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浙江和江西二叠/三叠系界线以下的软骨鱼类微体化石——华南二叠/三叠系界线上下鱼类序列研究之五[1)]

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摘要:记述了浙江长兴县煤山剖面、江西修水县四都乡东岭剖面和信丰县铁石口镇铁石口剖面二叠/三叠系界线以下的软骨鱼类10个类别的微体化石,包含5科6属5种,其中有3新属5新种,它们是:刘氏煤山鲨(*Meishanselache liui* gen. et sp. nov.)、王氏长兴鲨(*Changxingselache wangi* gen. et sp. nov.)、东岭中华尖齿鲨(*Sinacrodus donglingensis* gen. et sp. nov.)、修水滑齿鲨(*Lissodus xiushuiensis* sp. nov.)和江西多尖齿鲨(*Polyacrodus jiangxiensis* sp. nov.)。浙、赣两省的这批软骨鱼类微体化石显示两个特点:组成以弓鲛超科化石为主;发现于特提斯区三叠纪的鲨类与发现于中国南方晚二叠世的鲨类具有密切的亲缘关系。这是包含全球二叠/三叠系界线层型剖面和点位(GSSP)在内的全球二叠/三叠系界线以下软骨鱼类微体化石序列的首次报道。软骨鱼类是我国鱼类化石研究中最为薄弱的一个环节,本文化石的记述大大地填补了这个薄弱环节。

关键词:浙江,江西,二叠/三叠系界线,软骨鱼类微体化石

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1 前 言

二叠/三叠系界线也是古生界与中生界的分界,所以有条件的国家都积极争取拿下在层型剖面研究中最有份量的二叠/三叠系界线层型剖面和点位(GSSP)这枚"金钉子"。浙江长兴煤山D剖面最终在2001年由国际地质科学联合会批准作为全球二叠/三叠系界线层型剖面和点位(Yin et al., 2001)。

与长兴煤山剖面和其周边地区二叠/三叠系界线层上下无脊椎动物化石的研究相比,界线层上下鱼类化石的研究更需要加强。这是因为,它们既是剖面中脊椎动物的惟一代表,分类位置肯定;同时也是剖面中惟一既存在大化石又存在微体化石的门类。另外,

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界线研究应当是高精度的,牙形类被公认为处于主导地位,而鱼类微体化石常常与牙形类一起产出,煤山剖面主要层段(界线层 1、2 和 3)也不例外(Wang, 1995; Wang and Wang, 2003)。所以应该强化二叠/三叠系界线层上下鱼类,特别是界线层中鱼类微体化石的研究,它们包含软骨鱼类和辐鳍鱼类。

以往对华南二叠/三叠系界线层上下软骨鱼类化石的研究仅有两篇报道,一篇是对晚二叠世长兴组煤山段底部鱼类大化石的研究(Liu and Chang, 1963),另一篇是对早三叠世罗楼组弓鲛类和多尖齿鲨类微体化石的研究(Wang et al., 2001)。

本文对浙江长兴煤山剖面(Wang, 1995; Yin et al., 2001)、江西修水东岭剖面和信丰铁石口剖面(Zhu et al., 1998)等二叠/三叠系界线以下的软骨鱼类微体化石进行了描述。

由于篇幅的关系,辐鳍鱼类及相关的绝灭、复苏和辐射的讨论将另文发表。

2 标本记述

软骨鱼纲 Chondrichthyes Huxley, 1880

板鳃鲨亚纲 Elasmobranchii Bonaparte, 1838

目、科未定 Order and Family incertae sedis

煤山鲨(新属)*Meishanselache* gen. nov.

属型种 *Meishanselache liui* gen. et sp. nov. 。

特征 同属型种。

词源 Meishan,化石产地;selachos(G)希腊语,鲨类。

刘氏煤山鲨(新属、新种)*Meishanselache liui* gen. et sp. nov.

(图 1、2)

正型标本 一枚完整的皮质鳞突(dermal denticle)[1],中国科学院古脊椎动物与古人类研究所标本编号:IVPP V 14535.1。

标本 3 枚完整的皮质鳞突,IVPP V 14535.2~4。

产地与层位 浙江长兴煤山 D 剖面;晚二叠世长兴组煤山段底部,层位号:Cx-1~4。

特征 皮质鳞突冠部小,具数目不等、大小不一的小突起,小突起具向突起顶端方向会聚的细脊纹;基部大且厚呈块状,基部腹面具一小的髓孔。

词源 种名赠予中国已故的古鱼类学家刘宪亭先生。

描述 正型标本侧视呈椭圆形,冠部具 12 个大小不一的长方形或圆形小突起,每个小突起均具向突起顶端方向会聚的细脊纹;基部呈多边形,比冠部明显大,厚实呈块状,基部腹面具一小的髓孔。其他标本与正型标本的不同仅在于冠部小突起的多少和形状,以及皮质鳞突的大小。V 14535.2 最大,V 14535.3 的小突起呈小的尖锥状,V 14535.4 冠部仅有 2 个小突起。标本测量见表 1。

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1)皮质鳞突(dermal denticles)系指不同于典型的软骨鱼鳞片的一些形状特殊的鳞状突起,一般分布于软骨鱼头部。

表 1　刘氏煤山鲨(新属、新种)标本测量

Table 1　Mesurements of the specimens of *Meishanselache liui* gen. et sp. nov.　(mm)

标本 Specimen	冠部长 length of crown	冠部高 height of crown	基部长 length of base	基部高 height of base
V 14535.1	0.6	0.1	0.9	0.4
V 14535.2	1.0	0.1	1.7	0.7
V 14535.3	0.3	0.1	0.4	0.2
V 14535.4	0.4	0.07	0.6	0.2

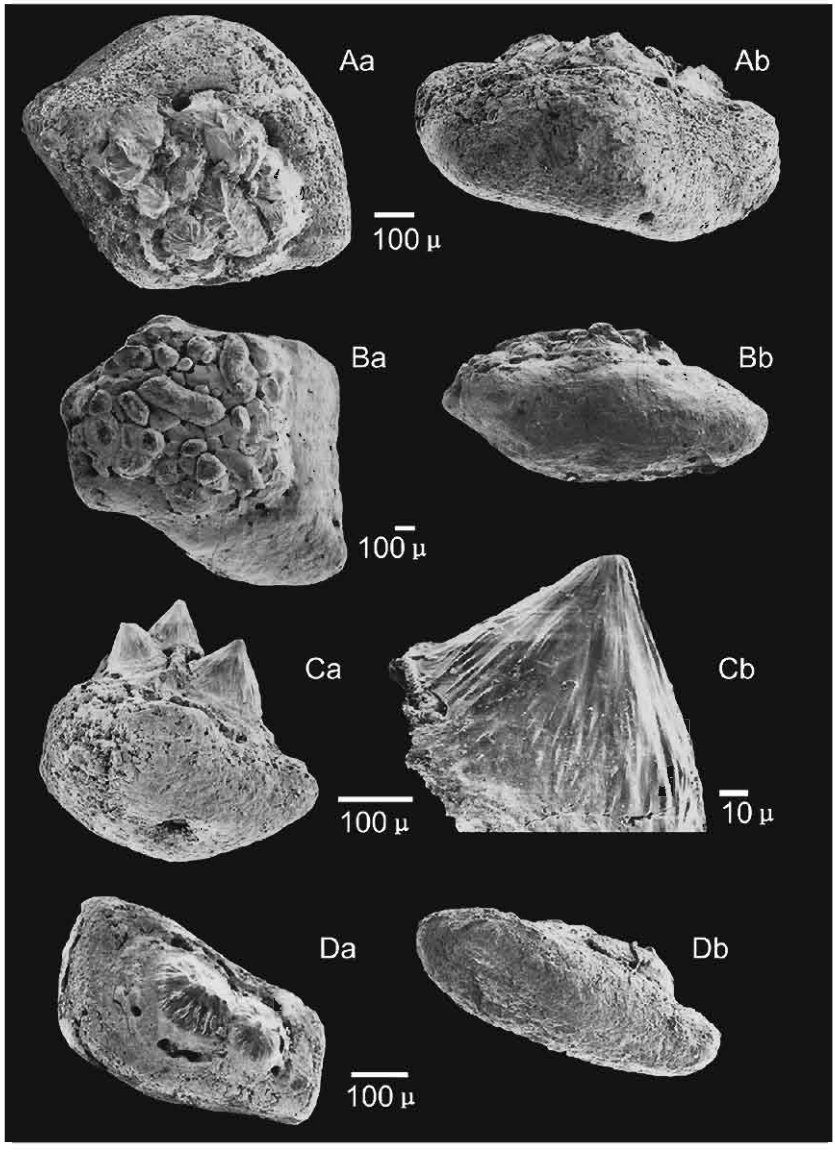

图 1　刘氏煤山鲨(新属、新种)皮质鳞突

Fig. 1　Dermal denticles of *Meishanselache liui* gen. et sp. nov.

A. V 14535.1, 正型标本 holotype; B ~ D. V 14535.2 ~ 4

Aa, Ba, Da. 冠视 in crown view; Ab, Bb, Ca, Db. 侧视 in lateral view; Cb. Ca 的局部放大 detail of Ca

比较 依据冠部构造、基部形状和具一髓孔等特征,本文记述的这类皮质鳞突应属于板鳃鲨类。但迄今尚未发现可资比较的化石记录,故而将其作为板鳃鲨亚纲中目、科未定的新属种——刘氏煤山鲨(*Meishanselache liui* gen. et sp. nov.)。

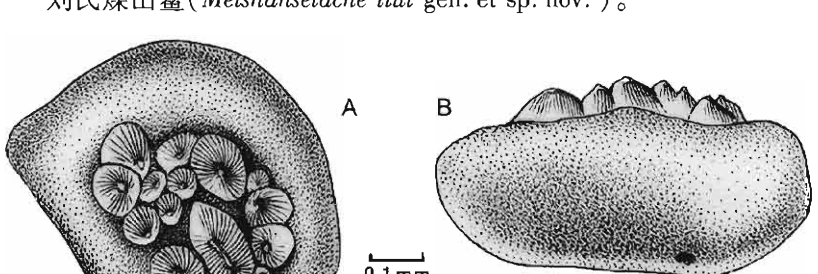

图 2 刘氏煤山鲨(新属、新种)皮质鳞突,正型标本复原

Fig. 2 Restoration of the dermal denticle of *Meishanselache liui* gen. et sp. nov., V 14535.1, holoytpe
A. 冠视 in crown view; B. 侧视 in lateral view

长兴鲨(新属)*Changxingselache* gen. nov.

