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The Izanami Plateau: Pre-accretionary origin of Japan's low latitude triassic pelagic carbonates

FRANCIS HIRSCH[1] & KEISUKE ISHIDA[2]

Key words: Triassic, Izanami plateau, Japan, pelagic carbonates, seamount, hot-spot, accretionary complexes, conodonts

Standing on the floating bridge of Heaven, Izanagi and Izanami created the first island. There the two united. From this union many islands and gods were born. Giving birth to the god of Fire, Izanami died. [Kojiki, 712 CE]

ABSTRACT

The Izanami plateau is the oceanic origin of Triassic pelagic limestones in Jurassic and Early Cretaceous accretionary complexes (AC) of Japan.

Well dated by conodonts and radiolarians, the Triassic ocean type carbonate plateau, from where blocks, in the Mino-Tamba (Ashio), Mikabu and Chichibu belts, are derived, has a characteristic history of deposition related to seamount, hot-spot and plate-motion. The Izanami plateau is characterized by the changing nature of its substrate, from Paleozoic platform carbonates in more internal areas, to pillow basalts in more external zones, and by the younging of the base of the Triassic carbonates covering that substrate. In the more internal zones, depositional hiatuses relate to post – Aegean and Early Carnian emersions. Lower – Middle Norian condensation preceded the drowning of the platform in the more external zones, where Late Norian and Rhaetian strata consist of bedded chert only.

Faunistically, the realm of the Izanami plateau has more Tethyan than Pacific conodont affinities with some specific endemism.

The low latitude Izanami plateau extended over a large area, off the Yangtse block, prior to its inclusion in Jurassic to Early Cretaceous AC.

RÉSUMÉ

Le plateau d'Izanami est l'origine océanique des calcaires pélagiques, incorporés dans les complexes accrétionnaires (AC) du Jurassique et Crétacé inférieur du Japon.

Bien datés à l'aide de conodontes et de radiolaires, des blocs calcaires de type océanique, dans les zones de Mino-Tamba (Ashio), Mikabu et Chichibu, proviennent de ce plateau carbonaté, dont l'histoire est liée à celle de seamount, hot-spot et mouvement de plaques.

Le plateau d'Izanami est caracterisé dans les zones internes par un soubassement carbonaté paléozoique, tandis que dans les zones externes des basaltes en coussins sont sous-jacents aux calcaires triasiques, dont la base se rajeunit en direction externe.

Des hiatus, post-égéen et eo-carnien, attribués à des emersions, sont caractéristiques aux zones les plus internes. Une condensation sédimentaire eomeso- norienne, précède, dans la zone la plus externe, l'ennoiement de la plateforme, dorénavant couverte de cherts tardi-noriens – rhétiens.

Du point de vue faunique, les conodontes du plateau d'Izanami sont plutôt d'affinité téthysienne que pacifique et un certain endémisme leur confère un caractère particulier.

Le plateau d'Izanami recouvrait une large étendue à basse latitude, située au large du bloc du Yangtse, avant son inclusion aux mélanges des complexes d'accrétion du Jurassique – Crétacé inférieur, de l'arc Nippon.

Introduction

In the Jurassic accretionary complexes of Japan, two types have been distinguished. A coherent- type of little disturbed series of mainly bedded cherts and a chaotic-type of blocks and lenses of limestone and bedded chert, scattered in argillaceous matrix. The cognate origin of both types, probably formed within the same belt has been recognized (Isozaki 1997).

The Triassic successions in Japan are mostly represented by bedded cherts and siliceous shales. Triassic carbonates occur as blocks, chaotically distributed within a muddy matrix. The origin of the particular fabric of this melange, is defined in the Warabiishi melange of southern Chichibu Terrane (Ishida 1989). Radiolarians and conodonts have been extracted from both rock types.

Bedded Cherts:

A typical example of the bedded chert type is found near Oze (Shimane Prefecture) where a 45 m thick section represents a

[1] Geological Survey of Israel, Malkhei Yisrael Street, 30, 95501 Jerusalem, Israel. E-mail: francis-hirsch@mrj.biglobe.ne.jp
[2] Laboratory of Geology, Laboratory of Geology, Faculty of Integrated Art and Sciences, University of Tokushima, 1-1 Minamijosanjima, Tokushima 770-8502, Japan. E-mail: ishidak@ias.tokushima-u.ac.jp

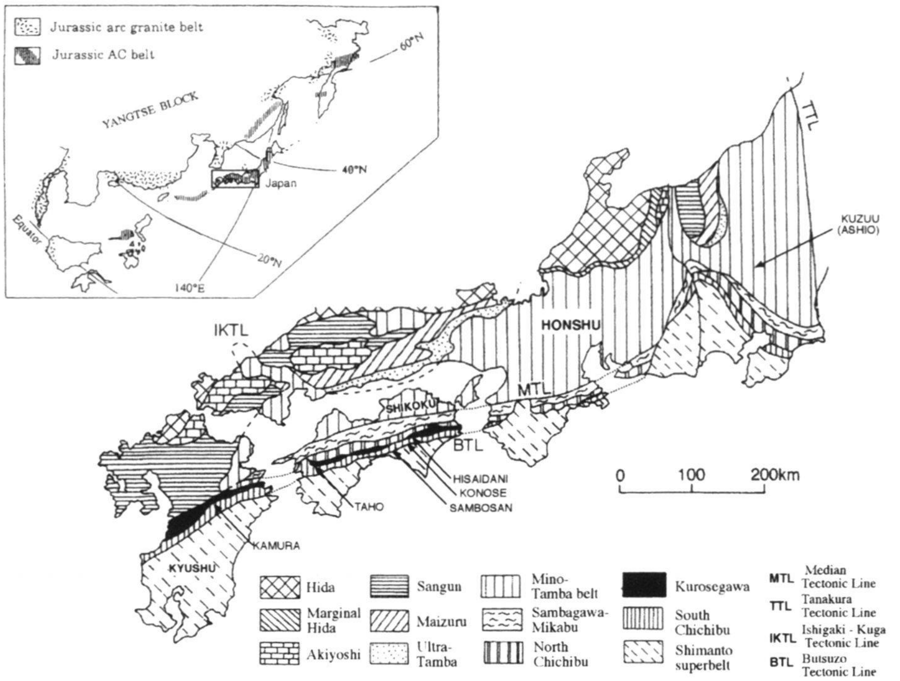

Fig. 1. Location Map of Tectonic Zones of SW Japan [after Ishida 1999) with generalized tectonic sketch map of the Far East (after Isozaki 1997).

fairly continuous Olenekian – Norian sequence (Koike 1981). In the Inuyama area, 80 m of bedded chert range from Middle to Late Triassic (Isozaki 1997).

