57. *The Taga Beds of the Zyoban Coal-field.*

(Contribution to the Geology of the Zyoban Coal-field, III.)

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The tuff-argyllite or tuffaceous mudstone of Hidati with *Sagarites* and shark's teeth is a typical or principal member of the Taga beds of Tokunaga¹⁾, who thought them to lie unconformably beneath his Tenpizan beds. The stratigraphical relation of the two formations is well visible along the sea-cliff of Turusi near the city of Hidati, Ebaraki Prefecture. In distant view, the two formations are unconformable; but approaching closely, no sharp boundary is traceable between them, where the conglomeratic basal part with large boulders of granitic and Palaeozoic rocks is lacking²⁾; in fact, the general aspect of their boundary is that of cross-bedding in a gigantic scale. Upstream of the Miyatagawa near by, the metamorphosed Palaeozoic rocks of the Abukuma plateau is unconformably overlain by a breccia-like conglomerate, which upward passes to a sandstone, partly calcareous and yielding numerous brachiopods³⁾ and not seldom shark's teeth; this sandstone, including the conglomerate at the bottom, is the basal deposit of the Taga beds, the tuff-argyllite of Hakusan, Sukegawa in the same city, occupying a position between this sandstone and the Tenpizan beds exposed along the coast. At two small salients, Turusi and Hazzaki, of the coast as well as Tenpizan near Isohara, the Tenpizan beds are richly fossiliferous, the dominant fossils being littoral molluscs, echinoid spines, barnacles, etc.; the rocks often contain abundantly triturated shell fragments. On the other hand, the tuff-argyllite of the Taga beds are very rare in macroscopic fossils.

The coarse conglomerate with large boulders of older rocks reappears at Tenpizan, a little north of Isohara, where again the expected unconformity can not be seen. There the top of the Taga is interbedded with thin beds of quartzose sandstone and the basal part of the Tenpizan with thin beds of tuff-argyllite. The Tenpizan conglomerate seems to be merely a local accumulation

1) S. Tokunaga: Geology of the Zyoban Coal-field (in Japanese). Mem. Fac. Sci. & Eng., Waseda University, No. 5, 1927.

2) The coarse-grained sandstone is locally calcareous. Sometimes it contains richly bipyramidal crystals of quartz, probably derived from the liparite of the Yunagaya series.

3) K. M. Hatai: The Cenozoic Brachiopoda of Japan. Sci. Rep. Tohoku Imp. Univ., Ser. II (Geol.), Vol. XX, 1940, p. 68.

of large boulders and pebbles of older rocks, of extremely limited extent. The unconformity, when it exists, is that of contemporaneous erosion.

At Tenpizan, the conglomeratic part of the Tenpizan beds is succeeded upwards by a sandstone with abundant echinoid spines; the same rock is exposed at Usuba, 2 km north-west of Isohara, where it directly overlies the Sirasaka shale of the Siramizu series, the oldest division of the Tertiaries of the Zyôban coal-field. Lately M. Eguchi found a mass of *Thyasira nipponica* Yabe and Nomura in the sandstone of Usuba; according to him, the sandstone is overlain by a tuffaceous mudstone which continues to the same rock exposed near Isohara, where it assumes a position as underlying the Tenpizan beds of Tenpizan. The sandstone, with conglomerate in its association, of Usuba are the basal deposit of the Taga beds. The Usuba sandstone and the Tenpizan beds are two deposits in the same sedimentary facies—Tenpizan facies; they occupy two different horizons, intervened by the tuff-argyllite, the principal member of the Taga beds.

The *Thyasira* mass in the Usuba sandstone is a peculiar occurrence; it is an accumulation of molluscan shells with both valves intact; and in nearly complete exclusion of other molluscs. The same occurrence was early known to T. Kochibe¹⁾, from Kamioka-Minamimae, Sekinami-mura, a place nearly half way from Usuba to Otu. This mollusc is not rare in the Tenpizan beds of Hazzaki and Turusi, but very rare in the nodulous Kokozura sandstone of Izura near Otu, which is otherwise very rich in large-sized molluscs.

It is here to be added that the fossils collected by Tokunaga in the Usuba sandstone are all elements of the Tenpizan fauna, preservation also being quite the same in the two cases.