属型种 *Changxingselache wangi* gen. et sp. nov.。

特征 同属型种。

词源 Changxing,化石产地所在县名;selachos(G)希腊语,鲨类。

王氏长兴鲨(新属、新种)*Changxingselache wangi* gen. et sp. nov.

(图 3、4)

正型标本 一枚完整的皮质鳞突,IVPP V 14536.1。

标本 3 枚完整的皮质鳞突,IVPP V 14536.2~4。

产地与层位 浙江长兴煤山 D 剖面;V 14536.1~2 产自长兴组下段(葆青段),层位号为 Act126;V 14536.3~4 产自长兴组上段(煤山段),层位号分别为长兴 39 和 Act232。

特征 皮质鳞突小,区分为冠部和基部。冠部由几乎平行、呈刀片状的细脊纹构成,细脊纹向后形成一共同的后壁或延伸呈棘刺状。基部比冠部大,大致呈圆盘形,腹面凹入,凹入处可见几个髓孔。

词源 种名赠予中国牙形类专家王成源先生。

描述 皮质鳞突小,区分为冠部和基部。正型标本冠部长 0.3 mm,基部长 0.3 mm。冠部由几乎平行的刀片状发育的细脊纹构成,脊纹向后形成一共同的后壁或延伸呈棘刺状。V 14536.1 具 4 条发育的细脊纹;V 14536.2 具 4 条发育的脊纹和 1 条不太发育的细脊纹;V 14536.3 具 5 条发育的细脊纹,其中中央的一条较短。以上 3 个皮质鳞突各自的脊纹向后延伸形成各自的后壁。V 14536.4 具 3 条发育的细脊纹和 1 条不太发育的细脊纹,这些脊纹向后延伸呈棘刺状。基部比冠部大,大致呈圆盘形,腹面凹入。腹面凹入处具数目不等的髓孔,V 14536.1 有 5 个髓孔,V 14536.2 具 3 个髓孔,V 14536.3 基部较大

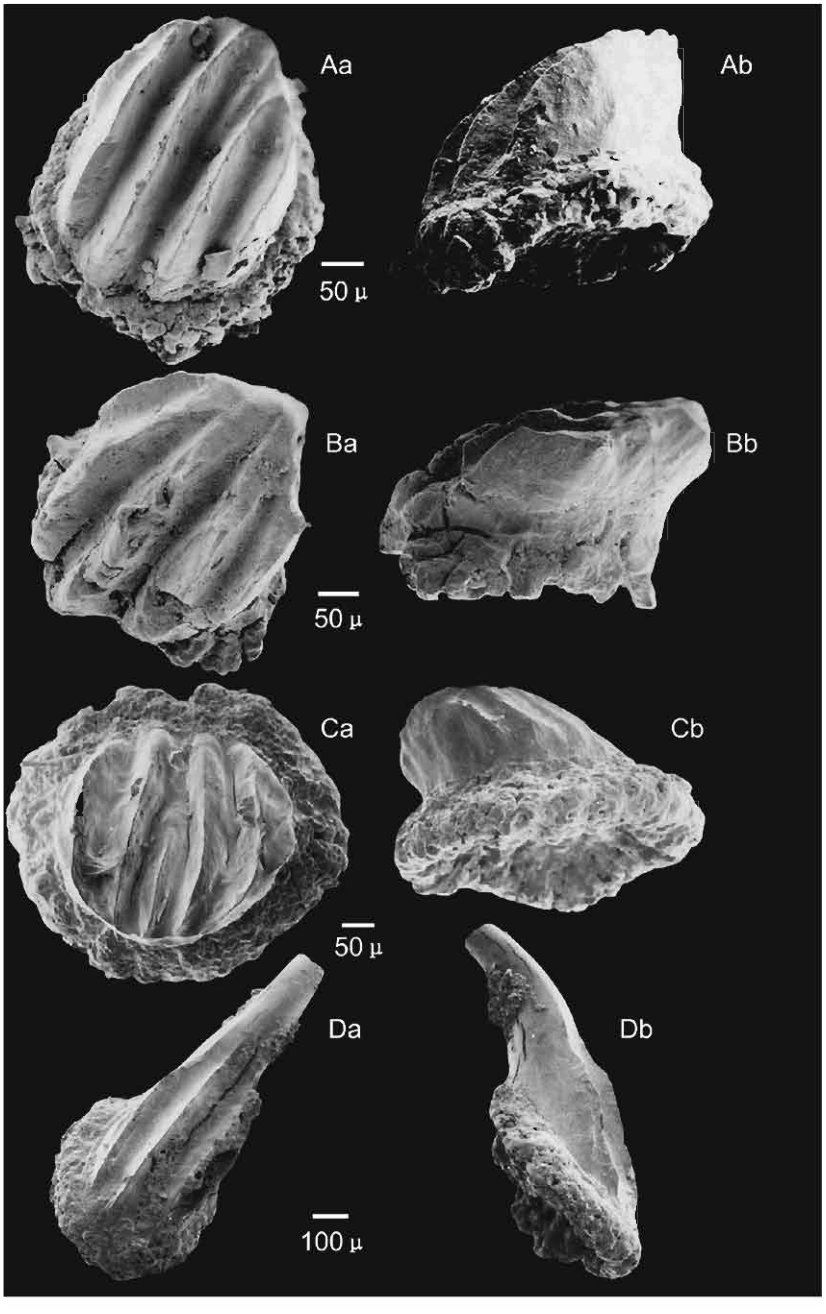

图 3　王氏长兴鲨(新属、新种)皮质鳞突
Fig. 3　Dermal denticles of *Changxingselache wangi* gen. et sp. nov.
A. V 14536.1, 正型标本 holotype; B ~ D. V 14536.2 ~ 4
Aa, Ba, Ca, Da. 冠视 in crown view; Ab, Bb, Cb, Db. 侧视 in lateral view

具 4 个髓孔,V 14536.4 具一个大的髓孔。

比较　依据皮质鳞突的结构,本文记述的这类皮质鳞突应归入板鳃鲨类。就冠部形

态而言,它们与产自玻利维亚晚白垩世的 *Rucabatis* 有某些相似之处(Cappetta, 1975),但基部构造相差甚远。此外,V 14536.4 与产自加拿大哥伦比亚地区中晚三叠世的 *Parvidiabolus obliqnus*(Johns et al., 1997)有某些相似之处,比如皮质鳞突长,后部延伸呈棘突状;但新标本与后者又存在明显的区别,比如冠部脊纹发育,呈刀片状且互相平行,基部呈圆盘状,中央凹入。因此,我们将本文记述的这类皮质鳞突作为目、科未定的一类新的鲨类化石——王氏长兴鲨(新属、新种)(*Changxingselache wangi* gen. et sp. nov.)。

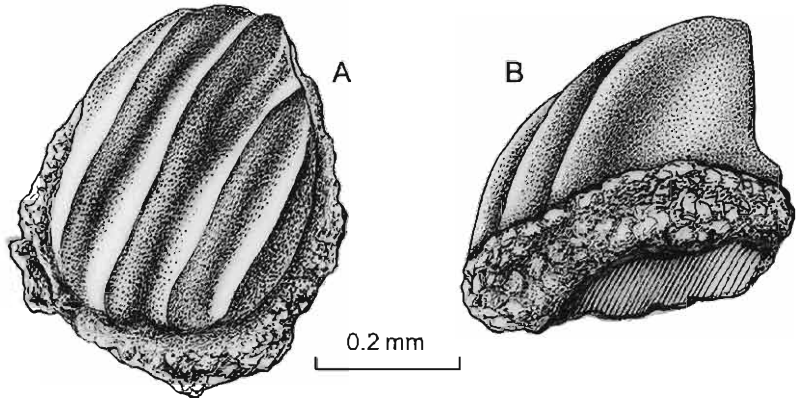

图 4 王氏长兴鲨(新属、新种)皮质鳞突,正型标本复原

Fig. 4 Restoration of the dermal denticle of *Changxingselache wangi* gen. et sp. nov., V 14536.1, holotype
A. 冠视 in crown view; B. 侧视 in lateral view

真鲨类 Euselachii Hay, 1902

栉棘鲨超科 Ctenacanthoidea Zangerl, 1981

栉棘鲨科 Ctenacanthidae Dean, 1909

栉棘鲨科(属种未定) Ctenacanthidae gen. et sp. indet.

