

中新統備北層群から産出した板鰐類化石群

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Selachian fauna from the Miocene Bihoku Group in Shobara area, Hiroshima Prefecture, southwest Japan

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Abstract

Seventeen species in the seventeen genera of selachians are described from the early Middle Miocene Bihoku Group in Shobara area, Hiroshima Prefecture, southwest Japan. Based on the association of several dominant species, *Carcharhinus*-*Isurus*-*Carcharias* assemblage is recognized. The paleoecologic character of the assemblage is inferred as coastal, warm temperate waters based on habitat of living selachian genera and other fossils associated with selachian in record.

Key words: Bihoku Group, shark teeth, selachian assemblage, paleoecologic characters, early Middle Miocene, description

はじめに

広島県北部に位置する庄原盆地には、中部中新統の備北層群が分布し、軟体動物などの化石を豊富に産出することが知られている。備北層群における板鰐類化石の研究は、日本産板鰐類化石産地の1つとして備北層群が紹介された後(後藤, 1972), 山岡(1987)による8科13属15種の板鰐類化石や山岡(1995)による鯨類の尺骨に突き刺さった板鰐類の歯化石の報告がある。しかし、これらは板鰐類化石の産出報告にとどめられており、化石標本の記載は行われていない。また、Itoigawa(1978)は備北層群を含む中部中新統から認められた板鰐類化石群集をもとに、西南日本の古環境について議論している。しかし、未記載の板鰐類化石標本をもとに群集を認定しており、その群集組成は明らかにされていない。

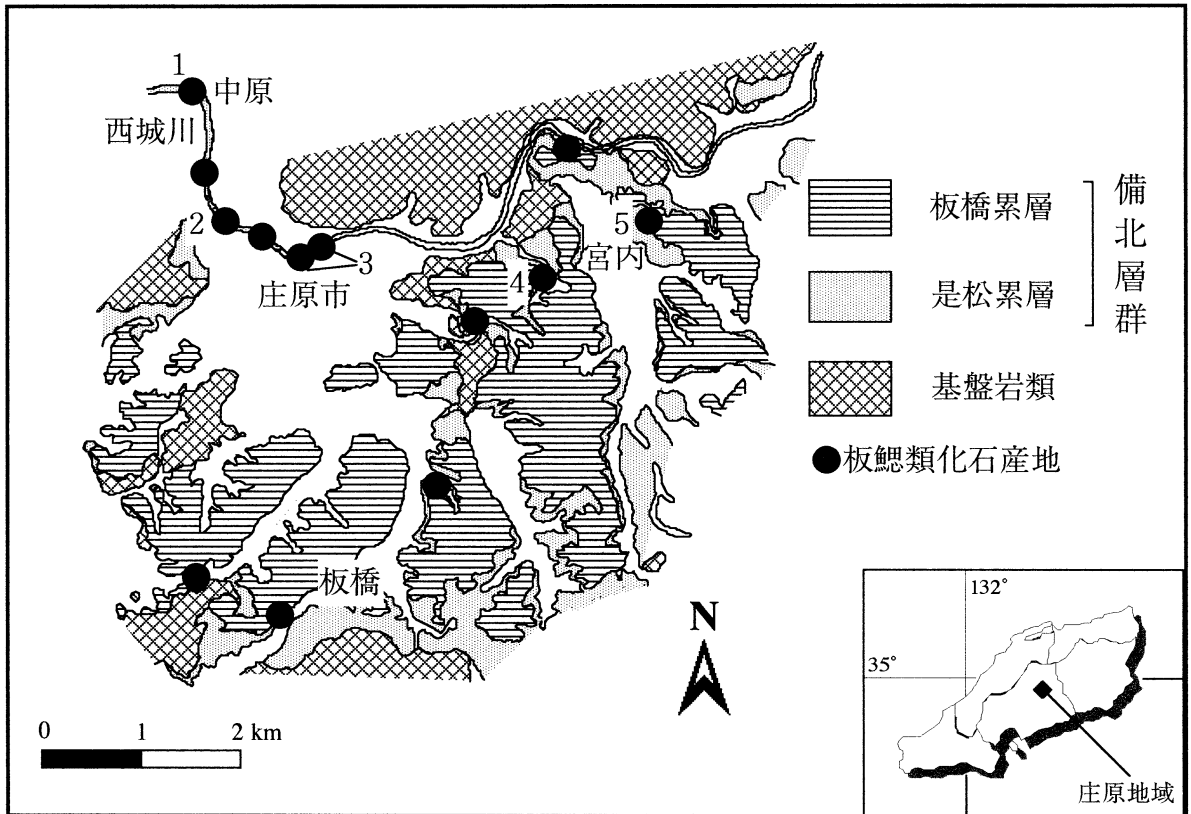
本研究では、庄原地域に分布する備北層群から産出した15科17属17種の板鰐類化石の記載を行ない、それらにもとづいて卓越種・随伴種を明らかにし、板鰐類化石群集の認定を試みる。さらに、群集を構成している種と同属あるいは近縁の現生板鰐類の生息環境、および既存の研究報告のうちの古環境の指標となる軟体動物などの化石とともに産出している板鰐類化石に関する報告を用い、板鰐類化石群集が示す庄原地域の堆積環境について考察する。

地質概説

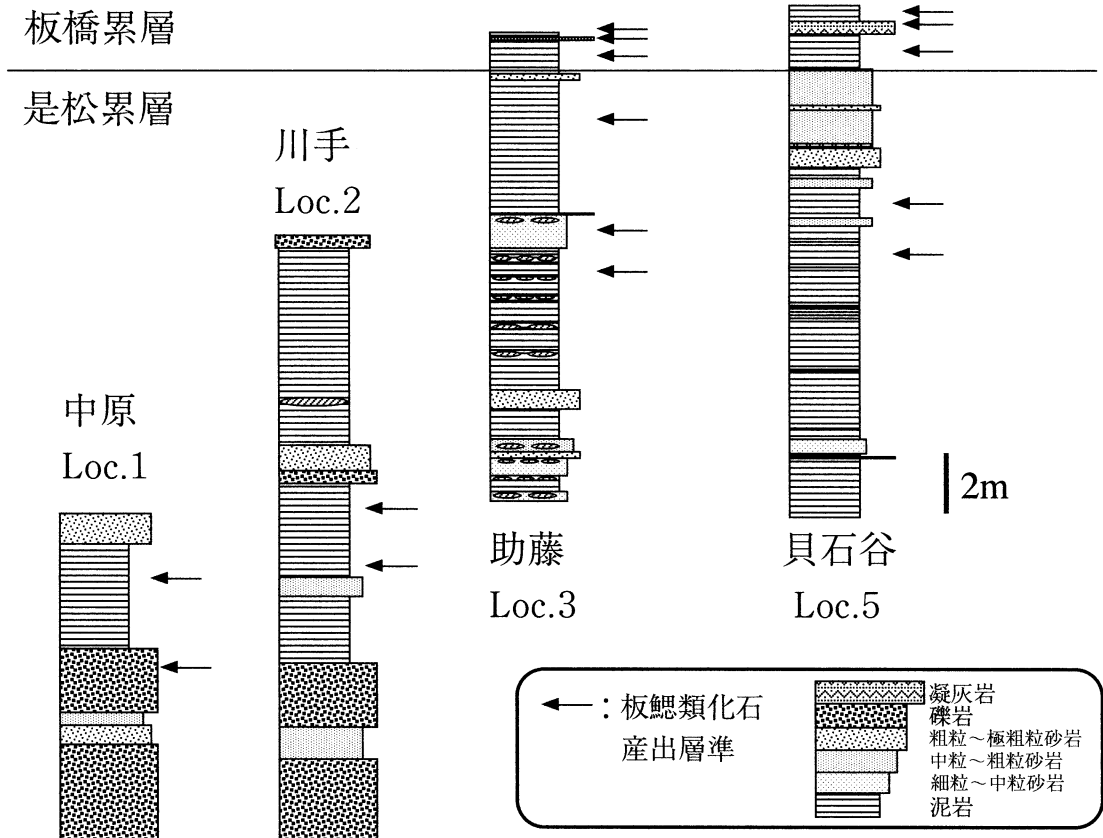
庄原盆地に分布する新第三系の備北層群は、凹凸の激しい白亜系の基盤岩とアバットの関係にあり、下部のは松累層と上部の板橋累層に区分されている(上田, 1989)。各累層の分布を第1図に示す。是松累層は新庄砂岩部層、赤川礫岩部層、三良坂礫岩部層から構成される。新庄砂岩部層は是松累層の大部分を占めており、主に中粒-粗粒砂岩からなる。最上部では粗粒砂岩層がみられ、上位の板橋累層との境界を示す鍵層として有効である(第2図)。赤川礫岩部層は、赤川および板橋地域東部においてみられる礫岩層である。三良坂礫岩部層は、三次・三良坂地域にみられる円礫岩を主体とした礫岩層である。板橋累層は、主に塊状の黑色泥岩からなり、本累層の中-上部では泥岩と極細粒砂岩との互層が卓越する。