A pelagic reference section in the Outer Zone (Shikoku), Subzone I of the Southern Chichibu accretionary complex (AC) consists of cherts near Kurano (Ishida 1981). Five "Schuppen" comprise in ascending order 10 m of Late Spathian (unit V), 4 m of Anisian – Early Ladinian (unit IV), 5 m of Anisian – Early Ladinian (Unit III), 1 m with the long ranging (Anisian – Early Carnian) *Gladigondolla tethydis* (Unit II) and 6 m of Late Carnian – Late Norian (Unit I). There is however no specific evidence for the Late Ladinian to Early Carnian time span.

Pelagic Limestones: In the present study, the following Triassic carbonates are investigated and compared: limestones within melanges of the Chichibu terrane at Kamura, Taho, Hisaidani and Sambosan, limestones at Yawatahama, Mikabu AC and limestones of the Adoyama Formation, Ashio AC.

The Chichibu terrane carbonates, at both the Kamura and Taho sections, stand out because of a significant break in the Early Anisian, generating a hiatus of most of the Middle Triassic (Koike 1981). Middle Triassic is poorly represented in the Hisaidani (Hisai-Valley) and the limestones are almost exclusively of Lower to Middle Norian age (Ishida 1987).

Similar features are found in the inner zone (Ashio AC) in the Kuzuu-Adoyama area (Honshu). The Adoyama Formation unconformably overlies the Middle Permian limestones of the Nabeyama Fm. It consists of a limestone breccia and bedded chert. The breccia contains conodonts of Permian, Dienerian-Spathian, Late Ladinian, Late Carnian and Early Norian age (Conodont Research Group 1974). These sediments belong to the Akasaka-Kuzuu seamount swarm in the Mino-Tamba-Ashio AC.

The highly metamorphic greenstones, consisting of metagabbro, pillow-basalts and hyaloclastites of the Mikabu AC contain intraformational lenses of Carboniferous, Permian and Triassic limestones in West and Central Shikoku, covered by Upper Jurassic cherts (Suyari et al. 1981; Kuwano 1979).

Greenstones: The petrology of the basic greenstone volcanics was well investigated in the Mino-Tamba belt (Sano & Tazaki 1989; Nakae 1991) and Mikabu complex in eastern Shikoku (Ozawa et al. 1997 c; Ozawa et al. 1999). The significance of the volcanics of the Mikabu greenstones in relation with the formation of accretionary complexes of eastern Shikoku was also put in evidence (Ozawa et al. 1997a). Radiometric ages are K-Ar hornblende ages, mainly obtained from tholeiites, showing a wide range from Permian to Jurassic.

Geological Background (Fig. 1)

Japan consists of a complex orogenic belt. It is referred to as a "Miyashiro type orogeny" (Maruyama et al. 1997), which is a revised concept of Pacific-type or cordilleran-type orogeny. Four episodes contributed to the origin of the Japanese Islands. An accretionary complex (AC), tectonically interlayered regional metamorphic belts and posterior granitoid intrusions characterize each cycle. The intrusion of granitoids is the most important process in Pacific-type orogeny. AC's are composed mainly of recycled granitic sediments with minor amounts of oceanic material, including huge oceanic plateaus. Ophiolites in Japan occur as accreted material of plume origin.

The Median Tectonic Line (MTL) divides present day Japan into an inner zone and an outer zone.

The MTL can be followed from Kyushu, crossing Shikoku into Honshu. The N to S younging accretionary complexes of both zones are accreted to the Yangtse block. Fragments of this craton are preserved in the Hida belts along the north coast of Kyushu and W Honshu.

The Inner zone to the N, consists of pre – Jurassic complexes: the Permian Akiyoshi belt, the metamorphic Sangun belt, the Maizuru and Ultra-Tamba belts, both encompassing Permian slope basin deposits and ophiolites. The former is unconformably covered by Triassic with Arcto-Pacific *Monotis* beds, the latter by Cretaceous molasse. These belts are separated from the Jurassic Mino-Tamba Complex by the northward dipping Ishigaki-Kuga Tectonic Line (IKTL). The Inuyama area belongs to the Mino-Tamba belt whereas the Adoyama Fm belongs to the coeval Ashio complex. The large limestone and greenstone block of Kuzuu belongs in the Mino-Tamba-Ashio Terrane. The composition of the greenstones in the Tamba terrane varies from tholeiite to peralkaline rocks that are regarded to originate from the oceanic crusts or seamounts on them (Nakae 1991). In this terrane, alkaline basalt of oceanic island origin (OIA) formed at 280Ma (Early Permian) and oceanic island tholeiites (OIT) at 335–340Ma (Early Carboniferous) (Sano & Tazaki, 1989). Based on the categories of Pearce & Cann (1973), the Carboniferous to Permian greenstones of the Tamba Terrane are tholeiites of MORB and OIA type, whereas the Mid-Late Triassic greenstones are of the OIA type (Nakae 1991).

The outer zone, south of the MTL, consists first of the metamorphic Sambagawa-Mikabu belt, followed by the Jurassic Complex of the Chichibu super-belt.

This super -belt is separated into the North and South Chichibu belts, by a syncline of the IKTL, filled with 'pre-Jurassic Kurosegawa' klippes.

The blocks of Kamura, Taho, Hisaidani and Sambosan belong into the Chichibu belt.

The southern Chichibu belt overrides the Cretaceous Shimanto super-belt, from which it is separated by the Butsuzo Tectonic Line (BTL). The Mikabu greenstone belt, belongs to the more external Jurassic – Cretaceous AC, but is at present exposed between MTL and the northern Chichibu belt.

In the greenstones of the Mikabu Terrane, amphiboles from a picritic basalt in Kanto Mountains gave a Middle Jurassic K-Ar age of 173.4 (+/-3.7) Ma (Ozawa et al. 1997b). Trace elements and isotope compositions of the igneous rocks from the Mikabu belt are similar to those of MORB. However, major element compositions and order of crystallization indicate a petrogenesis different from MORB. K-Ar dating of amphibolites indicates that the volcanism of the Mikabu Belt occurred over a long range from 200 Ma to 150 Ma (Lower to Upper Jurassic). This variation of age suggests that the origin of the Mikabu greenstone may not be a simple oceanic plateau but a seamount chain (Ozawa et al. 1997c). These ages of the greenstones are reasonable and supposed to be the age of younger activity because in the Mikabu Terrane the intra-basaltic limestone layers yield Late Triassic conodonts (Suyari et al. 1981) and the successive bedded chert yields Late Jurassic radiolarians of the *Cinguloturris carpatica* zone (Faure et al. 1991). Based on their petrological property, Ozawa et al. (1999) estimated that the upwelling of deep-mantle superplume probably produced the volcanic rocks of the Mikabu greenstone complex.

