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The Triassic Stratigraphy and Ammonite Fauna of Japan

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CONTENTS

Introduction 2
Acknowledgements 3
General View of the Japanese Triassic 3
Regional Geology and Stratigraphy of the Triassic 4
1. Triassic of the Kitakami Massif 4
(1) Distribution 4
(2) Historical 4
(3) Subdivision of the Triassic System 5
(1) The Lower Triassic 5
(A) Hiraiso Formation 5
(B) Osawa Formation 7
(2) The Middle Triassic 7
(A) Fukkoshi Formation 7
(B) Isatomae Formation 7
(C) Rifu Formation 10
(3) The Upper Triassic Saragai Group 10
(A) Shindate Formation 12
(B) Chonomori Formation 12
2. Triassic System in the Kwanto Massif 14
(1) The Lower Triassic System 14
(A) Iwai Formation 15
(B) Shionosawa Formation 15
(2) The Upper Triassic 15
3. Upper Triassic System in the Gifu Province 16
4. The Triassic System in the Maizuru Zone 16
(1) The Lower and Middle Triassic 17
(2) The Upper Triassic System 18
(A) The Arakura Formation 18
(B) The Nabae Group 18
(C) The Shidaka Group 18
(D) The Nariwa Group 19
5. Triassic in Shikoku 21
(1) The Lower Triassic 21
(A) Kurotaki Formation 21
(B) Taho Formation 22
(2) The Middle Triassic Zohoin Formation 22
(A) The Nakagawa Province 22
(a) The Kumagatani area 22
(b) The Usugatani area 23
(c) The Kito area 24
(B) The Zohoin area 24
(3) The Upper Triassic Kochigatani Group 27
(A) The Nakagawa area 27
(B) The Sampozan area 29
(C) The Sakawa Basin and its environs 30

(D) The Itadoriagawa area ... 31
(E) The Nomura Basin ... 32
6. Triassic System of Kyushu ... 33
(1) The Lower Triassic ... 33
(2) The Upper Triassic ... 33
(A) The Gokase area ... 33
(B) The Miyamadani area ... 34
(C) The Matsukuma area ... 34
(D) The Tanoura area ... 34
(E) The Takagochi area ... 34
7. Triassic in Yamaguchi Prefecture ... 35
(1) The Middle Triassic System in the Atsu area ... 35
(2) The Upper Triassic Mine Group ... 35
(A) The Asa area ... 36
(B) The Atsu area ... 36
(C) The Omine area ... 36
(D) The Mukaihata area ... 37
Permo-Triassic Boundary ... 37
Triassic-Jurassic Boundary ... 44
The Sedimentary Environment and Tectonic History of the Triassic System ... 47
General View of the Lower Triassic Ammonites of Japan ... 51
(1) *Glyptophiceras* zone. ... 52
(2) *Owenites* and *Aspenites* zone. ... 53
(3) *Anasibirites* zone. ... 54
(4) *Subcolumbites* zone. ... 56
The Middle Triassic Ammonites ... 57
(1) The Anisian Ammonites ... 57
(2) The Ladinian Ammonites ... 59
General View of the Upper Triassic Ammonites ... 63
Correlation of the Triassic of Japan ... 64
(A) Lower Triassic Correlation ... 64
(B) Middle Triassic Correlation ... 66
(C) Upper Triassic Correlation ... 67
Summary ... 68
Systematic Paleontology ... 69
References ... 124

ABSTRACT

The Triassic ammonites of Japan are known from the southern Kitakami Massif, the Kwanto Massif, the Maizuru Zone, and the Islands of Shikoku and Kyushu. Based upon them a biostratigraphical correlation of the Japanese Triassic is attempted.

The four ammonite zones recognized in the Lower Triassic and the Middle Triassic are correlative with the standard ammonite zones of the world, whereas the Upper Triassic ammonite fauna is insufficiently known for such purpose.

Besides descriptions and discussions on the Triassic stratigraphy and paleontology, remarks are given on the sedimentary environment and tectonic history of the Japanese Triassic Epoch.

Introduction

Since the first contribution on the ammonite fauna by Mojsisovics (1888), our knowledge on the Japanese Triassic ammonites have progressed through the works of Yabe (1903–18), Diener (1916), Yehara (1925–27), Yabe and Shimizu (1927–33), Shimizu (1930–32), Shimizu and Jimbo (1933).

The recent works by Sakagami (1955), Kummel and Sakagami (1960) in the Kwanto Massif, by Nakazawa and Shimizu (1955), Nakazawa, Shiki, Shimizu and Nogami (1954–58) in the Maizuru zone, and by Kambe (1960) in Kyushu Island have furnished new evidences on the Triassic ammonites of Japan. Although biostratigraphical correlation of the Lower and Middle Triassic can be undertaken on an intercontinental scale, the Upper Triassic is rather poor in ammonites because of the good development of nonmarine or near shore sediments.

The lithology of the Middle and Upper Triassic formations show remarkable similarity with one another in all of their localities, but the Lower and early Upper Triassic seems to be different regionally. It is considered that the homogeneity of the lithology of the Middle Triassic sediments may suggest a stable condition in the sedimentary environment and a later stage of the geosyncline.

The purpose of the present study is to clarify the biostratigraphy based upon the Japanese Triassic ammonites, to attempt correlation of the Triassic formations, and to analyse the sedimentary environment and tectonic history of the Triassic System of Japan.

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General View of the Japanese Triassic

The Triassic sediments of Japan are distributed (Table 1) in various districts excepting Hokkaido, but their occurrence in each district is restricted. Notwithstanding the restricted distribution the chronological sequence ranges from the Lower to the Upper Triassic, but the Rhaetian Stage has not been confirmed in any district.

The Triassic System in the Kitakami Massif has the widest distribution and shows a normal order in the Lower and Middle Triassic. However in the outer zone of Southwest Japan (Shikoku and Kyushu), the Triassic sequence is fragmental because of the complicated geologic structure, and mainly recognized are the upper part of the Middle Triassic and the

Upper Triassic formations. The Lower Triassic limestones are found as small lenticular bodies at only three outcrops of Kurotaki, Tao (Taho) and Kamura in the outer zone of Shikoku and Kyushu. In the inner zone of Southwest Japan, the Lower and Middle Triassic were recently discovered in the Maizuru zone. In Central Japan, the Lower and Upper Triassic rocks were recognized in the Kwanto Massif, but the Middle Triassic has not yet been discovered. No Triassic sediments are known from Hokkaido.

The Lower and Middle Triassic formations have yielded many characteristic ammonoids and marine pelecypods. Ammonities from the Upper Triassic formation are rare in Japan.

In general, the Triassic deposits of Japan can be divided into two facies of which the lower section is represented by the Lower and Middle Triassic formations, and the upper by the Upper Triassic. The first mentioned facies is composed of considerably thick, fine-grained sediments, i.e. black slate, sandy siltstone and argillaceous limestone, whereas the latter is characterized by coarse grained clastic rocks. The boundary between the two facies is drawn between the Ladinian and the Karnian, and this remarkable contrast of sediments is thought to be the reflection of orogenic movements, the so-called Akiyoshi orogeny, between the Middle and Upper Triassic. There is a remarkable difference in the distribution of the Lower and Middle Triassic sediments and the Upper Triassic deposits, and an unconformity is presumed between them.

The boundary between the Lower Triassic and the Upper Permian is an erosional and structural unconformity at several outcrops. The boundary between the Upper Triassic and the Lower Jnrassic is a distinct unconformity.

Subdivision of the Triassic has been made in the Kitakami Massif, the Kwanto Massif, the Chichibu Terrain of Shikoku and Kyushu, and in the Chugoku region (Table 1).

Regional Geology and Stratigraphy of the Triassic

1 Triassic of the Kitakami Massif

(1) **Distribution.** The Triassic strata surrounded by Upper Permian rocks crop out in a considerable wide area and form a broad synclinal basin structure of SSW to NNE trend with the axis plunging toward the south. The major part of these Triassic outcrops comprise the Inai Group of the Lower and Middle Triassic, and the remaining of the Upper Triassic Saragai Group. In the northeast of Sendai, there is the well known Middle Triassic Rifu Formation which has yielded abundant ammonoid fossils.

(2) **Historical.** The first work on the Triassic is by Naumann (1880) who pointed out that the ammonite beds which yielded *Perisphinctes athleta* belongs to the upper part of the "Hallstätter Schichten" and to the "Oberen alpinen Trias". Subsequently Mojsisovics (1888) described many Triassic ammonites from the Middle Triassic at Inai and Ogachi, and claimed the Fassanic age (lower Ladinian). Kikuchi (1891) reported on the geology of the Ishinomaki and Ichinoseki areas, north of Sendai, but the Mesozoic strata were not divided. Subsequently, K. Jimbo (1887) recognized that the Ceratite beds in the Kitakami Massif is covered by the *Monotis* Beds and succeeded by the Jurassic *Trigonia* Beds. Later Iki (1897), Otsuki (1901) and Kawasaki and Hachiya (1901) studied the geology of the Ogachi, Inai and Yanaizu districts. The latter author collected ammonites like *Monophyllites* at Iizuchi near Yanaizu, about 20 km north of Ishinomaki City (Hachiya, 1901, p. 202). Yabe (1900, p. 239) recorded "*Cladiscites*" and considered it to be ancestral to *Hyapocladiscites*, but later it was referred to *Sturia* aff. *sansovinii* Mojsisovics. Yabe (1903, p. 117) suggested the Anisian or Muschelkalk in the southern Kitakami Massif from the fauna described by Mojsisovics and he recognized *Monophyllites sphaerophyllus* Hauer in the collection of Hachiya. Diener (1916) described some am-

monites from Inai and *Monotis* and *Daonella*, from the Saragai, Nariwa and the Sakawa districts. In this paper Diener pointed out that the fauna from Inai is comparable with the Anisian fauna from the Himalayan Muschelkalk as already noticed by Yabe (Diener, p. 24). Yabe (1918) summarized the Triassic of Japan and placed the Inai Ceratite Beds in the Anisian, the *Daonella* Beds in the Ladinian, and the Saragai *Monotis* Beds in the Norian. Yabe suggested that the beds below the Ceratite Beds probably belong to the Lower Triassic Scythian age and named it the Ceratitite Beds. The Lower Triassic was confirmed by Kurosawa (1929) and Mabuti (1932) who discovered "*Pecten*" *ussuricus* (Bittner), "*P.*" *sichoticus* (Bitt.), "*P.* cf. *discites* (Schlotheim), *P. alberti virgalensis* (Wittenburg) etc. from Tate near Isatomae in the southern Kitakami Massif. Subsequently, many ammonites were described by Yabe and Shimizu (1927) and Shimizu (1930) from the Rifu *Daonella* Beds. In this report which is the first description of the Ladinian ammonite fauna of Japan, they called the Ceratite Beds of the Kitakami Massif as the *Hollandites* Beds, Shimizu (1930) revised the species which were described by Mojsisovics (1888) and Diener (1916), and added some new forms. According to Yabe and Shimizu (1933) the *Daonella* Beds should be included into the Inai Series.

Concerning the regional geology and stratigraphy of the Triassic formations in the Kitakami Massif, Oyama (1938), Shiida (1939), Inai (1939), Nagai (1940), Ichikawa (1948, Yasuda (1951), Handa (1953), Bando (1956), Mito (1957), Otomo (1957), Takahashi (1959) and Shikoda (1958) have contributed. Shimizu and Mabuti (1932) named the *Monotis* Beds of the Sargai area the Saragai Formation and described *Dictyoconites nipponicus*, *Placites* aff. *oxyphyllus* Mojsisovics and *Arcestes* aff. *origosarcus* Mojs. from its lower part and stated the age to be Karnian. Ichikawa (1951), Hanzawa (1954) and Onuki (1956) summarized the Triassic of the Kitakami Massif and Ichikawa subdivided it into: Hiraiso, Osawa Fukkoshi, and Inai Formations and the Saragai Group in ascending order, and included them into the Inai Group. Onuki and the writer (1958–59) reported on the Triassic System in the Kitakami Massif and described some ammonite fossils. Recently the writer described *Atractites hataii* from the Ladinian Rifu Formation (1963).

(3) **Subdivision of the Triassic System.** The succession of the Triassic System in the Kitakami Massif is as follows:–

	Jurassic	
	Unconformity or Fault	
Saragai Group	Chonomori Formation	Karno-Norian
	Shindate Formation	Karnian
	Unconformity ?	
Inai Group	Rifu Formation	Ansio-Ladinian
	Isatomae Formation	Anisian
	Fukkoshi Formation	Anisian
	Osawa Formation	Scythian
	Hiraiso Formation	Scythian
	Unconformity	
	Upper Permian (Toyoma Formation)	

Among these, the lower part of the Rifu Formation grades into the Isatomae Formation in the Rifu area.

(1) The Lower Triassic

(A) Hiraiso Formation (Ichikawa, 1946). Type locality: Hiraiso, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture.

This formation consists of conglomerate, calcareous greenish blue sandstone and siltstone; disconformable the with the upper Permian Toyoma Formation. The basal conglomerate is 30 cm to 30 m in thickness. The conglomerate consists of pebbles of granodiorite, quartz-diorite, tuff, limestone, siliceous porphyrite, chert, sandstone, aplite, glassy andesite, hornfels, hornblende prophyrite, hornblende andesite and basalt. Kano (1958) states that the pebbles are of granitic rocks i.e. biotite adamelite, biotite adamelite aplite, biotite granite aplite, granophyre, granophyric hornblende biotite trondhjemite, quartz bearing biotite hornblende micro-gabbro, biotite granodiorite or trondhjemite porphyry, biotite dacite, biotite plagiorhyolite, hornblende quartz monzonite, biotite trondhjemite etc. Thin beds of reddish sandy tuff and light greenish brecciate tuff occur at the basal part of this formation at Iriya, about 2 km east of Toyoma-cho, Taira, at about 3.5 km south of Yanaizu, and Funakoshi, 2 km west of Iinogawa, and their thickness is approximately 50 m to 0 m (Onuki and Bando, 1958, p. 256; 1959, p. 50).

Table 2. List of fossils from the Hiraiso Formation of the Inai Group

Specific name \ Locality number	1	2	3	4	5
"*Pecten*" *ussuricus* (Bittner)			×	×	
"*P.*" cf. *ussuricus* (Bittner)	×				
"*P.*" *ussuricus sichoticus* (Bittner)				×	
"*P.*" aff. *ussuricus sichoticus* (Bittner)	×				
"*P.*" cf. *alberti* (Goldfuss)	×				
"*P.*" *alberti virgalensis* (Witt.)	×				
"*P.*" cf. *minimus* (Kiparisova)	×				
Entolium discites (Schloth.)	×				
E. cf. *discites* (Schloth.)				×	
E. discites microtis (Bittner)	×				
Eumorphotis iwanowi (Bittner)	×				
E. sp.	×				
Myophoria aff. *ovata* (Goldfuss)	×				
M. aff. *laevigata* Albert.	×				
M. sp.	×				
Anodontophora aff. *fassaensis* Wissmann	×				
A. cf. *ovalis* Wissmann	×				
A. sp.	×				
Gervilleia ct. *exporrecta* (Lepsius)	×	×			
G. sp.	×				
Nuculopsis (*Palaeonucula*) spp.	×				
Palaeoneilo sp.	×				
Pleurophorus sp.	×				×
Dentalium sp.	×				
Wortheia ? sp.	×				
"*Schizodus*" sp.		×			
"*Cardium*" sp.		×			
Avicula sp.				×	
Myalina sp.				×	×
Nuculopsis sp.					×

1. Hiraiso 2. Nagasakiyama 3. Sakai 4. Tate 5. Toyoma-cho

The light greenish calcareous sandstone with arenaceous limestone layers above the basal conglomerate yielded many lower Triassic pelecypods (Table 2), but ammonoids are very rare. The upper part of this formation forms a thin alternation of calcareous light blue sandstone and dark grey fine sandstone, and grades upwards into the calcareous siltstone of the Osawa Formation. The boundary was drawn at the upper limit of the sandstone. In the Onagawa and Ogachi areas the Kojima Formation has been used for the basal conglomerate and sandstone of the Lower Triassic by many authors (Oyama, 1938 Inai and Oyama, 1940; Yasuda, 1951; Hanzawa, 1954; Otomo, 1957), but it is a synonym of the Hiraiso Formation. Cross-bedding or minor convolute structures are observed in the sandstone layers.

(B) Osawa Formation (Ichikawa, 1946). Type locality: Osawa, Motoyoshicho, Motoyoshi-gun, Miyagi Prefecture.

This formation consists of a banded alternation of well bedded calcareous fine sandstone and siltstone. The upper part of this formation consists of laminated dark blue calcareous slate; upper Scythian ammonites in the upper part. This formation is conformable with the subjacent Hiraiso Formation and is covered by the Fukkoshi Formation. The formation is about 180 m to 350 m in thickness. This formation yielded: *Eumorphotis* aff. *telleri* (Bittner), *Posidonia* sp., *Palaeonucula* ? sp., *Eumorphotis* sp., "*E.*" cf. *martini* Kiparisova, "*Pecten*" *amusicus* (Bittner), *Deltopecten* ? sp., *Bellerophon* sp., *Equisetites* sp., "*Pecten*" sp., *Subcolumbites* cf. *perrini-smithi* Arthaber, "*Ophiceras*" ? spp.

Among them, "*Ophiceras*"? spp. were collected by Oyama (1938) and Ichikawa (1951) from Funato in Ogachi-cho, and Ichikawa (1951) recorded "*Ophiceras*" sp., "*Xenodiscus*" spp. and Prohungaritoid and Pseudoharpoceroid ammonites from the uppermost horizon of this formation. The species of *Subcolumbites* is important to decide the age of the upper limit of this formation. It occured from the uppermost horizon of this formation at Tate near Isatomae, Utatsu-cho.

(2) The Middle Triassic

(A) Fukkoshi Formation (Ichikawa, 1946). Type locality: Fukkoshi, about 2 km east of Tsuya, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture.

The formation was first proposed by Ichikawa, but originally it included the beds H4 of the Hiraiso Formation of Shiida (1939). This formation consists of light greenish sandstone, banded sandy slate and conglomerate. In the lower part there is a thin alternation of sandstone and sandy slate, and some non-continuous layers of conglomerate in the sandstone. Intraformational slumping mudstone shreds also occur at the basal and upper parts of this formation, but not in the middle part in general.

The pebbles of the conglomerate mainly consist of chert, slate, quartz diorite, hornblende quartz diorite and hornblende porphyrite. This formation is about 600 m to 0 m in thickness (See Table 4). The boundary between the Lower Triassic Osawa Formation and this formation is a conformity. It is conformably underlain by the middle Triassic Isatomae Formation.

This formation yielded: *Spiriferina* sp. (cf. *S. fragilis* Schlotheim), *S.* sp. (cf. *S. stacheyi* Salter), *S.* sp., *Terebratula* sp., "*Pteria*" sp., *Isocrinus* sp. (Ichikawa, 1951); *Balatonites* cf. *kitakamicus* (Diener), *Gymnites watanabei* (Moijsisovics) and *Hollandites* spp. (Shimizu, 1930); *Rikuzenites nobilis* Yabe (Yabe, 1949).

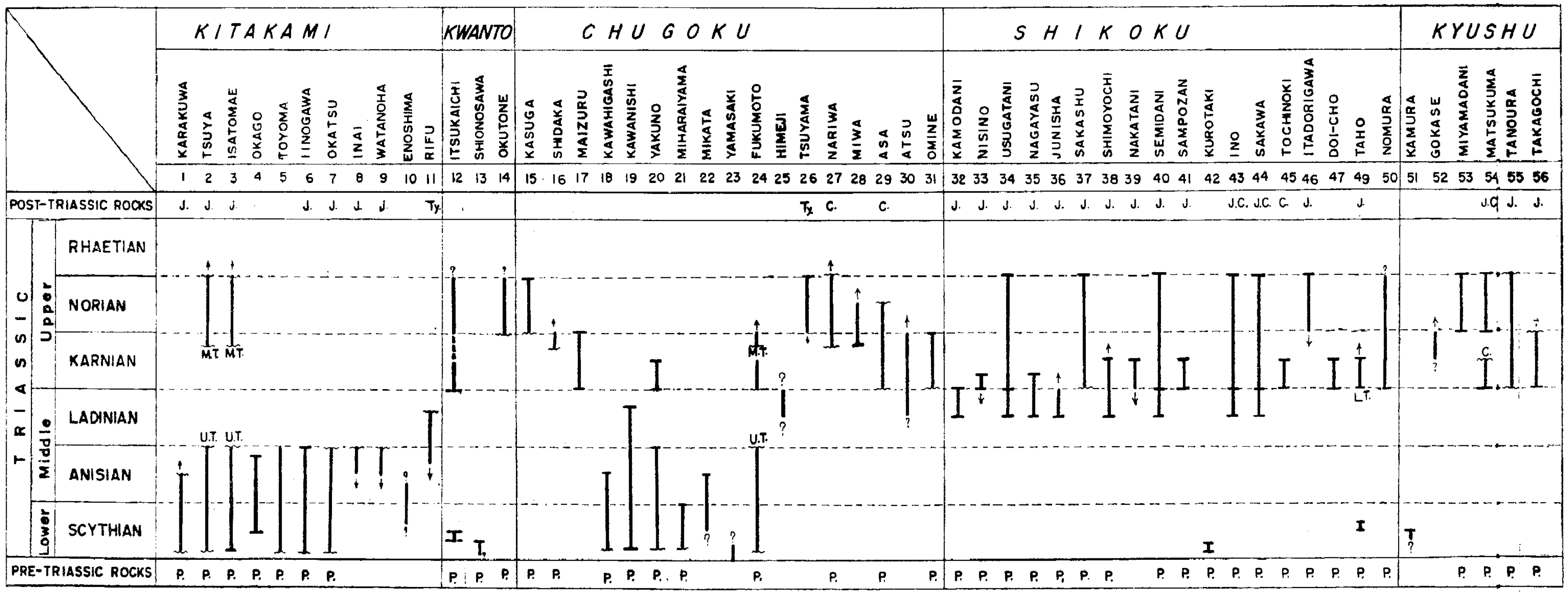
(B) Isatomae Formation (Onuki, 1956). Type locality: Isatomae, Utazucho, Motoyoshi-gun, Miyagi Prefecture.

This formation name was proposed by Kurosawa (1929) and used by Mabuti (1932), but no precise definition had been given to it. Later Onuki (1956) defined this formation, and the present author follows him.

The formation, about 500–1600 m in thickness, consists of well banded calcareous slate and dark blue siltstone, sometimes intercalated with massive greywacke sandstone. The laminae of very fine sandstone or siltstone in the slate distinguish it from the black shale of the Osawa Formation.

This formation rests with conformity upon the Fukkoshi Formation and its upper part is covered by the upper Triassic Saragai or by the Jurassic formations with un-

Table I. DEVELOPMENT AND DISTRIBUTION OF THE TRIASSIC SYSTEM IN THE JAPANESE ISLANDS SHOWING CHRONOLOGIC RANGES AND STRATIGRAPHIC RELATIONSHIP WITH SUPERJACENT AND SUBJACENT CHRONOLOGIC UNITS



P. : Permian
J. : Jurassic
C. : Cretaceous
Ty. : Tertiary
L.T. : Lower Triassic
M.T. : Middle Triassic
U.T. : Upper Triassic
〰 : Unconformity
— : Fault
-- : Infered fault

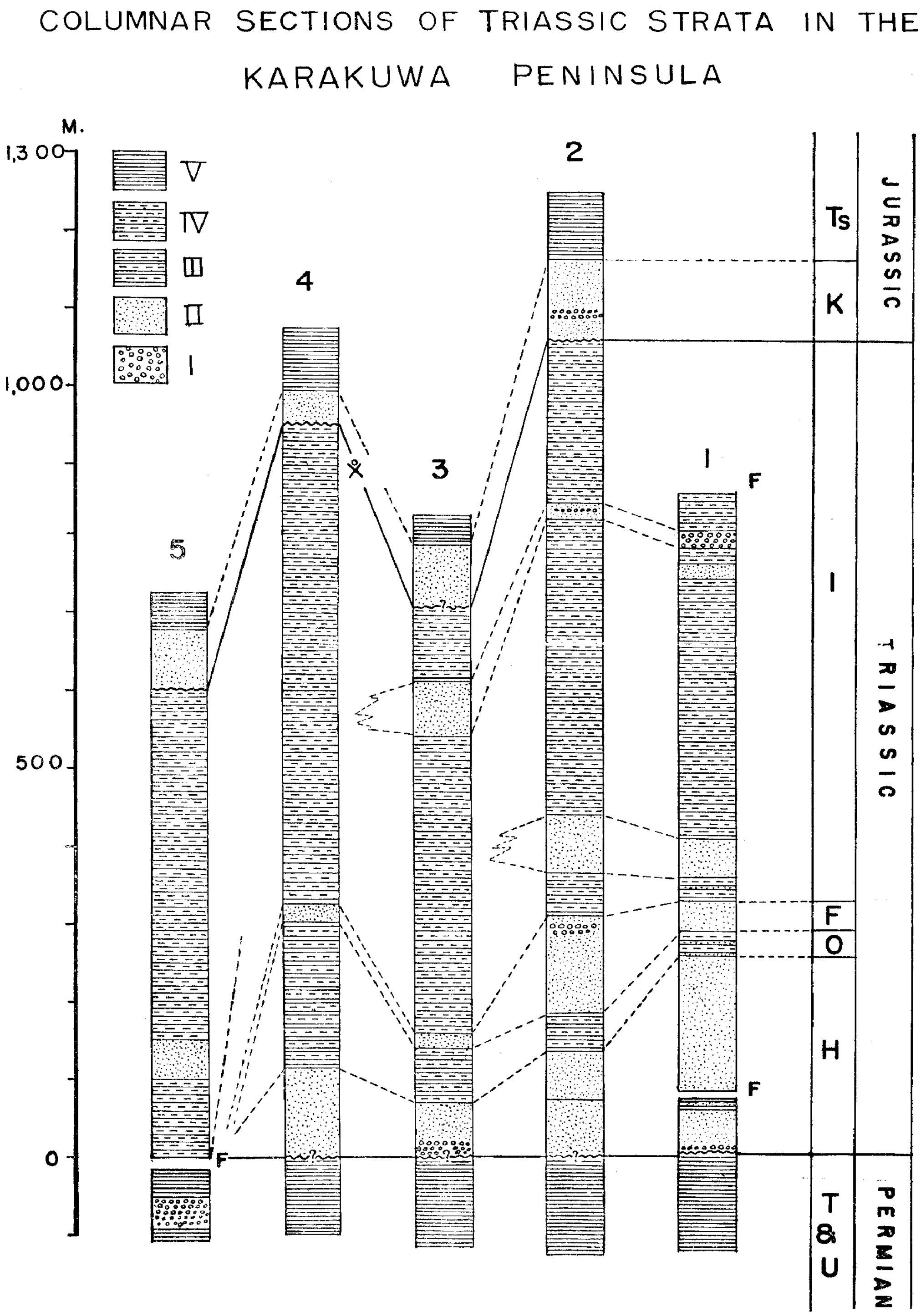


Fig. 4. Columnar sections of the Triassic strata in the Karakuwa Peninsula, southern Kitakami Massif.

T:	Toyoma Formation	U:	Usuginu Conglomerate
H:	Hiraiso Formation	O:	Osawa Formation
F:	Fukkoshi Formation	I:	Isatomae Formation
K:	Kosaba Formation	Ts:	Tsunakizaka Formation
I:	Conglomerate	II:	Sandstone
III:	Alternation of calcareous black shale and sandy shale		
IV:	Calcareous banded shale	V:	Black shale

conformity. The Ladinian and the lower Karnian sediments are missing between the Anisian Isatomae Formation below and the Karno-Norian Saragai Group above. In the Kitakami Massif this formation has the widest distribution among the Triassic units and yielded characteristic Anisian ammonites.

The ammonites from this formation were studied by Mojsisovics, Yabe, Diener, Shimizu, and recently by Onuki and Bando (1959). The fossils from this formation are listed by Onuki and Bando (1959, Table 4). This formation was first correlated with the Ladinian Fassanic age by Mojsisovics (1888), but later Yabe (1903) and Diener (1916) referred it to the Anisian. The ammonites fauna of this formation is comparable with those of the Alps, Himalaya, Timor, Malaya, Indochina, Thailand, New Zealand, North America, Northern Alaska and Eastern Siberia.

(C) Rifu Formation (Ichikawa, 1949). Type locality:Rifu, Matsushima-cho, Miyagi-gun, Miyagi Prefecture.

Yabe (1918) first recorded *Daonella* from the Rifu area and proposed the name of *Daonella* Beds. Subsequently Yabe and Shimizu (1927) described many fossils from this beds, and later Shimizu (1931) added some ammonites from the same formation. Yabe (1918), and Yabe and Shimizu (1933) considered the *Daonella* Beds of the Rifu area to rest upon the *Hollandites* Beds (Isatomae Formation) of the Inai area with conformity and they placed it in the Ladinian. The formation name was first proposed by Ichikawa (1949) and its type locality is the vicinity of Rifu, about 15 km northeast of Sendai.

The formation, about 500 m in thickness, consists of dark gray, fine-grained sandstone and siltstone in the upper part, and of fine-grained sandstone with laminae in the lower. The general rock facies resembles the Isatomae Formation, especially the lower part. The middle part of this formation consists of a thin alternation of gray blue sandstone and black sandy shale.

The boundary between this formation and the Isatomae Formation is not exposed, but it is considered to be below the part which yielded *Paraceratites* cf. *trinodosus* (Mojsisovics). The upper part of this formation yielded many Ladinian ammonites, i.e., *Protrachyceras reitzi* (Boeckh), *Monophyllites wengensis* (Klipstein), "*Ptychites*" *compressus* Yabe and Shimizu, *Japonites* cf. *dieneri* (Martelli), *Anagymnites* aff. *acutus* Hauer, etc., and other fossils as *Daonella kotoi multistriata* Yabe and Shimizu, *D. densisulcata* Y. and S., etc. The fossils from this formation are listed in Table 3. The upper part of this formation is covered by the Tertiary System with unconformity.

Yabe and Shimizu (1927) once divided this formation as follows:

Daonella Beds { Upper Division or Upper *Daonella* Beds
Lower Division or Lower *Daonella* Beds
Monophyllites wengensis Zone or *Monophyllites* Zone
Ptychites compressus Zone or *Ptychites* Zone

Recently Onuki and Bando (1959) subdivided it into three members and recognized four fossil zones as follows:

Ladinian	Upper member	(d) *Daonella kotoi multistriata* Zone
		(c) *Monophyllites wengensis* Zone
		(b) *Protrachyceras reitzi* Zone
Anisian	Middle member	(a) *Paraceratites trinodosus* Zone
	Lower member....	Unknown fossil beds

The faunal analysis and chronological significance are discussed later.

(3) The Upper Triassic Saragai Group

The Upper Triassic Saragai Group occurs in a small area of the synclinal basin of the Inai Group and rests unconformably upon it, and is unconformably overlain by the Jurassic

Table 3. Synonymic list of the lower Triassic ammonites from the Taho Formation

Yehara (1927)	Shimizu and Jimbo (1933)	Bando (1963)
Meekoceras cf. *lingtiense* Krafft and Diener	*Meekoceras japonicum* Shimizu and Jimbo	*Meekoceras japonicum* Shimizu and Jimbo
	Meekoceras japonicum tenui Shimizu and Jimbo (MS)	*Meekoceras japonicum compressum* Bando
Meekoceras kuharanum Yehara *Kymatites* cf. *typus* Waagen	*Meekoceras kuharanum* Yehara	*Hemiprionites kuharanus* (Yehara)
Meekoceras morianum Yehara	*Meekoceras morianum* Yehara	*Hemiprionites morianus* (Yehara)
Meekoceras morianum Yehara	*Meekoceras shikokuense* Shimizu and Jimbo	*Hemiprionites shikokuensis* (Shimizu and Jimbo)
Meekoceras cf. *markhami* Diener	*Meekoceras orientale* Shimizu and Jimbo	*Meekoceras orientale* Shimizu and Jimbo
Meekoceras katoi Yehara	*Meekoceras katoi* Yehara	*Hemiprionites katoi* (Yehara)
Meekoceras cf. *boreale* Diener	*Meekoceras japonicum* Shimizu and Jimbo *Meekoceras orientale* Shimizu and Jimbo	*Meekoceras japonicum* Shimizu and Jimbo *Meekoceras orientale* Shimizu and Jimbo
Meekoceras sawatanum Yehara	*Meekoceras sawatanum* Yehara	*Hemiprionites sawatanus* (Yehara)
Ophiceras tahoense Yehara *Flemingites* sp.	*Meekoceras tahoense* (Yehara)	*Hemiprionites tahoensis* (Yehara)
Ophiceras multiplicatum Yehara *Sibirites* sp.	*Anasibirites multiplicatus* (Yehara)	*Anasibirites multiplcatus* (Yehara)
Meekoceras onoi Yehara *Meekoceras akamatsui* Yehara	*Anasibirites onoi* (Yehara)	*Anasibirites onoi* (Yehara)
Xenodiscus pacificus Yehara *Xenodiscus* sp.	*Anasibirites pacificus* (Yehara)	*Anasibirites pacificus* (Yehara)
Xenodiscus kotoi Yehara	*Anasibirites pacificus kotoi* (Yehara)	*Anasibirites pacificus kotoi* (Yehara)
Xenaspis cf. *marcoui* Hyatt and Smith	*Wyomingites* sp. nov. aff. *aplanatus* (White)	*Wyomingites* cf. *aplanatus* (Yehara)
	Meekoceras kuharanum compressum Shimizu and Jimbo (MS)	*Hemiprionites kuharanus iyonus* Bando
	Meekoceras obscurum Shimizu and Jimbo (MS)	*Anasibirites archiperipheras* Bando

sediments. Their distributions are in the Saragaizaka and Chonomori-Atagoyama areas of Motoyoshi-gun, Miyagi Prefecture.

The Saragai Group is subdivided into the Shindate Formation below and the Chonomori Formation above, together amounting to 500–600 m in thickness.

(A) Shindate Formation (Onuki and Bando, 1958). Type locality: Shindate, Matsuiwa-cho, Kesennuma City, Miyagi Prefecture.

This formation consists of massive, light greenish arkose sandstone below the *Monotis* bearing Chonomori Formation. At the basal part there is a thin conglomeratic sandstone with intercalated sandstone, slate and chert pebbles. Thin mudstone layers occur in the middle to upper parts, and in the upper part there are some cross-bedding structures, and two layers of thin coaly shale intercalated in the mudstone layers. The thickness of this formation is 60 m to 300 m in the Saragaizaka area and 250 m to 300 m in the Chonomori-Atagoyama area. In the latter area the conglomeratic sandstone at the basal part of this formation contains small pebbles of sandstone, slate, chert and andesitic rocks. No fossils have been found from this formation, thus the age cannot be decided precisely.

(B) Chonomori Formation (Shiida, 1939). Type locality: Chonomori, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture.

The Chonomori Formation is composed of an alternation of black sandy shale, thin banded shale, and micaceous argillaceous sandstone. The *Monotis* beds can be subdivided into four fossil zones from Cl to C4 in ascending order by the evolutional characters of the *Monotis* shell sculpture (Onuki and Bando, 1958, table 2 and 3).

Naumann (1881) was the first to describe *Monotis salinaria*, *M. salinaria richmondiana* from this formation at Saragaizaka. His discovery of *Monotis* was also the first find of the Triassic System in Japan. Subsequently Diener (1916) described *Monotis ochotica densistriata* from this formation. Later Kurosawa (1929, MS) studied the stratigraphy of the *Monotis* bearing beds at Saragaizaka and discovered new types of *Monotis* which correspond to *M. kurosawai* Sakaguti, *M. zabaikalica* Kiparisova and *M. calvata* Marwick. Shimizu and Mabuti (1932) discovered *Placites* aff. *oxyphyllus* Mojs., *Arcestes* aff. *oligosurcus* Mojs., and *Dictyoconites nipponicus* Shimizu and Mabuti, from the lower part of this formation at Saragaizaka (Shimizu and Mabuti, 1940–41).

Shimizu and Mabuti subdivided this formation into five fossil zones, namely *Dictyoconites* zone, *Placites* zone, *Monotis densistriata* zone, *M. pachypleura* zone and *M.* n. sp. zone. The last named fossil zone corresponds to the *Monotis zabaikalica* zone of present usage. Subsequently Yabe and Shimizu (1933, p. 89) refered the sandstone with *Dictyoconites* to Karnian age, and considered the age of this formation to be Karno-Norian. Sakaguti (1939) described *M. kurosawai* from the collection of Kurosawa, but this species is a synonym of *M. zabaikalica* which was described by Kiparisova (1936) from the Kolyma and Indigirka regions in Eastern Siberia, and *M. calvata* described by Marwick (1953) from New Zealand is comparable with the Siberian form. In New Zealand, Marwick (1953, p. 58) referred his species to the Otpairian (Rhaetian) and placed its horizon above that of the *M. richmondiana*, zone.

Ichikawa (1951, '54, '58) subdivided the Saragai Group into three beds; the upper, middle and lower, and recognized 7 fossil zones, namely Sl to S7. He included these fossil zones into the Norian Stage, but his zonal index fossil, *M. tenuissima*, has not been described. He placed it below the *Dictyoconites* zone (S2). Ichikawa recorded *Oxytoma* and *Tosapecten suzukii hirogariformis* Kobayashi and Ichikawa which are characteristic in the *Halobia-Tosapecten* Beds in the Sakawa Basin (Kobayashi and Ichikawa, 1951, p. 104).

Onuki and Bando (1958) discussed on the Karno-Norian boundary and drew it between the Cl (*M. scutiformis* zone) and C2 (*M. densistriata* zone) horizons.

The boundary between the Isatomae Formation and the base of the Shindate Forma-

Table. 4. List of fossils from the Rifu Formation Bando (1963)

Specific name	Yabe & Shimizu (1927) Shimizu* (1930)			Onuki & Bando (1959), Bando (1962)**, Bando (1963)***			
	Low.		Up.	L.	Upper		
	P	M		a	b	c	d
Monophyllites wengensis (Klipstein)***					×		
M. cf. *wengensis* (Klipstein)***	×	×	×	×	×	×	
M. sphaerophyllus (Hauer)				?			
M. ? sp. nov. indet.		×					
"*Ptychites*" *compressus* Yabe and Shimizu	×	×		×	×	×	
"*P*". *compressus hamadaensis* Onuki and Bando				×			
P. rifunus Yabe and Shimizu	×	×					
P. yabei Shimizu*		×					
P. aff. *cognatus* (Oppel)						×	
P. nipponicus Bando, n, sp.***					×		
P. miyagiensis Bando, n. sp.***					×		
P. sp. cf. *P. trocheaeformis* (Lindstroem)					×		
P. sp. A	×				×	×	
P. sp. B	?				×	×	
P. sp. C		×			×	×	
P. sp. D				×			
P. sp. E						×	
P. sp. F					×		
Flexoptychites matsushimaensis Bando, n. sp.***					×		
Beyrichites chitanii Yabe and Shimizu		×					
Arpakdites? sp. indet.	?						
Hollandites nipponicus (Shimizu)*		×					
Gymnotoceras paucicostatus (Yabe and Shimizu)	×						
Paraceratites cf. *trinodosus*(Mojsisovics)***	?			×			
P. aff. *trinodosus* (Mojs.)	?			×			
P. cf. *wardi* (Smith)		×					
P. orientalis (Yabe and Shimizu)***	×	×					
P. cf. *clarkei* Smith***					×		
P. cf. *trinodosus* (Mojs.)***				×			
Protrachyceras reitzi (Boeckh)***					×		
P. sp. A					×	×	
P. sp. B***					×		
Tropigastrites aff. *halli* (Mojsisovics)						×	
T. ? sp. indet.***						×	
Japonites cf. *ugra* (Diener)						×	
J. cf. *dieneri* (Martelli)***					×		
Epigymnites aff. *jollyanus* (Oppel)***					×		
Anagymnites aff. *acutus* Hauer***					×		
Kellnerites cf. *bosnensis* Hauer***				×			

Table 4. (Continued)

K. n. sp.***				×			
Danubites sp. indet.						×	
Nevadites ? angusticostatus Yabe and Shimizu		×					
Syringonautilus japonica Yabe and Shimizu		×					
Pleuronautilus (*Holconautilus*) *yabei* n. sp.					×	×	
Pleuronautilus ? sp.		×					
Atractites hataii Bando**						×	
Nautiloidea gen. et sp. indet.						×	
Daonella kotoi multistriata Yabe and Shimizu		×	×				×
D. densisulcata Yabe and Shimizu		×	×	×	×	×	
Myoconcha hamadaensis Yabe and Shimizu	×					×	
"*Pecten*" sp.	×						
Pedalion sp.	×						
Megalodosus sp.				?			
Nucula ? sp.						×	
Spiriferina kaneharai Yabe and Shimizu	×						
S. cf. *lilangensis* Stoliczka	×			×	×	×	

tion can not be observed, but the difference in the lithologic characters between them are remarkable. The assumed hiatus between them may correspond to the Ladinian to the lower Karnian stage of the Kitakami Massif, thus pointing to that there was a rather large tectonic movement. The "Utazu Movement" was proposed for it by Kobayashi (1948), who considered its movement to be prior to the Norian age. Onuki and Bando (1958) stated that the age of this movement is rather the upper Ladinian Stage than the Norian Stage, and they proposed for it the name "Matsuiwa Movement."

On the other hand, the boundary between the Saragai Group and the Jurassic rocks have been considered to be an unconformity, but the contact has not been found in this district. In the Saragaizaka area the lithologic character of the uppermost part of the Chonomori Formation (C4 zone *M. zabaikalica* zone) resembles those of the Niranohama Formation of the Lower Jurassic, both of which are composed of light gray arkose sandstone with black shale bands. Considering from their distribution and from that the zone of C4 horizon is missing near the presumed boundary, the Jurassic beds probably may be unconformable with the Saragai Group. In the Atagoyama area, about 6.5 km northwest of Tsuya, the Jurassic Atagoyama Formation, which is composed of dark gray fine sandstone, rests upon the Chonomori Formation with presumed unconformity.

2 Triassic System in the Kwanto Massif

The Triassic System in the Kwanto Massif is distributed in the following areas: (1) Iwai near Itsukaichi, Nishitama-gun, Tokyo, (2) Futamatao, Oomi-cho, Nishitama-gun, Tokyo, (3) Shionosawa, Ueno-mura, Gunma Prefecture, and (4) Okutone.

The areas of (1) and (3) expose the Lower Triassic formations with characteristic ammonite and bivalve faunas, but the Middle Triassic has not been found in any of the outcrops. The Upper Triassic beds, especially the *Monotis* bearing beds, are exposed in all of the outcrops except the Shionosawa area.

(1) The Lower Triassic System

The Lower Triassic in the Kwanto Massif is represented by two units; (A) the Iwai Formation in the vicinity of Iwai near Itsukaichi, Nishitama-gun, Tokyo, and (B) the Shionosawa Formation at Shionosawa, Ueno-mura, Tano-gun, Gunma Prefecture.

(A) Iwai Formation (Ichikawa and Kudo, 1951). Type locality: Iwai, Itsukaichi-cho, Nishitama-gun, Tokyo.

Fujimoto (1926) was the first to discover some Scythian ammonites and "*Pseudomonotis*" *ochotica* Keyserling from Iwai, and subsequently Shimizu (1932) found *Ophiceras* sp. in the collection of Fujimoto and stressed that it closely resembles *Ophiceras* aff. *demissum* (Oppel) from the lower Scythian beds of Greenland. Still later Choh (1939) and Kobayashi *et al.* (1943) discovered brachiopod and pelecypod fossils from a horizon a little above the "*Ophiceras*" Beds, and Kudo (1946) found some species of *Halobia* and recorded a new occurrence of the *Monotis* fauna. Ichikawa and Kudo (1951) cleared up the startigraphical relation between the Iwai Formation with "*Ophiceras*" and the overlying beds, which consist of the Arai Formation and the *Halobia* and *Monotis* bearing beds. Sakagami (1955) described "*Ophiceras*" *iwaiense* Sakagami, "*O.*" sp., *Vishnuites* sp., "*Proptychites*" aff. *rosenkrantzi* Spath and *Kingites shimizui* Sakagami. These ammonite species were revised by Kummel and Sakagami (1960) and the following species were redescribed by them: *Dieneroceras iwaiense* (Sakagami), *Dieneroceras* sp., *Owenites shimizui* (Sakagami), *Paranannites* sp. *Aspenites* sp. and *Juvenites* sp.

According to them the Iwai Formation has two fossil beds: the *Owenites* beds below and the *Aspenites* beds above. Kummel (1959, p. 436) noticed that most of the ammonites described by Sakagami (1955) probably belong to the zone of *Meekoceras gracilitatus* rather than to the lower Scythian age.

This formation, about 40 m thick, consists of massive sandstone and black shale with dark gray impure limestone lenses. Black shales are rather calcareous and dominant in the upper part, and are said to have yielded many ammonite fossils and a small pelecypod fauna. At the lower part of this formation the conglomeratic sandstone layers are composed of angular pebbles of serpentine, diabase, other green rocks and limestone pebbles with *Neoschwagerina*. The contact between this conglomeratic sandstone and the ammonite bearing beds cannot be observed in this locality.

(B) Shionosawa Formation (Ozaki and Shikama, 1954). Type locality: Shionosawa, Ueno-mura in Gunma Prefecture.

The Shionosawa Formation consists of conglomeratic schalstein with limestone boulders, and is about 30 m thick. From the limestone blocks they found pelecypods as *Eumorphotis multiformis* (Bittner), *Gervilleia* cf. *exporrecta* (Lepsius) and *Anodontophora canalensis* Catullo. Later Ichikawa and Yabe (1955) described a new type of *Eumorphotis*, namely *E. multiformis shionosawensis*, and still later Yabe (1956) described from this formation, *Anodontophora canalensis* Cat., *A. fassaensis* Wissmann, *Bakevellia ussurica rostrata* Yabe, *Pecten* spp. and *Naticopsis* spp. etc.

This formation has its base unexposed and its top abutting against a fault of the Sanchu Graben at the northern side, and the stratigraphical relation with the Chichibu Paleozoic remains unknown (Ozaki and Shikama, 1954).

(2) **The Upper Triassic**

Tha *Halobia* Beds and the *Monotis* Beds represent the Upper Triassic in the vicinity of Iwai. The former was first discovered by Kudo (1946) at about 20 m northeast of the Lower Triassic Iwai Formation. He recorded *Halobia molukkana* Wanner, *H.* cf. *austriaca* Mojs., *H.* sp., *Palaeoneilo* spp., *Trigonucula sakawana tokomboensis* Ichikawa etc. from this beds. Ichikawa and Kudo (1951, p. 31) regard the beds to be middle Karnian. The beds are in thrust fault contact with the Iwai Formation, and the relation with the *Monotis* Beds remains unknown.

The *Monotis* Beds consists of light greenish calcareous sandstone, dark gray arenaceous fine sandstone with mica flakes. It rests upon the Iwai Formation with angle dip in the Iwai area, but its boundary is obscure. This beds yielded, according to Ichikawa (1951,

p. 30–31; 1951b, p. 43–48), *Monotis ochotica* (Keyserling),*M. ochotica densistriata* (Tell.), *M. ochotica eurachis* (Tell.), *M. ambigua*(Tell.), *M. pachypleura* (Tell.), *M. zabaikalica* (Kip.), *M. zabaikalica intermedia* (Kobayashi and Ichikawa), *M. iwaiensis* Ichikawa. The thickness of this formation bearing the *Monotis* fauna is about 50 m (Ichikawa and Kudo, 1951).

In the Okutone area in the upper reaches of the Tone River, the *Monotis* bearing beds was discovered by Toya, Kobayashi, Ogi and Fujimoto (1958) and it was named the Okutone Group. According to them the *Monotis* fauna occured from the Idosawa and Higashimatasawa Formation, from where *Monotis ochotica* (Keyserling), *M.* cf. *ochotica* (Keys.), *M. ochotica eurachis* (Tell.), *M. pachypleura* (Tell.), *M. multistriata* Kob. and Ich., and *M. tenuicostata mabara* Kob. and Ich. were recorded. These formations comprise light gray arkose sandstone and dark gray sandy shale.

In the vicinity of Futamatao, Omi-cho, Nishitama-gun, Tokyo, a single specimen of *Monotis ochotica* (Keys.) was collected by Takagi (1944) from a sandstone, which he regarded as equivalent with the Kochigatani Group in the Sakawa Basin. According to him the *Monotis* bearing beds consist of sandstone, conglomeratic sandstone, limestone and chert, and the contact between the *Monotis* Beds and the Paleozoic "Chichibu Series" cannot be observed, but the relation may be a fault. The formation is said to be a deposit of the deltaic area judging from the distribution and lithologic character (Takagi, 1944, p. 196–198).

3 Upper Triassic System in the Gifu Province

The *Monotis* Beds was first recorded by Hayasaka (1919) in the vicinity of Myogatani, Kasuga-mura, in the eastern part of the Ibuki Mountain, and later Wakimizu (1920) described its geology and reported that the beds are composed of black shale. The *Monotis* fossils collected by Wakimizu were identified by Kobayashi (1935) with *M. ochotica eurachis* (Tell.) and *M. ochotica pachypleura* (Tell.). Subsequently Seki (1939) described that the Norian *Monotis* Beds overlies with unconformity the Paleozoic Kasuga Formation and the so-called "Ibukiyama thrust" is an event later than the Norian stage. In his paper the *Monotis* beds was named as the Myogatani *Monotis* Beds, and in his subsequent paper (Seki, 1951) the Upper Triassic beds were subdivided into (1) Breccia conglomerate beds with chert and slate brecciate pebbles, (2) Alternation of dark gray sandstone and black shale, and (3) Black mudstone, and an alternation of argillaceous sandstone and sandstone with the *Monotis* fauna in ascending order. Seki recorded *Monotis zabaikalica* (Kip.) from this formation based upon Ichikawa's identification.

Recently Ichikawa, Ohashi and Hirano (1961) pointed out that the Upper Triassic beds is slightly younger than the Maizuru Zone and the beds of Yamaguchi Province. The thickness of this formation is unknown.

4 The Triassic System in the Maizuru Zone

The Triassic strata are well developed in the Maizuru Zone. The Lower and Middle Triassic are in a continuous succession as in the Kitakami Massif, but the distribution of the Ladinian formation is restricted. The Upper Triassic Series in this zone extend from Maizuru Bay to the Oga district.

Kochibe (1891) first recorded the occurrence of Mesozoic pelecypods from Heki in the Yakuno district. These fossils were referred to *Trigonia*, *Pholadomya*, *Lima* and *Cardium* by Yokoyama (1891), and regarded as of Jurassic age. Later Kobayashi (1935–36) proposed the name of Heki Formation for the Mesozoic strata.

The occurrence of the Anisian was clarified through the discovery of Anisian ammonites from the Yakuno district by Koga (1948). On the other hand Kambe (1950) found Triassic pelecypods, among which such genera as *Myophoria, Gervilleia,* and *Nucula* ?, were found from the vicinity of Shidaka. The name of "Maizuru Zone" was first proposed by Matsushita (1950) for the zonal distribution of the Paleozoic and Mesozoic strata in the eastern Chugoku Province.

Subsequent studies on the stratigraphy of the Triassic were by Nakazawa, Shiki, Shimizu and Nogami from 1954 to 1958.

Concerning the paleontology, Nakazawa and Shimizu (1955) described the important Scythian ammonite, *Glyptophiceras japonicum.* This contribution is very valuable in the stratigraphy of the Scythian strata of Japan. On the other hand, some papers on the pelecypods were published by Nakazawa, 1952–56; Kobayashi and Ichikawa, 1952; Kambe, 1951. Recently Nakazawa (1958) summarized the Triassic System in the Maizuru Zone.

(1) **The Lower and Middle Triassic**

The Lower and Middle Triassic formations are exposed in the Fukumoto, Mikata district, Miharaiyama, Yakuno, and the Oe districts.

In the Fukumoto district the Lower and Middle Triassic are represented by the Fukumoto Group which is composed of the Kusano Formation, about 300 m thick, Kyogakubo Formation (260–300 m thick) and the Miyanooku Formation (170 m thick) in ascending order.

The Kusano Formation is mainly of sandstone and an alternation of sandstone and conglomerate. The Kyogakubo is of an alternation of shale and sandstone with thin conglomerate layers. The Miyanooku, the uppermost part of this group is mainly of shales and sandy shales with intercalated sandstone. The lower two formations are characterized by the Scythian fauna, i.e. "*Pecten*" *ussuricus, Eumorphotis* aff. *maritima* etc., and the Miyanooku Formation by the *Hollandites-Danubites* fossils of the Anisian stage.

In the Mikata district the Triassic series is similar with those of the Fukumoto district and is referred to the Fukumoto Group. The age is Scythian based on the lithological characters.

In the Miharaiyama district the Triassic Miharaiyama Group includes the lower part of the Niikuradani Formation and the upper part of the Gannosudani Formation. The former consists of basal conglomerate, which rests unconformably upon the upper Permian and bluish gray sandstone, and the latter consist of conglomerate, bluish gray sandstone and siltstone. From the Gannosudani Formation, *Neoschizodus* cf. *laevigatus* (Zeithen), *Palaeoneilo* sp. aff. *elliptica* Kipar., *Rhynchonella* sp. aff. *griesbachi* etc., have been recorded.

In the Yakuno district, the Lower and Middle Triassic is known as the Yakuno Group and is classified into the Honodani and the Waruishi Formations. The Honodani consists of sandstone with shales and the Waruishi of shales and sandy shales. The first mentioned is situated below the latter and is about 300 m in thickness and the latter is 440–550 m thick. The Waruishi Formation is characterized by *Hungarites* sp. aff. *proponticus* Toula, *Hollandites* ? sp., *Danubites japonicus* Shimizu and *Michelinoceras* sp. (Nakazawa, 1958). Nakazawa distinguished two zonules, the *Hungarites* and the *Hollandites-Danubites* zonules, and he stated that the faunal change between the two formations is in accordance with that seen in the Fukumoto Group.

In the Oe district the Triassic series is subdivided into two formations in the vicinity of Kawanishi. Of them the Ichio Formation consists of fine to medium grained, calcareous sandstone with intercalated shale and conglomerate with rarely small lenses of oolitic limestone, about 350 m thick, and the Oro Formation of shales and sandy shales rarely intervening thin sandstone, about 480–620 m thick.

The Oro Formation yielded "*Entolium*" cf. *discites* (Schloth.), "*Pecten*" *ussuricus* Bitt., *Eumorphotis* aff. *tenuistriata* Bitt., etc. *Monophyllites* cf. *sphaerophyllus* (Hauer) recorded from it was referred to *M.* cf. *wengensis* (Klipst.) from the Rifu Formation.

In the vicinity of Kawahigashi, the Yakuno Group consists of the Hirobatake Formation (320 m thick), which is composed of shale and sandy shale in the upper part, yielded *Neoschizodus* cf. *laevigatus* (Zieth.), "*Pecten*" *ussuricus* Bitt., *Lingula* cf. *borealis* Bitt. and *Spiriferina* sp. etc.

The Narawara Formation (460 m thick) consists of sandy shale or fine-grained sandstone, and it yielded the same fauna as the Hirobatake Formation, but the following species are new to it: "*Pecten*" cf. *minimus* Kipar., *Claraia* aff. *desidens* Bitt., and *Paleoneilo* sp. cf. *elliptica* Kipar.

(2) **The Upper Triassic System**

(A) The Arakura Formation

Nakazawa and Okada (1949) first recognized a member in the Nabae Group at Arakura in Maizuru City and subdivided it into four beds, i.e. Nl to N4. Later Nakazawa proposed the Arakura Formation and described it (1958). This formation (430 m thick) is an alternation of shale, sandstone and conglomerate, with thin coal layers. The lower limit is not exposed at the type locality, but it is presumed to rest with clino-unconformity upon the Upper Permian Maizuru Group. The formation yielded *Monophyllites arakurensis* Nakazawa, *M.* sp., *Halobia*? sp., *Posidonia* sp. and *Spiriferina* sp. etc. Nakazawa referred this formation to the Ladino-Karnian stage and proposed for it the time name of Arakuran age. He placed it between the Ladinian Fujinohiran and the Karnian Sakawan age in the Triassic subdivision of Ichikawa. The writer (1961) discussed on the Arakuran age and referred it to the Karnian age based upon paleontological evidence. *Monophyllites arakurensis* illustrated by Nakazawa may belong to *Mojsvarites* by the sutures being more complicate than that of *Monophyllites* (Bando, 1961, p. 331).

(B) The Nabae Group

The Upper Triassic Nabae group is distributed in the Nabae, Matsunoodera, Ikenouchi, Yaba, Monobe, Yakuno and Fukumoto areas, and was subdivided by Nakazawa and Okada (1949) into N1 to N4 formations at the type locality of Nabae. This group is composed of an alternation of shale, sandstone and conglomerate with thin coal seams in N1 formation in the type locality, 70 m thick, and of fine to medium grained sandstone with lenticular conglomerates (N2 formation), about 130 m thick, well bedded black shales and sandy shales (N3 formation), 380 m thick, and of fine to medium grained muddy sandstone (N4 formation), 360 m thick. The Nl formation yielded *Minetrigonia hegiensis obsoleta* Nakazawa and *Bakevellia subhekiensis* Nakazawa etc. The N2 formation produced *Minetrigonia hegiensis, M. hegiensis obsoleta, Homomya matsushitai* Nakazawa, *Cardinia triadica* Kobayashi and Ichikawa, *Bakevellia matsushitai* Nakazawa etc. The N3 formation is characterized by the *Anodontophora* faunule: *A.* ? aff. *manmuensis* Reed, *A.* ? aff. *minima* Mansuy, *Schafhautlia* cf. *astartiformis* (Munster), and *Halobia, Palaeopharus* and *Pleuromya* ?. *Bakevellia hekiensis* (Kobayashi and Ichikawa), *B. oyogiensis* Nakazawa, *Cardinia japonicus* Kobayashi and Ichikawa, *Lima yataensis* Nakazawa, *Volsella* sp. are species restricted to the N3 formation. The *Halobia* fauna consists of *H. kawadai* Yehara, *H.* cf. *austriaca* Mojs., *H. obsoleta* Kobayashi and Aoti. And the others include *Tosapecten nabaensis* Nakazawa and *Pseudolimea naumanni* (Kobayashi and Ichikawa). The N4 formation yielded *Neoschizodus semicostatus* Nakazawa and *Pleuromya wakasana* Nakazawa from the Nabae district, but its horizon is rare in fossil yield in general.

(C) The Shidaka Group

This group name was first proposed by Ogawa (1897) as the "Shidaka Series", but later Kambe (1951) named it the Shidaka Group. The group is characterized by coal bearing strata and many plant fossils were described from it by Oishi (1932). These plant fossils include the genera *Cladophlebis, Zamites, Taeniopteris, Czekanowskia* and *Podozamites*. Yabe (1922) once considered these plant beds to be of Jurassic age, and later Kobayashi

(1937–39) expressed that the Shidaka flora is Liassic to Karnian in age because of the strong resemblance with the Liassic Kuruma and Mine flora. Afterward Kambe (1950) discovered some marine fossils, namely *Myophoria, Gervilleia, Nucula* ? from the basal part of this group and pointed out that the first one resembles *M. laevigata* or *M. timorensis* and referred it to Triassic. Still later Kambe (1951) distinguished the following fossils: *Myophoria tangoensis* Kambe, *M. shidakaensis* Kambe, *M. sp.* cf. *laevigata elongata* Phylippi and *M.* sp. cf. *M. laevigata rotunda* Philippi.

Nakazawa (1958) found some species of "*Bakevellia*" which is related to "*B.*" *okuyamaensis* Nakazawa from the Lower Triassic of other districts, and thus he referred this group to the Lower Triassic age. The present writer considers that this group may be Upper Triassic rather than Lower Triassic because no plant beds occur in other Lower Triassic outcrops except for the only record of plant remains from the upper part of the Osawa Formation at Tate near Isatomae in the Kitakami Massif. They show some resemblance to the lower part of the Nariwa Group in both lithologic and floral characters rather than to the Lower Triassic. It is thought that paleontological evidence is still insufficient to determine the Upper Triassic age of it.

(D) The Nariwa Group

The Nariwa Group is distributed in the Tsuyama, Nariwa and Oga districts, and is characterized by the *Monotis* fauna and plant fossils. In the Nariwa district, the first appearance of *Monotis* was recorded by Kaneta (1888) from Nariwa-cho. Subsequently Sato (1913) stated that the *Monotis* beds rest with conformity upon the plant beds. Diener (1916) described *M. ochotica eurachis* (Tell.) and still later Ozawa (1924, '25, '26) clarified that the Paleozoic limestone rests upon the Nariwa group with low-angle thrust and called it the "Oga decke". Akagi (1927) divided the Nariwa Group into two beds, the *Monotis* Beds above and the plants beds below, and later Oishi (1930, '31, '33, '39,' 40) described many plant fossils from this group and referred it to the Rhaeto-Liassic age. The plant fossils were studied by Oishi and Yamashita (1935), Oishi and Hujioka (1938). The next work was by Kobayashi (1935–38) who stressed that the plant beds are situated below the *Monotis* Beds as in Yamaguchi Province. Recently Kawai (1951) subdivided this group into three beds, the lower, middle and upper, and described the geologic structure in this area. Subseqeunt works have been done by Nakano (1952) Teraoka (1959), Tokuyama (1961) and Yoshimura (1961), and paleontologically Nakazawa (1959) described *Germanonautilus kyotanii* Nakazawa and *Arcestes* (*Stenarcestes*) sp., from the *Monotis* Beds at Jito. According to Teraoka (1959) the Nariwa Group is subdivided into three formations of the Mogamiyana, Hinabata and Jito Formations in ascending order.

The present writer reported on the Triassic of this area (Bando, 1961) and discussed on the upper limit of this group. The stratigraphical sequence of the Upper Triassic in this area is as follows:

		Cretaceous Kenseki Group
		Unconformity
Jito Formation	Upper (200—320m)	4 Dark gray slate (100–150 m)
		3 Alternation of quartzose sandstone and shale (150 m)
		2 Alternation of arokose sandstone and thin carbonaceous shale (20 m)
	Lower (200–300 m)	1 Dark gray sandy shale and fine sandstone with *Monotis* fauna
		Conformity
Hinabata Formation (600 m)		4 Alternation of quartzose sandstone, carbonaceous shale, conglomerate, and black shale (280 m)
		3 Conglomerate (5 m)
		2 Alternation of sandy shale and sandstone with thin coal

	layers and plant beds (100 m)
	1 Quartzose sandstone and conglomerate in basal part (200 m)
	Conformity
Mogamiyama Formation (700 m)	2 Thin alternation of dark gray slate and fine grained sandstone (150 m)
	1 Coarse grained to medium grained quartzose sandstone with coal seams and plant beds (550 m)
	Unconformity or fault
	Yamaguchi Group (Upper Permian)

In the Nariwa district the Mogamiyama Formation is missing and the Jito Formation is covered by the Kenseki Group (Cretaceous) with clino-unconformity. The *Monotis* fauna occurs from the lower part of the Jito Formation. The Permo-Triassic boundary is a fault contact at Iwahata. In the southeastern margin of the area the Mogamiyama Formation rests with unconformity upon the Permian phyllite or semi-schist of the Yamaguchi Group.