庄原地域の備北層群からは軟体動物化石を豊富に産出することで知られ、大きく2つの型に区分されている(岡本・今村, 1971)。それらは是松累層から産出する門ノ沢動物群(Otuka, 1939; 鎮西, 1981)の要素と板橋累層から産出する東別所動物群(粕野, 1964)の要素に類似した軟体動物化石群である。上田(1991)は軟体動物化石群集をもとに備北層群の古環境について議論しており、是松累層堆積時を暖流の影響を強く受ける沿岸域とし、板橋累層堆積時を水深200mを大きくは超えない貧酸素的な環境としている。作本(1997)は、3つの十脚甲殻類化石群集を識別し、それらをもとに是松累層堆

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第1図 調査地域位置図庄原地域の地質図および板鰓類化石産地 (上田, 1989 を修正)



第2図 化石産地の柱状図. Loc.4では露頭が消失したため, その柱状図を示すことができない.

積時の古環境を上部～下部浅海帯上部の温暖な海域としている。

備北層群の堆積年代について、上田（1989）は浮遊性有孔虫化石をもとに推定されている既存の研究報告を総括した結果、Blow's zone の N.8-10 帯に含まれるとしている。岡本（1992）は、備北層群より Blow's zone の N.8-9 帯の浮遊性有孔虫および Martini（1971）の NN 4 に対比されるナンノ化石を認めている。山本（1999）は、是松累層および板橋累層下部から産出したナンノ化石をもとに、その堆積期を Martini（1971）の NN 4 上部に対比させている。Nomura（1992）は、備北層群中の Foram. Sharp Line の年代について 14.3 Ma と指摘している。本報告では、岡本（1992）により微化石で示されている年代を考慮して、備北層群の地質年代を Blow's zone の N 8-9 帯（16.4-14.8 Ma; Berggren *et al.*, 1995）として扱うことにする。

板鰐類化石

本論で検討した標本は、庄原市在住の故広瀬繁登氏宅に収蔵・保管されているおよそ 550 点である。これらは、広瀬氏が中心になり庄原市内の子どもらによって 12 年間かけて採集されたものである。一部の標本は産地不明

であったが、標本には産地番号および標本番号が付記しており、化石産地の地質調査を行なうことでそれぞれのおおまかな産出層準を推定することが可能であった。また、標本の破損が著しいものについては検討の対象外とした。

検討の結果、5 産地から 15 科 17 属 17 種の板鰐類化石が認められた（第 1 表）。これらのうち、*Carcharhinus* 属が卓越し、全産出数の 55% 近くを占める。ついで *Isurus* 属、*Carcharias* 属の順で多く認められた。種ごとにみると、*Carcharias acutissima* は 15%、*Isurus desori* は 10% の割合で産出している。このほか、*Isurus hastalis*、*Galeocerdo aduncus*、*Rhinoptera* sp.、*Cetorhinus* sp.、*Hexanchus* sp. などの 15 種を随伴する。エイ類の尾棘化石も随伴して認められたが、化石のデータが少ないこと、比較のための現生標本が入手困難であることから同定には至らなかった。産地別においても、すべての産地で *Carcharhinus* spp. が卓越して認められた。本属以外の産地別の産出量をみると、産地 1 では *Rhinoptera* sp. およびエイ類の尾棘化石が 15% ちかくを占め優勢している。産地 2 および産地 3 では、*Carcharhinus* spp. 以外の優勢は認められなかった。産地 4 では、*C. acutissima* が優勢して認められた。産地 5 においては、*I. desori*、*C. acutissima* の優勢のほか *I. hastalis*、*G. aduncus*、*Dasyatis* sp. が

第 1 表 板鰐類化石の産出リストおよび群集。

	Locality				
	1	2	3	4	5
<i>Hexanchus</i> sp.		+	+	+	+
<i>Squalus</i> sp.	+				
<i>Squatina</i> sp.	+		+	+	+
<i>Carcharias acutissima</i>	+	+		A	C
Odontaspidae gen. et sp. indet.				+	
<i>Isurus hastalis</i>	+		+	+	R
<i>Isurus desori</i>	+		+		+
<i>Isurus planus</i>			+		C
<i>Carcharodon megalodon</i>				+	+
<i>Alopias</i> sp.	+		+	+	+
<i>Cetorhinus</i> sp.	+	+	+		
<i>Hemipristis serra</i>	+				+
<i>Galeorhinus</i> sp.	+				
<i>Galeocerdo aduncus</i>	+	+			
<i>Carcharhinus</i> spp.	C	R	R	A	C
<i>Sphyrna</i> spp.	+				+
<i>Dasyatis</i> sp.	+				R
<i>Aetobatus</i> sp.	+			+	+
<i>Myliobatis</i> sp.	+				+
<i>Rhinoptera</i> sp.	R	+	+		+
caudul spine, Batoidea	R				

Assemblage

Carcharhinus-Isurus-Carcharias

+: <10, R: <20%, C: 20-30%, A: >30%

随伴して認められた。

550 標本の板鰓類化石のうち、産出の割合が全産出数の 10% 以上を示した優占属に着目して検討した結果、備北層群からは *Carcharhinus-Isurus-Carcharias* 群集を認めることができた。

板鰓類化石群集が示す古海況

Carcharhinus-Isurus-Carcharias 群集を構成する属・種の生態的特性をもとに、群集が示す古環境について議論する。なお、化石属・種の生息環境については、それぞれの現存する同属もしくは近縁な属の生態的特性を参考に、同層準からの板鰓類以外の化石の古生態も考慮に入れ考察を行う。