Inoue (1997) obtained K-Ar (hornblende) ages of 199.4 +/- 10.3Ma, straddling the Triassic- Jurassic boundary in Kanto. At Toba in the Kii Penninsula, Jurassic ages of 142 to 151 +/- 8Ma, 149 to 153 +/- 8 Ma were obtained from whole rock tholeiite and alkaline basalt. In Kamiyama, East Shikoku, tholeiite whole rock provided a Jurassic age of 186 +/- 10Ma. Whole rock of tholeiite and alkaline basalt, the alkaline basalt containing rocks of high-Nb/Zr ratio of HIMU grade, provided at Tsurugi-san, in East Shikoku, a Jurassic age of 157 +/- 8Ma. At Toyonaga, Central Shikoku, whole rocks tholeiite ages are also Jurassic, ranging from 143 +/- 7Ma and 163 +/- 8Ma to 185 +/- 9Ma and 186 +/- 10 Ma.

In the North Chichibu Terrane, K-Ar (hornblende) ages of alkaline basalt in East Shikoku are 263.3 (+/-5.5) Ma and 255.2 (+/-5.4) Ma (Upper Permian) (Yamamoto 1995).

The southern Chichibu AC in Shikoku (Nakagawa Group) is subdivided into four tectonic subzones (Ishida 1987). Subzones I and III are exclusively composed of coherent bedded cherts and turbidites. Subzones II and IV are characterized by melange within a matrix of turbidites. The turbidites are younging from north (subzone I) to south (subzone IV).

Subzone II is mainly composed of melanges of pillow basalts and pillow breccia, pelagic limestone blocks of Carboniferous, Permian and to a small extent also Triassic age, Triassic to Middle Jurassic chert and Middle to Late Jurassic turbidites.

Subzone IV, similar in composition, differs from zone II by the high ratio of its exclusively Late Triassic carbonate blocks and by its younger turbidites of Late Jurassic – Early Cretaceous age.

Radiometric age and composition of the Southern Chichibu pillow basalts are not well known. A Carnian age can be assumed for the pillow basalts and tuffs at Hisaidani.

Litho- and biostratigraphy of the Triassic pelagic limestone Facies (Fig. 2)

Kamura (Watanabe et al. 1979; Koike 1996)

At Kamura (Miazaki Prefecture, Takachiho town, Kyushu) three limestone formations are found in two laterally correlative up to 120 m wide blocks, 1.4 km apart:

- Middle Permian (Guadalupian) Iwato Limestone, separated by fault from the next,

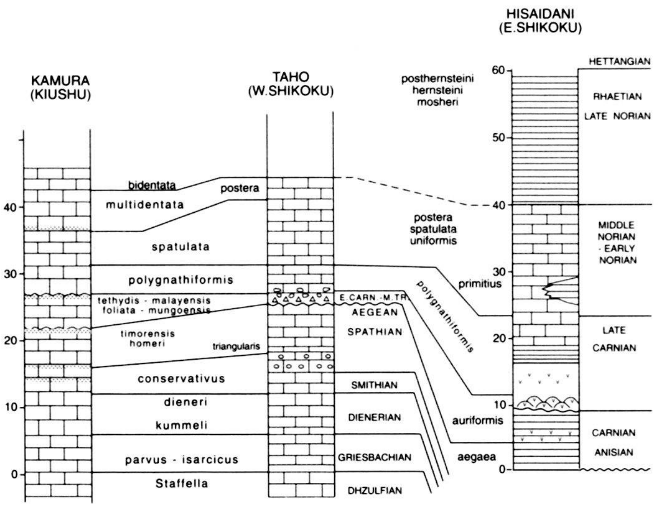

Fig. 2. Stratigraphic columnar sections of Kamura, Taho and Hisaidani, with conodont fauna. (after Watanabe 1979; Koike 1979; Ishida 1987; Ishida & Hirsch 2001).

- Late Permian (Kuman) Mitai Limestone, up to 20 m thick, contains fusulinids 8m below its top;
- Triassic Kamura Limestone, up to 37 m thick.

The Kamura Limestone yields conodonts, allowing the recognition of several zones. The 16m thick Early Triassic strata consist of 3 m of Griesbachian (Lower Induan) at its base, yielding *Hindeodus parvus-Isarcicella isarcica*, followed within the interval between 6 and 12 m above base by the Dienerian (Upper Induan) *Neospathodus dieneri*, while the uppermost part contains the Smithian *N. conservativus*, Late Spathian (Upper Olenekian) *N. homeri* and lowermost Aegean (Lower Anisian) *Chiosella timorensis.* The Middle Triassic consists of a 5m thick Late Ladinian middle sequence with *Sephardiella mungoensis.* The Upper Triassic consists of up to 16 m thick strata with the Late Carnian *Metapolygnathus polygnathiformis*, Early Norian *Ancyrogondolella spatulata*, Middle Norian *Mockina multidentata* and Late Norian *Mockina bidentata.* Brecciated limestones separate the limestone intervals. A fault separates the uppermost part of the upper sequence from bedded chert. The microfacial analysis shows that, while the Lower Triassic interval is slightly dolomitic, having therefore a higher ratio of sparite, the micritic ratio within the sequence increases upwards while the size of skeletal components decreases. Radiolarians occur only in the upper sequence. Ammonoids are more frequent in the lower part, while conodonts seem more equally distributed, though condensations are assumable above the brecciated horizons.

A Lower Spathian hiatus may exists within the lower sequence. The hiatus between the lower and middle sequences encompasses an Anisian – Early Ladinian interval. The hiatus between the middle and upper sequences is of Early Carnian age.

Taho (Koike 1979, 1996)

In the Shirokawa town (Ehime Prefecture, Shikoku) at the village of Taho-kamigumi, limestones, chert and sandstone are sporadically exposed over about 750 m. The surface exposures permit the recognition of a 41 m thick limestone section, consisting of 25 m of Lower Triassic, a 1 m thick mixed breccia and 15 m of Upper Triassic. A drilling of 50 m revealed a 27 m Permian sequence, below 23 m of Triassic strata.

The Lower Triassic encompasses the Griesbachian *Hindeodus parvus* and *Isarcicella isarcica,* the Dienerian *Neospathodus kummeli* and *N. dieneri,* the Smithian *N. conservativus,* the Spathian *N. triangularis, N. homeri* and lowermost Anisian *Chiosella timorensis* below the mixed breccia. This breccia yields fragments with conodonts representing Anisian – Early Carnian zones. The upper Triassic interval is represented by the zones of *Metapolygnathus nodosus* (Late Carnian) and *Ancyrogondolella spatulata* (Early Norian).