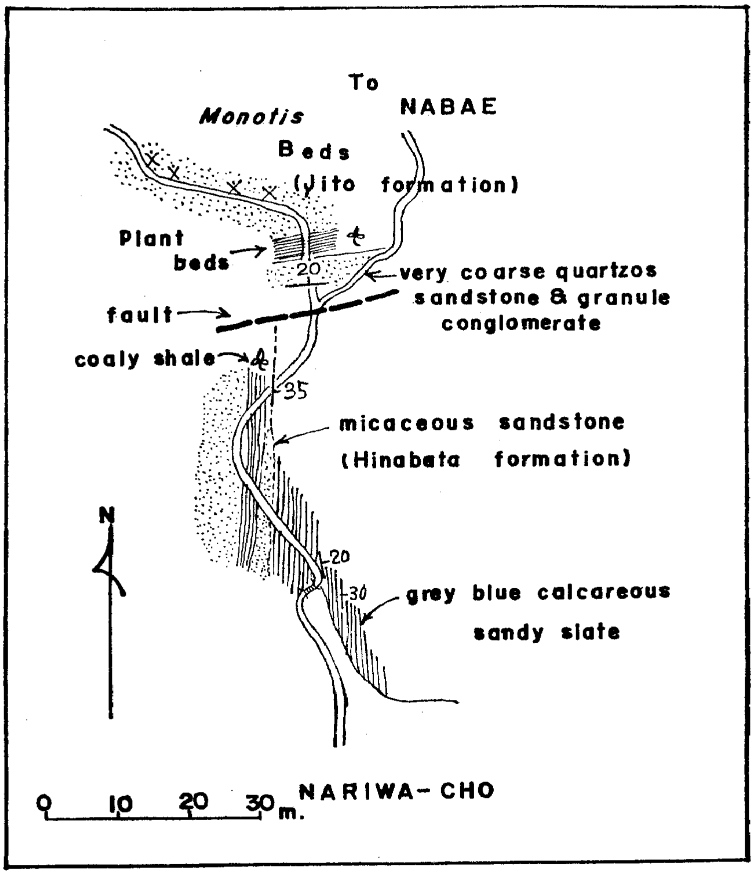


Fig. 6. Geologic route map showing the geostructural relation between the *Monotis* Beds and the plant beds in the vicinity of Eda, Nariwa Province, Okayama Prefecture.

Besides the *Monotis* fauna characteristic fossils were recorded by Nakano (1952), namely *Palaeopharus maizurensis* Kobayashi and Ichikawa, *Minetrigonia katayamai* Kobayashi and Ichikawa, *Oxytoma* spp., *Lima sp.* etc. from the western part of this area, and he named the fossiliferous strata the Kyowa Formation. The fauna is characteristic of the Karnian age, and the age of the Nariwa Group must be regarded as the Karno-Norian.

5 Triassic in Shikoku

(1) The Lower Triassic

The Lower Triassic strata have been known from the vicinity of Kurotaki in Kochi Prefecture and at Taho near Uonashi in Ehime Prefecture. The former is the Kurotaki Formation and has yielded many pelecypods of the Lower Triassic, and the latter is the Taho Formation, from which many characteristic ammonites of the *Anasibirites* fauna have been found.

(A) Kurotaki Formation (Matsushita, 1926). Type locality: Izumigatani, Kurotaki, Nangoku City, Kochi Prefecture.

Early in 1890, Naumann and Neumayr found the Triassic limestone at the present type locality, but at that time the original limestone had already been quarried and only some limestone blocks remained. Naumann and Neumayr stated that.

> "Kaum ist der Ananaigawa erreicht, so folgt auch schon links vom Wege Idzumigatani, ein Kleines Seitenthal, das wegen des Vorkommens triadischer Kalk unser Interesse beanspruchen muss. Die Versteinerungen im Thal die Kalkbrennerei betrieb, ubrig geblieben ist. Sonst sind keine Spuren von Klak ausfindig zu machen. Das Gestein scheint abgebaut zu sein."

Matsushita (1926) first proposed the name of Kurotaki Formation and recorded many pelecypods from the limestone blocks at Kurotaki.

The fossils reported by Matsushita are: *Eumorphotis multiformis* (Bitt.), *E.* aff. *iwanowi* (Bitt.), *E.* sp., *Posidonia* sp., "*Pecten*" cf. *ussuricus* (Bitt.), "*P.*" cf. *sichoticus* (Bitt.), "*Entolium*" *discites* Schloth., "*E.*" *discites microtis* (Bitt.), *Pleuronectites* spp., *Gervilleia* cf. *exporrecta* (Leps.), *Plagiostoma* ? sp., *Mysidioptera* sp., *Myalina* aff. *schamarae* (Bitt.), *Myophoria* aff. *laevigata* Alb., *Anodontophora canalensis* Cst., *A. fassaensis* Wissm., *Bellerophon* sp., *Naticopsis* sp., *Productus* sp. and *Pteria* spp.

Matsushita pointed out that these species are almost all in common with those of the Lower Triassic fauna in Ussuriland and that some are identical with those of the Alps, Hungary, Germany and the Salt Range. Consequently, concerning the geological age, he stated it to be the Lower Triassic. Since Matsushita's work no fossil has been recorded from this formation. The present writer visited this locality several times, but could collect no fossil. The geological section in this locality is as follows:

Section in the vicinity of Kurotaki(from the north side to the south)

Permian?	Chert: light blue or gray banded chert (100 m)
	——— Fault ———
	Chert: light blue banded chert (N50°E, 60°SE) (150 m)
	——— Fault ? (30 m) ———
Triassic?	Sandstone and banded shale (100—120 m)
	Alternation of calcareous greenish blue sandstone and laminated siltstone (N 65°E, 90° or E-W, 45°N) (100-120 m)
	——— Fault ? ———
Permo-Carboniferous?	Chert: crushed and disturbed banded chert (20 m)
	No outcrop (10-20 m)
	Hornblende granodiorite (20 m outcrop)
	No outcrop (20 m)
	Phyllite or phyllitic black shale
	Schalstein: red or greenish, brecciated, well bedded schalstein (N 70° W, 60° N or E-W, 60°–70°N) (500 m)
	Sandstone and phyllite: alternation of greenish sandstone and phyllite (100 m)
	Chert (800 m)

(B) Taho (Tao) Formation (Ikebe, 1936). Type locality: Taho, Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture.

Stratigraphical and paleontological studies on the Taho Formation were first made by Yehara (1926); later he described many Lower Triassic ammonites from this formation. The Lower Triassic at Taho was first named by him as the *Meekoceras* Beds. Later Shimizu (1932) restudied the Taho Formation and remarked that the *Meekoceras* Beds of Yehara should be called the *Anasibirities* Beds; he correlated it to the Columbitan age of the upper Scythian subdivision of Spath (1930). Subsequently Shimizu and Jimbo (1933) revised the species reported by Yehara. Suzuki (1935) reported on the geology of this area, and Ikebe (1936) stated that the Paleozoic-Lower Triassic contact is a thrust fault which he called the "Uonashi Thrust". The name of this formation was first proposed by Ikebe, but it is included in the Upper Triassic beds with *Proarcestes* which was first described by Shimizu (1930) at 450 m west of the Lower Triassic outcrop. Ichikawa (1951) defined the Taho Formation as Lower Triassic and named the upper part the *Proarcestes* Beds (Upper Triassic).

The Taho Formation is dark gray argillaceous limestone lens, and yielded many characteristic ammonites and pelecypods.

Recently Conodont fossils were collected from this limestone; they are similar to the ones from the *Meekoceras* zone in Nevada of North America (Müller, 1956). The limestone of this formation also appears at Kawamukai, about 1.2 km east of Taho; it yielded *Gervilleia* cf. *exporrecta* Leps.

The stratigraphical relation between the Taho Formation and the Permian *Neoschwagerina* limestone is probably a fault extending E-W in the northern margin of the distribution of the Triassic.

The boundary between the Lower Triassic and the Jurassic Torinosu Formation is considered to be a fault judging from the deformation of the rocks.

The majority of the fossils consist of ammonites among which the species of *Anasibirities* are most common. Consequently this fauna is obviosuly represented by *Anasibirities* which has a species related with those of North America, Timor, South China, Salt Range, Himalaya and western Canada.

The fossils from this formation are: *Anasibirities kingianus inaequicostatus* (Waagen), *A. archiperipheras* n. sp., *A. shimizui* n. sp., *A. onoi* (Yehara), *A. pacificus* (Yehara), *A. ehimensis* n. subsp, *A. intermedius* n. sp., *A. multiplicatus* (Yehara), *A.* sp., *Hemiprionities katoi* (Yehara), *H. tahoensis* (Yehara), *H. morianus* (Yehara), *H. kuharanus* (Yehara), *H. kuharanus iyonus* n. subsp. *H. sawatanus* (Yehara), *H. shikokuensis* (Shimizu and Jimbo), *H.* sp., *Meekoceras japonicum* Shimizu and Jimbo, *M. japonicum compressum* n. subsp., *M. orientale* Shimizu and Jimbo, *M.* sp., *Arctoprionites yeharai* n. sp., *A. minor* n. sp., *A. nipponicus* n. sp., *Wyomingites* cf. *aplanatus* (White), X*enoceltites* aff. *evolutus* (Waagen), *Anodontophora canalensis* Cat., *Eumorphotis shikokuensis* (Yehara) and *Gervilleia* cf. *exporrecta* Leps.

The fauna is referred to the upper Owenitan age or to the zone of *Anasibirites multiformis*.

(2) The Middle Triassic Zohoin Formation

The Middle Triassic series in Shikoku is represented by the Zohoin Formation of upper Ladinian; it yielded *Daonella* fossils. The distribution of the Zohoin Formation in Shikoku is in the Nakagawa and Sakawa Provinces.

(A) The Nakagawa Province

(a) The Kumagatani Area

Suyari (1958) first discovered *Daonella* at Kumagatani, the easternmost locality of this formation in Shikoku. He also recorded the Zohoin Formation in the west of Sakari, about 3 km west of the above locality. In this area the Zohoin Formation consists of gray blue fine-grained sandstone and calcareous black shale with light greenish sandstone lens. Suyari states the thickness of the formation to be about 80 m; the boundary between the adjacent beds is covered by vegetation. The writer considers that this formation was inserted by a fault as a small lens and is associated with the Torinosu sandstone and shales along the extension of the fault. Only a single specimen of *Daonella* sp. was collected by Suyari. According his description the northern part of this formation is in contact by E-W fault with the Middle Permian Hisone Group and the southern part is in fault contact with the Middle to Upper Permian Wakasugi Formation.

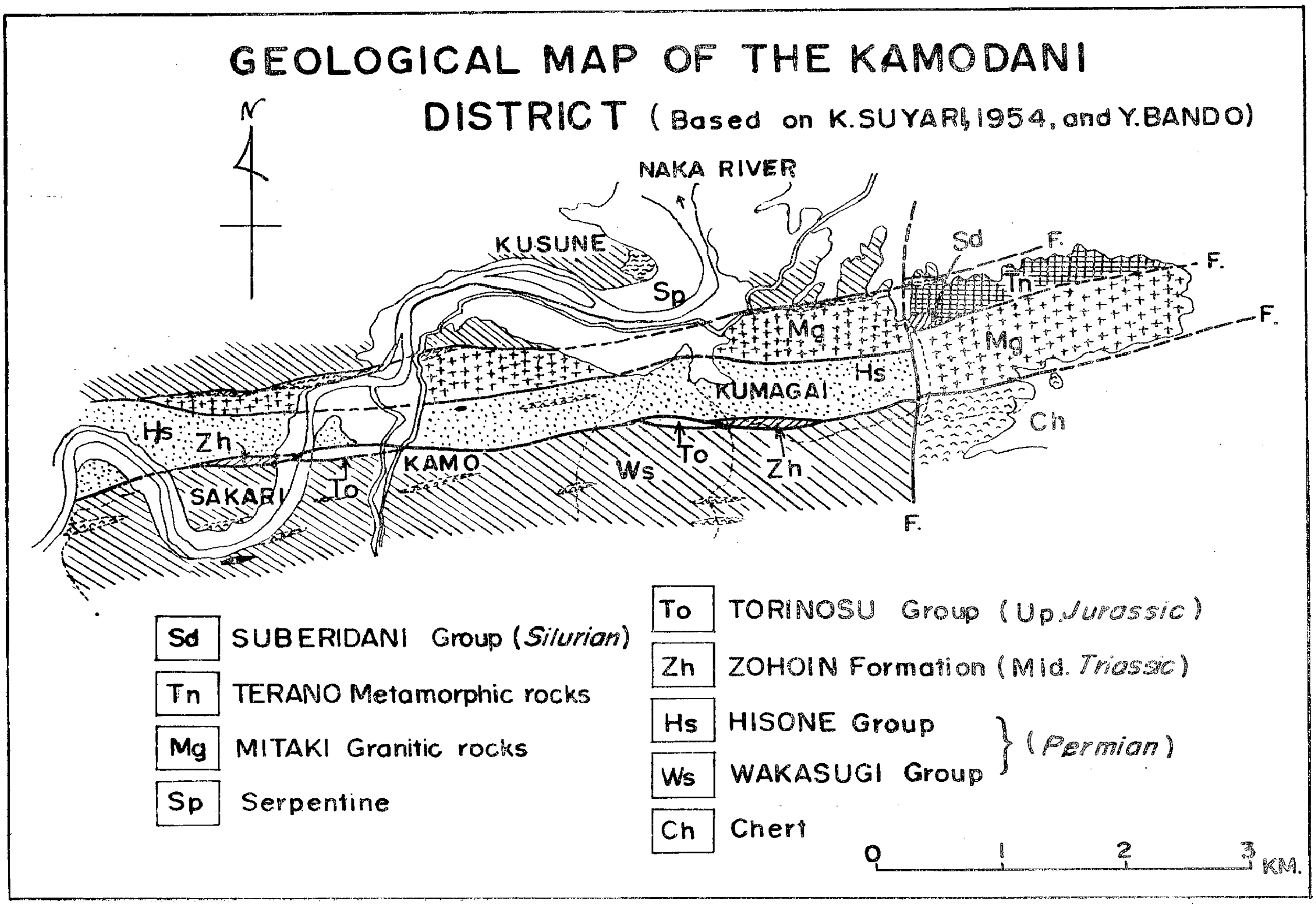


Fig. 7.

(b) The Usugatani Area

In the Usugatani area, Kaminaka-cho, Naka-gun, Tokushima Prefecture, the Zohoin Formation was first recorded by Shinohara (1941) and by Kobayashi and Iwaya (1941) at Usugatani, Gorodani and Nagayasu. According to Kobayashi and Iwaya (1941) the Zohoin Formation had been considered to be inserted as Schuppen-structure and makes several thrust sheets or Decken, and that the *Daonella* bearing Zohoin Formation is conformably covered by the Upper Triassic Kochigatani Group, which yielded *Monotis ochotica* from the upper part and *Rhynchonella*, *Spiriferina*, *Palaeoneilo*, *Halobia*, *Pecten* and other marine fossils from the lower part. Later Hirayama, Yamashita, Suyari and Nakagawa (1956) proposed the name of Usugatani Formation for the *Daonella* bearing formation of this srea,but this is a synonym of the Zohoin Formation in the Sakawa Basin.

The Zohoin Formation in this area extends from the western part of Tsuzuraguchi to the western part of Gorodani. The general lithology is dark gray calcareous sandy shale and fine grained calcareous sandstone. The lower limit of this formation is a thrust fault inclined towards the north and generally associated with the Torinosu Formation at all of the outcrops. Upwards the formation seems to be followed by the Upper Triassic Kochigatani Group with presumable conformity.

The fossils recorded from this formation are *Daonella sakawana* Moj. and *D. katoi* Mojs. by Kobayashi and Ichikawa (1951) from this area, and recently *D. indica* Bitt., *D. iwayai* Kob. and Tok. *D. subquadraata* Yabe and Shimizu, *D. subquadrata symmetrica* Kob. and Tok., and *D. pectinoides* Kob. and Tok. were described by Kobayashi and Tokuyama (1959). Concerning the ammonoids only *Protrachyceras* ? sp., had been listed from this area by Kobayashi and Ichikawa (1951). Recently, six ammonite species were received from Mr. K. Hashimoto; among them four are identical with *Protrachyceras* cf. *pseudo-archelaus* (Boeckh) and are from the *Daonella* bearing beds at Annomoto, Nagayasu, in this area. *Protrachyceras pseudo-archelaus* (Boeckh) has been recorded from the *Daonella* Beds in Swiss and commonly occurs from the zone of *Protrachyceras archelaus* of the "Wengen Schichten" in the southern Alps. Consequently the age of this formation in this area is upper Ladinian, and it may be of a horizon a little higher than that of the Zohoin Formation at the type locality in the Sakawa Basin, from where *Protrachyceras* aff. *archelaus* (Laube) was described by Shimizu (1930).

(c) The Kito Area

In this area the Zohoin Formation is distributed at Junisha, Shimoyochi, Kominono and Semidani as a thin thrust sheet. The rock facies are almost similar to those in the Usugatani area. At Junisha, abundant *Daonella* fossils were found this formation, being first discovered by Shinohara (1941), who later also discovered *Daonella* from Shimoyochi, Kominono and Semidani. His contributions to the Middle Triassic in this area are valuable. Later Yamashita (1950) reported on the geology of this area and its structure. The geological map of this area was made by Hirayama, Yamashita, Suyari and Nakagawa (1956). Kobayashi and Tokuyama (1959) found *Daonella indica, D. subquadrata zohoinensis, D. subquadrata symmetrica* at Junisha, and *D. kotoi* and *D. hiratai* Kobayashi and Tokuyama at Semidani.

At Junisha the Zohoin Formation gradually changes from the *Daonella* bearing black shales to sandy shale with plant remains but still above the greywacke sandstone. The general strike is N 80E with dip of about 80 degrees towards the north. The thickness is about 200 m. This formation is distributed from Junisha to Semidani in narrow belt form in east-west direction. The southern margin of distribution of the Triassic corresponds to the lower part of this formation which is in contact with the Upper Permian Wakasugi Formation (Hirata, Yamashita, Suyari and Nakagawa, 1959) or with the Jurassic Torinosu Formation with fault. The upper part is considered to be followed by the Upper Triassic *Halobia* Beds with fault contact at Semidani.

The stratigraphical relation between the *Daonella* bearing Zohoin Formation and the *Haloboia* Beds of the Kochigatani Formation could not be determined in this area.

(B) The Zohoin Area

The Zohoin Formation has its type locality in the vicinity of Zohoin, Sakawa-cho in the Sakawa Basin. The first occurrence of *Daonella* was recorded by Nasa (1885). Later Mojsisovics (1888, p. 174) described *Daonella kotoi* and *D. sakawana* from the Zohoin. The *Daonella* from Zohoin was also studied by Kittle (1912, p. 74), who separated the species into seven groups, the ones from Zohoin being included into the groups of *D. sturi* and *D. lommeli*. Diener (1916, p. 25–26) described *D. sakawana* from Zohoin. Yabe and Shimizu (1927, p. 108) classified the *Daonella* from Zohoin into three species and newly described *D. kotoi alta*,

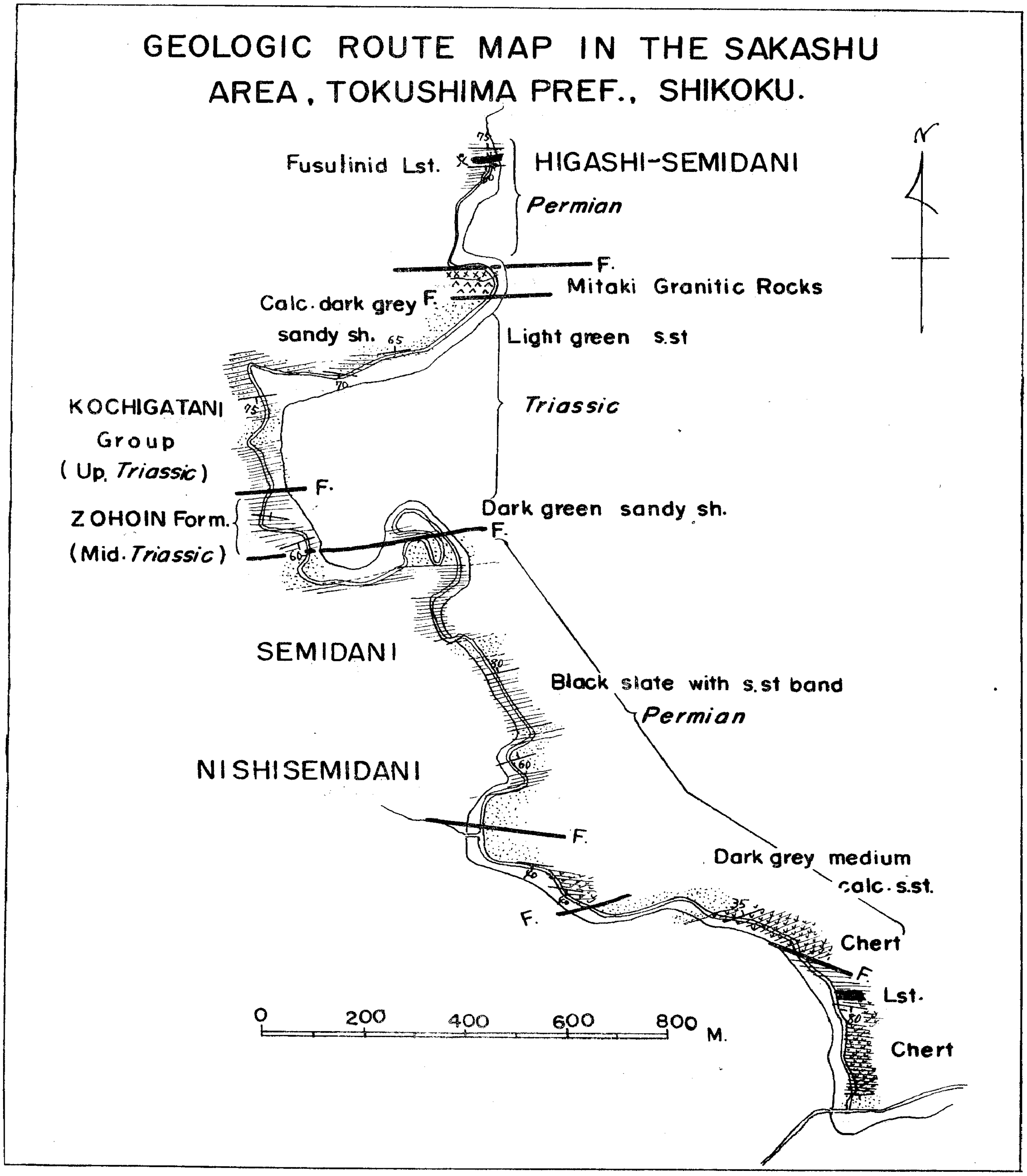


Fig. 8.

D. densistriata and *D. densistriata subquadrata* Yabe and Shimizu. In the same year, Yehara (1927) proposed the name of Zohoin series for the *Daonella* bearing formation. The first ammonite fossils were described by Shimizu (1930), and these consisted of *Protrachyceras* aff. *archelaus* (Laube) and *Thisbites* ? *orientalis* Shimizu from the Zohoin Formation at

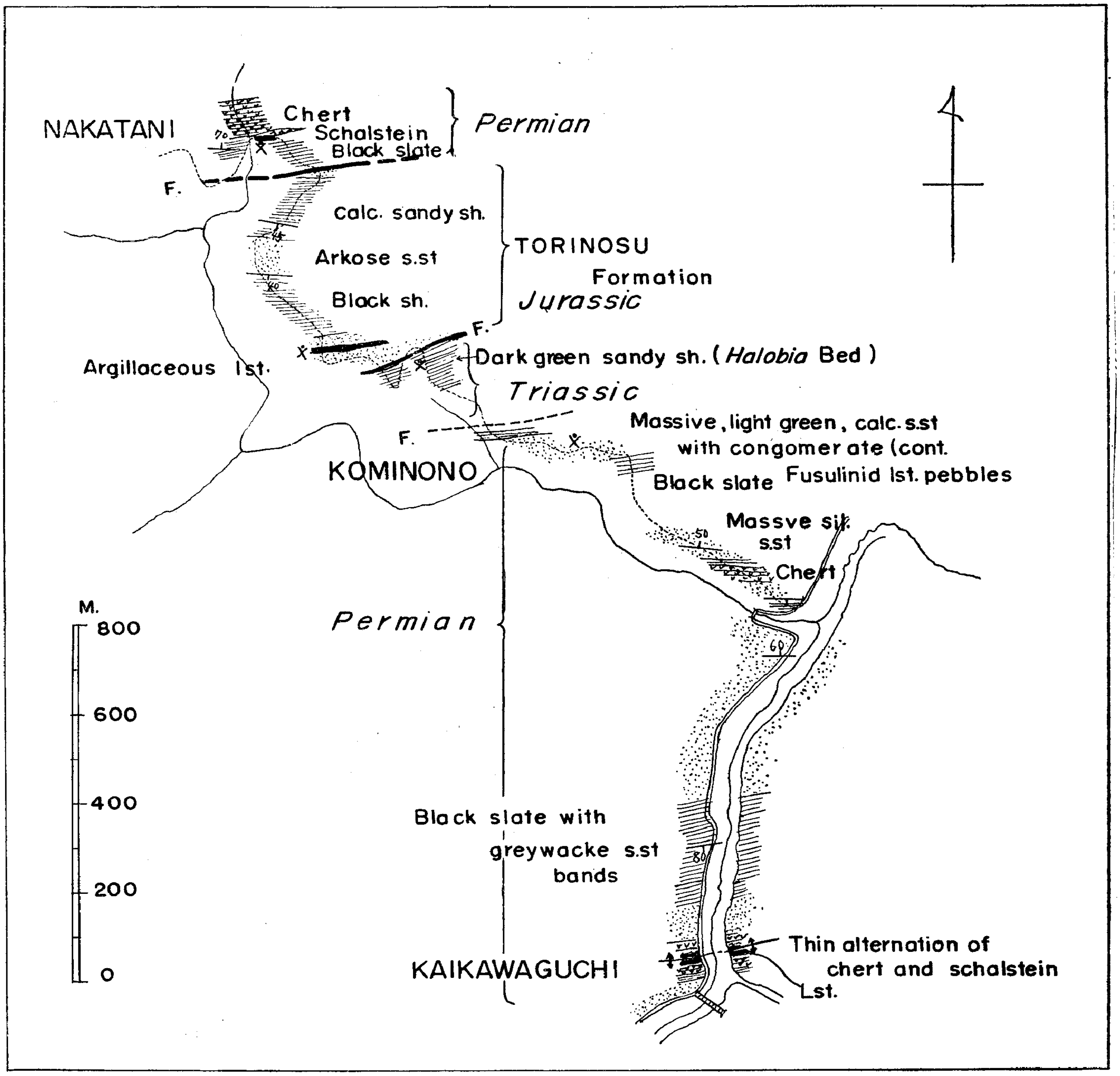


Fig. 9. Geologic route map in the Nakatani Valley, Tokushima Prefecture, Shikoku.

Zohoin. Yamanouchi and Hirata (1936) discovered a new occurrence of this formation in the Ino Basin, midway between Kochi City and the Sakawa Basin, and recorded *D. densisulcata* Yabe and Shimizu at Kuroiwa in Ino-cho. Kobayashi (1931) stated that the Triassic series is distributed in four zonal provinces; (1) Toganotoge, (2) Zohoin, (3) Yamamuro, Kochigatani, Shimoyama and Kusaka, (4) Owarabi, and he recorded *D. kotoi* from Okazaki, in the western part of Sakawa-cho, and *D. densisulcata* from Yokoyamadani, at about 1.5 km east of Zohoin. Recently, Kobayashi and Ichikawa (1951) and Suyari (1961) described their observations on the Zohoin Formation. Kobayshi and Tokuyama (1959) recorded *Daonella tenuistriata* Kobayashi and Tokuyama, *D. indica*, *D.* cf. *spitiensis* Bitt., *D. iwayai*, *D. kotoi* var., *D. subquadrata zohoinensis*, *D. subquadrata symmetrica*, *D. pectinoides*, *D. asymmetrica* Kob. and Tok., and D. *hiratai* from the Zohoin Formation at Zohoin, Okazaki and Ino.

The Zohoin Formation of about 100 m in thickness at the type locality consists of dark gray calcareous sandy slate with fine-grained sandstone and dark greenish gray graywacke sandstone layers. The general strike is N70–80E with dips of 50—60 degrees northwards. Both northern and southern parts of their distribution are cut by faults, by which they come into contact with the Permian rocks.

The fossils from this formation are characterized by *Daonella* and *Protrachyceras*. Especially *Protrachyceras* aff. *archelaus* (Laube) described by Shimizu is important to decide the age of this formation and the stratigraphical relation with the Rifu Formation in the Kitakami Massif. This species is also the zonal index fossil of the upper Ladinian (*Protrachyceras archelaus* zone) and is common in the Wengen Formation in the southern Alps, and the *Daonella* shales of Spiti and Timor.

No Middle Triassic strata have yet been discovered in the western part of the Sakawa Basin.

(3) **The Upper Triassic Kochigatani Group**

The Upper Triassic marine strata are distributed in the Nakagawa and Kito areas in Tokushima Prefecture; Sampozan, the Sakawa Basin, Owa-rabi in Kochi Prefecture; and in the vicinity of Itadorigawa, Doi-cho, Taho and Nomura-cho in Ehime Prefecture. These Triassic outcrops include the so-called "Chichibu terrain", each of which forms a narrow belt trending E-W or ENE-WSW.

(A) The Nakagawa Area

In this area the Upper Triassic Series is distributed at Nishino, Usugatani, Nagayasu, Sakashu, Shimoyochi, Kominono and Semidani. Yokoyama (1911) was first to find "*Pseudomonotis*" from this area, and later Yehara (1927) proposed the "Kochigatani Series" for the Upper Triassic beds of the Sakawa Basin. In his paper some *Monotis* from Tenkai-san, about 1.5 km east of Semidani, were also described. Yehara described: *Monotis ochotica* (Tell.), *M. ochotica eurachis* (Tell.) and *M. subcircularis* Gabb. Later Shinohara (1941) recorded *M. ochotica* from Sakashu, and *M. ochotica, Minetrigonia* sp., *Oxytoma* sp., and *Lima* sp. from Usugatani. And, Yehara (1941) described "*Pseudomonotis*" and *Oxytoma* sp. from Usugatani and Sakashu, and *Halobia* cf. *kawadai* Yehara from this srea. Fossils were later collected by Iwaya, Hashimoto and Shinohara from Usugatani, and were reported by Kobayashi and Ichikawa (1951). The writer recorded a new occurrence of *Halobia* at Tsuzuraguchi near Nisino, about 3 km west of Usugatani (Bando, 1960).

The Upper Triassic Kochigatani Group in this area is composed of the Sabutani Formation, which is characterized by the *Halobia* and *Oxytoma* fauna, and the *Monotis* bearing Umegatani Formation. The first name was proposed by Ichikawa, Ishii, Nakagawa, Suyari and Yamashita (1953) and the type locality was designated as Sabutani; the latter was named by Hirayama, Yamashita, Suyari and Nakagawa (1956), the type locality being at Umegatani in Usugatani, a locality name which is not indicated in the map in the scale of 1/50000.

The Sabutani Formation is about 30–50 m thick and consists of coarse to medium grained greenish sandstone and conglomerate in the lower part, and of dark green, fine grained sandstone and argillaceous sandstone in the upper. The Umegatani Formation consists of argillaceous sandstone and micaceous fine grained sandstone with granule to pebble sized conglomerate layers. According to Hirayama, Yamashita, Suyari and Nakagawa (1956) and Suyari (1960) greenish tuff fragments are included. An unconformity is recognized at Sakashu to separate the Sabutani Formation from the subjacent beds. Ichikawa, Ishii, Nakagawa, Suyari and Yamashita (1953) state the contact to be a remarkable clinounconformity at Sakashu. The basal conglomerate of the Sabutani Formation rests upon the Middle Permian Hisone Formation with uneven surface.

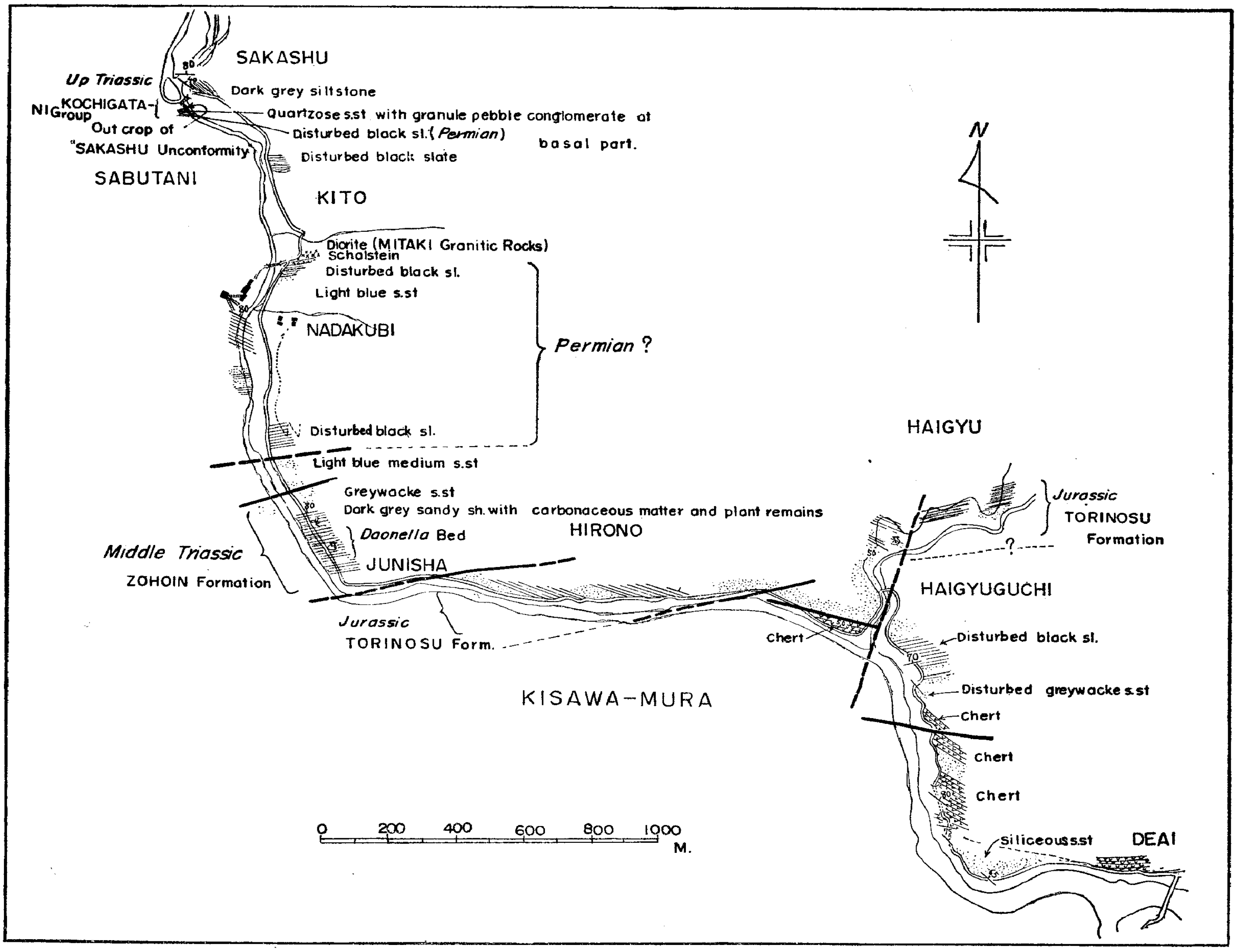


Fig. 10. Geologic route map in the Sakashu area, Tokushima Prefecture, Shikoku.

The Sabutani formation yielded: *Oxytoma pulchra* Kob. and Ichi. *Minetrigonia katayamai* Kob. and Ich., *Mytilus nasai* Kob. and Ich., *M.* cf. *tenuiformis* Kob. and Ich., *Chlamys mojsisovicsi* Kob. and Ich., *Lima naumanni* Kob. and Ich., *Myophoria* sp., *Halobia kawadai* Yehara, *H.* sp., *Gervilleia* sp., *Schautlia* ? sp., *Anodontophora* sp., *Palaeoneilo* sp., *Tosapecten suzukii* (Kob.), etc.

The Umegatani Formation has yielded the *Monotis* fauna, which comprises *M. ochotica* (Keyserling), *M. ochotica densistriata* (Tell.), *M. ochotica eurachis* (Tell.). *M. zabaikalica* (Kiparisova), *M. zabaikalica intermedia* Kob. and Ich.

The stratigraphical boundary between the Sabutani Formation and the Umegatani Formation could not be observed directly but from their similar distribution and intimate relation it is considered to be a conformity. Further, there is no break in the faunal character between them.

The contact between the *Monotis* bearing Umegatani Formation and the Upper Jurassic Torinosu Formation could not be observed directly anywhere. The Sabutani Formation comes into contact with the Torinosu Formation with fault at Kominono. However considering from the straigraphical hiatus shown by the non-development of the

Lower and Middle Jurassic and Rhaetian strata as already noticed by Hirayama, Yamashita, Suyari and Nakagawa (1956), their relation should be considered an unconformity. On the other hand, the relation between the Zohoin Formation and the Sabutani Formation may a conformity at Nagayasu and Shimoyochi, but the boundary is obscure. At Nagayasu the Zohoin Formation with *Daonella* gradually changes into the Sabutani Formation with *Halobia* which lithology becomes arenaceous.

Concerning the distribution of the Upper Triassic Kochigatani Group in this area, it may be said that the Sabutani Formation shows closer relation with the Zohoin Formation than with the Umegatani Formation. This is important in interpreting the tectonic history.

(B) The Sampozan Area

This area is situated at about 16 km east of Kochi City. The Triassic of this area was first recorded by Suzuki (1931, p. 13) who proposed the name of Sampozan Series. His collections were studied by Kobayashi (1931) who recognized *Daonella* cf. *kotoi alta* Yabe and Shimizu, *D.* sp., *Rhynchonella sambosanensis* Kobayashi, *Pecten* spp., *Spiriferina* sp. etc. Later Yabe and Shimizu (1932) described *Spongiomorpha sampozanensis* Yabe and Sugiyama, from the limestone of this group, and pointed out that it is closely related to *Spongiomorpha minor* Frech from the Norian strata of the Alps. According to Kobayashi the age of this Series is Ladino-Karnian based on the fossil evidence, but Yabe and Shimizu (1932, p. 91) pointed out that the generic determination of Kobayashi's "*Daonella*" is somewhat doubtful because the specimens are fragmental, and that they may be assigned to *Halobia* as well. Moreover there is no other example of Ladinian limestone in Japan, whereas a Karnian limestone occurs in the Sakawa Basin. Later Ichikawa (1951) correlated this formation with the Zohoin Formation (upper Ladinian). Later Tokuyama (1957) described "*Rhynchonella*" *noichiensis* Tokuyama from the Sampozan Limestone. Kobayashi (1959) stated that the *Daonella* once described by himself from this formation is doubtful because of the imperfect preservation. Tokuyama (1959) found that the *Rhynchonella sanbosanensis* reported from the formation may belong to *Holcorhynchia* whose range is Karnian to Dogger. Consequently Kobayashi and Tokuyama (1959, p. 5) assigned the Karnian age to the limestone of the Sampozan Formation, and mentioned that the *Daonella* in question may belong to *Halobia*.

The Sampozan Formation has its type locality in the vicinity of Sampozan near Noichi-cho, Kami-gun, Kochi Prefecture. It is composed of black shale, greywacke sandstone, lenticular limestone, chert and schalstein. In the type locality the following rock facies are distinguished from the north to the south.

Outcrop section in the vicinity of Sampozan area

Chert....bluish gray banded chert (N70E, 85N)

——————— ?

Limestone (50 m)

——————— ? ———————

Chert

——————— ? ———————

Sandstone and siltstone.... alternation of laminated gray sandstone and dark gray siltstone. (100 m?) (N70°E, 80°N).

——————— Fault ———————

Limestone....dark gray limestone (non-fossiliferous) (50 m)

Chert....dark blue banded chert with thin laminated sandy slate and siliceous sandstone (80?-100 m) (N80°E, 55°N)

——————— ? ———————

Triassic

Schalstein....red or greenish schalstein with impure limestone pebbles (20-30m). Abundant Stromatoporoid fossils.

Conformity

Limestone .... light gray limestone with calcite veins. (70–80 m?)
Abundant Spongiomorphoid coralline fossils.

Fault (Butsuzo Tectonic Line)

Cretaceous (Doganaro Formation)

The southern margin of this formation is cut by the Butsuzo Tectonic Line and comes into contact with the black shale and sandstone of the Cretaceous Doganaro Formation (Katto, 1956; Katto *et al*, 1958) of the Shimantogawa Group, and the northern extension is probably bounded by fault with the Permian strata.

The above mentioned fossils were collected from the limestone of the southern part of this formation. The writer thinks the age is Karnian rather than Ladinian judging from the development of the Karnian limestone such as in Sakashu of the Nakagawa area and in the Sakawa Basin, and from the faunal evidence. Considering from the development of the Ladinian strata in Japan, no limestone has yet been recorded as already noticed by Yabe and Shimizu (1932).

(C) The Sakawa Basin and its environs

The Sakawa Basin is a classical locality of the Triassic strata in Shikoku since Naumann's first contribution (1885). Nasa (1885) recorded *Monotis* and *Avicula* from Owada in Kusaka-mura and from Kashiwai in this Basin. Later Sagawa (1898) discovered *Monotis ochotica* (Keyserl.) at Owarabi, about 14 km WNW of the Sakawa Basin; this is the northernmost occurrence of the Triassic System in this Basin. Still later Ogawa (1902) and Sagawa (1900) mapped the area. Yehara (1927) described on the distribution of the Upper and Middle Triassic and stated that in the Sakawa Basin they can be divided into two series as follows:

(a) Kochigatani Series (Upper Triassic)
Pseudomonotis (*Monotis*) Bed at Otogo, Kochigatani and Kasayadani.

(b) Zohoin Series (Middle Triassic)
Daonella Bed

Subsequent contributions on the Trassic of this area were made by Kobayashi (1931), Hashimoto (1933), Yamanouchi and Hirata (1936), Kobayashi, Aoti and Hukasawa (1940), Kobayashi and Iwaya (1940), Kurata (1940), and recently by Katto, Suyari, Ishii and Ichikawa (1956) and Suyari (1961).

Kobayashi, Aoti and Hukasawa (1940) subdivided the Kochigatani Group into; the lower formation or the *Avicula* Bed, the middle formation or the *Myoconcha* Bed, (*Pecten* Bed) and *Halobia* bed in ascending order, and the upper formation or the *Monotis* bed. The lower and middle formation were correlated with the Hirabara Formation of the Mine group in Yamaguchi Province and the upper with the Saragai Group in the Kitakami Massif.

Concerning the paleontological studies Mojsisovics (1888) first described *Monotis ochotica* from Kochigatani, and subsequently Diener (1916) described *M. ochotica* (Keyserl.) from Kochigatani. Yehara (1927) reported "*Pseudomonotis*" (*Oxytoma*) *zitteli* (Tell.), "*Oxytoma*" *mojsisovicsi* Tell., *Pentacrinus* sp., *Spiriferina* sp., *Arpadites sakawanus* Mojs., *Halobia kawadai* Yehara, *Orthoceras* sp., and some Radiolarians from the Kochigatani Group. Later Shimizu (1930–31) described *Paratrachyceras* cf. *hofmanni* (Boeckh), *P.* sp. nov., *Thisbites orientalis* Shimizu, *Proarcestes* aff. *hanieli* Welter and *P.* aff. *bicarinatus* Münster from the same group and referred them to the Karnian age. Kobayashi and Aoti (1943) described *Halobia kawadai* Yehara, *H. sedaka* Kob. and Aoti, *H. obsoleta* K. and A., *H. molukkana* Wanner, *H. multilineata* K. and A., *H. alta* K. and A., *H. multistriata* K. and A., and *H. longissima* K. and A.

Some pelecypods were described from this group by Kobayashi and Ichikawa (1949–

50) who subdivided this group into four beds; the *Oxytoma-Mytilus* Bed, the *Halobia-Tosapecten* Bed, the *Myoconcha* Bed and the *Monotis* Bed in ascending order.

According to them the *Oxytoma-Mytilus* Bed yielded *Oxytoma yeharai* Kobayashi and Ichikawa, *O. kashiwaiensis* K. and I., *O. pulchara* K. and I., *O. sujimabara* K. and I., *O. sedaka* K. and I., *Halobia* aff. *aotii* K. and I., *H. longissima* K. and A., *Myophoria okunominetaniensis* K. and I., "*Mytilus*" *tenuiformis* K. and I., *M. tenuiformis punctatus* K. and I., *M. nasai* K. and I., *M. nasai nagaides* K. and I., *M. nasai hirataides* K. and I., *Pleurophorus oblongatus* K. and I., *P. oblongatus compressus* K. and I., *Sakawanella triadica* I. The *Halobia-Tosapecten* Bed contains "*Nucula*" *iwayai* I., *Trigonucula sakawana tokomboensis* I., *T. sakawana lata* I., *Palaeoneilo* cf. *tenelliformis* K. and I., *Oxytoma subzitteli* K. and I., *Halobia kawadai* Yehara, *H. sedaka* K.and A., *H. obsoleta* K. and A., *H. molukkana* Wanner, *H. aotii* K. and I., *H. alta* K. and I., *M. multilineata* K. and A., *H. longissima* K. and A., *Anodontophora kochigataniensis* K. and I., *A. kochigataniensis hiratai* K. and I., *A. carinatus* K. and I., "*Megalodosus*" sp., *M. dieneri longa* I.

The *Oxytoma-Mytilus* Bed is exposed at Shimoyama, Otogo, Kusaka and Okuminotani, and consists of greenish-blue fine-grained calcareous sandstone. The next younger or *Halobia-Tosapecten* Bed comprises light greenish sandstone with conglomeratic sandstone layers. Tokuyama (1957) described *Punctospirifer triadicus* Tokuyama and *P. triadicus kashiwaiensis* Tok. from the *Oxytoma-Mytilus* Bed of Kobayashi and Ichikawa at Kashiwai and Okuminotani, and *Spiriferinoides sakawanus* Kobayashi, *S. yeharai* Kobayashi and Tokuyama, *S. nasai* Tok., *Sakawairhynchia tokomboensis* Kob. and Tok. and *S. katayamai* T. from the *Halobia-Tosapecten* Bed at Shimoyama, Tokombo, Nakajima and Kuromagari in the Sakawa Basin.

The present writer collected *Paratrachyceras* n. sp. at Shimoyama from a horizon which is almost equivalent with the Upper Triassic at Tokombo where *Paratrachyceras* cf. *hofmanni* (Boeckh) and *Paratrachyceras* sp. nov.? were recorded by Shimizu (1930). The species described in this paper closely resemble *P. hofmanni* from the zone of *P. aonoides* (middle Karnian) of the Mediterranean Province. Consequently the *Halobia-Tosapecten* Bed of Kobayashi and Ichikawa corresponds to the zone of *Paratrachyceras hofmanni* and may be correlated with the zone of *P. aonoides* of the Alpine Upper Triassic.

The *Myoconcha* Bed is characterized by *Myoconcha trapezoidalis* K. and I., *Oxytoma zitteli* (Tell.) but it yielded *Tosapecten suzukii* of the *Halobia-Tosapecten* Bed. This bed at Umenokidani consists of the typical dark gray sandy shale and sandstone. The youngest or *Monotis* Bed is characterized by the *Monotis* fauna which consists of the group of *M. scutiformis* to that of *M. zabaikalica*. This bed is known from the vicinity of Ino, Yamamuro, Shimoyama, Otogo, Kusaka and Okuminotani. In the Ino area the *Monotis* Bed occurs as a "Schuppe" between the Zohoin Formation of the southern part and the *Halobia* Bed of the northern. The stratigraphical relation between the *Monotis* Bed and the Upper Triassic beds is not observed in the Sakawa Basin due to the heavy vegetation and to the complicated geological structure.

(D) The Itadorigawa Area

In this area the Upper Triassic *Monotis* fauna was first discovered by Ishii (1949) from the northern part of Itadorigawa, Doi-cho, Higashiuwa-gun, Ehime Prefecture. His original specimens seem to have been collected from sandstone blocks derived from the *Monotis* bearing bed at about 600 m south of Itadorigawa. This is confirmed from that the *Monotis* fauna could not be found at his original locality, although it was found in the southern part of this area. The writer observed the original outcrops at this point in 1961 and collected *Monotis ochotica densistriata* (Tell.) from the lower part and *M. zabaikalica* Kipar. from a horizon at 50–70 m above of the *ochotica* Bed.

The *Monotis* Beds of this area is thought to be preserved in complete sequence from

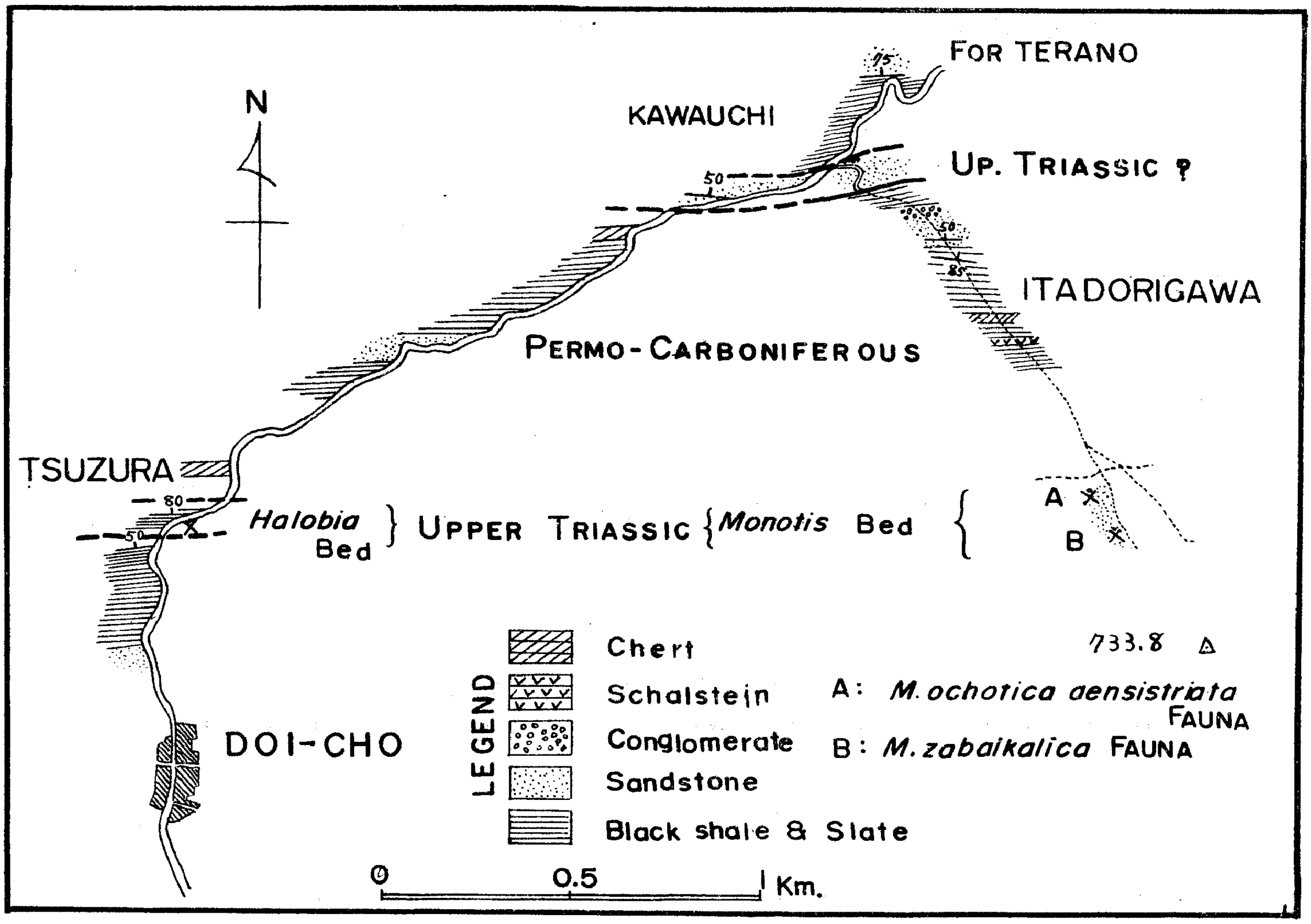


Fig. 12. Geologic route map in the Itadorigawa and Doi-cho areas, Ehime Prefecture, Shikoku.

the group of *M. ochotica densistriata* to that of *M. zabaikalica*. Those *Monotis* bearing beds consist of calcareous light greenish sandstone, but the lowermost and upper limits are covered by thick vegetation. The subjacent beds probably consist of the Permo-Carboniferous strata. The Carboniferous stratigraphy and fusulinid paleontology of this area was studied by Ishii (1956–58). Recently a new type of Ostracode was collected by Ishizaki (1952, MS) from the sandstone of the *Monotis* Beds (Fig. 13).

At Kawachi, about 1 km northwest of Itadorigawa, are found micaceous argillaceous sandstone intercalating bituminous shale and conglomeratic sandstone (10 m thick) with well rounded pebbles of granitic rocks, quartz porphyrite and hornfels. The upper part of the above sandstone and conglomeratic sandstone bed consists of dark greenish arkose sandstone (10 m thick), and its southern margin comes into contact with the Permian ? black shales by fault. The lithology of this bed at Kawachi seems to be closely allied with the lower part of the *Monotis* Beds, but no fossil evidence has been found from this bed.

At Tsuzura, about 500 m north of Doi-cho or at about 3 km west of Itadorigawa, the 20 m thick *Halobia* Beds of black shale are inserted between the Permian black shale in the southern part and the banded chert in the northern part with presumable fault. This *Halobia* Bed probably corresponds to the lower part of the *Monotis* Beds of Itadorigawa and along the same tectonic line extending from east to west; the *Monotis* Beds has not been found from this locality.

(E) The Nomura Basin

The Upper Triassic sediments in this area are distributed at Kubonotani, about

1.25 km east of Nomura-cho, Higashiuwa-gun, Ehime Prefecture, and inserted by fault in the Permian rocks. They consist of black sandy shale with the *Halobia* fauna in lower part and of thin alternations of arkose sandstone and micaceous argillaceous sandstone, with *Monotis ochotica densistriata* in the upper. The *Halboia* bearing formation is about 30 m thick, but that of the *Monotis* Bed is obscure. The difference in lithologic characters between them is remarkable.

This area is the western margin of distribution of the Triassic System in Shikoku and is situated at about 2 km north-west the Lower of Triassic locality of Taho.

6 Triassic System of Kyushu

The Triassic marine formations in Kyushu are distributed at Kamura, Gokase, Miyamadani, Matsukuma and Takagochi. The vicinity of Kamura consists of the Lower Triassic, whereas the other localities have the development of the Upper Triassic Series.

(1) The Lower Triassic

The Lower Triassic formation at Kamura, Takachiho-cho, Miyazaki Prefecture in east-central Kyushu, was first discovered by Saito, Kambe and Katada (1958) and described by Kambe (1960). According to them the Lower Triassic, or the Kamura Formation is composed of light gray limestone yielding early Triassic molluscs. The formation rests with conformity upon the Permian dark gray limestone, which yielded *Neoschwagerina* and *Yabeina*. The total thickness of the Triassic limestone is about 100 m and at the contact with the Permian limestone it strikes N 80 E and dips at 75 degree towards the north. The fossils recorded by them are *Eumorphotis* cf. *multiformis* (Bitt.), "*Entolium*" cf. *discites* (Schloth.), *Anodontophora* cf. *canalensis* Cat., *Gervilleia* cf. *exporrecta* (Leps.), *Aspenites* sp., *Parahedenstroemia* sp., *Clypites* sp..

The ammonites from the Kamura Formation indicate the lower Owenitan, *Meekoceras gracilitatus* zone of the Scythian Stage of Spath's chronological subdivisions for the Lower Triassic based on the ammonoids. The above authors regard the boundary between the Permian and the Triassic to be a conformity. The writer considers that there is a break in the faunal sequences as mentioned below.

The faunal character of this formation resembles that of the Iwai Formation at Itsukaichi, Kwanto Region, but the bivalve fauna of wider distribution occurs also in the Hiraiso Formation in the Kitakami Massif, the Shionosawa Formation in the Kwanto Massif, the Oro Formation in the Maizuru Zone, and from the Kurotaki Formation in Shikoku.

(2) The Upper Triassic

(A) The Gokase Area

The Upper Triassic series in this area was first discovered by Tamura (1960) at Gokase-cho, Nishiusuki-gun, Miyazaki Prefecture. According to him the Upper Triassic series yielded *Oxytoma* cf. *multistriata* Tokuyama, which was first described from the Aso Formation of the Miné Group in Yamaguchi Prefecture, and *Tosapecten suzukii* (Kobayashi) from the about 4 m thick limestone layer. The bed is composed of coarse sandstone (7 m) black shale and limestone (12 m) which yielded the fossils in ascending orders. The limestone is well bedded, dark colored arenaceous and oolitic. This locality is situated at the western extension of the Lower Triassic Kamura Formation at Kamura. According to Tamura, the lithologic character of this formation closely resembles that of the Upper Triassic Tanoura Formation (Tamura, Kanmera, Akazu and Yamashita, 1958) in Kumamoto Prefecture. Judging from the faunal character of this formation it is referred to the upper Karnian as done by Tamura. Kambe (1957) considered this formation to be equivalent with the Jurassic Tonegawa Formation.

(B) The Miyamadani Area

The Upper Triassic *Monotis* Bed was first discovered by Yamashita (1896) at Miyamadani, Kuriki-mura, Yatsushiro-gun, Kumamoto Prefecture. Later Ohtani (1926) studied the Yatsushiro Mesozoic strata and distinguished the Kawamata Formation, the Torinosu Formation and the Triassic strata. According to Ohtani the Upper Triassic beds yielded *Monotis ochotica* (Keyserling) and is composed of an alternation of sandstone and shale. He says that this formation was covered by the Kawamata Formation with unconformity in the southern part, cut by a fault in the northern part and comes into contact with the Paleozoic strata. Recently Kanmera (1951) clarified the distribution of the Triassic System in this area. According to Ichikawa the species of *Monotis* from this area, which are now preserved in the Geological Institute of the University of Tokyo, comprise *M. ochotica densistriata* (Tell.), *M. ochotica eurachis* (Tell.).

(C) The Matsukuma Area

Ohmachi (1937) first discovered the Upper Triassic series in the vicinity of Matsukuma, Yatsushiro-gun, Kumamoto Prefecture. He recorded *M. ochotica* (Keyaserl.), but did not give details on the geology of the area. Kanmera (1951) reported that the Triassic rocks in this area consist of massive, black sandy shale with intercalated calcareous sandstone lenses, and that the *Monotis* fauna which consists of *M. ochotica* (Keyserl.), *M. ochotica densistriata* (Tell.), *M. ochotica eurachis* (Tell.), and *Oxytoma* sp. cf. *O. czekanowskii* (Tell.) is from the micaceous black shale. The typical occurrence of this formation is between Misaka and Nakatsumichi, where it extends with NE-SW trend in a narrow belt, about 200 m in width, but thins out at about 2 km west of the Kuma River. Tamura, Kanmera, Akazu and Shimoyama (1958) discovered some Karnian fossils as *Tosapecten suzukii* (Kobayashi), *T. suzukii* aff. *forma hirogariformis* Kobayashi and Ichikawa, *T. suzukii inflata* K. and I., *Palaeopharus maizurensis*, and *Halobia kawadai* from this area. They proposed the name of Matsukuma Formation for the Karnian strata which yielded the fossils. This formation was correlated by them with the Kochigatani Group. According to their description the Karnian Matsukuma Formation (about 200 m thick) is characterized by fine-grained sediments as calcareous siltstone and shales. Tamura (1959) restudied the fossils from this area and described: *Mytilus* (*Falcimytilus*) *nasai nagaides* Kobayashi and Ichikawa, *Halobia kawadai* Yehara, *H. molukkana* Wanner, *H.* sp., *Pleuromysidia dubia* Ichikawa, "*Pleuromysidia*" *kanmeria* Tamura, *Tosapecten pseudohiemalis* K. and I., *Pleuromya forsbergi nipponica* K. and I., *Myoconcha trapezoidalis* K. and I., and *Palaeopharus oblongatsu* (K. and I.); he correlated it with the Kochigatani Group in the Sakawa Basin.

The boundary between the Matsukuma and the subjacent Koaki Formation (Permian) is stated by them to be a fault, and that the upper part of this formation is covered by the Cretaceous Yatsushiro Formation? with unconformity.

(D) The Tanoura Area

The Triassic series in the Tanoura area consist of the *Monotis* Beds and the Karnian Tanoura Formation, which was described by Tamura, Kanmera, Akazu and Yamashita (1958). Tamura (1959) described *Frenguelliella* (*Kumatrigonia*) *tanourensis* Tamura and *Tosapecten suzukii* (Kobayashi) from this formation. Later, Tamura (1960) reported on the Tanoura Formation which about 100 m thick and composed of sandstone, sandy shale and limestone. According to him, some ammonoids were found from the formation.

(E) The Takagochi Area

Although Orita and Matsumoto were the first to discover the Triassic of this area. Tamura (1960) was the first to record it. *Halobia* sp. was first discovered by these authors, but without details.

7 Triassic in Yamaguchi Prefecture

The Triassic System in this prefecture is distributed in the Asa, Atsu, Omine and Miwa areas. Among them, the last mentioned one is situated in the easternmost part. The Triassic formations in this prefecture are of Upper Triassic age except for the upper Ladinian beds of the Atsu area.

(1) The Middle Triassic System in the Atsu Area

Some Middle Triassic fossils were discovered by Kobayashi (1935) from this area. One is *Daonella yoshimurai* from the black shale of Shirogahara, Isa-mura, Miné-gun in Yamaguchi Prefecture. This species was described by Kobayashi upon the material collected by Yoshimura. The occurrence of *Daonella* from the "Atsu Series" was made known by Ozawa (1926), but its description is due to Kobayashi. According to Ozawa (1926) the *Daonella* Bed occupies the relatively upper part of this series and is Ladinian in age whereas the lower thick non-fossiliferous part was considered to be of Lower Triassic age and equivalent to the "*Meekoceras bed*" of the Taho Formation. This *Daonella* bearing formation was named the Kumanokura Formation by Hase (1947). The lower fossiliferous beds was named the Zuiko Formation (Ozawa, 1925) and the Hongo Formation by Hase (1951). Accordingto Hase (1951) the *Daonella* Bed is about 800 m thick and composed of sandstone and conglomerate intercalated with layers of coaly shale. *Daonella yoshimurai*, *Anodontophora* spp. and *Oxytoma* sp. are said to have been collected from a dark grey shale with coal layers or coaly shale. Katayama (1939) reported on a new fossil locality and added some species of the Karnian age, but none were described by him.

