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PERMIAN AMMONOID FAUNA OF THE KITAKAMI MASSIF, NORTHEAST JAPAN
—BIOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY

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Abstract: Biostratigraphy and paleobiogeography of Permian ammonoids from the Southern Kitakami Massif are studied. Four ammonoid zones, the *Agathiceras* (middle Sakamotozawan to lower Kanokuran), *Timorites* (uppermost lower Kanokuran to upper Kanokuran), *Araxoceras* (Lower to middle Toyoman) and *Neogeoceras kitakamiense* (upper Toyoman) Zones, in ascending order, are proposed. Based on the ammonoids and fusulinids, the Sakamotozawan, Kanokuran and Toyoman Series are correlated with the Sakmarian to Bolorian, Kubergandian to Midian (Abadehian) and Dzhulfian to Dorashamian intervals, respectively. During Permian time, four ammonoid provinces, namely the Boreal, Equatorial American, Equatorial Tethyan and Peri-Gondowanan Provinces are recognizable. The occurrences of *Timorites, Cibolites* and araxoceratid ammonoids suggest that the Southern Kitakami Massif, together with the Sikhote-Alin Block, had belonged to the Equatorial Tethyan Province adjoining the South China Block during Middle to Late Permian time.

Keywords: Permian, ammonoid fauna, biostratigraphy, paleobiogeography

INTRODUCTION

The Kitakami Massif in the northeastern Honshu, Japan is geologically divided into two terranes, the Northern Kitakami and Southern Kitakami Massifs. These two terranes are of entirely different origin. Sediments of the Northern Kitakami Massif are mostly of Jurassic accretionary complexes and consist of shale, chert, limestone and basic volcaniclastic rocks. The Southern Kitakami Massif, which is mainly composed of pre-Silurian basement rocks and mostly shallow marine Middle-Upper Paleozoic and Mesozoic sequences, is a microcontinent accreted to the Asian continent during late Jurassic time. Although the paleomagnetism has proved to be a powerful tool toward reconstructing the paleogeography of continental blocks, no Paleozoic paleomagnetic data are available from the Kitakami Massif, because the Paleozoic rocks in the massif had strongly been remagnetized in Early Cretaceous time (Fujiwara and Morinaga, 1988). In such a case, paleobiogeaphic data are expected to help solve this problem.

Since Naumann (1881) discovered a Triassic bivalve *Monotis*, many geological and paleontological studies have been carried out in the Southern Kitakami Massif. Such studies have contributed much towards interpreting the tectonic history of not only the massif but also of the Japanese Islands. The Permian strata are also widely distributed in the Southern Kitakami and yield abundant fossils, such as fusulinids, corals, brachiopods and molluscs. Although ammonoid fossils constitute a relatively minor component of such faunas, the Southern Kitakami Massif is the only terrane in Japan that yields ammonoids from many stratigraphic horizons of the Permian sequence. In this paper, a Permian ammonoid biostratigraphy and paleobiogeography of the Southern Kitakami are discussed.

The present writer wishes to express his thanks to Professor Tsunemasa Saito of Tohoku University and Professor Brian F. Glenister of the University of lowa for their critical reading of the manuscript.

STRATIGRAPHIC OUTLINE OF THE PERMIAN IN THE SOUTHERN KITAKAMI MASSIF

Permian strata of the Southern Kitakami Massif are divided into the Sakamotozawan, Kanokuran and Toyoman Series, in ascending order. The Sakamotozawan Series unconformably overlies Carboniferous formations correlative with the Toumaisian to Moscovian Series. At the unconformable contact, sediments equivalent to the uppermost Carboniferous and probably the Asselian Stage of Early Permian are missing.