(图 5)

标本 一枚完整的鳞片,IVPP V 14537。

产地与层位 浙江长兴煤山 D 剖面;长兴组下段(葆青段),层位号:Act133。

描述 鳞片小,长 0.5 mm,宽 0.5 mm。由冠部、颈部和基部三部分构成。冠部薄,表面具 5 条细脊纹,其中 4 条在前部二分叉;中间一条比其他 4 条靠前,前部三分叉。鳞片向后弯曲与基部几乎平行。鳞片冠部腹面呈 3 条宽脊纹状。颈部明显,颈后具 2 个明显颈孔。基部大致呈斜菱形,略凸出,中央是一小的髓孔。

比较 本文记述的这种鳞片与产自我国湖南锡矿山晚泥盆世的栉棘鲨(*Ctenacanthus* sp.)(Lelièvre and Derycke, 1998)有某些相似处,比如冠部具脊纹、脊纹前二分叉或三分叉等。但新标本的脊纹数目少于栉棘鲨,因而不能归入该属。由于目前仅有一枚鳞片标本,我们将其作为栉棘鲨科未定属种(Ctenacanthidae gen. et sp. indet.)。

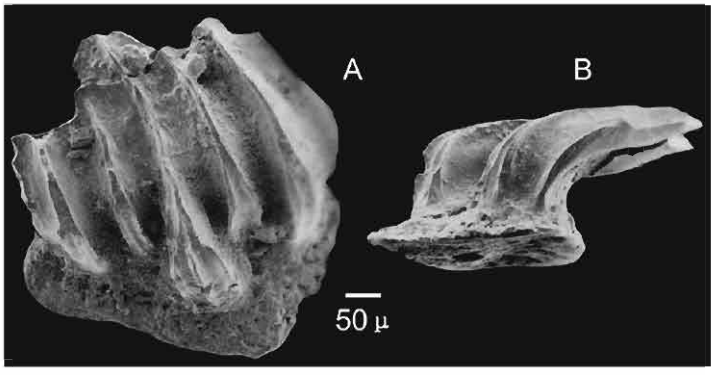

图 5　栉棘鲨科(属种未定),一枚完整鳞片

Fig. 5　A scale of Ctenacanthidae gen. et sp. indet, V 14537

A. 冠视 in crown view; B. 侧视 in lateral view

弓鲛超科 Hybodontoidea Zangerl, 1981

弓鲛超科鳞片类型 1 Hybodontoid scale type-1

(图 6)

标本　2 枚完整的鳞片,IVPP V 14538.1 ~2。

产地与层位　江西信丰;长兴组上段,V 14538.1 层位号:T4,V 14538.2 层位号:T7。

描述　鳞片小,V 14538.1 长 0.5 mm,V 14538.2 长 1.0 mm。鳞片区分为冠部、颈部和基部。冠前部圆后部尖,冠边缘呈锯齿状,冠表面均具贯穿整个冠表面、大致呈平行分布的长脊纹,冠前部中央则具一呈纺锤形的双脊纹构造,冠部腹面基本光滑。颈部明显,在冠部和基部之间形成明显的收缩。基部大致呈方形或斜方形,中央凸出,具一小的髓孔。

比较　本文记述的这两枚鳞片与产自德国中三叠世(Lower Muschelkalk)的弓鲛鳞片冠部都具贯穿整个冠部的、几乎平行的长脊纹(Reif, 1978, fig. 9A),但新标本冠面前部中央具一呈纺锤形的双脊纹。新标本与本文后述的修水滑齿鲨(*Lissodus xiushuiensis* sp. nov.)的鳞片的区别在于冠部脊纹

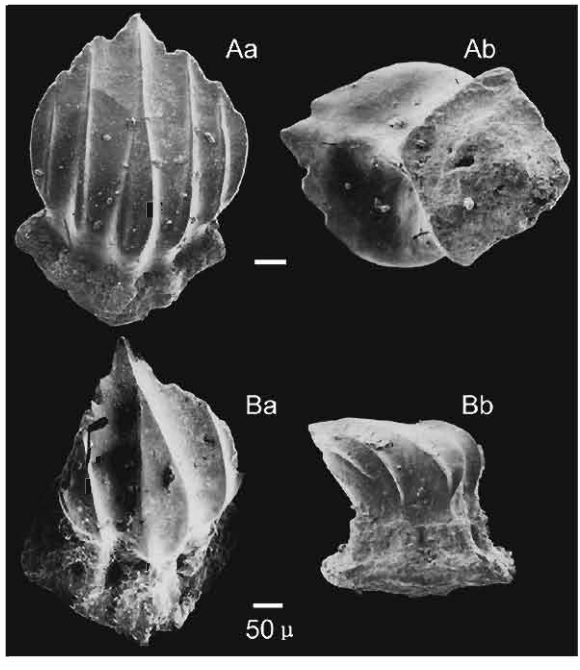

图 6　弓鲛超科鳞片类型 1

Fig. 6　Scales of hybodontoid scale type-1

A. V 14538.1; B. V 14538.2

Aa, Ba. 冠视 in crown view; Ab. 基部视 in basal view; Bb. 侧视 in lateral view

的形状,后者冠部的脊纹长不达冠中部。由于标本少,我们将这两枚鳞片作为弓鲛超科鳞片类型 1(Hybodontoid scale type-1)。

弓鲛科 Hybodontidae Owen, 1846

弓鲛科(属种未定)Hybodontidae gen. et sp. indet.

(图 7)

标本 2 枚完整鳞片,IVPP V 14539.1~2。

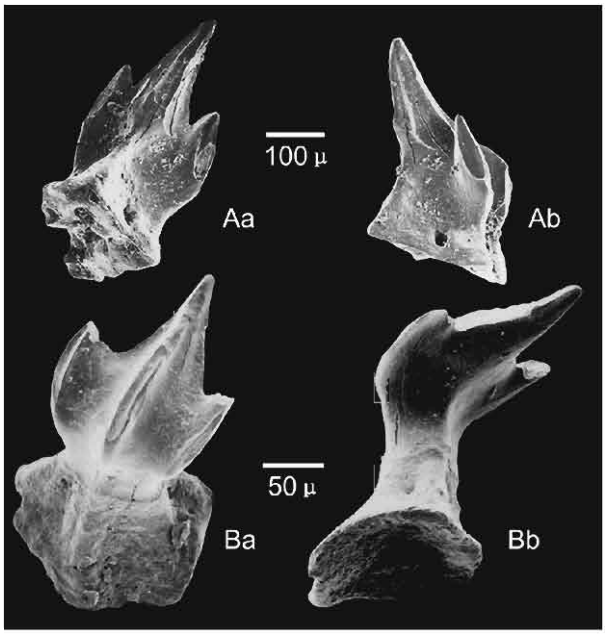

图 7 弓鲛科(属种未定),鳞片

Fig. 7 Scales of Hybodontidae gen. et sp. indet.

A. V 14539.1; B. V 14539.2

Aa. 腹视 in basal view; Ab, Bb. 侧视 in lateral view; Ba. 冠视 in crown view

产地与层位 浙江长兴煤山剖面;V 14539.1 产自长兴组煤山段顶部,层位号:AEL879;V 14539.2 产自长兴组下部(葆青段),层位号:Act140。

描述 鳞片很小,V 14539.1 长 0.2 mm,V 14539.2 长 0.1 mm,鳞片区分为冠部、颈部和基部。鳞片冠部均呈三尖状,中央刺尖最长,两侧的侧刺尖较短,各刺尖表面均具一细的脊纹。颈部明显高,为冠部与基部之间一明显的收缩部,颈后具小的颈孔。基部呈方形(V 14539.1)或近圆形(V 14539.2),光滑,中央凹入。

比较 本文记述的这两枚鳞片与产自日本中二叠世的弓鲛科鳞片(Reif, 1979)比较相近,如鳞片冠部是 4 条或更多脊纹和一个尖突,鳞片颈部发育,鳞片基部具 4 个或更多突起。因此,我们亦将其作为弓鲛科属种未定的一类化石。

尖齿鲨科 Acrodontidae Casier, 1959

中华尖齿鲨(新属)*Sinacrodus* gen. nov.

属型种 *Sinacrodus donglingensis*。

特征 同属型种。

词源 Sinae(L)拉丁语,中国;acrodus,尖齿鲨科的科型属名。

东岭中华尖齿鲨(新属、新种)*Sinacrodus donglingensis* gen. et sp. nov.

(图 8、9)

正型标本　一枚完整的皮质鳞突,IVPP V 14540.1。

标本　5 枚完整的鳞片,IVPP V 14540.2,V 14541.1 ~3 以及 V 14542.1。

产地与层位　江西修水东岭剖面,浙江长兴煤山 D 剖面,江西信丰铁石口剖面;V 14540.1 ~2产自东岭剖面长兴组上段底部,层位号:Xdfo-2;V 14541.1 ~3 产自煤山 D 剖面长兴组煤山段,层位号分别为 Act232,Act232 和长兴 39;V 14542.1 产自铁石口剖面长兴组上段,层位号:T13。

特征　皮质鳞突冠部厚,冠顶部平,纵向脊纹发育、不对称,冠顶横向脊纹向冠缘延伸构成切割冠缘的垂直脊纹。基部比冠部高,基部具纵向粗脊,粗脊间具大的营养孔,基下部略扩大,基部腹面凹入,中央具一小髓孔。鳞片为弓鲛类型,冠部具高的尖端,其上具明显的脊纹,脊纹从冠基伸至冠顶。颈部不明显。基部多结节近圆盘状,盘状边缘呈缺刻状,基部腹面或平或凹入,具多个髓孔。

词源　Dongling,正型标本所在剖面名称;-ensis(L)拉丁语,地名常用后缀。

描述　皮质鳞突分为冠部和基部。冠部厚,冠部顶面扁平,纵向的脊纹发育、不对称,从纵向脊纹向侧面发出 10 条横向脊纹,横向脊纹向冠缘延伸构成呈缺刻状的冠缘垂直脊纹,垂直脊纹间向内凹入。皮质鳞突基部比冠部高,基上部明显收缩凹入,基部下部具纵向粗脊,粗脊间具数个大的圆形或椭圆形营养孔。基部向下逐渐扩大,基部腹面凹入,中央具一小的髓孔。正型标本测量见表 2。

表 2　东岭中华尖齿鲨(新属、新种)正型标本测量

Table 2　Mesurement of the holotype of *Sinacrodus donglingensis* gen. et sp. nov.　(mm)