Consequently the lower part of the Kumanokura Formation is upper Ladinian, but the upper part is of Karnian age.

(2) The Upper Triassic Miné Group

The Upper Triasic Mine Group in Yamaguchi province is distributed in the Atsu, Omine and Asa areas. Recently Hase (1961) discovered a *Monotis* bearing formation in the eastern part of this province.

The Triassic System was first recorded by Yokoyama (1891, 1905) on some plant fossils then thought to be of Rhaetian age. Later Inoue (1896), Suzuki (1904, 1906) and Ogura (1922) surveyed the area, and Kobayashi (1926) proposed the name of "Miné Formation" for the coal bearing Upper Triassic formations in the Miné district. He subdivided it into two parts, of which the lower part has yielded abundant plant fossils such seen in the Nariwa district and also the *Monotis* fauna, and the upper part corresponds to the Yamanoi Plant Bed of Yokoyama, and was considered to be equivalent to the Daido Flora in Korea and the Mongugai Flora in eastern Siberia. Later Oishi (1932), and Oishi and Takahashi (1936) described the fossils from Yamanoi, Tubuta, Kusaigawa, Momonoki, Ojigase and Michiichi, and regarded them to be of Rhaetian age and equivalent with the Nariwa Flora in the Nariwa district. Still later Katayama (1938, '39) subdivided the Miné Group into the three formations, the Hirabara, Momonoki and Aso Formations in ascending order, and regarded the age to range from the Karnian to the Norian.

The fossils from the Miné Group recorded by Kobayashi and Katayama (1938) are: *Halobia charlyana* Mojsisovics, *Edentula ozawai* Kobayashi, *Oxytoma zitteli* (Tell.), *Minetrigonia hegiensis* (Saeki), *Lima naumanni* Kobayashi and Ichikawa, and "*Pleurophorus*" sp. aff. *P. perlongus* Böhm as a significant elements, and they reported *Tosapecten suzukii*, *Lima naumanni* and *Monotis* sp. from the Aso Formation.

They stressed that the age of the plant beds of this group is not restricted to the Rhaetian but to the Karno-Norian just as that of the Nariwa Flora. On the other hand Kobayashi and his collaborators (1940) correlated the limestone of the Zuiko Formation with the Sampozan Formation in Shikoku. Kobayashi and Aoti (1943) described *Halobia* *kawadai* from the Miné area, and *H. multistriata* Kobayashi and Aoti and *H.* cf. *molukkana* Wanner from the Asa area. Concerning the plant fossils from the Miné Group, Kon'no (1949) stressed on the stratigraphical importance of *Equisetites* and pointed out that *E. naitoi* Kon'no closely resembles *E. intermedius* Sidtman, which was described from the Rhaetian strata of Sweden. Recently Hase (1951) and Tokuyama (1958, '62) contributed to the Triassic stratigraphy of this province. The following description on the stratigraphy in this incorporates the above contributions.

(A) The Asa Area

The Miné Group in this area consists of the Nakazuka, Yamanoi, and Kamosho Formations in ascending order. The Nakazuka Formation, first described by Hase (1947) is composed of four members; (1) fine to coarse grained sandstone with layers of conglomerate and sandy shale (100–200 m thick), (2) alternation of black shale, sandy shale, sandstone and conglomerate with coal seams in the lower part (200–600 m thick), it yielded *Halobia aotii* Kobayashi and Ichikawa (=*H. multistriata* Kobayashi and Aoti), *Equisetites naitoi* Konno, *Tosapecten suzukii* (Kobayashi), *Oxytoma* sp., *Anodontophora* sp., *Atomodesma*(?) sp., *Loxonema* sp., (3) massive sandstone and black shale (200–400 m thick) with *Anodontophora* sp., (4) alternation of sandstone and shale (200–300 m thick). The Yamanoi Formation consists of sandstone and shale with *Estherites* cf. *kawasakii* (Ozawa and Watanabe) and *E.* cf. *coreanica* (Ozawa and Watanabe); about 1300 m thick. This formation rests upon the Nakazuka Formation with conformity. The Kamosho Formation consists of massive sandstone (200–400 m thick) in the lower part; alternation of black shale. laminated sandy shale and sandstone (300 m. thick) with *Monotis scutiformis* (Tell.) (Kobayashi, 1935) in the middle; and of massive sandstone (300 m thick) in the uppermost part. This formation was considered by Kobayashi, Ichikawa and Hase (1951) to range from the upper Karnian to the lower Norian.

(B) The Atsu Area

The Upper Triassic series in this area consists of the Hirabara and Momonoki Formations.

The Hirabara Formation, first proposed by Katayama (1938), is an alternation of sandstone, black shale and conglomerate, about 400–500 m in thickness. The fossils recorded by Katayama (1939), Kobayashi (1935), Kobayashi and Katayama (1938), Kobayashi and Ichikawa (1949) and Tokuyama (1957) comprise *Minetrigonia katayamai* Kobayashi and Ichikawa, *Halobia* sp., *Cardium* sp., "*Gervilleia*" sp., *Palaeopharus* aff. *perlongus* (Böhm), *Anodontophora* sp., *Edentula ozawai* Kobayashi, *Lingula* sp., *Oxytoma zitteli* (Tell.) etc.

The Momonoki Formation, first proposed by Katayama (1938), comprises an alternation of sandstone, shale and conglomerate. The thickness was not measured because of the narrow distribution.

(C) The Omine Area

(a) The Hirabara Formation: According to Katayama (1938), the Takiguchi Formation which is subjacent to the Hirabara was included into the basal part of the Hirabara by Hase (1951). The present paper follows the stratigraphical order of Hase. This formation comprises four members; (1) an alternation of limestone conglomerate, sandstone and shale with some coal seams, and *Oxytoma* sp. and *Anodontophora* sp., 180–300 m thick, (2) an alternation of sandstone and conglomerate, and of conglomerate, sandstone and shale with some coal seams in the upper part, 100–450 m thick, (3) is composed of massive, fine to coarse sandstone with conglomerate and black shale, 80–250 m thick; it yielded: *Halobia kawadai*, *Oxytoma subzitteli*, *Minetrigonia katayamai* Kobayashi and Ichikawa, *Palaeopharus* aff. *perlongus* (Böhm), *Anodontophora* sp., *Mytilus* sp., *Rhynchonella* sp. etc., (4) consists of 50 m thick black shale with sandstone layers, and yielded *Lima naumanni* Kobayashi and Ichikawa, *Lima naumanni obliqua* K. and I., *Oxytoma zitteli* (Tell.), *Halobia* sp., *Minetrigonia katayamai* K. and I., *Rhychonella nasai* K. and I., *R. tokomboensis* Kobayashi, *R. hirabarensis* Tokuyama, *Sakawairhynchia katayami* Tokuyama etc.

The boundary between this formation and the subjacent Permo-Carboniferous Gampi Group or the Beppu Group is a fault at most outcrops.

(b) The Momonoki Formation, 850–1050 m thick: The upper part of this formation is an alternation of sandstone and shale with coal seams; and yielded *Halobia* sp. aff. *aotii* Kobayashi and Ichikawa.

The lower part is an alternation of sandstone, shale and conglomerate with thin coal layers. The contact between this formation and the Hirabara Formation is a slight disconformity (Hase, 1951); some pebbles of the Hirabara Formation are found in the basal conglomerate of this formation.

(c) The Aso Formation, 1550–1700 m thick: although first named by Katayama (1938), it was subdivided into three members by Katayama and Hase (1947), whereas Tokuyama (1958) divided it into four members. The lower part of this formation consists of fine to coarse grained sandstone with black shale with thin layers of conglomerate and coal seams in the lower part. The middle part is an alternation of sandstone and shale with coal layers and *Eumorphotis* aff. *spitsbergensis* (Böhm), *Tosapecten suzukii* (Kobayashi), *Lima naumanni*, *Lima naumanni obliqua* K. and I., *Chlamys mojsisovics* K. and I., *Cuneigervillia* sp., "*Rhynchonella*" *asoensis* Tokuyama, *R. subflabellata* Tok., *Plagiostoma* sp. etc. The upper part is of sandstone with black shale which yielded *Tosapecten suzukii* (Kob.), *Anodontophora* sp., "*Rhynchonella*" *asoensis* Tok., "*R*". *subflabellata* Tok. and *Palaeopharus* sp. etc. According to Tokuyama (1958) the contact between the Momonoki Formation and the base of this formation is a slight unconformity, and this boundary had been included in the Momonoki Formation of Katayama and Hase.

(D) The Mukaihata Area

Recently Hase (1961) described *Monotis scutiformis typica* (Kiparisova) and *M. mukaihatensis* Hase from Mukaihata, Miwa-cho, Kuga-gun, Yamaguchi Prefecture. According to him the Triassic strata seem to be a small "Schuppe" in the sheared Paleozoic rocks of the Kuga Group, which comprises black to dark gray siltstone with fine sandstone laminae He states that the *Monotis* Bed of Mukaihata may better be assigned to the lower Norian than to the upper Norian, and may be correlated to the Kamosho Formation.

Permo-Triassic boundary

In the Kitakami Massif the contact between the Lower Triassic and the Permian rocks can be observed at several outcrops. One of which is at 600 m west of Sawanaichaya of Aonozawa, Karakuwa-cho, Motoyoshi-gun, Miyagi Prefecture. At this place the 30 cm thick basal conglomerate of the Hiraiso formation rests upon the black slate of the Upper Permian Toyoma Formation with a slight uneven surface and discordance in their strike and dip as already mentioned by Onuki and the writer (1959, p. 54). The other locality is at Hiraiso, the type locality of the Hiraiso Formation, where the Osawa Formation and the Fukkoshi Formation, and the basal conglomerate of the Hiraiso Formation (5 m. thick) rest upon the black slate of the Upper Permian Toyoma Formation. The latter is considered to overlie the Iwaizaki limestone which yielded some Middle Permian fossils, i.e. *Neoschwagerina*, *Parafusulina*, *Verbeekina* at Iwaizaki, about 5.5 km northeast of the boundary. The outcrop of the contact is a disconformity, and the rock characters and the fauna show a distinct hiatus between these formations. From the calcareous light greenish sandstone above the basal conglomerate there have been found such important fossils as, *Entolium discites* (Schloth.), *E. discites microtis* (Bitt.), "*Pecten*" cf. *ussuricus* Bitt., "*P*". aff. *minimus* (Kipar.), *Leptochondrica alberti virgalensis* (Witten.), *Pseudomonotis iwanowi* (Bitt.), *Anodontophora* aff. *fassaensis* Wiss., *A.* cf. *ovalis* Wiss., *Myophoria* aff. *ovata* Goldf., *M. laevigata* Alb., and *Gervilleia* cf. *exporrecta*(Leps.). This fauna is equivalent to the *Ophiceras* Beds in Eastern Greenland (Spath, 1935) and almost comparable with the basal conglomerate of the Lower Triassic formation of Ussuri where the contact between the Lower Triassic and the Permian is an unconformity. The same kind of contact as mentioned above can also be observed at Takizawa, at about 7km. northwest of Shizugawa and at Karakuwa in Ogachi. At both outcrops the 10–15 m. thick basal conglomerate lies upon the black slate of the Upper Permian Toyoma Formation with uneven surface. At the former outcrop the basal conglomerate seems to rest upon the black sandy slate of the Toyoma Formation with almost flat surface, but the discordance in strike and dip can be recognized between these beds.

Consequently the unconformity between the Lower Triassic Hiraiso Formation and the Upper Permian Toyoma Formation with the *Bellerophon* fauna is a slight disconformity. However considering from the general geostructures and distribution of those formations there is a structural difference between them. Further the lithologic character of these formations in juxtaposition changes abruptly at this boundary.

From faunal evidence the age of the basal conglomerate may not be correlative with the base of the Otoceratan, but to the Gyronitan as in the case of Ussuri.

In the Kwanto Massif the Lower Triassic series is represented by the Iwai and Shionosawa Formations. The contact between the middle Scythian Iwai Formation and the Permian beds can not be observed, but at about 60–70 meters below the Owenitan Beds there is a conglomerate with *Neoschwagerina* limestone pebbles. This conglomerate was first described by Yabe and Shimizu (1933, p. 89), and concerning it they said that whether this is a limestone of primary origin and itself Permian in age, is a question yet to be settled.

The writer had a chance to make field observations in 1962 and found that this conglomerate is composed of angular pebbles of green rocks, i.e. diabase, serpentine, and other basic igneous rocks, and of limestone with *Neoschwagerina*, and the matrix consists of calcareous sandstone. However, the stratigraphical relation with the superjacent *Owenites* Beds could not be determined owing to the poor outcrop. The contact below this conglomerate, may be a fault with the Fusulinid limestone of Shohozan along the Kanyo valley.

The other Lower Triassic outcrop in the Kwanto Massif was first noticed by Iwai (1947), and subsequently Ozaki and Shikama (1954) discovered Lower Triassic fossils as *Eumorphotis multiformis* (Bittner), *Anodontophora canalensis* Catullo, *Gervilleia* cf. *exporrecta* (Lepsius) etc., from a limestone block in the conglomeratic schalstein. They named this fossiliferous beds the Shionosawa Formation and described the fauna in a subsequent paper (Ozaki and Shikama, 1954, p. 42–45), but the contact between this Lower Triassic formation and the subjacent strata was not determined. Judging from their cross section the *Eumorphotis* beds is probably underlain by dark gray slate (Permian ?).

In the Maizuru zone the contact between the Lower Triassic and Permian has been recorded at many localities. In the Fukumoto district, Okayama Prefecture, Nakazawa, Shiki and Shimizu (1954) suggested an unconformity between the Lower Triassic Kusano Formation of sandstone and conglomerate with *Myophoria* aff. *laevigata* (Zeigh.), "*Pecten*" *sichoticus* Bitt., *Eumorphotis* etc., and the Upper Permian Kose Group. Subsequently Nakazawa and Shiki (1954) found an angular unconformity at Miharaiyama between the basal conglomerate (15–30 m. thick) of the Lower Triassic Niikuradani Formation of chert, serpentine, altered andesitic green rocks, limestone with *Neoschwagerina*, *Pseudofusulina*, and calcite pebbles, and the Upper Permian Minamitani Group. The age of the Niikuradani Formation is based upon *Myophoria* aff. *laevigata* which was found from the superjacent Gannosudani Formation. They stated that this unconformity may be important in the hiatus of the late Paleozoic crustal movements in Japan. Later they found the contact at

Okuyama-hontani, Narawara in the Oe district, Kyoto Prefecture, and observed that the basal sandstone of the Lower Triassic Narawara Formation, which yielded "*Pecten*" cf. *ussuricus, Claraia* aff. *decidens* Bittner etc., rests upon the Upper Permian beds of the Yakuno Group with a clino-unconformity (Nakazawa and Shiki, 1958, p. 64).

The unconformity was also discovered at the base of the Hannyaji Formation of the Shidaka Group, but concerning the age of this group opinions diverge among authors. Nakazawa, Shiki, Shimizu and Nogami (1958) and Nakazawa (1958) summarized the Triassic System in the Maizuru Zone and pointed out that the contact between the lower Triassic and Permian appears as a para-unconformity at all of the outcrops, but from the geostructure the relation must be a clino-unconformity. The writer thinks these cases are similar to those in the Kitakami Massif.

In the Outer Zone of Southwest Japan, the Lower Triassic Series is distributed at Kurotaki and Taho in Shikoku and Kamura in Kyushu as already mentioned.

Yehara stated on the Permo-Triassic boundary at Taho that "There is no unconformity nor abrupt change in the kind of rocks (except that the brownish-black limestone containing *Neoschwagerina craticulifera* is limited to the Permian); but there is a faunal break between the two systems, and the faunal boundary must be drawn within the shale (60 m. thick) intercalated between the *Neoschwagerina* limestone and the *Meekoceras* beds." He said that at Taho, as in the case of India and Timor, the stratigraphical relation between the Lower Triassic and the Permian is a conformity; but there may be a faunal break between the two systems within an extremely narrow distance (1927, p. 146–147). Later, at the same place, Shimizu (1932, p. 10) observed the boundary and noticed that it is a fault. According to Shimizu the boundary between the Lower Triassic limestone and the shale beds, and between that shale beds and the *Neoschwagerina* limestone are obscure, but there is a possibility of a strike fault between the shale beds and the Permian *Neoschwagerina* limestone. Subsequently Suzuki (1935, p. 10–11) agreed with Shimizu's observation and pointed out that the Taho formation is inserted by fault extending in E-W trend, and the Triassic comes into contact with the Permian limestone by fault and with the Torinosu Formation (Jurassic) or Ryoseki Formation (Cretaceous) also by fault. Still later, Ikebe (1936) found a thrust fault between the Lower Triassic Taho Formation and the Permian limestone, the former overlapped by the later, and proposed the name of "Uonashi thrust". The Permian limestone was named by Ikebe as the Nomura Group and he recognized the following fossils: *Neoschwagerina craticulifera* Schwager, *Verbeekina verbeeki* (Geinitz), *Staffella*? sp., *Bigenerites*? sp., *Glomospira* ? sp., *Lonsdaleia* sp. and *Mizzia velebitana* Schubert. Ikebe also found another Lower Triassic limestone which yielded *Gervilleia* cf. *exporrecta* Leps. at Asahi-machi, 2 km east of Taho. At this outcrop, the Lower Triassic limestone comes into contact with the Permian Nomura Group by a fault of E-W strike and 50 N dip.

The present writer had an opportunity to observe the boundary in 1960–'62 and came to the conclusion that the boundary between the Taho Formation and the Permian beds is a distinct fault with fault breccia and the general strike of the Taho Formation differs from that of the Permian (Fig. 15). The Permian rocks at the thrust portion are composed of greywacke sandstone with banded black shale, both of which are so brecciated that their original bedding is obscured. At present there is no evidence for a conformity between the *Anasibirites* Beds of the Taho Formation and the *Neoschwagerina* limestone. Moreover there is a distinct faunal break between them, and the lower Scythian fauna from the Otoceratan to the Flemingitan and the larger part of the Upper Permian are missing.

Recently an outcrop showing the contact between the Lower Triassic and Permian was found by Kambe (1957) at Kamura, Takachiho-machi, Miyazaki Prefecture in southern Kyushu. According to Kambe the Lower Triassic Kamura Formation, which is character-

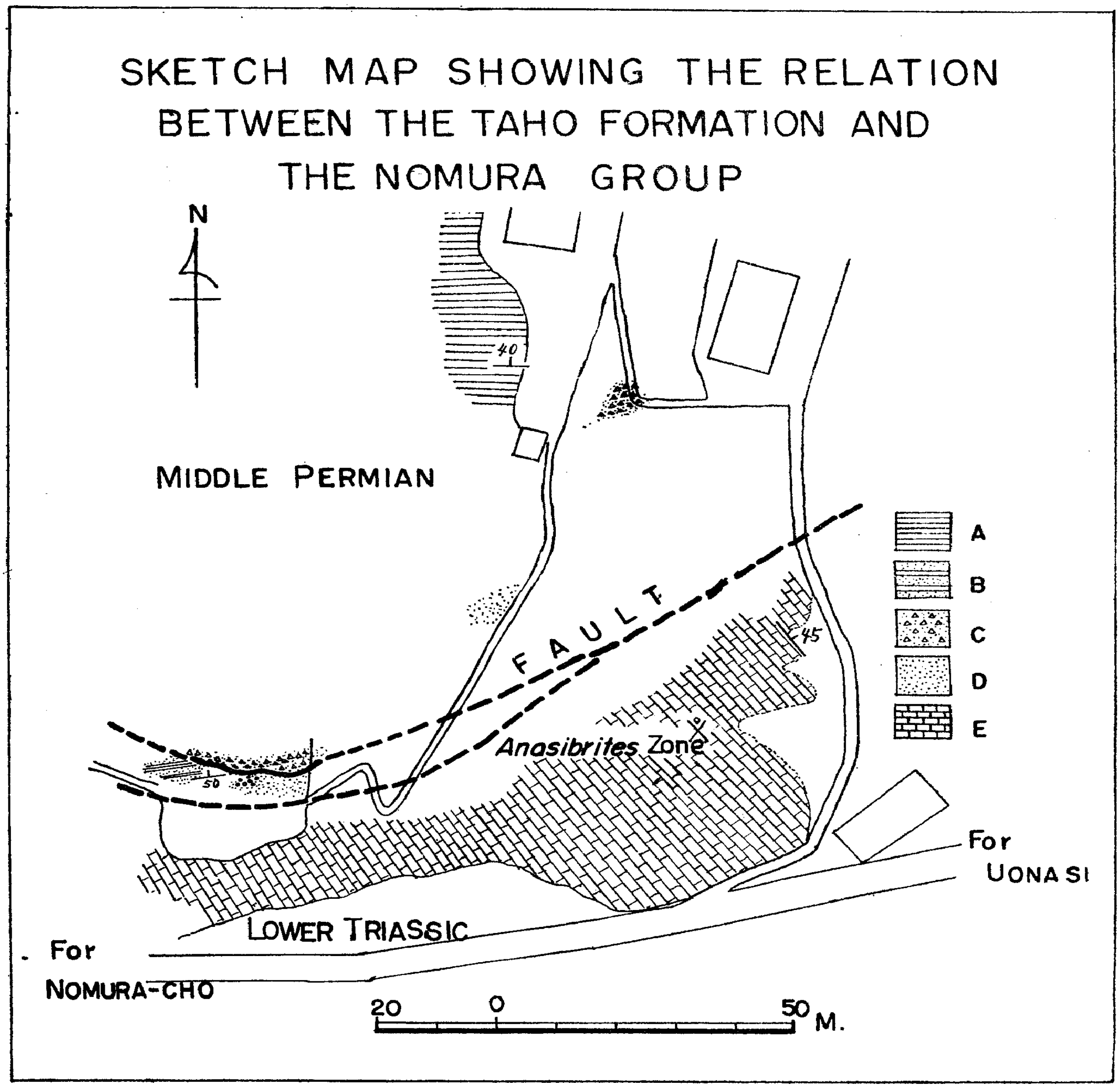


Fig. 15.
A: disturbed slate, B: banded alternation of sandstone and slate, C: brecciated sandstone, D: sandstone, E: argillaceous limestone (Taho Formation).

ized by the *Aspenites* fauna, rests upon the Permian *Yabeina* limestone with conformity. However the writer thinks that there is a hiatus between them, and it is marked by the absence of beds of the Chideruan Stage of the Upper Permian to the beds of Gyronitan Stage of the Lower Triassic.

Outside of Japan, Griesbach (1891) drew the boundary between the Permian and the Triassic System below the *Otoceras* Beds, which yielded *Otoceras woodwardi* Griesb. and *Ophiceras medium* Griesb., in the Himalayas. Waagen (1895, p. 1) drew the said boundary at the base of the Ceratite Formation. He suggested that considerable physical changes in the conditions of the deposition of rocks took place between the formation of the topmost beds of the *Productus* limestone (Upper Permian) and strata of the Ceratite Formation. He also stated that some unfossiliferous beds intervene at most places and conglomerates sometimes are deposited at the base of the Ceratite Formation. Waagen considered that a certain amount of denudation must have taken place before deposition of the later beds. Diener (1895) placed the boundary between the *Otoceras* Beds characterized by *Otoceras woodwardi*, *Ophiceras sakuntala*, *Prosphingites*, *Medlicottia* etc. and the *Productus* shales just as done by Griesbach. Diener (1900, p. 1–5) also discussed on the boundary between the Triassic and the Permian in his paper, "Ueber die Grenze des Permo-und Triassystems im ostindischen Faunengebiete", and said that the marine Permian strata of the Alps which lies below the Werfen Beds is not equivalent with the fauna of the *Otoceras* of the Himalayas, but are analogous with the *Productus* Limestone. Diener considered that the *Otoceras* Beds is older than the fossiliferous part of the Alpine Werfen Beds, and suggested a faunal relation between the Werfen fauna and the fauna of *Proptychites* Beds of Ussuri. Krafft (1901, p. 275) stated that "*Medlicottia*" (*Episageceras*) *dalailamae* Diener from the *Otoceras* Beds of the Himalayas is identical with "*M.*" (*Episageceras*) *wynnei* Waagen from the Upper *Productus* Limestone of the Salt Range in sutures, and that the upper part of the middle *Productus* Limestone of the Salt Range and the Ammonite (*Otoceras*) horizon of the *Productus* shales, which both yielded *Xenaspis carbonaria* Waagen and *Cyclolobus oldhami* Waagen, are comparable. Nevertheless, Noetling (1903), drew the boundary between the Permian and Triassic System below the *Meekoceras* Beds (*Meekoceras lilangensis* zone) in Spiti or below the *Prinolobus noetlingi* zone of Niti. Accordingly, Noetling placed the *Otoceras woodwardi* zone and the *Ophiceras tibeticum* zone in the Upper Permian System. The divergence in opinion may be because there is a gradual transition from the *Productus* shales to the *Hedenstroemia* Beds in the Himalayas. The lithological change from the *Meekoceras* Beds to the *Ophiceras* Beds is more abrupt than between the *Otoceras* beds and the *Productus* Shales (Diener, 1912). In the Alps there is no distinct unconformity between the Permian *Bellerophon* Limestone and the shales of the lower Werfen (Seis) Beds, but the lithological change between the two beds is rather more abrupt than between the *Productus* Shales and the *Otoceras* Beds. Diener (1912) stated that

> There is no stratigraphical break in the uninterrupted sequence of beds, which in the Himalayas connects the Permian and Triassic system, but there is a distinct paleontological break or hiatus at the base of the *Otoceras* beds. In the Himalayan region there is no gradual shading-off from a Paleozoic to a Mesozoic marine fauna through an intermediate group. This absolute distinction between the brachiopods of the Kuling shales and of the *Otoceras* beds is so sharp that the limit between the two faunae offers itself as the most natural boundary of the two systems.

Diener also correlated the Alpine *Bellerophon* Limestone with the Upper *Productus* Limestone of the Salt Range and with the Kuling Shales with *Bellerophon uigilii* of the Himalayas.

At Djulfa in Armenia, Arthaber (1911, p. 194) stated that the Lower Triassic Cephalopod zone with *Xenodiscus*, *Stephanites* and *Paratirolites* was quite conformable with the Permian Cephalopod zone, which is characterized by *Gastrioceras* and *Popanoceras tschernyschewi* Stoj., as in the Salt Range and the Himalayas without any breaks, and that it is synchronous with the Kund-Chat and Jabbi Beds of the Upper *Productus* Limestone of the Salt Range of India.

Böse (1917, p. 43–46) placed the *Bellerophon* Limestone of the Alps and the *Hungarites-Otoceras* Beds of Djulfa in Armenia above the Kuling Shales of Spiti, which yielded *Bellerophon*, or in the Upper Permian System, and in a horizon almost comparable to the zone of *Episageceras wynnei* of the Salt Range. Spath (1934, p. 24) followed Böse's opinion that the Djulfa Beds should be placed above the Upper *Productus* Limestone and the *Paralecanites* Beds of the *Bellerophon* Limestone of the Southern Alps. Spath (1934, p. 24) drew the boundary between the Triassic and the Permian above the zone of *Paralecanites sextensis* (Uppermost Prototoceratan) or below the zone of *Otoceras woodwardi* (Otoceratan).

In Southern China, Chao (1959) recognized a remarkable break between the Triassic and Permian Systems in western Kwangsi and said that sometimes a part of the lower divisions is absent and at places the Upper Permian Hoshan Limestone is wanting and this is well shown in the Chashanao section between the Hochieh and the Maokou Limestones. The writer was attracted by the Lower Triassic sections illustrated by Chao, which show a remarkable unconformity between the Triassic and the Permian Systems. A break is demonstrated in the section at the east of Lolou village in the Linglo district, where the Middle Permian Maokou Limestone, which yielded *Neoschwagerina*, *Verbeekina*, *Wentzelella*, *Waagenophyllum* from its lower part and *Yabeina* in its upper part, is succeeded by the Lower Triassic shales with ammonoid fossils of Gyronitan or higher stages. At another section at Kaoyunling, southwest of Tsoteng in the Tientung district, Chao demonstrated a remarkable disconformity between the Lower Triassic and the Upper Permian Hoshan Limestone. According to Chao's (1959) columnar section there are considerable breaks between the Kaoyunling and Naliling sections, and between the Naliling section and Chashanao sections. In the latter section the sediments of the Flemingitan and the Owenitan stages are wanting, and higher beds (*Subcolumbites* Beds) immediately lie upon the Maokou Limestone with remarkable unconformity.

In Timor, Wanner (1911, p. 178) discovered the Lower Triassic formation at Biwak Kapan and mentioned on the boundary between the Triassic and the Permian Crinoid Limestones. According to him the boundary is a transitional change from the Permian reddish Crinoid Limestone, which yielded Brachiopods and *Fenestella*, to the Lower Triassic formation with limestone bands containing "*Meekoceras*" *timorensis* (Wanner), *M. indoaustralicum* Wanner, *Flemingites timorensis* Wanner, *Pseudosageceras multilobatum* Noetling. Later Welter (1922, p. 84) observed the boundary at the same place as studied by Wanner, and discovered it to be within a distance of only 1 cm between the Permian *Productus* zone and the Lower Triassic *Meekoceras* zone.

In North America, White (1880) described a marine Lower Triassic fauna from the Aspen Mountains of Idaho, which he stated to be older than any other Triassic fauna known in America and younger than any known Permian except the fauna of the Lower Triassic *Meekoceras* Beds.

Peale (1879) observed that this formation lies with conformity upon the Carboniferous, and below the Red Beds. The subjacent Carboniferous limestone yielded *Productus multistriatus* Meek, which was recorded by Smith from the uppermost Paleozoic beds of California, and which is said to be a characteristic Permian fossil in northern Europe. Smith (1901) observed the boundary below the *Meekoceras* Beds in Inyo County, California, and mentioned that below it there are several hundred feet of non-fossiliferous shales underlain with a siliceous *Fusulina* limestone.

In his study of southeastern Idaho, Girty (1927, p. 50) drew an unconformity between the Upper Permian Rex Chert Member of the *Phosphoria* Fromation with *Productus* and the Woodside Shale with *Terebratula* and *Myalina* which lies below the *Meekoceras* zone of Ross Fork Limestone. He stated that there was local emergence and a local condition of non-marine deposition between these epochs, and that the Permian material may have drifted to its place of burial.

Subsequently Muller and Ferguson (1939, p. 1581) found important lower Scythian fossils, namely "*Claraia*" *stachei* (Bittner), "*C.*" *aurita* (Hauer) and "*C.*" *clarai* (Emmrich), from the bituminous shales and limestone about 150 feet above the base of the Candelaria Formation of Nevada which rests with unconformity upon the Permian and with angular unconformity upon the Ordovician. Until this time no pre-*Meekoceras* fossil zone of the standard division had been discovered in North America, but this occurrence of "*Claraia*" shed light on the correlation of the pre-*Meekoceras* Beds in North America. Especially "*Claraia*" *clarai* is restricted to the lower part of the Seis Beds of the Werfen Formation in southern Tirol, and "*Claraia*" *stachei* had been described by Spath (1930, p. 46–47) from the *Ophiceras* and *Proptychites* Beds of Greenland. This ranges according to Spath (1935) from the Upper *Glyptophiceras* Beds to the *Proptychites* Beds or from the upper Otoceratan to the lower Gyronitan, "*C.*" *clarai* also had been described from Eastern Transbaikalia by Kiparisova (1932, p. 22–23, 29).

Newell and Kummel (1941, p. 205) discussed on the boundary in Idaho, Montana and Wyoming and stated that a hiatus exists between the lower Scythian, which is represented by the Woodside and Dinwoody Formations, and the underlying Mid-Permian *Phosphoria* Beds. This involving all of the Upper Permian (Captian and Ochoa), and they recorded an unconformity between the *Phosphoria* Beds and the Woodside and Dinwoody Formations of the Lower Triassic in their subsequent paper (Newell and Kummel, 1942, p. 949).

Recently Kummel (1954, 1957) stated that the contact between the Dinwoody Formation and the *Phosphoria* Formation in southwestern Montana and southwestern Idaho is a conformity and no physical evidence of a hiatus has been recognized. But in southwestern and central Wyoming and the southern Wasatch Mountains in Utah, there is evidence of an unconformity between the Dinwoody and *Phosphoria* Formations. According to Love (1957) the Permian-Triassic contact in the Casper-Alcova area in central Wyoming is at the top of the Ervay Limestone Tongue of the *Phosphoria* Formation, even though there are red beds and anhydrites both above and below it. In another area of northern and northeastern Wyoming, the same feature was observed by Love (1957). Hose and Repenning (1959) described the stratigraphy of the Confusion Range in Utah and discussed on the contact between the Lower Triassic Thanyes Formation and the Permian Gerster Limestone. They stated that the lower contact of the Thaynes formation is at the base of a light olive-gray and pinkish gray partly bioclastic limestone or very light gray porcellanite, and that directly beneath the contact is a pale red to yellowish gray limestone which contains chert nodules and no angular unconformity exists between the two formations in the area between Cowboy Pass and the southern part of Millard Rdige. The Thaynes Formation, however, does not indicate the lowermost Triassic but rather the late Early Triassic (Owenitan). Accordingly Hose and Repenning (1959) pointed out that the absence of the lower half of the Lower Triassic suggests a regionally significant hiatus at the Gerster-Thaynes contact, although no physical evidence for such a hiatus has been found.

In northern Alaska the Permian-Triassic boundary between the Beds with *Otoceras boreale*, *Ophiceras* cf. *tibeticum*, *O.* spp., *Proptychites* spp., "*Claraia*" *stachei* and the Beds of Permian age is considered to be a conformity along the Canning River of the Arctic coast, but in the same correlation table (Chart 8a) the unconformity was drawn between the Beds with *Boreosomus* (placed in the same stratigraphical horizon as the *Otoceras* Beds of Canning River) and the Permian System (Kummel, 1957).

In Canada the occurrence of the "*Claraia*" *stachei* Beds has been reported from the Alberta Rocky Mountains, Northeastern British Columbia and south of the Peace River, the Dunedin River, and from the Liard River and the Toda River district. The contact between these beds and the Permian has been recorded to be a conformity in the Alberta Mountain and the Dunedin River. In Alberta of the Canadian Rockies, Warren (1945, p. 481) recognized that the Sulphur Mountain Member, which yielded many Lower Triassic ammonites from the Otoceratan to the Flemingitan age, of the Spray River Formation rest with apparent conformity upon the Rocky Mountain Quartzite of Pennsylvanian and Permian ? age, although there is undoubtedly a time break at the base of the Spray River Formation. Later, Mclearn and Kindle (1950, p. 128) suggested that some uplift and erosion at the end of Paleozoic may have taken place in Northeastern British Columbia, but no positive evidence was given.

In Arctic Canada, Tozer (1961) stated that the Permo-Triassic boundary is not marked by an angular unconformity in the Sverdrup Basin and in all sections of Queen Elizabeth Island where the Triassic rests upon the Permian, the rocks of each system appear to be structurally conformable, however, an abrupt change in lithology occurs at this boundary and it is probably para-conformable indicating an interval of non-deposition and marine regression, and that there is no evidence of continuous sedimentation from the Permian to the *Otoceras* Beds of the Lower Triassic. From the regional standpoint Tozer considered that the Permo-Triassic boundary is probably a gently undulation unconformity. Tozer's opinion seems to describe the boundary between the the upper part of the Toyoma Formation and the Hiraiso Formation of the southern Kitakami Massif in Japan.

In Eastern Greenland, Spath (1935) subdivided the Lower Triassic System into five fossil beds, namely the *Glyptophiceras*, the *Ophiceras*, the *Vishnuites*, the *Proptychites* and the *Anodontophora* Beds in ascending order, and considered them to rest on the Permian. Kummel (1957) placed this *Glyptophiceras* Beds of the lowermost Scythian age upon the Permian with conformity.

In Ussuri, which is near to the Japanese Triassic province, Kiparisova (1938, p. 294) described the boundary in Russuki Island. According to her, the basal conglomerate (Horizon I) with the Lower Triassic fauna [(*Gervilleia exporrecta* Leps., *Myophoria laevigata* (Ziet.) and *Anodontophora canalensis* (Cat.)] rests upon the eroded surface of granite with remarkable unconformity, and the superjacent beds (Horizon II) yielded *Velopecten bittneri* Kiparisova and *V. minimus* Kipar. Along the western coast of the Ussuri Gulf, the basal horizon represented by conglomerate rests with unconformity upon the eroded surface of the Permian which yielded *Protophiceras nicolai* Diener, *Myophoria laevigata* Ziet., *Gervilleia exporrecta* Leps. according to Wittenburg (1916) (Kiparisova, p. 295–296). The same basal conglomerate was recorded by Kiparisova (1938) from the Eastern Coast of the Ussuri Gulf based on the field notes of Krysthtofovichs, from the Region of Abreak Bay based on Preobrajensky's exploration (1927), from the Putiatin Island where the Lower Triassic beds with *Eumorphotis multiformis* Bitt. and *Pseudomonotis* cf. *tridentina* Bitt. etc., rest with unconformity upon the Permian shales and sandstone with a flora of *Cordaites*. The same basal conglomerate has been recorded from Askold Island, the Western coast of the Amur Gulf, and from the Lianchikhe River. These columnar sections are given in the paper of Kortz (1959). From the faunal character of *Proptychites nicolai*, *Gervilleia exporrecta*, *Myophoria laevigata* and *Anodontophora canalensis* etc., the writer considers that this basal conglomerate may not be the true basal zone (Otoceratan) of the Scythian age. Kummel (1959, p. 433) referred it to the Gyronitan age in his paper. The writer believes that this basal conglomerate in Ussuri bears close relation to the basal conglomerate of the Hiraiso Formation of the Kitakami Massif from the rock facies and faunal characters. Consequently the stratigraphical horizon of the basal conglomerate of Ussuri and Kitakami Massif may be drawn not below the Otoceratan, but between the Otoceratan and the Gyronitan stage.

Triassic-Jurassic Boundary

Concerning the boundary between the Triassic and Jurassic Systems, the stratigraphical relation between the *Monotis* bearing bed and the superjacent Jurassic beds may be focussed also in Japan. In the Nariwa and Yamaguchi provinces, the Rhaetian problem has been discussed by many authors in Japan. In Shikoku and Kyushu the Triassic-Jurassic boundary has been drawn between the *Monotis* Bed and the Jurassic Torinosu Formation, but the actual boundary generally is a fault contact.

In the Kitakami Massif the Triassic-Jurassic boundary is between the Upper Triassic Saragai Group and the Lower Jurassic Niranohama or Atagoyama Formation, but the actual contact could not be observed as already mentioned. The uppermost Chonomori Formation (the *Monotis zabaikalica* Bed) of the Saragai Group is composed of light gray arkose sandstone with carbonaceous matter and the lithology closely resembles the Niranohama Formation which yielded *Alsatites onoderai* Matsumoto and *Isastrea* (*Latomeandra*) *yabei* (Eguchi), both of which are of Lower Juassic Hettangian age. The Atagoyama Formation rests upon the *Monotis* Beds in the vicinity of Motoyoshi-cho, but the actual contact could not be observed. The Atagoyama Formation consists mainly of dark gray sandstone and sandy shale at the type locality, but no paleontological evidence has been found. From the lithologic characters it is judged to be Lower Jurassic and to correspond to the Niranohama or Hosoura Formation in the vicinity of Utatsu-cho. There are considerable breaks in the distribution of the Jruassic and the *Monotis* bearing bed, especially in the Kitakami Massif where the *Monotis* bearing Saragi Group and the Lower Jurassic Niranohama and Hosoura Formations are probably covered with clino-unconformity by the Middle Jurassic Aratozoaki and Arato Formations in the vicinity of Utatsu and Shizugawa-cho. The Middle Jurassic series rests directly upon the Middle Triassic Isatomae Formation with distinct unconformity. For such reason the Saragai Group shows close relation with the Lower Jurassic in distribution, even though the Middle Triassic Isatomae Formation below and Lower Jurassic Series above are missing in the Karakuwa, Hashiura and Mizunuma districts.

Based upon the unconformity and geostructural difference between the Saragi Group and the Niranoyama Formation, Onuki and Bando (1958) proposed the "Matsuiwa Crustal Movement" and considered the geological age to be Rhaetian. Hayami (1959) reported on the development of the lower part of the Saragai Group in the Mizunuma district, about 8 km northeast of Ishinomaki City, and stated that about 300 m thick arkose sandstone in the Mizunuma district is equivalent to the Upper Triassic Saragai group even though there is no paleontological evidence. He suggested that the lower part of the Niranohama Formation may be Rhaetian from the occurrence of the *Buramesia*, a genus hitherto known from the Rhaetian Napeng Beds in Burma. Equivalent or strata comparable with it also occur in Laos and the Norian bed of Molucca. The writer thinks that the non-fossiliferous arkose sandstone superjacent to the *Monotis zabaikalica* Bed may be a facies transitional to the Niranohama Formation and also be Rhaetian in age, although some dobut is reserved. In the Karakuwa area, the Lower Jurassic Kosaba Formation of the Karakuwa Group rests directly upon the Middle Triassic Isatomae Formation; the Saragai Group is missing between them. In the Hashiura district the Lower Jurassic Magenous Formation rests upon the Isatomae Formation with unconformity, without the Upper Triassic bed between them. In Nariwa Province the Upper Triassic Nariwa Group is distributed in a rather wide area and has yielded a rich *Monotis* fauna and plant remains. These fossil yielding beds have been discussed by many previous authors. The first work on the plants was by Yokoyama who considered the plant bed to rest upon the Norian *Monotis* Bed. This opinion was suported by Oishi (1930–40) who made paleobotanical studies on the so-called Nariwa Flora. Kobayashi (1935–38) stressed that the plant bed lies blow the *Monotis* Bed in the Nariwa and Yamaguchi areas and its age was judged to be Karno-Norian. In Nariwa and Yamaguchi province the Upper Triassic *Monotis* Bed is covered by the Cretaceous Kenseki Group with clino-unconformity. Although the boundary between the Jurassic and the Upper Triassic cannot be observed, the Rhaetian problem must be reserved because a rather thick bed of sandy shale, arkose sandstone and black shale with plant fossils rests upon the *Monotis* Bed in the Nariwa area.

In the eastern part of Shikoku the Upper Triassic and the Upper Jurassic Torinosu Formation are in fault contact and the Lower Jurassic has not been found. In this area the Torinosu Formation comes into close contact with the Karnian Bed (Kochigatani Group), but not with the Norian *Monotis* beds. According to Hirayama, Yamashita, Suyari and

Nakagawa (1956) the Torinosu Formation almost comes into contact with the Sabutani Formation which corresponds to the lower part of the Kochigatani Group of Karnian age, or with the Middle Permian Hisone Formation by fault. However from the development of the basal conglomerate the boundary between them was thought to be an unconformity. In the Sakawa Basin the Upper Triassic Kochigatani Group and the Torinosu Formation seem to be in fault contact at Shimoyama and Kochigatani. At Shimoyama the lower part of the Kochigatani Group with *Paratrachyceras* comes into contact with the sandstone of the Torinosu Formation by a fault extending in E-W direction. According to Katto, Suyari, Ishii and Ichikawa (1956) the upper Kochigatani Group (*Monotis* bearing bed) comes into contact with the Torionosu Formation by a fault at Otogo in the Kochigatani area.

The boundary between the Upper Triassic and Jurassic series in Kyushu is expected between the Torinosu Formation and the Upper Triassic. Matsumoto, Noda and Miyahisa (1962) stated that the Jurassic Torinosu Formation rests upon the Triassic *Monotis* Bed with unconformity in the vicinity of Tanoura, western Kyushu.

In Yamaguchi Province the Triassic and Jurassic series show independent distribution because of the so-called Nagato Tectonic line. The actual boundary in this area is not yet known.

From a survey of literature of the boundary between the *Monotis* Bed and superjacent Jurassic bed in the Circum-Pacific region, an analogous relation and some resemblance can be found with the case of Japan. For instance, in New Zealand the Otapirian series (Hecter, 1870) in the Hokonui district, Southland, has been considered to be Rhaetian by Hector (1878) and Marwick (1953), but to be Lias by Cox (1878) and to range from late Karnian to the Rhaetian by Trechmenn (1918). This series is characterized by the common occurrence of *Clavigera* and *Ratsellingera*, and yielded *Monotis clavata* Marwick, which is almost the same as *M. zabaikalica* Kiparisova or *M. kurosawai* Sakaguti from Ussuriland and Japan, and *Arcestes* cf. *rhaeticus* Clark which was recorded by Trechmann from 3000 feet or more above the *Monotis* Beds on the coast of Kawhia. *Monotis* was generally accepted by New Zealand geologist to be typical of the Wairoa Series (Norian) (Marwick, 1953, p. 19). According to Grant-Mackie (1959) the boundary between the Rhaetian Otapirian Beds and the Jurassic Aratauran Beds (Hettangian-Sinemurian) is a conformity and deposition was continuous thus there is no change in lithology in the Awakino gorge, south-west Auckland.

In South America the *Monotis ochotica* bearing limestone in Peru, Ecuador, and Columbia has been regarded to be in part, Norian in age, and in eastern Ecuador and northern Peru these limestone seem to grade into the Jurassic without break (Kummel and Fuchs, 1953, p. 113).

In North America there is reported to be an unconformity in Shasta County, California, between the Upper Triassic and Lower Jurassic beds, where the uppermost Triassic bed yielded the characteristic Rhaetian ammonite *Choristoceras marshi* Hauer and the Jurassic beds the Sinemurian fauna (Sanborn, 1952 in Silberling, 1957, p. 1471). In Carson City Reno area of Nevada the contact is described to be a conformity between the *Monotis subcircularis* Bed (identified by Muller) and the "*Arietites*" bearing bed (Early Jurassic age) (Gianella, 1936, Silberling, 1957, p. 1472). In the western Humboldt Range of Neavada, there has been suggested an unconformity between the *Monotis* bearing beds and the overlying Lower Jurassic beds.

In British Columbia, Westermann (1962) described a rich *Monotis* fauna from the upper part of the Pardonet Formation (Norian). According to him the boundary between the *Monotis* Beds and the basal conglomerate of the Jurassic (Sinemurian or ? Pliensbachian) Fernie Group is a disconformity and the Rhaetian and Hettangian beds are absent between them.

In Alaska the boundary was considered to be an unconformity (Kummel, 1957); the

Rhaetian beds are lacking.

In Arctic Canada, Tozer (1961) stated that non-marine deposits (Upper Heiberg) occur above the youngest marine Triassic beds, which yielded *Monotis ochotica* of Norian age and the Jurassic, but the boundary between the lowermost Jurassic-Triassic will depend upon the age of the non-marine upper Heiberg Beds. According to Tozer the first Jurassic marine transgression after the Norian in the Archipealgo was the Toarcian, and typical non-marine upper Heiberg Beds are overlain by about 200 feet of sandstone and hard red ferruginous sandstone, with poorly preserved marine pelecypods, including a pteriid and *Pleuromya*. He placed these non-marine beds in the interval between the Norian and the Toarcian and stated that the boundary in the Arctic Archipelago may resemble that of East Greenland.

In East Greenland, the Triassic-Jurassic boundary has been drawn within the non-marine Kap Stewart Formation, from which Rhaetian and Hettangian floras were distinguished by Harris (in Donovan, 1957), in the north side of the Scoresby area.

Tutskov (1954–55) once referred the upper part of the Nariwa Group to the Rhaetian based upon his studies on the marine Rhaetian strata in Russia. However, there is considerable discussion concerning the marine Rhaetian among the Russian geologists. Afizky (1959) discovered some upper Norian ammonites from the Rhaetian strata in the Kolyma River district which were referred to by Tutskov. Consequently the boundary between the Norian and the Rhaetian beds seems to be a problem in this area. Popow (1961) suggested that the ed which yielded the Norian-Rhaetian mixed fauna and that the upper two ammonite zones, namely *Sirenites argonauta* and *Pinacoceras metternichi* zones, sould be included in the Rhaetian age. Some species in the fauna of the Karnian Kochigatani Group in Japan have been recorded from the Rhaetian beds in Ussuriland by Tutskov. Regarding the Rhaetian problem Slavin (1961) asserted that the Rhaetian deposits include formations of ages referable to both the Jurassic and the Triassic.

The Sedimentary Environment and Tectonic History of the Triassic System

The lithologic character of the Lower Triassic formations of Japan can be classified into two types, (1) Conglomerate, sandstone and shale facies and (2) Limestone facies. The first mentioned is represented by the Triassic series in the Kitakami Massif, the Kwanto Massif and the Maizuru Zone.

In the Kitakami Massif several thin layers of arenaceous limestone (10 cm thick) are interbedded in the lower part of the Hiraiso Formation, which is composed of greenish gray sandstone and siltstone. These limestone layers form a coquinoid. The upper part of the Hiraiso Formation consists of an alternation of sandstone and shale without limestone layers.

Limestone nodules or blocks are found in the Lower Triassic formations in the Kwanto Massif and they yielded characteristic ammonite fossils and a bivalve fauna. The lithology of the strata intercalating these limestone blocks consist of black shale, sandstone and a conglomeratic schalstein. The Lower Triassic strata in the Maizuru Zone is lithologically similar to those of the Kitakami Massif rather than to the outer zone of Southwest Japan, being characterized by limestone facies. The Taho Formation (*Anasibirites* fauna) in Shikoku is composed of argillaceous limestone and many coquinoid limestone layers.

In the Kitakami Massif the Lower Triassic series forms a megacyclothem begining with the sandstone and conglomerate facies of the Hiraiso Formation and ranging up to the siltstone facies of the Osawa Formation. Such a sedimentary sequence may be also recognized in the Lower Triassic sections in the Maizuru Zone (Nakazawa, 1958). The upper Scythian strata generally consist of fine-grained sediments which resemble siltstone and banded shale with fine sandstone layers.

Considering from the lithologic characters of the Lower Triassic strata it is recognized in general that their sedimentation commenced with coarse sediments and ended with fine materials. There are several layers of interformational corrugated strata in the coarse grained sediments of early Scythian stage. From these facts it may be that the early Scythian sediments were deposited under a deltaic condition in the littoral zone at the time of transgression, but during the late Scythian the lithofacies indicated that the sedimentation basin changed gradually into a neritic or rather deep sea environment where there was deposited sediments of the flysch type. The limestone facies of the Taho, Iwai and Kamura formations of the middle Scythian Stage corresponds to the type intermediate between the littoral to the nertic environment during the transgressive phase from the lower Scythian.

In the Kitakami Massif the Anisian sediments begin from rather coarse grained ones consisting of sandstone and conglomerate and rest with conformity upon the siltstone of the Lower Triassic Osawa Formation. The coarse grained sediments are called the Fukkoshi Formation, and are discontinuous and variable in facies laterally as well as vertically; their thickness changes locally. Slumping and cross-bedded structures are observed in this sandstone, and contemporaneous mudstone shreds arranged parallel with the stratification are common. The horizons with the intraformational mudstone shreds are restricted to the lower and upper parts of the formation. The contemporaneous mudstone breccia have irregular, rectangular or spheroidal forms and slump into the sandstone with pebbles of chert, siltstone, quartz, diorite, and porphyrite.

Judging from these lithologic and sedimentary features the depositional environment of the early Anisian may have been a shallow shelf of the near shore with a rather steep slope, but the interbedded siltstones suggest a temporarily stagnant water condition. The mudstone shreds are probably due to turbidity currents which torn off or ripped up the mud fragments from the unconsolidated bottom mud bed to deposit them in the argillaceous sediments. Concerning the origin of such slumping structure many previous autors should be mentioned, especially Kuenen (1950), who explained that on a steep slope such as small delta fronts in inland seas, stones and fragments can tumble down separately one by one and in open water, a different type of movement is the sudden slumping due to submarine landslides, rock falls and mud slumps occurs. Koide (1955) stated that the origin of such slumping structure and intraformational shreds are closely related with the process of geosynclinal development and he proposed the name of flowage siltstone for these mudstone shreds. Hatai and Funayama (1956) mentioned that slumping structure may be also due to some kind of submarine sliding before consolidation of the sediments. Crowell (1957) described the process of such disturbances and recognized three processes, i.e. (1) the existance of turbidity currents that bring gravel to the site of deposition (2) the presence of an underlayer of soft mud (3) sufficient bottom inclination so that with instability the mixture of mud pebbles moves downslope and he proposed the name of "sulmping overfold" for the types belong to the larger scale disturbances. At any rate, the intraformational disturbances observed in the Lower Triassic Hiraiso Formation and the Middle Triassic Fukkoshi Formation may be related with the nature of the geosynclinal basin in which the sediments of both formations were deposited. These corrugated beds are found prior to the megacylothems of the Lower and Middle Triassic.

The middle and upper Anisian sediments in the Kitakami Massif comprise fine grained, thick Flysch sediments such as are observed in the Anisian strata of the Maizuru Zone.

In the Kitakami Massif the sediments of the Ansian and lower Ladinian show rather similar lithologic features, but their distributions suggest a slight change in their sedimentation basin, but no hiatus or physical break can be observed between them. In the Maizuru Zone, the Anisian to Ladinian is represented by the Oro Formation which consists of the same type of Flysch sediments as observed in the Kitakami Massif. Notwithstanding the similarity in the lithology of the lower and upper Ladinian strata, their sediments have different distribution in Japan (Table 1). Remarkable differences are noted in the distribution of the lower Ladinian (*Protrachyceras reitzi* zone) and the upper Ladinian (*P. archelaus* zone), and this may indicate a change in their sedimentation basins, but from their lithologic resemblances the environment must have been favorable for the continued deposition of the Flysch type since the lower Ladinian period. The upper Ladinian strata of Japan are developed typically in southwest Japan, whereas the lower Ladinian is missing there at all of the localities. Consequently the stratigraphical relationship between the lower and upper Ladinian is at present obscure in Japan.

Remarkable physical breaks have been recognized in the middle Karnian Stage. In general, the Upper Triassic sediments higher than the middle Karnian are composed of non-marine coarse grained sediments with coal layers in contrast with those of the lower Karnian and Middle Triassic sediments which have fine grained Flysch deposits. In the Kitakami Massif the upper Karnian consists of non-fossiliferous arkose sandstone intercalated with thin layers of coaly shale in its upper part; they rest with unconformity upon the Anisian strata.

The *Monotis* bearing formation consists of coarse grained sediments (micaceous sandstone and mudstone) succeeded upwards with the upper Karnian Beds at all localities. A remarkable unconformity had been recorded at the base of the upper Karnian in the Sakashu area in Shikoku (Ichikawa, Ishii, Nakagawa, Suyari and Yamashita, 1953) and in the Inner Zone of Southwest Japan at the base of the middle Karnian strata. The sediments of the *Monotis* bearing beds suggest a near shore environment, and the abundant mica flakes in the sandstone and mudstone may have been supplied from the decomposed granitic rocks of the source area. With regard to the source area of the Upper Triassic sediments Kobayashi (1941, p. 318) mentioned that the granitic rocks and injection gneiss introduced by palaeoplutonism were eroded during Karno-Nornian time and hence arkose sandstone sporadically occur in the Karno-Norian and later formations.

In Japan, the stratigraphical relation between the *Monotis* bearing beds and the Karnian *Oxytoma-Halobia* Beds can not be observed directly and their actual contact is generally a fault. Considering from the non-marine coal bearing bed below the *Monotis* Beds there was probably a slight movement prior to the deposition of non-marine sediments below the *Monotis* Beds or during the post-depositional epoch of the *Oxytoma-Halobia* Beds.

The *Monotis* bearing formations have widest distribution in the Japanese Triassic, and it is belevied that the Upper Triassic transgression was the most extensive during the Triassic Period. Concerning the Upper Triassic transgression, Smith (1904) stressed that the wide spread occurrence of beds with *Monotis ochotica* around the northern shores of the Pacific and around the Arctic Ocean shows a transgression of the sea on what was formerly a continental border, and that these forms were endemic in the Boreal region, and made their way southward when the transgression of the sea extended to both sides of the Pacific.

Comparing the lithologic characters and the thickness of the Upper Triassic formations between the Chugoku region and the Shikoku and Kyushu Islands, the sediments of the upper Karnian to Norian strata in the former region in the Inner Zone of Southwest Japan are composed of sediments coarser than that of the latter on the Pacific side, and the thickness of the former attains about five to ten times that of the latter.

The evidence of the earliest tectonic movements of the Triassic Period of Japan is recognized between the Upper Permian and Lower Triassic in the Kitakami Massif and in the Maizuru Zone by the erosional unconformity. In the Kitakami Massif layers of tuff breccia are inserted in the basal part of the Lower Triassic Hiraiso Formation and show a sort of red bed. These tuffaceous or red beds are restricted to the western wing of the synclinorium extending from NNE to SSW in the central part of the southern Kitakami Massif; no fossils have been found. If this tuffaceous or red bed suggests or indicates a terrestrial condition, the western part of the Kitakami Massif may have been uplifted during the earliest Scythian Epoch or the post Upper Permian Toyoma Formation. Whether the Hiraiso Formation of the Toyoma and Yanaizu districts is lowermost Scythian is doubtful because no fossils have been found from it in this area.

There is no doubt of the tectonic movement prior to the deposition of the Lower Triassic in the Kitakami Massif and the Maizuru Zone. In the Outer Zone of southwest Japan, a distinct difference of the rock disturbance between the Triassic and the Permian strata is evident. An exceptional case is the conformable relation between the Upper Permian and the Scythian limestone in central Kyushu, but in this section the faunal break between them seem to be distinct regardless of the same limestone lithology.

A significant unconformity between the Permian and the Triassic, but not Lower Triassic, was found by Ichikawa, Ishii, Nakazawa, Suyari and Yamashita (1953) in the Sakashu area, Shikoku. This is an important evidence for the Permo-Triassic unconformity in the Outer Zone of Southwest Japan, and the tectonic movements was during the Post-Permian to Pre-Karnian age.

The Scytho-Anisian boundary in Japan is generally a conformity in the Kitakami Massif and the Maizuru Zone, but in the outer zone of southwest Japan no evidence has been found, and the Lower Triassic sediments form a Schuppe structure in general. Anisian sediments have not been found in this region, but recently Nakazawa (1962) stated on the new occurrence of the Anisian fauna, namely *Ussurites yabei*, *Paraceratites* sp., *Hollandites* sp., *Entolium discities*, *Anodontophora* sp., from Uonashi, about 5 km east of Taho, Ehime Prefecture, Shikoku; the details have not been described.

The non-development of Anisian sediments in the outer zone of southwest Japan suggests an erosional stage during the Pre-Kochigatani or Pre-Karnian Epoch in this region. The Aniso-Ladinian boundary is a conformity in the Rifu area, northeast Japan, and the Maizuru Zone, but that between the lower and the upper Ladinian has not been found because of their isolated distribution. These features may suggest a change of the sedimentation basin in which thick flysch type sediments accumulated during between the lower and the upper Ladinian Stage (Table 1). In the western part of the Chugoku region the Lower Triassic and Anisian to lower Ladinian sediments have not been found. This indicates a remarkable erosional stage during the Lower and early Middle Triassic age in this region.

In Japan, there are remarkable breaks in development and distribution between the Upper Triassic and the Lower and Middle Triassic formations. In the Kitakami Massif the Ladinian and the lower Karnian formations are missing between the Anisian Isatomae Formation and the Upper Triassic Saragai Group. This unconformity is considered to be comparable with those in the Nariwa and Shidaka areas in southwest Japan.

Ozawa (1923) noticed that the Akiyoshi limestone is covered with unconformity by the Upper Triassic Miné Group in Yamaguchi province. Kobayashi (1941) restudied this area and stressed on the orogeny between the Palaozoic Tsunemori Group and the Upper Triassic Miné Group. Kobayashi proposed the name of Akiyoshi orogenic movement for this unconformity and stated that the same kind of evidence is recognized at the base of the Norian Nariwa Group and its equivalent formations in the Nariwa and Gifu areas and at the base of the Saragai Group in the Kitakami Massif. He suggested that if the Miné Group, the upper part of the Zohoin Formation and the Sampozan Formation were all Ladino-Karnian, the facies-difference among them would be considerable, and that the Outer Zone of Southwest

Japan was not affected by the Akiyoshi orogenesis. Whereas, at present, the unconformity at Sakashu is evidence of the Akiyoshi orogenesis in the Outer Zone of Southwest Japan. The age of the unconfomity at Sakashu falls between the Ladinian and the Karnian Stage and the majority of the Lower and Middle Triassic sediments may have been eroded away at that time in the Outer Zone of Southwest Japan.

The Karno-Norian boundary is a conformity in the Kitakami Massif, the Nariwa district and Yamaguchi Province, but in these areas a remarkable unconformity is recognized between the upper and lower Karnian. These features are also suggested between the *Oxytoma-Halobia* Beds and the *Monotis* bearing beds of the Kochigatani Group in the Outer Zone of Southwest Japan and the lithologic character and distribution are different between them. However, there are no actual data at the present time. In the Outer Zone of Southwest Japan, layers of coal or coaly shale are common below the *Monotis* Beds in the Saragai Group,Nariwa Group, and the Miné Group but are not found in any Upper Triassic outcrops. The horizon of the coal deposits is probably the upper part of the *Oxytoma-Halobia* Beds of the Kochigatani Group.

The marine Upper Triassic sediments are composed of shallow sea facies in general, i.e. quartzose and arkose sandstone, argillaceous sandstone, micaceous sandstone and pebble to granule conglomerate, whereas the corresponding deep sea sediments have not been found.

Matsumoto and Kanmera (1949, p. 84) pointed out that the *Monotis* bearing strata in the Yatsushiro-Kuma district in western Kyushu resembles in structural feature the Upper Jurassic and Paleo-Cretaceous strata.

General View of the Lower Triassic Ammonites of Japan

Triassic ammonoids are known from the Kitakami Massif, the Kwanto Massif, the Maizuru Zone, the Outer Zone of Shikoku and Kyushu, among which the Scythian fauna is restricted to Iwai near Itsukaichi in Tokyo and Taho near Uonashi in Ehime Prefecture, Shikoku. An important Scythian ammonite, *Aspenites* was recorded from the Kamura Formation near Takachiho-machi, Miyazaki Prefecture in Kyushu (Kambe, 1960). In the Kitakami Massif no typical Lower Triassic ammonoids have been described until recently. The upper Scythian index ammonite, *Subcolumbites* cf. *perrni-smithi* (Arthaber), was collected by Onuki, Masuda and Mii (1960) from the upper part of the Osawa Formation at Tate near Isatomae, Utatsu-cho, in the southern Kitakami Massif. This ammonite determines the horizon of the Lower Triassic formations (Hiraiso and Osawa Formation).

The Iwai Formation yielded typical middle Scythian ammonites, *Aspenites* sp., *Owenites shimizui* (Sakagami), *Dieneroceras iwaiense* (Sakagami), *Paranannites* sp. and *Juvenites* etc.; described by Sakagami (1955) and Kummel and Sakagami (1960). These were formerly included into *Ophiceras* by Shimizu (1932) and Ichikawa (1951).

In the Maizuru Zone Nakazawa (1958) recorded Lower Triassic ammonites as *Anakashimirites* sp., *Pseudosageceras* aff. *multilobatum* Noetling from the Kusano Formation of the Fukumoto Group, *Meekoceras* sp. from the lower part of the Honodani Formation (Yakuno Group) and *Ophiceras* sp. from the Yakuno Group, but did not describe them. *Glyptophiceras japonicum* Nakazawa and Shimizu was described from the black shale at Nakanotani, Tomisu-mura, Shiso-gun, Hyogo Prefecture, but unfortunately the original beds which yielded it is unknown; it is a single specimen, which indicates the lowermost Scythian of Japan.