Originally Tokunaga divided his Younger Zyôban series into three parts, in descending order,

- Tenpizan beds
- Unconformity
- Taga beds
- Unconformity²⁾
- Toyoma beds (Tôzenzi beds)

The type locality of the Toyoma beds being outside the Taga district, name

1) T. Kochibe: Zyohoku Tisizu-Hen (Geology of Northern Hidati), 1883.

2) Near Izura, a bluish gray tuff-argyllite of the Taga with abundant *Sagarites*, Tokunaga observed, resting in clinounconformity on the Tôzenzi sandstone which is nodulous and abounds in fossils at the coast of Izura.

Tôzenzi beds is preferable for the lowest division. The Tôzenzi beds is the same as the Kokozura sandstone of Sokabe and the Tabasaka sandstone of the writer in the Part I of this paper.

In the foregoing paragraphs, it has been shown that the "unconformity" beneath the Tenpizan beds is stratigraphically insignificant; then it naturally follows that the Tenpizan beds must be amalgated with the Taga beds, as much as the basal deposits of the latter—Usuba sandstone—are quite the same in sedimentary facies and have the same fauna as the Tenpizan beds. The following division and nomenclature are suggestive in this connection.

	New	Tokunaga
Taga beds	{ Tenpizan sandstone.....	Tenpizan beds
	{ Taga tuff-argyllite }	Taga beds
	{ Usuba sandstone }	

While the base of the Taga is well defined, its upper limit is still unsettled, the Tenpizan sandstone being deposits of very limited extent equivalent to a part of the Taga tuff-argyllite.

The sedimentary deposits of the Tenpizan facies occupy many small areas or, better expressed, occur in many small patches, arranged on two nearly parallel lines extending from Usuba and Tenpizan southward over 24 km to Hidati, the localities of the Tenpizan sandstone lying on the coastal line and those of the Usuba sandstone on the inner. The localities are (from north to south):

Inner line: East of Yunoami, Sekinami-mura; Usuba, Isohara-mati; Kezurikiyasiki, Minami-Nakagô-mura; Tomobe; Miyata, Hidati.

Outer line: Tenpizan; Kohama, northeast coast of Takahagi; south side of the mouth of the Kanuki-gawa; north side of the mouth of the Yanazugawa, near Kawaziri; Simoaida, south of Kawaziri; Turusi; Hazzaki.

While the stratigraphical relation of the Usuba sandstone to the other formations is unknown at the northernmost locality on the inner line, the sandstone is always unconformable to the underlying older rocks at all other places:—the Sirasaka shale at Usuba; the Iwaki sandstone at Kezurikiyasiki, granodiorite and chlorite schist at Tomobe, and granodiorite and metamorphosed Palaeozoic at Miyata. On the other hand, the Tenpizan sandstone of the outer line stands in a close stratigraphical relation with the Taga tuff-argyllite at all the localities and never in direct contact with the older formations.

The distinction of these two horizons of sandstones is so important that without this conception, misunderstanding has long prevailed about the Taga

beds among the Cenozoic geologists, including Tokunaga himself and also the writer. Formerly the latter has born in mind that the patches of these sandstones are remnants of an once wide spread sandstone and conglomerate at the beginning of a new, post-Taga cycle of sedimentation, and on account of a quite young aspect of its molluscan fauna, he put the boundary between the Pliocene and the Miocene at the base of the sandstones.¹⁾ This was an error.

On lithological nature and sedimentary condition, the Usuba sandstone seems to be a group of coastal deposits under the strong influence of translating waves, breakers and undertow, and the inner line or the line of the Usuba sandstone to mark an approximate position of a temporary ocean coast. A similar explanation, however, can not be applied to the Tenpizan sandstone of the outer line or the Tenpizan sandstone line, since the sandstone does not rest on the older rock-floor, but occurs as patches amid an extensive deposition area of the contemporaneous fine-grained Taga argyllite, which, though usually more or less sandy and sometimes interbedded with thin sandstone beds, is, as a whole, a group of sedimentaries in a rather calm sea water, showing some disturbance only beneath the base of, and around the Tenpizan sandstone patches.

Nowhere is there a trace of small islets of granitic and other older rocks near the Tenpizan sandstone patches as the source of the material.