The lower and middle divisions of the Permian sequence show a marked lateral variation in lithofacies. The lower part of the standard of reference sequence of the Sakamotozawa Formation consists mainly of sandstones with a basal conglomerate, and the sandstone grades upward into shales which intercalate thin limestones. The upper part of the formation consists of thick dark gray limestones. The Sakamotozawan Series comprises three fusulinid zones, namely the *Robustoschwagerina shellwieni, Chalaroschwagerina vulgaris* and *Pseudofusulina fusiformis* Zones, in ascending order (Chol, 1973). The upper part of the *P. fusiformis* Zone yields *Misellina claudiae.*

The lower part of the standard section of the Kanokura Formation is composed of sandstones and conglomerates which are associated with subordinate amounts of shales. The uppermost part of the lower part is sometimes calcareous and fossiliferous. The upper part of the formation consists mainly of gray limestones. The Kanokuran Series comprises three fusulinid zones, the *Monodiexodina matsubaishi, Colania kotsuboensis* and *Lepidolina multiseptata* Zones (Choi, 1973). *Lepidolina multiseptata and L. kumaensis* co-occur in the upper part of the *L. multiseptata* Zone. Such smaller foraminifers as *Abadehella* aff. *coniformis* and *Colaniella* aff. *minima,* which are characteristic species of the Abadehian to lower Dzhulfian interval (Okimura *et al.*, 1985), begin to appear in the middle horizon of the *L. multiseptata* Zone developed at lwaizaki, Kesennuma district (Ishii *et al.*, 1975).

The Toyoman Series is represented by a monotonous lithofacies composed mainly of black shales with subordinate amounts of congiomerates, sandstones and limestones. The lenticular limestones intercalated in the upper part of the Toyoman yield smaller foraminifers and fusulinid, such as *Colaniella parva, C. cylindrica* and *Palaeofusulina* sp. (Tazawa, 1975; Ishii *et al.*, 1975).

The Toyoman Series is unconformably overlain by the Triassic Hiraiso Formation. The Hiraiso Formation is considered to be coeval with or to be younger than the Smithian Substage of the Nammalian Stage, because the Osawa Formation, which conformably overlies the Hiraiso Formation, is correlative with the Spathian Stage based on ammonoid fossils (Bando and Shimoyama, 1974; Bando and Ehiro, 1982; Ehiro, 1993). Therefore, the lower half of the Scythian Series is considered to be lacking in the Southern Kitakami Massif.

THE PERMIAN AMMONOID ZONES IN THE SOUTHERN KITAKAMI MASSIF

Fifteen genera of ammonoids have hitherto been reported from Permian strata in the Southern Kitakami Massif. They are as follows: Goniatitida-*Agathiceras, Pseudogastrioceras, Stacheoceras, Waagenoceras* (?), *Timorites* and *Cyclolobus;* Prolecanitida- *Propinacoceras, Medlicottia* and *Eumedlicottia;* Ceratitida-*Paraceltites, Cibolites, Xenodiscus, Paratirolites* (?), *Araxoceras* and *Prototoceras.*

Because localities of these ammonoids are geographically scattered in the massif, the stratigraphic horizon of these ammonoids in each district were correlated with the standard succession based on lithostratigraphy, other fossil criteria, mainly of fusulinids, or both. As a result, three ammonoid zones were proposed in the Kanokuran and Toyoman Series (Ehiro, 1987). They are the *Timorites* Zone, *Araxoceras* Zone and *Medlicottia kitakamiensis* Zone, in ascending order. The horizon of ammonoid fossils and their stratigraphic ranges are shown in Fig. 1.