Hisaidani (Ishida 1987; Ishida & Hirsch 2001)

In the southern Chichibu AC of Shikoku, Triassic rocks are part of the Nakagawa Group. In its subzone IV, in the Hisaidani canyon (Kito village, Tokushima Prefecture) Carnian pillow lavas, pillow breccia and basaltic tuff overlie Anisian – Carnian bedded cherts with *Neogondolella aegaea* (the specimen, being shorter, wider and having a narrow platform, is clearly a *Neogondolella* and probably not a junior synonym of *Chiosella timorensis*), *N. shoshonensis, Nicoraella kockeli* and *Metapolygnathus* aff. *auriformis.* The greenstones are covered by a 30 m thick Late Carnian-Middle Norian sequence of micritic pelagic limestones, alternating with some bedded chert. Most of the limestone sequence belongs into the Early Norian. The *Metapolygnathus primitius* zone at base, straddles the Carnian – Norian boundary whereas its top encompasses a condensation of the Early Norian *M. primitius, Ancyrogondolella spatulata, A. triangularis* and Middle Norian *Mockina postera-elongata* zones. *A. spatulata*, represents a third of all specimens recorded (Ishida & Hirsch 2001). The limestone sequence is followed by 21 m of Late Norian – Rhaetian (*Misikella hernsteini, M. posthernsteini*) and 9 m of Jurassic (Hettangian) bedded chert.

Sambosan

Forming a landmark in the Kochi coastal plain (Shikoku), the limestone block of Sambosan, resting on a substratum of basalt, is composed of 180 m of dark Upper Carnian limestone with *Halobia* and conodonts such as *Metapolygnathus polygnathiformis* and *M. nodosus* (Koike 1979).

In blocks, W of the city of Kochi (Tamura 1983) and at the Kuma River (Kiushu) (Tashiro et al. 1984), shallow water limestones with Megalodonts occur.

Adoyama

These sediments belong to the Akasaka-Kuzuu seamount swarm in the Mino Tamba-Ashio AC (Maruyama et al. 1997). The Adoyama limestone breccia contains conodonts which were listed in the frame of 'Conodont Research Group' (1974), nomenclature emended by present authors. It encompasses the Permian *Gondolella* cf. *idahoensis* Youngquist, Hawley & Miller, *Lochriea* aff. *commutatus commutatus* (Branson & Mehl) and *L.* aff. *commutatus homopunctatus* Bishoff, *Hindeodus* aff. *typicalis* (Sweet), the latter ranging into the Lower Triassic; the Dienerian-Spathian *Neospathodus* cf. *cristagalli* (Huckriede), *N.* cf. *pakistanensis* Sweet, *N.* cf. *triangularis* (Bender), *N.* cf. *homeri (Bender)* and the lowermost Anisian *Chiosella* cf. *timorensis* (Nogami); the Late Ladinian *Sephardiella japonicus* (Hayashi) and *S.* cf. *diebeli* (Kozur & Mostler), Late Carnian-Early Norian *Metapolygnathus polygnathiformis* (Budurov & Stefanov) and Early Norian *Metapolygnathus permicus* (Hayashi), *M. nodosus* (Hayashi), *M. echinatus* (Hayashi) and *Ancyrogondolella "abneptis"* (Huckriede). An apparent hiatus of the post-Aegean and Early Carnian time-intervals seems to exist also here.

Yawatahama and Motoyama areas

Lenses of Triassic limestone within the metamorphic greenstones of the Mikabu AC yield recrystalized conodonts of Late Carnian - Middle Norian age. *Metapolygnathus polygnathiformis* and *Ancyrogondolella spatulata* occur in localities near Yawatahama, W. Shikoku, and *Metapolygnathus primitius, Sephardiella pseudodiebeli* and *Ancyrogondolella "abneptis"* in Motoyama, Central Shikoku (Suyari et al. 1980, 1981; Kuwano 1979).

Extent and significance of the middle Triassic and early Carnian hiatus

Limestone platforms are well known from Tethys, e.g. the Kreios Plateau (Tollmann & Kristan-Tollmann 1985). During low sea level stands, evaporites formed, or, if these structures were exposed, sedimentary breaks occurred, witnessed by breccia and conglomerates, thus providing clues as to the depositional history of tectonism and sea level changes. Such a global sea level drop occurred in the Lower Carnian and has generated the "Saharan salinity crisis" (Busson 1982) that left huge evaporites in the Western Tethys. Conglomerates and breccia witness the event worldwide (Hirsch 1994b).

Similar features, when due to regional tectonism, may provide a clear 'identity tag' for palinspastic reconstructions. Their presence would point to relative vicinity within the area of origin.

Both Kamura and Taho limestones, and possibly the Adoyama limestone, are marked by a significant break, shortly after the end of the Lower Triassic, generating a hiatus of most of the Middle Triassic. At Kamura this hiatus encompasses the time span between Early Anisian and Late Ladinian. In the Taho section, Aegean (Early Anisian) beds are covered by the "mixed zone" (Koike 1981), which contains Middle Triassic and Carnian fragments, covered unconformably by Late Carnian- Early Norian beds. Though this Middle Triassic hiatus can only be referred to a local tectonic event, like exceptional activity of the hot spot plume witnessed by the nearby tuffs (Hisaidani, section VI, Ishida 1998), the Early Carnian hiatus may relate to the Saharan salinity crisis.

Conodont faunal associations

Middle and Late Triassic conodont faunal associations define palaeo-biogeographic realms. Paleolatitude is crucial for their definition. The low latitude Tethys realm (Hirsch 1994a) is characterized in the alpine-himalayan orogeny, from the Alps to Timor.

The Pacific realm, is a difficult concept. Best documented in North America, the Pacific terranes are of mixed origin: some are true Tethyan, others are less so, some are not at all so; some are allied to the North American craton and some are craton-bound non-terranes. The Nevadan and NE British Columbia successions are of low and medium latitude (Orchard 1991d).

A comparison of the Middle and Upper Triassic faunal spectra from Japan with Tethys and Pacific realms reveals more Tethyan affinities, though affinities with Pacific associations are also present as well as some degree of endemism.

The Pacific associations:

The data on Middle - Upper Triassic associations is based on Mosher (1973), Nicora (1976), Orchard (1991a,b,c,d; 1994), Bucher & Orchard (1995), Orchard & Tozer (1997) and Orchard et al. (2001).

Anisian: Besides cosmopolitan *Chiosella timorensis* at its base, *Neogondolella* seems to dominate. *N. constricta, N. aldae* and the craton-bound *N. shoshonensis* occur.

Nicoraella kockeli is found in Nevada. Mosher (1968) mentioned *N. mombergensis,* though this probably needs revision. *Ladinian:* Besides *N. aldae,* most taxa have a cosmopolitan character. *Paragondolella excelsa* appears. The Early Ladinian contains *Sephardiella truempyi,* followed by the Middle Ladinian *S. hungaricus*, whereas the Late Ladinian (sutherlandi zone) is defined by *Sephardiella mungoensis.*

Early Carnian: Mosherella newpassensis.

