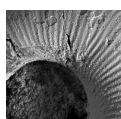


First occurrence of *Pictetia* (Ammonoidea) from the Albian of Japan and its systematical implications

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Here, we describe for the first time the occurrence of well preserved *Pictetia* from the Albian of northeastern Japan (Miyako Group) and discuss the implications for the systematic assignment of the genus. A detailed systematic description of *P. astieriana* based on the newly collected material is given. Earlier systematic assignment to lytoceratids resulted from similar conch morphology and ornamentation. Based on the new knowledge of the development of the juvenile suture lines, *Pictetia* is tentatively assigned to the Hamitidae. • Key words: systematics, Ancyloceratina, Hamitidae, *Pictetia*, Cretaceous, Northwest Pacific, Miyako Group, Japan.

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For ammonoids with an uncoiled conch, Wiedmann (1966) introduced the taxon Ancyloceratina. This group originated in the Late Jurassic (Early Tithonian) and had a remarkable taxonomic and morphological diversification in the world's oceans during the Cretaceous (Cecca 1997, 1998). The systematics of the higher taxa of the Ancyloceratina is based on the primary suture line and not on conch shape or ornamentation. Besides the primary suture line, the adult body chamber, one of the diagnostic features for genus determination, was unknown from *Pictetia*. Therefore, any further systematic assessment of *Pictetia* was impossible. Nevertheless, it turned out that *Pictetia* lacks any diagnostic lytoceratid characters such as the septal lobe, a character that constitutes the monophyly of Lytoceratoidea, and was therefore excluded from this taxon (Hoffmann *et al.* 2009, Hoffmann 2010). Earlier systematic assignment to lytoceratids resulted from the similar conch morphology and ornamentation.

Newly collected specimens of *Pictetia astieriana* from the Lower Albian of the Miyako Group (NW Japan) represent the first reliable report of *Pictetia* from the Cretaceous of the Northwest Pacific. This new material is well preserved including the juvenile part of the shell and allows a detailed description. This sheds new light on the higher systematic assignment of *Pictetia*.

Geological setting

The Miyako Group in the Rikuchu area in Northeast Japan (Fig. 1) is an Upper Aptian–Lower Albian siliciclastic sequence with abundant shallow-marine fossils such as rudists and orbitolinids (Hanai *et al.* 1968, Sano 1991, Iba & Sano 2007). This group is subdivided in four formations: Raga, Tanohata, Hiraiga and Aketo formations in ascending order (Hanai *et al.* 1968). Late Aptian ammonites such as *Nolaniceras yaegashii*, *Hypacanthoplites subcornuerianus* and *Eodouvilleiceras matsumotoi* have been recovered from the Tanohata Formation and the lower part of the Hiraiga Formation (*e.g.*, Obata 1969, Obata & Futakami 1992). Based on the ammonite fauna described by Obata (1969) and Obata & Futakami (1992) including *Douvilleiceras mamillatum*, the upper part of the Hiraiga Formation and the Aketo Formation belong to the Lower Albian. Specimens referable to *Pictetia* have been collected from the float, probably originating from the Aketo Formation (Fig. 1).

Systematic palaeontology

Morphological terms in the systematic description are those used in the *Treatise on Invertebrate Paleontology*

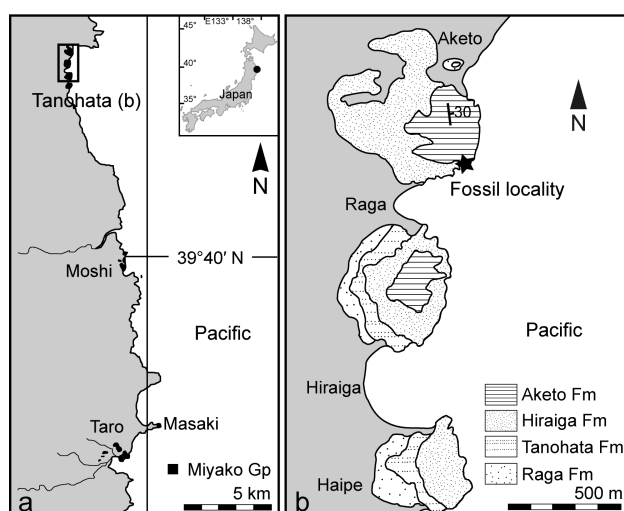


Figure 1. Locality map of *Pictetia astieriana* in the Rikuchu area, Northeast Japan. *Pictetia astieriana* specimens have been collected from the float, probably originating from the Aketo Formation. Geological map based on Fujino *et al.* (2006).