Carcharhinus 属および *Isurus* 属の歯化石は国内の中新統から豊富に産出しており、現在最も繁栄している板鰓類である。*Carcharhinus* 属の現生種は 29 種が知られており、種によって生息域は異なるが主に温暖な沿岸表層域に生息している (Compagno, 1984b)。現生の *Isurus* 属は、外洋表層域に生息することが知られている (Compagno, 1984a)。しかし、Kuga (1985) は、化石種の *I. hastalis* や *I. desori* が沿岸域に生息していたことを示唆している。また、既存の研究報告からも、同じ層準から古海況が沿岸域を示す軟体動物化石とともに *Isurus* 属が多く産出している傾向がみられる (矢部・長澤, 1997 など)。したがって、*Isurus* 属は沿岸域に生息していたものと考えられる。*Carcharias* 属は、漸新統および中新統から豊富に産出しており、現生では 2 種が知られている (Compagno, 1984a)。現生の *Carcharias* 属は主に温暖な沿岸域の砂質底やサンゴ礁、岩礁域に生息している (Compagno, 1984a)。備北層群では *C. acutissima* はサンゴの化石が産出する層準に多く産出しており、現生の *Carcharias* 属と類似した環境に生息していたことが示唆される。

産地 1 において優勢した産出を示す *Rhinoptera* 属の現生種は、熱帯～亜熱帯のサンゴ礁域に生息している (益田・小林, 1995)。国内での本属の化石は、瑞浪層群明世累層および生俵累層から多く認められている (糸魚川ほか, 1985)。それによると、熱帯的な環境が推定されている宿洞相に比べ亜熱帯的な環境とされる明世累層や生俵累層からより多くの *Rhinoptera* 属が産出している。これらのことから、中新世の *Rhinoptera* 属は亜熱帯域に生息していたことが示唆される。産地 5 では、*Dasyatis* 属および *Galeocerdo* 属の優勢した産出が認められた。*Dasyatis* 属は、一部の種を除いて大半は温暖な沿岸底層域に生息している (益田ほか, 1975)。現生の

Galeocerdo cuvier は、主に熱帯～亜熱帯の沿岸域に生息している (益田ほか, 1975)。化石種の *G. aduncus* も古海況が沿岸域を示す第三系から報告されており (糸魚川ほか, 1985)、その生息域は現生の *Galeocerdo* 属とほぼ一致していたものと考えられる。このほか、備北層群から稀な産出を示す *Hexanchus* 属は、現生種において特徴的な生息環境を示す。現生の *Hexanchus* 属は、海域の表層付近においても生息が確認されているものの、その主要な生息域は外洋底層域とされている (Compagno, 1984a)。上野ほか (1984) は芦屋層群から *Heterodontus* sp. などの沿岸域を示す多くの板鰓類化石とともに *Hexanchus* 属の産出を報告しており、その中で、当時も含めて少なくとも中新世以前の *Hexanchus* 属は沿岸域に生息していたこと示唆している。備北層群においても例外ではなく、同じ層準から *Hexanchus* 属とともに *Pitar* sp. などの浅海性の軟体動物化石が多く認められた。

以上のことから、大観して本群集は温暖な沿岸域を示す群集と考えられる。

備北層群の堆積環境については、軟体動物、十脚甲殻類、底生有孔虫化石によって推定されている。それらの化石により推定されている古海況は本報告の板鰓類化石群集が示すそれとほぼ一致している。しかし、軟体動物や底生有孔虫の化石群集には寒冷種が認められており、それらは庄原地域に冷水塊が流入していたことを示している (氏家, 1976; 野村, 1988)。備北層群産の *Carcharhinus-Isurus-Carcharias* 群集に認められた *Cetorhinus* 属の現生種は、温帯～寒帯域に生息しており (Compagno, 1984a)、板鰓類化石においておそらく本属の産出が冷水塊の流入を支持するものと示唆される。

Systematic palaeontology

Class Chondrichthyes
Subclass Elasmobranchii
Superorder Squalomorpha
Order Hexanchiformis
Family Hexanchidae
Genus *Hexanchus* Rafinesque, 1810
Hexanchus sp.

(Pl. 1, Figs. 1-2)

Materials: All of the specimens are tooth fossils; 1 (Y-32) from Loc. 2, 2 (S-445, S-1102) from Loc. 3, 2 (Sip-12870, Sip-8593) from Loc. 4, 9 (Si 2-3700, Si 2-40542, Si 2-1117, Si 2-408, Si 2-4483, Si 2-1025, Si 2-4405, Si 2-24054, SiB-15623) from Loc. 5.

Description: Teeth large, 11 to 14 mm in height.

Upper teeth preserved in the main cusp, easy to break in cusplets and root; crown elongate, conical; the main cusp largest, distal cusplets smaller; lingual face of crown strongly convex, labial face of crown gently convex; mesial margin gently “S-shaped”, distal margin nearly straight; mesial margin with nine serrations; root thick, various in outline.

Lower teeth preserved nearly complete; all cusps inclined distally, the main cusp largest, distal cusplets smaller; lingual face of crown convex, labial face of crown flat or gently convex; mesial margin gently convex, distal margin nearly straight; mesial margin of main cusp with 20 clear serrations, distal margin of main cusp and both margins of cusplets smooth.

Remarks: *Hexanchus agassiz* described by Cappetta (1987) is different from the present species in regular distal cusplets with straight mesial margin. *Hexanchus microdon* reported by Uyeno *et al.* (1972) from the Cretaceous formations is different from the present species due to followings: (1) only six to seven cusps (2) the third cusp slightly longer than second one. *Hexanchus ehimensis* reported by Katto *et al.* (1977) from the Cretaceous in Ehime Prefecture is different from the present species due to followings: (1) cusp longer (2) cusp narrower. In the present genus, only two living species, *H. griseus* and *H. vitulus*, are reported. Lower teeth of *H. vitulus* are different from the present species in having larger main cusp. Some upper teeth resemble that of the present species. In this respect, there is a need for further study including comparison with present specimens. *H. griseus* resembles the present species in shape of the crown and root of the lower tooth. And also Cappetta (1987) suggested that *H. griseus* is synonym relation to the present species. There is a slight difference between the present species and *H. gigas* described by Karasawa (1989) in the serrations size of mesial margin.

Order Squaliformes

Family Squalidae

Subfamily Squalinae

Genus *Squalus* Linnaeus, 1758

Squalus sp.

Materials: All of the specimens are tooth fossils; 1 (N-1350) from Loc.1, 1 (S-1117) from Loc.3.

Description: Teeth small, 4.6 mm in height; crown low, wide and thick; cusp inclined distally; lingual face of crown gently convex, labial face of crown flat; labial face of crown

base with pronounced apron, basal process reaching to or over root base; mesial margin nearly straight, distal margin clearly notched; cutting edges finely serrated; root thick, rectangular in outline.

Remarks: The present genus is known from the Upper Cretaceous to Recent formations of the world (Cappetta, 1987). In Japan genus *Megasqualus* reported by Nomura *et al.* (1991) is different from the present specimens (teeth width; 4.6 mm) in having teeth width more than 10 mm.

Superorder Squatinomorphii

Order Squatiniformes

Family Squatinidae

Genus *Squatina* Dumeril, 1906

Squatina sp.

(Pl. 1, Fig.3)

Materials: All of the specimens are tooth fossils; 3 (N-2305, N-249, N-1158) from Loc.1, 1 (S-1103) from Loc.3, 1 (Sip-6728) from Loc.4, 2 (SiB-15642, Si 2-290) from Loc.5.

Description: Teeth small, 5 to 7 mm in height; cusp conical, thick, slender, erect and lingually curving; crown base horizontally spreads; lingual face of crown strongly convex, labial face of crown gently convex; labial face of crown with basal process; root horizontally spreads; lingual face of root convex stronger than that of crown, labial face of root nearly flat or gently concave; root base gently convex.