标本 Specimen	冠部长 Length of crown	冠部宽 Breadth of crown	冠部高 Height of crown	基上部长 Length of upper part of base	基下部长 Length of lower part of base	基部高 Height of base	基部宽 Breadth of base
V 14540.1	0.5	0.3	0.15	0.1	0.15	0.25	0.2

鳞片为弓鲛类型。鳞片小,区分为冠部、颈部和基部,颈部不明显。鳞片冠部具高的尖端,其上具长脊纹或呈棘刺状。前者如 V 14540.2 和 V 14541.1,后者如 V 14541.2 以及 V 14542.1。颈部不明显,但冠部与基部交界处常具营养孔。基部多结节近圆盘状,基部腹面或平(如 V 14540.2 和 V 14541.1)或凹入(如 V 14541.3),具多个髓孔。

比较　这里将皮质鳞突与鳞片组合在一起是基于从修水发现的皮质鳞突与鳞片产在同一地点同一层位,再联系到其他地点相同特征的鳞片。这里记述的皮质鳞突与 *Acrodus* (Agassiz, 1838)和 *Lissodus*(Brouth, 1935)的牙齿在形态上有某些相似。与 *Acrodus* 的相近处在于冠部具脊纹,基部具许多脉孔等。但这里记述的皮质鳞突与 *Acrodus* 的牙齿存在一些明显的区别:冠部顶面扁平,冠缘厚,呈缺刻状。基部上部明显凹入,明显不同于后者。与 *Lissodus* 牙齿的相近处在于冠部有些高,明显与基部分开,冠部横向脊纹发育等。这里记述标本与它的不同是,冠表面扁平,冠缘厚,呈缺刻状。鳞片属于弓鲛类型(Maisey, 1983)。主要基于皮质鳞突的形态,我们在此建立一新属,命名为中华尖齿鲨(新属)(*Sinacrodus* gen. nov.)。*Acrodus* 为一典型的中生代鲨类属,发现于斯匹兹贝尔根、俄罗斯地台、西欧(Stensiö, 1921),但也被发现于美国得克萨斯早二叠世的地层中(Johnson,

1981; Zidek et al., 2003)。

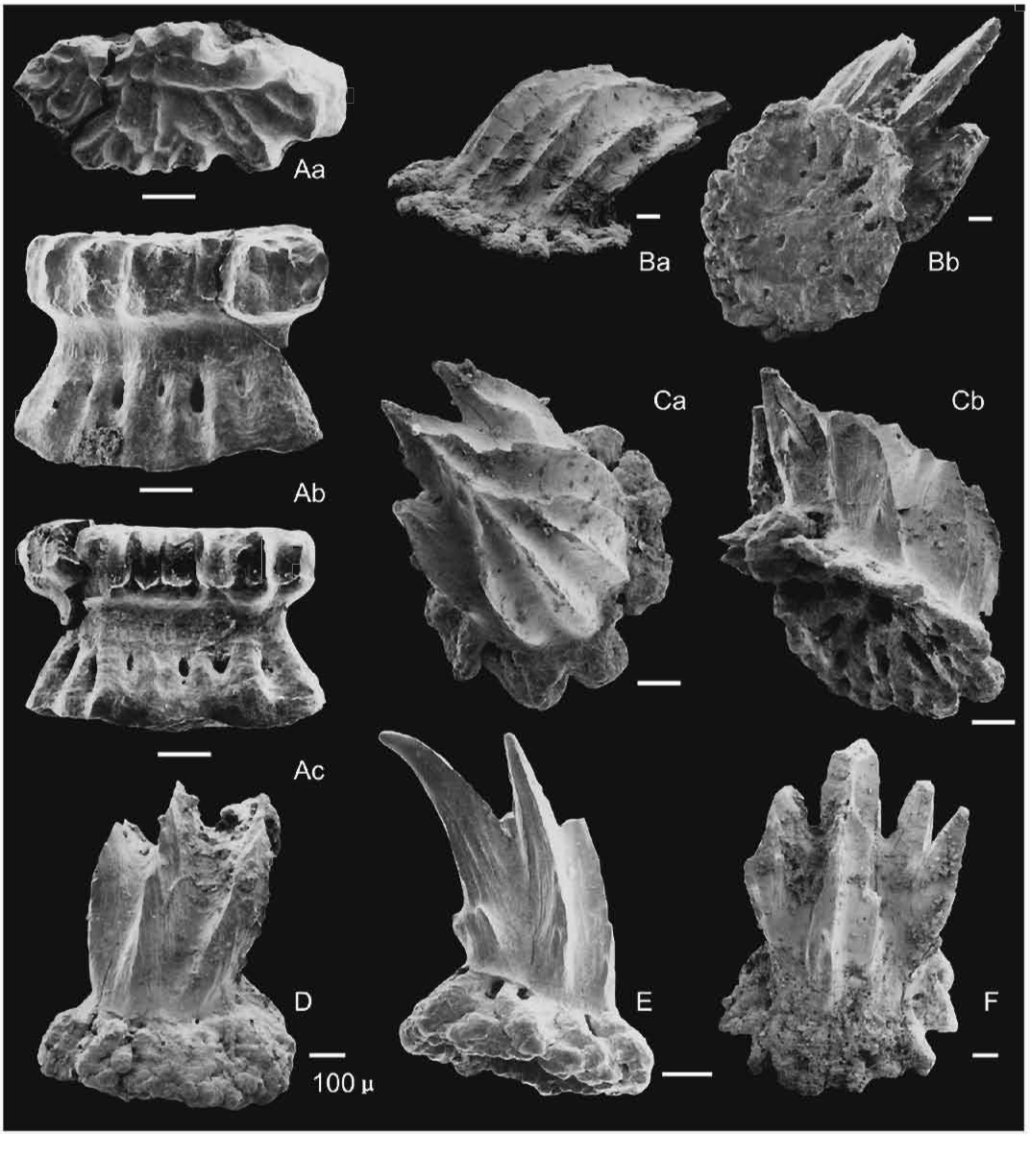

图 8 东岭中华尖齿鲨(新属、新种)

Fig. 8 *Sinacrodus donglingensis* gen. et sp. nov.

A. V 14540.1,正型标本(一枚完整的皮质鳞突)holotype (a dermal denticle);

B ~ F. V 14540.2, V 14541.1 ~ 3, V14542.1(5 枚完整的鳞片 five complete scales)

Aa. 冠视 in crown view, Ab. 侧视 in lateral view, Ac. 另一面侧视 in another lateral view;

Ba, Ca, D, F. 冠视 in crown views; Bb. 基部视 in basal view; Cb, E. 侧视 in lateral view

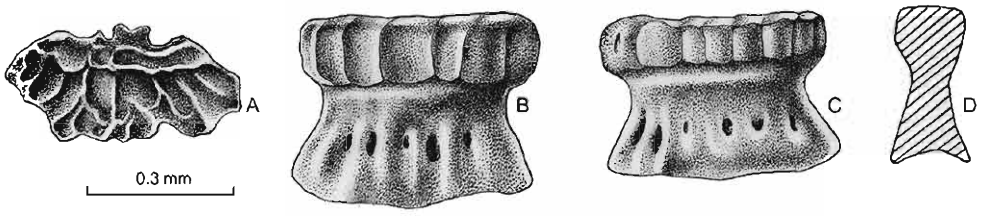

图 9　东岭中华尖齿鲨(新属、新种)皮质鳞突,正型标本复原

Fig. 9　Restoration of the dermal denticle of *Sinacrodus donglingensis* gen. et sp. nov., V 14540. 1, holotype

A. 冠视 in crown view; B. 侧视 in lateral view; C. 另一面侧视 in another lateral view; D. 横向断面视 in transverse outline view

多尖齿鲨科 Polyacrodontidae Glückman, 1964

滑齿鲨属 *Lissodus* Brough, 1935

修水滑齿鲨(新种) *Lissodus xiushuiensis* sp. nov.

(图 10)

正型标本　一枚牙齿,IVPP V 14543. 1。

标本　2 枚完整鳞片,IVPP V 14543. 2, V 14544. 1。

产地与层位　江西修水和信丰;V 14543. 1 ~ 2 产自修水长兴组上段底部,层位号:Xdfo-1;V 14544. 1 产自信丰长兴组上段上部,层位号:T2。

特征　牙齿小,主齿尖发育,偏向唇侧,侧齿尖不发育;单一的纵向咬合面脊纹发育连贯,冠部唇侧具一不大的钝角形唇突;冠部舌侧中部的中央位置具一小的附属突起,该突起的外侧具有 2 个更小的突起。冠侧超出基部。基部舌侧具上、下两排孔。鳞片冠部薄,前部圆,后端尖;冠前部具平行的细脊纹,脊纹短于冠部长的一半,向前延伸达基部;颈部明显,颈后具颈孔。基部呈菱形,中央略凸出,具一小的髓孔。

词源　Xiushui,正型标本的产地;-ensis(L)拉丁语,常用地名后缀。

描述　牙齿小,从主齿尖中央到牙齿一侧边缘长 0. 7 mm。牙齿区分为冠部和基部。牙齿虽然仅保存了一侧,但主要特征几乎全反映出来了。牙齿冠部与基部几乎等高。牙齿冠部主齿尖钝圆,侧齿尖不发育;单一的纵向咬合脊纹发育,贯穿主齿尖;冠部唇侧具一钝角形的唇突(labial peg),不太大;冠部舌侧中部的中央位置具一小的附属突起,突起上具三叉形的脊纹,该突起的外侧具 2 个更小的附属突起。冠部外侧超出基部外侧。基部舌侧具上、下两排脉孔,脉孔较大但数目不多。鳞片区分为冠部、颈部和基部。冠部薄,前部圆,后端尖;冠前部具平行的细脊纹,脊纹长短于冠部长的一半,向前延伸穿过颈前部达基部。颈部明显,颈后具颈孔。基部呈菱形,中央略凸出,凸出部具一小的髓孔。