The Lower Triassic ammonites from the Taho Formation in Shikoku were first described by Yehara (1925); he recorded *Meekoceras, Kymatites, Ophiceras, Xenodiscus, Xenaspis, Flemingites, Sibirites* and *Lecanities.* He correlated them with the fauna of the

Meekoceras Beds of California and of the Himalayas. However his identification as later suggested by Spath (1930) needed revision and the assemblage should be referred to the fauna of the *Anasibirites multiformis* Beds of Timor and one species of *Meekoceras* recorded by Yehara, namely *Meekoceras onoi*, belongs to *Anasibirites* according to Shimizu and Jimbo (1933) and Spath (1934). Kummel (1954, 1959, 1960) pointed out that Yehara's "*Meekoceras*" fauna probably belongs to the *Anasibirites* zone and the majority of the ammonite species from the Taho Formation belong to *Anasibirites* and *Hemiprionites* of the zone of his *Anasibirites multiformis* of the upper Owenitan.

The writer studied the Lower Triassic ammonites from the Taho formation which are preserved in the Institute of Geology and Paleontology, Tohoku University, besides his own collections. He came to the conclusion that the majority of them belong to *Anasibirites*, *Hemiprionites*, *Arctoprionites*, *Xenoceltites*, *Wyomingites* and *Meekoceras* as described in this paper. Biostratigraphically the fauna indicates the middle Scythian age, especially the Owenitan stage. The *Anasibirites* and *Hemiprionites* fauna probably corresponds to the *Anasibirites multiformis* zone, which is known from Timor, Kashmir, Kiangsu and Hupeh in China, British Columbia, Queen Elizabeth Island, and from Utah and Idaho in western United states of America.

Comparing with the fauna of the Iwai Formation the Taho fauna has no species in common with it or with those of the Kamura Formation in the Island of Kyushu. The fauna of the latter two formations contains species of *Aspenites* and *Owenities*, both of which are absent in the *Anasibirites* fauna from the Taho Formation.

In Kyushu, ammonites of *Aspenites* sp., *Parahednenstraemia* sp. and *Clypites* sp. were recorded from the Kamura Formation at Kamura, Takachiho-machi, Miyazaki Prefecture (Kambe, 1960), therefore, their relation with other faunas is not clear.

Biostratigraphically the Lower Triassic of Japan can be classified into four ammonoid zones as follows: -1) the *Glyptophiceras* zone of Hyogo Prefecture, 2) the *Owenites* and *Aspenites* zone of the Iwai and Kamura Formations, 3) the *Anasibirites* and *Hemiprionites* zone of the Taho Formation, 4) the *Subcolumbites* zone of the Osawa Formation. Among them the *Glyptophiceras* zone is questionable because the strata which yielded it is unknown.

(1) ***Glyptophiceras*** zone

Glyptophiceras japonicum was first described by Nakazawa and Shimizu (1955) from the sandstone-slate formation at Nakano-tani, Tomisu-mura, about 8 km east of Yamasaki-cho, Shiso-gun, Hyogo Prefecture. This formation is of lenticular shape because of being sliced and incorporated by fault into the Upper Permian coarse grained sandstone with *Yabeina* cf. *yasubaensis* Toriyama, *Y.* sp. cf. *Y. columbiana* (Dawson), *Lepidolina toriyamai* Kanmera, *Pseudodoliolina* sp. and *Schwagerina* sp. They proposed the name of "*Glyptophiceras* Beds" for this formation. The genus *Glyptophiceras* first reported by Spath (1930, p. 33–39) from Cape Stosch and Clavering Island in Eastern Greenland was assigned to the *Otoceras* and *Ophiceras* Beds or the Otoceratan in his chronological classification (Spath, 1930, p. 76; 1943, p. 27). Spath included *Xenodiscus himalayanus* Griesbach from the *Ophiceras* Beds of Pastannah, Kashmir (Diener, 1913, p. 3–5, pl. 2, fig. 4) into this genus. In the subidivision of the Lower Triassic in Greenland, Spath (1935, p. 104) placed the *Glyptophiceras* Beds in the lower Otoceratan and regarded it to range from the lower *Glyptophiceras* Beds to the upper *Ophiceras* Beds. The Japanese species was compared with *G. gracile* Spath and *G. himalayanum* (Gliesbach) by Spath, but it more resembles *G. aequicostatus* (Diener), the holotype of this genus, than the above species in the form of the venter and the shell ornamentation. This is the only distinct species respresented in the Japanese lowermost Scythian. *Ophiceras* sp. and *Xenodiscus* sp. were recognized from the Hiraiso Formation (Oyama, 1938; Ichikawa, 1951), and from the lower part of the Yakuno Group (Nakazawa, 1953; Nakazawa and Shiki, 1958; Nakazawa, 1958), but unfortunately they have not been described. The writer had a chance to study the collection of Oyama from the Kitakami Massif in 1938, and the majority of the specimens preserved in the Institute of Geology and Paleontology, Tohoku University, Sendai, but their preservation do not permit their identification with *Ophiceras*. Accordingly the writer accepts the *Glyptophiceras* Beds of Hyogo Prefecture as the lowermost horizon of the Scythian Stage in Japan, and correlates it with the upper beds of the *Ophiceras* Limestone of Kashmir, the *Glyptophiceras* Beds and the lower *Ophiceras* Beds of eastern Greenland, the lower part (*Otoceras* zone) of the Dinwoddy Formation (Kummel, 1957, p. 1479), and the *Otoceras boreale* Beds of the upper part of the Sadlerrochi Formation in northern Alaska (Kummel, 1957, p. 1501). On the other hand it may be also of the same horizon as the lowest fossil zone with *Otoceras* of the Spray River Formation of Alberta in the Canadian Rockies (Warren, 1945,) and with the *Otoceras* Beds of the Blind Fiord Formation on the south side of Bunde Fiord, Axel Heiberg Island, and on the west coast of Ellesmere Island in Northern Canada (Tozer, 1961). In eastern Siberia this beds is considered to be almost comparable with those from Eastern Verkhoyan (Popow, 1958, 1962; Kiparisova, 1961), and from the Kolyma River, the Russky Island and Ussuri (Kiparisova, 1961).

(2) ***Owenites* and *Aspenites* zone**

The Iwai formation at Iwai near Itsukaichi, Tokyo, is a classical Lower Triassic ammonite locality of Japan. From this formation, Fujimoto (1926) collected an ammonite which was later referred by Shimizu (1932, p. 93) to *Ophiceras* sp. aff. *O. demissum* Oppel. Sakagami (1955) described some ammonites from this formation and according to him there are two ammonite beds, namely *Ophiceras* Beds and *Aspenites* Beds in ascending order. These ammonites were revised by Kummel and Sakagami (1960), who referred them to:– *Owenites shimizui* (Sakagami), *Dieneroceras iwaiense* (Sakagami), *Dieneroceras* sp., *Paranannites* sp., *Juvenites* sp., *Aspenites* spp. They stated that these are of the middle Scythian *Meekoceras* zone. This fauna is known from several localities in California, Nevada, Utah and Idaho (Smith, 1932; Kummel, 1954), from the Queen Elizabeth Islands (Tozer, 1958, 1961), from Timor (Welter. 1922), from Western Southland in New Zealand (Kummel, 1959), from Ussuri and Arctic Siberia (Kiparisova, 1958, 1961; Popow, 1939), from Montenegro in Yugoslavia (Petkovic and Mihajlovic, 1935), from Chios in Greece (Renz, 1928; Renz and Renz, 1948) and in Albania (Arthaber, 1911).

The Lower Triassic of Iwai can be subdivided into 1) the Upper fossil Beds with *Aspenites*, and 2) the Lower fossil Beds with *Owenites*, *Dieneroceras*, *Paranannites*, *Juvenites* and *Aspenites*. The writer applies the name of *Aspenites* zone to the Upper fossil Beds and the *Owenites* zone for the Lower fossil Beds (Bando, 1961, p. 327). The *Aspenites* zone lies about 17 meters above the *Owenites* zone and consists of marl lenses which yielded many small pelecypods and ammonoids (Sakagami, 1955, p. 134).

The writer observed this locality in 1962 and noticed that the sandstone facies below the *Owenites* zone is composed of calcareous light greenish blue fine grained sandstone and shows close resemblance with those of the Hiraiso Formation in the Kitakami Massif.

The *Aspenites* fauna was recorded by Kambe (1960) from the Kamura Formation of Kyushu which is composed of light gray limestone and rests with conformity upon the Permian limestone which yielded *Neoschwagerina* and *Yabeina*. The *Aspenites* fauna from this formation consists of *Aspenites* sp., *Parahedenstroemia* sp. and *Clypites* sp., in association with *Eumorphotis multiformis* (Bittner), *Entolium* cf. *discites* (Schloth.), *Pteria ussurica* Kiparisova and "*Pecten*" cf. *minimus* Kipar. etc.

These ammonites apparently have the same character as those from the Iwai Formation and belong to the *Meekoceras* Zone. Judging from the occurrence of *Parahedenstroemia*, the *Clypites* Beds extend their chronological range down to the upper Flemingitan age, because the fauna of the typical *Meekoceras* zone in this formation is missing.

(3) *Anasibirites* zone

The majority of the Lower Triassic ammonites from Japan occurred from the Taho Formation at Taho near Uonashi in Shikoku. The fauna includes, according to Yehara (1925), the species of *Meekoceras, Kymatites, Ophiceras, Xenodiscus, Xenaspis, Flemingites* and *Sibirites.* However, Spath (1930, 1934), Shimizu (1932), Shimizu and Jimbo (1933) and Kummel (1954, 1959, 1960), noticed that they belong to *Anasibirites* or *Hemipironites.* For instance *Meekoceras onoi* Yehara was placed in *Anasibirites* by Spath, and Shimizu and Jimbo. The fauna of the Taho Formation is composed of: *Anasibirites kingianus inaequicostatus* (Waagen), *A. archiperipheras* Bando n. sp., *A. shimizui* Bando n. sp., *A. onoi* (Yehara), *A. pacificus* (Yehara), *A. ehimensis* Bando n. sp., *A. intermedius* Bando n. sp., *A. multiplicatus* (Yehara), *A.* n. sp., *A.* sp. indet., *Hemiprionites katoi* (Yehara), *H. tahoensis* (Yehara), *H. morianus* (Yehara), *H. kuharanus* (Yehara), *H. kuharanus iyonus* Bando n. subsp., *H. sawatanus* (Yehara), *H. shikokuensis* (Shimizu and Jimbo), *H.* sp. indet., *Meekoceras japonicum* Shimizu and Jimbo, *M. japonicum compressum* Bando n. subsp., *M. orientale* Shimizu and Jimbo, *M.* sp. indet., *Wyomingities* cf. *aplanatus* (White), *Xenoceltites* aff. *evolutus* (Waagen), *Arctoprionites yeharai* Bando n. sp., *A. minor* Bando n. sp., and *A. nipponicus* Bando n. sp.

Table 5. THICKNESS OF THE TRIASSIC STRATA IN THE KITAKAMI MASSIF

(Based on ONUKI and BANDO, 1959)