(Arkell *et al.* 1957). Quantifiers used to describe the shape of ammonoid conch replicate those proposed by Matsu-moto (1954, p. 246). We apply the suture line terminology of Wedekind (1916) with E (external lobe), A (adventive lobe), L (lateral lobe), U (umbilical lobe) and I (internal lobe); see also Kullmann & Wiedmann (1970) and Korn *et al.* (2003). For the characterization of ontogenetic changes of the conch morphology, we follow Korn (2010). For the morphological description, we use the following abbreviations: dm = diameter, uw = umbilical width, wh = whorl height, ww = whorl width, CWI = ww/dm, WWI = ww/wh, UWI = uw/dm, WER = whorl expansion rate.

Suborder Ancyloceratina Wiedmann, 1966

Undoubtedly, the Ancyloceratina represent a heterogeneous group containing ammonites with a quadri- or quinquelobate primary suture (Wright *et al.* 1996) as well as taxa with anaptychi and aptychi (Engeser & Keupp 2002). Therefore, it is generally accepted that the Ancyloceratina *sensu* Wiedmann (1966) represent a polyphylum (Doguzhaeva & Mikhailova 1982, Engeser & Keupp 2002, Hoffmann *et al.* 2009).

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Turrititaceae Gill, 1871
Family Hamitidae Gill, 1871

Genus *Pictetia* Uhlig, 1883

Type species. – *Crioceras astierianus* d'Orbigny, 1842, p. 468, pl. 115^{bis}, figs 3–5; by subsequent designation of Spath (1923, p. 21).

Remarks. – The diagnosis given by Wright *et al.* (1996) is very short and insufficient. However, a more comprehensive diagnosis was presented by Casey (1960, p. 3). The genus was discussed in detail by Hoffmann *et al.* (2009). Unfortunately, most of the diagnostic features like the morphology of the adult body chamber or the course of the primary suture line were unknown. Nevertheless, Bert (2012) proposed the monogeneric subfamily Pictetinae and, based on conch morphology and suture line, tentatively put his new taxon within the Macroscaphitidae.

Due to the observed early juvenile suture line development, we tentatively assign *Pictetia* to the Hamitidae and reject both ideas introduced by Bert (2012). A new subfamily is not necessary and as we will show below, the Macroscaphitidae are not the closest relatives of *Pictetia*.

Occurrence. – *Pictetia astieriana* occurs in the Lower Albian of Japan (Miyako Group, Aketo Formation, reported herein) and of Tunisia (*mammillatum* zone, *radenaci* zone = middle part of the *mammillatum* zone; Chihaoui *et al.* 2010, Latil 2011).

Pictetia astieriana was reported from the middle Albian of England (*dentatus* zone; Spath 1923), France (lectotype from the *dentatus* zone; Kennedy 2006), California (*packardii* zone associated with *Cleonicerias*; Rodda & Murphy 1992), Austria (Vorarlberg, *dentatus* zone; Föllmi 1989), Madagascar (*inaequinodum* zone; Collignon 1949, 1963; Hoffmann *et al.* 2009), and Bulgaria (*dentatus* zone; Ivanov 1993).

Pictetia depressa was found in the Lower Albian of Eng-land (*mammillatum* zone; Casey 1960, 1980), Bulgaria (*tar-defurcata* zone; Ivanov 1993), and a single *P. aff. depressa* comes from South Africa (*mammillatum* zone, Mzinene Formation Albian II–III; Kennedy & Klinger 1978). The lectotype of *P. depressa* (Fig. 4) was reported from the Gault inférieur of Switzerland (Sainte-Croix) by Pictet & Campiche (186, p. 29, pl. XLV, figs 3a–d). According to Renz (1968, pp. 8, 9) it seems likely that the lectotype of *P. depressa* was found in the Lower Albian *mammillatum* zone. *Pictetia* sp. was discovered in the Lower Albian (*mammil-latum* zone) of California by Rodda & Murphy (1992) and from northeast Germany (pers. comm. J. Lehmann). Occurrences of *P. astieriana* in the Upper Aptian (*e.g.* Sinzow 1905, p. 323 for Mangyshlak) are neither figured nor are stratigraphic details known. Therefore, we regard the distribution of the genus as restricted to the Early and Middle Albian.