比较　这里记述的牙齿与产自美国得克萨斯早二叠世的 *Lissodus zideki*(Johnson, 1981)及产自斯匹兹贝尔根早三叠世的 *L. angulatus*(Stensiö, 1921)比较接近,比如主齿尖发育,侧齿尖不发育,冠部光滑等。但此处记述的牙齿其主齿尖偏向唇侧,唇突呈一钝角形,冠部舌侧中部具有附属突起、脉孔数目少等不同于美国和斯匹兹贝尔根的标本。此

外，牙齿冠部与基部联接处呈水平线而不同于 *L. angulatus*。因此，我们依据牙齿特征，将这里记述的标本命名为修水滑齿鲨（新种）（*Lissodus xiushuiensis* sp. nov.）。*Lissodus* 主要见于中生代，但亦有少量石炭纪和二叠纪的种类（Duffin, 1985; Hampe, 1996; Rees and Underwood, 2002; Duncan, 2004）。

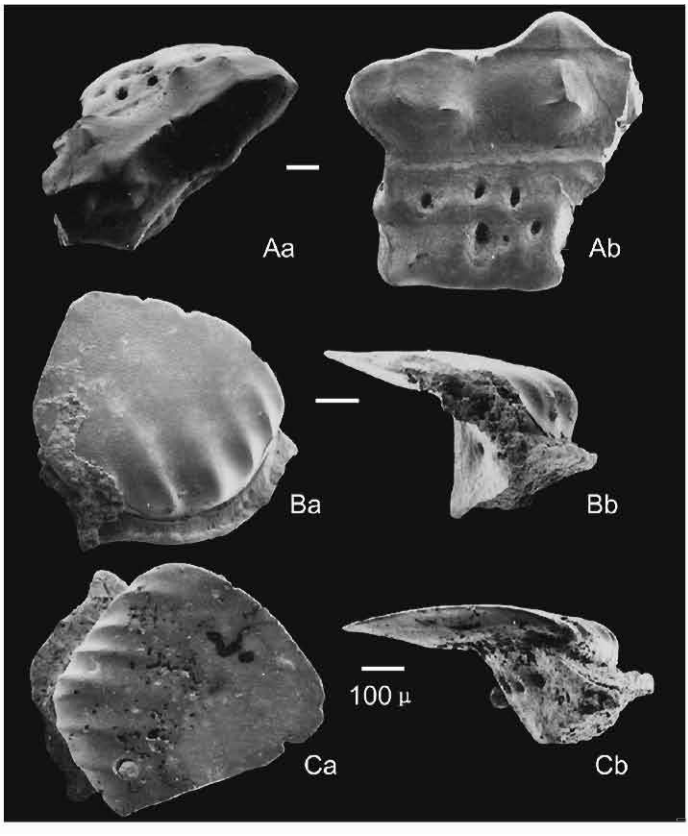

图 10 修水滑齿鲨（新种）

Fig. 10 *Lissodus xiushuiensis* sp. nov.

A. V 14543.1，正型标本（一枚牙齿）holotype (a tooth); B ~ C. V 14543.2, V 14544.1（2 枚完整鳞片 two complete scales）; Aa. 咬合面视 in occlusal view; Ab. 舌面视 in lingual view; Ba, Ca. 冠视 in crown view; Bb, Cb. 侧视 in lateral view

多尖齿鲨属 *Polyacrodus* Jaekel, 1889

江西多尖齿鲨（新种）*Polyacrodus jiangxiensis* sp. nov.

（图 11、12）

正型标本 一枚近乎完整的牙齿，IVPP V 14545。

产地与层位 江西修水；长兴组上段底部，层位号：Xdfo-1。

特征 牙齿小，牙齿冠部低，纵向和横向均不对称；主齿尖不明显，单一的纵向咬合面脊纹不从主齿尖通过；从纵向咬合面脊纹向两侧发出的众多横向咬合面脊纹在冠缘均形

成网状细脊纹。牙齿冠部和基部间形成明显的凹入部。基部唇面具上下两列小营养孔,其中下面一列比上面一列的孔要略大;舌面则具大致呈一列但上下略交错的营养孔。基部腹面变窄形成一腹纵脊,腹纵脊上具几个小的髓孔。

描述　一枚近乎完整的牙齿,仅一侧略缺失。牙齿小,冠部主齿尖到冠部一侧的直线长度为 0.9 mm。牙齿区分为冠部和基部。牙齿冠部低、纵向和横向均不对称;主齿尖光滑,位于牙齿冠部中央,但不太明显;侧齿尖不发育;一条纵向咬合面脊纹从牙齿冠部中央穿过,但不通过主齿尖最高点,而是绕过主齿尖;从纵向咬合面脊纹向冠部两侧发出许多横向咬合面脊纹,脊纹在冠部侧缘形成网状细脊纹,在舌侧更显发育。牙齿冠部侧缘超出基部,二者间形成明显凹入。牙齿基部具丰富的营养孔;唇侧上表面(upper labial root face)窄,具一水平列小营养孔;唇侧下表面具有一列略大的营养孔;基部舌侧则具与唇侧下表面大小相近、但排列有交错的营养孔;牙齿基部腹面变窄并形成一腹纵脊,腹纵脊上具几个小的营养孔。

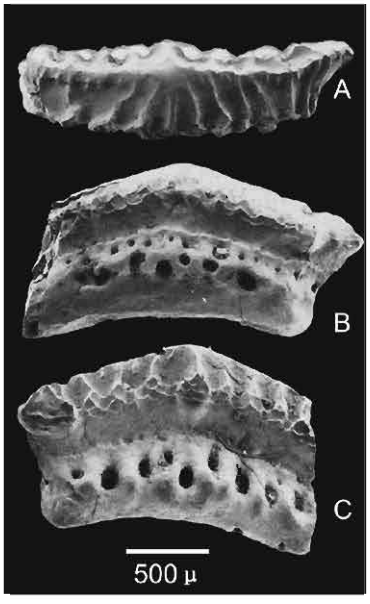

图 11　江西多尖齿鲨(新种)牙齿正型标本

Fig. 11　Tooth of *Polyacrodus jiangxiensis* sp. nov., V 14545, holotype
A. 咬合面视 in occlusal view; B. 唇面视 in labial view; C. 舌面视 in lingual view

比较　这里记述的牙齿与产自美国得克萨斯早二叠世的 *Polyacrodus lapalomensis*(Johnson, 1981; Duffin, 1985)和产自广西田东早三叠世罗楼组的田东多尖齿鲨(*P. tiandongensis* Wang et al., 2001)比较相近,比如牙齿冠部具一主齿尖,侧齿尖不发育,牙齿基部具许多营养孔等。但修水标本明显不同于两个已知种类的是:冠部主齿尖光滑,纵向咬合面脊纹没有穿过主齿尖,横向咬合面脊纹在冠缘形成网状细脊纹等。此外,主齿尖小,明显不同于田东多尖齿鲨。因此,我们将修水的新标本命名为江西多尖齿鲨(新种)(*Polyacrodus jiangxiensis* sp. nov.)。多尖齿鲨属为一典型的中生代鲨类,它被发现于西欧、前苏联、格陵兰等地中生代地层中(Stensiö, 1921, 1932; Patterson, 1966; Johns, 1996),该属也曾见于北美早二叠世的地层中(Johnson, 1981; Duffin, 1985)。

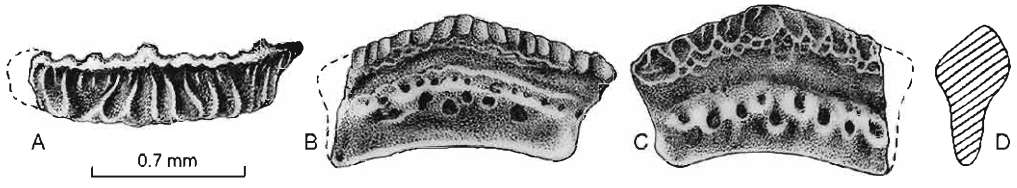

图 12　江西多尖齿鲨(新种)牙齿,正型标本复原

Fig. 12　Restoration of the tooth of *Polyacrodus jiangxiensis* sp. nov., V 14545, holotype
A. 咬合面视 in occlusal view; B. 唇面视 in labial view; C. 舌面视 in lingual view;
D. 横断面视 in transverse outline view

新鲨类 Neoselachii Compagno, 1977

新鲨类牙齿类型 1 Neoselachian tooth type-1

(图 13)

标本 一枚牙齿,IVPP V 14546。

产地与层位 江西修水东岭剖面;长兴组上段底部,层位号:Xdfo-1。

描述 牙齿冠部保存好,但基部不太好。冠部大致呈三角形,宽为 0.75 mm,中央是一个大的主齿尖;两侧各有一个小的侧齿尖,侧齿尖的刃部向上。牙齿冠部纵向咬合面脊纹光滑、很细,每个齿尖的唇侧和舌侧均具长短不一的一条横向脊纹。牙齿上具纤维状的类珐琅质构造。唇侧基板(labial buttress)与基部的过渡部仅部分保存。

比较 这里记述的牙齿的冠部特征与产自加拿大哥伦比亚地区中晚三叠世的 *Synechodus volaticus*(Johns et al., 1997)有一些相似,比如均呈三尖齿状,中央齿尖大等。由于修水的新标本基部未保存,难以进一步比较。此外,新标本具有纤维状的类珐琅质构造,因而我们将其作为新鲨类牙齿类型 1(Neoselachian tooth type-1)。