Remarks: The present genus is known from the Oligocene to Recent formations of the world (Cappetta, 1987). In Japan it has often been reported, but most of the specimens weren't identified to the level of species. The present specimens resemble the specimens from the Miocene formations (the Mizunami Group; Itoigawa *et al.*, 1985) and slightly differ from the specimens from the Pliocene or Pleistocene in the ratio of tooth height and width, and their oblique cusp scale. Teeth of the living species resemble to that of the Pliocene or Pleistocene formations rather than those from the Miocene beds.

Superorder Galeimorphii

Order Lamniformes

Family Odontaspidae

Genus *Carcharias* Agassiz, 1843

Carcharias acutissima Agassiz, 1843

(Pl. 1, Fig.5)

Materials: All of the specimens are tooth fossils; 9 (N-

10135, N-660, N-8346, N-9300, N-10701, N-8328, N-6982, N-7686, N-8327) from Loc.1, 1 (Ka-86) from Loc.2, 2 (S-1435, S-1046) from Loc.3, 36 (Sip-14617, Sip-10834, Sip-13003, Sip-10461, Sip-10232, Sip-10355, Sip-12815, Sip-10575, Sip-10895, Sip-15119, Sip-10118, Sip-5758, Sip-11050, Sip-14349, Sip-5609, Sip-8061, Sip-5265, Sip-84256, Sip-14745, Sip-12531, Sip-10016, Sip-5610, Sip-8592, Sip-11379, Sip-10715, Sip-12707, Sip-4968, Sip-6724, Sip-12196, Sip-6723, Sip-11081, Sip-11376, Sip-10469, Sip-15081) from Loc.4, 29 (Si 2-12905, Si 2-1825, Si 2-2144, Si 2-12906, Si 2-2571, Si 2-1384, Si 2-604, Si 2-1499, Si 2-3858, Si 2-3656, Si 2-3901, Si 2-4239, Si 2-1019, Si 2-1960, Si 2-947, Si 2-4211, Si 2-948, Si 2-1822, Si 2-1673, Si 3-12929, Si 2-4056, Si 2-1369, Si 2-4706, Si 2-4210, Si 2-1031, Si 2-3900, Si 2-645, Si 2-244, Si 2-12907) from Loc.5.

Description: Teeth slender with acute main cusp, 10 to 20 mm in height; crown elongates upward; anterior tooth crown narrower, thicker than lateral tooth; intermediate tooth narrower, thinner than anterior and lateral tooth; view of mesial margin curving lingually; lingual face of crown strongly convex, labial face of crown gently convex; lingual face of crown with striae elongating from crown base to middle; cutting edges smoothed, declined or disappeared around crown base; a pair of cusplet small, thick and labially curving; root high, thick; anterior tooth root cusp elongates downward without laterally spreading; lateral tooth root laterally spreading.

Remarks: The present species is known from the Oligocene to Pliocene formations of the world (Cappetta, 1987). *O. winkleri* from the Middle Eocene, Lutetian in Belgium (Cappetta, 1987) is distinguished from the present species in having wider crown base, cusplets larger, with no striae in the lingual face. *O. cuspidatus* reported by Bosch (1971) is different from the present specimens in having wider crown, lower root without clear division into two in the anterior tooth. In Japan the present species has been obtained from the Lower to Upper Miocene beds. *Odontaspis* sp. from the Upper Oligocene Ashiya Group (Uyeno *et al.*, 1984) has typical features in having striae in the lingual face and a pair of small cusplets. Therefore, the specimens from Ashiya Group should be identified as *C. acutissima*. *Odontaspis* sp. indet. (NSGR-V-2, NSGR-V-3) from the upper Lower Miocene to lower Middle Miocene Orito Formation (Kobayashi and Sasagawa, 1987) can be distinguished from the present species by the absence of striae. *O. taurus* from

the Pleistocene Shimosa Group (Naruse *et al.*, 1994) is with no striae, therefore is different from the present species. Recent *Odontaspidae* has no striae on the lingual face of crown.

Odontaspidae gen. et. sp. indet.

Materials: All of the specimens are tooth fossils; 2 (Sip-12213, Sip-13777) from Loc.4, 1 (Si 3-13067) from Loc.5.

Description: The specimens lack crown base, and root; teeth small, 8 (+) mm in height; cusp acutely erect and slender; lingual face of crown strongly convex, labial face of crown gently convex; lingual face of crown without striae; straight cutting edges without serrations.

Remarks: The present specimens resemble *Eugomphodus cuspidatus* and *O. volax* described by Karasawa (1989) with no striae on lingual face of crown. But it is difficult to identify precisely the present specimens which lack the crown base including cusplets and the root.

Family Lamnidae

Genus *Isurus* Rafinesque, 1810

Isurus hastalis (Agassiz, 1843)

(Pl. 2, Fig.3)

Materials: All of the specimens are tooth fossils; 2 (N-296, N-8343) from Loc.1, 3 (S-15660, S-1565, S-1308) from Loc.3, 1 (Sip-13738) from Loc.4, 13 (Si 2-591, Si 2-602, Si 2-1041, Si 2-1098, Si 2-1562, Si 2-1779, Si 2-1797, Si 2-1821, Si 2-3855, Si 2-3859, Si 2-8859, Si 3-10881, SiH-15583) from Loc.5.

Description: Teeth large, 14 to 35 mm in height.

Upper teeth isosceles triangular in outline; crown nearly erect or slightly inclined distally; lingual face of crown strongly convex, labial face of crown flat; cutting edges without serrations; both mesial and distal margins straight; root clearly divided in two; root base gently convex.

Lower teeth narrow, thick; cusp straightly elongates upward; root thick, rectangular in outline.

Remarks: The present species is known from the Oligocene to Pliocene formations of the world (Yabe and Hirayama, 1998). This species is distinguished from other species in having straight margins with broad tooth width.

Isurus desori (Agassiz, 1843)

(Pl. 3, Fig.1)

Materials: All of the specimens are tooth fossils; 6 (N-8345, N-8344, N-2316, N-423, N-8565, N-6399) from

Loc.1, 1 (S-910) from Loc.3, 30 (Si 2-1817, Si 2-1365, Si 2-510, Si 2-4047, Si 2-945, Si 2-653, Si 2-1864, Si 2-1315, Si 2-946, Si 2-227, Si 2-1113, Si 2-4689, Si 2-1383, Si 2-327, Si 2-573, Si 2-1173, Si 2-1069, Si 2-1945, Si 2-15519, Si 2-788, Si 2-640, Si 2-1588, Si 2-1958, Si 2-340, Si 2-4689, Si 2-385, Si 2-1097, Si 3-9035, Si 3-4789, SiH-15536) from Loc.5.

Description: Teeth large, 11 to 24 mm in height.

Upper teeth crown wide, thick, strongly inclined distally; lingual face of crown strongly convex, labial face of crown flat; cutting edges without serrations; mesial margin convex, distal margin strongly concave; root high, wide and thick; root unclear divided in two; root base gently convex.

Lower teeth large, 10 to 24 mm in height; crown wide, thick; cusp straight elongates upward; cutting edges straight around cusp, crown base horizontally spreading; root high, thick and clearly divided in two.

Remarks: This species is known from the Oligocene to Miocene formations of the world. The present species is different from *I. hastalis* with strongly inclined distal cusp, from *I. planus* in having narrower crown. The crown of Recent *I. oxyrinchus* is narrower and slenderer than the present species.

Isurus planus (Agassiz, 1856)

(Pl. 3, Fig. 2)

Materials: All of the specimens are tooth fossils; 1(S-1082) from Loc.3, 1(Si 2-3899) from Loc.5.