Late Carnian: The genus *Metapolygnathus* fully dominates, among which *M. polygnathiformis.* The *M. nodosus* Zone is characterized by a wide specific spectrum of conodonts. The morphologies of species assigned here to *Metapolygnathus* have a wide range. *M. reversus* has a loop-like basic cavity and a nude platform, whereas *M. zoae* and *M. samueli* have an elongated loop-like basic cavity and nodes on the platform. A very short and rounded platform, with loop-like basic cavity, characterizes *M. stephanae,* which appears in the latest Carnian - earliest Norian *primitius* Zone.

Early Norian: The Early Norian is characterized by conodonts with moderate to strongly split basic cavities as well as sharp denticles on the platform margins.

In the Pacific realm, a specific predominance of *Ancyrogondolella quadrata, A. uniformis* and *A. triangularis* over forms with affinities to *A. spatulata* seems to occur. In the uppermost part of the Early Norian, "*Epigondolella*" *transitia* shows strong reduction of its split basic cavity and a narrowing of the platform.

Middle Norian: The Middle Norian is characterized by the development of simplified morpho-types (Hirsch 1994b). An amygdaloid basic cavity and platform margins with sharp denticles characterizes the taxon *Mockina*. The large specific diversity *of Mockina* encompasses *M. multidentata, M. elongata, M. matthewi, M. carinata, M. tozeri, M. spiculata, M. postera* and *M. serrulata. M. postera* is exceptionally common in British Columbia (Orchard & Tozer 1997).

Late Norian: The strong reduction of the platform characterizes *Mockina bidentata,* together with *M. englandi,* which still shows similarity with *M. postera*.

Rhaetian: Mockina mosheri ends the lineage of platform conodonts. *Misikella* is only known from terranes. *Misikella posthernsteini* is present, though not abundant in the Haida Gwaii (Canada) (Carter 1993).

Tethyan associations:

A large and disparate literature exists for this realm (Mosher 1968; Kozur & Mock 1974, Budurov 1976, 1977; Gazdzicki & al. 1979; Kovacs & Kozur 1980; Krystyn 1980, 1983; Kovacs 1986, 1993; Budurov & Sudar 1990).

Anisian: Chiosella timorensis, Neogondolella aegaea and *Gladigondolella carinata* mark the lowermost part of the Anisian. *Gladigondolella tethydis* ranges from Anisian to Early Carnian.

The genus *Neogondolella* is well represented by *N. constricta, N. bulgarica, N. bifurcata, N. cornuta,* and *N. eotrammeri. Nicoraella kockeli* marks a short interval at the base of the upper Anisian and *Paragondolella excelsa* appears.

Ladinian: A number of parallel, depth controlled lineages, consist of: (a) *Neogondolella trammeri, N. praehungarica, N. basisymmetrica, N. suhodolica, N. transita* and *N. fuelopi*.

(b) *Paragondolella excelsa, P. foliata* and *P. inclinata*.

(c) *Sephardiella shagami, S. truempyi, S. hungarica, S. mungoensis* and *S. diebeli*.

(d) *Gladigondolella tethydis* and *G. malayensis*.

At the very top of the stage *Mosherella microdus* appears. The extinction of the genera *Neogondolella* and *Sephardiella* characterize a global event near the Ladinian – Carnian boundary.

Early Carnian: The base of the Carnian still yields Sephardic migrants e.g. *Pseudofurnishius*. The substage is characterized by the recovery from Late Ladinian extinctions. This is expressed by a variety of taxa ranging from *Metapolygnathus polygnathiformis* to *M. tadpole, M. auriformis,* and *M. carnicus*. In the deeper environment *Gladigondolella tethydis* and *G. malayensis* still occur.

Late Carnian: Metapolygnathus polygnathiformis, M. nodosus, M. noah, M. carpathica, M. parvus, M. echinatus and *Cavitella cavitata*.

Early Norian: Metapolygnathus permicus, Ancyrogondolella spatulata, A. quadrata, A. triangularis and *Norigondolella hallstattensis*. The Tethyan character of *A. spatulata* and *N. hallstattensis* was stated by Orchard (1991d).

Middle Norian: Ancyrogondolella uniformis, A. spatulata, Mockina postera, M. multidentata and *Norigondolella steinbergensis*.

Late Norian: Mockina bidentata and *Norigondolella steinbergensis*.

The lineage of *Misikella* ranges from Middle Norian to Rhaetian.

Rhaetian: is characterized by *Misikella posthernsteini*.

Conodont associations from bedded chert and pelagic limestones of the Izanami plateau area (Plate 1):

The literature consists of several publications in English or in Japanese with English abstracts (Hayashi 1968; Koike 1981,1982; Ishida 1981, 1984; Nakazawa & al. 1994). (Tethyan [T], Pacific [P] and Endemic (E) affinities are indicated):

Anisian: Neogondolella aegaea, N. cornuta (=constricta), N. shoshonensis [P], *N. bulgarica, N. acuta* [T], *Chiosella timorensis* [T], *Nicoraella kockeli, Gladigondolella carinata* [T], *G. tethydis* [T] and *Paragondolella excelsa*.

Ladinian: Paragondolella excelsa, P. foliata, Sephardiella hungarica, S. japonica, S. mungoensis, Gladigondolella tethydis [T], *G. malayensis* [T].

Early Carnian: Gladigondolella tethydis [T], *G. malayensis* [T], *Metapolygnathus polygnathiformis*.

Late Carnian: Metapolygnatus polygnathiformis, M. nodosus, M. primitius, M. communisti.

Early Norian: Metapolygnathus primitius, M. permicus, Ancyrogondolella quadrata, A. uniformis, A. spatulata [T], *Norigondolella hallstattensis* [T].

Middle Norian: Ancyrogondolella spatulata [T], *A. uniformis, Mockina postera, M. zapfei, M. elongata* [P], *M.* aff. *matthewi* [P], *M.* aff. *spiculata* [P], *M. shamiseni* (E) and *M. sakurae* (E).

Late Norian: Mockina bidentata, M. hisaidaniensis (E), *Norigondolella steinbergensis, Misikella hernsteini, M.* cf. *longidentata*.

Rhaetian: M. aff. *mosheri, Misikella hernsteini, M. posthernsteini*.

The dominance of *Ancyrogondolella spatulata* and its range from Lower to Middle Norian suggests a Tethyan character. However, the presence in the Middle Norian of a number of endemic forms with affinities to Pacific taxa seems distinctive for the realm in which the Izanami plateau evolved.