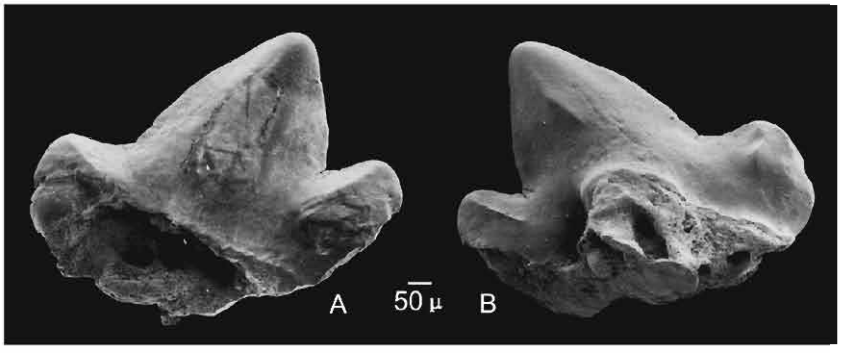

图 13 新鲨类牙齿类型 1

Fig. 13 Neoselachian tooth type-1, V 14546

A. 唇面视 in labial view; B. 舌面视 in lingual view

新鲨类鳞片类型 1 Neoselachian scale type-1

(图 14)

标本 2 枚完整的鳞片,IVPP V 14547.1 和 V 14548.1。

产地与层位 浙江长兴,江西信丰;V 14547.1 产自长兴煤山 D 剖面长兴组下段(葆青段),层位号:Act140;V 14548.1 产自信丰长兴组上段,层位号:T10。

描述 鳞片小,V 14547.1 长 0.1 mm,V 14548.1 长 0.3 mm。鳞片可区分为冠部、颈部和基部。冠部薄,冠表面和冠腹面均光滑无纹饰,冠表面具纤维状的类珐琅质构造;冠前部圆,后部尖,无缺刻。颈部明显,颈后具小的颈孔。基部呈四菱形,中央明显凹入。

比较 此处记述的鳞片与弓鲛超科鳞片类型 1 的区别十分明显:冠部光滑无任何纹饰,基部呈四菱形,明显凹入。由于鳞片冠部具纤维状的类珐琅质构造,这一特点又是新

鲨类所具有,所以我们将其作为新鲨类鳞片类型 1(Neoselachian scale type-1)。

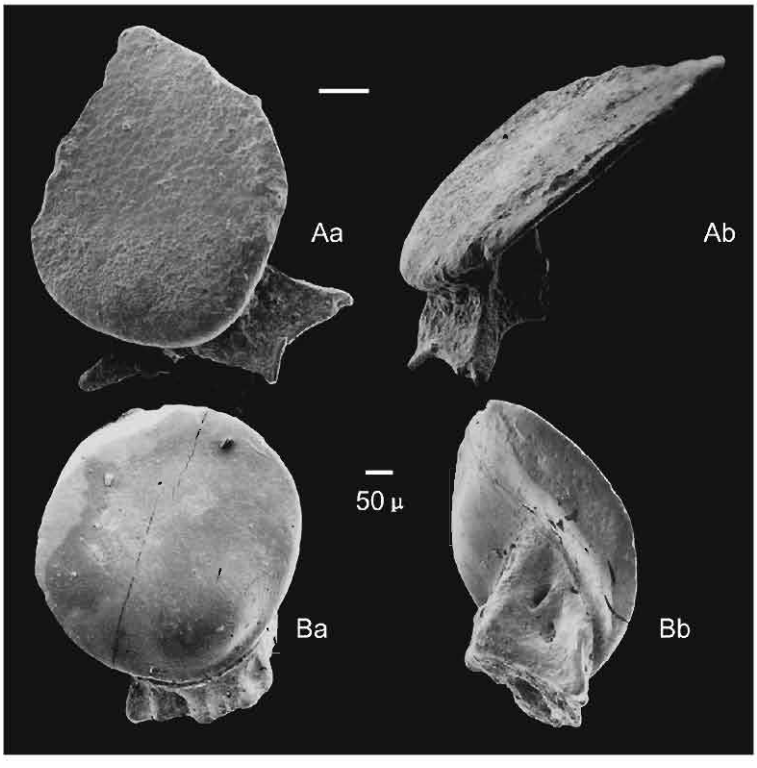

图 14　新鲨类鳞片类型 1

Fig. 14　Neoselachian scale type-1

A. V 14547.1; B. V 14548.1; Aa, Ba. 冠视 in crown view; Ab. 侧视 in lateral view; Bb. 颈部和基部视 in neck and basal view

3　讨论

3.1　浙江和江西二叠/三叠系界线以下的软骨鱼类微体化石及其特点

本文记述了软骨鱼类 3 新属、5 新种,栉棘鲨科未定属种,弓鲛超科鳞片类型 1,弓鲛科未定属种,新鲨类牙齿类型 1 和新鲨类鳞片类型 1,共 10 个类别的鱼类微体化石。浙江和江西二叠/三叠系界线以下的这批软骨鱼类微体化石显示了以下两个特点:1)在组成方面以弓鲛超科的化石为主,包含 1 新属 3 新种和弓鲛超科鳞片类型 1 以及弓鲛科未定属种。2)全球早三叠世已知的主要鲨类属,比如 *Lissodus*、*Acrodus*、*Polyacrodus* 等(Stensiö, 1921, 1932; Patterson, 1966),其中仅有个别种或相近的属出现在古生代(Johnson, 1981; Zangerl, 1981; Duffin, 1985; Cappetta, 1987; Turner, 1993; Goto, 1994; Riemann et al., 2002; Zidek et al., 2003),而晚二叠世的近似的属种仅仅出现在华南,比如本文记述的东岭中华尖齿鲨(*Sinacrodus donglingensis* gen. et sp. nov.)、修水滑齿鲨(*Lissodus xiushuiensis* sp. nov.)、江西多尖齿鲨(*Polyacrodus jiangxiensis* sp. nov.)。类似的情况也见于长兴的辐

鳍鱼类大化石(Lehman, 1966; Liu and Wei, 1988)。不难看出,发现于特提斯区三叠纪的鲨类与发现于华南晚二叠世的鲨类具有密切的亲缘关系。

3.2 浙江长兴晚二叠世长兴组中的鱼类化石

浙江长兴长兴组分为上下两段,上段为煤山段,下段为葆青段。已记述的煤山段的鱼类化石包含鱼类大化石和微体化石,它们由三个亚纲的化石组成,即硬骨鱼纲的辐鳍鱼亚纲和肉鳍鱼亚纲以及软骨鱼纲的板鳃鲨亚纲。辐鳍鱼亚纲包括煤山中华扁体鱼(*Sinoplatysomys meishanensis* Wei, 1977)和赵氏始龙鱼(*Eosaurichthys chaoi* Liu & Wei, 1988)。肉鳍鱼亚纲包括空棘鱼目的粗纹长兴鱼(*Changxingia aspratilis* Wang & Liu, 1981)、魏氏长兴鱼(*Changxingia weii* Jin, 1997)和新槐杨公鱼(*Youngichthys xinhuainsis* Wang & Liu, 1981)。板鳃鲨亚纲包括长兴中华旋齿鲨(*Sinohelicoprion changhsingensis* Liu & Chang, 1963)、刘氏煤山鲨(*Meishanselache liui* gen. et sp. nov.)、王氏长兴鲨(*Changxingselache wangi* gen. et sp. nov.)、东岭中华尖齿鲨(*Sinacrodus donglingensis* gen. et sp. nov.)以及分布于煤山段顶部的弓鲛科未定属种(Hybodontidae gen. et sp. indet.)。

到目前为止,发现于长兴组葆青段的仅为软骨鱼类微体化石,包括王氏长兴鲨(*Changxingselache wangi* gen. et sp. nov.)、栉棘鲨科未定属种(Ctenacanthidae gen. et sp. indet.)、弓鲛科未定属种(Hybodontidae gen. et sp. indet.)以及新鲨类鳞片类型 1(Neoselachian scale type-1)。

浙江长兴是我国迄今惟一一个既包含鱼类大化石,又包含鱼类微体化石的晚二叠世鱼类化石产地;长兴组发现的鱼类化石不论其代表的门类还是化石数量,都是我国这一地质时期最为丰富的鱼群。

3.3 华南二叠-三叠系界线上下的软骨鱼类

华南二叠-三叠系界线上下的软骨鱼类包含浙江长兴、江西修水和信丰晚二叠世长兴组以及广西田东早三叠世罗楼组的化石。

长兴组上段的软骨鱼类包含长兴中华旋齿鲨、刘氏煤山鲨、王氏长兴鲨、东岭中华尖齿鲨、修水滑齿鲨、江西多尖齿鲨、弓鲛超科鳞片类型-1、弓鲛科未定属种以及新鲨类牙齿类型 1 和新鲨类鳞片类型 1。长兴组下段包括王氏长兴鲨、栉棘鲨科未定属种、弓鲛科未定属种和新鲨类鳞片类型 1。其中王氏长兴鲨、弓鲛科未定属种和新鲨类鳞片类型 1 为长兴组上、下两段共有的软骨鱼类化石;东岭中华尖齿鲨、弓鲛科未定属种和弓鲛超科鳞片类型-1 则向上延伸可达长兴组顶部。

早三叠世罗楼组软骨鱼类产出的层位属于奥伦尼克阶(Olenekian)司帕斯期(Spathian)早期,化石包括作登弓鲛(*Hybodus zuodengensis*)、乐氏弓鲛(*Hybodus yohi*)和田东多尖齿鲨(*Polyacrodus tiandongensis*)(Wang et al., 2001)。弓鲛属和多尖齿鲨属都是全球中生代常见的软骨鱼类。

软骨鱼类是我国鱼类化石研究中最为薄弱的一个环节,华南二叠-三叠系界线层上下的软骨鱼类化石大大地填补了这个薄弱环节。

致谢　王成源、王志浩研究员赠送本文记述的部分采自长兴煤山剖面的鱼类微体化石,徐自强先生陪同到煤山剖面 P/T 界线层采样,金幸生先生协助观察浙江自然博物馆馆藏的长兴组煤山段已研究的鱼类大化石。朱敏、张江永先生审阅文稿并提出宝贵的修改意见;于小波先生修改外文摘要。2003 年 9 月在拉脱维亚和爱沙尼亚举行的第二届格罗斯鱼类国际研讨会期间,G. Johnson 和 A. Ivanov 博士与第一作者讨论了本文涉及的部分化石。张文定、周会先生摄制扫描电镜照片和扩印古组织学磨片的照片;沈文龙先生绘制精美的插图,作者在此致以衷心的感谢。