Description: Teeth large, 20 (+) mm in height; strongly inclined distally; outline of mesial margin labially curving around apex of cusp; crown thick, wide; lingual face of crown strongly convex, labial face of crown flat; cutting edges without serrations; mesial margin convex, distal margin strongly concave; root lacking.

Remarks: The present species is known from the Middle Miocene formations of Japan and America (Itoigawa *et al.*, 1985). The crown of the present species is wider than that of *I. desori* and distal inclination stronger than in *I. hastalis*. *Parotodus benedeni* is distinguished from the present species in having thicker crown.

Family Otodontidae

Genus *Carcharodon* Muller and Henle, 1838

Carcharodon megalodon Agassiz, 1843

(Pl. 2, Figs.1-2)

Materials: All of the specimens are tooth fossils; 1 (Ka-

315) from Loc.2, 1 (S-62) from Loc.3, 3 (Si 2-4242, Si 2-572, Si 2-1674) from Loc.5.

Description: Two upper anterior teeth, two lateral teeth are examined.

Upper anterior teeth large, about 50 mm in height; teeth acute triangular in outline; crown wide, thick; lingual face of crown strongly convex, labial face of crown flat or gently concave; cutting edges coarsely serrated, serration size regular; mesial and distal margins straight or gently concave; lingual face of crown with clear cervical band an isosceles triangular in outline; root high, thick, clearly divided in two. Lateral teeth large, 10 to 20 mm in height; crown low, wide and thick; lingual face of crown strongly convex, labial face of crown flat or gently convex; unclear cervical band; root rectangular unclear divided in two.

Remarks: The present species is known from the Miocene to Pliocene formations of Japan (Yabumoto and Uyeno, 1994). It is different from *C. angustidens* and *C. auriculatus* due to absence of lateral cusplets, from *C. carcharias* in having clear cervical band, larger crown size.

Family Alopiidae

Genus *Alopias* Rafinesque, 1810

Alopias sp.

Materials: All of the specimens are tooth fossils; 3 (N-8337, N-8339, N 2307) from Loc.1, 1 (S-1068) from Loc.3, 2 (Sip-14626, Sip-10234) from Loc.4, 2 (Si 2-1075, Si 2-4697) from Loc.5.

Description: Teeth small, about 5 mm in height; crown slender with acute cusp, inclined distally without curving; crown base horizontally spreads; lingual face of crown convex, labial face of crown flat or gently convex; cutting edges without serrations, smoothed from apex to middle of crown; mesial margin nearly straight, gently concave around crown base; distal margin strongly concave; root wide, thick; root high for tooth size; root base gently convex.

Remarks: The present genus is known from the Mizunami Group (Itoigawa *et al.*, 1985) in Japan. Itoigawa *et al.* (1985) described *Alopias* cfr. *latidens*, *Alopias* sp. and *Alopias* cfr. *exigua* from the Mizunami Group. The crown of *A. cfr. latidens* and *Alopias* sp. is wider than that of the present specimens. And it is different from *A. cfr. exigua* in crown shape.

Family Cetorhinidae

Genus *Cetorhinus* Blainville, 1816

Cetorhinus sp.

(Pl. 1, Fig.4)

Materials: All of the specimens are gill raker fossils; 5(N-430, N-9799, N-10138, N-6926, Na-459) from Loc.1, 1(K-24) from Loc.2, 1(S-17) from Loc.3.

Description: Gill raker thin and large, 15(+) mm in length; like a fishhook in outline; the specimens easy to break; in the curve point, slightly wide.

Remarks: The present genus is known from the Eocene to Recent formations (Cappetta, 1987). *Cetorhinus* sp.1 reported from the Mizunami Group (Itoigawa *et al.*, 1985) resembles the present specimens in the shape of the curve point. Therefore, they are identified as the same species. The shape of curve point is different between the present species and living *Cetorhinus maximus*. However, the shape of curve point varies by its position on the gill arch (Uyeno and Matsushima, 1974). Therefore, fossil specimens need to be compared with the Recent specimen.

Order Carcharhiniformes

Family Hemigaleidae

Genus *Hemipristis* Agassiz, 1843

Hemipristis serra Agassiz, 1843

(Pl. 3, Fig.3)

Materials: All of the specimens are tooth fossils; 3 (N-8324, N-2301, N-2306) from Loc.1, 2 (Si 3-10950, Si 2-4693) from Loc.5.

Description: Teeth large, 13 to 20 mm in height.

Upper teeth crown thin, triangular in outline, inclined distally in apex to middle of cusp; lingual face of crown gently convex, labial face of crown flat or gently concave; mesial margin convex, distal margin concave; both cutting edges clearly serrated, in particular serrations of distal margin larger than that of mesial margin.

Lower teeth slender, cusp elongates upward; lingual face of crown strongly convex, labial face of crown flat or gently convex; labial face of crown base divided in two along root; cutting edges clear from apex to base of cusp, disappear in crown base; both laterals of crown base having a pair of or two pairs of small cusplets; root high, thick and apex of root clearly elongates downward; lingual face of root strongly convex, labial face of root gently concave.

Remarks: The present species is known from the Middle to Late Miocene formations (Yabumoto and Uyeno, 1994; Yabe and Hirayama, 1998). The present genus has *H. curvatus*, *H. serra* and *H. elongatus*. Recent *H. elongatus* is

different from the present species in having narrower crown. The Eocene *H. curvatus* is different from the present species in serrations shapes of the mesial margin.

Family Triakidae Gray, 1851

Genus *Galeorhinus* Blainville, 1816

Galeorhinus sp.

Materials: All of the specimens are tooth fossils; 2 (N-1364, N-2459) from Loc.1, 1 (Si 2-2146) from Loc.5.

Description: Teeth small, 3 mm in height; root lacking; cusp strongly inclined distally; lingual face of teeth obscured with rock; labial face of crown flat; mesial margin straight, distal margin with a notch, coarse serrations in crown base.

Remarks: The present genus is known from the Upper Cretaceous to Recent formations of the world (Cappetta, 1987). *G. latus* reported by Bosch (1971) is different from the present specimens in having wide crown and fine serrations. *Galeorhinus* sp. from the Upper Miocene Senhata Formation (Yabe and Hirayama, 1998) is different from the present specimens in having longer main cusp. The present specimens resemble *G. affinis* from the Lower Miocene Mizunami Group (Itoigawa *et al.*, 1985). But it was difficult to identify species because of lingual face of crown being covered with rock.

Family Carcharhinidae

Genus *Galeocerdo* Muller and Henle, 1837

Galeocerdo aduncus Agassiz, 1843

(Pl. 3, Fig.4)

Materials: All of the specimens are tooth fossils; 3 (N-659, N-216, N-217) from Loc.1, 1 (Y-328) from Loc.2, 10 (Si 2-395, Si 2-3856, Si 3-11728, Si 2-603, Si 2-4240, Si 2-4212, Si 2-446, Si 2-2071, Si 2-3894, Si 2-3921) from Loc.5.

Description: Teeth large, 10 to 13 mm in height; tooth triangular in outline; crown high, moderately thick, cusp wide, inclined distally; lingual face of crown convex, labial face of crown flat; mesial margin gently "S-shaped", distal margin with a notch; cutting edges with clear serrations; root high, moderately thick and gently divided in two; crown base convex.

Remarks: The present species is known from the Lower Oligocene to Pliocene formations of the world (Cappetta, 1987). *G. contortus* is different from this species in having slender, twisted crown (Kent, 1994). It is different from *G. cuvier* in having smaller, narrower cusp (Kent, 1994).

Genus *Carcharhinus* Blainville, 1816*Carcharhinus* spp.