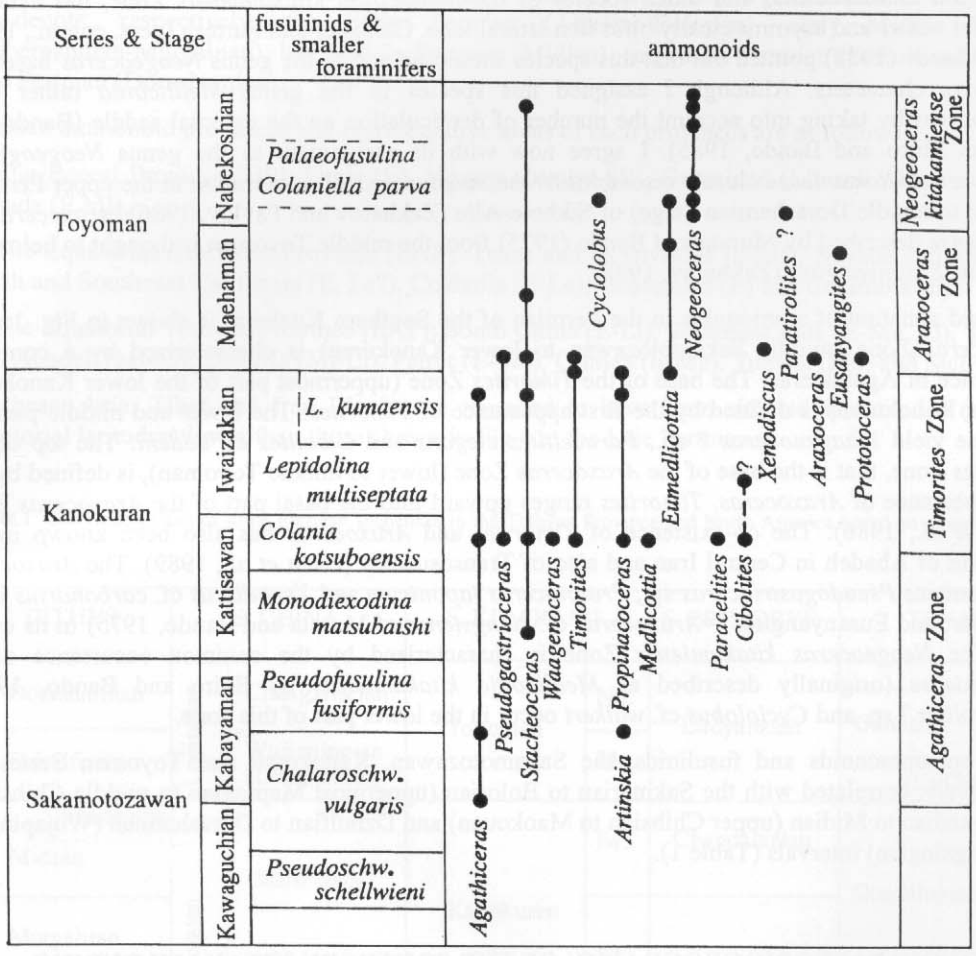

Fig. 1 Stratigraphic distribution of Permian ammonoids and Permian ammonoid zones in the Southern Kitakami massif.

I now have some additional ammonoids from the Sakamotozawan Nakadaira Formation in the Nakadaira district and from the middle part of the Ochiai Formation (Ehiro, in preparation). The latter is correlated with the Kanokuran to middle Toyoman, in the Kesennuma district. The ammonoid fauna of the Nakadaira Formation is rather monotonous, and about 10 specimens of *Agathiceras* sp. and one specimen of *Artinskia* sp., have so far been collected from the middle and upper parts of the formation in association with some nautiloids. Based on these new data, I propose to add the *Agathiceras* zone below the *Timorites* zone in the Permian sequence of the Southern Kitakami. This zone extends from the middle part of the Sakamotozawan to the lower part of the Kanokuran.

The newly found fauna of the Ochiai Formation includes *Timorites* n. sp., *Propinacoceras* sp. and some other indeterminable species. *Timorites* is common. The fossil horizon is situated about one hundred meters above the horizon of *Lepidolian multiseptata,* and belongs to somewhere around the boundary between the Kanokuran and Toyoman Series (=the boundary of the Abadehian and Dzhulflan). However, it is difficult to correlate the fossil horizon precisely with the standard succession, because of the lack of key beds and other useful fossil data.