CHONDRICHTHYAN MICROREMAINS UNDER PERMIAN-TRIASSIC BOUNDARY BOTH IN ZHEJIANG AND JIANGXI PROVINCES, CHINA – FIFTH REPORT ON THE FISH SEQUENCE STUDY NEAR THE PERMIAN-TRIASSIC BOUNDARY IN SOUTH CHINA

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Key words　Zhejiang, Jiangxi, Permian-Triassic boundary, chondrichthyan microremains

Summary

The Permian-Triassic boundary strata are stable throughout the whole Yangtze Platform, especially, the GSSP of Permian-Triassic boundary defined at the Meishan section D, Changxing County of Zhejiang Province, China. But none of fish microfossils in the Permian-Triassic boundary beds in South China were formally described before. This is the first report on fish microfossils in the GSSP of P/T boundary in the world. The chondrichthyan microfossils dealt with in this paper were collected from the Permian-Triassic boundary beds in Meishan section of Changxing County, Zhejiang Province, Dongling section of Xiushui County and Tieshikou section of Xinfeng County, Jiangxi Province, South China. The chondrichthyan remains include Elasmobranchii order and family incertae sedis: *Meishanselache liui* gen. et sp. nov., *Changxingselache wangi* gen. et sp. nov., Ctenacanthidae gen. et sp. indet.; Hybodontoidea: Hybodontoid scale type-1, Hybodontidae gen. et sp. indet.; Acrodontidae: *Sinacrodus donglingensis* gen. et sp. nov.; Polyacrodontidae: *Lissodus xiushuiensis* sp. nov., *Polyacrodus jiangxiensis* sp. nov.; and Neoselachian tooth type-1, Neoselachian scale type-1.

The material described herein is housed in the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences.

1　Systematics

Elasmobranchii Bonaparte, 1838
Order and Family incertae sedis
Meishanselache gen. nov.

Type species　*Meishanselache liui* gen. et sp. nov.

Diagnosis　As that of the type and only species, *Meishaselache liui* gen. et sp. nov.

Distribution　So far known only from Late Permian in China.

Etymology　The genus name derives the Meishan Hill, Changxing County and selachos (Greek), meaning sharks.

Meishanselache liui gen. et sp. nov.

(Figs. 1,2; Table 1)

Etymology The species is named after the late Professor Liu Hsien-ting, a famous paleoichthyologist of China.

Holotype A complete dermal denticle, IVPP V 14535.1.

Material Other three complete dermal denticles, IVPP V 14535.2 ~ 4.

Locality and horizon Lower part of the Meishan Member of the Changxing Formation in the Meishan section D, Changxing County, Zhejiang Province, China.

Diagnosis Dermal denticles various in size. Its crown with several tubercles, various both in form and number, each tubercle with fine and convergent ridges. Its base large and thicker than crown with small pulp opening on ventral side.

Remarks The dermal denticles described herein should belong to Elasmobranchii (Chondrichthyes) judging by features of the crown and base, particularly a small pulp cavity in the base. But we cannot find any similar fish fossil, therefore the dermal denticles can be named as *Meishanselache liui* gen. et sp. nov. referred to Elasmobranchii order and family incertae sedis.

Changxingselache gen. nov.

Type species *Changxingselache wangi* gen. et sp. nov.

Diagnosis As that of the type and only species, *Changxingselache wangi* gen. et sp. nov.

Distribution So far known only from Late Permian in China.

Etymology The genus name derives from Changxing County and selachos (Greek), meaning sharks.

Changxingselache wangi gen. et sp. nov.

(Figs. 3,4)

Etymology The species is named after Dr. Wang Cheng-yuan, a famous conodont worker in China.

Holotype A complete dermal denticle, IVPP V 14536.1.

Material Other three complete dermal denticle, IVPP V 14536.2 ~ 4.

Locality and horizon The Baoqing Member (V 14536.1 ~ 2) and the Meishan Member (V 14536.3 ~ 4) of the Changxing Formation in the Meishan section D, Changxing County, Zhejiang Province, China.

Diagnosis Dermal denticle usually small. Its crown with several parallel and blade-like ridges, conical margin in posterior. Its base larger than crown, rounded and concave with several pulp cavities on ventral side.

Remarks The dermal denticles dealt with herein are similar in crown shape to those of *Rucabatis* coming from the Upper Cretaceous of Bolivia (Cappetta, 1975), but differ much in structure of its base. Specimen of V 14536.4 is similar in crown shape to *Parvidiabolus obliqnus* (Johns et al., 1997) from the Middle and Upper Triassic of Columbia, Canada, such as a long denticle crown and long conical cusp-shape in posterior of the crown, but differs much in having a crown with developed parallel and blade -like ridges in the surface and a rounded and concave denticle base. Therefore the dermal denticles described herein can be named as *Changxingselache wangi* gen. et sp. nov. referred to Elasmobranchii order and family incertae sedis.

Euselachii Hay, 1902
Ctenacanthoidea Zangerl, 1981
Ctenacanthidae Dean, 1909
Ctenacanthidae gen. et sp. indet.
(Fig. 5)

Material A complete scale, IVPP V 14537.

Locality and horizon The Baoqing Member of the Changxing Formation in the Meishan section D, Changxing County, Zhejiang Province.

Remarks The scale described herein is similar in shape to that of *Ctenacanthus* sp. coming from the Upper Devonian of Hunan, China (Lelièvre and Derycke, 1998) such as the crown with ridges in anterior bifurcating or trifurcating. But the scale differs from *Ctenacanthus* sp. in having less number of ridges. Therefore the scale dealt with herein can be regarded as Ctenacanthidae gen. et sp. indet.

Hybodontoidea Zangerl, 1981
Hybodontoid scale type-1
(Fig. 6)

Material Two complete scales, IVPP V 14538.1 and V 14538.2.

Locality and horizon Upper member of the Changxing Formation, Xinfeng County, Jiangxi Province.

Remarks Scales described herein are similar in shape to those of Hybodontidae coming from the Lower Muschelkalk of Germany (Reif, 1978) such as the crown with parallel ridges from anterior to posterior. But the scales of Xinfeng differ from the latter in having a spindle-shaped ridges at antero-central part of crown surface. The scales differ from those of *Lissodus xiushuiensis* sp. nov. in having long crown ridges. Therefore the scales dealt with herein can be regarded as hybodontoid scale type-1.

Hybodontidae Owen, 1846
Hybodontidae gen. et sp. indet.
(Fig. 7)

Material Two complete scales, IVPP V 14539.1 and V 14539.2.

Locality and horizon V 14539.1 in top of the Meishan Member of the Changxing Formation in the Meishan section Z; V 14539.2, in the Baoqing Member of the Changxing Formation in the Meishan section D, both Changxing County, Zhejiang Province.

Remarks Scales dealt with herein are similar in scale shape to those of Hybodontidae coming from the Middle Triassic of Kuzuu District of Japan (Reif, 1979), such as the crown with four or more ridges and a cusp. The cusp points in a distal direction. Scale neck is well developed. Scale base has four or more processes. Therefore scales dealt with herein should be also assigned to Hybodontidae gen. et sp. indet.

Order Euselachii Hay, 1902
Superfamily Hybodontoidea Zangerl, 1981
Acrodontidae Casier, 1959
***Sinacrodus* gen. nov.**

Type species *Sinacrodus donglingensis* gen. et sp. nov.

Diagnosis As that of the type and only species, *Sinacrodus donglingensis* gen. et sp. nov.

Distribution Upper Permian of South China.

Etymology The genus name derived Sinae (Latin), meaning China and acrodus, the

type genus of the family Acrodontidae.

Sinacrodus donglingensis gen. et sp. nov.

(Figs. 8, 9; Table 2)

Etymology The species name derives from the Dongling section, Xiushui County of Jiangxi Province, China.

Holotype A complete dermal denticle, IVPP V 14540.1.

Material Five complete scales, IVPP V 14540.2, V 14541.1~3, and V 14542.1.

Locality and horizon Upper member of the Changxing Formation, Dongling section of Xiushui County (V 14540.1 and 2) and Tieshikou section of Xinfeng County (V 14542.1), Jiangxi Province; Meishan section of Changxing County, Zhejiang Province (V 14541.1~3), China.

Diagnosis Dermal denticle small, its crown flat with longitudinal crest developed and asymmetrical and several transverse crests, stretched downward to crown rim, notched and thick. Its root higher than its crown, with several large vascular foramina on both lateral sides. Its root concave, with a small pulp opening on ventral side. Scale hybodontid type. Scale crown high with pointed cusp and ridges, runned downward from cusps to processes of scale base. Scale neck undeveloped. Scale base platebasket-like in form, flat or concave with several pulp openings in ventral side.

Remarks The dermal denticle dealt with here and scale V 14540.2 can be referred to the same genus and species because they were reported from the same locality and horizon (Xd-of-2). The scales described herein coming from both the Meishan section, Changxing County and the Tieshikou section of Xinfeng County are similar in general shape to that of V 14540.2.

The dermal denticle described herein is similar to the teeth of both *Acrodus* (Agassiz, 1838) and *Lissodus* (Brough, 1935). It is similar to the former, such as crown surface carrying crests and denticle root carrying several foramina. But the denticle differs much from *Acrodus* in having a flat crown with notched and thick crown rim and having a contracted upper part of the denticle root. The denticle is similar to the tooth of *Lissodus* in having a high crown, a clear boundary between denticle crown and roof, crown surface carrying developed transverse crests. It differs from the latter in having a flat crown surface with notched and thick crown rim. Scales are hybodontid-like in form. Therefore the denticle and scales dealt with here can be named as a new genus, *Sinacrodus* gen. nov. and a new species, *S. donglingensis* gen. et sp. nov.