At the climax of the transgressing Taga sea, the sea level was more than 100 m higher than at present and the shore line might be situated far interior than the Usuba line, and perhaps very close to the eastern border of the Abukuma plateau; the distance from the ancient shore to the Tenpizan sandstone line is never less than 4 km. Usual undertow is insufficient as a transporting agency off shore to carry for such distance such enormous masses of coarse shore material, including large boulders several meters in diameter, to the Tenpizan sandstone line. Such a sudden, temporal and local change of sedimentary condition as shown by the Tenpizan sandstone is ascribable, the writer assumes, better to

1) This view had another palaeontological basis on a tooth of *Stegolophodon latidens* (Clift), a Pontian elephant, from Hanareyama of Kuzi, Ibaraki prefecture. According to F. Takai, it is not *latidens*, but *Stegodon elephantoides* (Clift) of the later Pliocene. F. Takai: Cenozoic Mammals of Japan, Preliminary Report (in Japanese). Jour. Geol. Soc. Japan, Vol. XLV, No. 541, 1938, pp. 750, 751.

The fossil tooth was unearthed from near the boundary between the Taga argyllite and the overlying Tenpizan sandstone. This sandstone was called by R. Aoki the "Hanareyama series", who considered it resting unconformably on the Taga tuff-argyllite and overlain unconformably by the Tokyo beds. H. Yabe: Recent Stratigraphical and Palaeontological Studies of the Japanese Tertiary. Special Publication of Bernice P. Bishop Museum, No. 7, 1921, p. 784.

Tsunami than to any other causes. This assumption needs further verification.

The molluscan fauna of the Tenpizan sandstone, though possessing a young aspect as a whole, still has the shells of *Thyasira nipponica* Yabe and Nomura and *Lucinoma* "*acutilineata* Conrad" in abundance, which are two elements common of the molluscan faunas of the older Sirado and Yunagaya series. The Taga tuff-argyllite is poor in molluscan remains, but yields not seldom shark's teeth; those from a clay-pit for cement industry of Hakusan, Sukegawa, in the city of Hidati, enumerated in Tokunaga's paper, are as follows:

<i>Carcharodon megalodon</i> (Charlesworth)	Pl. VI, fig. 1
<i>Carcharodon carcharias</i> (Linné)	Pl. VI, fig. 4
<i>Carcharodon</i> cf. <i>carcharias</i> (Linné)	Pl. VI, fig. 6
<i>Carcharodon</i> cf. <i>arnoldi</i> Jordan	Pl. VI, fig. 7
<i>Carcharodon</i> sp.	Pl. VI, fig. 9
<i>Carcharodon</i> sp.	Pl. VI, fig. 10
<i>Carcharias</i> cf. <i>cuspidatus</i> (Agassiz)	Pl. VI, fig. 8
<i>Isurus hastalis</i> (Agassiz)	Pl. VI, figs. 13, 14
<i>Isurus</i> sp.	Pl. VI, fig. 16

He further figured a tooth of *Carcharodon megalodon* from the Usuba sandstone of Kezurikiyasiki. While this identification is correct, that of the Hakusan tooth is an error, the tooth being a somewhat aberrant form of *Carcharodon rondeleti* Müller and Henle (*C. carcharias* (Linné)) with many prominent vertical wrinkles on both crown faces; his two teeth of *Isurus* may better be assigned to *I. retroflexa* (Agassiz) than to *I. hastalis*.

Many years ago, a small, but fine collection of shark's teeth from the same pit was donated by Mr. I. Saga¹⁾ to the Institute of Geology and Palaeontology, Sendai; it contains some of the specimens figured in Tokunaga's paper. This collection comprises

Family Notidanidae

Notidanus sp. indet.

Family Lamnidae

Odontaspis (*Synodontaspis*) cf. *iacurva* Davis

Odontaspis (*Synodontaspis*) cf. *vorax* Le Hon

Isurus retroflexa (Agassiz)

Isurus benedeni (Le Hon)

Carcharodon rondeleti Müller and Henle

1) The generosity of Mr. Saga is here greatly acknowledged.

? *Carcharodon rondeleti* Müller and Henle

Carcharodon (*Carcharoc'és*) *sagai* Yabe, nov.