		KARAKUWA	TSUYA	ISATOMAE	OKAGO	TOYOMA	IINOGAWA TOKURA	OKATSU	WATANOHA	ENOSHIMA	RIFU
Post-Triassic		Jurassic	Jurassic	Jurassic		Jurassic	Jurassic	Jurassic	Jurassic		Tertiary
SARAGAI Gr.	CHONOMORI Form.		60-200 m.	20-250 m.							
	SHINDATE Form.		250-300 m.	270-300 m.							
INAI Group	RIFU Form.										500 m.
	ISATOMAE Form.	500-700 m.	600-700 m.	800 m.	1600 m.	1400-1600 m.	1400-1600 m.	25-1500 m.	700-800 m	500 m.+	?
	FUKKOSHI Form.	250 m.	250-350 m.	0-500 m.	150-600 m.	0-150 m.	0-600 m.	10-450 m.		15-40 m.	
	OSAWA Form.	300 m.	280-300 m.	250 m.	?	300 m.	180-230 m.	350 m.		250 m.	
	HIRAISO Form.	250 m.	170-270 m.	150-300 m.	100 m.+	200-250 m.	150 m.	230-250 m.			
Pre-Triassic		Permian	Permian	Permian	Permian	Permian	?	Permian ·			

~~~~ Unconformity ═══ Fault ------- Infered boundary

The majority of these ammonites comprise species of *Anasibirites* and and their individual number is largest. The species reported as *Meekoceras* are referred to *Hemiprionites* (Table 5). In addition, the writer recognized species of *Arctoprionites, Xenoceltites* and *Prosphingties*? from the Taho Formation. They may be referred to the *Anasibirites* fauna of Timor, North America, Eastern Canada, Salt Range, Himalayas, South China, Albania and Mongishlak. On the other hand the species of *Hemiprionites, Arctoprionites* and *Xenoceltites* are identified with those from Spitsbergen. The *Anasibirites* fauna of the Taho Formation is of an age not earlier than the *Owenites* and *Aspenites* zone of the Iwai Formation at Itsukaichi, Tokyo, and the *Aspenites* zone of the Kamura Formation. On the other hand they are distinctly older than the *Subcolumbites* zone of the Osawa Formation at Tate in the southern Kitakami Massif.

Anasibirites was first recognized in the Salt Range of Pakistan by Waagen (1895, p. 3), who called this horizon as "the upper Ceratite Limestone" and separated it from the Bivalve Limestone. The Upper Ceratite Limestone corresponds to the lower half of the Bivalve Limestone and was placed in the Middle Triassic. Mojsisovics (1896) separated *Anasibirites* as a subgenus of *Sibirites* and placed it in the Lower Triassic. Diener (1912,
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p. 35) subdivided the Lower Triassic of the Himalayas into four Ammonite zones, namely the Zone of *Otoceras woodwardi*, the Zone of *Meekoceras markhami* (*Meekoceras* Beds), the Zone of *Flemingites rohilla* (*Hedenstroemia* Beds) and the Zone of *Anasibirites spiniger* (Byans) in ascending order, and correlated the *Anasibirites spiniger* zone with the Upper Ceratite Limestone in the Salt Range. Later Spath (1921, p. 301) recorded the species of *Anasibirites* including *A. ibex* (Waagen), *A. angulosus* (Waagen), and *A. spiniger* (Krafft) from the Nodule Beds of Trident, Sassendal, Spitsbergen, and considered the horizon to be near to the borderline between the *Flemingites* beds below and the *Stephanites* zone. The *Stephanites* zone represents the Lower Triassic fauna of Kcira in Albania and was considered by Diener (1913, p. 121) to be homotaxial with the *Hedenstroemia* stage of India. Spath (1934, p. 27) included it into the Owenitan stage in his classification of the Lower Triassic by ammonoid fossils. Subsequently Welter (1922) described a large *Anasibirites* fauna from Anak Saban in Timor, the majority of which belong to his *Anasibirites multiformis* and *A. robustus.* However *A. multiformis* described by Welter included many forms which were classified into many species of *Anasibirites* by Mathews (1929) and *Hemipriontes* was separated from them by Spath (1934).

Welter considered the *Anasibirites* Beds (*Owenites* zone) and the *Owenites* zone to be of the same horizon as the *Flemingites* and *Kashmirites* zones of Kashmir, the *Hedenstroemia* Beds of the Himalayas, the *Ceratites* Sandstone of the Salt Range, and the *Tirolites* Beds of California. Moreover, he placed the *Columbites* Beds of California between the *Anasibirities* limestone and the *Owenites* limestone of Timor (Welter, 1922, p. 92).

Hyatt and Smith (1905, p. 49) described *Aanasibirites noetlingi* (Hyatt and Smith) from the *Meekoceras* Beds of Union Wash, Inyo Range, California, and Mathews (1929) and Smith (1932) described many *Anasibirites* species from the Pinecerst Formation in Utah and the *Owenites* subzone of the *Meekoceras* zone at Union Wash, Inyo Mountain, California, where they are associated with *Meekoceras gracilitatus, Owenites koeneni, Inyoites oweni, Lanceolites bicarinatus, Pseudosageceras multilobatum,* and others. Smith (1932, p. 14) considered the *Anasibirites* zone to be a subzone of his *Meekoceras* zone, which includes the *Anasibirites* and the *Owenites* subzones, and *Pseudosageceras multilobatum* subzone in descending order. In the studies by Spath (1934), McLearn (1945), and Kummel (1957) it was placed as an independent zone in the upper Owenitan Stage. Kummel (1957) adopted the *Anasbirites multiformis* zone for the upper Owenitan and placed it upon the *Meekoceras gracilitatus* zone in the lower Owenitan Stage.

According to Kummel (1954, p. 186), *Anasibirites* is associated with *Hemiprionites, Gurleyites, Wasatchites,* and *Anawasatchites* in the lower shale unit of the Thaynes Formation in Idaho. Recently Kummel and Steel (1962) described *Xenoceltites youngi* Kummel and Steele, X. sp., *Wyomingites* cf. *aplanatus* (White), *W. whiteanus* (Waagen), *Arctoprionites* sp. and other ammonites from the *Meekoceras gracilitatus* zone of Elko County in Nevada. They distinguished *Arctoprionites* from the Himalayas and Salt Range species which were recorded by Diener (1912–13).

In Spitsbergen, Frebold (1910) and Spath (1912, 1934) described *Arctoprionites nodosus* (Frebold), *A. tryelli* Spath, *A.* n. sp., *Genoceltites subevolutus* Spath, X. *gregoryi* Spath, X. *spitsbergensis* Spath, *Hemiprionites garwoodi* Spath, *Gurleyites freboldi* Spath, and *Wasatchites tridentinus* Spath. The upper part of the *Posidonomya* Beds is said to be represented by the *Arctoceras* fauna which includes *Arctoceras, Prosphingites, Tellerites, "Meekoceras"*, and *Pseudosageceras.* Frebold considered this lower ammonoid fauna to be comparable with the Ceratite sandstone of the Salt Range, the *Flemingites flemingianus* zone of Pakistan and in part with the *Hedenstroemia* Beds of the Himalayas. He considered that the upper fauna is equivalent in part with that of the Olenek Beds in eastern Siberia, and the *Columbites* fauna of southeastern Idaho. Spath (1934) placed the fauna of the

Posidinimya Beds in the upper Owenitan (*Anasibirites* zone) age, and the forms of *Xenoceltites* and others in his Columbitan age with some doubt. Subsequently Kummel (1960, p. 513) discussed on the age of the *Arctoceras* fauna of Spitsbergen and mentioned *Arctoprionites* and *Hemiprionites*. *Anasibirites* has been reported from South China by Tien (1933), Hsu (1936), and Chao (1959). The latter author described many Lower Triassic ammonoids of western Kwangsi. Tien (1933, p. 34–35) first described the *Anasibirites* fauna, which included "*Sibirites*" cf. *kingianus* Waagen from the lower part of the Tayeh Limestone, Nienyuya, Chingmen, Hupei, and considered them comparable with the upper Ceratite Limestone of Chidroo, Salt Range and the *Anasibirites multiformis* fauna from the *Owenites* limestone of Timor. Tien also subdivided the Lower Triassic of South China into the *Ophiceras* Beds, the *Meekoceras* Beds, the *Tirolites* Beds, and the *Beneckeia* Beds in ascending order. The *Anasibirities* fauna was placed by him in the *Tirolites* Beds.

Subsequently Hsu (1936) described *Xenodiscus*, *Tirolites*, *Anasibirites*, and *Celtites*, from the Lower Triassic of Chunhwachen southwest of Nanking. Chao (1959) described some *Anasibirites* from Tiengno, Pakung, Linglo and from the Tsoteng district in western Kwangsi, and pointed out that the typical Owenitan forms like *Owenites*, *Prosphingites*, *Paranannites*, *Anasibirites*, *Meekoceras*, *Kashmirites* and *Aspenites* are associated with *Proptychites*, *Clypeoceras*, *Koninckites* and *Ussuria*, all of which are generally confined to the Lower Eo-Triassic. He concluded that these genera persisted longer in Kwangsi than in other parts of the world.

In Arctic Canada Tozer (1961) described many Lower Triassic ammonites from the Queen Elizabeth Islands. He subdivided the Owenitan into the *Meekoceras* Beds and the *Wasatchites* Beds. The fauna of the *Wasatchites* Beds were collected from thin beds above the base of the Blind Fiord Formation and it comprises *Wasatchites tardus* (McLearn) and *Xenoceltites subevolutus* Spath. This fauna was correlated by him with the *Anasibirites multiformis* zone of the upper Owenitan age.

Collignon (1934, p. 74) compared the Lower Triassic ammonites from Madagascar Island with Yehara's species and correlated the horizon of *Aspidites* and *Meekoceras* of Barabanja and the upper horizon of the Tsaramborana (*Ophiceras* Beds) in Madagascar with the "*Meekoceras*" Beds of the Taho Formation based on the occurrence of *Meekoceras markhami* Diener and *Pseudomonotis iwanowi* Bitt. This comparison, unfortunately, is not accepted at present. Spath (1935, p.112) pointed out that the misidentification of *Ophiceras* recorded by Collignon, and stated that the Madagascar fauna is characterized by notably *Flemingites*, and includes nothing of Gyronitan or Otoceratan age.

(4) ***Subcolumbites* zone**

Typical Lower Triassic ammonites from the Osawa Formation in the Kitakami Massif have been known only from some incomplete ammonites, i.e. "*Ophiceras*" sp., "*Xenodiscus*" sp., Prohungaritoid, Pseudoharpoceratoid and Keyseringitoid ammonites (Oyama, 1938; Ichikawa, 1950), but Onuki, Masuda and Mii (1961) collected *Subcolumbites* cf. *perrini-smithi* (Arthaber) from the formation at a coastal cliff of Tate near Isatomae, Utatsu- cho, Miyagi Prefecture. This species was described from Kcira in Albania (Arthaber, 1908, 1911) and from Maradovuno, Chios in Greece (Renz, 1928; Renz and Renz, 1948). This genus was also recorded from Kangsi in south China as *Subcolumbites kwangsianus* Chao (Chao, 1959, p. 128). On the other hand *Subcolumbites multiformis* Kiparisova (Voinova, Kiparisova and Robinson, 1947; Kiparisova, 1954, 1961), *S. solitus* Kiparisova (1961) and *S. anomalus* Kiparisova (1961), were described from Ussuri, *Columbites* sp. nov. of Welter 1922, p. 150) from the upper Scythian of Timor may belong to *Subcolumbites* as mentioned by Kummel (1961, p. 528).

Concerning the chronological significance of the *Subcolumbites* zone, Smith (1932) correlated the Albanian *Subcolumbites* Beds with the *Columbites* fauna of Paris Canyon, Bear Lake County, Idaho, and with the Olenek fauna of northern Siberia which was once recorded by Mojsisovics (1886). Spath (1934, p. 33) stated that the *Albanites-Subcolumbites* fauna of Albania and Timor are probably younger than the *Columbites* fauna of Idaho, and thus he placed the *Subcolumbites* Beds of Albania and Timor between the so-called Columbitan and Prohungaritan in his subdivision of the Lower Triassic. However, Kiparisova and Popow (1946) regarded the *Columbites* zone to be of the same age as the *Subcolumbites* zone, and they denied the Prohungaritan age of Spath's classification. According to Kiparisova (1961) the Columbitan age was marked with an interrogation, and the Prohungaritan age was placed in the *Subcolumbites* zone, and the Owenitan in the *Prosphingites* zone. In China the *Subcolumbites* zone was placed in the uppermost Columbitan age, but the Prohungaritan was included in the Columbitan (Chao, 1959, p. 176).

According to Chao (1959) some species of the *Albanites-Subcolumbites* fauna of Albania are also found in the Columbitan sediments of Kwangsi, like *Hemilecanites discus* (Arthaber) in the Chashanao section and *Hellenites* cf. *praematurus* (Arthaber) in the Naliling section near Lolous. Thus he correlated the *Procarnites-Leiophyllites* zone of Kwangsi with the *Subcolumbites* zone. He included the Prohungaritan in the Columbitan age.

Smith (1932, p. 19) recognized the *Leiophyllites-Albanites* fauna from Timor namely, *Leiophyllites dieneri* Arthaber, *L. kingi* Diener, *L. pitamaha* Diener, *Albanites albanus* Arthaber, *Procarnites kokeni* Arthaber and *P. skanderbegis* Arth. He stated that this fauna apparently occurs at the top of the Lower Triassic of Timor and are all identical with the species from the *Columbites* zone of Albania. *Leiophyllites kingi* and *L. pitamaha* have been reported by Diener (1895, p. 108) from the lower Muschelkalk of India. Smith compared the Himalayan lower Muschelkalk with the *Columbites* Beds of Albania and the same horizon in Timor.

Concerning the lower Muschelkalk of India, Krafft (1912, p. 68) insisted that the horizon of *Rhynchonella griesbachi* and at least half of the nodular limestone with *Leiophyllites* should be included in the Lower Triassic.

In Japan, aside from the ammonites from the Osawa formation, no uppermost Scythian form has been recorded; forms representative of the Columbitan or Prohungaritan have not been found any other locality of the Kitakami Massif. The Lower Triassic faunal sequence of the Kitakami Massif is incomplete, no lower Scythian ammonoid has occurred to date, but instead there is a bivalve fauna, e.g. *Entolium discites* (Schloth)., "*Pecten*" *ussuricus* (Bitt.), "*P.*" *alberti* (Goldf.), "*P.*" *sichoticus* (Bitt.) and *Gervilleia* cf. *exporrecta* (Leps.) etc. Accordingly the *Subcolumbites* from the Osawa Formation is important to decide the upper limit of the lower Scythian in the Kitakami Massif. The writer (1961, p. 327) had stated that the age of the uppermost beds of the Osawa Formation probably include the Columbtian-Prohungaritan. Concerning the boundary of the lowermost Anisian and *Subcolumbites* zone of the Osawa Formation, it is evident that the *Subcolumbites* zone is covered with conformity by the sandstone of the Fukkoshi formation which yielded *Gymnites watanabei* (Mojsisovics), *Balatonites kitakamicus* (Diener) and *Hollandites.* Consequently the Anisian-Scythian boundary is at the base of the Fukkoshi Formation in the Kitakami Massif.

The Middle Triassic Ammonites

The Middle Triassic deposits are known from the southern Kitakami Massif, the Maizuru Zone, the Zohoin Formation in Shikoku and Kyushu, and Yamaguchi province. The Anisian deposits are restricted to the Kitakami Massif and the Maizuru Zone.

(1) The Anisian Ammonites

Numerous Anisian ammonites occur from the Isatomae Formation in the Kitakami

Massif, a unit classically known as the Inai Series or the *Hollandites* Beds. The fauna has been described by many authors since Mojsisovics' contribution in 1888. The Anisian depostits of the Kitakami Massif are the Fukkoshi, Isatomae and the Rifu formations, which extend to the upper Ladinian in age.

The ammonites from these formations are characterized by the species of *Hollandites, Japonites, Ussurites, Leiophyllites, Monophyllites, Sturia, Ptychites, Rikuzenites, Balatonites, Kellnerites, Paraceratites*, and "*Danubites*". The majority of these ammonites are from the Isatomae Formation at Isatomae, Tokura, Yanaizu, Ogachi, Inai, Watanoha, and from the Rifu Formation at Tatta.

Mojsisovics (1888) first described from the Kitakami Massif the following ammonites:–*Ceratites* (*Hollandites*) *japonicus* Mojs., *C.* (*H.*) *haradai* Mosj., *Ceratites* (*Danubites*) *naumanni* Mojs., *Gymnites watanabei* Mojs., *Anolcites* (*Balatonites*) *gottschei* Mojs. and *Ceratites* (*Japonites*) *planiplicatus* Mojs. Diener (1916) added *Hollandites nodai* Diener, *Ptychites inaicus* Diener, *Gymnites* sp. aff. *kirata* Diener, *Sturia japonica* Diener, *Anolcites*? (*Balatonites*) *kitakamicus* Diener, and *Ussurites yabei* Diener. Later Shimizu (1930) revised these ammonites and described *Hollandites japonicus crassicostatus* Shimizu, *Danubites japonicus* Shimizu, *Balatonites kitakamicus* (Diener), *B. gottschei* (Mojs.), *Danubites* cf. *kansa* Diener, *Sturia* ? sp., *Cuccoceras* aff. *submarinoii* Shimizu, *Balatonites* cf. *kitakamicus* (Diener) and *Leiophyllites* cf. *pseudopradiumna* (Welter). This ammonite bearing formation was named the *Hollandites* Beds by Yabe and Shimizu (1930, p. 102). Later Yabe (1949) described *Rikuzenites nobilis* from the Isatomae Formation at Yanaizu along the Kitakami River, and Onuki and Bando (1959) described *Struia* cf. *sansovinii* Mojs., *Hollandites japonicus tokuraensis* Onuki and Bando and *Beyrichites* sp. from the same formation at Tokura, Shizugawa-cho.

Yabe and Shimizu (1927) described from the Rifu Formation *Paraceratites* aff. *trinodosus* (Mojs.), but the exact horizon was not mentioned. The Rifu Formation yielded ammonites of Ladinian forms, and Anisian forms are rare. The ammonites from this formation are associated with *Daonella, Myoconcha*, and *Spiriferina*. Yabe and Shimizu named it the *Daonella* Beds. Onuki and Bando (1959) described some ammonites and recorded a new occurrence of *Protrachyceras reitzi* (Boeckh) from the Rifu Formation at Hamada near Shiogama City, and subdivided the formation into (a) *Paraceratites trinodosus* zone, (b) *Protrachyceras reitzi* zone. (c) *Monophyllites wengensis* zone and (d) *Daonella kotoi multistriata* zone in ascending order. The writer studied the ammonites in the collection of the Institute of Geology and Paleontology, Tohoku University, and distinguished *Paraceratites* cf. *trinodosus* (Mojsisovics) from the same formation at Tatta, at about 1.5 km west of Hamada station along the Senseki Electric Car Line, Miyagi Prefecture. At Rifu the boundary between the Anisian and the Ladinian is drawn between the *Paraceratites trinodosus* zone and the *Protrachyceras* zone.

In the Maizuru Zone, Nakazawa, Shiki and Shimizu (1954) recorded Anisian ammonites as *Hollandites, Danubites* and *Michelinoceras*, from the Miyano-oku Formation (Fukumoto Group). Later they reported *Hungarites* aff. *proponticus* Toula, *Hollandites* ? sp., *Danubites japonicus* Shimizu, *Beyrichites* sp., *Pseudosageceras* ? sp., and *Michelinoceras* sp. from the Waruishi Formation of the Yakuno Group. On the other hand *Monophyllites* cf. *sphaerophyllus* (Hauer) and *Daonella*? sp. were recorded by Nakazawa and Nogami (1958) from the Oro Formation of the Yakuno Group. The ammonite is probably conspecific with *M.* cf. *wengensis* (Klipstein) of Yabe and Shimizu (1927) from the Rifu Formation. Nakazawa (1958) described *Monophyllites arakurensis* Nakazawa which he found in association with *Halobia, Lima, Spiriferina* and *Posidonia*, from the Arakura Formation at Arakura near Maizuru City, and correlated this formation with the Ladinian to Karnian age. The writer believes that his *Monophyllites arakurensis* may be *Mojsvarites* rather than *Monophyllites*.

It belongs to the Karnian Stage from its complicated sutures, shell ornamentation and faunal association. Except for *M. arakurensis*, the Middle Triassic ammonites from the Maizuru Zone have not been described.

(2) **The Ladinian Ammonites**

The Ladinian ammonites of Japan were first described by Yabe and Shimizu (1927) from the Rifu Formation. They distinguished *Monophyllites* cf. *wengensis*, "*Ptychites*" *compressus*, *Ptychites rifunus*, *P.* spp., *Beyrichites chitanii*, *Paraceratites wardi*, *P. orientalis*, *Nevadites*? *anagusticostatus*, *Gymnotoceras paucicostatus*, and *Arpadites*? sp. Subsequently Shimizu (1930) added *Ptychites yabei* and *Hollandites nipponicus*, from the Rifu Formation. Onuki and Bando (1959), distinguished five ammonites (Table 4), which included *Protrachyceras reitzi*, *Japonites* cf. *ugra*, and *Tropigastrites* aff. *halli*. Recently the writer (1963) described a dibranchiate cephalopod, *Atractites hataii*, from the *Protrachyceras reitzi* zone of the Rifu Formation, and in this paper the following ones, *Ptychites nipponicus* Bando n. sp., *P. miyagiensis* Bando n. sp., *P.* sp. cf. *P. trocheaeformis* (Lindstroem), *P.* spp., *Flexoptychites matsushimaensis* Bando n. sp., *Kellnerites* cf. *bosnensis* Hauer, *K.* n. sp., *Paraceratites* cf. *clarkei* Smith, *Monophyllites wengensis* (Klipst.), *M. sphaerophyllus* (Hauer), *Japonites* cf. *dieneri* (Martelli), *Epigymnites* aff. *jollyanus* (Oppel) *Anagymnites* aff. *acutus* Hauer, *Hungarites* n. sp. are described. The stratigraphical horizon of *Monophyllites sphaerophyllus* is not definite.

Almost all of the ammonites from the Rifu Formation occur from the *Protrachyceras reitzi* zone or the *Monophyllites wengensis* zone at Hamada near Shiogama City.

In the Maizuru Zone, *Monophyllites* cf. *sphaerophyllus* has been recorded by Nakazawa and Nogami (1958) from the upper part of the Oro Formation (Yakuno Group) in the Oe district. From the association with *Daonella*? this horizon belongs to the Ladinian Stage.

Two Ladinian ammonites:–*Protrachyceras* aff. *archelaus* (Laube) and *Thisbites orientalis* Shimizu, were described by Shimizu (1930, p. 13–18) from the Zohoin Formation at Zohoin near Sakawa-cho in Shikoku. The first one occurred in association with *Daonella densisulcata* Yabe and Shimizu, and was referred to the Ladinian Stage. The latter species was compared with *T. haushoferi* Mojs. from the lower Karnian of the Alps (Shimizu, 1930, p. 18). If the latter species occured from the Zohin Formation, its age should be extended to the lower Karnian, whereas Shimizu stated that the *Daonella* Beds of Zohoin correspond to the Upper *Daonella* Beds of the Rifu Formation. Kobayashi and Ichikawa (1951) collected *Monophyllites* sp. and *Protrachyceras* aff. *archelaus* (Laube), but they were not described. They also reported *Trachyceras* (*Protrachyceras* ?) spp. from the Zohoin Formation at Junisha and Fujinohira in the Nakagawa district, Tokushima Prefecture (Kobayashi and Ichikawa, 1951, p. 93). The writer studied the ammonite collection of Mr. K. Hashimoto from the Zohoin Formation at Annomoto and Gorodani of Nagayasu, Kaminaka-cho, Naka-gun, in the Nakgawa district, and distinguished *Protrachyceras* cf. *pseudo-archelaus* (Boeckh). This species is characteristic in the *Protrachyceras archelaus* Zone and indicates the upper Ladinian stage in the Mediterranean Province. *P. pseudo-archelaus* may be a form younger than the typical *P. archelaus* from the shell ornamentation. Consequently the stratigraphical horizon of this ammonite bearing beds is stratigraphically a little higher than the beds with *P.* aff. *archelaus* of the Zohoin Formation at the type locality in the Sakawa Basin.

The Anisian ammonites from the Isatomae Formation were first described by Mojsisovics (1888) who referred them to the lower Ladinian Buchenstein Bed (*Protrachyceras reitzi* zone) of the Alps, and compared them with the fauna from the Bed of Humbold Range of Nevada in North America. Later Mojsisovics (1896, p. 691) with regard to the ammonites from this formation stated.

"Ich habe diese Fauna in meiner Arbeit von 1888 der norische Stufe (Ladinian

Stage) zugerechnet ich und halte auch heute an diese Bestimmung fest. Es sind nur wenige Gattungen vertreten, nämlich *Ceratites*, *Arpadites*, *Danubites*, *Japonites*, *Anolcites* und *Gymnites*, von welche die Mehrzahl sich auch in der anisiche Stufe findet. Doch sind andererseit auch Typen vertreten, welche bisher noch niemals in anisischen Sedimenten gefunden wurden, wie *Arpadites*, während *Anolcites*, ein Glied aus der Entwicklungsreihe der Tirolitiden, bis jetzt weden in den anisischen Bildungen der indischen Provinz, noch in den gleichalterigen Sedimenten der Arktis nachgewiesen werden konnte. *Anolcites* tritt in der Mediterranporovinz zum erstenmale in dem bosnischen Horizonte auf und reichte aufwärte bis in die jülischen Ablagerungen. Seine Hauptentwicklung erreicht aber *Anolcites* in der norischen Stufe der Mediterranprovinz. Von den übrigen Gattungen hat sich *Japonites* bisher nur noch in den bosnischen Schichten der indischen Triasprovinz gefunden, bildet daher den einzigen Typus, welcher, von Japan abgesehen, nur in der anisischen Stufe gefunden wurde. Es kann jedoch wegen dieses Umstandes *Japonites* noch lange nicht als eine für die anisische Stufe ausschliesslich charakteristische Gattung betrachtet werden, und da gerade das gleichzeitige Auftreten mit *Arpadites* und *Anolcites* in den japanischen Ammonitenkalken einen Fingerzeig für die Annahme gibt, dass *Japonites* auch in höheren Horizonten noch vorhanden war. Die Gattung *Danubites*, welcher der von mir als *Ceratites naumanni* beschreibene Ammonit angehört, ist in der Mediterranprovinz gleichfalls noch nicht in norischen Sedimenten nachgewiesen worden, während die philetisch warscheinlich mit *Danubites* zusammenhangenden Gattung *Buchites* sowohl in den karnischen, als auch in den juvavischen Sedimenten der Mediterranprovinz zu Hasue ist. Die japanischen Ceratiten schliessen sich dagegen nach ihren Dimensionen und ihrem Entwicklungsstadium den Ceratiten der anisischen und fassanischen Faunen an, und dieser letzteren (der fassanischen) möchte ich den auch die in Rede stehende kleine japanischen Fauna zurechnen."

Mojsisovics' opinion was repeated in 1899 and he emphasised that the Japanese ammonite fauna shows close relationship with the Californian forms described by Meek and Gabb. Yabe (1903) against Mojsisovics' opinion believed that the Kitakami Triassic is not Ladinian but Anisian, and referable to the Muschelkalk from paleontological evidence. He said that *Japonites* should be referred to the Anisian as already pointed out by Diener (1895). In North America, Smith (1914) discussed the age of the Humbold fauna of Nevada, which was referred by Mojsisovics to the Fassanic substage of the Tirolic series, and Smith correlated them with the Buchenstein Beds of the Alps, and stated that they still belong to the Middle Triassic (Muschelkalk) horizon. The West Humbold fauna shows no affinity with the Rikuzen fossils (the Isatomae Formation) of the Kitakami Massif and not a great deal with the Buchenstein horizon of the Mediterranean. Diener (1915) agreed in general with Smith's opinion and regarded the "Ceratite" Bed of the Kitakami Triassic as Anisian in age. Diener, moreover, distinguished *Sturia japonica* Diener and *Ussurites yabei* Diener from the Isatomae Formation, and stated that the fauna of the Kitakami Triassic is essentially of the Himalayan type. Yabe and Shimizu (1927) proposed the name of *Hollandites* Beds for the Ceratite Beds of Yabe, 1918, in the upper part of the Inai Series (Group). Shimizu (1928) restudied some of the ammonites described by Mojsisovics and Diener, and distinguished *Balatonites kitakamicus* (Diener) (= *Anolcites*? *kitakamicus*). He stated that this species resembles *B. egregius* Arthaber from Reiflingerkalk of the Alps. Yabe and Shimizu (1927) were the first to describe species of *Ptychites*, *Paraceratites*, *Gymnites*, *Beyrichites*, *Monophyllites*, *Nevadites* ? and *Daonella* etc. from the Rifu area near Sendai and they proposed the name of *Daonella* Beds for this ammonite bearing formation. The fauna included some Anisian ammonites as, *Paraceratites* aff. *trinodosus*, *P.* cf. *wardi*, *P. orientalis*, *Nevadites*? *angusticostatus*, *Beyrichites chitanii*; they considered the *Daonella* Bed as comparable with the Himalayan Muschelkalk and partly with the *Daonella dubia* zone of Nevada in North America. They believed this mixed Aniso-Ladinian fauna to be due to the survival of Anisian ammonites as mentioned by Smith (1914), who stated that the Ladinian fauna of the *Daonella dubia* zone of Nevada contains some Anisian relic forms. Consequently Yabe and Shimizu considered the *Daonella* Beds in Japan to be Ladinian in age.

In another paper, Yabe and Shimizu (1932), placed the *Daonella* Beds of the Inai Group in almost the same horizon as the *Daonella* Bed of the Sakawa Basin and of Nagato (Yamaguchi Province), and the upper part of the Atsu Series in southwest Japan. At any rate, Yabe and Shimizu (1927) stressed that the fauna of the *Hollandites* Beds of the Inai Group is essentially of the Himalayan in type, that of the *Daonella* Beds is partly Himalayan and partly Nevadan, and that *Ptychites compressus* is closely related to *Ptychites kokeni* of Ussuriland. *Gymnotoceras*, a genus characteristic of the northern region is represented by a species in the *Daonella dubia* Zone of Nevada. Recently Onuki and Bando (1959) reported *Sturia* cf. *sansovinii* and *Beyrichites* sp. from the Isatomae Formation. The former one is almost identical with the species of the Muschelkalk of the Alps and the Himalayas. *Sturia sansovinii* is characteristic in the Tethyan geosynclinal sediments, and has been recorded from Malaya (Kummel, 1960) and Timor (Welter, 1915). This species resembles *S. japonica* which is characteristic in the Isatomae Formation (Japan) and in the Anisian beds of Ussuriland (Kiparisova, 1954, 1961).

Kiparisova (1961) described many ammonites from Ussuriland, among which some are mutual to the Triassic fauna of Kitakami. The Ussuri fauna described by Kiparisova contains, the Olenekian Fauna (uppermost Scythian): *Atractites* sp., *Megaphyllites immaturus* Kipar., *Danubites* aff. *floriani* Mojs., *D. admaris* Kipar., *D. incertus* Kipar., *Preflorianites inflatus* Kipar., *P. maritimus* Kipar., *P.* aff. *maritimus* Kipar., *Leiophyllites praematurus* Kipar., *Eophyllites* cf. *refractus* Spath, *E. amurensis* Kipar. etc.

Anisian Fauna: *Hollandites* cf. *japonicus* Mojs., *Acrochordiceras* aff. *balarma* Diener, *Anagymnites* sp., *Discoptychites* aff. *compressus* (Yabe and Shimizu), *Ptychites austroussuriensis* Kipar., *Hungarites solimani* Toula, *H.* sp., *Prohungarites*? *popowi* Kipar., *Balatonites* sp., *Paraceratites trinodosus* Mojs., *P. binodosus* (Hauer), *Acanthoceras* sp., *Sturia* cf. *japonica* Diener, *S.* sp., etc.

Ladinian Fauna: *Discoptychites* aff. *kokeni* Wittenburg, *Protrachyceras* aff. *furcatum* (Münster), *Hungarites* aff. *fittingensis* Smith, *Gymnotoceras* cf. *paucicostatus* Yabe and Shimizu, *G. medvedevi* Kipar., *Ptychites mangara* Diener, etc.

Most of the Ussuri fauna occurred from the Abrek Bay Region in the Strelok Strait, Amur Gulf coastal region, Russuki Island, the Ussuri Gulf coastal region, the Rakovki River area, the Kamenuski River area, and the Verkhoyansk region.

According to Kiparisova (1961), *Ptychites compressus* Yabe and Shimizu belongs to the subgenus *Discoptychites* (Diener, 1916), but the writer believes that the holotype species resembles *Flexoptychites* more than *Discoptychites*.

Considering from the fauna of Ussuriland it is noticeable that the species of *Atractites* from the Olenekian Beds of Vladivostok is characteristic from the Anisian to Liassic, and in Japan it occurred from the upper part of the Rifu Formation (lower Ladinian) (Bando, 1963).

In Japan, *Paraceratites trinodosus* occurs in the lower part of the Rifu Formation. It has not been found in the Isatomae Formation, and does not occur in association with *Sturia*, but it seems to occupy a horizon a little higher than that of *Sturia*.

The upper part of the Rifu Formation yielded *Protrachyceras reitzi* and *Monophyllites wengensis* etc., and is almost equivalent to the Ladinian Buchenstein Beds (Zone of *Protrachyceras reitzi*) and the Zohoin Formation, which yield *Protrachyceras* aff. *archelaus* and *P.* cf. *pseudo-archelaus*, in Shikoku. It is also intimately related to the Wengen Beds (Zone of *Protrachyceras archelaus*) of the upper Ladinian in the Alps.

In eastern Asia ammonites comparable with the Middle Triassic fauna of the Kitakami Massif, and Shikoku were recorded from Indochina by Mansuy (1912), Patte (1922, 1926) and by Saurin (1956) from northeastern Laos and northern Annam. Especially, the Beds with *Paraceratites trinodosus* and *Protrachyceras reitzi* in Indochina is comparable with the Rifu Formation and the upper part of the Isatomae Formation in the Kitakami Massif, and the Beds with *Protrachyceras archealus* in the Phon-tho region of Tonkin described by Mansuy (1912, p. 70) may be correlated to the Zohoin Formation in Shikoku.

Kummel (1950) described some Middle-Upper Triassic ammonites from the Mae Moh River Region in northern Thailand. He recognized Anisian forms as, *Ptychites* sp., *Tropigymnites* cf. *chandra* (Diener), *Balatonites* spp. In his paper, he described Upper Triassic ammonites as *Paratrachyceras* cf. *regoledanum* (Mojs.), *Cladiscites* cf. *beyrich* Welter, *Lobites* cf. *ellipticus* (Hauer) and *Joannites* cf. *klipsteini* (Mojs.). The lower part of the Doi Chang Formation and the Hong Hoi Formation may be correlated with the Isatomae Formation, but the upper part of them may be comparable with the lower part of the Kochigatani Group in Shikoku.

The Anisian ammonites recorded from Malaya by Savage (1950) were referred to *Paraceratites, Sturia, Ptychites,* and *Acrochordiceras* and correlated with the Anisian *Paraceratites trinodosus* zone. The ammonites described by Kummel (1960) from the Triassic of the Kuala Lipis region consisted of *Paraceratites trinodosus, Sturia sansovinii, Acrochordiceras* sp. and *Ptychites* sp. This fauna is allied with the upper part of the Isatomae Formation and the lower part of the Rifu Formation.

The Triassic fauna of Timor resembles the Triassic fauna of the Kitakami Massif. The upper Ladinian ammonites from the Zohoin Formation in Shikoku are related to the Ladinian ones of the *Daonella lommeli* zone of Timor. According to Welter (1915) most Anisian ammonites occur in Timor in the Muschelkalk of the Nifoekoko, Oemari and Oilette regions. The fossil beds were regarded by him to be equivalent with the Muschelkalk of the Alps and Himalayas, and of Eastern Siberia in part. Welter regarded *Struia sansovinii* to range from the zone of *P. trinodosus* to that of *Trachyceras aonoides* of the Upper Triassic, and *Monophyllites wengensis* to indicate the same horizon as *Protrachyceras archealus* which occurred from the *Daonella lommeli* zone in Timor. Later Wanner (1931) recorded *Daonella indica* Bitt. from the Kekneno Group of Timor.

The fauna of the Isatomae Formation may be correlated with the Anisian Etalian Stage (Hokonui System), which has *Leiophllites marshalli* Browne, *Ussuria cultrata* B., *Beaumontites tepungai* B., *B. fraseri* B., *B. bartrumi* B., *Daonella etc.*, in New Zealand. Marwick (1953, p. 12) correlated the Etalian Stage with the Anisian Beds of Spitsbergen and California (U.S.A.). The upper part of the Rifu Formation or the lower part of the Zohoin Formation may be equivalent with the Ladinian Kaihikuan Stage (Hokonui System), which yielded *Hollandites parki* Wilck, *Daonella apteryx* Marwick, *Myophoria thomsoniana* (Wilck), *Spiriferina kaihikuana* Trechmann etc. Trechmann (1918, p. 168) and Marwick (1953, p. 13) referred this Beds to the Ladino-Karnian.

In South America, Trümpy (1943) recorded "*Nevadites*" *sutanensis* Jaworski, "*N.*" cf. *lissoni* J., and "*Anolcites*" *dieneri* J. from the middle part of the Payande Formation at Payande, Columbia, and correlated this fauna with the Kanrian Beds of Peru. The species from the Payande Formation were identified by Trümpy with those of Jaworski (1922) from Northern Peru. *Nevadites* is characteristic in the Anisian beds of North America (Smith, 1914), and has been recorded by Yabe and Shimizu (1927) from the lower part of the Rifu Formation (upper Anisian). Spath (1934, p. 37) stated that Jaworski's specific identification does not indicate the Norian because it contained younger species. Kummel and Fuchs (1953) stressed on the necessity of a restudy of this fauna.

The Middle Triassic fauna of North America is closely related with the Middle Triassic

Inai Group of Japan. Smith (1914) described many Middle Triassic ammonites from the Pit Shale (Ladinian) in California and the *Daonella* zone of the lower part of the Star Peak Formation in the Humboldt Range, Nevada. Judging from the fauna the lower part of the Pit Shale and the *Daonella dubia* zone with *Paraceratites trinodosus* in the Star Peak Formation are intimately related with the Isatomae Formation and the lower part of the Rifu Formation. Recently Silberling (1962) discussed on the limits of Smith's "*Daonella dubia* Zone" and restudied the stratigraphic distribution of the Middle Triassic ammonites at Fossil Hill, Humboldt Range, Nevada. According to him the Middle Triassic beds at Fossil Hill and eleswhere in northwestern Nevada are characterized by the species of *Paraceratites, Gymnotoceras, Nevadites,* and *Anolcites.* He proposed informally the *Gymnotoceras* Zone for these beds, and stated that the immediately overlying beds which yielded sporadic specimens of *Protrachyceras* are called the *Protrachyceras* Zone, and that the boundary between the *Gymnotoceras* Zone and the *Protrachyceras* Zone, is approximately the Anisian-Ladinian stage boundary. Silberling subdivided the *Gymnotoceras* Zone into 11 ammonite beds, viz, the *Paraceratites vogdesi* Beds, *P. clarkei* Beds, *P. cricki* Beds, *Gymnotoceras blakei* Beds, *G.* (*Frechites*) *nevadanus* Beds, *G. meeki* Beds, *G. dunni* Beds, *Navadites hyatti* Beds, *N. humboldtensis* Beds, *Anolcites furlongi* Beds, *A. gabbi* Beds in descending order.

Considering Siblerling's study *Paraceratites trinodosus* occurs mainly from the *P. vogdesi* Beds at the uppermost horizon of the *Gymnotoceras* Zone, and *P. clarkei,* which is most closely related with *P. orientalis* Yabe and Shimizu, and *P. wardi* Smith occur in the *P. clarkei* Beds, and *Tropigastrites halli* (Mojs.) belongs to the *Gymnotoceras blakei* Beds. Almost all species of *Nevadites* is known from the *N. hyatti* Beds and *N. humboldtensis* Beds in the comparatively lower part of the *Gymnotoceras* Zone.

In northeastern British Columbia, Canada, the *Beyrichites-Gymnotoceras* fauna was suggested by Mclearn (1953, p. 1219) to be similar to the late Anisian species. In the Peace River Foothills in northeastern British Columbia, Mclearn (1947, 1953) distinguished the *Nathorstites* fauna from the "Dark Siltstone" which yielded the genera *Nathorstites, Sagenites, Protrachyceras, Paratrachyceras, Proarcestes, Silenticeras* etc., and referred it to the Ladinian or earliest Karnian. The Beds may probably be correlated with the Zohoin Formation or the lower part of the Kochigatani Group in Shikoku.

In Arctic Canada, the *Daonella frami* Bed, about 400 feet above the base of the Schei Point Formation, Bjorne Peninsula, Ellesmere Island, which yielded *Protrachyceras* sp. and *Ptychites nanuk* Tozer (Tozer, 1961), can be correlated with the lower part of the Rifu Formation (Inai Group.)

The Gastinean Volcanic Group in the Juneau district in Alaska has yielded *Protrachyceras lecontei* and *Atractites* cf. *A. phillipi* (P.S. Smith, 1939; Kummel, 1957). In addition to this fauna, Kummel (1957) distinguished Anisian fossils from the lower part of the Shablik Formation in northern Alaska. This Middle Triassic fauna includes *Hungarites* sp., *Proteusites* n. sp., *Pseudoharpoceras* n. sp., *P. parvus* (Smith), *Hollandites*? sp., *Daonella* cf. *dubia, D.* cf. *mousoni* and *Posidonia* sp. The fauna of this bed of northern Alaska correlate it to the Isatomae Formation in the Kitakami Massif.

General View of the Upper Triassic Ammonites

The Upper Triassic ammonites from Japan have been described from the Saragai Group (Kitakami Massif), the Kochigatani Group in the Sakawa Basin (Shikoku), the *Proarcestes* Bed at Taho in western Shikoku and from the Jito Formation (Nariwa Province). The ammonites from Shikoku are almost all of Karnian age, and those from the other areas of Karno-Norian age.

The species from the Saragai Group are *Placites* aff. *oxyphyllus* Mojsisovics and

Arcestes aff. *oligosurcus* Mojsisovics, both of which were recorded by Shimizu and Mabuti (1932) from the horizon between the *Monotis ochotica densistriata* Bed above and the *Dictyoconites* Bed below. *Arcestes oligosurcus* was described from the Hallstatt Kalk of the northern Alps and regarded as a Norian form. *Placites oxyphyllus* occurs from the Norian Bed of the Hallstatt Kalk in the Northern Alps and Sicily. The writer discussed on the geo-chronology of the lower part of the Saragai Group and placed its horizon into C 2 zone and above the *Monotis scutiformis* zone (Onuki and Bando, 1958).

An Arcestid ammonite was described by Nakazawa (1959) from the black shale of the Jito Formation at Kojintawa near Jito, Nariwa-cho, Kawakami-gun, Okayama Prefecture. This species is said to be *Arcestes* (*Stenarcestes*) sp. and is represented by a single species from the Upper Triassic of the Nariwa basin. At the original locality of this species there occur abundant *Monotis* in the black shale with fine-grained sandstone.

The Upper Triassic ammonites from the Kochigatani Group were described by Shimizu (1930) to consist of *Paratrachyceras* cf. *hofmanni* (Boeckh), *P.* sp. nov. ? from Tokombo and Kaisekiyama, *Thisbites orientalis* Shimizu from Zohoin, and *Proarcestes* aff. *bicarinatus* Münster from Yamaguchi of Kochigatani.

The writer collected *Paratrachyceras* n. sp. from Shimoyama in this basin; it is closely related to *P. hofmanni* and is a representative of the zone of *P. aonoides* (middle Karnian) of the Mediterranean Province. *Proarcestes* aff. *bicarinatus* suggests the Karnian age. The species from Zohoin, *Thisbites orientalis* is Upper Triassic because it indicates the Karno-Norian age in the Alps, Timor, Himalayas, and Sicily. The *Paratrachyceras* Bed at Shimoyama and Tokombo is considered to be of the same horizon as the *Halobia-Tosapecten* Bed of Kobayashi and Ichikawa (1951).

The other Triassic ammonite described by Shimizu (1931) from Taho was named *Proarcestes* aff. *hanieli* Welter which indicates the Karnian age. *Proarcestes hanieli* was described by Welter and Arthaber from the Upper Triassic limestone of Nifoekoko in the Island of Timor and was stated to be Karnian (Welter, 1914; Arthaber, 1927). The original occurrence of this ammonite from Taho is about 500 m west of the locality of the Lower Triassic limestone (Taho Formation) and the boundary between the *Proarcestes* Bed and the Lower Triassic is a fault.

Correlation of the Triassic of Japan

(A) Lower Triassic Correlation

The Lower Triassic series in Japan comprise the Hiraiso Formation in the Kitakami Massif, the Shionosawa Formation in the Kwanto Massif, the Kurotaki Formation in Shikoku, and lower part of the Yakuno Group, the Miharaiyama Group and the Fukumoto group in the Maizuru Zone all of which are characterized by a bivalve fauna. The Osawa Formation in the Kitakami Massif, the Iwai Formation in the Kwanto Massif, the Taho tion in Shikoku, the *Glyptophiceras* bed in the Maizuru Zone, and the Kamura formation in Kyushu are all characterized by ammonoids.

The writer subdivided the Lower Triassic Series of Japan into the *Glyptophiceras* zone, the *Owenites* and *Aspenites* zone, the *Anasibirites* zone and the *Subcolumbites* zone in ascending order. The *Glyptophiceras* zone is recognized only at Nakano-tani, Tomisu-mura, Shiso-gun, Hyogo Prefecture. The *Owenites* and *Aspenites* zone is distinguished in the Iwai Formation of the Kwanto Massif and the Kamura Formation in Kyushu and both formations yielded species of *Aspenites*. The *Anasibirites* zone is represented by the fauna from the Taho Formation which has yielded many species of *Anasibirites*, *Hemiprionites*, *Arctoprionites*, *Meekoceras*, *Xenoceltites* and *Wyomingites* etc. However, this zone has not been found in the other Lower Triassic series of Japan. The *Subcolumbites* zone was distinguished in the upper part of the Osawa Formation of the Inai Group in the southern Kitakami Massif; it is upper Scythian. In the Kitakami Massif the Osawa Formation can be traced from the Karakuwa Peninsula to the Onagawa area.

The Hiraiso Formation which yielded "*Pecten*" *ussuricus* (Bittner), "*P.*" *ussuricus sichoticus* (Bittner), *Entolium discites* (Schloth.), *E. discites microtis* (Bitt.), *Pseudomonotis* (*Eumorphotis*) *iwanowi* (Bitt.), *Anodontophora* aff. *fassaensis* Wiss., *A.* cf. *ovalis* Wiss., *Gervilleia* cf. *exporrecta* (Leps.) etc., may be comparable with the Shionosawa Formation in the Kwanto Massif with *Eumorphotis multiformis* (Bitt.), *Gervilleia* cf. *exporrecta* (Leps.), *Anodontophora canalensis* Catullo etc., and the Kurotaki Formation in Shikoku, which has almost all of its species common with those of the Hiraiso Formation. From the Lower Triassic Series of the Maizuru Zone there have been recorded *Entolium* cf. *discites*, *E.* cf. *microtis* (Bitt.), *Eumorphotis* aff. *maritima* Kiparisova, *E.* aff. *tenuistriata* (Bitt.), *Claraia* aff. *decidens* Diener, "*Pecten*" *ussuricus* (Bitt.), "*P.*" aff. *sojalis* Wittenburg, "*P.*" *amuricus* Bitt., *Leptochondrica*? *minima* (Kipar.), *L.* ? aff. *virgalensis* Witt., *L.* ? cf. *bittneri* (Kipar.), *Pteria* aff. *murchisoni* (Geinitz), *Anodontophora* cf. *fassaensis bittneri* Frech, and *Neoschizodus* cf. *laevigatus* (Ziet.) etc.

Some of these species are common with those from the Hiraiso Formation, the Shionosawa Formation, the Kurotaki Formation and the Kamura Formation. According to Nakazawa (1961) the Maizuru Zone resembles the Kitakami region in lithology and in fossil assemblages, and show a marked contrast with the Outer Zone of Central and West Japan. The Shionosawa, Kurotaki, Taho and Kamura formations, all of the Outer Zone of Southwest Japan, are composed of limestone or limestone block-bearing sediments, whereas the Lower Triassic Series in the Kitakami Massif and the Maizuru Zone consist of sandstone, siltstone and both have basal conglomerate. In the Kitakami Massif the fossils occur from thin calcareous sandstone layers in the lower part of the Hiraiso Formation.

Table 6. CORRELATION TABLE OF THE LOWER TRIASSIC IN JAPAN
(Based upon the ammonites)

		KITAKAMI	KWANTO		MAIZURU		SHIKOKU		KYUSHU
STANDARD AMMONITE STAGES*	NAME OF LOWER TRIAS ZONES**	INAI Group	IWAI Form.	SHIONOSAWA F.	TOMISU F.	YAKUNO & FUKUMOTO Gr.	KUROTAKI F.	TAHO F.	KAMURA F.
PROHUNGARITAN	*Prohungarites similis*	*Subcolumbites* Zone							
COLUMBITAN	*Columbites parisianus*								
	Tirolites cassianus							F.	
OWENITAN	*Anasibirites multiformis*		F.					*Anasibirites* Z. F.	?
	Meekoceras gracilitatus		*Owenites–Aspenites* Z. F.	F.			?		*Aspenites* Zone
FLEMINGITAN	*Flemingites flemingianus*	*Entolium–Eumorphotis* Zone		*Eumorphotis* Zone		*Entolium–Eumorphotis* Zone	*Entolium–Eumorphotis* Zone		?
	Koninckites volutus								
GYRONITAN	*Xenodiscoides fallax*								
	Prionolobus rotundatus								
	Proptychites rosenkrantzi								
	Visnuites decipiens			?	?		?		
OTOCERATAN	*Ophiceras commune*				*Glyptophiceras* Zone				
	Otoceras woodwardi								
BASEMENT		PERMIAN	PERMIAN	PERMIAN	PERMIAN	PERMIAN	PERMIAN	PERMIAN	PERMIAN

*: After SPATH (1930, 1934)
**: After KUMMEL (1957)

The faunal relation between the Lower Triassic ammonoids and bivalves is obscure in the Kitakamai Massif because no ammonoids occur from the Hiraiso Formation, and the *Subcolumbites* zone is situated in the uppermost part of the Osawa Formation at Tate near

Isatomae. Consequently, the *Subcolumbites* zone is considered to be of a horizon higher than that of the *Eumorphotis-Entolium* Bed. The writer thinks that the *Eumorphotis-Entolium* fauna may range from the Gyronitan to the Owenitan in Japan. Kambe (1960) reported that the *Aspenites* fauna occurred in association with *Eumorphotis multiformis, Pteria ussurica, Anodontophora* sp., *Pecten* cf. *minimus,* and *Entolium* cf. *discites* from a limestone, and this is important for age determination, correlation, and stratigraphy.

It is adequate to draw the boundary of the Hiraiso and Osawa formations, between the Owenitan and the Columbitan, and it is thought to almost correspond to that between the Kusano and the Kyogakubo formations (Fukumoto Group) in the Maizuru Zone.

The *Eumorphotis-Entolium* Beds of the Hiraiso, the Shionosawa, and the Kurotaki formations, and of the lower part of the Fukumoto Group and the Yakuno Group in the Maizuru Zone have yielded no ammonoids. The *Eumorphotis-Entolium* fauna shows great resemblance with that of the Ussuri region, especially to the basal part ($T_1{}^{1a}$) of the Indian stage of the Lower Triassic. The resemblance can be recognized in the fauna of the Werfen Beds of the Himalayan Lower Triassic Series. *Entolium discites* (Schl.) is mutual to the Werfen Beds in the Alps. Nakazawa (1961) described "*Pecten*" aff. *sojalis* from the Maizuru Zone, and it also occurs in the Werfen fauna of the Alps. Nakazawa described *Entolium discites microtis* (Bitt.) from the same Maizuru zone and considered it to be identical with those from the Scythian beds of Szechuan in western China (Ku, 1948, p. 247).

In the Concepcion area in Chile, Groeber (1924) distinguished "*Pecten*" *discites, Modiola* cf. *paronai, Myophoria neuquensis, Mentzelia mentzelii* from Zapara and El Challao near western Argentina and he considered the fauna to resemble the one of the uppermost Muschelkalk. Whereas Kummel and Fuchs (1953) stated that these so-called Muschelkalk fossils should be restudied.

(B) **Middle Triassic Correlation**

The Middle Triassic Series in the Kitakami Massif consists of the Fukkoshi, Isatomae and the Rifu formations. These formations yielded many ammonites. The Fukkoshi Formation is lower Anisian because it yielded *Balatonites* cf. *kitakamicus, Gymnites watanabei* and *Hollandites* sp. and rests upon the *Subcolumbites* Bed of the Osawa Formation with conformity. The Isatomae Formation rests upon the Fukkoshi Formation and is characterized by Anisian ammonites as *Hollandites japonicus, Monophyllites sphaerophyllus, Sturia japonica, S.* cf. *sansovinii, Balatonites kitakamicus, Rikuzenites nobilis* etc. The Rifu Formation contains *Paraceratites* cf. *trinodosus* in the lower member, whereas the upper member yielded lower Ladinian fossils as *Protrachyceras reitzi, Monophyllites wengensis,* "*Ptychites*" *compressus, Japonites* cf. *ugra, J.* cf. *dieneri, Epigymnites* aff. *jollyanus, Anagymnites* aff. *acutus* etc. Therefore, the Rifu Formation ranges from the upper Anisian *Paraceratites trinodosus* Zone to the lower Ladinian *Protrachyceras reitzi* Zone (Onuki and Bando, 1959; Bando, 1961). The lower member of the Rifu Formation, which yielded *P.* cf. *trinodosus* and *Kellnerites* cf. *bosnensis,* may be comparable with the upper part of the Isatomae Formation or to the Isatomae Formation, their lithologic characters are similar.

In the Maizuru Zone, the *Danubites-Hollandites* Bed of the Miyanooku Formation and the larger part of the Waruishi Formation which yielded *Hungarites, Danubites* and *Hollandites* may be correlated to the Fukkoshi and Isatomae Formations in the Kitakami Massif. The *Monophyllites* cf. *sphaerophyllus* Bed of the Oro Formation (Yakuno Group) is thought to be a correlative of the upper part of the Rifu Formation, because it is associated with *Daonella*?.

The Zohoin Formation in Shikoku yielded *Protrachyceras* aff. *archelaus, P.* cf. *pseudoarchelaus, Daonella indica, D. tenuistriata, D. alta, D. iwayai, D. jkotoi, D. sakawana, D. subquadrata, D. pectinoides, D. asymmetrica, D. hiratai,* etc. This fauna can be referred to the upper Ladinian (*Protrachyceras archelaus* zone). It is considered to be succeeded chronologically by the Rifu Formation, even though no formation equivalent to the Rifu has been found in Shikoku and Kyushu.

In Yamaguchi province, the Ladinian *Daonella yoshimurai* was recorded from the Kumanokura Formation (Atsu Group). The writer considers it to be upper Ladinian in age.

In the Maizuru Zone, *Monophyllites arakurensis* occurred from Nakazawa's (1958) Arakura Formation at Arakura, Maizuru City; its age was ragerded to be Ladino-Karnian from the association with *Halobia, Lima, Spiriferina* and *Posidonia*. Nakazawa proposed the name of Arakuran and placed it between the Fujinohiran and the Sakawan of Ichikawa's chronological subdivision of the Japanese Triassic System. The writer finds that *Monophyllites arakurensis* may belong to *Mojsvarites* (Karnian) and the formation which yielded it should be referred to the Karnian rather than to the Ladino-Karnian age (Bando, 1961).

(C) **Upper Triassic Correlation**

The Saragai Group in the Kitakami Massif includes the *Monotis* bearing bed (Chonomori Formation) and the nonfossiliferous Shindate Formation in descending order. The lower part of the Saragai Group was regarded by Yabe and Shimizu (1933) as Karnian. Onuki and Bando (1958) also referred the non-fossiliferous massive sandstone below the *Monotis* bearing bed to the Karnian. The lithology of the Shindate Formation below the *Dictyoconites* Bed resembles the Hinabata and Mogamiyama formations in the Nariwa area. *Dictyoconites* described by Shimizu and Mabuti (1941) is a Karnian fossil. Consequently the lower part of the Saragai Group is Karnian in age. The typical marine Karnian formations as found in the Kwanto Massif and southwest Japan are missing in the Kitakami Massif although the Lower and Middle Triassic Series are developed.

The *Monotis* bearing bed in the Kwanto Massif yielded the fauna from the zone of *M. ochotica densistriata* to the zone of *M. zabaikalica* in the vicinity of Iwai, but the fauna of the lowermost or *M. scutiformis* zone, seems to be missing. At Iwai the *Halobia* Bed has been recognized, but the lower Karnian *Oxytoma* Bed is not known. On the other hand, the *Monotis* Bed in the Okutone area consists of a rather thick bed like that in the Chugoku area in southwest Japan, but stratigraphically it should be studied in detail. The *Monotis* Bed is distributed in the vicinity of Kasuga in Gifu Province and in the Tsuyama and Nariwa districts in the Maizuru Zone. In the Nariwa district the lower part (Mogamiyama and Hinabata Formations) of the Nariwa Group may be Karnian. Both formations contain plant beds or coal seams, and in the upper part of the *Monotis* Bed there are several plant beds which may be Rhaetian. The Upper Triassic series between the Kasuga area and the Tsuyama-Nariwa district belongs largely to the Karnian Nabae Group. In the Yamaguchi area the *Monotis* Bed which yielded *M. scutiformis typica* is referrable to the *M. scutiformis* zone of the Saragai Group. The Kamosho formation in the Asa area of Yamaguchi province yielded *M. scutiformis* with *Tosapecten suzukii* and is comparable with the above fossil bed.

In the Nakagawa area in eastern Shikoku the lower part of the Upper Triassic Kochigatani Group is called the Sabutani Formation and it yielded Karnian fossils. On the other hand, the *Monotis* bearing formation is called the Umegatani Formation and was referred to Norian age, but this *Monotis* Bed corresponds to the upper part of the Kochigatani Group in the Sakawa Basin. In the Sakawa Basin no formational name has been proposed, and a remarkable difference in lithologic features are recognized between the Karnian bed (the lower part of the Kochigatani Group) and the Norian bed (the upper part of the Kochigatani Group). In the vicinity of Sakashu a remarkable unconformity has been recognized at the base of the Karnian Sabutani Formation. This unconformity is seen between the Permian black shale and the Karnian bed; it suggests a hiatus between the Karnian and the upper Ladinian. In the vicinity of Itadorigawa, the writer found a *Monotis*

Bed. According to Ichikawa (1961) a *Halobia* Bed was found in this area. In the Nomura Basin, western Shikoku, the contact between the *Monotis* bed and the *Halobia* Beds has not been found, but both seem to have close relation in their distribution.

In Kyushu the Karnian is represented by the Matsukuma, the Takagochi and the Tanoura Formations; their faunal character refere them to the Kochigatani Group in the Sakawa Basin. A remarkable unconformity between the Karnian Tanoura Formation and the Permian Kozaki Formation was found at Itebana near Umiura in the Tanoura area. This unconformity corresponds to the one in eastern Shikoku.