Medlicottia kitakamiensis, and index species of the *Medlicottia kitakamiensis* Zone, has a rather wide, flat venter and asymmetrically bifid first lateral lobe. Glenister and Fumish (pers. comm., 1985) and Zakharov (1988) pointed out that this species should belong to the genus *Neogeoceras* based on the above characters. Although I assigned this species to the genus *Medlicottia* rather than *Neogeoceras* by taking into account the number of denticulation on the external saddle (Bando and Ehiro in Ehiro and Bando, 1985). I agree now with its assignment to the genus *Neogeogeras. Neogeoceras kitakamiense* closely resembles *N. thaumastum*, which is common in the upper Permian (Midian to middle Dorashamian Stage) of Sikhote-Alin (Zakharov and Pavlov, 1986). *Araxoceras* cf. *kiangsiense* described by Murata and Bando (1975) from the middle Toyoman is thought to belong to the genus *Eusanyangites* (Zakharov, 1988).

A revised zonation of ammonoids in the Permian of the Southern Kitakami is shown in Fig. 1. The *Agathiceras* Zone (middle Sakamotozawan to lower Kanokuran) is characterized by a common occurrence of Agathiceras. The base of the *Timorites* Zone (uppermost part of the lower Kanokuran to upper Kanokuran) is defined by the first appearance of *Timorites*. The lower and middle parts of this zone yield *Waagenoceras* ? sp., *Paraceltites elegans* and *Cibolites* cf. *uddeni*. The top of the *Timorites* Zone, that is the base of the *Araxoceras* Zone (lower to middle Toyoman), is defined by the first appearance of *Araxoceras. Timorites* ranges upward into the basal part of the *Araxoceras* Zone (Ehiro *et al.*, 1986). The co-existence of *Timorites* and *Araxoceras* has also been known in the Dzhulfian of Abadeh in Central Iran and also of Transcaucasia (Zhou *et al.*, 1989). The *Araxoceras* Zone contains *Pseudogastrioceras* sp., *Prototoceras japonicum* and *Xenodiscus* cf. *carbonarius* in its lower part and Eusanyangites (=*Araxoceras* cf. *kiangsiense* of Murata and Bando, 1975) in its upper part. The *Neogeoceras kitakamiense* Zone is characterized by the common occurrence of *N. Kitakamiense* (originally described as *Medlicottia kitakamiensis* by Ehiro and Bando, 1985). *Paratirolites* ? sp. and *Cyclolobus* cf. *walkeri* occur in the lower part of this zone.

Based on ammonoids and fusulinids, the Sakamotozawan, Kanokuran and Toyoman Series are respectively, correlated with the Sakmarian to Bolorian (uppermost Mapingian to middle Chihsian), Kubergandian to Midian (upper Chihsian to Maokouan) and Dzhulfian to Dorashamian (Wujapingian to Changxingian) intervals (Table 1).

AMMONOID PALEOBIOGEOGRAPHY OF THE SOUTHERN KITAKAMI DURING PERMIAN TIME

Although many Permian ammonoids genera show a world-wide distribution, some genera, including those which have also been found from the Southern Kltakami, show considerable provincialism. These latter genera should be expected to give some information concerning a gross paleogeographic relationship between the Southern Kitakami Massif and other continents.

The geographic distribution of Permian ammonoids is shown on a Middle Permian reconstruction map (Figs. 2-4). Ammonoid data were taken from various sources. The paleogeographic map wastamen from Scotese and McKerrow (1990), with the following modifications and additions: 1) The western part of the North China - Tarim Block is located at latitudes lower than that of Scotese and McKerrow (1990) and the block is arranged in an E-W trend. 2) The suspect terranes of western North America are divided into some microcontinents and moved to the south. 3) The

microcontinental block of Southern Kitakami, Sikhote-Alin and Allochthonous "Timor" are tentatively placed in the equatorial or subequatorial latitudes and adjacent to the South China Block. Ammonoid- bearing rocks in Timor are mostly of allochthonous origin derived from the north during Miocene time (Audley-Charies and Harris, 1991). Accordingly, it is separated from autochthonous Timor which belongs to the Australian continental domain.