(Pl. 3, Figs.5–6)

Materials: All of the specimens are tooth fossils; 28 (N-125, N-8084, N-2173, N-5018, N-5898, N-650, N-8335, N-7249, N-7559, N-2104, N-8332, N-1171, N-8338, N-6489, N-8596, N-8877, N-10169, N-13, N-659, N-4195, N-7482, N-7594, N-1170, N-1279, N-8341, N-8869, N-8336, N-8340) from Loc.1, 6 (Ka-128, Ka-149, Ka-125, Ka-319, Y-137, Y-321) from Loc.2, 3 (S-290, S-1116, S-772) from Loc.3, 14 (Sip-7329, Sip-11765, Sip-10468, Sip-10926, Sip-14885, Sip-9198, Sip-12533, Sip-13759, Sip-12692, Sip-13495, Sip-13776, Sip-10470, Sip-12696, Sip-11927) from Loc.4, 34 (Si 2-4482, Si 2-3857, Si 2-348, Si 2-4826, Si 2-4214, Si 2-3958, Si 2-4537, Si 2-2749, Si 2-952, Si 2-953, Si 2-1207, Si 2-4404, Si 2-1820, Si 2-4320, Si 2-1015, Si 2-4049, Si 2-4686, Si 2-4710, Si 2-4481, Si 2-605, Si 2-4687, Si 2-2031, Si 2-1961, Si 2-4217, Si 2-4319, Si 2-4538, Si 2-9984, Si 3-4790, Si 2-1126, Si 3-12931, Si 2-1018, Si 2-3774, Si 2-291, Si 3-12991) from Loc.5.

Description: Teeth moderate, about 15 mm in height.

Upper teeth high, wide, thin and triangular in outline; lingual face of crown convex, labial face of crown flat; mesial margin gently “S-shaped”, distal margin concave; cutting edges serrated, particularly coarse around base; root high, wide; root base convex.

Lower teeth with slender, erect or slightly inclined distally; lingual face of crown convex, labial face of crown gently convex; cutting edges finely serrated; root low, wide and thick; root base nearly straight.

Remarks: The present genus is known from the Middle Eocene to Recent formations of the world (Cappetta, 1987). This genus has 29 living species. Their teeth resemble each other. In condition of isolated occurrence, it is difficult to distinguish from each species.

Family Sphyrnidae Gill, 1872

Genus *Sphyrna* Rafinesque, 1810*Sphyrna* spp.

Materials: All of the specimens are tooth fossils; 5 (N-4209, N-5531, N-8325, N-8326, N-8333) from Loc.1, 3 (Si 2-2539, Si 2-462, Si 2-1116) from Loc.5.

Description: Teeth moderate, 7 to 10 mm in height; crown width varied, moderately thick; cusp strongly inclined

distally; crown base horizontally spreads; lingual face of crown convex, labial face of crown flat; mesial margin gently concave, distal margin clearly notched; cutting edges smooth without serrations; root low, wide and similar to that of *Carcharhinus*.

Remarks: The present genus is known from the Lower Miocene to Recent formations of the world (Cappetta, 1987). The present specimen is different each other in cusp width and apex direction of the cusp. Therefore, the *Sphyrna* species from the Bihoku Group would include more than one species. Around sea of Japan, 3 species are known; *S. zygaena*, *S. lewini* and *S. mokarran*. Adult teeth of these species differ from the present specimens in having serrations.

Superorder Batoidea

Order Myliobatiformes

Superfamily Dasyatoidea

Family Dasyatidae

Genus *Dasyatis* Rafinesque, 1810*Dasyatis* sp.

Materials: All of the specimens are tooth fossils; 1 (N-unfound) from Loc.1, 9 (Si 2-4705, Si 2-11729, Si 2-unfound) from Loc.5.

Description: Teeth small, 2 mm in width; upper outline of crown rhombic, oval or circular; in lingual face of tooth, root exposed, in labial face of tooth, crown covered; root lacking or covered by rock.

Remarks: The present genus is known from the Upper Cretaceous to Recent formations of the world (Cappetta, 1987). Having the characteristic tooth shape of Batoidea, this genus is easy to identify as *Dasyatis*. But it is difficult to identify species. Most of the described specimens have not been identified to species level.

Superfamily Myliobatoidea

Family Myliobatidae

Genus *Aetobatus* Blainville, 1816*Aetobatus* sp.

(Pl.3, Fig.7)

Materials: All of the specimens are tooth fossils; 1 (N-5934) from Loc.1, 1 (Sip-10791) from Loc.4, 1 (Si 2-3895) from Loc.5.

Description: Arched teeth large, long, wide, thin and 25 mm in width; tooth lateral edges gently curving, rounded; crown surface smoothed, flat; root with about 30 parallel grooves,

broad, deep and clear.

Remarks: The present genus is known from the Upper Paleocene to Recent formations of the world (Cappetta, 1987). In Japan the present genus has been obtained from the Oligocene to lower Middle Miocene formations. The present specimens are assigned to *Aetobatus* in having arched crown and rounded tooth edges. Upper teeth specimens of *Aetobatus arcuatus* described by Okumura *et al.* (1994) were identified with the present specimens in having the gently curving lateral edges. But it is different from the present specimens with wider tooth. Lower tooth of Recent *A. narinari* is more strongly curved than the present specimens.

Genus *Myliobatis* Cuvier 1817

Myliobatis sp.

(Pl.3, Fig.8)

Materials: All of the specimens are tooth fossils; 2 (N-14, N-7777) from Loc.1, 3 (Si 3-10103, Si 3-11566, Si 2-4628) from Loc.5.

Description: Teeth small, 30 mm in width; tooth shape hexagonal; tooth thick, cervical band and root piled parallel; crown surface smooth, flat or gently convex; cervical band thin, unclear; root thick with parallel grooves.

Remarks: The present genus is known from the Lower Paleocene to Recent formations of the world (Cappetta, 1987). The present specimen shows diagnostic characters of the genus *Myliobatis* which is a long, narrow and hexagonal tooth. This genus contains about 150 nominal fossil species (Cappetta, 1987). But the present specimens are imperfectly preserved. It is difficult to identify the species based on the imperfectly preserved.

Family Rhinopteridae

Genus *Rhinoptera* Cuvier, 1829

Rhinoptera sp.

(Pl.3, Fig.9)

Materials: All of the specimens are tooth fossils; 16 (N-1125, N-9389, N-816, N-273, N-255, N-847, N-10458, N-283, N-9686, N-2356, N-unfound, N-733, N-655, N-603, N-14, N-7777) from Loc.1, 1 (Ka-87) from Loc.2, 2 (S-1046, S-1274) from Loc.3, 10 (Si 3-12930, Si 3-10102, Si 2-4172, Si 2-4321, Si 2-4173, Si 2-4237, Si 2-4675, 4676, Si 3-10103, Si 3-11566, Si 2-4628) from Loc.5.

Description: Teeth large, about 15 mm width; crown wide, hexagonal in outline and without curving; crown surface flat

or gently convex, smoothed; cervical band thin, unclear; root with about 20 parallel grooves, wide and rectangular in outline.

Remarks: The present genus is known from the Paleocene to Recent formations of the world (Cappetta, 1987). This genus has been reported from the Mizunami Group (*Rhinoptera* sp.: Itoigawa *et al.*, 1985) and the Sekinobana Formation (*Rhinoptera* sp.: Karasawa, 1989) in Japan. They are identified with the present specimens in crown shape. This genus resembles specimens of *Myliobatis*, but it is different from *Myliobatis* in having longer and less wider crown (Cappetta, 1987).

caudal spine, Batoidea

Materials: All of the specimens are caudal spine fossils; 5 (N-7475, N-603, N-10234, N-653, N-2355) from Loc.1, 1 (K-82) from Loc.2, 1 (Si 2-4675, 4676, Si 3-257) from Loc.5.

