITH, 1927 (SILBERLING, 1956). TOZER (1967) mentioned that "a negative characteristic of the fauna of the *dilleri* zone is the absence of *Juvavites*". In California the following species are common in this zone (SILBERLING and TOZER, 1968):

Tropites dilleri SMITH (as revised by SILBERLING, 1959)
Discotropites sandlingensis (HAUER)
Paratropites spp.
Leconteiceras californicum HYATT and SMITH
Hannaoceras (*Sympolycyclus*) *nodifer* (HYATT and SMITH)
Spirogmoceras shastense (SMITH) (as revised by SILBERLING, 1959)
Traskites (including the subgenera *Shastites, Stantonites* and *Neanites*)
Californites nerriami HYATT and SMITH

The faunal assemblage of the Horizon 1 (Ya) seems to be comparable with that of the *Tropites welleri* zone of North America in which many species of *Discotropites* except *D. sandlingensis* are known. *Discotropites* cf. *plinii* and *D. quinquepunctatus* from Okinawa are probably more advanced than *D. sandlingensis*. *Jovites dacus* and *Hannaoceras* (*H.*) *henseli* are widespread species in the Upper Carnian and reported from many regions other than North America.

Table 2. Chart showing the distribution of the described species in other regions of the world.

Species from Okinawa \ District	European Alps	Hungary & Rumania	Balkan Peninsula	Sicily	Himalaya	Timor	Western America	Western Canada	Alaska & Arctic Region	North-East Siberia
Discotropites cf. *plinii*	*			*	*	*	*	*		
Discotropites quinquepunctatus	**			**			*			
Hoplotropites cf. *arionis*	*			*						
Hoplotropites cf. *georgii*	*			*	*					
Hannaoceras (*Hannaoceras*) *henseli*	**	**			**	**	*	**		
Arietoceltites arietitoides	*				**					
Arnioceltites cf. *arietitiformis*	*			*						
Jovites cf. *dacus*	*	*	*	*	*	*			*	
Juvavites (*Juvavites*) cf. *kellyi*						*	*			
Sirenites cf. *nanseni*								*	*	*

** identical * probably identical (cf.)

Hannaoceras (*H.*) *henseli* is characteristics of the *Juvavites* (*J.*) cf. *kellyi* zone in Okinawa.

As mentioned above, the ammonoid fauna of the Horizon 1 (Ya), 2 (LYa), 3 (To) and 4 (Aka) of Okinawa contains the same or probably identical species to those of the *Tropites welleri* zone of North America. Therefore, the upper part of the Upper Member of the Nakijin Formation is correlated with the *Tropites welleri* zone of the Upper Carnian.

The limestone beds between the Horizons 2 and 9 of the Nakijin Formation may be correlated to the *Tropites dilleri* zone. Table 2 shows the geographic distribution of the described species in the main Triassic regions of the world.

Concluding remarks

The ammonoid fauna from Okinawa is characterized by the species belonging to the families Tropitidae, Choristoceratidae, Tropiceltitidae, Haloritidae, Trachyceratidae, Thisbitidae and Arcestidae. Many of them are referred to the known species which are widespread or cosmopolitan, and comprise a mixed assemblage of the Northeast Pacific of North America and the Tethys-Indonesian elements.

For the Triassic in Japan they are entirely new. On the basis of the faunal assemblage and the stratigraphic occurrence, at least two distinct ammonoid zones are recognized in the Nakijin Formation, the *Sirenites* cf. *nanseni* zone and the *Juvavites* (*J.*) cf. *kellyi* zone in ascending order. These ammonoid zones are respectively referable to the *Sirenites nanseni* zone (upper Lower Carnian) and the *Tropites welleri* zone (middle Upper Carnian) of North American Upper Triassic.

Inspite of the great efforts ammonoids were previously known only sparsely in the Upper Triassic of Japan. It was therefore difficult to subdivide the Upper Triassic on the basis of ammonoids. The sequence established in the present study on the ammonite bearing Triassic strata in Okinawa would be regarded as a reference section of the Carnian in the Japanese province in particular with respects to the biostratigraphic zonation and interregional correlation.