In this map, Permian ammonoid localities are grouped into four provinces as given below. Ages of the ammonoid-bearing formations in each of these localities are shown in parentheses. E, Me, Ml, Le, Ll denote, respectively, the Early Permian (Asselian-Bolorian), early Middle Permian (Kubergandian-Murgabian), late Middle Permian (Midian), early Late Permian (Dzhulfian) and late Late Permian (Dorashamian).

Permian ammonoid provinces and representative areas of each provinces are as follows:

1) The Boreal Province [BP]: Urals (E), Novaya Zemlya (E), Greenland (Ll) and Arctic region of Canada (E.Ml).

2) The Equatorial American Province [EAP]: Texas and its environs (E-Ml), Nevada and Idaho (E), North and Southeast California (E, Le?), Coahuila (E-Le), Guatemala (E) and Columbia (E).

3) The Equatorial Tethyan Province [EAP]: South China (E-Ll), Southeast Asia (E-Me, Ll), Tibet (E, Le), Abadeh (Ml-Li), Dzhulfa (Ml-Ll), Pamir (E-Me), Crimea (E-Me), Tunisia (Me) and Sicily (Me).

Southeast Asia, Tibet and Iran Blocks are regarded to have been situated in latitudes (southern equatorial latitudes) lower than those shown in Fig.4 in the Late Permian.

Table 1 Correlation chart of some Permian sequences in the Tethyan Province and North America based on ammonoids and fusulinids.

<table>
<tr><th>TETHYS</th><th colspan="3">S. CHINA</th><th colspan="2">S. KITAKAMI</th><th>S. PRIMORYE</th><th colspan="2">TEXAS</th></tr>
<tr><td>Dorashamian</td><td rowspan="2">Lopingian</td><td>Changxingian</td><td rowspan="2">Toyoman</td><td>Nb.</td><td rowspan="2">Ludyanzian</td><td></td><td></td></tr>
<tr><td>Dzhulfian</td><td>Wujiapingian (Longtanian)</td><td>Me.</td><td colspan="2">Ochoan (La Colorada)</td></tr>
<tr><td>Abadehian</td><td rowspan="6">Yangsingian</td><td rowspan="3">Maokouan</td><td rowspan="3">Kanokuran</td><td>Iw.</td><td>Chandalazian</td><td rowspan="3">Guadalupian</td><td>Cp.</td></tr>
<tr><td>Midian</td><td rowspan="2">Kt.</td><td rowspan="2">Nb: Nabekoshian
Me: Maehaman
Iw: Iwaizakian
Kt: Kattisawan
Kb: Kabayaman
Kw: Kawaguchian
Cp: Capitanian
Wd: Wordian
Rd: Roadian
Ct: Cathedralian
Hs: Hessian
Ln: Lenaxian
Nl: Nealian</td><td>Wd.</td></tr>
<tr><td>Murgabian</td><td>Rd.</td></tr>
<tr><td>Kubergandian</td><td rowspan="3">Chihsian</td><td rowspan="3">Sakamotozawan</td><td rowspan="2">Leonardian</td><td rowspan="2">Ct.</td></tr>
<tr><td>Bolorian</td><td>Kb.</td></tr>
<tr><td>Artinskian (Yakhtashian)</td><td rowspan="3">Qiannanian</td><td rowspan="2">Kw.</td><td>Hs.</td></tr>
<tr><td>Sakmarian</td><td rowspan="2">Mapingian</td><td rowspan="2">Wolfcampian</td><td>Ln.</td></tr>
<tr><td>Asselian</td><td></td><td>Nl.</td></tr>
</table>