Description: Shaft slender, gradually tapering, about 160 mm in maximum length; shaft nearly straight; anterior shaft relatively wide, flat with rounded edge; dorsal face of anterior shaft nearly flat, with maximum 16 narrow longitudinal ridges; ventral face of anterior shaft nearly flat or gently concave, with maximum 8 narrow longitudinal ridges; posterior shaft narrow with acutely edge; dorsal face of posterior shaft nearly flat, with narrow longitudinal ridges; ventral face of posterior shaft strongly convex, with wide, deep longitudinal ridges; sides of shaft with anteriorly directed denticles, about 8 to 10 per 10 mm; each denticle conical, acutely apex.

Remarks: The caudal spine of order Myliobatiformes have not been reported much in Japan. The present specimen is different from the caudal spine of "*Dasyatis*" *nipponesis* from the Mizunami Group reported by Itoigawa *et al.* (1985) in having more rounded anterior edge of shaft.

ま と め

1. 庄原地域に分布する備北層群から 15 科 17 属 17 種の板鰓類化石を認めた。
2. 備北層群産の板鰓類化石における属の組み合わせをもとに *Carcharhinus-Isurus-Carcharias* 群集が認められた。
3. 本群集を構成する属の多くは、現生においても認められる。現生属の生息環境および板鰓類化石とともに産出した軟体動物化石などのデータをもとに検討した結果、本群集の示す古海況は温暖な沿岸域と推定された。

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Explanation of Plate

Plate 1

1 a-b *Hexanchus* sp. Si 2-4483

lower tooth a: lingual xiew b: labial view

2 a-b *Hexanchus* sp. Y-32

upper tooth a: lingual xiew b: labial view

3 a-b *Squatina* sp. N-2305

a: lingual xiew b: labial view c: mesial view

4 *Cetorhinus* sp. K-24

5 a-c *Carcharias acutissima* Si 2-1396

a: lingual xiew b: labial view c: mesial view

Scale bar: 1 cm

Plate 1

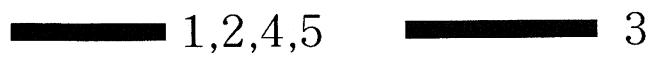
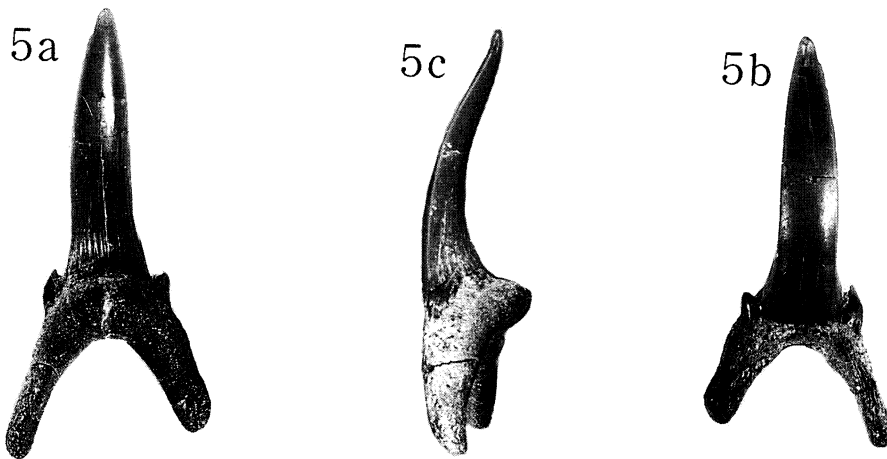
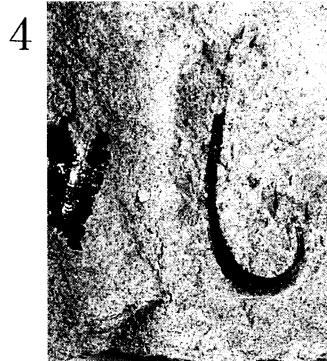
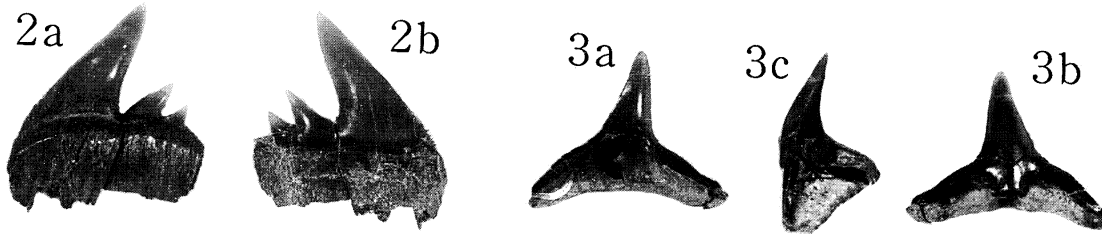