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Takeshi ISHIBASHI

Upper Triassic Ammonites from Okinawa-jima
Part I

Plates 26～29

Plate 26

Explanation of Plate 26

Figs. 1–5. *Discotropites* sp. cf. *D. plinii* (MOJSISOVICS) ..... Page 201

1. GK. F 381, lateral view
2. GK. F 382, lateral view with slight whitening
3. GK. F 383, a fragmentary ventrolateral body
4. GK. F 384, ventral view
5. GK. F 385, ventral view

Figs. 6–9. *Discotropites quinquepunctatus* (MOJSISOVICS) ..... Page 203

6. GK. F 396, a fragmentary body whorl
7. GK. F 387, lateral view
8. GK. F 388, a fragmentary body whorl
9. GK. F 389, lateral view

Fig. 10. *Discotropites* sp. indet..... Page 204

GK. F 390, a fragmentary body whorl

(Figures natural size)

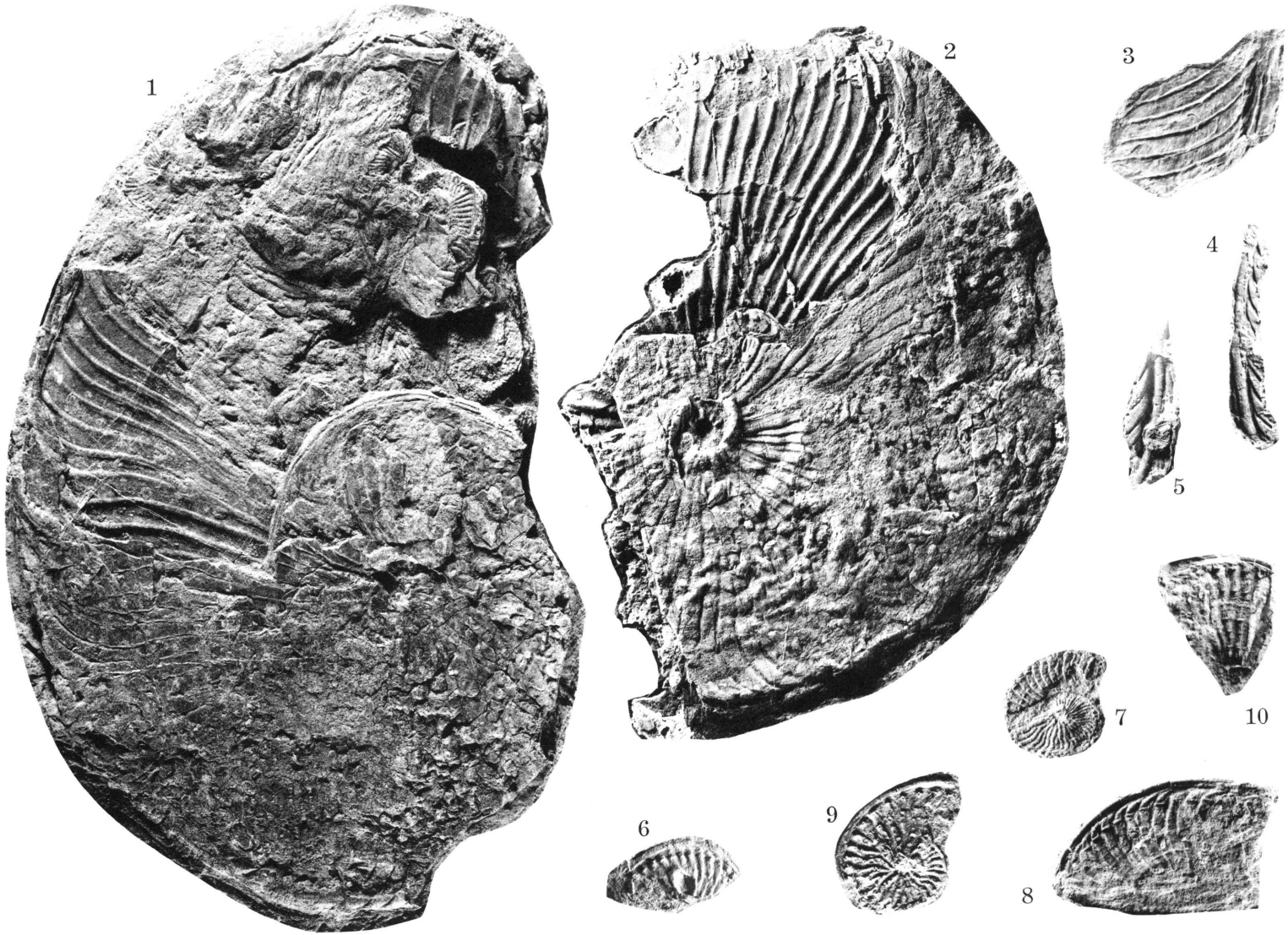

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Plate 27

Explanation of Plate 27

Figs. 1–3. *Hoplotropites* sp. cf. *H. arionis* (MOJSISOVICS) ..... Page 205
1. GK. F 391, a fragmentary body whorl
2. GK. F 392, lateral view
3. GK. F 393, lateral view

Fig. 4. *Hoplotropites* sp. cf. *H. georgii* (MOJSISOVICS) ..... Page 206