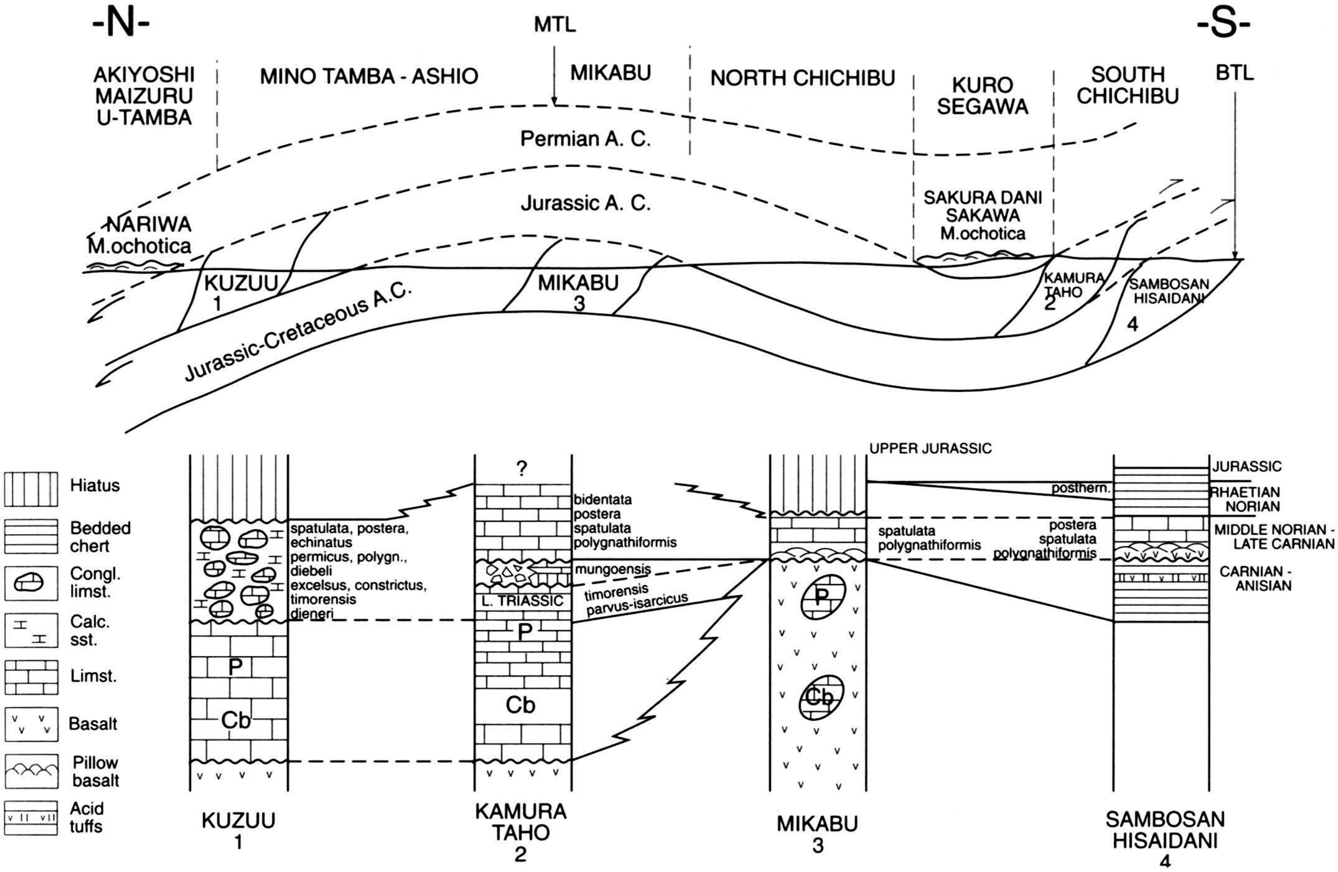

Fig. 3. Schematic Tectonic cross-section of SW Japan, prior to the Late Creteceous activation of the Median Tectonic Line (MTL), with distribution of limestone sections of (1) Kuzuu (Ashio), (2) Kamura-Taho, (3) Mikabu, (4) Hisaidani -Sambosan.

Discussion and results

History of deposition:

In terms of history of deposition, the Izanami plateau comprises ocean type limestones, surrounded by deep sea bedded cherts. The tectono-environmental history of the limestones is of particular interest, since it provides the realm with some palaeogeographic identity.

The range of the lower sequence of limestones is Griesbachian – earliest Anisian. Only at Kamura, a thin Late Ladinian middle sequence occurs, whereas the upper sequence is Late Carnian – Norian. The Middle Triassic hiatus points to a tectonic uplift-event within the Izanami realm, whereas the Early Carnian hiatus correlates well with the global Saharan crisis. The carbonate platform undergoes drowning in the external part of the plateau, where Middle Norian limestones are replaced by Late Norian bedded chert (Sambosan, Hisaidani). The Middle Triassic tectonic phase is witnessed in the chert facies by abundant acid tuffs (Ishida 1987). A correlation of this activity with synchronous events in the Alpine region (Brandner 1984) may be more than just random and related with the opening of Neotethys.

The similar events, found at the same time in the different occurrences of the Izanami limestones, suggests a coherent plateau and not just a swarm of sea-mounts, which once off the plume, that generated them, may undergo their own histories of rising and drowning.

Environmental conditions:

Depth, salinity and palaeolatitude control faunal provincialism.

Middle Triassic *Neogondolella* is more frequent in shelf environments whereas the ratio of *Paragondolella* increases towards the outermost shelf (Hirsch 1994a).

In confined areas, like the Germanic and Sephardic provinces, faunal specializations have occurred, as in the Sephardic *Pseudofurnishius*, which is not found in Japan. *Gladigondolella* (Earliest Anisian – Early Carnian) and *Norigondolella hallstattensis* (Norian) are believed to represent pelagic low latitudes. It may be reasonable to assume that a high ratio of *Ancyrogondolella spatulata*, which is dominant in the conodont associations of the Izanami plateau as well as in the bedded cherts, is low latitude related.

Palinspastic reconstruction of the Izanami Plateau: (Fig. 3)

Elements derived from the Izanami plateau are found in both the northern Inner Zone and southern Outer Zone, encompassing the belts of the Mino-Tamba AC (Ashio, Honshu), southern Mikabu and southern Chichibu AC.

In the Inner Zone, the Triassic Adoyama Limestone rests unconformably on Carboniferous and Permian Fusulinid limestones. In the Outer Zone, the Triassic Kamura limestone, located in subzone II of the Southern Chichibu AC overlies conformably limestones of Permian age. In the same tectonic unit's subzone IV, limestones of Norian age at Hisaidani and Late Carnian at Sambosan, directly overlie pillow basalts. The limestones grade upwards into bedded chert of Triassic – Jurassic age.