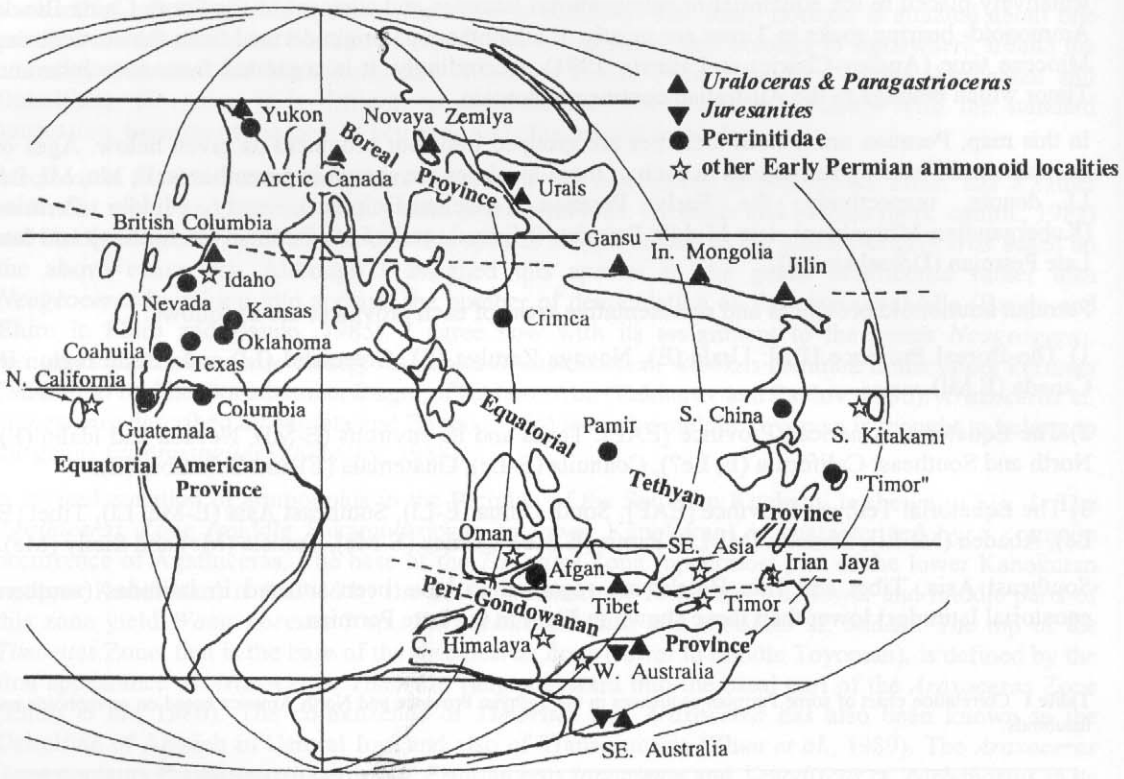

Fig. 2 Distribution of some selected Early Permian ammonoids. Base map is that form the Kazanian (approximately equivalent to the Murgabian) and is after Scotese and McKerrow (1990) with modifications and additions by the author (see text).

4) Peri-Gondowanan Province [PGP]: Western Australia (E-Me, Le), Southeastern Australia (E-Me), Timor (autochthonous) (E), Himalayas (E-Le, Ll?), Salt Range (Ml-Le, Ll?) and Madagascar (Ml-Ll).

North China (E-Me) Block and British Columbia (E-Me) might have been borderlands between BP and ETP/EAP. Locations of the Southern Kitakami (E-Ll), Sikhote-Alin (Southern Primorye) (Ml-Ll) and "Timor" (allochthonous) (E-Ml) during Permian time are not clear, but they are considered to belong to ETP based on ammonoids to be mentioned later.

Among the Early Permian ammonoids, some genera of Goniatitida show provincialism (Fig. 2). Localities of Juresanites (Metalegoceratidae), Paragastrioceras and Uraloceras (Paragastrioceratidae) are mainly distributed in BP and PGP, whereas the genera of Perrinitidae are restricted to the EAP and ETP (Nassichuk *et al.*, 1965; Furnish, 1973), except for those reported from Yukon Territory, Canada (Tharalson, 1984). Unfortunately, no ammonoid as mentioned above has been found from the Southern Kitakami Massif, so I have no Early Permian ammonoid paleobiogeographic data for the massif.