GK. F 394, ventrolateral view, × 2

Figs. 5–22. *Hannaoceras* (*Hannaoceras*) *henseli* (OPPEL) ..... Page 207
5. GK. F 395, lateral view, with whitening
6. GK. F 396, lateral view
7. GK. F 397, lateral view
8. GK. F 398, lateral view
9. GK. F 399, lateral view
10. GK. F 400, lateral view
11a. GK. F 401, lateral view of external mould
11b. GK. F 402. rubber cast of Fig. 11a
12. GK. F 403, lateral view
13. GK. F 404, lateral view
14. GK. F 405, a fragmentary body whorl
15. GK. F 406, lateral view
16. GK. F 407, lateral view
17. GK. F 408, a fragmentary body whorl, with ventral part of *Arnioceltites* cf. *arietitiformis* (MOJSISOVICS)
18. GK. F 409, a fragmentary body whorl
19. GK. F 410, a fragmentary body whorl
20a. GK. F 411, lateral view of external mould
20b. GK. F 412, rubber cast of Fig. 20a
21. GK. F 413, a fragmentary body whorl, with whitening
22. GK. F 414, ventral view

Figs. 23a–b. *Thisbites* sp. A ..... Page 217
23a. GK. F 457, lateral view of external mould
23b. GK. F 458, rubber cast of Fig. 23a

(Figures natural size except as indicated)