Plate 2

1 a-c *Carcharodon megalodon* Ka-315

a: lingual view b: labial view c: mesial view

2 a-c *Carcharodon megalodon* Si 2-572

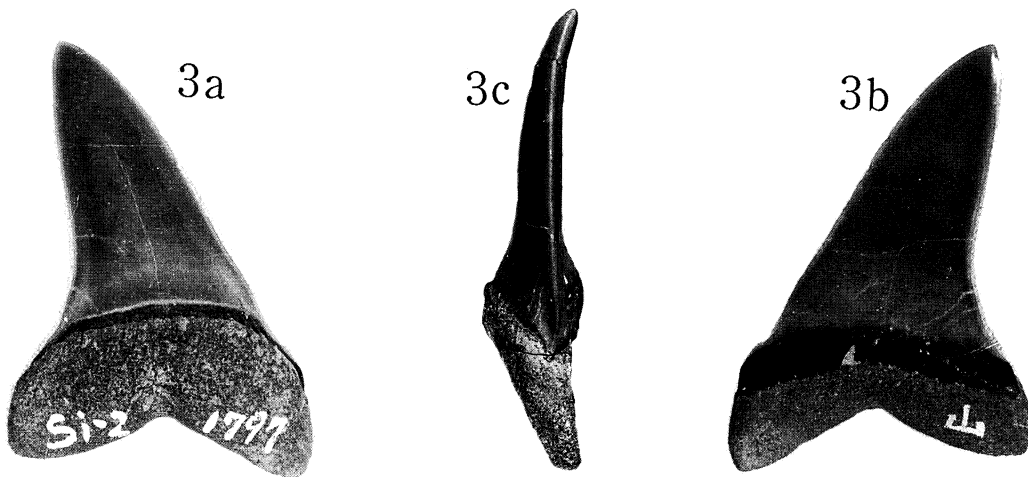
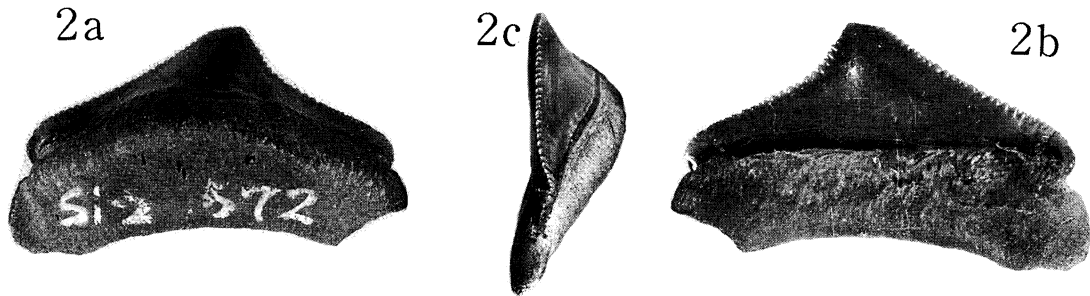
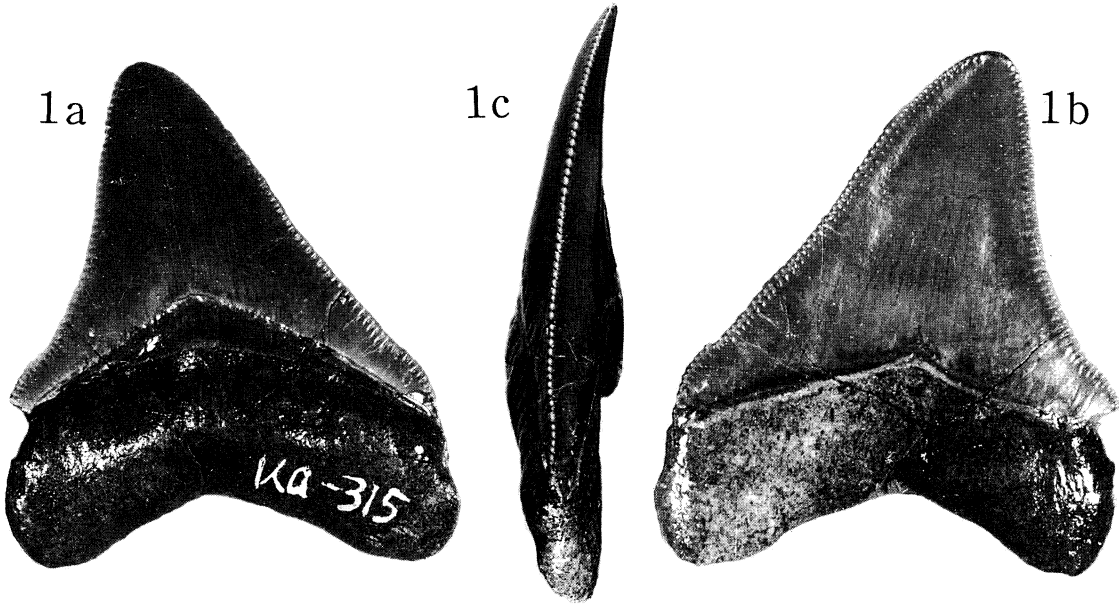
a: lingual view b: labial view c: mesial view

3 a-c *Isurus hastalis* Si 2-1797

a: lingual view b: labial view c: mesial view

scale bar: 1 cm

Plate 2

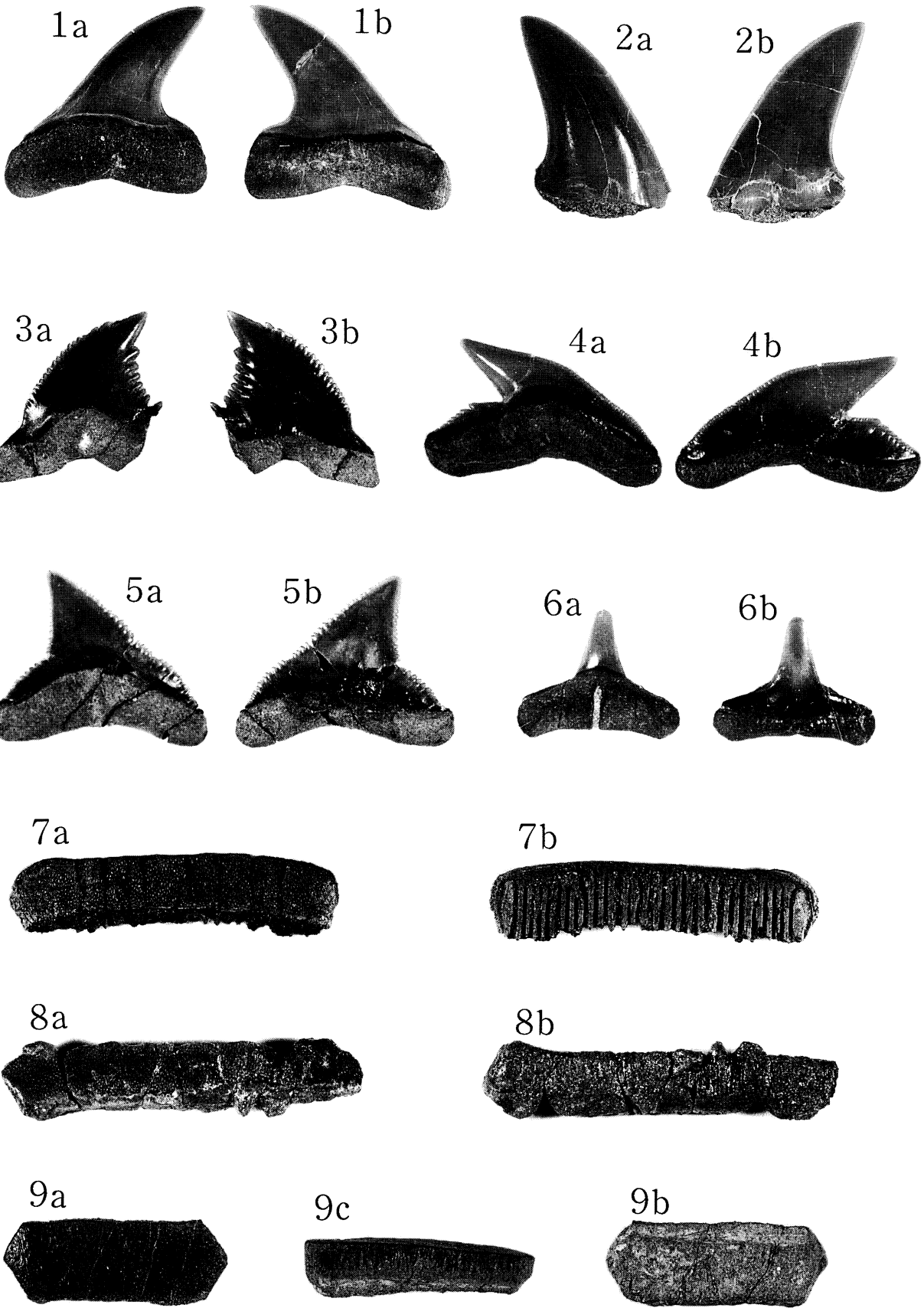


— 1,2,3

Plate 3

- 1 a-b *Isurus desori* Si 3-9035
a: lingual view b: labial view
- 2 a-c *Isurus planus* Si 2-38996
a: lingual view b:labial view
- 3 a-b *Hemipristis serra* N-8324
a: lingual view b: labial view
- 4 a-c *Galeocerdo aduncus* Ne-332
a: lingual view b: labial view
- 5 a-b *Carcharhinus* spp. N-105760
upper tooth a: lingual view b: labial view
- 6 a-b *Carcharhinus* spp. Si 2-605
lower tooth a: lingual view b: labial view
- 7 a-b *Aetobatus* sp. Si 2-3859
a: occlusal view b: basal view
- 8 a-c *Myliobatis* sp. N-1125
a: occlusal view b: basal view
- 9 a-b *Rhinoptera* sp. M-85
a: occlusal view b: basal view c: profile view
- scale bar: 1 cm

Plate 3



1,2,7,8,9 3,4 5,6