The lithology of the Upper Triassic Series is remarkably uniform, the lower part of the Karnian is composed of rather fine-grained sandstone and silt stone, whereas the upper part is characterized by coarse grained facies with intercalated layers of plant beds or coal seams. These features can be observed from the upper part of the Karnian to the base of the *Monotis* Bed. The lithologic character of the *Monotis* Bed is uniform, consisting of calcareous sandstone or argillaceous sandstone. The upper part of the *Monotis* Bed commonly has arkosic sandstone or black shale with intercalated plant beds or carbonaceous matters.

Summary

The Triassic stratigraphy and ammonite fauna of Japan may be summarized as follows:–

(1) The Lower Triassic of Japan can be divided into (1) the *Glyptophiceras* zone, (2) the *Owenites* and *Aspenites* zone, (3) the *Anasibirites* zone and (4) the *Subcolumbites* zone in ascending order.

(2) The Lower Triassic formations with the *Entolium-Eumorphotis* fauna may be correlated with the Gyronitan-Flemingitan Stage and be placed between the *Glyptophiceras* zone (Otoceratan) and the *Owenites-Aspenites* zone (Lower Owenitan).

(3) The Lower Triassic ammonites from the Taho Formation include species of *Anasibirites*, *Hemiprionites*, *Wyomingites*, *Arctoprionites* and *Xenoceltites*, and are comparable with those from the *Anasibirites multiformis* zone of the upper Owenitan Stage of the world.

(4) The Middle Triassic ammonites of Japan mainly occur from the Kitakami Massif and the Maizuru Zone. The lowermost Anisian is represented by the *Leiophyllites* fauna and the uppermost by the *Paraceratites* fauna. The Ladinian is composed of the *Protrachyceras reitzi* zone below and and *P. archelaus* zone above; the former is represented by the upper part of the Rifu Formation and the latter by the Zohoin Formation.

(5) The Upper Triassic Series is rather rare in ammonoids, but some species of *Paratrachyceras*, *Proarcestes*, *Arcestes*, *Stenarcestes* and *Placites* are characteristic. The bed with *Paratrachyceras* and *Proarcestes* in the lower part of the Kochigatani Group is correlative with the Karnian Stage, and the bed with *Placites* and *Arcestes* in the Chonomori Formation (Saragai Group) and with *Stenarcestes* of the Jito Formation (Nariwa Group) are all representative of the Norian stage.

(6) The *Monotis* bed is included into the horizon of the *Placites* and *Arcestes* zone or of the *Stenarcestes* zone.

(7) The Permo-Triassic boundary is drawn below the *Glyptophiceras* zone, but its exact contact could not be observed. In the Kitakami Massif and the Maizuru Zone the boundary is below the Lower Triassic *Entolium-Eumorphotis* Beds, and its contact with older rocks is a disconformity with uneven erosional surface.

(8) The Scythian-Anisian boundary is between the *Subcolumbites* zone of the Osawa Formation and the *Leiophyllites-Gymnites* zone of the Fukkoshi Formation in the Kitakami Massif.

(9) The Anisian-Ladinian boundary is drawn between the *trinodosus* and *reitzi* zones in the Rifu Formation.

(10) The Ladinian-Karnian boundary is between the *Protrachyceras archelaus* or *P. pseudo-archelaus* zone and the *Paratrachyceras hofmanni* or *Oxytoma-Halobia* Bed, but the actual contact could not be observed.

(11) The Karnian-Norian boundary is between the *Oxytoma-Halobia* Bed and the *Monotis* Bed, and based upon the ammonite fauna it is between the *Paratrachyceras* or *Proarcestes* Bed and the *Placites* or *Stenarcestes* Bed.

(12) The upper part of the *Monotis* bed with intercalated layers of coal seams or plant bed possibly belongs to the Rhaetian.

(13) The Lower Triassic series in the outer zone of southwest Japan is almost composed of limestone facies, but in northeast Japan and the Inner Zone of southwest Japan it consists of conglomerate, sandstone and shale facies.

(14) The Middle Triassic series generally consists of fine grained sediments of the Flysch type, whereas the Upper Triassic series is composed of coarse grained sediments.

(15) Remarkable tectonic events during the Triassic in Japan are recognized between the Upper Permian and the Lower Triassic, and during the post-Ladinian or Pre-Karnian Stage, a transitional change of the sedimentary basin may have been between the lower and upper Ladinian Stage.

SYSTEMATIC PALEONTOLOGY

Family Sibiritidae Mojsisovics, 1896
Genus *Anasibirites* Mojsisovics, 1896

Gentotype: *Sibirites kingianus* Waagen, 1895, p. 108, pl. 7, figs. 1a–c. (2a–c).

Anasibirites Mojsisovics, 1896, p. 615.
Anasibirites. Mojsisovics, 1899, p. 49.
Sibirites. Hyatt and Smith, 1905, p. 48.
Sibirites. Krafft and Diener, 1909, p. 125.
Pseudosibirites. Arthaber, 1911, p. 254.
Sibirites Diener, 1913, p. 31.
Anasibirites. Arthaber, 1914, p. 178.
Anasibirites. Welter, 1922, p. 138.
Sibirites. Yehara, 1927, p. 167.
Anasibirites. Mathews, 19292, p. 7.
Anasibirites. Smith, 1932, p. 69.
Anasibirites. Spath, 1934, p. 345.
Anasibirites. Chao, 1959, p. 327.

Remarks: – The genus *Anasibirites*, based upon *Sibirites kingianus* Waagen was separated by Mojsisovics (1899) from the genus *Sibirites* Mojsisovics, 1886, (Genotype *Sibirites pretiosus*), for some species of *Sibirites* reported from the Salt Range by Waagen (1895). Mojsisovics stated that some species of *Sibirites* from the Salt Range though near to the Arctic *Sibirites eichwaldi*, differ therefrom in many respects and form a characteristic group in their tendency to decided variation, and for this group the subgeneric name *Anasibirites* might be applied.

Mojsisovics's original description is "The species of *Anasibirites* is distinguished by narrow, rather rapidly increasing whorls, which possess a narrow, rounded or flattened external part. The ornamentation closes completely on the external part either describing a projecting external lappet (Curvicostati, Waagen) or traversing in a straight line on the external part (Rectecostati, Waagen). In the lateral sculpture, the contrast between strongly developed chief ribs and weaker secondary ribs occurring in the interspaces of the chief ribs, which mostly appear as intercalated and more rarely as bifurcated ribs, is more or less striking. Where marginal tubercles are present they are only on the chief ribs. The lateral ribs show a tendency to curve sigmoidally. In a few species they disappear entirely on the body-chamber."

Mojsisovics divided the genus *Sibirites* into the following subgenera: – *Sibirites*, s. str., *Anasibirites*, *Metasibirites*, and *Thetidites*.

In Japan, from the dark gray argillaceous limestone of the Taho Formation, Yehara (1927) described *Meekoceras onoi* Yehara, *M. akamatsui* Yehara, *Xenodiscus pacificus* Yehara, *X. kotoi* Yehara, *Ophiceras multiplicatum* Yehara, *Sibirites* sp. and *Xenodiscus* sp. All of these species were considered to belong to *Anasibirites* by Shimizu (1932), and Shimizu and Jimbo (1933). At that time, Shimizu and Jimbo reported on the occurrence of *A.* n. sp. aff. *spiniger* Diener. Recently, Kummel (1959, 1960) pointed out that the majority of the ammonite species described by Yehara from the Taho Formation belong to *Anasibirites* and *Hemiprionites* and that the fauna represents the zone of *Anasibirites multiformis*, which is known from Timor, the provinces of Kiangsu and Hupeh in China, British Columbia, and from Utah and Idaho in the United States of America.

Distribution: – Upper Scythian, Owenitan. Salt Range, Himalayas, Timor, Mongishlak, South China, Japan, North America and Albania.

Anasibirites kingianus inaequicostatus (Waagen)

Pl. 1, figs. 19a–b

Sibirites inaequicostatus Waagen, 1895, p. 113, pl. 8, figs. 7–8.
Anasibirites multiformis Welter, 1922, p. 138, pl. 169, figs. 17–18, pl. 170, figs. 6–8, (partim.).
Anasibirites perrini Mathews, 1929, p. 18, pl. 3, figs. 34–36.
Anasibirites kingianus inaequicostatus Smith, 1932, p. 72, pl. 79, figs. 16–17.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78331	15.0	6.0	0.40	4.5	0.75	4.0	0.26
Type species after Waagen (1895, p. 114, pl.8, figs.7-8)	16.0	7.0	0.43	6.5	0.93	5.0	0.31
	39.0	17.0	0.48	11.5	0.68	10.0	0.25

Remarks: – The sculpture changes near the body chamber of the adult specimens as pointed out by Waagen (1895, p. 114). The characteristic features of the shell sculpture serve to distinguish the present one from the other species of this genus. So far as the shell sculpture of the body whorl is concerned, this species may be mistaken for *A. multiformis* Welter s. str., *A. powelli* Mathews, *A. rollini* Math., and *A. salisburyi* Math. from Timor (Welter, 1922, p. 138) and from North America (Mathews, 1929), all of which are included by Smith (1932, p. 74) in the species of *A. tenuistriatus* (Waagen).

The material at hand is identified with *A. kingianus inaequicostatus*, originally described from the Upper Ceratite Limestone of Chidoro, Salt Range of India. This species has also been reported from the *Anasibirites* subzone of the Fort Douglas area, Utah, by Mathews.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. Saburo Shimizu.

Repository: – IGPS* coll. cat. no. 78331

Anasibirites archiperipheras Bando, n. sp.
Pl. 2, fig. 3a–b, 5a–b ; Pl. 6, fig. 12

Meekoceras obscurum Shimizu and Jimbo, 1933, p. 25.

Description: – Shell laterally compressed, discoidal, involute, umbilicus narrow, venter roundly arched. Sides almost flattened, convex on middle of flanks, maximum thickness at middle or about three-fifths of whorl height. Width of umbilicus very narrow, about one-seventh of total diameter of shell, shoulders rounded, somewhat abruptly rounded, and almost closed. Whorls high, about one-half of shell diameter. Width about one-eighth of total diameter. Venter roundly arched, slightly compressed. Surface with very fine projected radial striations, very weak to almost smooth.

Septa ceratitic, of three entire saddles and two lateral lobes. Peripheral lobe very shallow, rather long, terminate on peripheral edge. First lateral lobe well serrated into three to seven corrugations, deepest compared with other lobes, second lateral lobe also well serrated into five to six corrugations. First lateral saddle most elevated, larger than second lateral saddle. Saddles generally rather short and more or less acute at top. Auxiliary series slightly serrated on straight radial lines from umbilicus, its external margin on umbilical shoulder.

Measurements (*mm*): –

		D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no 45160	A.	36.0	16.0	0.44	9.5	0.59	4.5	0.13
	B.	37.0	20.0	0.55	11.5	0.56	5.5	0.15
	C.	—	19.0	—	11.0	0.58	5.0	—

Remarks: – The four specimens at hand from the Taho Formation were first named *Meekoceras obscurum* by Shimizu and Jimbo, but their description was left in manuscript form. They are redescribed as a new species in this article.

In the form of venter, whorl section, shell ornamentation, and the septa, the present species resembles *Anasibirites* rather than *Meekoceras*. Specifically, they are related to *Anasibirites emmonsi* Mathews from North America (Mathews, 1929, p. 14, pl. 12, = *A. welleri*, *A. crickmayri*, and *A. vanbuskirki*; Smith, 1933, p. 71, pl. 79, figs. 22–24), however the present forms are distinguished by having rounder periphery and some differences of the septa in the ventral part. The present specimens also resemble *Submeekoceras mushbachanum* (White) from North America (White, 1879, 1880; Smith, 1904, 1914; Hyatt and Smith, 1905; Spath, 1934) and from Timor (Welter, 1922), but the septa and width of umbilicus are not identical. The species is also related to *Anasibirites multiformis* Welter illustrated by Welter (1922, p. 138, pl. 170, figs. 9–10, 18–19. partim), but have more compressed whorl. *Anasibirites multiplicatus* (Yehara), which resembles *A. multiformis* was described as *Ophiceras* in the original description (Yehara, 1927, p. 162, pl. 14, fig. 4), and is similar to the present species by having an arched venter in whorl shape, but differs in the shape and size of umbilicus and septa. The present species shows some resemblance to the Indian *Meekoceras solitarium* Krafft and Diener from the *Hedenstroemia* Beds of Spiti in the form of shell and the general character of sutures, but is distinguished by the longer lateral lobes. In the general shell form, it also resembles *Meekoceras koninckianum*

* IGPS: Abbreviation for the Institute of Geology and Paleontology, Tohoku University, Sendai, Japan.

Waagen from the Ceratite Marls of Virgal, Salt Range (Waagen, 1895, p. 245, pl. 24, fig. 60), but have different septa and umbilical width as described by Shimizu and Jimbo (1933). In the form of venter and shell sculpture the species is allied to yet different from *A. desertorum* Smith from the *Meekoceras* zone, *Owenites* subzone, of North America (Smith, 1932, p. 71, pl. 56, figs. 19–20, non pl. 51, figs. 7–10).

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku.

Repository: – IGPS coll. cat. no. 45160 Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Anasibirites shimizui Bando, n. sp.

Pl. 3, figs. 10a–b

Description: – Form laterally compressed, involute. discoidal, with closed narrow umbilicus and arched venter as in *A. archiperipheras*. Whorl high, deeply embracing, well indented by inner volution. Height of last whorl about four-sevenths of total diameter of shell, width slightly exceeding one-half height of last whorl. Width of umbilicus very narrow, about one-seventh of total diameter; umbilical shoulder sharply rounded. Sides broadly convex, gently sloping from greatest width of shell, which is at one-third height.

Surface with radial striations, which project near peripheral sides. Septa ceratitic, of three entire saddles and two lateral lobes. Ventral lobe almost equal in depth to first lateral lobe, roundly terminates on peripheral edge, both sides well serrated into two or three corrugations. First lateral lobes well serrated into five to six, rather wide. Second lateral lobe shallow, about one-half depth of first lateral one, and well serrated as first lateral lobe. Auxiliary series considerably elevated, shallowly serrated, first auxiliary lobe situated in umbilical shoulder. Second lateral saddle more elevated than first lateral one.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78332	29.0 (24.0)	16.0	0.55	9.0	0.56	4.0	0.14

Remarks: – The single specimen was found in association with *Meekoceras obscurum* of Shimizu and Jimbo, which is described in this paper as *Anasibirites archiperipheras*.

The present specimen is similar to *Anasibirites archiperipheras* in the whorl ratio, ornamentation, width of umbilicus, and in the form of venter, but differs by the septa, easpecially by the form of the second lateral saddle and the anxiliary series. The general character of the shell form is related to *Meekoceras haydeni* Krafft and Diener from the *Meekoceras* Beds of Spiti in India (Krafft and Diener, 1909, p. 68, pl. 17, figs. 1–6, as *Koninckites*), although not identical and the auxiliary lobes are some what different.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku.

Repository: – IGPS coll. cat. no. 78332. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Anasibirites onoi (Yehara)

Pl. 2, figs. 16, 17 ; Pl. 3, figs. 13a–b, 14a–b, 15a–b, 16 ; Pl. 5, fig. 7

Meekoceras onoi Yehara, 1925, p. 38, pl. 13, fig. 1.
Meekoceras onoi Yehara, 1927, p. 153, pl. 13, fig. 1.
Anasibirites onoi (Yehara). Shimizu and Jimbo, 1933, p. 13.

Description: – Shell laterally compressed, involute, discoidal, umbilicus narrow, venter tabulated. Sides flattened, gently convex on flanks at one-third height of whorl. Height of whorl one-half of total diameter of shell; width of last whorl about three-fifths height. Umbilicus very narrow, about one-seventh or one-eighth total diameter of shell, inner whorls slightly exposed. Umbilical shoulders abruptly rounded, wall steep. Whorl indented at about one-third height by inner volution, outer whorl well embracing inner whorls. Venter narrowly tabulated, but somewhat subtabulated on body whorl.

Surface with radial fine flexuous ribs, projected near peripheral side, almost diminished on umbilical shoulders. Ribs originate at umbilical edge, very weak, become stronger near ventral margin, extend across venter.

Septa ceratitic, of roundly arched entire saddles and well serrated lobes. Ventral lobe shallow, short, divided by a narrow siphonal saddle into small entire branchs. First lateral lobe broad, deepest, serrated into six corrugations in last whorl; second lateral lobe comparatively shallow, with five corrugations. Auxiliary series a little shallower than second lateral lobe and consists of a rather short row of denticulations followed by three saddles in adult form.

Measurements (*mm*) : –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45169 (A-G)	52.0 (43.0)	26.0	0.50	15.0	0.58	7.0	0.13
	16.0	8.0	0.50	4.5	0.56	3.5	0.22
	11.0	5.5	0.55	4.0	0.61	2.5	0.22
	12.0	7.0	0.56	4.0	0.57	2.5	0.20

Remarks : – The present species was studied by Shimizu and Jimbo (1933), but no remarks concerning it was given in their original paper. This species was reported from the Taho Formation by Yehara (1927, p. 153) under the genus name *Meekoceras*, but subsequently Shimizu (1932), and Shimizu and Jimbo (1933) referred the species to *Anasibirites*. The single specimen illustrated by Yehara is not sufficiently preserved for comparison with other related species. For such reason, Shimizu and Jimbo's original specimen is redescribed in this article.

Shimizu and Jimbo stated that this species resembles *Anasibirites multiformis* Welter from Timor except for the septal elements which could not be compared as they were not illsutrated by Welter (1922, p. 138).

Anasibirites emmonis Mathews from the *Anasibirites* subzone of the Fort Douglas area in Utah, North America, which was described by Mathews (1929) and Smith (1932) is similar to the present one. But they are distinguished from one another by the umbilicus and ventral sutures. The present species is related with *Anasibirites tenuciostatus* (Waagen) (Waagen, 1895, p. 124, pl. 9, figs. 1–2) from the Upper Ceratite Limestone of the Chitta-Wan near Chari in the Salt Range, but the details of sculpture are different.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45169

Anasibirites pacificus (Yehara)

Pl. 3, figs. 5a–b, 6, 7a–b; Pl. 5, figs. 8, 11, 13, 14; Pl. 6, figs. 8, 9a–b, 11

Xenodiscus pacificus Yehara, 1927, p. 163, pl. 16, figs. 5–6.
Anasibirites pacificus (Yehara). Shimizu and Jimbo, 1933, p. 21.

Measurements (*mm*)–

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45171 (A-H)	19.0	7.5	0.39	5.5	0.73	—	—
	17.0	7.0	0.41	5.0	0.71	5.0	0.29
	—	6.0	—	5.0	0.83	5.0	—
	—	6.0	—	5.0	0.83	—	—
	—	6.0 (?)	—	4.0	0.66 (?)	5.0 (?)	—

Remarks: – Yehara first described the present species under the genus *Xenodiscus*, but subsequently Shimizu and Jimbo referred the same species to *Anasibirities*.

Anasibirites pacificus (Yehara) is closely allied to *Anasibirites chideruensis* (Waagen) from the Upper Ceratite Limestone of Chidoro, Salt Range (Waagen, 1895, p. 109, pl. 13, figs. 3–4) in the shell ornamentation, whorl shape, and in the ventral form, but slightly differs in the number of ribs on the sides in the early stage. Shimizu and Jimbo (1933) pointed out that this form most resembles *Anasibirites multiformis* Welter (Form 1, original 1) from Anak Saban in Timor Island (Welter, 1922, p. 138, pl. 169 (5), figs. 9–11), but the present species has more compressed whorls. This species resembles *A. ehimensis* Bando, n. sp. from the Taho Formation, but differs in having more numerous ribs.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 45171.

Anasibirites ehimensis Bando, n. sp.

Pl. 3, figs. 12a–c

Description: – Shell rather small, evolute, laterally compressed, discoidal, umbilicus wide and shallow, venter rounded. Whorl increase slowly in height, not very deeply embracing, outer whorl indented at about one-half height by inner whorl. Height of whorl about two-fifths total diameter of shell, width about one-third of total diameter or about five-sixths of height. Umbilicus wide, open, shallow, shoulder rounded, its width about one-third total diameter or almost equal to shell width. Venter rather broad, roundly arched, shoulder gently rounded from lateral side.

Surface with about 14 to 15 strong radial ribs, in outer volution, slightly projected at ventral shoulder, ribs unifrom in strength. Each ribs begins from umbilical margin, run radially on sides, cross venter in almost straight line.

Sides gently convex, slightly flattened, slope from umbilical shoulder to ventral shoulder, thickness at middle portion of flanks. Cross section of last whorl rounded, deeper than broad, rather elliptical.

Septa ceratitic, of rounded saddles and slightly serrated lobes; ventral lobe divided by a wedge-shaped siphonal saddle into a shallow small lobe without corrugations; external saddle entire, rounded, longest; first lateral lobe slightly corrugated, deepest, broad; first lateral saddle broadly rounded, shorter than external saddle; second lateral lobe very

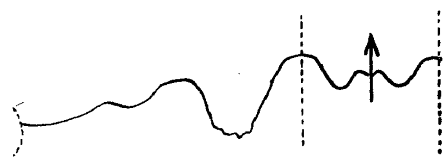

Fig. 16. Septa on *Anasibirites ehimensis* Bando, n. sp. ×6 (IGPS coll. cat. no. 45170)

shallow, broadest, indistinct in younger whorl. Auxiliary series almost straight, without denticulations.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no.	16.0 (13.5)	6.5	0.40	5.0	0.77	5.0	0.31
45170 (A-B)	11.0 (?)	4.0	0.36 (?)	3.5	0.87	3.5 (?)	0.31 (?)

Remarks: – The present new species is related with *Anasibirites multiformis* Welter (Form 1, Original 1) from Anak Saban, Timor (Welter, 1922, p. 138, pl. 169, figs. 9–11) in the sculpture, especially in the form of ribs, their spacing, and the prominence, but differs thereform by the more reguarly spaced and almost equal strengthed ribs. The septa in the Timor species has not been figured and thus comparison is inadequate.

The present form resembles *A. pacificus* (Yehara) in the ornamentation, but differs in the coarser ribbing and regularity.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwagun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Respository: – IGPS coll. cat. no. 45170.

Anasibirites intermedius Bando, n. sp.

Pl. 5, figs. 9a-b

Description: – Shell rather involute, laterally compressed, discoidal, rounded or tabulated narrow venter, umbilicus narrow. Whorl deeply embracing inner wholr, outer indented at about one-half height by inner. Height of whorl about one-half total diameter of shell, width about one-half height of shell. Umbilicus narrow, shallow, abruptly rounded shoulder, wall not vertical nor very high. Sides gently slope from umbilical shoulder to obtusely rounded ventral shoulder, sharp, distinct in adult. General form of venter narrowly tabulated, somewhat bicarinate in adult, but venter rounded in younger.

Surface with about 30 very fine radial ribs, in half of outer volution, forming falcoid or sickle-shape, most projected forward on ventral shoulder. Ribs originate at umbilical edge, extend to external siphonal part, transversely crossed by them in straight line. Each ribs equal in strength, become gradually prominent toward ventral margin, where most prominent, very weak at umbilical margin.

Fig. 17 *Anasibirites intermedius* Bando, n. sp. ×5 (IGPS coll. cat. no. 79171)

Septa ceratitic, of rounded saddles and slightly denticulated lobes; siphonal lobe divided by median small saddle, which forms somewhat tabulated termination at top, two lateral parts very narrow, shallow, without denticulations; external saddle longest, comparatively broad, somewhat angular at top; first lateral lobe narrow, deepest, denticulated in three points at bottom; first lateral saddle shorter than external one, rounded and entire, without corrugations; second lateral lobe narrow and shallow, with two denticulations at bottom; second lateral saddle shallowest, narrowest, forming entire rounded shape, without corrugations. Auxiliary series, not serrated nor denticulated, showing almost straight line.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79171 (A-C)	17.0	9.0	0.53	4.0	0.44	3.0	0.18
	15.0	7.0	0.46	4.0	0.57	3.0	0.20
	—	10.0	—	5.0	0.5	6.0 (?)	—

Remarks: – The present new species is closely allied with *Anasibirites tenuistriatus* (Waagen) from the Upper Ceratite Limestone of Chitta-Wan in the Salt Range (Waagen, 1895, p. 9, figs. 1–2) in the sculpture of the shell, but is distinguished by the ribs. The nature of the septa in the Salt Range species are unknown. The present form resembles *A. desertorum* Smith from the Lower Triassic *Meekoceras* zone, Owenitan substage, of Union Wash, Inyo Mountains, in North America (Smith, 1932, p. 71, pl. 51, figs. 7–10) in the ornamentation, form of venter, and width of umbilicus, but differs by having a more compressed whorl. It also resembles *A. multiformis* Welter (Form 5, Original 1), which was reported from Timor by Welter (1922, p. 138, pl. 170, figs. 6–8), but is distinguished by having a more compressed whorl and a more tabulated venter. The present one is also related with *A. madisoni* Mathews, *A. whitfieldi* Mathews, and *A. crickmayi* from North America (Mathews, 1929, p. 11, 16) in the shell sculpture, but these American forms are all synonymous with *A. multiformis* Wellter (Form 6, Original 1), described from Timor by Welter (1922, p. 138, pl. 170, figs. 11–13), as mentioned by Spath (1934, p. 348). It is distinguished from that species by the differences of the form of venter and narrower umbilicus.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 79171.

Anasibirites multiplicatus (Yehara)

Pl. 3, figs. 4a–b, 9a-b, 11a-b, 13a-b, 17; Pl. 5, figs. 10, 15; Pl. 6, figs. 6a–b, 7

Ophiceras multiplicatus Yehara, 1927, p. 162, pl. 14, figs. 4, 4a.
Anasibirites multiplicatus (Yehara). Shimizu and Jimbo, 1933, p. 20.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45173	26.0	11.5	0.44	7.5	0.65	6.0	0.23
	15.0	6.0	0.40	4.5	0.75	4.0	0.36

Remarks: – Yehara (1927, p. 163) stated that the present species is identical with *Ophiceras tibeticum* Gliesbach, but Shimizu and Jimbo revised the name to *Anasibirites multiplicatus* (Yehara). Spath pointed out that *Ophiceras multiplicatus* Yehara should be referred to *Anasibirites* and that the ornamentation is more distinct than *A. tenuistriatus* (Waagen) (Spath, 1934, p. 350). The materials are allied with *A. multiformis* Welter (Form 1, Original 2) from Timor (Welter, 1922, p. 138, pl. 169, figs. 12–13) in the form of whorl, shell ornamentation, and the umbilius, however it is distinguished from that species by having more compressed whorls and a little narrow umbilicus. As mentioned by Shimizu and Jimbo, it differs *A. hircinus* (Waagen) from the Upper Ceratite Limestone of Salt

Range in the weaker ornamentation. On the other hand, it is also allied with *A. noetlingi* (Hyatt and Smith) from the *Meekoceras* Beds of the Lower Triassic, Union Wash, Inyo Range, Inyo County, California, in North America, but differs in having a narrow umbilicus and more feeble ribs. The other American species, *A. desertorum* Smith, closely resembles the present species in the shell ornamentation, but has a little larger umbilicus and finer ribs. *A. emmonsi* Mathews has finer ribs and more robust inner volutions than the Japanese species.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 45173.

Anasibirites sp. A

Pl. 3, figs. 8a–b

Remarks: – Only a single specimen. Unfortunately the outer whorl is broken, but the septa excepting the siphonal lobe are well preserved.

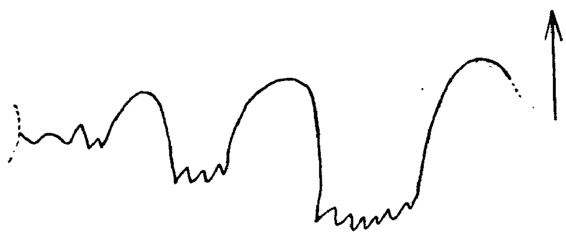

Fig. 18. Septa of *Anasibirites* sp. A. × 3.3 (IGPS coll. cat. no. 78334)

So far as the shell sculpture is concerned the present specimen may be identical with *Anasibirites parvumbilicatus* (Waagen) first described by Waagen (1895, p. 119, pl. 9, figs. 5–6) from the Upper Ceratite Limestone of Shiran-ki-Dok in the Salt Range, India, but since the septa of the Indian species are unknown strict comparison is difficult. The present form resembles *Anasibirites noetlingi* Hyatt and Smith (1905, p. 49, pl. 9, figs. 1–3) and Smith (1932, p. 74, pl. 9, figs. 1–3) from the Iyno Range, Inyo County, California, North America, but has coarser ribbing. Unfortunately the septa of the American species is unknown. Nothing is known on the exact stratigraphic occurrence of *A. noetlingi* in the United States of America, according to Kummel (1954).

The present one is distinguished from *Anasibirites angulosus* (Waagen), described by Waagen (1895, p. 117, pl. 8, figs. 1–13) from the Upper Ceratite Limestone of Chidoro in Salt Range and by Mathews (1929, p. 10) from Utah, North America, by having more rounded venter. The present species shows greatest resemblance with *A. parvumbilicatus* in the shell sculpture, but on the other hand, *A. parvumbilicatus* may be synonymous with *A. noetlingi*, both having characteristic shell sculpture. It is unfortunate that the Indian and North American species do not show their septa.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 78334.

Anasibirites sp. B

Pl. 2, figs. 11a–b; Pl. 3, figs. 1a–b, 2a–b

Remarks: – Two fragments of the outer whorl were studied. In the characteristics of the shell sculpture the present materials are related with *Anasibirites ibex* (Waagen) from the Upper Ceratite Limestone of Chidroo, Salt Range described by Waagen (1895, p. 121) and by Noetling (1905, pl. 28, fig. 3) from the same locality, but they have considerably stronger secondary ribs which extend from the ventral margin and die out on the middle height of the flanks. *A. ibex* was reported from the Fort Douglas area, Utah, in North America by Mathews (1929, p. 20). *Anasibirites robustus* Welter from Timor bears some resemblance with the present form in the features of ribs, but have more compressed whorl and coarser ribbing. The present specimens may be a new species, but unfortunately the material is insufficient for the proposal of a new species name.

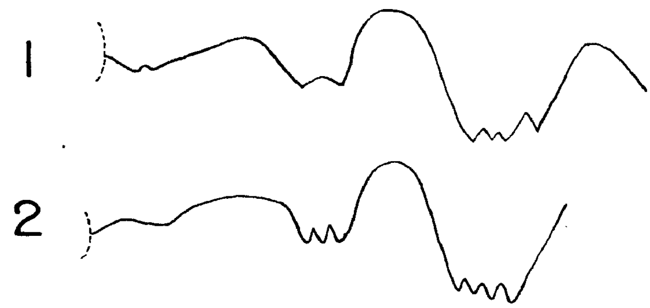

Fig. 19. Septa of *Anasibirites* sp. B. 1: ×4.5 2: ×5 (IGPS coll. cat. no. 45172)

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 45172, GLKU*–C106.

Anasibirites sp. C

Pl. 5, fig. 12

Remarks: – The material examined is a fragmental body chamber of the outer whorl and a side of the umbilical shoulder; most of the inner volution are not exposed. The shell shows only the ventral side on which fine oblique striations are seen on the venter. The venter is widely arched with subrounded ventral shoulders. Judging from the cross section of the specimen, the breadth of the shell is considerably wide. The shell surface has very fine transverse striations as in *Anasibirites.* It seems to be closely related to *Anasibirites multiformis* Welter (Welter, 1922, p. 138, pl. 169 (15), figs. 9–27, non figs. 17–18, pl. 170 (16), figs. 1–19, pl. 171, figs. 1–3, 8–10, non figs. 4–7, 11–14) reported from the *Anasibirites* subzone of the Fort Douglas area, Utah, in North America by Smith (1932, p. 74, pl. 79) and, as above mentioned, is very variable in form.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku.

Repository: – GLKU–C113

Family Meekoceratidae Waagen, 1895
Subfamily Meekoceratinae Waagen, 1895
Genus *Meekoceras* Hyatt, 1879

Genotype: *Meekoceras gracilitatus* White, 1879

* GLKU-Abbreviation for the Geological Laboratory, Kagawa University, Takamatsu, Kagawa Prefecture, Japan.

Meekoceras Hyatt, 1879, in White, p. 111.
Meekoceras. Hyatt, 1880, in White, p. 112.
Meekoceras (Part). Mojsisovics, 1882, p. 213.
Meekoceras (Part). Mojsisovics, 1886, p. 79.
Meekoceras. 1895, Waagen, p. 236.
Meekoceras. 1896, Diener, p. 46.
Meekoceras. 1897, Diener, p. 126.
Arctoceras. 1900, Hyatt, 1900, in Zittel, p. 559.
Meekoceras. 1903, Kittl, p. 69.
Meekoceras. 1904, Smith, p. 367.
Meekoceras. 1905, Hyatt and Smith, p. 140
Meekoceras. 1909, Krafft and Diener, p. 16.
Meekoceras. 1911, Arthaber, p. 243.
Meekoceras. 1914, Smith, p. 77.
Meekoceras. 1922, Welter, p. 126.
Meekoceras. 1927, Yehara, p. 153.
Meekoceras. 1929, Mathews, p. 6.
Meekoceras. 1934, Collignon, p. 34.
Meekoceras. 1934, Spath, p. 246.
Meekoceras. 1959, Chao, p. 309.
Meekoceras. 1961, Tozer, p. 65.

Remarks: – The genus *Meekoceras* is one of the most common in the fauna of the Lower Triassic ammonites. To date, the genus *Meekoceras* has been described from Idaho, California in North America (Hyatt, 1879; Smith, 1904; Hyatt and Smith, 1905; Smith, 1914; Mathews, 1929; Smith, 1932; Spath, 1934; Kummel and Steele, 1962), Arctic Canada (Tozer, 1961), Timor (Welter, 1922), Japan (Yehara, 1927; Shimizu and Jimbo, 1933), China (Tien, 1933; Chao, 1959), Eastern Siberia (Diener, 1895; Kiparisova, 1947 1961), India and Pakistan (Waagen, 1895; Diener, 1895, 1879; Krafft and Diener, 1909) and from the Alps (Kittle, 1903; Arthaber, 1911; Renz and Renz, 1948). However, Spath (1934, p. 246) and Kummel (1957, p. 142) mentioned that both North America and Timor are typical localities for *Meekoceras*. Spath stated that the Olenek fauna of Northern Siberia does not include the true *Meekoceras* (of Owenitan age) and the listing of some these "*Meekoceras*" as *Gyronites* and *Koninckites* by Diener is doubtful (1930, p. 82). On the other hand, Kummel (1959, p. 434) referred *Meekoceras* cf. *jolinkense* Krafft, which was described from Lipo, Kueichow, South China, to the genus *Prionolobus* and suggested that the other Chinese *Meekoceras*, namely *Meekoceras hodgsoni involutum* Hsu, may belong to the genus *Prionolobus* (1959, p. 435). The Japanese *Meekoceras* described by Yehara (1927) was first suggested by Spath (1930, p. 85) to be referable to the fauna of the *Anasibirites multiformis* Beds of Timor and that they are of an age not earlier than Stephanian, as Welter correctly stated, equivalent to the Upper Ceratite Limestone of the Salt Range or the zone of *Anasibirites spiniger* in the Himalayas. Subsequently, Shimizu and Jimbo (1933) mentioned that the "*Meekoceras*" fauna illustrated by Yehara should be included into the genus *Anasibirites*, e.g. "*Meekoceras*" *onoi* Yehara. The same opinion was also expressed by Spath (1934, p. 349–350) for "*Meekoceras*" *onoi* Yehara. Recently, Kummel (1954, p. 186; 1959, p. 435, 960, p. 1) pointed out that the "*Meekoceras*" fauna described by Yehara probably belongs to the *Anasibirites* zone and the majority of the ammonite species from the Taho Formation to *Anasibirites* and *Hemiprionites* of the zone of his *Anasibirites multiformis* which is known from Timor, Kiangsu and Hupeh in China, British Columbia, and Utah and Idaho in United States of America (1959, p. 435–436; 1960, p. 1). The writer came to the conclusion that: *Meekoceras morianum* Yehara, *M. katoi* Yehara, *M. kuharanum* Yehara, and *M. sawatanum* Yehara all belong to the genus *Hemiprionites*, and *Meekoceras onoi* Yehara and *Meekoceras akamatsu* Yehara to *Anasibirites* and are synonymous species.

But *Meekoceras* cf. *lingtiense* Krafft and Diener and *Meekoceras* cf. *markhami* Diener, which were described by Yehara, belong to *Meekoceras*. The latter two species were renamed by Shimizu and Jimbo as *Meekoceras japonicum* for *M.* cf. *lingtiense* and as *M. orientale* for *M.* cf. *markhami* (Shimizu and Jimbo, 1933, p. 14, 16).

Meekoceras japonicum Shimizu and Jimbo

Pl. 1, figs. 1a-b, 2a-b, 10, 11; Pl. 2, figs. 14a-b; Pl. 3, fig. 3

Meekoceras cf. *lingtiense* Krafft and Diener. Yehara, 1927, p. 154, pl. 15, fig. 2.
Meekoceras japonicum Shimizu and Jimbo. 1933, p. 14.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45159	48.0	25.0	0.52	12.0	0.48	8.0	0.17
	38.0 (30.0)	19.0	0.50	9.0	0.47	8.0	0.21
	29.0	14.0	0.48	6.0	0.43	5.0	0.17
	—	15.0	—	6.5	0.43	—	—
	—	11.0	—	6.0	0.55	5.5	—

Remarks: – Six specimens of this species were examined; all were collected from the Taho Formation in Shikoku. *Meekoceras* cf. *lingtiense* Krafft and Diener which was considered a synonym of this species by Yehara (1927), unfortunately, was not illustrated as to whorl sections. Shimizu and Jimbo pointed out that the species illustrated by Yehara differs considerably from *M. lingtiense* Krafft and Diener from the *Hedenstoremia* Beds in the Himalayas and from the Ceratite Formation of the Salt Range, and as a result, the latter authors proposed a new species name, namely *M. japonicum* Shimizu and Jimbo, for Yehara's species. It is unfortunate that the latter authors did not illustrate their own collections. This species is closely related to *M. pseudoplanulatum* Krafft and Diener from the *Hedenstroemia* Beds of Spiti in the general shell form, but is distinguishable in the septal elements, especially in the shape of the saddles, the auxiliary series, and of the siphonal septa.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45159.

Meekoceras japonicum compressum Bando, n. subsp.

Pl. 2, figs. 7a-b

Description: – Shell rather involute, laterally compressed, discoidal, venter narrowly tabulated, umbilicus narrow, open, rather shallow. Sides gently convex from umbilical shoulder to siphonal sides, maximum convexity about one-half shell height. Whorl deeply embracing about three-fourths height of inner by outer whorl, outer whorl indented at about one-third height by inner whorl. Height of whorl about one-half total diameter of shell, width about two-fifths height or one-fifth total diameter. Umbilicus very narrow, about one-sixth total diameter, open, shoulder rather sharply rounded, with considerably deep cylindrical wall. Venter narrowly tabulated, shoulder forming a sharp edge.

Surface smooth, without radial or spiral ribs. Septa ceratitic, of rounded, entire, and deeply incised lobes; siphonal lobe divided by a narrow and very short median lobe, terminate into two small points, their lateral parts denticulated into five or six points; external saddle narrowly rounded, short, their top at almost equal level to median portion of ventral lobe; first lateral lobe well denticulated into 9 or 10 points at bottom, considerably

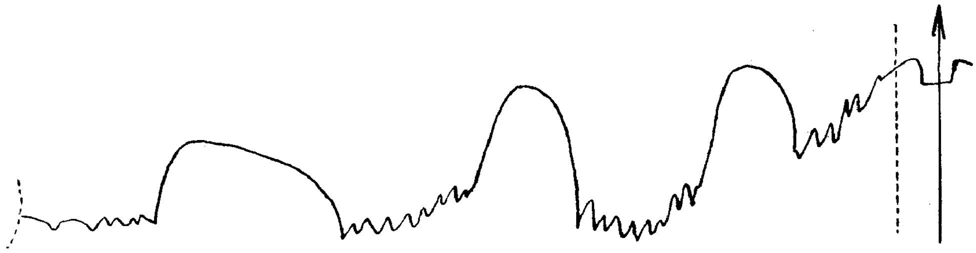

Fig. 20. Suture-line of *Meekoceras japonicum compressum* Bando, n. subsp. × 4 (IGPS coll. cat. no. 45163)

broad and deepest; first lateral saddle narrowly rounded, somewhat angular at top, entire, almost equal in length to external one; second lateral lobe short, broad, with about five denticulation at bottom; second lateral saddle braodest, shortest, roundly arched, entire, without corrugations. Auxiliary series well serrated into small numerous points along rather broad straight line.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45163	49.0 (36.0)	25.0	0.51	10.0	0.4	8.0 (6.0)	0.16

Remarks: – Only a single specimen was examined. The present new subspecies closely resembles *Meekoceras japonicum* Shimizu and Jimbo in the form of venter, shape of umbilicus, general features of the whorl section and septa, but differs by having more compressed whorls and broader lateral lobes. Concerning the shell ornamentation, the present form has almost smooth surface, whereas *M. japonicum* is sculptured with numerous fine radial ribs which form a falciform. The present form shows some resemblance with *M. gracilitatus* White from the Thaynes Formation, Idaho and from Utah, Nevada, California, as well as from Arcitic Canada, but possesses more compressed whorls, more angular saddles, and broader secondary saddle. In shell form, it is related with *M. planulatum* Koninck from the Ceratite sandstone of Koofri in India reported by Koninck (1863, p. 12, pl. 5, fig. 1) and by Waagen (1895, p. 255, pl. 24, fig. 2; pl. 39, fig. 2; pl. 40, fig. 1), but is distinguished by the ventral lobe, auxiliary septal series, and shell ornamentation.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45163.

Meekoceras orientale Shimizu and Jimbo

Pl. 1, figs. 3a-b

Meekoceras cf. *markhami* Diener. Yehara, 1927, p. 156, pl. 14, figs. 1–3.
Meekoceras orientale Shimizu and Jimbo. 1933, p. 16.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45174	45.0	22.0	0.45	10.0	0.46	9.0 (7.0)	0.20

Remarks: – In 1927, Yehara described *Meekoceras* cf. *markhami* Diener from the Taho Formation at Taho in Shikoku, but his description and figures were vague and do not serve for strict identification with *Meekoceras*. Moreover his specimens appear to be different from the Indian species in the width of umbilicus, the shell ornamentation, and the ventral lobe. Shimizu and Jimbo revised the species illustrated by Yehara and considered it to be a new species of *Meekoceras* and proposed for it the name of *Meekoceras orientale* Shimizu and Jimbo. But the latter authors failed to give a description of their proposed species and only published brief notes on the comparison of it with other species of *Meekoceras*.

The present species closely resembles *M. japonicum* Shimizu and Jimbo in the general shell form, but differs by having smoother surface, more flattened sides, and a broader auxiliary series. It shows considerable similarity with *M. pseudoplanulatum* Krafft and Diener (1909, p. 30, pl. 6, fig. 3) from Spiti in the feature of venter, whorl shape and in the form of septa as mentioned by Shimizu and Jimbo (1933, p. 16), however, it differs in the auxiliary ribs and the form of the umbilicus. It is also distinguished from *M. jolinkense* Krafft and Diener from Spiti (Krafft and Diener, 1909, p. 37, pl. 4, fig. 3; pl. 14, fig. 13) by having more compressed higher whorls, narrower venter and a broader auxiliary series in septa.

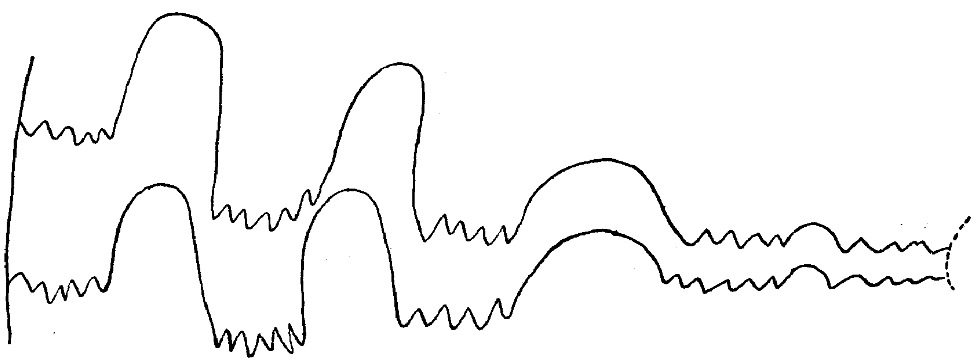

Fig. 21. Septa of *Meekoceras orientale* Shimizu and Jimbo ×4 (IGPS. coll. cat. no. 45174)

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45174.

Meekoceras sp.

Pl. 1, fig. 15

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78333	29.0	15.5	0.54	7.0	0.45	4.0	0.14

Remarks: – Only one specimen was examined. The form resembles *Meekoceras gracilitatus* White from the *Meekoceras* Beds of the Thaynes Formation, Idaho, and which was reported from Utah, Nevada, California, and Arctic Canada, but is distinguished by the narrower umbilicus and differences in septa, specially in the auxiliary series and in the narrower external saddle. In the whorl shape, it is similar to *Kymatites radiosum* (Waagen) (1895, p. 257, pl. 36, fig. 2) from the Ceratite Sandstone of Chitta-Wan, Salt Range,

Fig. 22. Septa of *Meekoceras* sp. indet. ×3.5 (IGPS coll. cat. no. 78333)

but differs in the shell ornamentation and in the septa of auxiliary series. *Kymatites radiosum* illustrated by Arthaber (1911, p. 246, pl. 21, fig. 14) shows a longer first lateral lobe, which is deeply incised and denticulated in three points at bottom. In general shape of the whorl this specimen is also allied to *Koninckites timorensis* (Wanner) from Biwark Kapan in Timor Island reported by Wanner (1911, p. 185, pl. 6, figs. 2–3; pl. 7, figs. 5–6), but differs by having a narrower auxiliary series and more rounded secondary saddle. Except for these slight differences, it is almost similar to Wanner's species in the feature of umbilicus, the ventral form, and the whorl shape.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 78333.

Genus *Wyomingites* Hyatt, 1900

Genotype: *Meekoceras aplanatum* White, 1880.

Wyomingites Hyatt, 1900, in Zittel, p. 556.
Wyomingites. Diener, 1915, p. 310.
Wyomingites. Spath, 1934, p. 249.
Wyomingites. Kummel, 1957, p. 141.

The genus *Wyomingites* was first proposed by Hyatt (1900, p. 556) based upon *Meekoceras aplanatum* described by White (1880) from North America. However, the general whorl aspects of this genus is closely similar to *Gyronites*, *Danubites*, *Xenodiscus*, and *Flemingites*. Because the present genotype species had been placed in various genera by many previous authors for instance, Mojsisovics (1886) put it in the genus *Xenodiscus*, Waagen (1895) referred it to *Xenaspis*, Frech (1902) included it in *Ophiceras*, Stolley (1911) to the *Gyronites*, Smith (1932) in *Flemingites*, but Smith correctly incorporated it in *Wyomingites*. Furthermore, the genera *Gyronites* and *Flemingites* are said to be similar to this genus at a certain growth stage (Spath, 1934, p. 250). On the other hand, the present genus shows resemblance to *Ophiceras* in general whorl shape. Stolley (1911, p. 123, pl. 9, fig. 5) reported *Gyronites aplanatus* from the *Arctoceras* Beds of Icefjord in Spitsbergen, but subsequently Spath (1934, p. 251) referred it to the group of *Svalbardiceras* on the basis of his comparative morphology of the specimens from the *Posidonomya* Shales of Spitsbergen.

In Japan, Yehara (1927, p. 165) once described *Xenaspis* cf. *marcoui* Hyatt and Smith from the Taho Formation at Taho in Shikoku, but this species was later included by Shimizu and Jimbo (1933, p. 22) in the genus *Wyomingites* as a new species with affinity to *aplanatsu* (White). The Japanese species is similar to the genus *Anasibirites*, but should be included in the genus *Wyomingites* by the character of the whorl, sculpture, and feature of the septa.

Distribution: – Upper Scythian, Owenitan. North America, New Zealand, Japan, and Northern Caucasia of Eastern Siberia.

Wyomingites cf. *aplanatus* (White)

Pl. 3, figs. 20, 21, 22; Pl. 6, figs. 10, 13, 14, 16; Pl. 8, figs. 4, 5

Meekoceras aplanatum White, 1879, p. 112.
Meekoceras aplanatum White. White, 1880, p. 112, pl. 31, fig. 1 (not fig. C, which is *Danubites*).
Xenodiscus aplanatus (White). Mojsisovics, 1886, p. 75.
Xenaspis aplanatus (White). Waagen, 1895, p. 290.
Wyomingites aplanatus (White). Hyatt, 1900, p. 556.
Ophiceras aplanatum (White). Frech, 1902, p. 631, fig. e.
Meekoceras aplanatum White. Smith, 1904, p. 373, pl. 41, figs. 4–6.
Meekoceras aplanatum White. Hyatt and Smith, 1905, p. 146, pl. 11, figs. 1–14; pl. 64, figs. 17–22; pl. 77, figs. 1–2.
Flemingites aplanatus. Smith, p. 51, pl. 11, figs. 1–14; pl. 22, figs. 1–23; pl. 39, figs. 1–2; pl. 64, figs. 17–32.
Wyomingites aplanatus. Spath, 1934, p. 250, fig. 84 (p. 249).
Wyomingites cf. *aplanatus.* Kummel, 1959, p. 444, figs. 5–6.
Wyomingites aplanatus. Popow, 1962, p. 43–44, pl. 6, fig. 4.
Wyomingites cf. *aplanatus.* Kummel, 1962, p. 696, pl. 99, figs. 3-4.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78338	19.0	6.5	0.34	4.5	0.69	6.5	0.34
GLKU-C127	18.5	7.0	0.38	4.0	0.22	7.5	0.41
GLKU-C118	18.5 (13.5)	7.0	0.47	3.5	0.5	6.5	0.35
GLKU-C114	17.0	5.0	0.29	3.5	0.70	6.0	0.35
GLKU-C116	—	5.0	—	4.0	0.80	6.5	—
GLKU-C117	—	5.5	—	3.5	0.63	6.5 (?)	—

Remarks: – The author considers that the illustrated specimens may correspond to the adolescence stage of *Wyomingites* by the goniatitic sutures or non-corrugated lobes analogous to the Lecanites stage. As regards the septa, the present form shows resemblance to those of *Xenaspis*, but differ in the size of the lobes.

The form is also related with *Xenaspis marcoui* Hyatt and Smith which was described from the *Owenites* subzone of the *Meekoceras* zone of Union Wash, Inyo Range, California, by Hyatt and Smith (1905) and Smith (1932), however it differs from that species by the slight difference of the siphonal lobe. It is also similar to *Flemingites bannockensis* Smith from the *Meekoceras* Beds of Idaho in North America in the general whorl shape, but that species differs from our specimens by showing a broad external saddle in the septal feature. Recently, Kummel (1959, p. 444) described the present species from the Malakoff Hill Group, Coal Creek, Wairaki Downs in New Zealand and compared it with *Flemingites timorensis* Wanner (1911, p. 187, pl. 7, figs. 1–2). Kummel and Steele (1962, p. 696) described the present species from the *Meekoceras gracilitatus* zone, Crittenden Spring, Elko County, Nevada.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 78338, GLKU–C127, GLKU–C118, GLKU–C114, GLKU–C115, GLKU–C116, GLKU–C117.

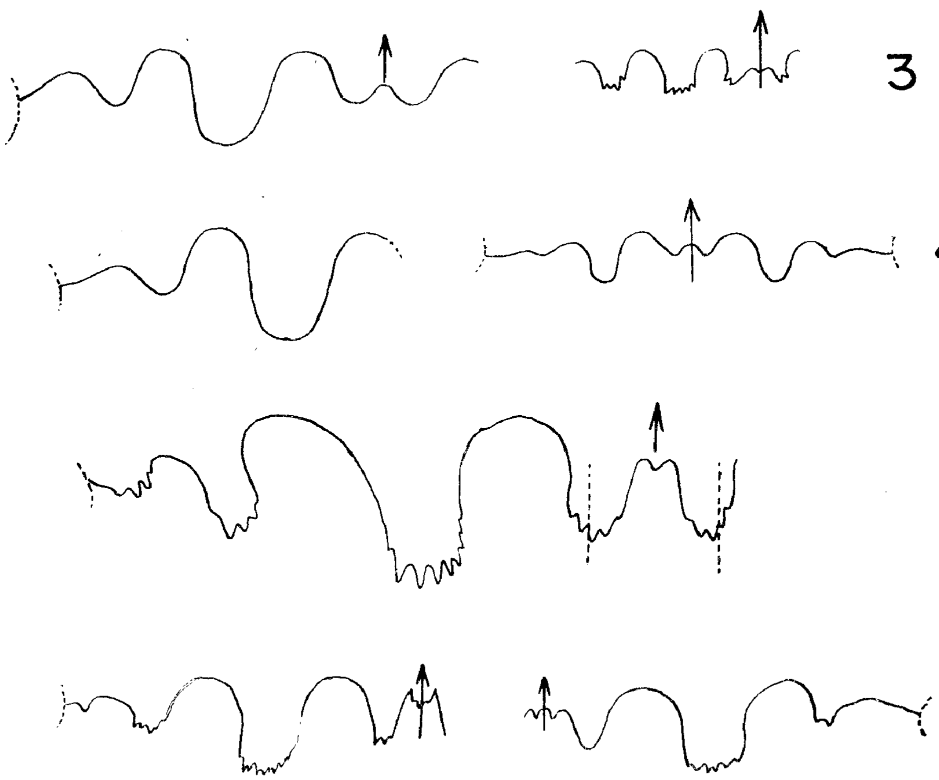

Fig. 23. Comparison of the types of septa of *Wyomingites aplanatus* (White).
1: *Wyomingites* cf. *aplanatus* (White), ×6, IGPS coll. no. 78338. (Coll. by Shimizu and Jimbo)
2: Same species as above. ×8 (GLKU-C114, Coll. by Bando, 1961)
3: Septa of White's type specimen, ×1 (U.S.G.S. Terr. Twelfth Ann. Rept., pt. 1, pl. 31, fig. 1d, 1880)
4: Smith's illustrated specimen. Septa of an adolescent specimen, ×4 (1932, U.S.G.S. Prof. Pap. 167, pl. 11, fig. 12).
5: Smith's illustrated specimen. Septa of an adult specimen. (1932, U.S.G.S. Prof. Pap. 167, pl. 22, fig. 3).
6, 7: Smith's illustrated specimen. Septa of an early mature stage, ×2 (1932, U.S.G.S. Prof. Pap. 167, pl. 22, fig. 5).

Family Xenoceltitidae Spath, 1930
Subfamily Xenoceltitinae Spath, 1930
Genus *Xenoceltites* Spath, 1930

Genotype: *Xenoceltites subevolutus* Spath, [=*Xenodiscus* cf. *comptoni* (non Diener), Frebold, 1930]

Xenoceltites Spath, 1930, p. 12.
Xenoceltites. Spath, 1934, p. 127.

The genus *Xenoceltites* was first named by Spath in 1930 for *Xenodiscus* cf. *comptoni* Diener of Frebold, which was described as a new species and designated as the genotype species, namely *Xenoceltites subevolutus* Spath. Concerning the characters of this genus Spath gave the following diagnosis:

"Shell compressed, discoidal, serpenticone Xenoceltitidae, with faint and distinct bulges on the inner whorls and irregular costation, generally causing constrictions, on the outer. Suture-line ceratitic, with two, faintly toothed, lateral lobes" (Spath, 1930, p. 127).

Accordingly, the Salt Range "*Dinarites*" *evolutus* Waagen and "*Ceratites*" *minutus*

Waagen of Diener (non Waagen) were considered by Spath to belong to the present genus. In general, the species of this genus commonly occur in immature form or insufficient numbers in Japan. The shell ornamentation is said to show a wide range of variation like *Anasibirites multiformis* Welter from Timor.

Distribution: – Upper Scythian, Owenitan to Columbitan. Spitsbergen, Siberia, Salt Range, South China, Utah and Nevada in North America, and Japan.

Xenoceltites aff. *evolutus* (Waagen)

Pl. 1, figs. 21a-b

Dinarites evolutus Waagen, 1895, p. 32, pl. 10, fig. 3.
Danubites cf. *evolutus* (Waagen). Frebold, 1930, p. 16–18,pl.3 fig. 6.
Xenoceltites evolutus (Waagen). Spath, 1934, p. 127.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78340	12.5	4.0	0.32	3.5	0.87	5.0 (3.0)	0.40

Remarks: – Only a single fragmentary specimen was examined. The material is almost identical with *Xenoceltites evolutus* (Waagen) which was described by Waagen (1895, p. 32, pl. 10, fig. 3) from Chidroo, near the junction between the Ceratites Sandstone and Upper Ceratite Limestone of the Salt Range, but unfortunately, in the absence of knowledge of their suture-line the present form cannot be compared accurately with Waagen's species, even though the whorl shape, indentation, form of umbilicus and the shell sculpture are closely allied with each other. It differs from *Xenoceltites minutus* (Waagen) from the Salt Range (Waagen, 1895, p. 31, pl. 7, figs.1–2, *Dinarites*) and the Alps (Philippi, 1901, p. 103), in the shallower embracement of the outer whorl. The Siberian form, "*Ceratites*" *minutus* Waagen, illustrated by Diener from the Gulf of Paris (Diener, 1896, p. 14, pl. 2, fig. 6) was distinguished from *X. minutus* and renamed as *X. russkiensis* Spath by Spath (1934, p. 130). The present form resembles *X. spitsbergensis* Spath from Spitsbergen (Spath, 1934, p. 128, pl. 9, figs. 1–2, pl. 11, figs. 5–8) in the whorl shape and septa, but differs in having more prominent ribs on their flanks. The species *X. spitsbergensis* was recently described by Kiparisova (1961, p. 50, pl. 9, figs. 7–8) from the Olenekian Bed of Ussuri. It is also similar to *X. gregoryi* Spath from Spitsbergen (Spath, 1934, p. 129, pl. 5, fig. 3; pl. 6, figs. 4–5, pl. 11, figs. 3–6), but differs in the shell ornamentation of the external side. Frebold (1930, p. 16–18) described "*Danubites*" cf. *evolutus* Waagen from the Fischniveau of Cape Wijk in Spitsbergen and stated that the septa show close relation with "*Xenaspis*" *marcoui* Hyatt and Smith (1905, pl. 7, figs. 26–33) as mentioned by Spath (1921).

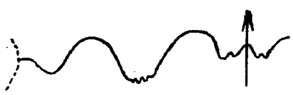

Fig. 24. Septa of *Xenoceltites* aff. *evolutus* (Waagen). ×10
(IGPS coll. cat. no. 78340)

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 78340.

Family Prionitidae Hyatt, 1900
Genus *Hemiprionites* Spath, 1929

Genotype: *Goniodiscus typus* Waagen, 1895.

Hemiprionites Spath, 1929, p. 270. (not seen)
Hemiprionites. Spath, 1934, p. 330–331.

Remarks: – The genus *Hemiprionites* was established by Spath (1929) based upon "*Goniodiscus*" *typus* Waagen from the Ceratite Formation of the Salt Range in Pakistan. This genus may be closely allied to "*Xenodiscus*", especially "*X.*" *schmidti* Mojsisovics (1886, p. 77, pl. 11, figs. 8–10). Typical species of *Hemiprionites* have been reported by Welter from Timor as *Anasibirites multiformis* Welter (1922, p. 140, pl. 171, figs. 13–14), but this was later included by Spath (1934) into the genus as a new species which he named *Hemiprionites timorensis* Spath. Other species of *Hemiprionites* have been recorded by Mathews (1919), namely *H. americanus* Mathews, and by Smith (1932), namely *H. walcotti* (Mathews), *H. utahensis* (Mathews) and *H. ornatus* (Mathews). Spath described *H. garwoodi* Spath from Utah in North America and from Spitsbergen.

As stated above previous to the systematic classification by Spath (1934, p. 330), all of the species of *Hemiprionites* from North America were included under the genus *Anasibirites.*

In Japan, Yehara (1927) described many Lower Triassic ammonites from the Taho Formation. His species are now included in the genera *Meekoceras, Kymatites, Ophiceras, Flemingites, Sibirites, Xenodiscus* and *Xenaspis.* Spath (1930, 1934) suggested that almost all of Yehara's species belong to the fauna of the *Anasibirites multiformis* Beds of Timor. Shimizu and Jimbo (1933) revised the specimens treated by Yehara and referred them to the genera *Meekoceras, Anasibirites* and *Wyomingites.* Recently, Kummel (1959, 1960) suggested that the majority of the ammonite species of the "*Meekoceras*" fauna from the Taho Formation may belong to the genera *Anasibirites* and *Hemiprionites.* The writer studied the Lower Triassic ammonites from the Taho Formation and came to the conclusion that certain changes should be made as, *Meekoceras kuharanum* Yehara and *Kymatites* cf. *typus* Waagen both belong to *Hemiprionites kuharanus* (Yehara), *Meekoceras morianum* Yehara is the same as *Hemiprionites morianus* (Yehara) and in part to *H. shikokuensis* (Shimizu and Jimbo), *Meekoceras katoi* Yehara is *H. katoi* (Yehara), *Meekoceras sawatanum* Yehara may be known as *H. sawatanus* (Yehara), and *Ophiceras tahoensis* Yehara and *Flemingites* sp. of Yehara should be referred to *H. tahoensis* (Yehara).

Distribution: – Upper Scythian, Owenitan. Salt Range, Timor, Utah and Idaho in North America, Spitsbergen, Eastern Russia, and Japan.

Hemiprionites katoi (Yehara)
Pl. 1, figs. 4, 9a-b, 12a-c

Meekoceras katoi Yehara, 1927, p. 157, pl. 15, fig. 3.
Meekoceras katoi Yehara. Shimizu and Jimbo, 1933, p. 16–17.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45161	40.0 (29.0)	22.0	0.55	12.0	0.55	4.5	0.11
	22.0 (17.5)	12.0	0.55	5.5	0.45	3.0	0.14
	18.5 (14.0)	10.0	0.54	5.5	0.55	2.0	0.11
	12.5 (9.5)	7.5	0.60	4.5	0.60	1.5	0.12

Remarks: – In the original description, Yehara (1927) stated that the septa are goniatitic but he did not illustrate the whorl section. In the subsequent work by Shimizu and Jimbo, it was pointed out that this species exhibits ceratitic septa. However, those authors identified this species as belonging to the genus *Meekoceras*, but later authors referred it to *Hemiprionites*. The writer includes these species into *Hemiprionites* because of the characters of the shell ornamentation, feature of the venter, form of the umbilicus, and the septal elements which are characterized by the ventral and umbilical septa. Specifically, the present species is closely allied to *Hemiprionites typus* (Waagen), the genotype, which was reported from the Upper Ceratite Limestone of Chidroo in Salt Range by Waagen (1895, p. 128, pl. 9, figs. 7–10, as *Goniodiscus*), but the two are not identical with one another, being distinguished by the umbilical septa and depressed whorl, and umbilicus.

So far as concerns the shape of the umbilicus and the form of the whorls, the present specimen resemble *H. timorensis* Spath from Timor (Welter, 1922, p. 138, pl. 171, figs. 13–14; Spath, 1934, p. 331) or *H. americanus* (Mathews) described by Mathews (1929, p. 32, pl. 5, figs. 22–27, as *Goniodiscus*), Smith (1932, p. 76, pl. 80, figs. 6–8, as *Anasibirites typus* (Waagen) and Spath (1934, p. 333) from the *Anasibirites* subzone of Fort Douglas area, Utah, in North America, but these American forms are closely related with *H. typus* (Waagen) rather than the Japanese species.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45161