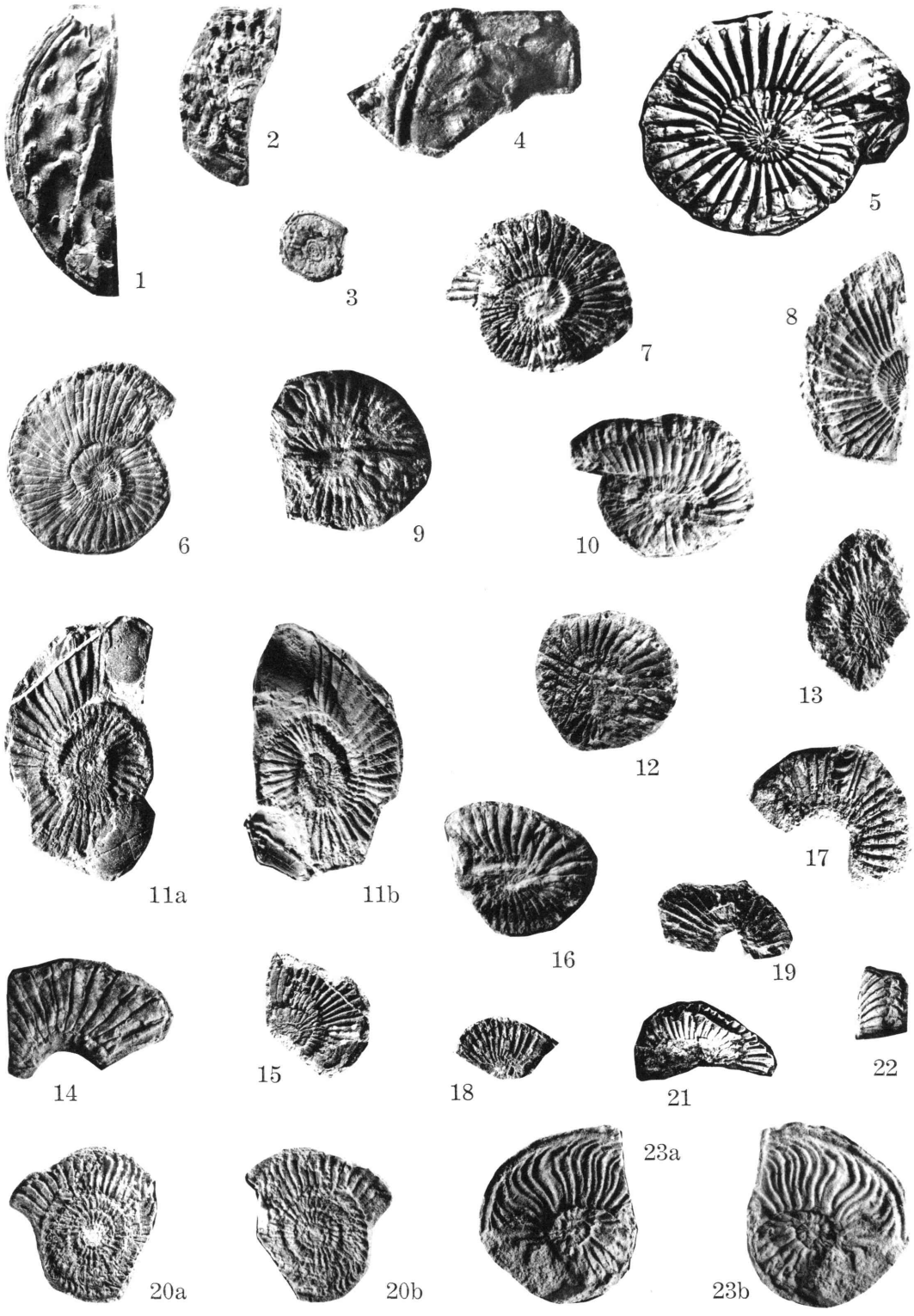

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Plate 28

Explanation of Plate 28

Figs. 1–6. *Arietoceltites arietitoides* (DIENER) ..... Page 209

1. GK. F 415, lateral view with whitening
2. GK. F 416, lateral and ventral view
3. GK. F 417, a fragmentary body whorl
4. GK. F 418, lateral view
5. GK. F 419, a fragmentary body whorl
6. GK. F 420, lateral view

Figs. 7–10. *Arnioceltites* sp. cf. *A. arietitiformis* (MOJSISOVICS) ..... Page 210

7. GK. F 421, lateral view
8. GK. F 422, lateral view
9. GK. F 423, a fragmentary body whorl
10. GK. F 424, ventral view, × 2

Figs. 11–13. *Jovites* sp. cf. *J. dacus* (MOJSISOVICS) ..... Page 212

11. GK. F 425, lateral view
12. GK. F 426, lateral view
13. GK. F 427, ventral view

Figs. 14–16. *Juvavites* sp. cf. *J.* (*Juvavites*) *kellyi* SMITH ..... Page 213

14. GK. F 428, lateral view
15. GK. F 429, lateral and ventral view
16. GK. F 434, lateral view

(Figures natural size except as indicated)