The Adoyama, Kamura and Mikabu limestones, having a substrate of Permian carbonates, are embedded in Callovian – Kimmeridgian turbidites, whereas the Hisaidani – Sambosan carbonates, overlying Triassic pillow basalts, are embedded in Kimmeridgian – Barremian turbidites (Ishida 1987).

Maruyama et al. (1997) have attributed the Sambosan limestones, devoided of Permian sedimentary substratum, to the Mikabu Plateau, which is characterized by a Paleozoic carbonate substratum. However, in our view, though Sambosan and Mikabu belong both to the same Jurassic – Lower Cretaceous AC, the Mikabu AC belt is of more internal origin than Hisaidani / Sambosan, in the external part of the Izanami plateau.

From this palinspastic view point, the greenstones of the Mino-Tamba-Ashio, Northern part of South Chichibu and Mikabu terranes have MORB or oceanic island origin and the younging of the volcanic ages from Early Carboniferous to Late Jurassic is consistent with their assumed alignment in space.

The motion of the Izanagi Plate across a number of plumes generated the seamounts on which the Izanami Plateau carbonates originated. This motion during the Triassic (~ 40Ma) at a speed of less than 5 cm / y (Maruyama et al. 1997), allows to estimate the length of the plateau to at least 2000 km. A similar distance must have separated the Izanami Plateau from the Arcto-Pacific *Monotis* beds belt, deposited on top of the Permian AC in Central Japan, as can be estimated from the similar 40 my timespan between the Norian drowning of the plateau and the Callovian arrival of the first plateau fragments at the subduction trench. (Fig. 4)

Finally, the timespan between the Callovian – Kimmeridgian turbidites, containing Paleozoic and Triassic blocks, in S. Chichibu subzone II and the Kimmeridgian – Barremian turbidites, containing only Late Triassic blocks, in subzone IV (Ishida 1987), suggests the arrival of plateau fragments over a time span of some 40Ma at a possibly much higher speed.

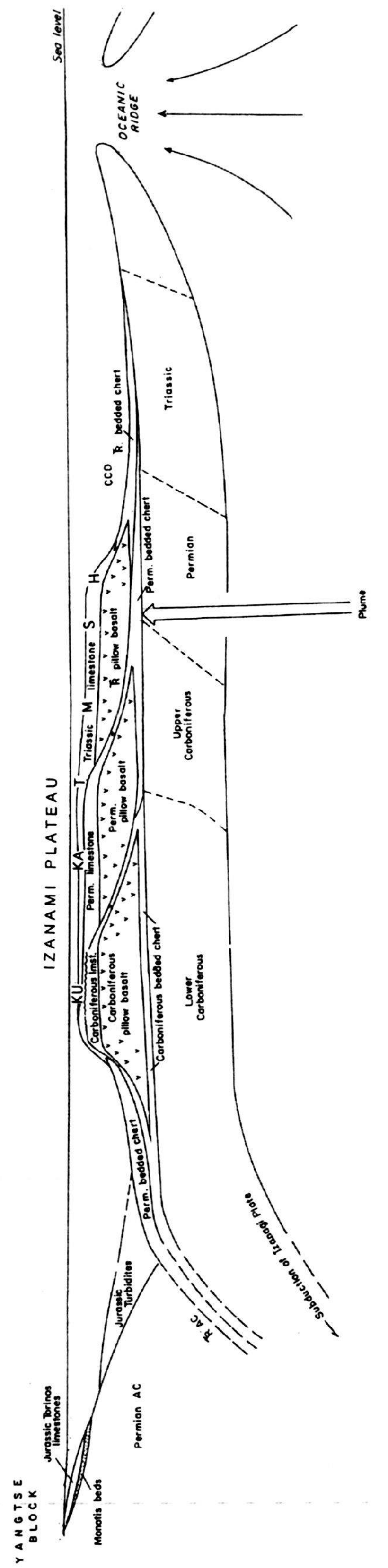

Fig. 4. Palinspastic sketch of the Izanami Plateau;
KU: Kuzuu, KA: Kamura, T: Taho, M: Mikabu, S: Sambosan, H: Hisaidani; AC: Accretionary complex.

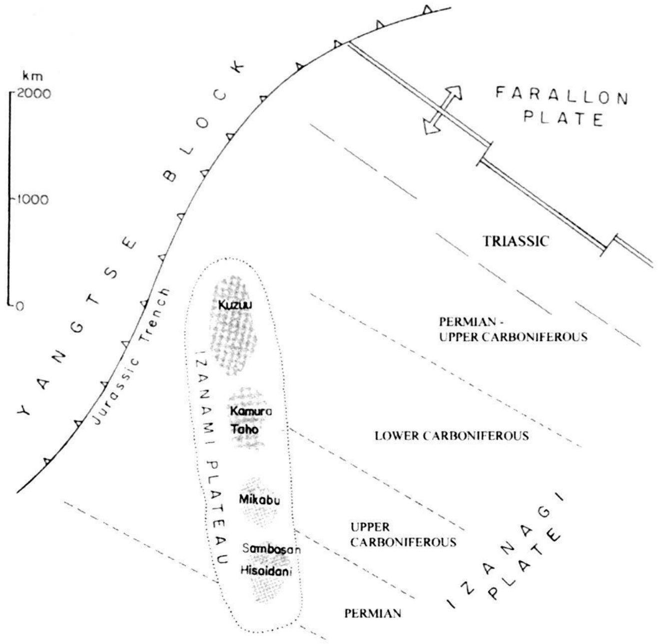

Fig. 5. Map showing Izanami Plateau and evolution of Izanagi Plate; TR: Triassic, P: Permian, UC: Upper Carboniferous, LC: Lower Carboniferous.

Conclusions

The Izanami oceanic plateau consisted of a sea mount chain that was probably produced by deep-mantle super plume upwelling over a very long time range, from Early Carboniferous to Late Jurassic.

The fragments from the Izanami oceanic carbonate plateau, which occur in the Mino-Tamba (Ashio), Mikabu and Chichibu belts, originated at low latitude on seamounts, surrounded by deep oceanic floor with bedded cherts. The seamounts underwent a combined motion: that of moving away from a spreading center and that of moving together with the Izanagi plate in direction of the subduction trench, located off the Yangtse Block (Fig. 5).

The substrate of the Izanami plateau consists in the more internal areas of the Paleozoic platform carbonates of the Akasaka – Kuzuu seamount swarms and of pillow basalts in the more external zones. The age of the greenstones of the Mino-Tamba-Ashio, Northern part of South Chichibu, and Mikabu terranes, from Early Carboniferous to Late Jurassic, became younger as the formation of the seamount chain that formed the composite of the Izanami plateau progressed.

Younging of the base of the Triassic carbonates above their substrate varies from Early Triassic in the more internal zones to Early Norian in the more external zones.