During the Middle and Late Permian, there are no genera endemic to BP and PGP. On the other hand, some genera of Goniatitida and Ceratidida are restricted to Eap and/or ETP (Fig. 3). Among the Middle Permian ammonoids, all the genera belonging to Kufengoceratinae (Cyclolobidae) have so far been reported from Texas, Coahuila and South China. Some genera of Paraceltitidae, such as

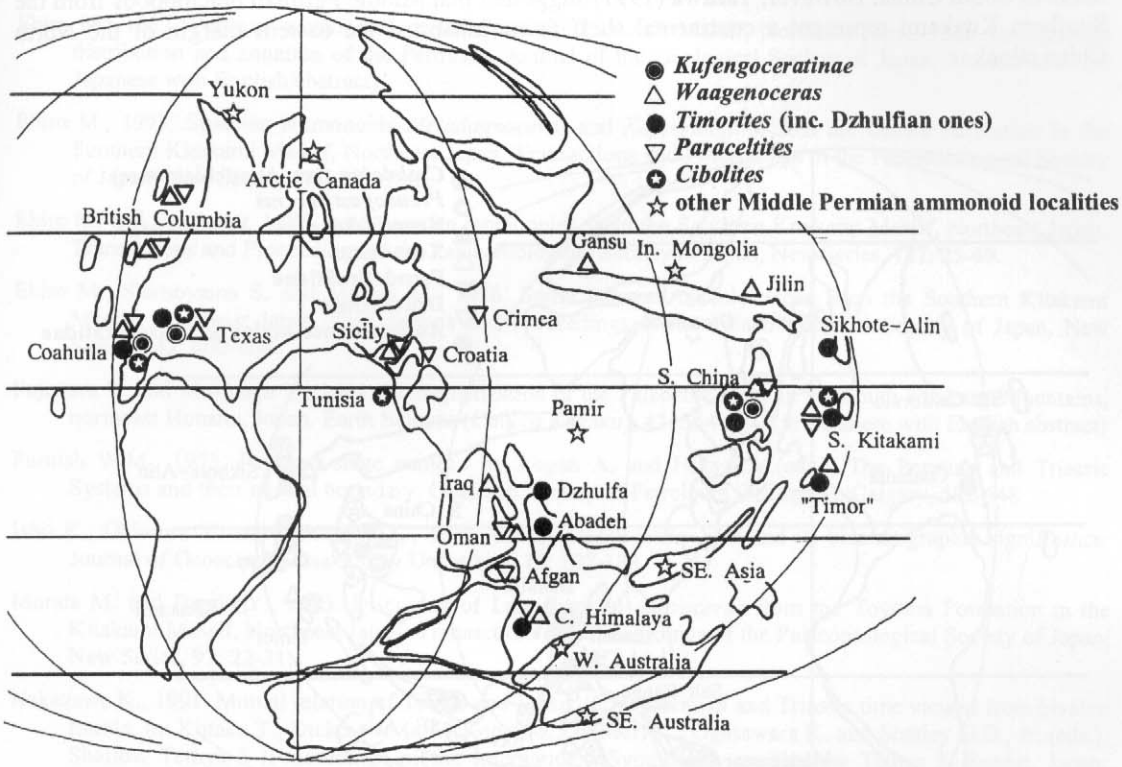

Fig. 3 Distribution of some selected Middle Permian ammonoids.

Cibolites, Nielsenoceras and *Doulingoceras* occur from Texas, Coahuila, Tunisia and Soukth China. Cycolobid genus Timorites, which ranges from the middle Middle Permian to early Late Permian, is also restricted to EAP and ETP, occurring in such localities as Texas, Coahuila, Dzhulfa, Abadeh and South China, except for one locality in Central Himalayas. *Cibolites* has been found from the Southern Kitakami, and *Timorites* from the Southern Kitakami, Southern Primorye of Sikhote-Alin and "Timor" Iallochthonous).