Family Carcharinidae

Carcharinus praejaponicus Yabe, nov.

There is no teeth of *Carcharodon megalodon* and *Isurus hastalis*, both common in the Neogene of Japan; their absence in the Taga tuff-argyllite of Hidati is remarkable, if not barely accidental.

There are two other localities of *Carcharhinus praejaponicus*, the Usuba sandstone (Brachiopoda bed) of Miyata-Kami, Hidati, very close to Hakusan, and the Sanka fossil horizon at the top of the Ogawa beds of T. Hayashi¹⁾, at Sanka, Simo-Egawa-mura, Enya-gun, Totigi prefecture. From the first locality, this species was found together with *Odontaspis vorax* (Le Hon) (Reg. No. 8662), while the same sandstone yielded to Tokunaga *Carcharodon megalodon* and *Isurus hastalis* at Kezurikiyasiki as stated above. At the second place teeth of *Carcharhinus praejaponicus* are very common (Reg. No. 73204), in association with *Carcharodon megalodon* (Reg. No. 73241), *Galeus* ? sp. (Reg. No. 66323) and *Pristiophorus* sp. (Reg. No. 66324). This is the first locality of the fossil teeth of the latter two genera in Japan.

Carcharodon megalodon and *Isurus hastalis* coexisted with *Carcharhinus praejaponicus* at the time of the Usuba sandstone and the Sanka fossil horizon of the Ogawa beds. Is the Sanka fossil bed contemporaneous with the Usuba sandstone and somewhat older than the Taga tuff-argyllite ?; this is a question to be answered by further studies.

Another rich locality of Neogene shark's teeth is Hanoura, Notozima, Isikawa Prefecture, from where, Ishiwara²⁾ reported:

Original name	Revised name
<i>Carcharias cuspidatus</i> (Agassiz)	<i>Odontaspis</i> cf. <i>incurva</i> (Davis)
<i>Isurus hastalis</i> (Agassiz)	<i>Isurus hastalis trigonodon</i> (Agassiz)

1) Tâkesi Hayasi: Topography and Geology of the Western Border of the Yamizo Mountainland (Graduation thesis, manuscript, Institute of Geology and Palaeontology, Tôhoku University, 1946).

He divided the Tertiary deposits between Kituregawa and Karasuyama in Totigi prefecture, in descending order: Ogawa beds, 260 m, with the Sanka fossil horizon (a 4 m thick tuffaceous sandstone) at its top; Koguti beds, 120 m with marine molluscs; Siwota beds, 100 m, with *Carcharodon megalodon* and *Aphrocallistes* beside many molluscs; the last one is unconformably underlain by the Karasuyama beds.

2) Y. Ishiwara: On Some Fossil Shark-Teeth from the Neogene of Japan. Sci. Rep. Tôhoku Imp. Univ., Ser. II (Geol.), Vol. V, No. 3, 1921.

<i>Carcharodon megalodon</i> (Charlesworth)	<i>Carcharodon megalodon</i> (Charlesworth)
<i>Carcharodon carcharias</i> (Linné)	<i>Carcharodon rondeleti</i> Müller & Henle
<i>Carcharodon</i> spp.	<i>Carcharodon</i> cf. <i>rondeleti</i> Müller & Henle

At this place, *Isurus hastalis* and *Odontaspis* cf. *incurva* are most common, while *Carcharhinus* is lacking. This locality and Hidati have in common two species: *Odontaspis* cf. *incurva* and *Carcharodon rondeleti*. These shark's teeth of Hanoura are from the Miocene Hanoura beds (=Nanao beds) of T. Ogawa.

Leaving the detailed descriptions of the shark's teeth from Hidati to another occasion, brief accounts of them are given below.

Notidanus sp. indet. A fragmental tooth from lower jaw, with only two anterior cusps preserved; first cusp with very fine anterior serrulation. Reg. No. 35423.

Odontaspis cf. *incurva* (Davis). Two teeth probably from lower jaw and one from upper. Slender recurved crown with markedly convex outer face and obtuse edges completely disappearing near the crown base. Reg. No. 35169.

Odontaspis cf. *vorax* (Le Hon). A smaller, more slender tooth than the former, with thick, broad, expanded root and 3 pairs of lateral denticles, of which the innermost ones are long and the others minute. Outer crown face also convex as in the former. Reg. No. 35170.