Hemiprionites tahoensis (Yehara)

Pl. 1, figs. 7a–b, 8; Pl. 2, figs. 4a–b, 18

Lecanites tahoensis Yehara, 1926, p. 13, figs. 6–7.
Ophiceras tahoensis (Yehara). Yehara, 1927, p. 161, pl. 15, figs. 4, 5, 7.
Meekoceras tahoensis (Yehara). Shimizu and Jimbo, 1933, p. 19.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no.	37.0	16.5	0.45	11.0	0.66	9.5	0.26
45158	25.0(?)	12.0	0.48	6.0	0.50	5.5	0.22

Remarks: – In the original description of *tahoensis*, Yehara stated that goniatitic septa are developed and these are composed of rounded entire saddles and entire lobes. He compared his species with *Ophiceras sakuntala* Diener and *O. medium* Griesbach, both from the Himalayas. However in the present specimens which are identical with Yehara's species the septa are ceratitic as already mentioned. According to Shimizu and Jimbo (1933, p. 19), the present species should be referred to *Meekoceras disciforme* Krafft and Diener from the *Meekoceras* Beds of the Himalayas, but the Japanese species can be distinguished from the Himalayan ones in having more compressed whorls, small involution, and by the difference of the sutures. They also compared the Japanese species with *Lecanites impressus* Waagen from the Lower Ceratite Formation of the Salt Range, and pointed out that it is distinguished from that species by the septa and involution. The writer considers the Japanese species to belong to *Hemiprionites* and not *Meekoceras* because of the features of the siphonal septa, the shape of the umbilicus, and the wide tabulated venter.

Specifically, the present species is closely allied with *Hemiprionites typus* (Waagen) described from the Upper Ceratite Limestone of Chidroo, Salt Range, by Waagen (1895, p.

128, pl. 9, fig. 7–10). On the other hand, the present species is related to *H. garwoodi* Spath (1934, p. 336, pl. 16, figs. 1, 3; pl. 17, figs. 3, 5) from Spitsbergen in the septa and the whorl shape, but differs in the width of the umbilicus.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45158.

Hemiprionites morianus (Yehara)

Pl. 2, figs. 1a–c, 2, 9a–b.

Meekoceras morianum Yehara, 1927, p. 155, pl. 13, figs. 2, 4, 5, non fig. 3.
Meekoceras morianum Yehara. Shimizu and Jimbo, 1933, p. 15.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45162	33.5 (25.0)	15.5	0.46	9.0	0.58	7.0	0.21
	25.0 (20.0)	12.0	0.48	7.0	0.58	7.0 (6.0)	0.28
	23.0	10.5	0.45	6.0	0.57	6.5	0.28
	—	18.0	—	8.5	0.47	7.0	—
Hemiprionites typus (Waagen), after Waagen (1895, p. 128)	44.0	21.0	0.48	—	—	6.0	0.14
	33.0	16.0	0.48	9.0	0.56	6.0	0.18

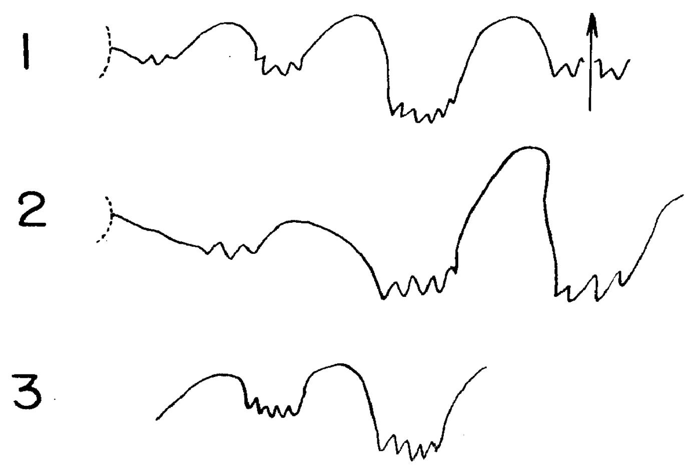

Fig. 25. Septa of *Hemiprionites morianus* (Yehara). 1: ×5, 2: ×4, 3: ×5 (IGPS coll. cat. no. 45162)

Remarks: – The present form is most related to *Hemiprionites typus* (Waagen) (1895, p. 128, pl. 9, figs. 7–10), the genotype, from the Upper Ceratite Limestone of Chidroo, Salt Range, in the shell form, the character of the septa, and the form of umbilicus, but in details, it is distinguished from that species by having larger umbilicus and by the small difference of the septa in auxiliary series. Yehara (1927) compared this species with *Meekoceras (Ambites) discus* Waagen and described it as *M. morianum* Yehara. But subsequently, Shimizu and Jimbo pointed out that it should be compared with *M. jolinkense* Krafft and Diener from the Himalayas and Timor. They distinguished their new species, namely *M. shikokuense* Shimizu and Jimbo, from the species illustrated in figure 3 by

Yehara (1927, pl. 13) and said that it possesses a narrower umbilicus. Unfortunately, those authors gave no description or illustrations for *M. shikokuense* which they said is a new species. *Meekoceras shikokuense* Shimizu and Jimbo is described in this article as *Hemiprionites shikokuensis* (Shimizu and Jimbo) by the writer because of such reason. The present species resembles *Hemiprionites tahoensis* (Yehara) in the shell form and the septa, but differs in the width of umbilicus.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45162.

Hemiprionities kuharanus (Yehara)

Pl. 2, figs. 12a-b

Meekoceras kuharanum Yehara, 1927, p. 155, pl. 14, fig. 5.
Meekoceras kuharanum Yahara. Shimizu and Jimbo, 1933, p. 14.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45165	36.5 (29.0)	21.0	0.58	10.5	0.41	3.0	0.08
	33.5	20.0	0.59	8.5	0.42	2.5	0.08
	21.5	12.5	0.57	6.5	0.50	2.0	0.09
	21.0	12.0	0.57	5.0	0.41	3.0	0.14

Remarks: – According to Yehara's original description this form is similar to *Kymatites typus* Waagen, and *Meekoceras sawatanum* Yehara, but are distinguished from these two species by the denticulation of the second lateral lobe.

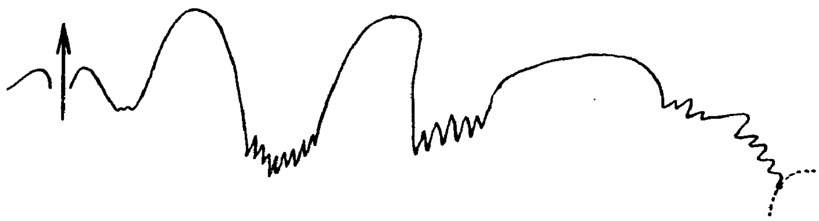

Fig. 26. *Hemiprionites kuharanus* (Yehara). ×3.3 (IGPS coll. cat. no. 45165)

This species resembles *Hemiprionites sawatanus* (Yehara) in having a narrow umbilicus, the whorl shape, and the form of venter, but differs in the siphonal septa and the first lateral lobe. Shimizu and Jimbo pointed out that the form assigned by Yehara to *Meekoceras kuharanum* Yehara rather resembles *M. radiosum* Waagen from the Ceratite Sandstone and from the Lower Triassic formations in Albania, but is distinguished from them in having more compressed whorl, narrower umbilicus, and some difference of the septa. The writer considers that the present species should be included into *Hemiprionites* rather than *Meekoceras* because of the character of the septa, especially in the siphonal and the auxiliary ones, and the form of the venter. Specifically the form is most allied with *H. americanus* (Mathews) from the *Anasibirites* Beds of Fort Douglas area, Utah, in North America in having narrow umbilicus, the general shell form, and the septal elements, but differs in the more compressed whorl.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45165.

Hemiprionites kuharanus iyonus Bando, n. subsp.

Pl. 1, figs. 14, 18; Pl. 2, figs. 15a-b

Meekoceras kuharanum compressum Shimizu and Jimbo, 1933, p. 24.

Description: – Form considerably compressed, discoidal, involute, imbilicus narrow, sides flattened. Venter narrow, tabulated, neither keels nor furrows. Shell surface smooth or with faint growth striations only on body chamber; on tubercles, spines, or strong radial folds. Umbilical shoulders abruptly rounded, wall rather steep. Maximum thickness at a portion of umbilical shoulder, therefrom gently convex to ventral shoulders. Septa ceratitic, entire saddles and serrated lobes rounded, somewhat angular. First lateral lobe serrated into four points, shallowly incised; second lateral lobe serrated into three points, latter shallower than first lateral lobe, about one-third in depth of first lateral lobe. Auxiliary series entire or goniatitic, consisting of a single lobe situated in umbilical shoulders.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no.	20.0	12.0	0.60	7.0	0.58	2.5	0.13
45167 (A-B)	—	15.0 (?)	—	8.0	0.54 (?)	3.0	—

Remarks: – The two specimens examined are identical with *Meekoceras kuharanum compressum* Shimizu and Jimbo from the Taho Formation, which has not been figured or described. This new subspecies is related with *Hemiprionites kuharanus* Yehara from the Taho formation (Yehara, 1927, p. 155, pl. 14, fig. 5), but it is distinguished by the narrow tabulated venter and shorter secondary lateral lobe. These differences had already been pointed out by Shimizu and Jimbo (1933, p. 24). The general shell form of the new subspecies resembles "*Meekoceras*" *radiosum* Waagen (1895, p. 257, pl. 36, fig. 2) from the middle region of the Ceratite Sandstone of Chidroo, Salt Range, and from Albania (Arthaber, 1911, p. 246, pl. 21, fig. 14). The so called "*Meekoceras*" *radiosum* was included by Spath (1934, p. 105) into the group of *Kymatites* Waagen. The present form is not identical with that species because the septa of the auxiliary series are different. *Kymatites radiosum* (Waagen) was reported from North America by Smith (1932, p. 59, pl. 51, figs. 1–4). As regards the present form, Shimizu and Jimbo stated that the material is similar to the above mentioned Indian species except for some differences as the more compressed whorls, narrower umbilicus and the character of the septa (1933, p. 14–15). On the other hand, the septal features of this species more resemble *Hemiprionites* than *Meekoceras* or *Kymatites*. Another Indian species, *M. infrequens* Krafft and Diener (1909, p. 44, pl. 30, fig. 7) from the Red Limestone of Malla Johar, India, resembles the present form in general shell feature, however the auxiliary series of the septa serve to distinguish the present one from that species.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45167.

Hemiprionites sawatanus (Yehara)

Pl. 1, figs. 5a–b; Pl. 2, figs. 8a–b, 13a–b

Meekoceras sawatanum. Yehara, 1927, p. 159, pl. 13, figs. 6, 7, 9, non fig. 8.
Meekoceras sawatanum Yehara. Shimizu and Jimbo, 1933, p. 17.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no.	26.0	14.0	0.54	6.5	0.47	3.0	0.12
45166	21.5 (17.0)	12.0	0.56	5.5	0.45	2.0	0.09

Remarks: – Two specimens were examined. These are the syntypes of *Meekoceras sawatanum* Yehara which was subsequently described by Shimizu and Jimbo. The original author, Yehara, did not figure the whorl section and some of the specimens appear to be slightly different in the septa, that is to say, the specimen of his figure 8 may belong to some other species as already suggested by Shimizu and Jimbo (1933, p. 17). In the form of umbilicus, whorl shape, and the form of the venter, the present species resembles *Hemiprionites kuharanus* (Yehara), but it is distinguished from that species by the second lateral saddle and the auxiliary series. The second lateral saddle of *H. kuharanus* (Yehara) is broader than that of the present species. It also resembles *Hemiprionites americanus* (Mathews), which was described from the *Anasibirites* Beds of Fort Dougras area, Utah, in North America by Mathews (1929, p. 32, pl. 5, figs. 22–27 (*Goniodiscus*), Smith (132, p. 76, pl. 80, figs. 5–8, (*Anasibirites*) and by Spath (1934, p. 333), in having narrow umbilicus, compressed whorls, and in the shell ornamentation, but it is distinguished from the American species by the form of the saddle and the secondary lateral lobe in the septal elements. In septal characters and external appearance, Yehara (1927, p. 160) compared this form with *Meekoceras disciforme* Krafft and Diener from the *Meekoceras* Beds of the Himalayas and with *M. aplanatum* White from the *Meekoceras* Beds of southeastern Idaho in North America, and he stated that this form differs from those species by the narrow umbilicus and the smooth surface. Subsequently, Shimizu and Jimbo (1933, p. 18) mentioned that this form is closely related with *Meekoceras eurasiaticum* (Frech) from the Werfen Beds of the Alps and from Spiti, and with *M. caplirense* Mojsisovics from the *Tirolities cassianus* zone of the Alps, but it is distinguished from these species by having narrow whorls and more compressed shell.

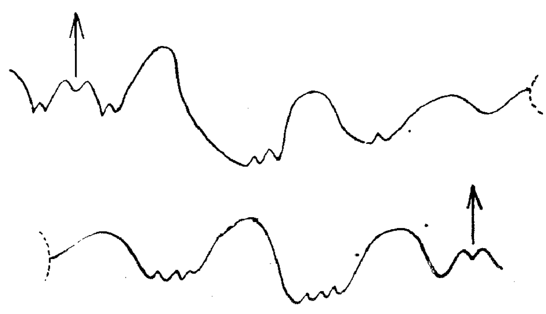

Fig. 27. Septa of *Hemiprionites sawatanus* (Yehara). ×4.5
(IGPS coll. cat. no. 45166)

The writer considers the present species to belong to the genus *Hemiprionites* and not *Meekoceras* by the characters of the venter, the whorl shape, and of the characteristic features of the septa.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45166.

Hemiprionites aff. *sawatanus* (Yehara)

Pl. 1, fig. 16

Meekoceras sawatanum Yehara, 1927, p. 159, pl. 13, figs. 6–9, (non fig. 8).
Meekoceras sawatanum Yehara. Shimizu and Jimbo, 1933, p. 17.

Description: – Form involute, discoidal, laterally compressed, deeply embracing, umbilicus very narrow. Sides flattened, gently convex from umbilical shoulder to ventral shoulder. Venter very narrow, forming a slightly tabulated or biangular shape. In whorl section width of shell about one-third of height. Umibilical shoulder abruptly rounded, their wall not very deep.

Shell surface smooth, almost flattened, without distinct radial rbis or folds on flanks.

Septa ceratitic, of three rounded saddles and two corrugated lobes. Two saddles on ventral side comparatively long, first lateral saddle commonly shorter than external one. Secondary saddle rounded, entire, shorter than other two saddles. First lateral lobe showing denticulation of four points at bottom, angular down-warping at internal edge. Secondary lateral lobe, denticulate into five to four points at bottom, shallower than first one. Auxiliary series indistinct, short and slightly denticulated.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
GLKU-C121	36.0 (?)	20.0 (?)	0.55 (?)	7.5	0.37	3.5	0.09
GLKU-C113	—	16.0	—	6.5	0.31	3.5	—

Remarks: – Two specimens of this species were exmained; the shell preserves only the umbilical part, but the whorl section and their septa can be observed. The septal elements of the present specimens are most allied to *Hemiprionites sawatanus* from the same locality as the present specimens. The septa originally described by Yehara (1927, p. 39, pl. 13, fig. 8a) shows no coorrugations in the secondary lateral lobe. The form in fig. 8 illustrated by Yehara (1927) differs from the other forms (figs. 6, 7,9) of the same species in the septa. At a glance, the septa is near to those of *Proptychites*, but the ventral form and the umbilical feature cannot be identified with that genus.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. Y. Bando.

Repository: – GLKU–C113 and GLKU–C121.

Hemiprionites shikokuensis (Shimizu and Jimbo)

Pl. 1, figs. 13, 20, 22; Pl. 2, figs. 10a–c

Meekoceras morianum Yehara, 1927, p. 155, pl. 13, fig. 3, partim.
Meekoceras shikokuense Shimizu and Jimbo, 1933, p. 15.

Description: – Shell involute, laterally compressed, discoidal, deeply embracing, outer whorl concealing about three-fourths of inner, and indented to one-third their height by inner whorl. Height of shell about one-half of total diameter of shell, width about one-half of height. Umbilicus narrow but slightly open and rather shallow, width being about one-sixth of diameter of shell. Whorl increases rather rapidly in height. Sides gently convex, from abruptly rounded umbilical shoulder; maximum thickness of shell at about one-half height. Venter flattened, bicarinate, with tabulate or concave peripheral space.

Surface almost smooth, but with weak radial falciformed striations of growth or with indistinct irreguarly spaced radial folds. No true ribs or spines on flanks or venter.

Septa ceratitic, saddles all rounded and entire, lobes all serrated. Ventral lobe short; median one narrowest and shortest, forming a wedge-shape and terminates in two points; two lateral parts divided into a sharp point. External saddle roundly arched at top and highest; entire, without indentations. First lateral lobe longest, not very broad, reaches down about twice as far as external one. Its sides gradually tapering toward bottom, where are seven denticulations. First lateral saddle rounded, entire, without serraitions, and high up almost equal to median saddle of siphonal lobe. Second lateral lobe narrower and shorter than first one, four denticulations at bottom. Second lateral saddle much broader than other saddles, gently convex on top, rather shallow. Auxiliary series slightly denticulated, begining from umbilical shoulders.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 45164	26.0 (19.0)	13.0	0.50	7.0	0.54	4.0	0.15
	25.0 (18.0)	13.0	0.52	6.5	0.50	4.0	0.16
	22.5 (17.0)	9.5	0.42	6.0	0.63	3.5	0.15
	19.0	10.0	0.53	5.0	0.50	2.5	0.13
	—	14.0	—	7.0	0.50	5.0	—
	—	11.0	—	5.5	0.50	4.0	—

Remarks: – In the original description of *Meekoceras morianum*, Yehara mentioned that this form is evolute, discodial, laterally compressed, not deeply embracing and not deeply indented by the inner whorl, and that the septa are goniatitic, saddles all rounded and entire, lobes entire, but on the lateral lobes the denticulations can be seen only by means of a magnifying glass. However these descriptions do not fit the illustrated specimens, because all of them show rather involute form, and instances the specimen of figure 4 (*H. morianus* (Yehara) differs from the specimen of figure 3. Shimizu and Jimbo (1933, p. 15) proposed without description or figures a new species *Meekoceras shikokuense* Shimizu and Jimbo for the different specimens illustrated by Yehara.

According to Shimizu and Jimbo the present form resembles *Meekoceras glacilitatus* White from the *Meekoceras* Beds of Idaho and Californian in North America, but can be distinguished by the whorl section and septa. *Meekoceras glacilitatus* was reported from the *Meekoceras* Beds of the Blind Fiord Formation, Ellesmere Island in Arctic Canada by Tozer (1961, p. 65). The form of the second lateral saddle and the auxiliary series resemble those of *Meekoceras glacilitatus*, but in general features it rather belongs to *Hemiprionites*. Specifically it is most related with *Hemiprionites utahensis* (Mathews) from the *Anasibirites* subzone of the Fort Douglas area, Utah, in North America reported by Mathews (1929, p. 33, pl. 6, figs. 29–31, *Goniodiscus*), Smith (1932, p. 77, pl. 80, figs. 9–10, *Anasibirites*) and by Spath (1934, p. 334), but slightly differs in the shell sculpture, the form of auxiliary series, and by having more compressed whorl.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 45164, GLKU–C140

Hemiprionites sp. indet.

Pl. 2, fig. 6

Remarks: – The single specimen at hand preserves only a part of the outer whorl, but shows the septal features.

Judging from the septal features, the material is considered to belong to *Hemiprionites* rather than to *Meekoceras*. Specifically, the present form resembles *H. timorensis* Spath, which was originally described by Welter from Timor under the name of *Anasibirites multiformis* Welter, but differs by having a more comporessed whorl. It is also allied with *H. americanus* Mathews from the *Anasibirites* Beds of Fort Douglas, Utah, in North America reported by Mathews (1929, p. 32, pl. 5, figs. 22–27, *Gonodiscus*), Smith (1932, p. 76, pl. 80, figs. 6–8, *Anasibirites typus* Waagen, partim), and by Spath (1934, p. 333), however it differs in the speta of the auxiliary series. On the other hand, the present form resembles *H. shikokuensis* (Shimizu and Jimbo) in the septa of the auxiliary series, but differs in the character of the umbilicus, the form of saddles, and in the shell ornamentation.

Occurrence and geological horizon: — *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirkokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 45175.

Genus *Arctoprionites* Spath, 1930

Arctoprionites Spath, 1930, p. 86.
Arctoprionites. Spath, 1934, p. 340.
Arctoprionites. Kummel, 1957, p. 145.

The genus *Arctoprionites* is included in the Prionitidae with *Prionites* Waagen, *Hemiprionites* Spath and *Gurleyites* Mathews.

Diagnosis: – The original diagnosis of Spath (1930, p. 86) is:

"More or less involute, discoidal shells with tabulate venter, tending to develop crenulation of latero-peripheral edges and costation or tuberculation on whorl sides. Suture-lines as in *Hemiprionites*, but with large external saddle and simple external lobe."

Remarks: – All of the Japanese specimens which occurred from the Taho Formation are immature forms and no adult specimens have been found to this time. The younger form of *Arctoprionites* is said to have the sculpture resembling the immature *Anasibirites* (Spath, 1921, p. 301; 1934, p. 340). Through a study of numerous Japanese specimens, the feature mentioned by Spath can be observed in the shell sculpture and form of the peripheries, which form crenulated ventral edges and characterized by transverse ridges crossing the venter. The genus *Arctoprionites* also shows close relation with *Wasatchites* Mathews (1929, p. 40), which was reported from the Upper Owentian in Utah, Timor, Spitsbergen and from Arctic Canada, and which had been considered to be transitional. The genus *Wasatchites,* on the other hand resembles *Kashmirites* Diener (1913, p. 33) in the character of the peripheries. Furthermore, the peripheral features of *Wasatchites* may be similar to *Anasibirites* or *Kashmirites* rather than to *Arctoprionites.*

Distribution: – Upper Scythian, Upper Owenitan (*Anasibirites multiformis* Zone) to Columbitan ?. Spitsbergen, Kashmir?, North America and Japan.

Arctoprionites yeharai Bando, n. sp.

Pl. 4, figs. 5, 6a–b, 7, 8, 11a–b; Pl. 6, fig. 17; Pl. 8, figs. 2, 3, 6

Description: – Shell small, rather involute, discoidal, slightly laterally compressed, more or less deeply embracing, umbilicus wide, venter tabulated. Sides convex from umbilical shoulder to ventral shoulder, maximum thickness a little above abruptly rounded umbilical shoulder. Umbilicus wide, about one-third of total diameter of shell, rather shallow, without distinct umbilical wall. Venter tabulated, with a crenulated peripheral margin on their flanks, and transversely crossed by numerous distinct ridges like *Kashmirites*, *Wasatchites*, or *Pronorites*. Whorls more or less deeply embracing, about two-thirds of inner whorl, outer whorl indented at about two-fifths height by inner whorl. Whorl height, about one-third total diameter of shell width a little less than height. Shell width almost equal to diameter of umbilicus.

Surface with distinct radial or somewhat falciradial ribs on outer whorl, with considerably robust folds like a tubercles, about 12–13 ribs on outer volution, most prominent near umbilical shoulder in younger whorl, gradually diminish toward latero-peripheral sharp edge. Each ribs reappear as crenulations at latero-peripheral edges and run across venter transversely; ribs tend to increase on outer whorl. Septa ceratitic, consisting of rounded saddles and slightly serrated lobes; ventral lobe narrow, shallow, denticulated into two points on both external base of median terminating point; external saddle rounded, comparatively broad, short, entire and at sharp ventrolateral edge; first lateral lobe broadest, deepest, slightly denticulated into three to four points at bottom first lateral saddle rounded, entire, narrower and shorter than external one, without corrugations; second lateral lobe narrowest, shallowest, without denticulations. Second lateral saddle, situated at umbilicus.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78335	15.5	6.0	0.39	5.0	0.83	5.0	0.32
	15.0	5.0	0.33	4.0	0.80	5.0	0.33
	14.0	5.0	0.35	5.0	1.0	5.0	0.35
	14.0 (11.0)	6.0	0.43	4.0	0.66	4.0	0.29
	13.0 (11.0)	5.0	0.39	4.0	0.80	4.0 (3.0)	0.30
	13.0 (11.0)	5.0	0.39	4.5	0.90	4.5 (3.5)	0.34
	14.0	5.0	0.34	4.5	0.90	4.5 (3.0)	0.33
	14.0	5.0	0.34	4.5	0.90	4.5 (3.0)	0.33
	13.0	5.0	0.39	4.0	0.80	3.5 (3.0)	0.27
	12.5 (11.0)	5.0	0.40	4.0	0.80	4.0 (3.0)	0.32
	10.5	4.5	0.43	3.5	0.78	3.0 (2.0)	0.29

Remarks: – Of the numerous specimens of this species examined, the majority are younger forms. In the shell sculpture and the form of venter the present new species closely resembles *Arctoprionites tyrrelli* Spath, from Spitsbergen which is characterized by having a sharp periphero-lateral edge with a faint clavus, falciradiate striae on the chambered portion, and ribs on the body-chamber, distinctly bullate at the middle of the side, and ending at the ventro-lateral edge (Spath, 1934, p. 342, pl. 14, fig. 5; pl. 17, fig. 6). That species is distinguishable from the present one in the form of venter, with more distinct transverse ridge on their peripheries. The form is similar to *Gurleyites freboldi* Spath in the surface ornamentation on the flnaks, but the peripheral aspect is different. It shows affinity with *Anasibirites ibex* (Waagen) from the Salt Range in the peripheral aspect and in the form of ribs, but it differs by having more prominent tuberculated ribs near the umbilical sides.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando.

Repository: – IGPS coll. cat. no. 78335.

Arctoprionites minor Bando, n. sp.
Pl. 4, figs. 4a-b, 10; Pl. 6, fig. 15

Description: – Shell small, rather involute, discoidal, more or less deeply embracing, umbilicus rather wide, considerably broad, tabulated venter crenulated at sharp periphero-lateral edges. Sides convex form umbilical shoulder to ventral shoulder, maximum thickness at about one-third whorl height. Umbilical shoulder abruptly rounded, their wall very short. Venter considerably broad, tabulated, with a sharp ventro-lateral edge ornamented with crenulations, and transversely crossed by distinct ridges. Whorls more or less deeply embracing, about two-thirds height of inner whorl, outer whorl indented at about one-half their height by inner whorl. Width of umbilicus a little less than one-fourth total shell diameter. Whorl height about one-half of total diameter, width about three-fourths to five-sixths their height. Shell width a little larger than umbilicus.

Surface with distinct radial ribs, begining from umbilical shoulder, run radially on finaks, and extened to ventro-lateral edges, forming distinct crenulations. Each ribs transversely cross venter; 11 to 12 on half of outer volution, without secondary ribs nor striations of growth.

Septa ceratitic, composed of rounded saddles and serrated lobes excepting secondary lateral one; siphonal lobe very narrow, shallow, slightly terminating in median part, external saddle rounded, broadest, but slightly shorter than first lateral saddle, without denticulations; first lateral lobe deeply incised, broader than second lateral lobe, serrated into three points at bottom; first lateral saddle rounded, entire, without denticulations; secondary lateral lobe narrow, shortest, without corrugations at bottom; second lateral saddle at umbilical shoulder, its inner side on umbilicus.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no.	15.0 (13.0)	8.0	0.53	6.0	0.75	4.0	0.37
78336	13.0	6.0	0.46	5.0	0.83	3.5	0.27

Remarks: – Two specimens were studied. The present species closely resembles *Arctoprionites yeharai* in shell ornamentation, but differs in the number and shape of the ribs which are characterized by being almost equally prominent from the umbilical margin to the ventral shoulder, and there are no tuberculated ribs on their flanks. The septa differs from that species by having shallow secondary lobe. *Arctoprionites tyrrelli* Spath is also similar to the present one in the shell sculpture and in the form of venter, but the Spitsbergen species is more laterally compressed. It is also similar with *Gurleyites freboldi* Spath from Spitsbergen in the whorl shape and in the shell sculpture, however that species shows a more deeply incised secondary lobe.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 78336.

Arctoprionites nipponicus Bando, n. sp.
Pl. 4, figs. 9a-b

Description: – Shell rather involute, lateally compressed, discoidal, deeply embracing, with narrow umbilicus and narrow tabulated venter. Sides flattened, gently convex from umbilical shoulder to ventral shoulder, maximum thickness at one-third whorl height.

Whorl high, deeply embracing about three-fourths their height of inner whorl, outer whorl indented at about one-half or less their height by inner whorl. Shell height a little less than one-half total shell diameter, width about three-fifths of height of last whorl. Umbilicus narrow, open, exposing inner volutions, its width about one-fourth of total diameter of shell. Umbilical shoulder abruptly rounded, without distinct umbilical wall. Umbilicus considerably shallow, and exposing protoconch. Venter narrow tabulated with a sharp latero-peripheral edges, ornamented with transverse ridges, connected with lateral ribs on their flanks.

Surface with numerous radial ribs, slightly convex forward on middle of flanks, most prominent at about two-thirds their height of flanks, but diminish near peripheral sides; ribs become weak on body whorl. Septa ceratitic, of rounded saddles and serrated lobes; external lobe rather broad, shallow, divided by short median saddle, U-shaped, external small lobe; external saddle broadly rounded, comparatively long, without denticulations; first lateral lobe well denticulated into three points at bottom, broadest, deepest; first lateral saddle broader and higher than external saddle, rounded, entire; second lateral lobe simple, very narrow, shallow, wedge-shaped; second lateral saddle considerably broad, shortest, without corrugations, internal end in umbilicus. External saddle sharp at latero-peripheral edges.

Measurements (*mm*): –

	D.	H.	H/D	W.	W/H	U.	U/D
IGPS coll. cat. no. 78337	16.0	7.5	0.47	4.5	0.60	4.0 (3.0)	0.25

Remarks: – A single specimen was studied. The present species is closely similar to *Arctoprionites tyrrelli* Spath (1934, p. 342, pl. 14, fig. 5; pl. 17, fig. 6) from the upper Scythian of Spitsbergen, but differs by having finer ribs and wider umbilicus.

In shell ornamentation the species is allied with Waagen's "*Meekoceras*" *falcatum* (1895, p. 242, pl. 36, fig. 4) from the Ceratite Sandstone of Chidroo, Salt Range, although it differs by the narrower umbilicus and tabulated venter with sharp ventro-lateral edges.

Occurrence and geological horizon: – *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku. Coll. H. Yabe, T. Sugiyama, S. Shimizu and N. Jimbo.

Repository: – IGPS coll. cat. no. 78337.

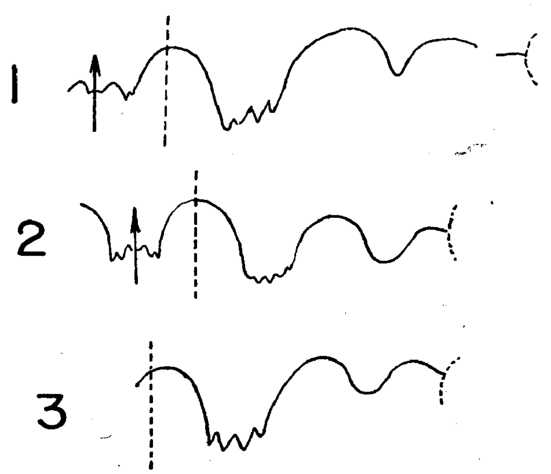

Fig. 28.
1: *Arctoprionites nipponicus* Bando, n. sp. ×6 (IGPS coll. cat. no. 78337)

2: *Arctoprionites yeharai* Bando, n. sp. ×6 (IGPS coll. cat. no. 78335)

3: *Arctoprionites minor* Bando, n. sp. ×6 (IGPS coll. cat. no. 78336)

Family Paranannitidae Spath, 1930
Subfamily Columbitinae Spath, 1930
Genus *Subcolumbites* Spath, 1930

Genotype: *Columbites perrini-smithi* Arthaber, 1908

Subcolumbites Spath, 1930, p. 77, 90.
Subcolumbites. Spath, 1934, p. 202.
Subcolumbites. Chao, 1959, p. 304.

The genus *Subcolumbites* was established by Spath (1930) based upon *Columbites perrini-smithi* Arthaber with the following diagnosis,

"Like *Columbites*, but with the tendency to carination more pronounced, reticulate ornamentation, and early tuberculate stage absent or inconspicuous".

The genotype *C. perrini-smithi*, is characterized by the narrow whorls, which are laterally compressed, and the rather wide umbilicus. The venter is subcarinate and the umbilical shoulder rounded. The shell ornamentation consists of numerous distinct lineations which form a falciradiate type and are inclined forwards on the ventral margin.

Distribution: – Upper Scythian. Albania, Chios, Timor?, Kawangsi (China), Eastern Siberia and Japan.

Subcolumbites cf. *perrini-smithi* (Arthaber)
Pl. 3, figs. 18, 19; Pl. 4, fig. 3

Columbites perrini-smithi. Arthaber, 1908, p. 277, pl. 12, fig. 1.
Columbites perrini-smithi. Arthaber, 1911, p. 262, pl. 23, figs. 19–20.
Columbites perrini-smithi Arthaber. Renz, 1928, p. 155.
Subcolumbites perrini-smithi (Arthaber). Spath, 1934, p. 203, pl. 7, figs. 5a–b.
Columbites perrini-smithi Arthaber. Renz and Renz. 1948–49, p. 20, pl. 11, figs. 7–7a.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79179	47.0 (39.0)	15.0	0.32	4.0	0.27	23.0	0.48
IGPS coll. cat. no. 76571	27.0 (?)	8.0	0.29 (?)	4.0 (?)	0.50 (?)	15.0	0.55 (?)
Arthaber's original forms (1911, p. 262)	38.0	15.0	0.39	12.0	0.80	16.0	0.42
	54.0	17.0	0.31	14.0	0.82	25.0	0.46

Remarks: – Two specimens were examined. This form is more compressed laterally than that of the typical *Subcolumbites perrini-smithi*, but this is considered to be due to secondary lateral deformation. The general shell form is almost identical with *S. perrini-smithi*, particularly in the form of venter, the shell width and in having a broad periphery.

Besides these Albanian forms, Renz and Renz (1948) described *Columbites* (*Subcolumbites*) *europaeus-perrini-smithi* from Chios in Greece as a form intermediate between *S. perrini-smithi* and *S. europaeus*.

Occurrence and geological horizon: – Dark gray blue calcareous sandy shales of the Osawa Formation at Tate near Isatomae of Utatsu-cho, about 60 km. northeast of Sendai, Motoyoshi-gun, Miyagi Prefecture. Upper Scythian, Columbitan age ?. Coll. Y. Onuki, K. Masuda and H. Mii.

Repository: – IGPS coll. cat. no. 79179, 76571.

Family Ptychitidae Mojsisovics, 1882
Genus *Ptychites* Mojsisovics, 1875

Genotype: *Ammonites rugifer* Oppel, 1865, Subsequent designation by Spath, 1951.

The genus *Ptychites* is the most common among the Triassic ammonites and is considerably dominant in the Middle Triassic age. Certain species of *Ptychites* have been divided into five groups by Mojsisovics (1882). These five groups are represented by *P. rugiferi*, *P. megalodisci*, *P. subflexuosi*, *P. opuleni* and *P. flexuosi*. Diener (1895) has reported numerous species of *Ptychites* from the Himalayan Muschelkalk but they did not include the group of *P. subflexuosi*.

Based upon the group of species the genus *Ptychites* has been subdivided into some new genera, *P. megalodiscus* being the type of the genus *Discoptychites* (Diener, 1961), *P. flexuosus* that of the genus *Flexoptychites* (Spath, 1951), *P. gerardi* Blanford the genotype of *Aristoptychites* (Diener, 1916), *P. mallentianus* (Stoliczka) from the Himalayas the type of the genus *Mallenopychites* (Diener, 1916) and *P. meeki* from North America was made the type of the genus *Alloptychites* (Spath, 1951).

The genotype of *Ptychites* in the narrow sense has been confused as to whether *P. rugifer* or *P. eusomus* (Beyrich) should be accepted as designated by Diener (1915). Concerning this problem Spath mentioned that as a formal selection, *P. rugifer* may be selected instead of *P. eusomus* as the genotype of *Ptychites*, but, pending a decision by the International Commission, Diener's selection has priority (Spath, 1951, p. 141).

Distribution: – The Alps, Germany, Balkan, Himalayas, Timor, Japan, North America, Eastern Siberia, Spitsbergen, and Thailand.

Ptychites nipponicus Bando, n. sp.
Pl. 11, fig. 1; Pl. 12, figs. 1a–b

Description: – Form involvute, laterally compressed. Whorls high, gradually increasing in height, with laterally compressed and fastigate venter; deeply embracing and deeply indented by inner whorl. Whorl height a little less than a half the total shell diameter, width about a half of height. Umbilicus considerably deep with steeply inclined

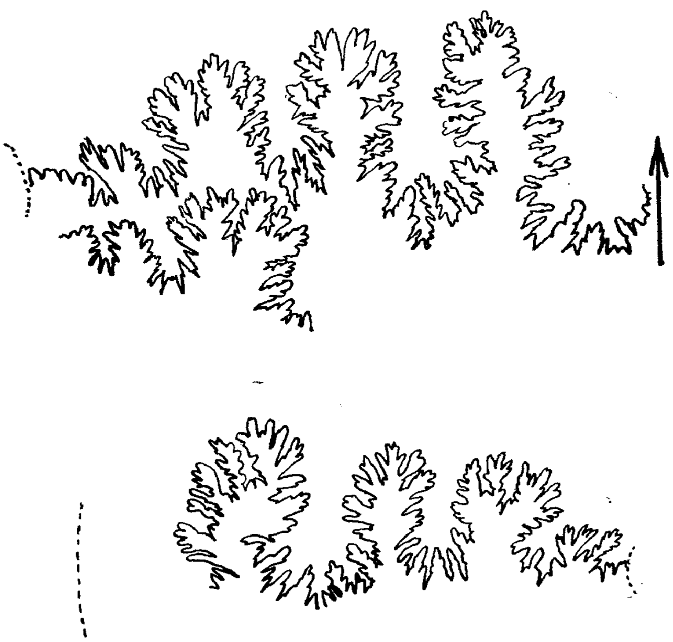

Fig. 29. Suture lines of *Ptychites nipponicus* Bando, n. sp. ×1 (IGPS coll. cat. no. 76542)

wall, its width a little less than one-fifth of total shell diameter. Sides slightly convex, shell surface with broad radial folds that run from umbilical margin almost straight across on sides. Maximum width at umbilical margin. Ribs almost flattened on umbilical margin and ventral side, 28 on outer whorl and most elevated at middle of flanks. Inner volutions exposed inside umbilicus in shape of narrow spiral band as in *Ptychites mallentianus* Stoliczka from Spiti.

Septa considerably incised, with three bifid principal saddles, first larger than remainder; highly foliaceous and deeply incised on base. Siphonal lobe short, deep. First lateral lobe deepest, most incised. Umbilical suture of two secondary branched auxiliary saddles and narrowly incised auxiliary lobe. *Myoconcha hamadaensis* Yabe and Shimizu adhered on the marginal side of flanks.

Measurements (*mm*):–

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76542 (Holotype)	165.0	74.0	0.45	41.0	0.55	27.0 (33.0)	0.16

Remarks: – This species is closely related to *Ptychites kokeni* Wittenburg (1909, p. 533, pl. 10, fig. 1) from Cape Wiattin of Bucht Bogdanowitsch, Gulf of Ussuri, in the shape and sculpture of the shell, width and shape of umbilicus, but the septa could not be compared with this form because of the simple description of that species by Wittenburg.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. Town Officials of Matsuhima-cho, Miyagi Prefecture.

Repository: – IGPS coll. cat. no. 76542.

Ptychites miyagiensis Bando, n. sp.

Pl. 13, figs. 1a–b; Pl. 14, figs. 1a–b

Description: – Form involute, discoidal, laterally compressed. Whorl completely embraces inner whorls, indented at about two-thirds of height of outer whorl by inner volutions. Venter of fastigate-form or an acute-form, umbilicus very narrow funnel-shaped with sharply acuted shoulder. Width of umbilicus, probably equal to one-sixth of total diameter of shell. Height of outer whorl about one-half of diameter, width of outer whorl about one-third of height.

Shell surface with rather numerous ribs, 14 to 15 on half revolution, slightly projected near venter. On umbilical margin and near venter, each ribs diminish in elevation and become almost flattened. Their elevation most prominent on middle portion of flanks.

Septa of three lateral saddles and four lobes; saddles highly foliaceous and secondary branches well serrated. First lateral saddle larger than remainder. Lobes deeply incised and serrated secondarily, first deepest, and ventral lobe situated at depth equal to first lateral lobe and terminating in deep point. Umbilical lobes well serrated in secondary branches, secondary auxiliary lobe situated on umbilical shoulder. Suture lines preserved on inner whorl.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79176 (Holotype)	180.0 (?)	86.0	0.48 (?)	53.0 (?)	0.62 (?)	30.0 (?)	0.16 (?)

Remarks: – The material is a broken part of the flanks, but the umbilicus, shell ornamentation and septa are well preserved. This species is closely related to *Ptychites studeri* Mojsisovics (1882) from the Mediterranean Triassic Province in the sculpture of shell and the whorl section, but it is distinguished by showing more complex sutures and more deeply indented whorls. *Ptychites nordenskjöldi* Mojsisovics from the Arctic Muschelkalk resembles this new species in the shell ornamentation, the width and shape of umbilicus, but is distinguished by the difference of the ventral sutures.

Occurrence and geological horizon: – Dark gray calcareous sandy shales of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 79176.

Ptychites sp. indet. [cf. *P. trocheaeformis* (Lindstroem)]

Pl. 15, figs. 1-2

Nautilus trocheaeformis Lindstroem, 1865, p. 3, pl. 1, fig. 2 (not seen).
Ptychites trocheaeformis (Lindstroem). Mojsisovics, 1882, p. 250.
Ptychites trocheaeformis (Lindstroem). Mojsisovics, 1886, p. 89, pl. 12, figs. 1–2; pl. 13, fig. 1.

Description: – Shell involute, discoidal, laterally compressed, with broadly arched venter. Whorl height a little less than half of total shell diameter, width probably a little less than shell height. Umbilicus very narrow, about one-seventh of total shell diameter, their shoulder abruptly rounded, with steeply inclined wall of cylindrical or funnel-shape. Surface with rather numerous radial ribs, somewhat convex on flanks, 15 to 16 on half revolution. Very fine growth radial striations on shell surface. Ribs begin from umbilical shoulder and run to ventral shoulder, most elevated on middle of two-thirds portion of flanks, but diminish on umbilical or ventral margin. Septa unknown.

Measurements (mm): –

	D	H	H/D	W	W/D	U	U/D
IGPS coll. cat. no. 79177	125.0	60.0	0.48	52.0(?)	0.87(?)	17.0	0.14

Remarks: – The material is an internal mould with one-third of the shell broken off. Accordingly, the indentation of the whorls by embracing the inner whorls could not be observed. In the shell sculpture, form of umbilicus, and the whorl section, the present specimen is closely related with *Ptychites trocheaeformis* (Lindstroem) from the Arctic Trias, Spitsbergen, illustrated by Mojsisovics (1886), but exact identification may be questioned because the suture has not been studied. *P. nordenskjoldi* Mojsisovics from the same Arctic Muschelkalk of Spitsbergen (Mojsisovics, 1886) is another species related to the present one, but it slightly differs in the number of ribs, and strict comparison of the sutures are at present impossible.

Occurrence and geological horizon: – Dark gray calcareous sandy shales of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 79177.

Ptychites sp. indet.

Pl. 15, figs. 3a–c

Description: – Shell high laterally compressed, completely involute, discoidal, with fastigate venter. Sides almost flattened on body chamber, shell surface of umbilical whorl ornamented with feeble radial folds, most elevated on middle part of flanks, but become indistinct on siphonal sides or umbilical margin.

Umbilicus funnel shaped, very narrow, its shoulder sharply rounded. Umbilical wall steeply inclined to inner whorl. Septa characteristic of typical *Ptychites*, first lateral lobe deepest in comparison with other lateral lobes, first lateral saddles higher than ventral saddle. Sutures preserved only on umbilical whorl.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
GLKU-C131	—	70.0	—	20.0	0.28	10.0 (?)	—

Remarks: – There are several specimens, some are badly crushed and others preserve a part of the body chamber and umbilical volutions. The sutures of the umbilical whorls closely resemble those of "*Ptychites*" *compressus* Yabe and Shimizu, but the present specimens are too incomplete for an acurate identification.

Occurrence and geological horizon: – Dark gray calcareous sandy shales of the Rifu Formation at Hamada?, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi* ?. Coll. Y. Bando.

Repository: – GLKU–C131.

Ptychites sp. indet.

Pl. 5, figs. 2a–b

Description: – Shell form involute, laterally compressed. Umbilicus probably almost closed, surface with radial folds on flanks except near venter and umbilical margin. Whorl section subrectangular, venter broadly arched, umbilicus narrow, surrounded by a steeply inclined wall. Umbilical margin sharply defined at maximum thickness of whorl. Shell with rather numerous radial ribs, which are broadest at about two-thirds height of flanks, and projecting forward. Each ribs die out near ventral margin and umbilical margin; 12 ribs in a part of last volution, probably 40 to 48 ribs on complete volution.

Suture lines well preserved except for a part of auxiliary series. Septa showing typical Ptychitid form of three saddles and lobes. Each saddles highly foliaceous and well serrated to secondary branch, ventral lobe terminate in central part and its sides corrugated. First lateral lobe indistinct, but deeply incised on base.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
GLKU-C128	—	36.0	—	32.0	0.88	12.0(?)	—

Remarks: – The single specimen examined is closely related to *Ptychites nordenskjöldi* Mojsisovics from Saurie Hook of Spitsbergen in the sutural elements and the form of ribs. Considering from the ribs the material also resembles *P. latifrons* Mojsisovics from the Arctic Upper Muschelkalk in Cap Tordsen Peninsula, but that species has more or less

Fig. 30. Comparison of sutures of this species with other related ammonites.
(1) *Flexoptychites flexuosus* (Mojsisovics), 1882, Taf. 64, fig. 3.
(2) 〃 〃 Taf. 63, fig. 4.
(3) 〃 〃 Taf. 63, fig. 6.
(4) 〃 〃 Taf. 63, fig. 7.
(5) 〃 〃 Taf. 66, fig. 3.
(6) *Ptychites acutus* Mojsisovics, 1882, Taf. 65, fig. 1.
(7) "*Ptychites*" *compressus* Yabe and Shimizu, 1927-29, pl. 10, fig. 8.
(8) 〃 〃 pl. 10, fig. 7.
(9) *Flexoptychites matsushimaensis* n. sp., 1964, pl. 5, figs. la-c.
(10) 〃 〃 pl. 5, figs. la-c.
(11) *Ptychites striatoplicatus* Hauer, 1888, Taf. 8, fig. 3.

strongly falciformed ribs which are projected on the sides and differ in the feature of the first lateral saddle of the septa. The present form also resembles *P. rugifer* (Oppel) from Spiti and *P. vidura* Diener from Tibet, but both differ in the character of the suture lines. There are no known species with which the present material can be identified. Even though the specimen studied is not a complete one, it is evident from the preserved features that it is a species new to science. However, it is given no formal name because of the state of its preservation.

Occurrence and geological horizon: – Dark gray calcareous sandy shales of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. Y. Bando.

Repository: – GLKU–C128.

Genus *Flexoptychites* Spath, 1951

Gentoype: *Ptychites flexuosus* Mojsisovics, 1882

The genus *Flexoptychites* was first proposed by Spath (1951) based upon *Ptychites flexuosus* Mojsisovics (1882, p. 261, pl. 63, fig. 2). According to the description of the type species, *P. flexuosus*, by Mojsisovics, the shell is compressed, with flattened convex sides, and with funnel shaped umbilicus. The greatest thickness is situated at half height of whorl. The shell ornamentation is characterized by 13–16 radial ribs, but in large specimens there may be as many as 24 ribs. The septa are closely allied to *P. studeri* (Hauer) from the *Binodosus* Beds of the Alps.

The Japanese species, especially "*Ptychites*" *compressus* Yabe and Shimizu and *P. rifunus* Yabe and Shimizu, both from the Rifu Formation, are closely related to *Flexoptychites* in the shape of ribs, the suture lines and their whorl section. They may belong to *Flexoptychites* rather than *Ptychites* in strict sense.

Distribution: – Alps, Balkan, Himalayas and Japan. Middle Triassic.

Flexoptychites matsushimaensis Bando, n. sp.
Pl. 5, figs. 1a–c

Description: – Shell much involute, discoidal, strongly compressed, with narrow umbilicus and fastigated venter. Sides flattened, with radial, slight folds, which are rather broad, somewht flexuous and flat but dominant on a half of height of ventral side, no ribs observed on inner half of umbilical sides. Whorl gradually increasing in height, broadest at half of heigth. Umbilicus very narrow, with funnel-shaped umbilicus surrounded by steeply inclined wall, its shoulder abruptly rounded. Shell surface with straight broad radial ribs, dominant on ventral sides and not on umbilical sides, become indistinct on body chamber, about 9 ribs on half of last volution.

Septa characterized by an oblique arrangement of lobes, deepest towards umblical margin. Two lateral lobes placed at same level and much serrated and enlarged at base. Siphonal lobe considerably short, terminating in a deep point. Second lateral and first auxiliary saddle highly foliaceous and deeply incised on base. Second lateral saddle rises highly foliaceous, well serrated secondary branch, as in adult form of *Flexoptychites flexuosus* (Mojsisovics). Umbilical suture consist of secondary branched, numerous auxiliary saddles and shallow auxiliary lobes.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79173 (Holotype)	112.0	60.0	0.53	20.0	0.33	12.0	0.11

Remarks: – The specimen examined is more or less laterally deformed, but the general shell shape, ornamentation and sutures are well preserved. This species is similar to *F. flexuosus* (Mojs.) in the suture lines, but differs in the form of ventral saddles and auxiliary series; and in more compressed whorl. It is closely related to "*P.*" *compressus* Yabe and Shimizu, but differs from that species by the umbilical sutures, number of lateral lobes, and the shape of ribs. There are more stronger radial ribs on the peripheral side of the flank, but not in "*P.*" *compressus* which has fine radial growth lines and slightly flexuosus radial folds which are rather broad and almost flattened. In the ornamentation of the shell surface this is related to "*P.*" *rifunus* Yabe and Shimizu rather than "*P.*" *compressus*, but it can not be identified with the former in the suture elements.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 79173.

Family Trachyceratidae Haug, 1894
Genus *Protrachyceras* Mojsisovics, 1893

Gentoype: *Trachyceras archelaus* Laube, 1869
Protrachyceras. Mojsisovics, 1893, p. 618.
Protrachyceras. Mojsisovics, 1896, p. 646.
Protrachyceras. Tornquist, 1898, p. 659.
Protrachyceras. Smith, 1904, p. 387.
Protrachyceras. Hyatt and Smith, 1905, p. 193.
Protrachyceras. Smith, 1914, p. 133.
Protrachyceras. Kummel, 1957, p. 158.
Protrachyceras. Kiparisova, 1961, p. 166.
Protrachyceras. Popow, 1961, p. 83.
Protrachyceras. Tozer, 1961, p. 75.

Remarks: – According to the original description of Mojsisovics (1893) the genus *Protrachyceras* was stated to be the forerunner of the genus *Trachyceras*, which genotype is *T. aon* Münster. The genus *Protrachyceras* has a geological range from Anisian to middle Karnian, and the species of the Ladinian Trachyceratidae almost all belong to this genus.

In the earlier form of this genus, the shell sculpture is characterized by having external knots on the central part of the sides. Spath (1951) pointed out that if the arrangement of their peripheral tubercles is considered a primary distinguishing feature, the genus *Protrachyceras* is connected with the genus *Trachyceras* by transitions (Spath, 1951, p. 43). The genus *Protrachyceras* is a close ally to the genus *Nevadites* (Smith, 1914) of North America by transitions. And the writer considers that the genus *Kellnerites* (Arthaber, 1912) may be a forerunner of this genus, as mentioned below, together with the genus *Anolcites* (Mojsisovics, 1893).

Distribution: – Spitsbergen, Sardinia, Balkan, Asia Minor, Himalayas, Timor, Indochina, Japan, Eastern Siberia and North America. Anisian-Lower Karnian.

Protrachyceras reitzi (Boeckh)
Pl. 10, figs. 1a-b, 2a-c, 3, 4a-b, 5

Ceratites reitzi. Boeckh, 1875, p. 157, pl. 7, fig. 3; pl. 8, figs. 3–5.
Ceratites reitzi Boeckh. Stürzenbaum, 1876, p. 256, pl. 5, fig. 2.
Trachyceras reitzi (Boeckh). Mojsisovics, 1882, p. 113, pl. 7, figs. 2–5.

Protrachyceras reitzi (Boeckh). Frech, 1903, p. 8, pl. 2, fig. 6.
Protrachyceras reitzi (Boeckh). Arthaber, 1906–8, pl. 38, figs. 1–2.
Protrachyceras reitzi (Boeckh). Mansuy, p. 6, pl. 1, fig. 7.
Protrachyceras reitzi (Boeckh). Onuki and Bando, 1959, p. 75, pl. 2, figs. 1–2.

Remarks: – Five specimens were studied, of which two are almost complete whereas the others are fragments of the outer whorl or body whorl. The occurrence of this species from the Rifu Formation has been already published by the writer (1958) and its details were described by Onuki and Bando (1959). The specimens described in this paper are more complete than those of the primary description, but slightly deformed laterally.

Protrachyceras reitzi was first included by Mojsisovics (1882, p. 93) into the *Trachycerata* (*Protrachycerata*) *subfurcosa* group. He pointed out that this species resembles *P. julium* (Mojsisovics) in the umbilical, lateral, and the marginal tubercles. This species is also allied to *Kellnerites bosnensis* (Hauer), which was first described by Hauer (1888, p. 24, pl. 6, figs. 1–2) as *Ceratites bosnensis*, a member of the *Paraceratites trinodosus* Zone in the Anisian, though later Arthaber (1912) referred it to *Kellnerites*, whereas Spath (1934) redescribed this species as the genotype of *Popinites* Salopek (1912). The present species resembles *Kellnerites bosenensis* in the shell sculpture, especially in the tubercular form of the ventral margin, but differs in having a ventral furrow and more numerous ribs. This species may be distinguished by the characteristic shell sculpture from any other known Middle Triassic ammonites. On the other hand, the present species closely resembles *Nevadites sinclairi* Smith (Smith, 1914, p. 126, pl. 82, figs. 1–3) in the general shape of the shell, but is distinguished by having a less number of tubercles on the ventral side of the flanks and more compressed whorls.

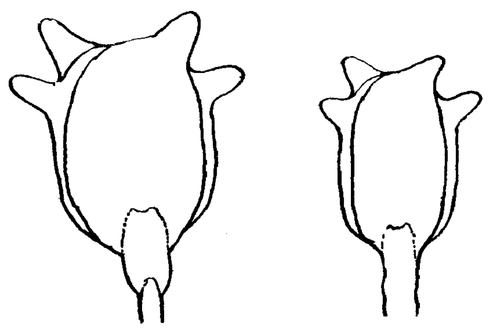

Fig. 31. Showing a cross-section of the outer whorl of *Protrachyceras reitzi* (Boeckh) from the Rifu Formation. × 1. IGPS coll. cat. no. 78339. Coll. Hatai and Bando.

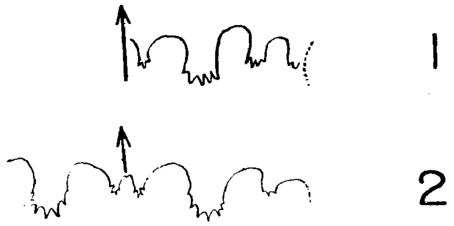

Fig. 32. Comparison of the septa of *Protrachyceras reitzi* (Boeckh).
(1) *Protrachyceras reitzi* (Boeckh) from the Rifu Formation, pl. 10, fig. 3.
(2) *Protrachyceras reitzi* (Boeckh), Mojsisovics, 1882, p. 113, pl. 7, fig. 5.

Occurrence and geological horizon: — Dark gray calcareous sandy shales of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai and Y. Bando.

Repository: – IGPS coll. cat. no. 78339.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 78339	60.0 (43.0)	23.5	0.39	12.0	0.52	22.5 (16.0)	0.38
	67.0	26.5	0.39	12.0?	0.46?	24.0	0.36
	—	30.0	—	12.0	0.40	26.0?	—
	—	24.0	—	11.0	0.45	—	—
	—	25.0	—	11.0?	0.44?	—	—
Mojsisovics's (1882, p. 113, pl. 7, figs. 2-5) form	80.0	28.0	0.35	25.0	0.88	32.0	0.40

Protrachyceras sp. indet.
Pl. 6, fig. 3

Description: – Form evolute, laterally compressed, with considerably flattened sides and rather widely umbilicate. Whorls higher than wide. Umbilicus a little larger than one-third of total diameter of shell, flattened, with sharply inclined umbilical wall and abruptly rounded umbilical shoulder. Venter unknown. Surface with about 13–14 primary ribs on a half of outer whorl, but some bifurcating on middle part of flanks, and only a single row of tubercles on ventral margin. Marginal tubercles correspond to marginal end of ribs. Ribs start from umbilical shoulder and continue obliquely to margins of venter.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79172	80.0?	31.0	0.38	—	—	28.0?	0.35?

Remarks: – The material is a badly broken external cast, and the septa are missing. In the shell sculpture, especially in having a single row of marginal tubercles, this material resembles *Protrachyceras reitzi* (Boeckh), but without a knowledge of the septa identification with that species is impossible.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi.*

Repository: – IGPS coll. cat. no. 79172.

Genus *Trachyceras* Laube, 1869
Subgenus *Paratrachyceras* Arthaber, 1914
Paratrachyceras n. sp.
Pl. 6, figs. 5a-b

Description: – Shell laterally compressed, ribs consist of broad primary and fine inserted secondary ribs among primaries. General form of ribs concave backward at flanks and project forward near ventral shoulder. Each ribs diminish in elevation near ventral furrow. Broad primary ribs bifurcate on flanks and slightly projected on ventral margin. Umbilicus and its shoulder missing. Part of flanks with many small adhered crinoid stems. Septa unknown.

Remarks: – The examined specimen is an incomplete body chamber with a part of the sinuous ribs and preserves the ventral regions. The other side of the flank is broken.

This specimen is comparable with *Trachyceras* (*Paratrachyceras*) in the compressed whorl, pattern of ribs and the nature of ventral furrow, with no tuberculation and very dense ribbing. As a result, this specimen seems to be closely related to *P. hofmanni* (Boeckh), but differs in density and bifurcating characters of the ribs. In the nature of ribs, this is also similar to *P. regoledanum* (Mojsisovics) from the Ladinian strata of the *Protrachyceras archelaus* Zone, however in the features of the flanks it is distinguished from that species. In addition, this specimen resembles *Dimorphites* from the Karnian strata of the Alps, Sicily, Greece and Timor, but differs in the character of the ventral shoulder and its furrow. On the other hand, *Trachyceras fasciger* Mansuy (Mansuy, 1912, p. 130, pl. 24, figs. 7a-d) from Yunnan, Indochina, differs from the present one in having a row of marginal tubercles near the ventral margin. Among the Japanese species of the Upper Triassic ammonites, *Arpadites sakawanus* Mojsisovics from the Sakawa Basin closely resembles this specimen, but the present form is distinguished by having more numerous falcoid ribs. *Paratrachyceras* sp. nov. of Shimizu (1930–31, p. 16, figs. 6–8) from the Upper Triassic Kochigatani Group of Tokombo and Kaisekiyama, near Sakawa, is similar to the present specimen in the sculpture of the shell and the ventral form, but is distinguished by having more numerous falcoid ribs.

Occurrence and geological horizon: – This material was collected by the writer from the Kochigatani Group at Shimoyama, at about 1.5 km northeast of Sakawa, Takaoka-gun, Kochi Prefecture, Shikoku.

The horizon was traced as the middle part of the Kochigatani Group or "*Halobia*, *Pecten* and *Myoconcha* Beds" by Kobayashi, Aoti and Hikasawa (1940). Katto, Suyari, Ishii and Ichikawa (1959), regarded the fossil beds as the upper member of the lower Kochigatani Subgroup which is represented by *Lima naumanni*, *Tosapecten suzukii*, *Halobia kawadai*, *H.* cf. *aoti*, *H. multilineata*, *Oxytoma dieneri*, *Anodontophora kochigataniensis* etc.