Most xenodiscacean ammonoids, except for Xenodiscus (Xenodiscidae) and Paratirolites (Dzhulfitidae), and all Late Permian otocerataceans are restricted to the EAP and ETP, appearing in such localities as Coahuila, Dzhulfa, Abadeh and South China (Fig. 4). *Pseudogastrioceras* is reported from some localities in ETP, such as Dzhulfa, Abadeh, SE, Asia and China. Permian otocerataceans are also known from the Southern Kitakami and Southern Primorye and *Pseudogastrioceras* from the Southern Kitakami. In Fig. 4, *Changhsingoceras* reported from South China is for the sake of convenience included in the genus *Cyclolobus*.

The Middle to Late Permian ammonoid faunas of the Southern Kitakami, Sikhote-Alin and "Timor" (allochthonous) are very much alike, and these three microcontinental blocks are considered to belong to ETP. The faunas of the former two are similar to that of South China particularly. Therefore, the Southern Kitakami and Sikhote-Alin are considered to have been situated near South China during Permian time. This conclusion corroborates results derived from analyses of fossil plants and blvalves. Asama (1985) stated that the Southern Kitakami belongs to the Cathaysia floral

province and Nakazawa (1991) showed that the Southern Kitakami bivalve fauna is allied to the fauna of South China. However, Tazawa (1991) suggested that Middle Permian brachiopods from the Southern Kitakami represent a continental shelf fauna inhabited the eastern margin of the North China Block.

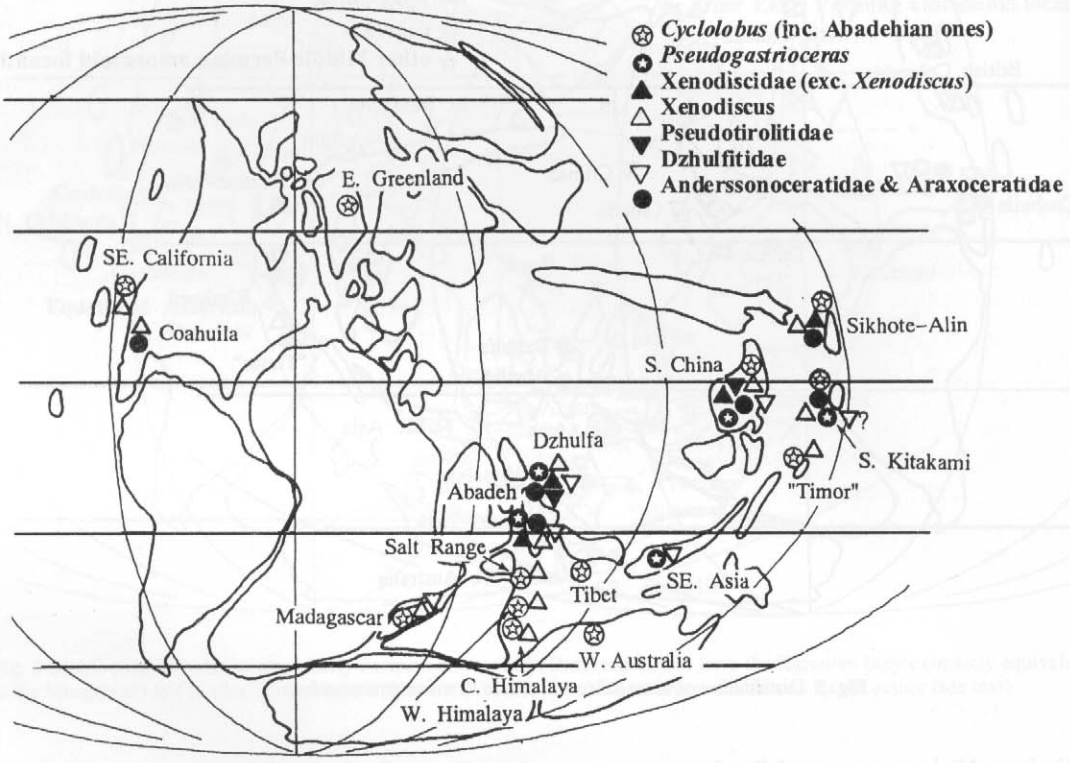

Fig. 4 Distribution of some selected Late Permian ammonoids.

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