Depositional hiatuses were due to the Post Aegean and Early Carnian emersions as well as the Lower – Middle Norian condensation prior to Late Norian drowning of the platform in the more external zones, while Late Norian was still carbonate dominated at Kamura only.

Faunistically, the realm within which the Izanami Plateau was deposited, as can be defined by its conodont associations, was Tethyan, mixed with elements of Pacific affinity and distinguished by the presence of some specific endemics.

The low latitude Izanami plateau extended over a very large area, off the Yangtse block, prior to its inclusion in Jurassic to Early Cretaceous AC.

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We are indebted to Mike Orchard (Geological Survey of Canada, Vancouver) and Fabrice Cordey (Université Claude Bernard, Lyon) for constructive review of the manuscript. We owe sincere thanks to Dr. Hiroaki Ozawa and Dr. Shigeki Motoyama (Naruto University of Education) who gave us valuable comments and information about greenstones in accretionary complexes of SW Japan. We warmly thank Peter Grossman and Doron Hirsch, as well as Nehama Shragai and "Nanako" Cohen (G.S.I. Jerusalem), for drafting and computer assistance. Tatsusuke Niki, Shigemi Sakai and Katsuaki Amita gave us access to the SEM (JEOL JSM 5400 LV) of the Forestry Institute of the Tokushima Prefecture. Kazunori Muto (JEOL overseas service division) Yamanishi Hiroaki and Sakura Ishida assisted us in processing the images.

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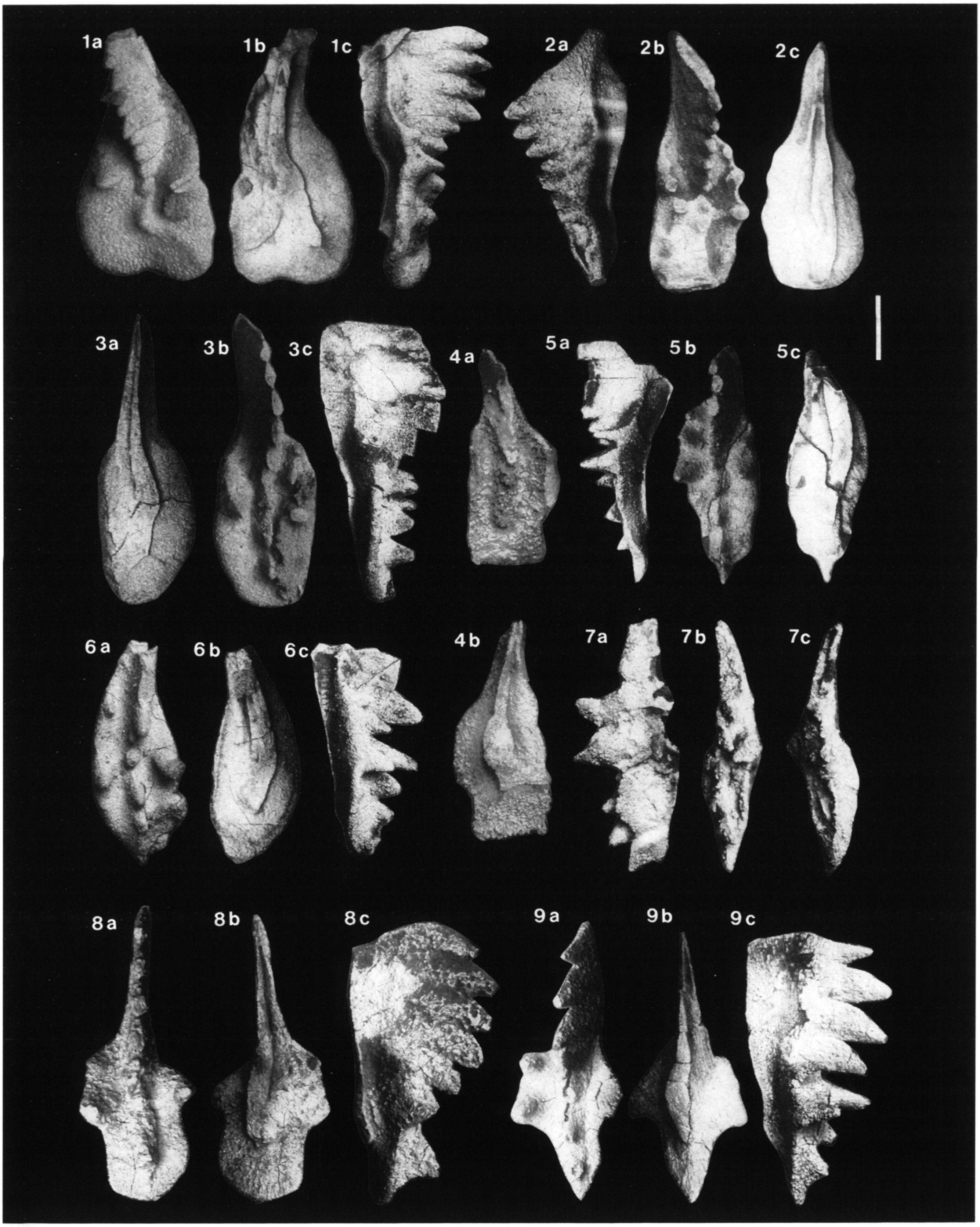
Plate 1

SEM photographs of conodonts from the Hisaidani sections. Scale bar indicates approximately 100 micron. The material is deposited in the collections of Tokushima University Triassic Conodonts (TKUTC).

1a, b, c: *Ancyrogondolella spatulata* (HAYASHI)
a: oral view; b: basal view; c: lateral view. TKUTC33-4/3.
2a, b, c: *Mockina* aff. *matthewi* ORCHARD
a: lateral view; b: oral view; c: basal view. TKUTC33-8/4.
3a, b, c: *Mockina postera* (KOZUR & MOSTLER)
a: basal view; b: oral view; c: lateral view. TKUTC33-1/42.
4a, b: *Metapolygnathus* aff. *permicus* (HAYASHI)
a:: oral view, scale bar C; b: basal view. TKUTC21-1/30.
5a, b, c: *Mockina* aff. *spiculata* ORCHARD
a: lateral view; b: oral view; c: basal view. TKUTC33-5/43.
6a, b, c: *Mockina sakurae* ISHIDA & HIRSCH
a: oral view; b: basal view; c: lateral view. TKUTC33-6/51.
7a, b, c: *Mockina* aff. *mosheri* KOZUR & MOSTLER
a: lateral view; b: oral view; c: basal view. TKUTC69-1/15.
8a, b, c: *Mockina shamiseni* ISHIDA & HIRSCH
a: oral view; b: basal view; c: lateral view. TKUTC23-2/7.
9a, b, c: *Mockina hisaidaniensis* ISHIDA & HIRSCH
a: oral view; b: basal view; c: lateral view. TKUTC95-1/19.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