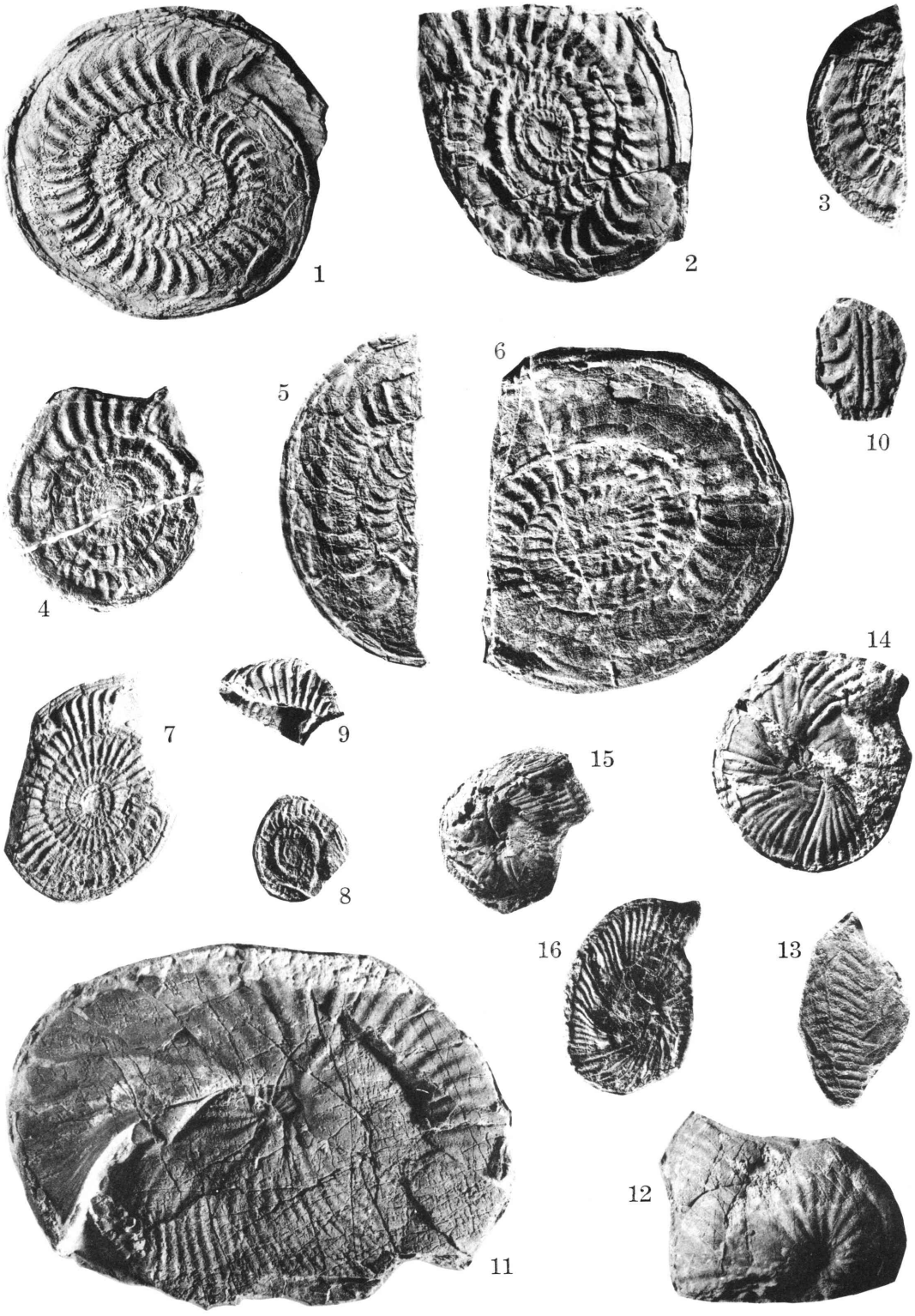

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Plate 29

Explanation of Plate 29

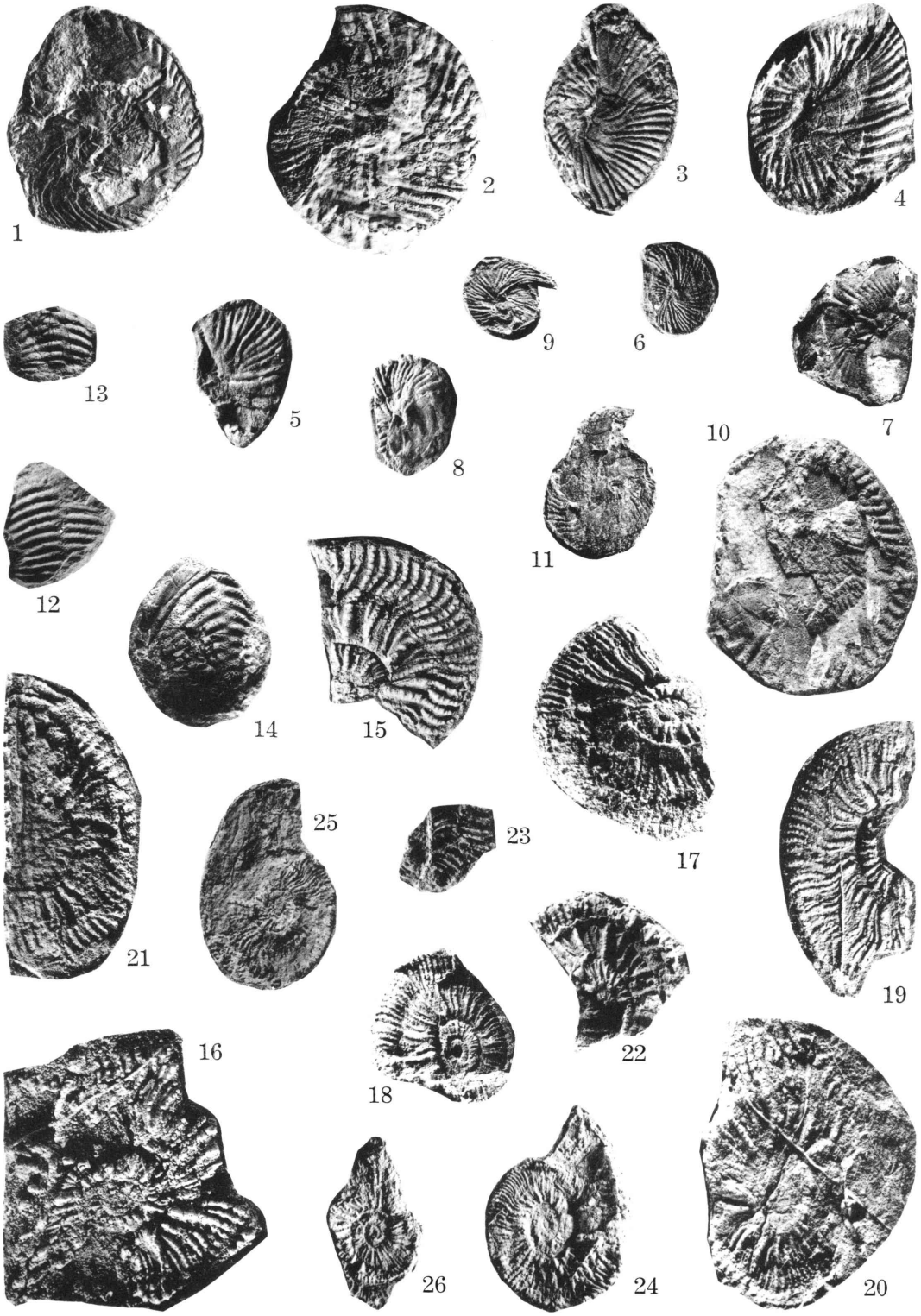
Figs. 1–14. *Juvavites* sp. cf. *J.* (*Juvavites*) *kellyi* SMITH.....Page 213

1. GK. F 430, lateral view
2. GK. F 431, lateral view
3. GK. F 432, lateral view
4. GK. F 433, lateral view
5. GK. F 435, lateral view
6. GK. F 436, lateral view
7. GK. F 437, lateral view
8. GK. F 438, lateral view
9. GK. F 439, lateral view
10. GK. F 440, lateral view
11. GK. F 441, lateral view
12. GK. F 442, ventral view (rubber cast)
13. GK. F 443, ventral view
14. GK. F 444, ventral view, × 2

Figs. 15–26. *Sirenites* sp. cf. *S. nanseni* TOZER.....Page 216

15. GK. F 445, lateral view with whitening, × 2
16. GK. F 446, lateral view, × 3
17. GK. F 447, lateral view, × 2
18. GK. F 448, lateral view with whitening, × 2
19. GK. F 449, a fragmentary body whorl with whitening, × 2
20. GK. F 450, lateral view, × 2
21. GK. F 451, a fragmentary body whorl, × 2
22. GK. F 452, lateral view with whitening, × 2
23. GK. F 453, a fragmentary ventral part, × 2
24. GK. F 454, lateral view
25. GK. F 455, lateral view
26. GK. F 456, lateral view, × 2

(Figures natural size except as indicated)



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