Polyacrodontidae Glükman, 1964

Lissodus Brough, 1935

Lissodus xiushuiensis sp. nov.

(Fig. 10)

Etymology The species name derives from Xiushui County, Jiangxi Province of China.

Holotype A tooth, IVPP V 14543.1.

Material Two scales, IVPP V 14543.2 and V 14544.1.

Locality and horizon Upper Member of the Changxing Formation, Xiushui County (V 14543.1~2) and Xinfeng County (V 14544.1), Jiangxi Province, China.

Diagnosis Tooth small, main cusp developed and deviated from central; lateral cusplets undeveloped, longitudinal occlusal crest continuous; labial protuberance small and blunt. Central accessory cusplet and two lateral accessory cusplets smaller than central accessory cusplet both on one side of lingual crown face. Lingual root face with upper row of small vascular foramina and lower row of large vascular foramina. Scale placoid type. Scale crown thin with parallel and fine ridges, stretched right posteriorly to middle part of scale crown. Scale neck developed with several foramina on neck back. Scale base rhombic and convex with small pulp opening.

Remarks The holotype (tooth) and scale (V 14543.2) dealt with here can be referred to the same species because they were reported from the same locality and horizon (Xdfo-1), another scale V 14544.1 described herein coming from the Tieshikou section of Xinfeng County is similar in general shape to that of V 14543.2.

The tooth described herein is similar to that of *Lissodus zideki* (Johnson, 1981) coming from the Lower Permian of Texas and *Lissodus angulatus* (Stensiö, 1921) coming from the Lower Triassic of Spitzbergen, such as the developed main cusp, undeveloped lateral cusplets and smooth crown. But it differs much from both *Lissodus zideki* and *L. angulatus* in having a main cusp deviated from crown central to labial face, and a blunt labial protuberance, accessory cusplets in lingual face of crown. It differs from *L. angulatus* in having a level boundary between tooth crown and base. Scales are placoid type in form. Therefore the tooth and scales dealt with herein can be named as a new species of the genus *Lissodus*, *L. xiushuiensis* sp. nov.

Polyacrodus Jaekel, 1889

Polyacrodus jiangxiensis sp. nov.

(Figs. 11, 12)

Etymology The species name derives from Jiangxi Province of China.

Holotype One nearly complete tooth, IVPP V 14545.

Locality and horizon Upper member of the Changxing Formation, Xiushui County, Jiangxi Province.

Diagnosis Tooth small. Tooth crown moderately asymmetrical longitudinally and transversely. Main cusp smooth, poorly developed. Lateral cusplet absent. A longitudinal occlusal crest persistent, discontinuous on main cusp. Transverse occlusal crests developed and took the form of nets on both labial and lingual sides of the crown margin. Root-crown contact slightly arcuate, root sulcus with arcuate oral and basal margins. Two rows of foramina on labial root face and a row of foramina on lingual root face. Root formed a ventral ridge and several pulp openings on the ridge.

Remarks The tooth described herein is similar to those of both *Polyacrodus lapalomensis* coming from the Lower Permian of Texas (Johnson, 1981; Duffin, 1985) and *Polyacrodus tiandongensis* (Wang et al., 2001) from the Lower Triassic of Guangxi, China, such as one main cusp, lateral cusplet absent, root with a lot of foramina, but the tooth dealt with here differs much from both *Polyacrodus lapalomensis* and *P. tiandongensis* in having a smooth main cusp and a longitudinal occlusal crest discontinous on main cusp, developed transverse occlusal crests forming nets on both labial and lingual sides of the crown margin. It differs also from *P. tiandongensis* in having a very small main cusp. Therefore the tooth dealt with herein can be named as a new species of the genus *Polyacrodus*, *P. jiangxiensis* sp. nov.

Neoselachii Compagno, 1977

Neoselachian tooth type-1

(Fig. 13)

Material One tooth, IVPP V 14546.

Locality and horizon Upper member of the Changxing Formation, Xiushui County, Jiangxi Province.

Description and remarks Outline of the tooth crown is triangular, central cusp is large, two lateral blades are curved upward; the longitudinal occlusal crest is smooth and imperceptible and the transverse occlusal crests persistent on both labial and lingual sides of both the central cusp and two lateral blades. There is one layer of haphazardly fibred enameloid on the tooth. We can not find specimen being similar to that described herein, therefore the tooth dealt with herein can be regarded as neoselachian tooth type-1, because it has one layer of haphazardly

fibred enameloid on the tooth.

Neoselachian scale type-1

(Fig. 14)

Material Two complete scales, IVPP V 14547.1 and V 14548.1.

Locality and horizon Baoqing Member of the Changxing Formation in the Meishan section D, Changxing County, Zhejiang Province; Upper member of the Changxing Formation, Xinfeng County, Jiangxi Province.

Remarks Scales dealt with herein differ from those of hybodontoid scale type-1 in having a smooth crown surface and a rhombic and concave scale base. Scales described here with a layer of fibred enameloid which is a characteristic of neoselachian can be regarded as neoselachian scale type-1.

2 Discussion

2.1 Characteristics of chondrichthyan microfossils near the Permian-Triassic boundary of both Zhejiang and Jiangxi provinces

There are ten kinds of chondrichthyan microfossils described in this paper, they show clearly two characteristics.

1) The chondrichthyan microfossils mainly consist of hybodontoid fossils such as *Sinacrodus donglingensis* gen. et sp. nov., *Lissodus xiushuiensis* sp. nov., *Polyacrodus jiangxiensis* sp. nov., Hybodontidae gen. et sp. indet. and Hybodontoid scale type-1.

2) *Acrodus*, *Polyacrodus* and *Lissodus* are representatives of Mesozoic chondrichthyan genera, though *Lissodus* has a stratigraphic range of Lower Carboniferous to Upper Cretaceous. In comparison with above Mesozoic genera, similar genera and species of Late Permian are only discovered in South China, such as *Sinacrodus donglingensis* gen. et sp. nov., *Lissodus xiushuiensis* sp. nov., *Polyacrodus jiangxiensis* sp. nov. Similar situation occurs also in actinopterygian fossils from both the Upper Permian of South China and the Triassic of Tethys (Stensiö 1921, 1932; Patterson, 1966; Poplin et al., 1997). This suggests the close affinities between the Triassic sharks found in Tethys and the Late Permian sharks found in south China.

2.2 Fish fossils in the Changxing Formation of the Meishan section, Changxing County, Zhejiang Province, China

The Changxing Formation of the Meishan section is divided into two members: the upper is Meishan Member and the lower is Baoqing Member. Fish fossils in the Meishan Member consist of three subclasses: Actinopterygii, Sarcopterygii and Chondrichthyes. Actinopterygian fossils include *Sinoplatysomys meishanensis* Wei, 1977 and *Eosaurichthys chaoi* Liu & Wei, 1988. Coelacanthiform sarcopterygians include *Changxingia aspratilis* Wang & Liu, 1981, *C. weii* Jin, 1997, *Youngichthys xinhuainsis* Wang & Liu, 1981. And chondrichthyan fossils consist of *Sinohelicoprion changhsingensis* Liu & Chang, 1963, *Meishanselache liui* gen. et sp. nov., *Changxingselache wangi* gen. et sp. nov., *Sinacrodus donglingensis* gen. et sp. nov. and Hybodontidae gen. et sp. indet.

Fish fossils in the Baoqing Member of the Meishan section are only discovered chondrichthyan microremains such as *Changxingselache wangi*, Ctenacanthidae gen. et sp. indet., Hybodontidae gen. et sp. indet. and neoselachian scale type-1. Hybodontidae gen. et sp. indet. ranges from top of the Baoqing Member to top of the Meishan Member.

Of all Late Permian localities in China, Changxing of Zhejiang Province is the only one where both macro- and micro- fish fossils have been described; and its fish fauna is most diversified and richest in quantity during this period in China.

2.3 Chondrichthyan fossils near Permian-Triassic boundary in South China

Chondrichthyan fossils near Permian-Triassic boundary in South China are discovered in the Changxing Formation of both Zhejiang and Jiangxi provinces and the Early Triassic Luolou Formation of Guangxi region.

Fish fossils in the upper member of the Changxing Formation include *Sinohelicoprion changhsingensis* Liu & Chang, 1963, *Meishanselache liui* gen. et sp. nov., *Changxingselache wangi* gen. et sp. nov., *Sinacrodus donglingensis* gen. et sp. nov., *Lissodus xiushuiensis* sp. nov., *Polyacrodus jiangxiensis* sp. nov., hybodontoid scale type-1, Hybodontidae gen. et sp. indet., neoselachian tooth type-1 and neoselachian scale type-1.

Fish fossils in the lower member of the Changxing Formation include *Changxingselache wangi* gen. et sp. nov., Ctenacanthidae gen. et sp. indet., Hybodontidae gen. et sp. indet. and neoselachian scale type-1.

Changxingselache wangi gen. et sp. nov., Hybodontidae gen. et sp. indet. and neoselachian scale type-1 are the common chondrichthyan fossils in both upper and lower members of the Changxing Formation; and *Sinacrodus donglingensis* gen. et sp. nov., Hybodontidae gen. et sp. indet. and hybodontoid scale type-1 achieve upward top of the Meishan Member.

The Early Triassic Luolou Formation (Spathian of Olenekian) of Guangxi region yields three forms of chondrichthyan fossils: *Hybodus zuodengensis*, *H. yohi* and *Polyacrodus tiandongensis* (Wang et al., 2001).

Chondrichthyan fossils are rarely known in China. The microremains coming from near the Permian-Triassic boundary of South China will greatly enrich our knowledge on chondrichthyans.

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