Isurus retroflexus (Agassiz). Anterior teeth resembling *I. desori*, with convex inner and flat outer crown face; crown somewhat lower than in that species, having relatively broad base. Posterior teeth with trigonal crown not so broad as in *I. hastalis* (s. s); a pair of feeble lateral denticles. Root stout, markedly thicker and broader than in *I. desori* and *I. hastalis*; the upper border of the inner face of root covered by a thin enamel layer extended to the base of crown. 13 teeth examined. Reg. No. 35165.

Isurus benedeni (Le Hon). A single specimen lacking its root; crown very convex on the inner face, very broad at base, curved strongly posteriorly and sickle-shaped, provisionally referred to the species named.

Carcharodon rondeleti Müller and Henle. Thin, flat, erect, trigonal teeth; root almost as broad as crown base, similarly flat, slightly emarginate at lower border. Inner face of crown gently convex, somewhat flattened at the middle part; edges serrated, serrae rather coarse and distinct, 9

or 10 in 10 mm. Height of crown 32 mm in the largest specimen. Reg. No. 35164. Ten teeth examined.

? *Carcharodon rondeleti* Müller and Henle. A large tooth, 75 mm in the total height, 50 mm in the height of crown, 50 mm in the breadth of crown base. Similar to the preceding ones, but with both crown faces vertically wrinkled; most resembling a tooth figured by R. Lawley¹⁾ of his *C. etruscus*, which is now generally thought to be identical with *C. rondeleti*. Probably an abnormal tooth of the latter species. This is the original specimen of *C. megalodon* (Pl. VI, fig. 1) of Tokunaga. Reg. No. 33711.

Carcharodon (Carcharocles) sagai Yabe, nov. Six teeth closely resembling *C. angustidens* Agassiz, but smaller in size and more slender in shape and having only a vestige of lateral denticles. Crown with the outer face slightly and the inner very convex; edges finely serrate, serrae 40–50, becoming rapidly weaker toward the apex. Root strongly lunate, with somewhat diverging branches which attenuate abruptly to the bluntly pointed distal end; inward projection at the base of crown fairly prominent. Reg. No. 35168.

Carcharhinus (Prionodon) praejaponicus Yabe, nov. A new specific name proposed, for convenience sake, for the fossil teeth of *Carcharhinus*, resembling those of the living *C. gangeticus* (Müller and Henle), *C. japonicus* (Temminck and Schlegel) and their cognates. Very variable in shape, some trigonal, some resembling *Galeocерdo* or *Galeus* and others inverted T-shaped like teeth of *Sphyrna*; all thought to belong to a single species in comparison with the teeth of living allies.

All of the fossil shark's teeth from Hakusan at hand are quite fresh in aspect, possessing acute edges, either entire or serrated, and sharp apices perfectly preserved; on the contrary, in the majority of them the roots are destroyed and in many cases the dentine is partially or entirely decayed; in the latter case the enamel layer alone is preserved and the interior is hollow. These two rather antagonistic conditions well exclude the suspicion on the selective collection of the fossil teeth by the fossil-hunters in the clay-pit, and seem to indicate that these teeth, separated from the jaws, dismembered and

1) R. Lawley: Studi comparativi sui pesci fossili coi viventi del generi *Carcharodon*, *Oxyrhina* e *Galeocерdo*, 1871, *Carcharodon*, Pl. 4, fig. 2. The vertical wrinkles are far better developed in the tooth from Hidati.

more or less shifted, were laid under the water not much strongly agitated; this is in good coincidence with the sedimentary condition of the mother rock, a massive, fine-grained tuff-argyllite, in which very delicate small tubular bodies of the pseudoplanktonic monoaxonid *Sagarites chitani* Makiyama are often well preserved. The decay of dentine of the teeth, the writer thinks, probably took place by their exposition to the air, after the excavation of the rock.

The living sharks of the genera *Notidanus*, *Odontaspis*, *Isurus*, *Carcharodon* and *Carcharhinus* being inhabitants of the neritic and bathyal zones of the tropical to temperate regions, the same habitat can be also assumed for the fossil sharks from the Taga beds of Hakusan.