Paratrachyceras is an extremely wide spread genus and indicates the Ladinian to Karnian. Typical forms are from the Mediterranean Triassic of the Alps, Spitsbergen, Balkan, Japan, Indochina, British Columbia, and North America. In Japan, this genus has been reported by Shimizu (1930–31) only from the Sakawa Basin. According to Shimizu, his other species of this genus was identified with *P. hofmanni* (Boeckh) and he correlated this horizon to the Zone of *P. aonoides* of the middle Karnian. Coll. Y. Bando.

Repository: – GLKU–C129.

Family Ceratitidae Mojsisovics, 1879
Genus *Kellnerites* Arthaber, 1912

Genotype: *Ceratites bosnensis* Hauer, 1887

Remarks: – The sutures are not visible in the two specimens examined, but it is generally accepted that they are ceratitic, with low, rounded, entire saddles.

The genus *Kellnerites* was first proposed by Arthaber (1912) based upon *Ceratites bosnesis* Hauer, which is characterized by having sculpture stronger than in the other species of Ceratitidae. One year later Salopek (1913) designated the same species for his new genus *Popinites*. Therefore, the latter is a synonym of the former. According to Smith (1914), his *Popinites* (*Kellnerites*) is the direct forerunner of the genus *Nevadites* and thus the ancestor of the Trachyceratids. Kutassy (1932) and Spath (1934) used the genus name *Popinites* instead of *Kellnerites*, whereas Diener (1915) accepted the generic name of *Kellnerites* and also the type species of Hauer from priority. Kummel (1957) like Diener also accepted *Kellnerites*. The genus *Kellnerites* is considered to be a form transitional from *Paraceratites* to *Protrachyceras* in the shell sculpture and the septal elements.

Kellnerites cf. *bosnensis* Hauer

Pl. 5, fig. 6

Ceratities bosnensis. Hauer, 1888, p. 24, pl. 6, fig. 1 (non fig. 2).
Ceratites bosnensis. Hauer, 1896, p. 254, pl. 7, figs. 13–14.
Ceratites (*Bosnites*) *bosnensis* Hauer. Frech and Renz, 1908, p. 455, pl. 16, fig. 2.
Ceratites (*Bosnites*) *bosnensis* Hauer. Renz, 1910, p. 34.
Ceratites (*Bosnites*) *bosnensis* Hauer. Renz, 1912, p. 572, fig. 9.
Ceratites (*Popinites*) *bosnensis* Hauer. Salopek, 1915, p. 31, pl. 3, fig. 2; pl. 7, fig. 1 (not seen).
Ceratites (*Kellnerites*) *bosnensis* Hauer. Diener, 1915, p. 98.
Ceratites (*Popinites*) *bosnensis* Hauer. Diener and Kutassy, 1933, p. 472.
Popinites bosnensis (Hauer). Spath, 1934, p. 459, fig. 151.

Description: – Form evolute, laterally compressed, with rather wide umbilicus. Whorl little embracing and little indented by inner volution, higher than wide and increasing rapidly in height. Whorl width about one half of height, umbilicus a little larger than one-third of total shell diameter. Sides slightly convex, with abruptly rounded umbilical and ventral shoulders. Form of venter unknown. Surface with strong lateral ribs, most of which start from umbilical shoulder, external straight on sides, and in strong knots on ventral shoulder. Secondary ribs between primary ribs, of variable length and beginning on flanks and ending in knots similar to those of primary ribs on ventral margin. Row of knots or tubercles consisting of three, umbilical, lateral, and marginals. First, umbilical knots, situated at one-third height of outer whorl and about 8 prominent tubercles in a half revolution. Row of lateral tubercles a little higher than two-thirds height of whorl, and about 10 tubercles prominent on a half of outer revolution. Marginal tubercles at end of ribs on ventral shoulder, and obliquely elongated forwards towards venter. Probably, 11 to 12 tubercles on a half of revolution. Number of lateral tubercles almost equal to marginals. Primary ribs do not bifurcate on flanks, secondary ribs not regular in distribution, hence number of lateral and marginal tubercles not equal. Septa unknown.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76367	49.0?	19.0	0.39?	10.0?	0.53	17.0	0.35
Hauer's type species (1888, p. 24, pl. 4. figs.1-2)	77.0 50.0	— —	0.41 0.38	— —	0.34 0.41	— —	0.33 0.24
Kraus (1916, p. 300) (after Spath, 1934)	71.0	—	0.35	—	0.32	—	0.37

Remarks: – The examined material comprises an external cast with half of the phragmocone missing. This form is related to *Kellnerites bosnensis* (Hauer) from the Bosnian Muschelkalk (Hauer, 1888 and 1896), but unfortunately the septa are not visible in this material. In strict sence, this is almost identifiable with Hauer's species shown in Figs. 13–14, Plate 7, in his paper on the Cephalopoda from the Trias of Bosnian (1896) and with the same species reported from the Hydra and Argolis by Frech and Renz (1908) in the arrangement of the rows of tubercles, and the width of umbilicus.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Tatta? along the Tohoku Railway Line, Matsushima-cho, Miyagi-gun, Miyagi Prefecture. Uppermost Anisian, Zone of *Paraceratites trinodosus* ? Coll. Town Officials of Matsuhima-cho, Miyagi Prefecture.

Repository: – IGPS coll. cat. no. 76367.

Kellnerites n. sp.
Pl. 5, fig. 3

Description: – Evolute, discoidal, laterally compressed, with slightly convex sides and comparatively wide umbilicus. Whorls little embracing, little indented by inner whorls and increasing rapidly in height. Shell width about half of height. Umbilicus width a little less than one-third of total shell diameter. Sides slightly convex, with abruptly rounded umbilical and ventral shoulders. Shape of venter unknown. Shell surface with strong radial ribs superposed with three rows of tubercles classified into umbilical, lateral, and marginal. Each ribs start from umbilical margin, run radially on flanks, and end with strong tubercles on ventral shoulder. Secondary ribs between strong primary ribs, beginning on ventral shoulder, their length or strength variable. Primary ribs do not bifurcate. Three rows of tubercles, namely, umbilical, lateral, and marginal, on sides. Number of tubercles on umbilical and lateral parts equal to each other in grade of projection, about 9 knots in half revolution. Marginals with about 12 tubercles in half of last volution. Umbilical row at about one-third height of whorl, and lateral a little higher than two-thirds height of whorl. Ribs and tubercles characteristically very prominent; very fine radial striae on shell surface. Septa unknown.

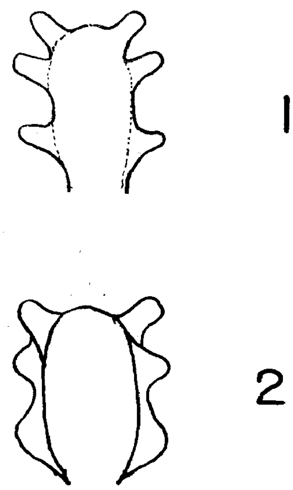

Fig. 33.
1: Cross-section of the outer whorl of *Kellnerites* cf. *bosnensis* (Hauer). ×1, IGPS coll. cat. no. 76367
2: The whorl section of *Kellnerites* n. sp. ×1, IGPS coll. cat. no. 76569

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76569	43.0	15.5	0.36	8.0?	0.52?	13.5	0.31

Remarks: – The examined material consists of an external cast with the outer half of the phragmocone lost. This specimen shows close resemblance to *Kellnerites bosnensis* (Hauer), from which it differs in the more prominent ribs or tubercles, with the very fine radial striations on the shell surface. These ribs and tubercles are sharply elevated on the whorls compared with Hauer's type species. Although this may be a new species of *Kellnerites*, unfortunately the material is an external cast and the septa are unknown.

This species seems to be the most highly sculptured one in the genus *Kellnerites*, which is known to have the most outstanding sculpture in the family Ceratitidae as already mentioned by Arthaber (1935). It also shows features near to those of the Trachyceratidae, especially it may be connected with *Protrachyceras reitzi* (Boeckh) in the form of both lateral and marginal tubercles.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Tatta? along the Tohoku Railway Line, Matsushima-cho, Miyagi-gun, Miyagi Prefecture. Uppermost Anisian, *Paraceratites trinodosus* Zone? Coll. Town Officials of Matsushima-cho, Miyagi Prefecture.

Repository: – IGPS coll. cat. no. 76569.

Genus *Paraceratites* Hyatt, 1900

Paraceratites cf. *clarkei* Smith

Pl. 4, figs. 2a–b

Paraceratites clarkei. Smith, 1914, p. 91, pl. 40, figs. 15–23; pl. 52, figs. 1–2.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76567	61.0?	23.0	0.38?	—	—	18.0	0.29?
Smith (1914, type specimens)	38 54	19 28	0.50 0.52	11 14	0.58 0.50	9 13	0.24 0.24

Remarks: – This specimen closely resembles *P. clarkei* from the Middle Triassic *Daonella dubi* Zone of Nevada, North America described by Smith (1914) in the shell form and the features of septa. While the present specimen is very similar to *P. orientalis* Yabe and Shimizu, it differs by having wider umbilicus and entire first lateral saddle. It is distinguished from *P. trinodosus* Mojsisovics by the narrow umbilicus, more compressed whorls and many lateral tubercles. In the shell ornamentation, this specimen is similar to *P. brembanus* (Mojsisovics), especially in the form of ribs and tubercles, but is distinguished from that species in having more compressed whorls. Smith stated that *P. brembanus* is a form intermediate between his *P. clarkei* and *P. newberryi*.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation, at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 76567.

Paraceratities orientalis Yabe and Shimizu

Pl. 6, fig. 1

Ceratites (Paraceratites) orientalis. Yabe and Shimizu, 1927, p. 121 (21), pl. 11(2), figs. 6–8.

Description: – Form involute, laterally compressed. Whorls high and increasing rapidly in height. Sides flattened, ventral shoulders subangular, venter narrow, smooth and round. Whorl height about two-fifths total shell diameter, width about one-fifth of height. Width of umbilicus less than one-third shell diameter. Surface with strong radial ribs and umbilical, lateral, and marginal tubercles. Umbilical and lateral tubercles, equal in number, about 15 to a revolution, marginal tubercles about 25 to a revolution, most of which correspond to ribs in number on ventral shoulder by bifurcation of principal ribs on lateral tubercles. Umbilical wall touches but does not overlap lateral row of tubercles in inner whorl. Outer whorl embraces a little more than half height of inner. Septa ceratitic, saddles entire, but first lateral saddle more or less ammonitic, and with serrated lateral lobes.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 60899	68.0 (53.0)	28.0	0.41	12.0?	0.19?	21.0 (14.0)	0.31

Remarks: – A well preserved internal mould. This species was first described from the Railway cutting, locality mark, C, northeast of the Rifu station by Yabe and Shimizu (Op. cit.), and is now preserved in the Institute of Geology and Paleontology, Tohoku University.

This species closely resemble *P. clarkei* Smith from the *Daonella dubia* Zone of Nevada as mentioned by Yabe and Shimizu (*op. cit.*), but is distinguishable therefrom by the septa of the first lateral saddle and the shallower first lateral lobe. This species is closely related to *P. elegans* Mojsisovics, the genotype, in the ornamentation and the septa, but it is distinguished by the position of the lateral row of tubercles.

Occurrence and geological horizon: – A railway cutting, locality mark C of Yabe and Shimizu, northeast of Rifu station, the Tohoku Railway Line, Matsushima-cho, Miyagi Prefecture. Uppermost Anisian, *Paraceratites trinodosus* Zone?

Repository: – IGPS coll. cat. no. 60899 (Same specimen as IGPS coll. cat. no. 35174).

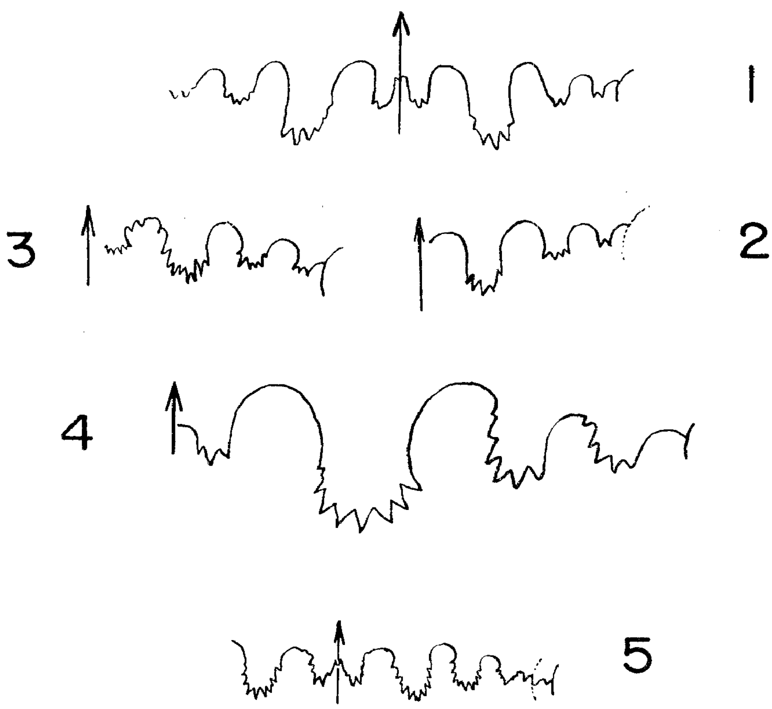

Fig. 34. Comparison of suture lines
1. *Paraceratites clarkei* Smith (after Smith, 1914)
2. *Paraceratites* cf. *clarkei* Smith from the Rifu Formation, pl. 4, fig. 2, ×1.
3. *Paraceratites orientalis* Yabe and Shimizu (after Yabe and Shimizu, 1927-29)
4. *Paraceratites trinodosus* Mojsisovics (after Smith, 1914)
5. *Paraceratites elegans* Mojsisovics (genotype of *Paraceratites*, after Mojsisovics, 1882)

Paraceratites cf. *trinodosus* Mojsisovics

Pl. 5, figs. 5a-b

Ceratites trinodosus. Mojsisovics, 1882, p. 29, pl. 8, figs. 5–7, 9; pl. 37, figs. 6–7.
Ceratites trinodosus Mojsisovics. Hauer, 1887, p. 26.
Ceratites trinodosus Mojsisovics. Arthaber, 1896, p. 197, pl. 23, fig. 1.

Ceratites trinodosus Mojsisovics. Hauer, 1896, p. 252.
Ceratites trinodosus Mojsisovics. Arthaber, 1896, p. 268.
Ceratites trinodosus Mojsisovics. Diener, 1900 p. 5.
Ceratites trinodosus Mojsisovics. Martelli, 1904, p. 80, pl. 5, fig. 1.
Ceratites trinodosus Mojsisovics. Airaghi, 1905, p. 243.
Ceratites trinodosus Mojsisovics. Arthaber, 1906, pl. 35, fig. 17.
Ceratites trinodosus Mojsisovics. Renz, 1906, p. 385.
Ceratites trinodosus Mojsisovics. Diener, 1907, p. 48, pl. 3, fig. 5.
Ceratites trinodosus Mojsisovics. Renz, 1909, pl. 9, fig. 2.
Ceratites trinodosus Mojsisovics. Renz, 1911, p. 19, pl. 19, fig. 7.
Ceratites trinodosus Mojsisovics. Diener, 1913, p. 47.
Ceratites (*Paraceratites*) *trinodosus* Mojsisovics. Smith, 1914, p. 92, pl. 39, figs. 1–19; pl. 52, figs. 12–18.
Ceratites (*Paraceratites*) aff. *trinodosus* Mojsisovics. Yabe and Shimizu, 1927, p. 118 (18), pl. 11(2), fig. 10.
Paraceratites trinodosus (Mojsisovics). Spath, 1934, p. 436, fig. 146.
Paraceratites trinodosus (Mojsisovics). Kummel, 1960, p. 3, pl. 1, figs. 3–6.

Description: – Form involute, laterally compressed, with rather wide umbilicus. Whorls increasing rapidly in height; whorl height a little less than half of total shell diameter. Umbilicus wide about one-third of total diameter. Umbilical shoulder abruptly rounded, sides flattened and sloping gently to ventral shoulder, a part of venter slightly deformed. Venter raised in median part showing a keel like ridge. Shell surface with numerous fine radial ribs, some of which bifurcate at third height of flanks and end in fine knots on ventral shoulders. Each ribs begins from umbilical shoulders; bifurcation of ribs usually has lateral knots. About 11 to 12 lateral knots and 18 marginal knots on a half revolution.

Septa ceratitic, saddles entire, four lobes visible, a second small auxiliary just outside on umbilical wall.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 58822	32.0 (19.0)	14.0	0.44	6.0?	0.43?	11.0 (8.0)	0.34

Remarks: – The present specimen resembles *P. trinodosus* (Mojsisovics) in the ornamentation of the shell surface, especially in the features of rather fine radial ribs with a row of lateral and marginal knots, rather wide umbilicus, and in the form of subcarinate venter. Moreover, the suture lines almost coincide with that species. But there are a little more numerous ribs, or lateral knots, on the flanks than in the type species illustrated by Mojsisovics. In the feature of the ribs the present form may be identical with *Ceratites balatonitiformis* Hauer (Hauer, 1888, p. 27, pl. 6, fig. 5) from the Bosnian Muschelkalk or *Ceratites brembanus* Mojsisovics, both species of whose septa are unknown. On the other hand, *Ceratites balatonitiformis* Hauer is closely related to *P. trinodosus* or *Ceratites vindelicus* Mojsisovics (Mojsisovics, 1882, pl. 10, fig. 7). Typical *P. trinodosus* is connected by numerous transitions with *P. binodosus* as mentioned by Mojsisovics (1882) and Spath (1934). In the form of ribs and the rows of tubercles, however, the present species is considered to be identical with *P. trinodosus* figured by Renz from the Asklepieion in Argolis (Renz, 1906, p. 386). Smith (1914, p. 92, pl. 34, figs. 1–19; pl. 52, figs. 12–18) described several examples of the species from the *Daonella dubia* zone, *P. trinodosus* subzone, of Nevada, and from his forms it is noticed that variation exists in this species. Spath (1934) mentioned that the forms described by Smith are perhaps not identical with the Alps types because of the tendency to develop coarse tuberculation on the outer whorl, and one may accept Smith's statements that they are forms intermediate between his *Paraceratites clarkei* and *P. newberryi*. *Ceratites multinodosus* Hauer from the Bosnian Muschelkalk described by Hauer (1892, p. 260, pl. 3, figs. 1a–b) closely resembles the present form in the ribs and form of tubercles, but it is distinguishable by the more compressed whorls.

In Japan, this species has already been described from the Rifu Formation at Akanuma, northeast of Rifu station along the Tohoku Railway Line, by Yabe and Shimizu (op. cit., p. 118, (18), pl. 11, (2), fig. 10). Those specimens are preserved in the Institute of Geology and Paleontology, Tohoku University, but the form of venter or the rows of marginal knots are too obscure to be considered as identical with the present specimen.

Occurrence and geological horizon: – The thin alternation of fine sandstone and calcareous dark gray sandy shale of the Rifu Formation at Tatta, at about 1.5 km. west of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Uppermost Anisian, *Paraceratites trinodosus* Zone. Coll. S. Hanzawa.

Repository: – IGPS coll. cat. no. 58822.

Family Balatonitidae Spath, 1951

Genus *Balatonites* Mojsisovics, 1879

Balatonites oyamai Bando, n. sp.

Pl. 5, figs. 4a-b

Description: – Form evolute, laterally compressed, ornamented, with fastigate venter. Sides almost flattened, with numerous radial ribs. Whorls rather high, a little larger than one-third of total shell diameter in outer whorl, and probably embraces about half height of inner whorls. Umbilicus wide, equal to height of last whorl in width and a little more than one-third of shell diameter. Venter very narrow, more or less fastigate. Umbilical shoulder abruptly rounded, with shallow umbilical wall. Surface with radial ribs, 24 to 25 in half outer whorl, inserted in rather deep radial furrows. About five ribs to each furrow. Ribs composed of primaries and secondaries, latter start from ventral shoulders and die out on middle portion of flanks. Ribs accompanies three rows of very fine tubercles, divided into umbilical, median, and marginal rows. Umbilical row on umbilical shoulder, and marginal row on ventral shoulder. Umbilical and median tubercles almost equal in number because situated on same primary rib, 14–15 ribs or tubercles in number. Septa unknown.

Measurements (mm) : -

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 62558	46.0 (27.0)	18.0	0.39	6.0?	0.33?	18.0 (11.0)	0.39

Remarks: – This new species resembles *Balatonites kitakamicus* (Diener) (1915, p. 17, pl. 2, fig. 2, as *Anolcites ? kitakamicus* Diener) from Inai and Iwaida, southern Kitakami Massif, which was subsequently described by Shimizu (1930–35, p. 71, pl. 24, figs. 8–12), but it is distinguished by having deep radial furrows on the flanks, more distinct tubercles and finer ribs. The species described by Shimizu as *Balatonites* cf. *kitakamicus* (Diener) may belong to this new species. This new species, also, is closely related to *B. kingi* Smith from the *Daonella dubia* zone of the Shoshone Mountains, Nevada, North America which was described by Smith (1914, p. 120, pl. 90, figs. 11–12), however it is distinguished by the sculpture. In the numbers and the features of ribs, this species resembles *B. semilaevis* Hauer (Hauer, 1888, p. 29, pl. 7, figs. 6a-b) from the Bosnic Muschelkalk, but in that species there are no median tubercles. It is also distinguished from *B. ottonis* Buch by having more compressed whorls. Whilst, the present form resembles *B. jovis* Arthaber (Arthaber, 1896, p. 63) from the lower Gross-Hartmannsdorfer Schichten(=lower Wellenkalk) at Gross-Hartmannsdorf, Niederschlesien, Germany, in the shell sculpture; especially in the ribbing form and row of tubercles, but the German species has no deep radial furrows as in the Japanese species. *B. jovis* was also described by Rassmuss (1915, p. 296) from the same Niederschlesian Muschelkalk. Rassmuss described 12 species of *Balatonites* in his paper, among which *B.* aff. *trinodosus* Hauer and *B. ergregius* Arthaber both are considered to be related with *B. kitakamicus* (Diener) in general shell sculpture.

The specific name is given in honor of Professor Toshiji Oyama of the Ibaragi University who collected this specimen during his stratigraphic study of the Ojika Peninsula in Miyagi Prefecture.

Occurrence and geological horizon: – Dark gray calcareous sandy shales of the Isatomae Formation at Iwaida of Watanoha-cho, at about 6 kilometers east of Ishinomaki City, Miyagi Prefecture. Anisian, associated with *Balatonites kitakamicus* (Diener). Coll. T. Oyama.

Repository: – IGPS coll. cat. no. 62558A.

Family Ussuritidae Hyatt, 1900

Genus *Monophyllites* Mojsisovics, 1879

Monophyllites wengensis (Klipstein)

Pl. 9, fig. 1

Ammonites wengensis. Klipstein, 1845, p. 120, pl. 6, fig. 11.
Phylloceras boeckhi. Mojsisovics, 1870, p. 110, pl. 5, fig. 7.
Lytoceras wengensis (Klipstein). Mojsisovics, 1873, pl. 17, figs. 7–9.
Monophyllites wengensis (Klipstein). Mojsisovics, 1882, p. 207, pl. 78, figs. 10–12.
Monophyllites cf. *wengensis* (Klipstein). Salomon, 1895, p. 191, pl. 7, figs. 8–9.
Monophyllites wengensis (Klipstein). Tommasi, 1899, p. 33, pl. 4, fig. 5.
Monophyllites wengensis (Klipstein). Frech, 1903, p. 38.
Monophyllites wengensis (Klipstein). Martelli, 1904, p. 101, pl. 8, fig. 4.
Monophyllites wengensis (Klipstein). Renz, 1911, p. 46, pl. 3, figs. 1–2.
Monophyllites cf. *wengensis* (Klipstein). Tommasi, 1913, p. 74, pl. 4, fig. 27.
Monophyllites wengensis (Klipstein). Welter, 1915, p. 97, figs. 4–5.
Monophyllites cf. *wengensis* (Klipstein). Yabe and Shimizu, 1927, p. 110 (10), pl. 12 (3), figs. 1–6.
Monophyllites wengensis (Klipstein). Kutassy, 1933, p. 594.
Monophyllites wengensis (Klipstein). Spath, 1934, p. 288, pl. 17, fig. 4.
Monophyllites aff. *wengensis* (Klipstein). Popow, 1961, p. 109, pl. 26, fig. 4.

Remarks: – The septa are of the *Monophyllites wengensis* type rather than of the *M. sphaerophyllus* (Hauer) type, having slightly more subdivided lateral lobes than in later species from the Wengen Beds in the Alps.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 63273	135.0	55.0	0.36	30.0?	0.55?	40.0	0.29
Type specimen (pl. 17, fig. 4, after Spath, 1934)	70(58)	—	0.43	—	?	—	0.35
Welter (p. 92, figs. 4-5)	148	47(58)	0.32	43	0.92	57	0.39
Martelli (p. 101, pl. 8, fig. 4)	46	18	0.39	15	0.83	15.5	0.34

The suture lines of *Monophyllites wengensis* is referred to the advanced form of *M. sphaerophyllus* as mentioned by many previous authors, but in the shell ornamentation, the former is said to be distinguishable by having coarser and more flexiradiate striations on sides, projected peripherally (Spath, 1934, p. 287).

M. wengensis described from the Marmolata Limestone by Mojsisovics (1882, p. 207, pl. 78, figs. 10–12) closely resembles the present form in the septa, which seems to be evidence that it should be included into *M. sphaerophyllus* rather than in *M. wengensis*. In Japan several specimens of *M.* cf. *wengensis* have been reported by Yabe and Shimizu from the Rifu Formation and it was pointed out by Spath (1934) that they may be referred to *M. sphaerophyllus* because of the fine striations and lack of a radial ridge on the umbilical whorls. As above mentioned, the present material has the same characteristic shell ornamentation features as the typical *M. wengensis.*

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi.* Coll. S. Mabuti.

Repository: – IGPS coll. cat. no. 63273.

Monophyllites cf. *wengensis* (Klipstein)
Pl. 9, fig. 2

Ammonites wengensis. Klipstein, 1845, p. 120, pl. 6, fig. 11.
Monophyllites wengensis (Klipstein). Mojsisovics, 1882, p. 207, pl. 78, figs. 10–12.
Monophyllites wengensis (Klipstein). Tommasi, 1899, p. 33, pl. 4, fig. 5.
Monophyllites wengensis (Klipstein). Martelli, 1904, p. 101, pl. 8, fig. 4.
Monophyllites wengensis (Klipstein). Renz, 1911, p. 46, pl. 3, figs. 1–2.
Monophyllites wengensis argolica. Renz, 1911, p. 44, pl. 3, figs. 3, 3a-b.
Monophyllites wengensis (Klipstein). Welter, 1915, p. 97, figs. 4–5.
Monophyllites cf. *wengensis* (Klipstein). Yabe and Shimizu, 1927, p. 110 (10), pl. 12 (3), figs. 1–6.
Monophyllites wengensis (Klipstein). Spath, 1934, p. 288, pl. 17, fig. 4.
Monophyllites aff. *wengensis* (Klipstein). Popow, 1961, p. 109, pl. 26, fig. 4.

Measurements (mm.): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76572	—	28.0	—	15.0	0.54	20.0?	—

Remarks: – A fragment of *Monophyllites* composed of an external cast and a part of the internal mould of the outer whorl was studied. This species is distinguished from *M. sphaerophyllus*, *M. simonyi* Hauer, *M. aonis* Mojs. and *M. arthaberi* Welter, which are characterized by having numerous faint flexuous striations on the shell surface, in the ridges on their sides. But these characters are also seen in *M. wengensis argolica* Renz from the Wengen Limestone of Griechenlands. It may be identical with the latter species in having flexuous ridges on the outer whorls.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecutre. Lower Ladinian, Zone of *Protrachyceras reitzi.* Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 76572.

Monophyllites sphaerophyllus (Hauer)
Pl. 8, fig. 1

Ammonites sphaerophyllus. Hauer, 1851, p. 113, pl. 18, fig. 11.
Phylloceras sphaerophyllus (Hauer). Mojsisovics, 1869, p. 586, pl. 16, fig. 2.
Monophyllites sphaerophyllus (Hauer). Mojsisovics, 1882, p. 206, pl. 79, figs. 1–3.

Monophyllites sphaerophyllus. Hauer, 1887, p. 33.
Monophyllites sphaerophyllus Hauer, 1892, p. 280.
Monophyllites sphaerophyllus (Hauer). Diener, 1900, p. 21.
Monophyllites sphaerophyllus (Hauer). Martelli, 1904, p. 99, pl. 8, fig. 3; pl. 9, fig. 6.
Monophyllites sphaerophyllus (Hauer). Arthaber, 1906, pl. 36, fig. 1.
Monophyllites sphaerophyllus (Hauer). Diener, 1907, p. 105, pl. 13, fig. 11.
Monophyllites sphaerophyllus (Hauer). Kittle, 1908, p. 523.
Monophyllites wengensis var. *sphaerophylla.* Renz, 1910, p. 491, fig. 7.
Monophyllites wengensis var. *sphaerophylla.* Renz, 1911, p. 22, pl. 1, fig. 4.
Monophyllites sphaerophyllus (Hauer). Diener, 1915, p. 204.
Monophyllites sphaerophyllus (Hauer). Kutassy, 1933, p. 593.
Monophyllites sphaerophyllus (Hauer). Spath, p. 287, fig. 100, b,c,e.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 58527	191.0 (125.0)	83.5	0.43	27.0	0.32	61.0 (25.0)	0.32
Mojsisovics (1882, pl. 79, figs. 1a–b.)	129	54	0.43	35	0.66	42	0.32
Martelli (1904, p. 99, pl. 8 (4), fig. 3; pl. 9 (5), fig. 6.)	175?	70	0.40?	52	0.74	56	0.32?
Renz (1911, p. 22, pl. 1, fig. 4.)	85	30	0.35	22.5	0.75	35	0.40

Remarks: – The material is somewhat laterally deformed and thus the original form of the whorl is more or less doubtful, but the septa and the shell sculpture are well preserved. In the features of the septa, the present specimen is considered to be identical with *M. sphaerophyllus* (Hauer), or it may present a somewhat earlier stage of the species. On the other hand, the material has a slightly more advanced suture line than those of *M. spitsbergensis* (Oeberg) from Ice Fjord in Spitsbergen, and differs from *M. wengensis* in having more simple sutures.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada?, Shiogama City, Miyagi Prefecture. Uppermost Anisian ?, Zone of *Paraceratites trinodosus* ?. Coll. T. Sugiyama.

Repository: – IGPS coll. cat. no. 58527.

Family Gymnitidae Waagen, 1895
Genus *Japonites* Mojsisovics, 1893
Japonites cf. *dieneri* (Martelli)
Pl. 7, figs. 1a–b, 2, 5

Gymnites dieneri Martelli, 1904, p. 113.
Japonites cf. *dieneri* (Martelli). Diener, 1907, p. 89, pl. 10, figs. 1–2.
Japonites dieneri (Martelli). Kraus, 1916, (not seen).
Japonites dieneri (Martelli). Renz, 1935, p. 59.

Description: – Material laterally compressed, discoidal, evolute, with acute or somewhat keeled venter. Whorls strongly inflated, a little higher than broad in last volution. Transverse section strongly compressed. Umbilicus shallow, almost flattened, its diameter about half of total diameter of shell. Umbilical shoulder abruptly rounded, its wall almost flattened. Volution with numerous, slowly increasing whorls, which may overlap each other to about one-third of their height. Transverse section helemet-shaped as mentioned by Diener (1907). Shell surface with radial, straight ribs, about 17 on half of outer volution, short and restricted in lower portion of flanks, about two-thirds of their height, and re-

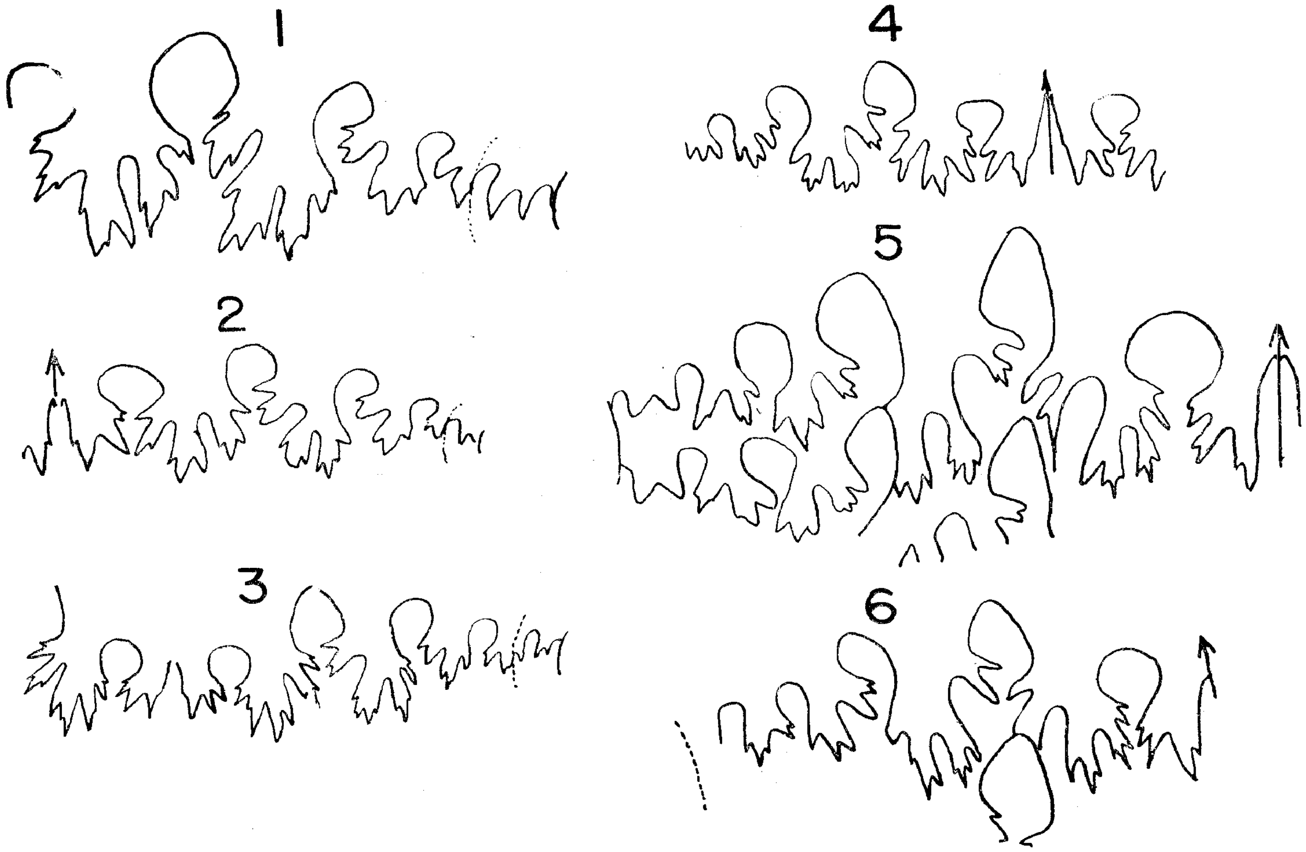

Fig. 35. Comparison of sutures
1. *Monophyllites wengensis* Klipstein, suture line of the present species, ×1
2. Same of the above, ×1
3. *Monophyllites wengensis* Klipstein by Mojsisovics (1882, p. 207, pl. 78)
4. *Phylloceras boeckhi* Mojsisovics (=*M. wengensis*) by Mojsisovics, paratype (1870, p. 110, pl. 5, fig. 7).
5. *Monophyllites wengensis argolica* Renz by Welter (1915, pl. 86, fig. 2).
6. *Monophyllites wengensis* Klipstein from Timor by Welter (1915, ibid, p. 95, fig. 4).

mainder of siphonal edge almost diminish in elevation. Ribs slightly recurved in a part of outer whorl, but not throughout, as in typical *Japonites* described by Mojisisovics (1893). Inner volutions, consist of four volutions, exposed in umbilicus, show a narrow spiral band with many radial folds. Suture line not preserved.

Measurements (mm): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79174	73.0 91.0	19.0 24.0	0.26 0.26	12.0 8.0?	0.63 0.33?	36.0 46.0 (35)	0.49 0.50
Martelli's type species	121.0	32.0	0.26	20.5	0.64	58.0	0.48
Diener (1907, p. 89)	125	35(30)	0.28	21	0.60	65	0.51
IGPS coll. cat. no. 79174	— 76.0	21.0 18.0	— 0.24	9.0? 8.0?	0.43? 0.44	— 30.0	— 0.46

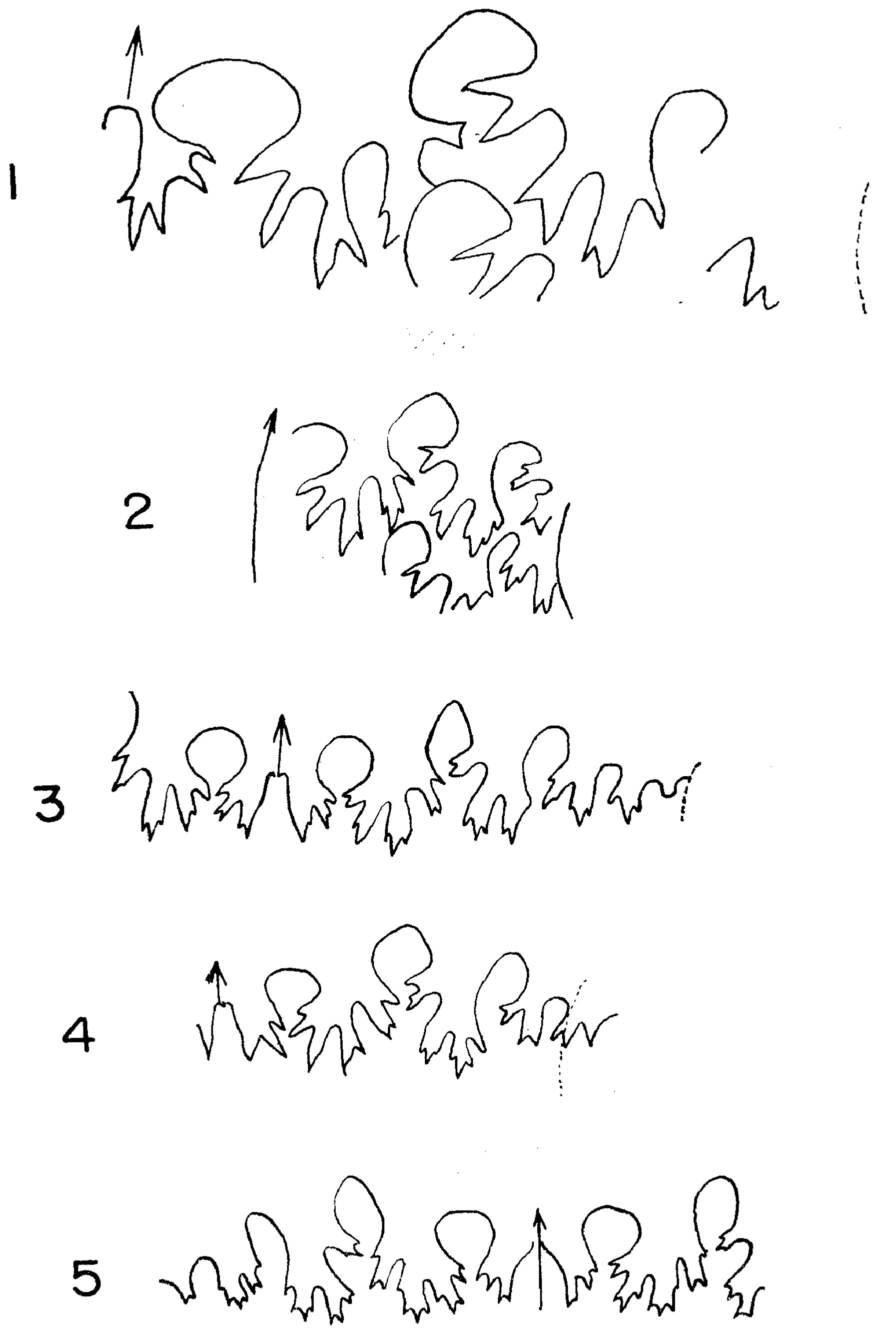

Fig. 36. Suture lines of *Monophyllites sphaerophyllus* (Hauer) (All figures in natural size)
1–2. The present specimen, IGPS coll. cat. no. 58527.
3. After Mojsisovics (1882), from the gray limestone of Dont in Val di Zoldo, Venetian Alps.
4. The specimen preserved in the collection of the Institute of Geology and Paleontology, Tohoku University, from Swinica, Daghestan of Kaukasus, IGPS coll. cat. no. 7020)
5. After Hauer (1851) from the Marmorata beds of Venetian Alps, type species.

Remarks: – Four specimens were examined; one is an internal mould and the others are external casts. From the specimens of external cast, almost entire forms were obtained by making plaster casts of the impressions.

The specimens are almost identical with the type species, *Japonites dieneri* (Martelli) (1904), from the Muschelkalk of Boljevici in Montenegro. Martelli originally placed it in

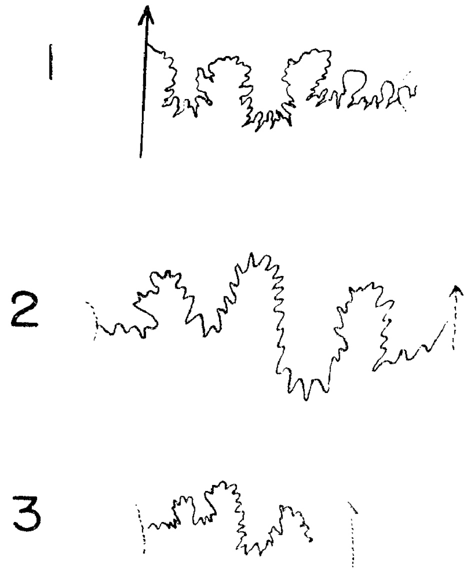

Fig. 37. Comparison of the suture lines in *Japonites dieneri* Martelli.
(1); Original species of Martelli (1904, p. 113, fig. 7)
(2): *Japonites* cf. *dieneri* by Diener (1907, pl. 10, fig. 1c)
(3): IGPS. coll. cat. no. 79174.

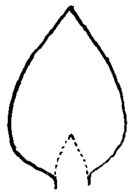

Fig. 38. Cross-section of the outer whorl of *Japonites* cf. *dieneri* (Martelli) showing the compressed helmet-shape.

the genus *Gymnites*. The present form resembles *Tropigymnites planorbsi* (Hauer)(1896), which is the genotype of *Tropigymnites*, Spath (1951), from the Bosnian Muschelkalk of Haliluci near Sarajevo, who misplaced it in the genus *Sibyllites*.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai and Y. Bando.

Repository: – IGPS coll. cat. no. 79174.

Genus *Epigymnites* Diener, 1882

Genotype: *Gymnites ecki* Mojsisovics, 1882

Remarks: – According to Mojsisovics, the original description of this form is intermediate between *Gymnites inclutus* (Beyrich) and *Gymnites humboldti* Mojsisovics so far as the relation of the involution and the height ratio of the shell are concerned. *Epigymnites* was first proposed by Diener based upon *Gymnites ecki* described from the Mediterranena Triassic Province by Mojsisovics, being distinguished by features distinctly different from the typical *Gymnites*. On the other hand, it is said that this genus is connected with *Buddhaites* Diener (1895, Genotype: *Gymnites* (*Buddhaites*) *rama*) (Spath, 1951, p. 171). However, the genus *Buddhaites* can be distinguished from this genus by having much narrower umbilicus, which is almost entirely closed and only slightly exposes the inner volution, and the sharply acute venter is keel-like. The author considers that *Gymnites jollyanus* (Oppel) belongs to this genus.

Distribution: – Alps, Balkan, Himalayas and Japan. Ladinian-Karnian.

Epigymnites aff. *jollyanus* (Oppel)

Pl. 4, fig. 1

Ammonites jollyanus. Oppel, 1863, p. 271, pl. 75, fig. 4.
Ammonites jollyanus Oppel. Stoliczka, 1865, p. 51.
Gymnites jollyanus (Oppel). Mojsisovics, 1882, p. 235, in description of *G. humboldti* Mojs.
Gymnites jollyanus (Oppel). Diener, 1895, p. 51, pl. 10, fig. 7; pl. 12, fig. 1.
Gymnites jollyanus (Oppel). Noetling, 1905, pl. 17, fig. 2.
Gymnites jollyanus (Oppel). Diener, 1907, p. 109.
Gymnites jollyanus (Oppel). Diener, 1913, p. 72.

Description: – Shell rather involute, discoidal, laterally compressed, with narrow umbilicus and flattened sides. Venter not preserved. Adult, large in form, its total diameter about 258 mm. Sides very flat, slope gently towards abruptly rounded or slightly arched umbilical shoulder. Whorls gradually increase in size, indented at about one-half of height by inner whorl. Umbilicus shallow, opened. Maximum width of whorls about equal to middle part of flanks. Height of last whorl about two-fifths of total diameter of shell, width of umbilicus about one-fourth of total diameter. Siphonal part not preserved, but was probably narrowly arched. Surface ornamented with very fine radial growth striations, extending from one-third of height of whorls to siphonal sides; radial ribs broad. Latters stronger near middle of flanks, but flat and appear along a spiral line which coincides with middle part of flanks. Form sort of chain-like ridge on flanks. Compressed strongly, original whorl section not ascertained; but sprial ridge observed to become gradually obsolete towards aperture. Septa unknown.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 79178	258.0	102.0	0.39	38.0?	0.37?	73.0(51)	0.28
Diener (1895, p. 51, pl. 10, fig. 7)	84.0	39.0	0.46	14.0	0.36	21.0	0.25
Diener (1913, p. 72)	315.0	152.0	0.48	—	—	60.0	0.19

Remarks: – This material may be identical with *Gymnites* (*Epigymnites*) *jollyanus* (Oppel) in the features of umbilicus, the shell form and the characteristic ornamentation. However there is slight difference recognized in the ornamentation of the shell, especially of the low undulated broad ribs on the outer sides. In the typical *G.*(*E.*) *jollyanus* these features are not observed. In the ornamentation of the shell surface, on the other hand, the present material resembles *Epigymnites ecki* Mojsisovics which has characteristic rows of median tubercles on the flanks of the outer whorl and these tubercles connect each radial ribs. It is distinguished from that species, however, by the wider umbilicus. *E. jollyanus* had been considered to have restricted occurrence from only the Himalayan Muschelkalk according to Oppel (1863), Stoliczka (1865), and Diener (1895, 1907, 1913), however, it is quite similar in the general shell form except for the small difference in the umbilicus width with the European *E. ecki* described by Mojsisovics (1882), Salomon (1895), Renz (1908, 1910), DeToni (1914), and Gordon (1927).

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: — IGPS coll. cat. no. 79178.

Genus *Anagymnites* Hauer, 1900
Anagymnites aff. *acutus* (Hauer)
Pl. 7, fig. 4

Gymnites acutus. Hauer, 1892, p. 282, pl. 10, fig. 6; pl. 11, fig. 2.
Anagymnites cf. *acutus* (Hauer). Smith, 1914, p. 54, pl. 97, figs. 13–14.
Anagymnites acutus (Hauer). Gugenberger, 1917, p. 135

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS. coll. cat. no. 79180	99.0 (90.0)	26.0	0.26	7.5	0.34	45.5	0.46
Hauer's type species (1892, p. 282)	93	33	0.29	23	0.69	40	0.43

Remarks: – This specimen closely resembles the named species described by Hauer (1892) from the middle Triassic of Bosnia, but the present form differs in having more compressed whorls. The present specimen is also related to *Japonites planorbis* (Hauer) from the Bosnic Muschelkalk, but is not identical, differing therefrom in the shallower embraced inner whorl. In general, the whorls of *Japonites planorbis* are more shallowly embraced than those of *Anagymnites acutus*, but the other features are closely similar with each other.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 79180.

Family Celtitidae Mojsisovics, 1893
Genus *Tropigastrites* Smith, 1914
Tropigastrites (?) sp. indet.
Pl. 7, fig. 3

Description: – Form evolute, discoidal, laterally compressed, with wide umbilicus. Whorls low, increasing very slowly in height. Umbilicus very wide, shallow, almost flattened. Width of whorl slightly greater than height. Whorls overlap each other to about one-third of height.

Surface with strong lateral ribs extending obliquely forward from umbilical shoulders and die out high on flanks. Cross section of outer whorl helmet shaped, with high and sharp acute venter. Septa unknown.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76573	—	12.0	—	8.0	0.66	29.0?	—

Remarks: – The material consists of badly broken whorls. In the sculpture of the outer whorl the present specimen is allied to the mature form of *Tropigastrites halli* Mojsisovics described from the Himalayas, and reported from North America by Hyatt and Smith (1905) and Smith (1914). In Japan, Onuki and Bando (1959) described a form related to the present one from the Rifu Formation, but exact identification is impossible because of the septa being unknown and the specimen not sufficiently preserved. This specimen resembles *Pseudodanubites dritarashtra* (Diener) from the Himalayas in the shell form, but the ribs run obliquely to the venter and have sharper venter in our material compared with those of *Tropigastrites* or the typical *Japonites*.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, *Protrachyceras reitzi* Zone. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 76573.

Family Hungaritidate Waagen, 1895
Genus *Hungarites* Mojsisovics, 1879
Hungarites nipponicus Bando, n. sp.
Pl. 6, figs. 2a–c, 4a–b

Description: – Form compressed, involute, discoidal, deeply embracing, with narrow umbilicus. Whorls very high, their height a little less than three times width. Sides almost flattened, become gradually convex on middle part of flanks. Venter narrow, subtabulated, with a sharp high central keel. Ventral shoulder flanked by sharp angles, its angle about 130°, central keel sharply elevated from venter. Surface ornamented with rather strong falcate or biconcave folds which die out on outer half of flanks and have lateral tubercles by dilation on middle part of flanks. These tubercles elongate to become parallel with the venter are found on ventral angle, but lower than that of flanks. Septa unknown.

Measurements (*mm*): –

	D	H	H/D	W	W/H	U	U/D
IGPS coll. cat. no. 76568	—	30.0	—	11.0	0.37	12.0?	—

Remarks: – The shape and ornamentation of the present specimen almost coincide with the characters of the genus *Hungarites*, which is restricted to the Middle Triassic. Specifically the present specimen resembles *H. sagorensis* Mojsisovics from the Alps in the form of venter and in the shell ornamentation, but differs from that species in having more prominent folds. Moreover the material at hand shows resemblance with *H.* ? *boeckhi* Roth., but is distinguished from that form in having more sharp and higher median keel on the narrow venter. Also *H.* sp. indet. described by Diener (1913, p. 58, pl. 7, fig. 5) seems to be closely related to the present specimen.

Occurrence and geological horizon: – Dark gray calcareous sandy shale of the Rifu Formation at Hamada, at about one kilometer northwest of Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture. Lower Ladinian, Zone of *Protrachyceras reitzi*. Coll. K. Hatai.

Repository: – IGPS coll. cat. no. 76568.

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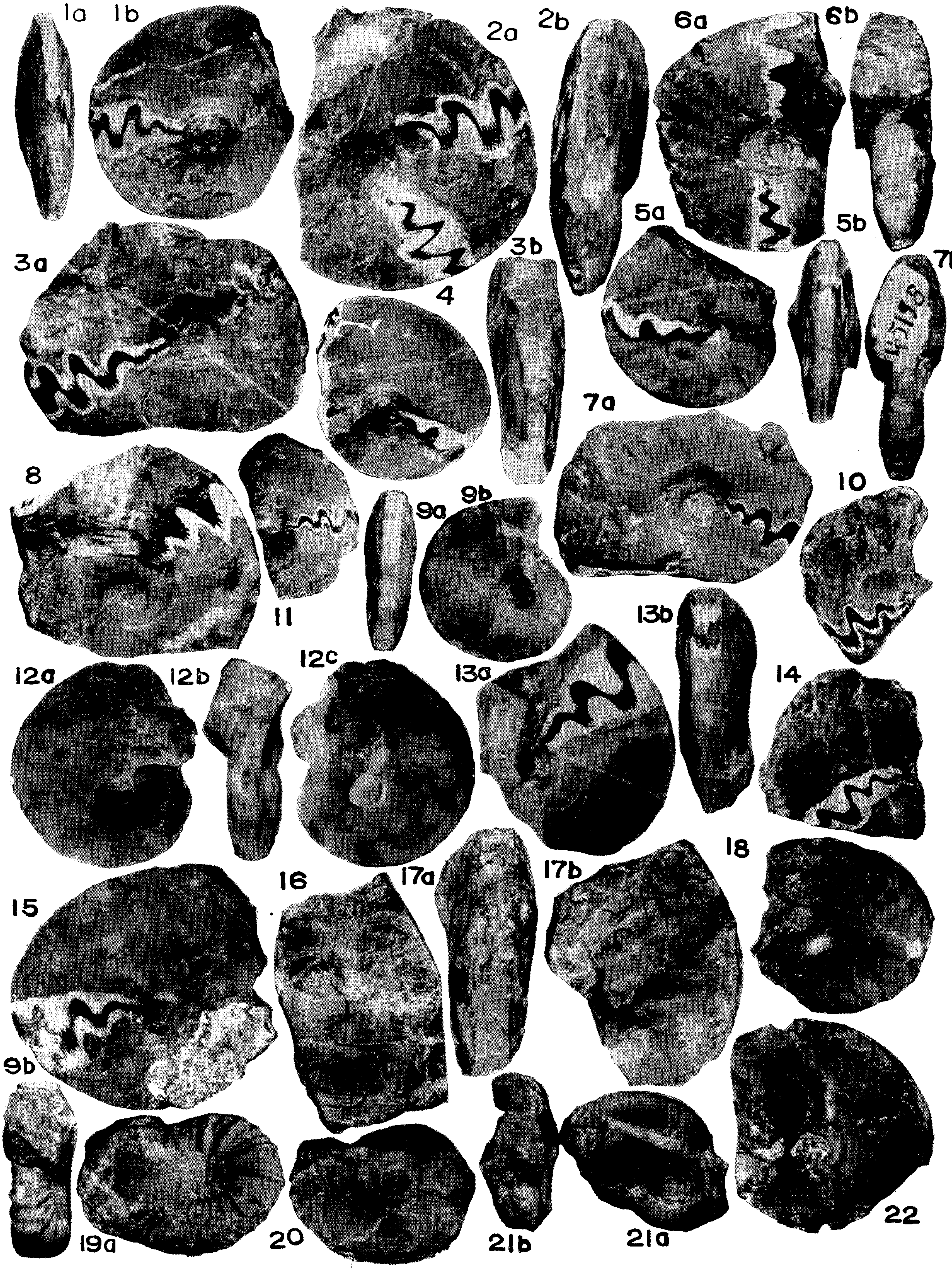
Plate 1

Figs. 1a–b, 2a–b, 10, 11. *Meekoceras japonicum* Shimizu and Jimbo .... p. 80
Figs. 1a–b. IGPS coll. cat. no. 45159A. × 1
Figs. 2a–b. Holotype, IGPS coll. cat. no. 45159B. × 1
Fig. 10. IGPS coll. cat. no. 45159C. × 1
Fig. 11. IGPS coll. cat. no. 45159 D. × 1
Figs. 3a–b. *Meekoceras orientale* Shimizu and Jimbo .... p. 81
Holotype, IGPS coll. cat. no. 45174. × 1
Figs. 4, 9a–b, 12a–c. *Hemiprionites katoi* (Yehara) .... p. 87
Fig. 4. IGPS coll. cat. no. 45161A. × 1.5
Figs. 9a–b. IGPS coll. cat. no. 45161B. × 1.5
Figs. 12a–c. IGPS coll. cat. no. 45161C. × 3
Figs. 5a–b. *Hemiprionites sawatanus* (Yehara) .... p. 92
Figs. 5a–b. IGPS coll. cat. no. 45166. × 1.5
Figs. 6a–b, 17a–b. *Hemiprionites shimizui* Bando (MS) × 1.5
Figs. 7a–b, 8. *Hemiprionites tahoensis* (Yehara) .... p. 88
Figs. 7a–b. IGPS coll. cat. no. 45158A. × 1
Fig. 8. IGPS coll. cat. no. 45158B. × 1.5
Figs. 13, 20, 22. *Hemiprionites shikokuensis* (Shimizu and Jimbo) .... p. 93
IGPS coll. cat. no. 45164. × 1.5
Figs. 14, 18. *Hemiprionites kuharanus iyonus* Bando, n. subsp .... p. 91
Fig. 14. IGPS coll. cat. no. 45167A. × 1.5
Fig. 18. Holotype, IGPS coll. cat. no. 45167B. × 1
Fig. 15. *Meekoceras* sp. .... p. 82
IGPS coll. cat. no. 78333, × 1.5
Fig. 16. *Hemiprionites* aff. *sawatanus* (Yehara) .... p. 93
GLKU–C113. × 1.5.
Figs. 19a–b. *Anasibirites kingianus inaequicostatus* (Waagen) .... p. 70
IGPS coll. cat. no. 78331. × 2
Figs. 21a–b. *Xenoceltites* aff. *evolutus* Waagen .... p. 86
IGPS coll. cat. no. 78340. × 2

All figured specimens were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando). Photo by K. Kumagai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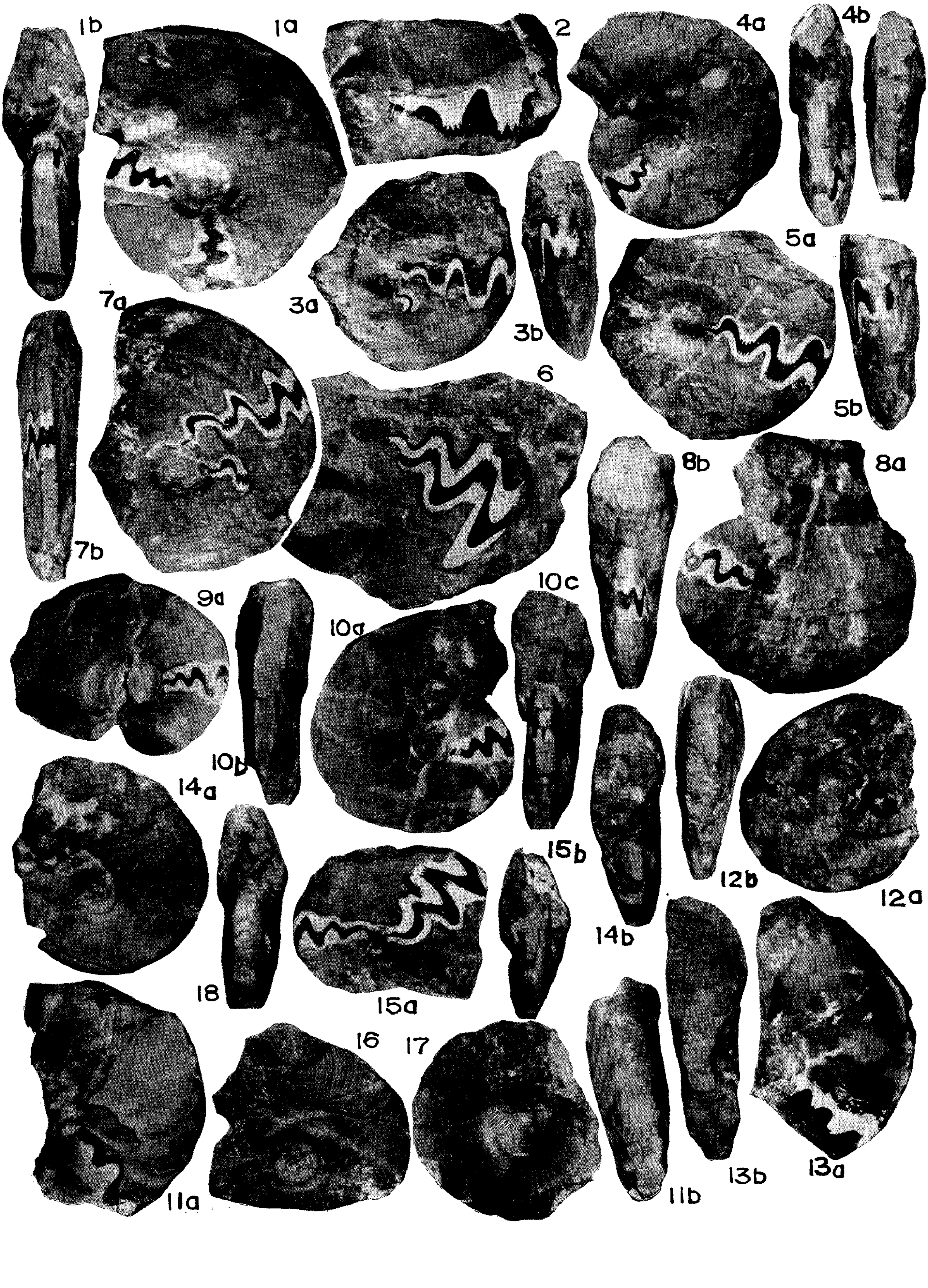
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Plate 2

Figs. 1a–b, 2, 9a–b. *Hemiprionites morianus* (Yehara) .... p. 89
  Figs. 1a–b. IGPS coll. cat. no. 45162A. × 1.5
  Fig. 2. IGPS coll. cat. no. 45162B. × 1.5
  Figs. 9a–b. IGPS coll. cat. no. 45162C. × 1.5
Figs. 3a–b, 5a–b. *Anasibirites archiperipheras* Bando, n. sp. .... p. 71
  Figs. 3a–b. IGPS coll. cat. no. 45160A. ×1
  Figs. 5a–b. Holotype, IGPS coll. cat. no. 45160B. × 1
Figs. 4a–b, 18. *Hemiprionites tahoensis* (Yehara) .... p. 88
  Figs. 4a–b. IGPS coll.cat. no. 45158E. × 1.5
  Fig. 18. GLKU–C103. × 2
Fig. 6. *Hemiprionites* sp. .... p. 95
  IGPS coll. cat. no. 45175. × 1
Figs. 7a–b. *Meekoceras japonicum compressum* Bando, n. subsp. .... p. 80
  Holotype, IGPS coll. cat. no. 45163. × 1
Figs. 8a–b. 13a–b. *Hemiprionites sawatanus* (Yehara). .... p. 93
  Figs. 8a–b. IGPS coll. cat. no. 45166A. × 1.5
  Figs. 13a–b. IGPS coll. cat. no. 45166E. × 2
Figs. 10a–c. *Hemiprionites shikokuensis* (Shimizu and Jimbo) .... p. 93
  IGPS coll. cat. no. 45164C. × 1.5
Figs. 11a–b. *Anasibirites* sp. B .... p. 77
  IGPS coll. cat. no. 45172A. × 1.5
Figs. 12a–b. *Hemiprionites kuharanus* (Yehara) .... p. 90
  IGPS coll. cat. no. 45165. × 1
Figs. 14a–b. *Meekoceras japonicum* Shimizu and Jimbo .... p. 80
  IGPS coll. cat. no. 45159E. × 2
Figs. 15a–b. *Hemiprionites kuharanus iyonus* Bando, n. subsp. .... p. 91
  Holotype, IGPS coll. cat. no. 45167B. × 1
Figs. 16, 17. *Anasibirites onoi* (Yehara) .... p. 72
  Fig. 16. IGPS coll. cat. no. 45169A. × 2
  Fig. 17. IGPS coll. cat. no. 45169B. × 3

All figured specimens were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando). Photo by K. Kumagai

Plate 3

Figs. 1a–b, 2a–b. *Anasibirites* sp. B .... p. 77
    Figs. 1a–b. GLKU–C106. × 1.5
    Figs. 2a–b. IGPS coll. cat. no. 45172B. × 1.5
Fig. 3. *Meekoceras japonicum* Shimizu and Jimbo .... p. 80
    Holotype, IGPS coll. cat. no. 45159B. × 1
Figs. 4a–b, 9a–b, 11a–b, 13a–b, 17. *Anasibirites multiplicatus* (Yehara) .... p. 76
    Figs. 4a–b. IGPS coll. cat. no. 45173A. × 2
    Figs. 9a–b. IGPS coll. cat. no. 45173D. × 1.5
    Figs. 11a–b. IGPS coll. cat. no. 45173B. × 1.5
    Figs. 13a–b. IGPS coll. cat. no. 45173C. × 1.5
    Fig. 17. IGPS coll. cat. no. 45173E. × 1
Figs. 5a–b, 6, 7a–b. *Anasibirites pacificus* (Yehara) .... p. 73
    Figs. 5a–b. IGPS coll. cat. no. 45171B. × 2
    Fig. 6. IGPS coll. cat. no. 45171C. × 2
    Figs. 7a–b. IGPS coll. cat. no. 45171A. × 2
Figs. 8a–b. *Anasibirites* sp. A .... p. 77
    IGPS coll. cat. no. 78334. × 1
Figs. 10a–b. *Anasibirites shimizui* Bando, n. sp. .... p. 72
    Holotype, IGPS coll. cat. no. 78332. × 1.5
Figs. 12a–c. *Anasibirites ehimensis* Bando, n. sp. .... p. 74
    Holotype, IGPS coll. cat. no. 45170. × 2
Figs. 13a–b. 14a–b, 15a–d, 16. *Anasibirites onoi* (Yehara) .... p. 72
    Figs. 13a–b. IGPS coll. cat. no. 45169F. × 2
    Figs. 14a–b. IGPS coll. cat. no. 45169 E. × 1
    Figs. 15a–d. IGPS coll. cat. no. 45169C. × 1
    Fig. 16. IGPS coll. cat. no. 45169 D. × 3
Figs. 18, 19. *Subcolumbites* cf. *perrini-smithi* (Arthaber) .... p. 99
    IGPS coll. cat. no. 79179. × 1
Figs. 20, 21, 22. *Wyomingites* cf. *aplanatus* (White) .... p. 84
    Fig. 20. GLKU–C114. × 1.5
    Fig. 21. GLKU–C115. × 1.5
    Fig. 22. GLKU–C127. × 1.5

The specimens illustrated in Figs. 1–17 and 20–22 were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando) and the specimens of Figs. 18 and 19 were collected from the *Subcolumbites* zone of dark gray blue calcareous sandy shales of the Osawa Formation at Tate near Isatomae of Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture, in the southern Kitakami Massif (Coll. Y. Onuki, and K. Masuda). Photo by K. Kumagai

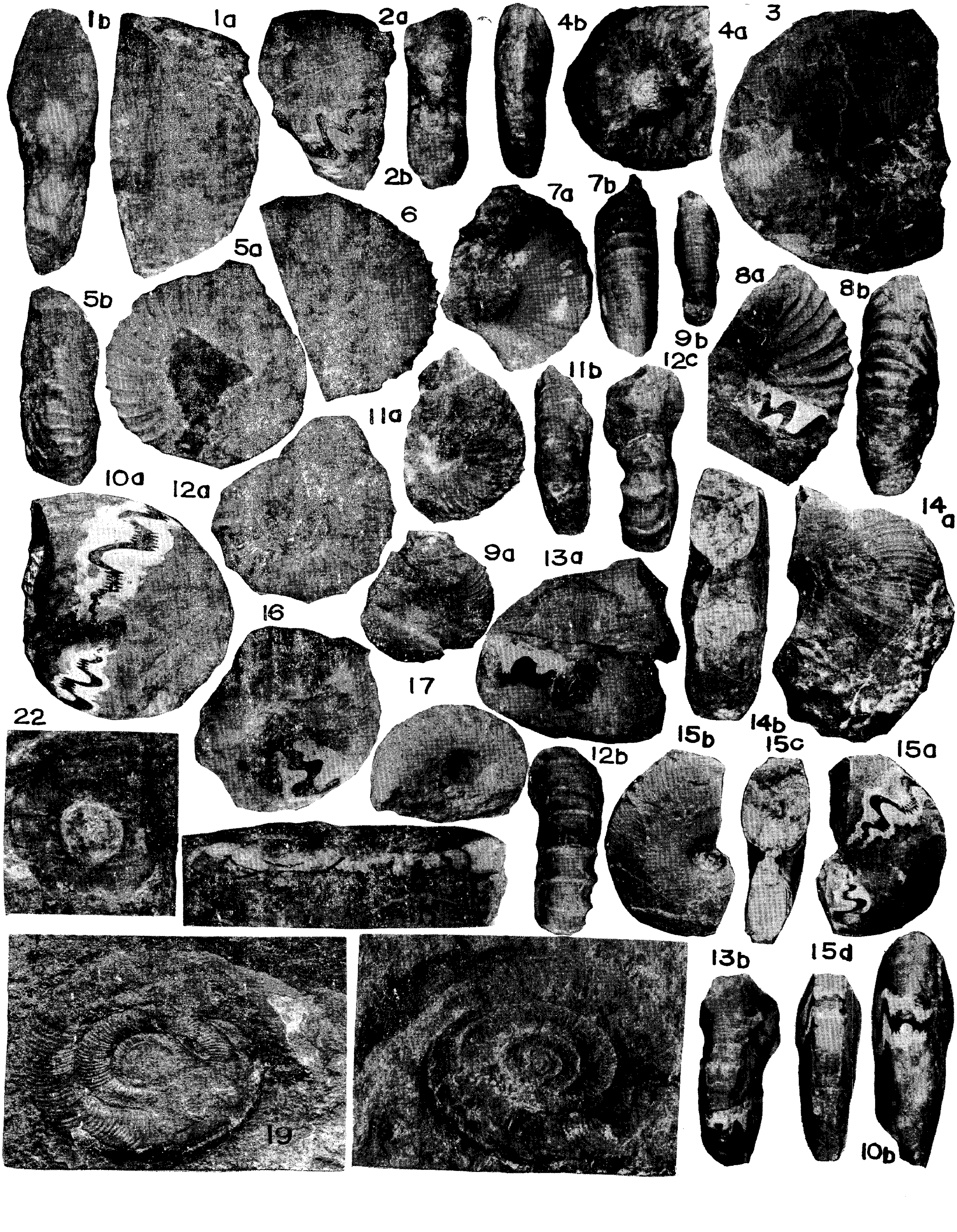
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Plate 4

Fig. 1. *Epigymnites* aff. *jollyanus* (Oppel) .... p. 122
IGPS coll. cat. no. 79178, × 2/3 (Gypsum cast of the internal mould).

Figs. 2a–b. *Paraceratites* cf. *clarkei* Smith .... p. 112
IGPS coll. cat. no. 76567. × 1 (Fig. 2b- Plaster cast of the internal mould of Fig. 2a).

The illustrated specimens in Figs. 1–2 were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. K. Hatai).

Fig. 3. *Subcolumbites* cf. *perrini-smithi* (Arthaber) .... p. 99
IGPS coll. cat. no. 76571. × 1

Figs. 4a–b, 10. *Arctoprionites minor* Bando, n. sp. .... p. 97
Figs. 4a-b. Holotype, IGPS coll. cat. no. 78336A. × 2
Fig. 10. IGPS coll. cat. no. 78336B. × 2

Figs. 5, 6a–b, 7, 8, 11a–b. *Arctoprionites yeharai* Bando, n. sp. .... p. 95
Fig. 5. IGPS coll. cat. no. 78335A. × 2
Figs. 6a–b. IGPS coll. cat. no. 78335C. × 2
Fig. 7. IGPS coll. cat. no. 78335B. × 2
Fig. 8. Holotype, IGPS coll. cat. no. 78335J. × 2
Figs. 11a–b. IGPS coll. cat. no. 78335F. × 2

Figs. 9a–b. *Arctoprionites nipponicus* Bando, n. sp. .... p. 97
Holotype, IGPS coll. cat. no. 78337. × 2

The specimens illustrated in Figs. 4–11 were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando) and the specimen of Fig. 3. was collected from the *Subcolumbites* Zone of dark gray blue calcareous sandy shales of the Osawa Formation at Tate near Isatomae of Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture, in the southern Kitakami Massif (Coll. Y. Onuki, and K. Masuda). Photo by K. Kumagai

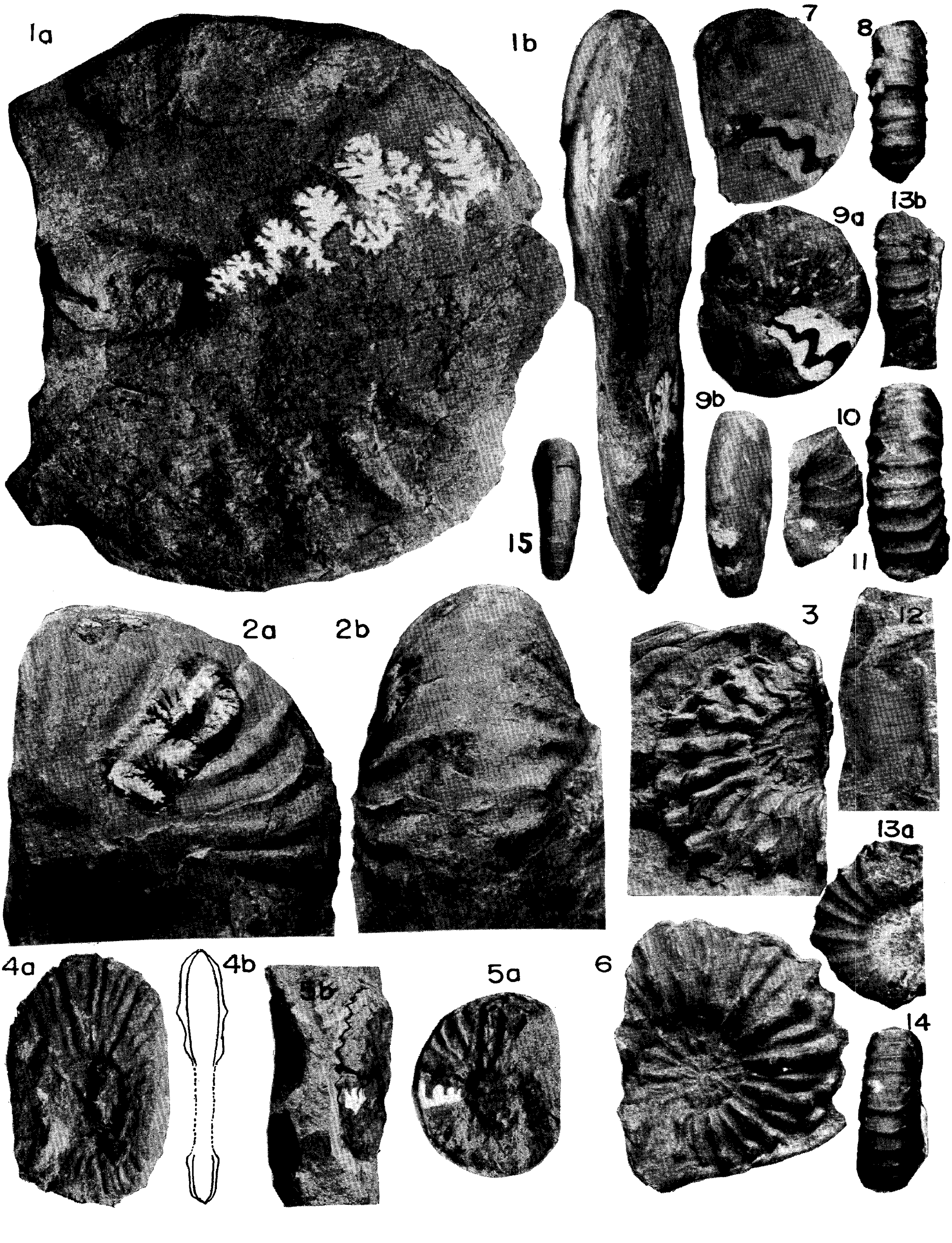
Plate 5

Figs. 1a–c. *Flexoptychites matsushimaensis* Bando, n. sp. .... p. 104
Holotype, IGPS coll. cat. no. 79173. × 1
Figs. 2a–b. *Ptychites* sp. .... p. 103
GLKU–C128. × 1
Fig. 3. *Kellnerites* n. sp. .... p. 111
IGPS coll. cat. no. 76569. × 1 (Plaster cast of the external mould).
Figs. 4a–b. *Balatonites oyamai* Bando, n. sp. .... p. 115
Holotype, IGPS coll. cat. no. 62558A. × 1
Figs. 5a–b. *Paraceratites* cf. *trinodosus* Mojsisovics .... p. 113
IGPS coll. cat. no. 58822. × 1.
Fig. 6. *Kellnerites* cf. *bosnensis* Hauer. .... p. 110
IGPS coll. cat. no. 76367. × 1 (Plaster cast of the external mould).

The specimens illustrated in Figs. 1–2 were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, Shiogama City, Miyagi Prefecture (Coll. K. Hatai and Y. Bando). The specimens of Figs. 3,5 and 6 are from the dark gray calcareous sandy shale of the *Paraceratites trinodosus* Zone of the Rifu Formation at Tatta, Matsushima-cho, Miyagi Prefecture (Coll. S. Hanzawa and Y. Bando). The specimen of Figs. 4 is from the dark gray calcareous sandy shale of the Isatomae Formation at Iwaida of Watanoha-cho, at about 6 km east of Ishinomaki City, Ojika-gun, Miyagi Prefecture, and associated with *Balatonites kitakamicus* (Diener) (Coll. T. Oyama).

Fig. 7. *Anasibirites onoi* (Yehara). .... p. 72
IGPS coll. cat. no. 45169G. × 3
Figs. 8, 11, 13, 14. *Anasibirites pacificus* (Yehara) .... p. 73
Fig. 8. IGPS coll. cat. no. 45171D. × 2
Fig. 11. IGPS coll. cat. no. 45171F. × 2
Fig. 13. IGPS coll. cat. no. 45171E. × 2
Fig. 14. IGPS coll. cat. no. 45171G. × 2
Figs. 9a–b. *Anasibirites intermedius* Bando, n. sp. .... p. 75
Holotype, IGPS coll. cat. no. 79171. × 2
Figs. 10, 15. *Anasibirites multiplicatus* (Yehara). .... p. 76
Fig. 10. IGPS coll. cat. no. 45173.H. × 1.5
Fig. 15. IGPS coll. cat. no. 45173E. × 1
Fig. 12. *Anasibirites* sp. C .... p. 78
GLKU–C113. × 1.5

The specimens illustrated in Fig. 7–15 were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando). Photo by K. Kumagai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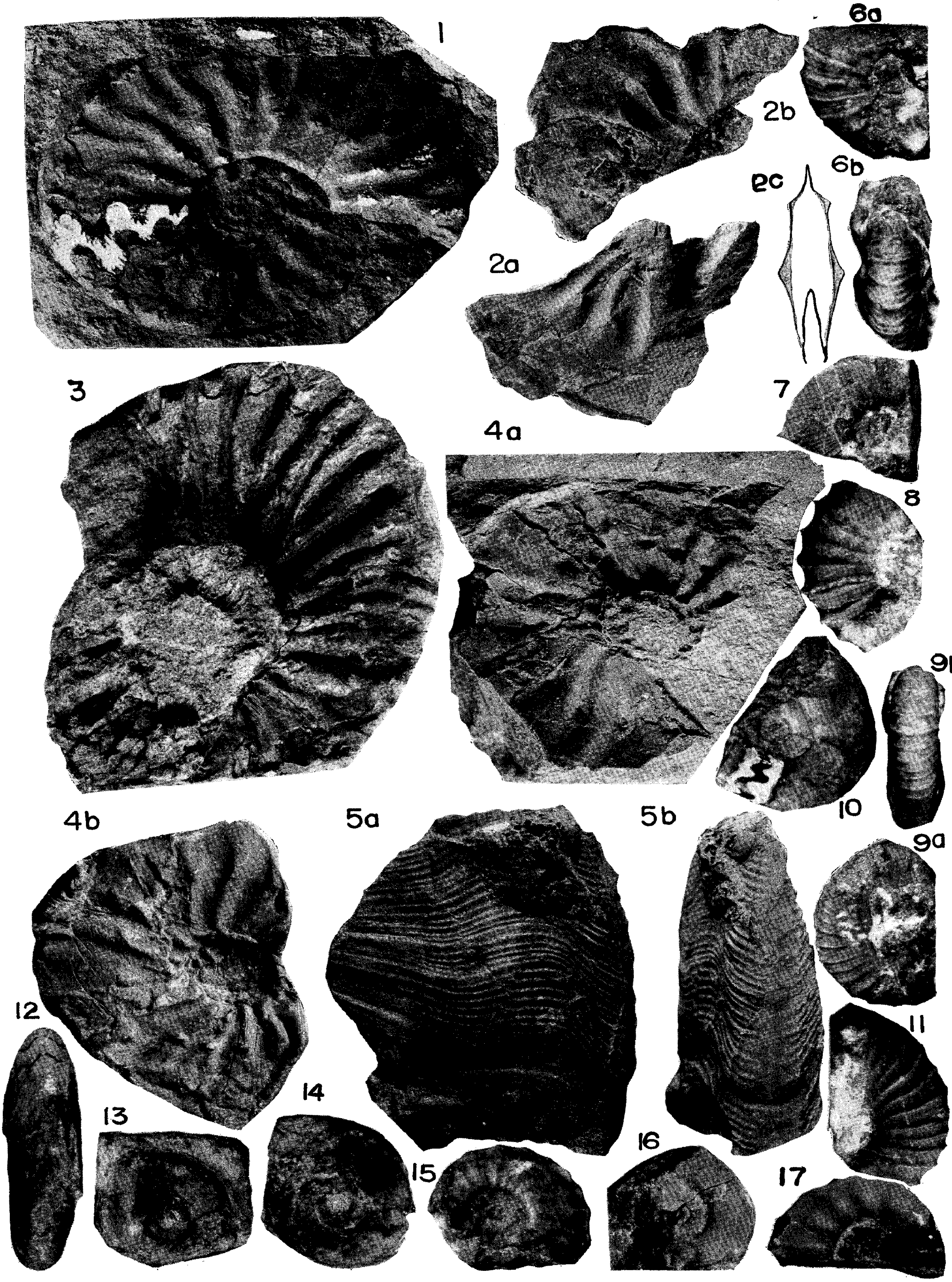
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Plate 6

Fig. 1. *Paraceratites orientalis* Yabe and Shimizu .... p. 112
Holotype, IGPS coll. cat. no. 60899. × 1

Figs. 2a–c, 4a–b. *Hungarites nipponicus* Bando, n sp. .... p. 124
Figs. 2a–c. IGPS coll. cat. no. 76568. × 1
Figs. 4a–b. IGPS coll. cat. no. 76568 × 1 (Fig. 4b-Plaster cast of the internal mould of Fig. 4a).

Fig. 3. *Protrachyceras* sp. .... p. 108
IGPS coll. cat. no. 79172. × 1

Figs. 5a–b. *Paratrachyceras* n. sp. .... p. 108
GLKU–C129. × 1

The specimen illustrated in Fig. 1 was collected from the *Paraceratites trinodosus* Zone ? of the Rifu Formation at a railway cutting, mark C by Yabe and Shimizu, 1927–29, northeast of the Rifu station, the Tohoku Railway Line, Matsushima-cho, Miyagi-gun, Miyagi Prefecture (Coll. H. Yabe and S. Shimizu). The specimens of Figs. 2,3 and 4 were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, Shiogama City, Miyagi Prefecture (Coll. K. Hatai and Y. Bando). The specimen illustrated in Fig. 5 is from the fine-grained argillaceous sandstone of the lower part of the Kochigatani Group (Karnian) at Shimoyama, at about 1.5 km northeast of Sakawa, Takaoka-gun, Kochi Prefecture, Shikoku (Coll. Y. Bando).

Figs. 6a–b, 7. *Anasibirites multiplicatus* (Yehara) .... p. 76
Figs. 6a–b. IGPS coll. cat. no. 45173J. × 1.5
Fig. 7. IGPS coll. cat. no. 45173K. × 1.5

Figs. 8, 9a–b, 11. *Anasibirites pacificus* (Yehara). .... p. 73
Fig. 8. IGPS coll. cat. no. 45171D. × 2
Figs. 9a-b. IGPS coll. cat. no. 45171H. × 2
Fig. 11. IGPS coll. cat. no. 45171G. × 2

Figs. 10, 13, 14, 16. *Wyomingites* cf. *aplanatus* (White) .... p. 84
Fig. 10. IGPS coll. cat. no. 78338B. × 1.5
Fig. 13. IGPS coll. cat. no. 78338A. × 1.5.
Fig. 14. GLKU–C118. × 1.5
Fig. 16. GLKU–C116. × 1.5

Fig. 12. *Anasibiritіes archiperipheras* Bando, n. sp. .... p. 71
IGPS coll. cat. no. 45160D. × 1.5

Fig. 15. *Arctoprionites minor* Bando, n. sp. .... p. 97
IGPS coll. cat. no. 78336B. × 2

Fig. 17. *Arctoprionites yeharai* Bando, n. sp. .... p. 95
IGPS coll. cat. no. 78335A. × 2

The specimens illustrated in Figs. 6–17 were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando). Photo by K. Kumagai

Plate 7

Figs. 1a–b, 2, 5. *Japonites* cf. *dieneri* (Martelli) .... p. 118

Figs. 1a-b. IGPS coll. cat. no. 79174A. × 1 (Fig. 1b-Plaster cast of the internal mould of Fig. 1a).

Fig. 2. IGPS coll. cat. no. 79174B. × 1

Fig. 5. IGPS coll. cat. no. 79174C. × 1

Fig. 3. *Tropigastrites* (?) sp. .... p. 123

IGPS coll. cat. no. 76573. × 1

Fig. 4. *Anagymnites* aff. *acutus* (Hauer) .... p. 123

IGPS coll. cat. no. 79180. × 1

All of the illustrated specimens were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama-City, Miyagi Prefecture (Coll. K. Hatai and Y. Bando). Photo by K. Kumagai

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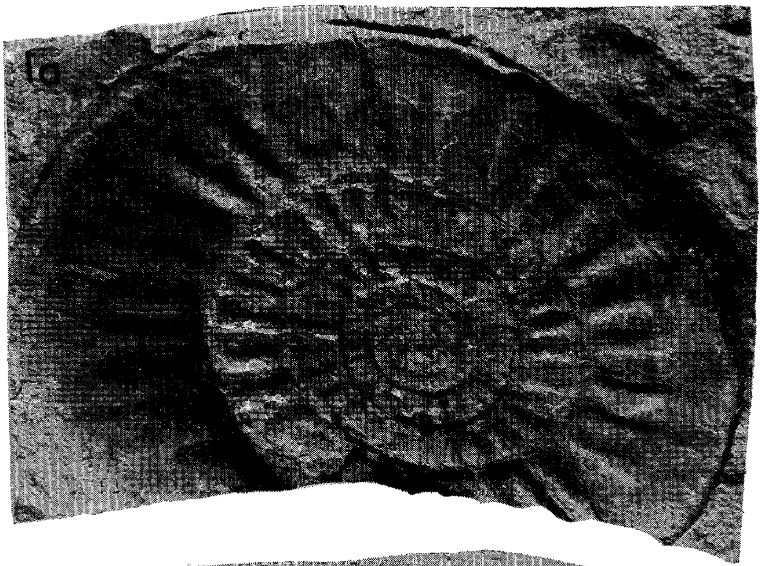

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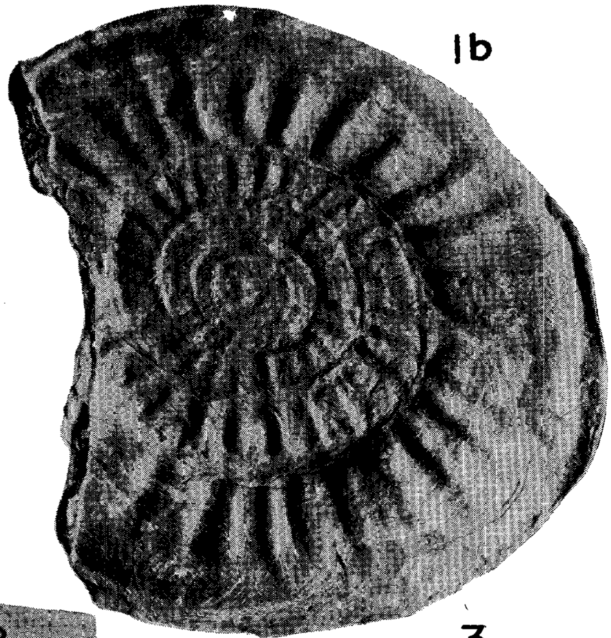

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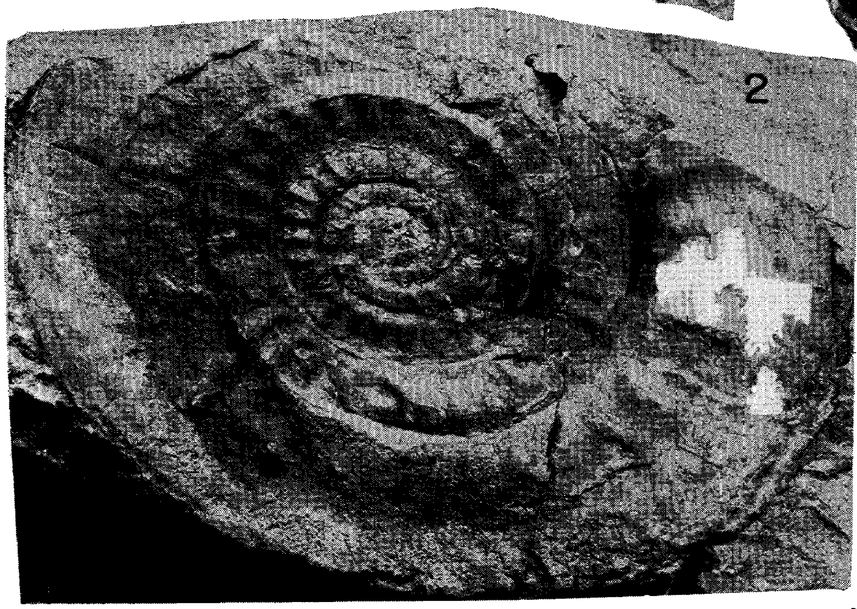

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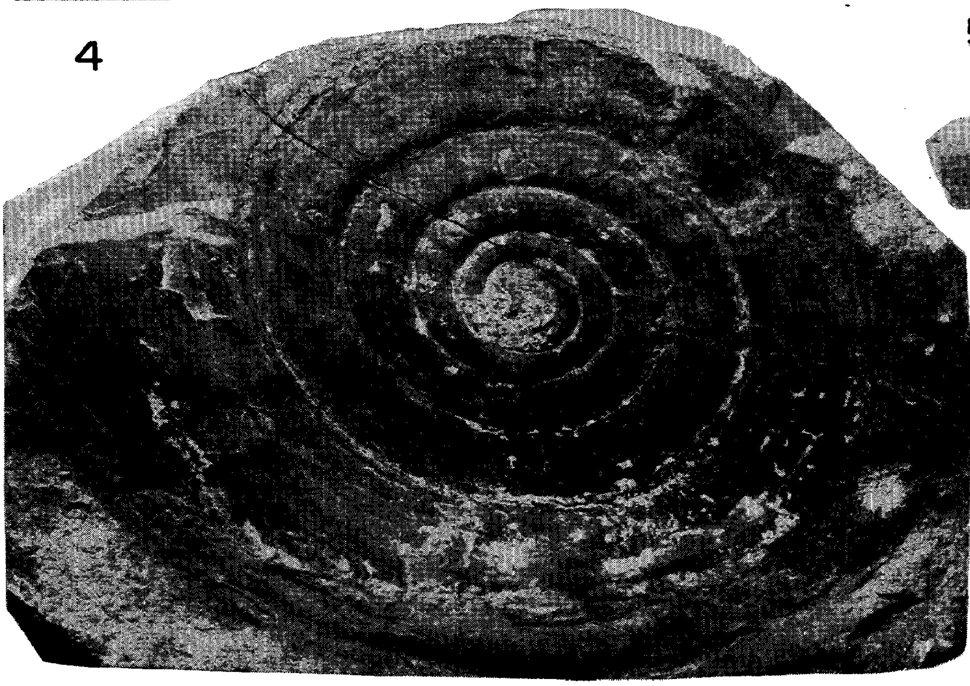

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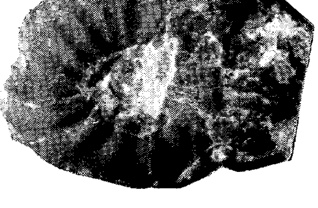

4 5

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Plate 8

Fig. 1. *Monophyllites sphaerophyllus* (Hauer) .... p. 117
IGPS coll. cat. no. 58527. × 1
The illustrated specimen was collected from the dark gray calcareous sandy shale of the lower part of the Rifu Formation at Hamada?, Shiogama City, Miyagi Prefecture (Coll. T. Sugiyama).

Figs. 2, 3, 6. *Arctoprionites yeharai* Bando, n. sp. .... p. 95
Fig. 2. IGPS coll. cat. no. 78335J. × 2
Fig. 3. IGPS coll. cat. no. 78335O. × 2
Fig. 6. IGPS coll. cat. no. 78335D. × 2

Figs. 4, 5. *Wyomingites* cf. *aplanatus* (White) .... p. 84
Fig. 4. GLKU–C114. × 1.5
Fig. 5. GLKU–C117. × 1.5.
The specimens illustrated in Figs. 2–6 were collected from the *Anasibirites* Beds of the Taho Formation at Taho near Uonashi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture, Shikoku (Coll. H. Yabe, T. Sugiyama, S. Shimizu, N. Jimbo and Y. Bando). Photo by K. Kumagai

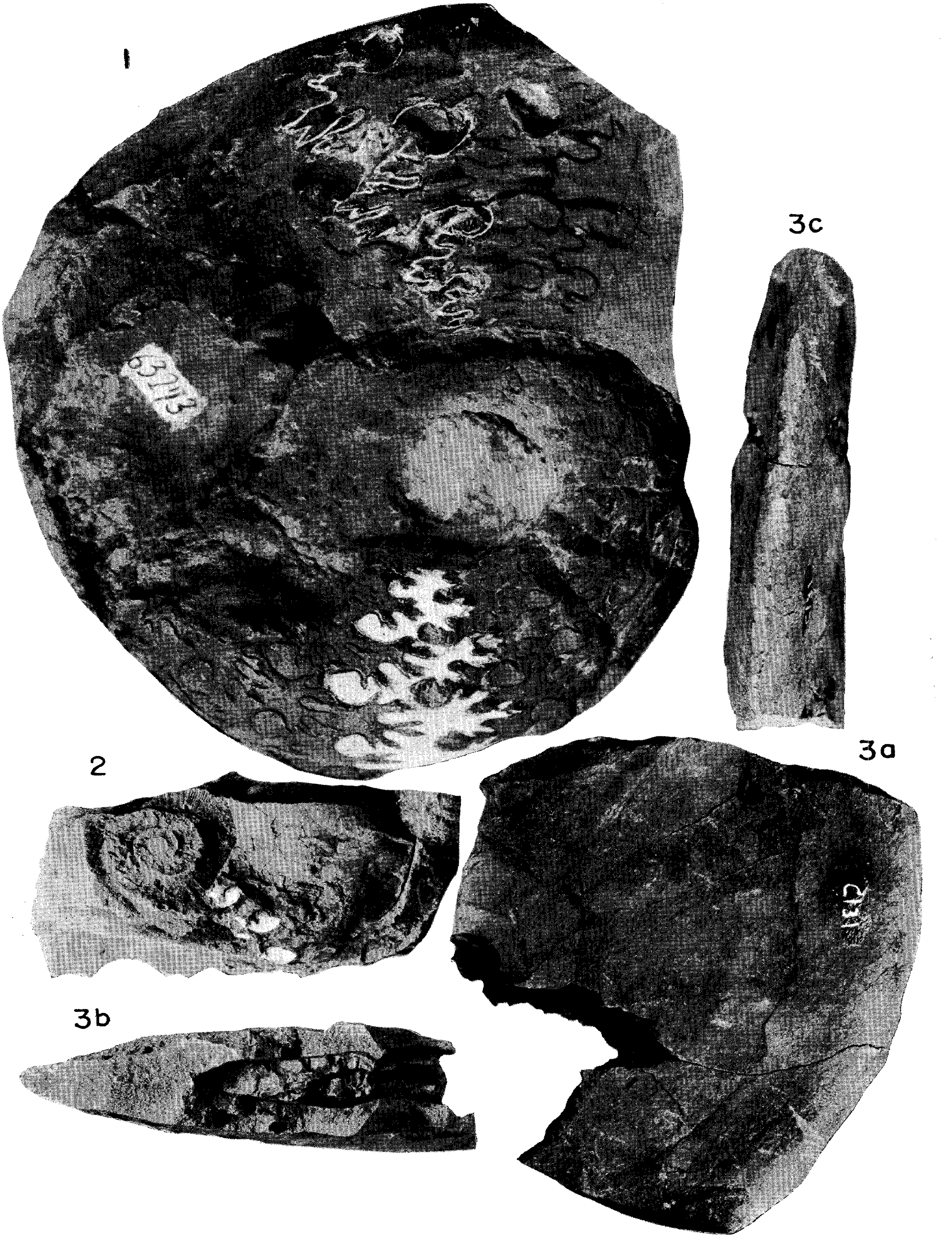
Plate 9

Fig. 1. *Monophyllites wengensis* (Klipstein) .... p. 116
IGPS coll. cat. no. 63273. × 1

Fig. 2. *Monophyllites* cf. *wengenesis* (Klipstein) .... p. 117
IGPS coll. cat. no. 76572. × 1

Figs. 3a–c. *Ptychites* sp.

All of the illustrated specimens were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. S. Mabuti and Y. Bando). Photo by K. Kumagai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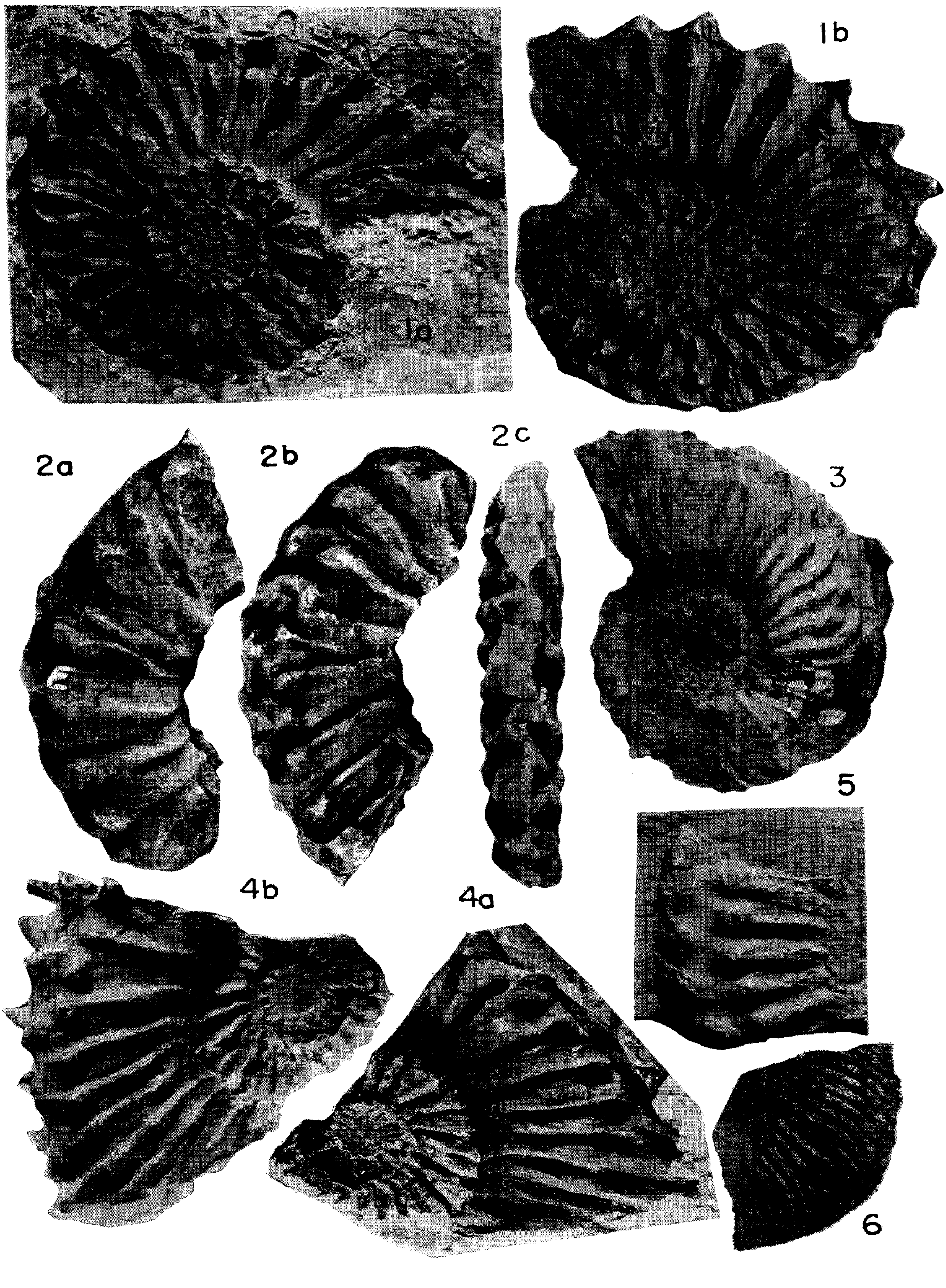
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Plate 10

Figs. 1a–b, 2a–c, 3, 4a–b, 5. *Protrachyceras reitzi* (Boeckh) .... p. 106

Figs. 1a–b. IGPS coll. cat. no. 78339A. × 1 (Fig. 1b–Plaster cast of the internal mould of Fig. 1a).

Figs. 2a-c. IGPS coll. cat. no. 78339E. × 1

Fig. 3. IGPS coll. cat. no. 78339B. × 1

Figs. 4a–b. IGPS coll. cat. no. 78339C. × 1 (Fig. 4b-Plaster cast of the internal mould of Fig. 4a).

Fig. 5. IGPS coll. cat. no. 78339D. × 1

Fig. 6. *Protrachyceras* cf. *pseudo-archelaus* (Boeckh)

GLKU–C141. × 1

The illustrated specimens in Figs. 1–5 were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. K. Hatai). The specimen of Fig. 6 was collected from the dark gray calcareous sandy shale of the *Protrachyceras archelaus* Zone of the Zohoin Formation at Annomoto, Nagayasu, Kaminaka-cho, Naka-gun, Tokushima Prefecture, Shikoku (Coll. K. Hashimoto). Photo by K. Kumagai

Plate 11

Fig. 1. *Ptychites nipponicus* Bando, n. sp. .... p. 100
Holotype, IGPS coll. cat. no. 76542. × 1
Figs. 2—4. *Protrachyceras* cf. *pseudo-archelaus* (Boeckh)
Fig. 2. IGPS coll. cat. no. 76571A. × 1 (Plaster cast of the internal mould).
Fig. 3. IGPS coll. cat. no. 76571B. × 1
Fig. 4. GLKU–C134. × 1

The illustrated specimen in Fig. 1 was collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. Town Officials of Matsushima-cho, Miyagi Prefecture). The specimens of Figs. 2–4 were collected from the dark gray calcareous sandy shale of the *Protrachyceras archelaus* Zone of the Zohoin Formation at Annomoto, Nagayasu, Kaminaka-cho, Naka-gun, Tokushima Prefecture, Shikoku (Coll. K. Hashimoto). Photo by K. Kumagai

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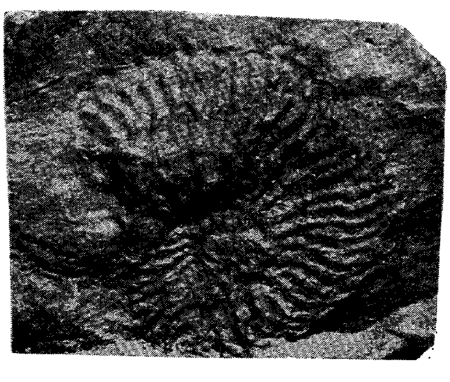

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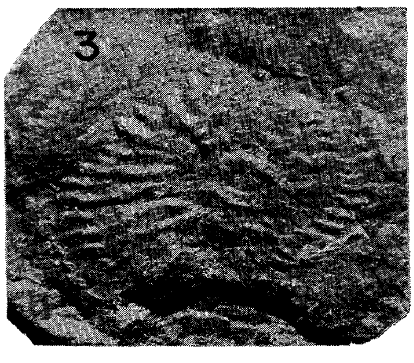

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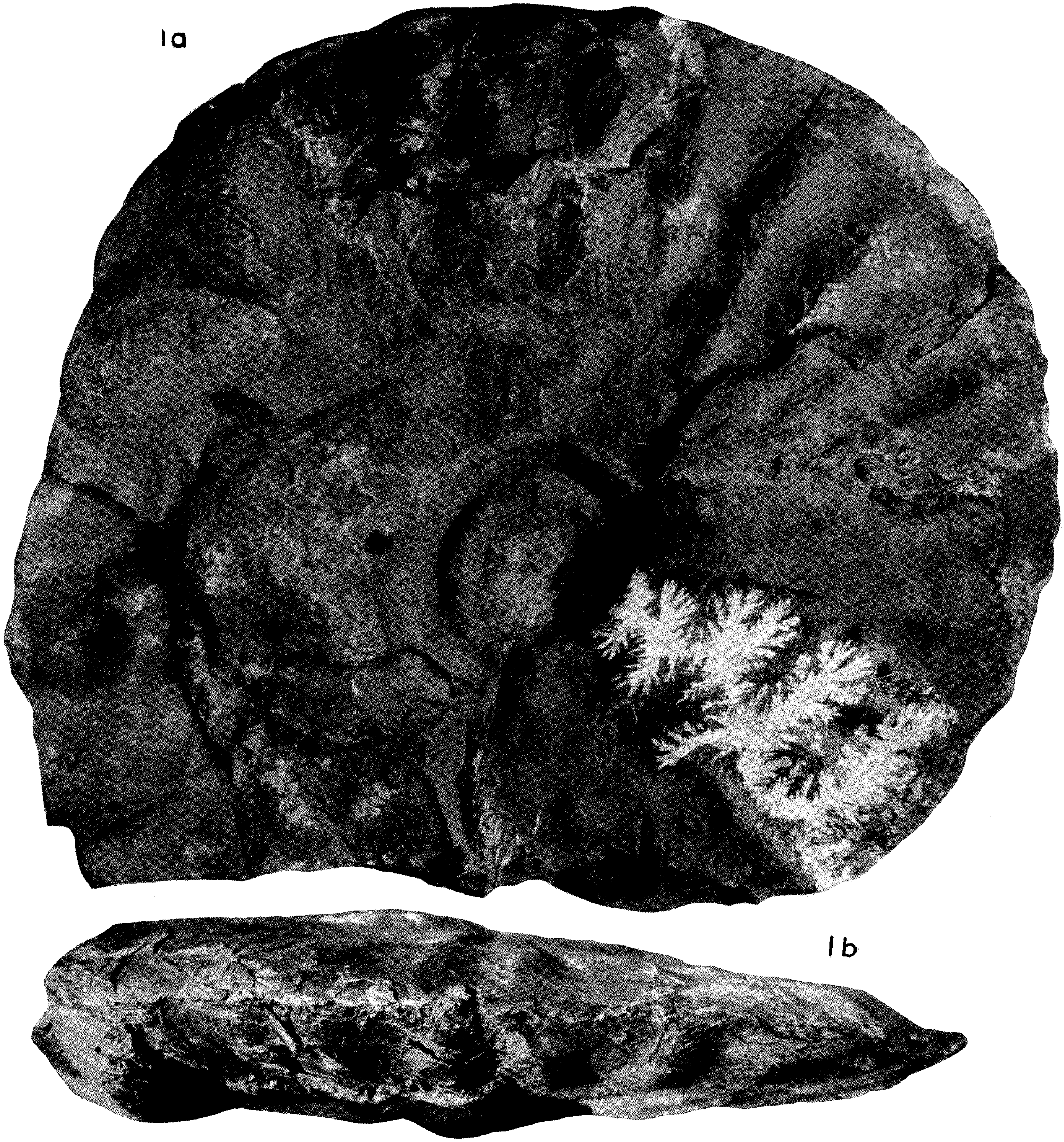
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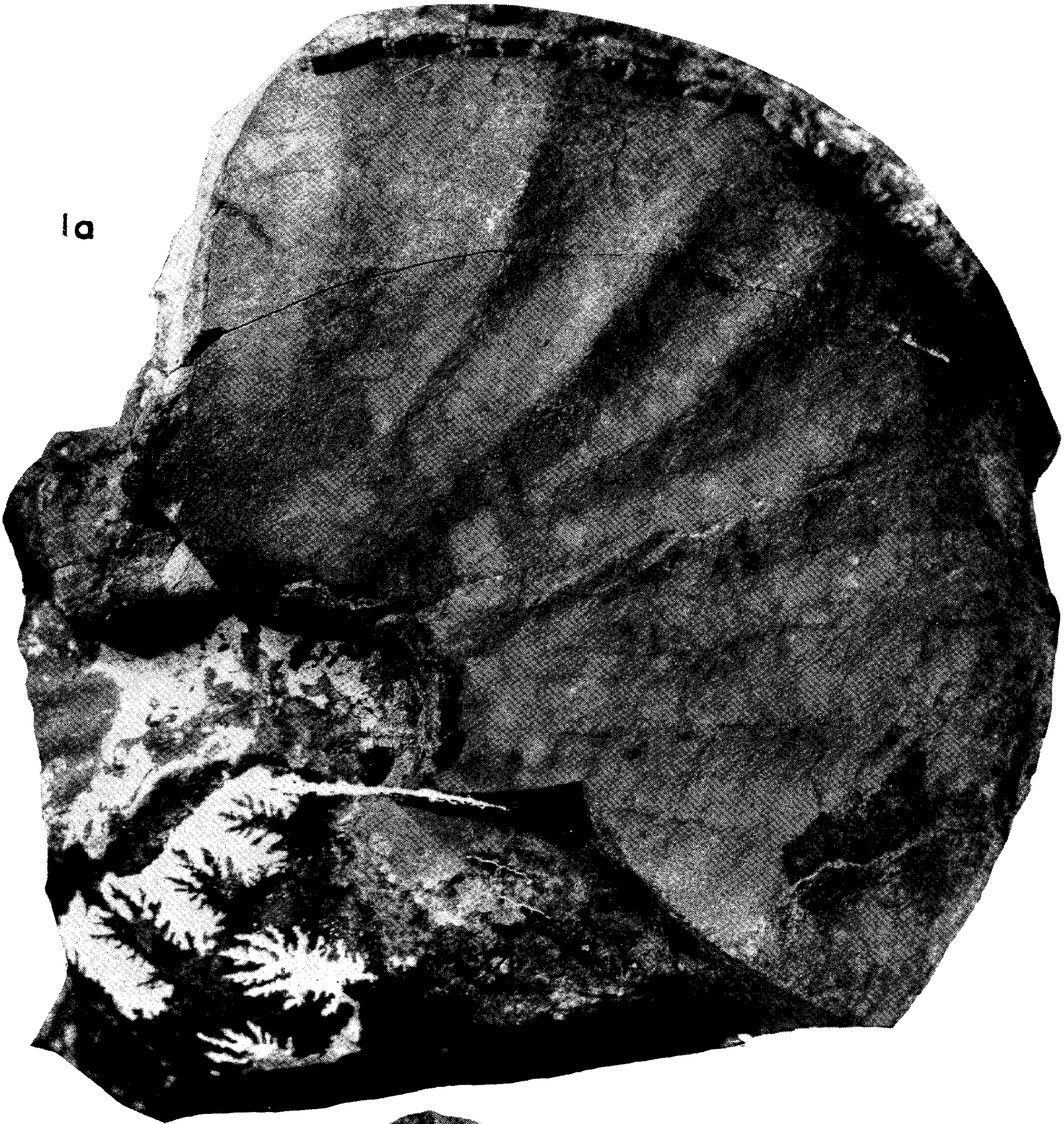
Plate 12

Figs. 1a–b. *Ptychites nipponicus* Bando, n. sp. .... p. 100
Holotype, with *Myoconcha hamadaensis* Yabe and Shimizu on the shell surface, IGPS coll. cat. no. 76542. × 1

The specimens was collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. Town Officials of Matsushima-cho, Miyagi Prefecture). Photo by K. Kumagai

Plate 13

Figs. 1a–b. *Ptychites miyagiensis* Bando, n. sp. .... p. 101
Holotype, IGPS coll. cat. no. 79176. × 1
The specimen was collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. K. Hatai). Photo by K. Kumagai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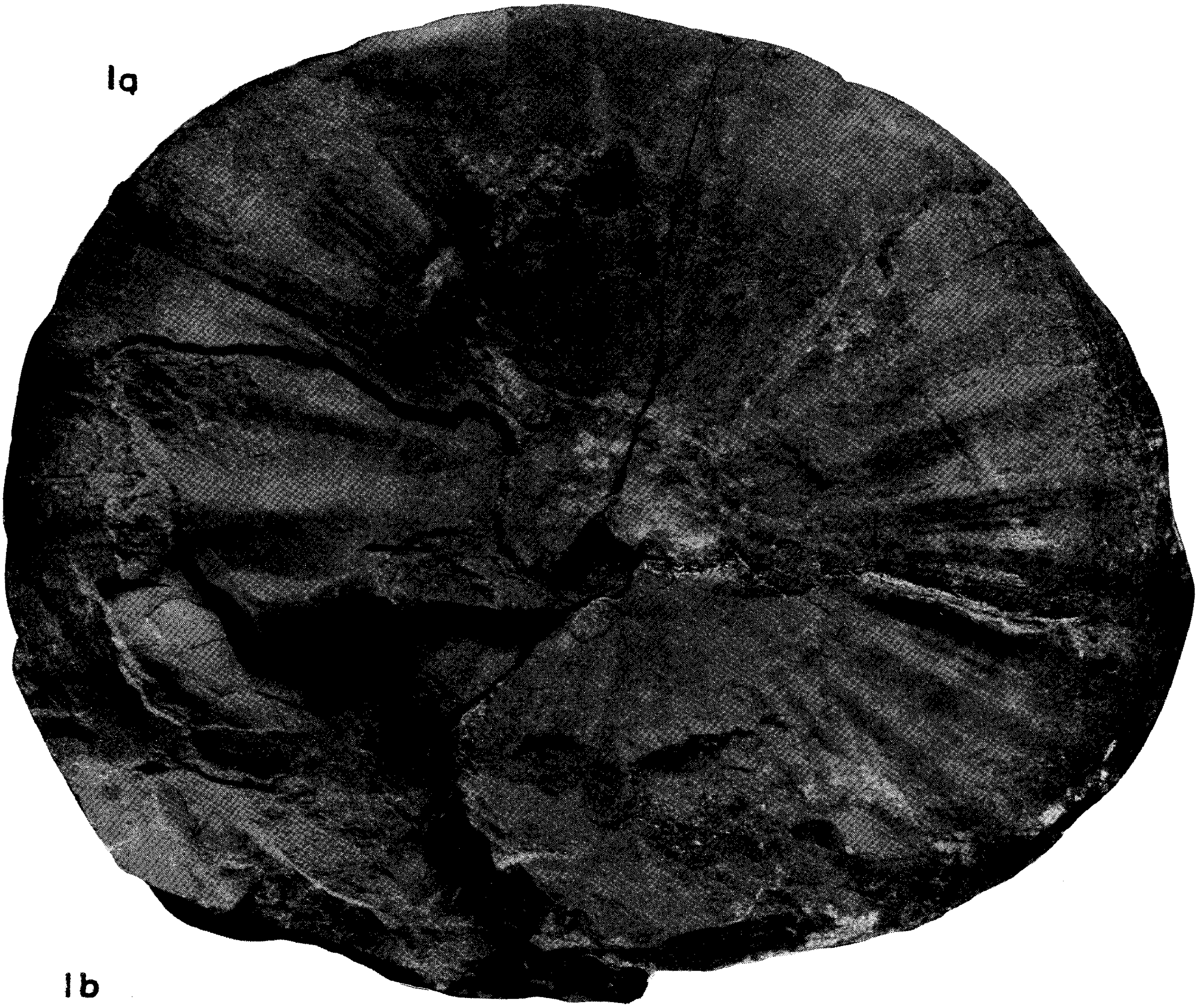
1b

1a



1b

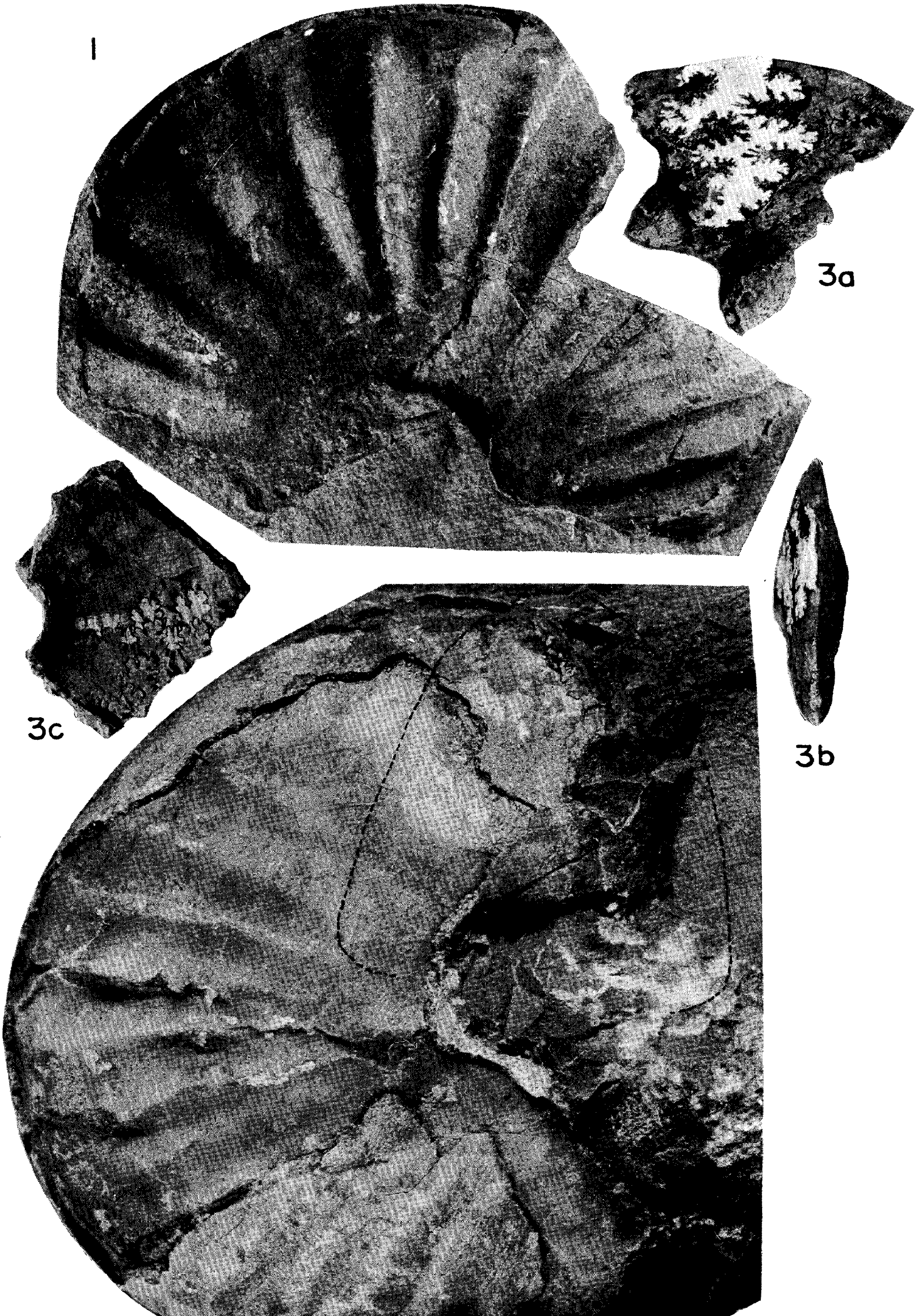
Plate 14

Figs. 1a–b. *Ptychites miyagiensis* Bando, n. sp. .... p. 101
GLKU–C132. × 1
The specimen was collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. Y. Bando). Photo by K. Kumagai

Plate 15

Figs. 1–2. *Ptychites* sp. [cf. *P. trocheaeformis* (Lindstroem)] .... p. 102
Fig. 1. IGPS coll. cat. no. 79177A. × 1.
Fig. 2. IGPS coll. cat. no. 79177B. ×2.
Figs. 3a–c. *Ptychites* sp. .... p. 103
GLKU–C131. × 1

All of the illustrated specimens were collected from the dark gray calcareous sandy shale of the *Protrachyceras reitzi* Zone ? of the Rifu Formation at Hamada, at about one kilometer northwest of the Hamada station along the Senseki Electric Car Line, Shiogama City, Miyagi Prefecture (Coll. K. Hatai and Y. Bando). Photo by K. Kumagai



1 3a 3c 3b 2