The Pacific was the largest ocean during the Cretaceous and therefore plays a key role for the understanding of ammonite biogeography on a global scale. This is the first reliable report of *Pictetia* from the Northwest Pacific (Fig. 5). *Pictetia* co-occurred with mesogean taxa (*e.g.* rudist and orbitolinids; Masse 1992) indicating the Cretaceous tropical marine environment and biotic realm.

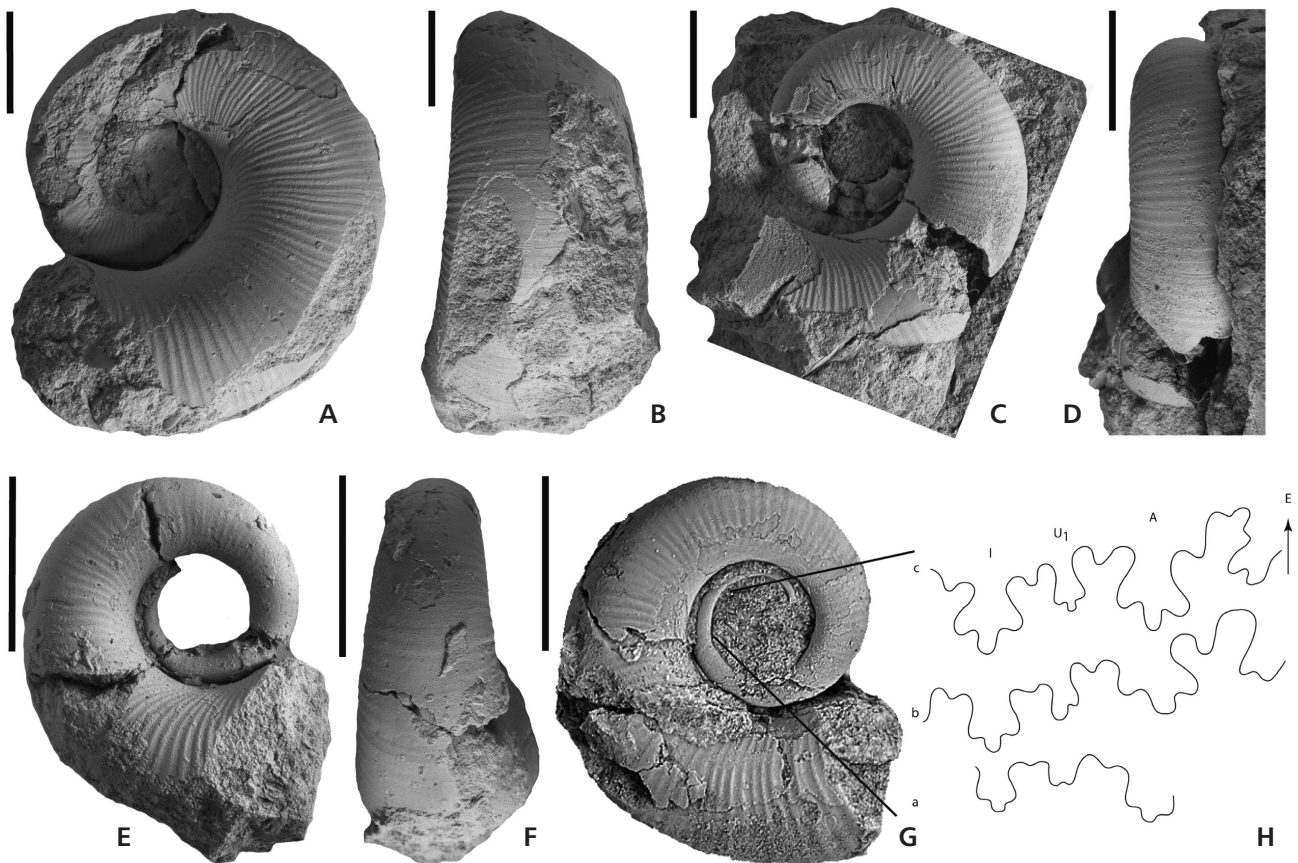


Figure 2. *Pictetia astieriana* from Japan (Miyako Group). • A, B – IPMM 62956, C, D – IPMM 62959, E, F – IPMM 62951, G – IPMM 62960, most complete specimen with the juvenile part of the conch preserved with a low WER, H – suture line drawings after complete extraction of the juvenile conch of *P. astieriana* (specimen G) with a) at Wh 0.8 mm, b) at Wh 1.0 mm, c) at Wh 1.1 mm showing a quadrilobate suture with trifold I, U₁ and A lobe, a broad E and bifid saddles; scale bar = 10 mm.

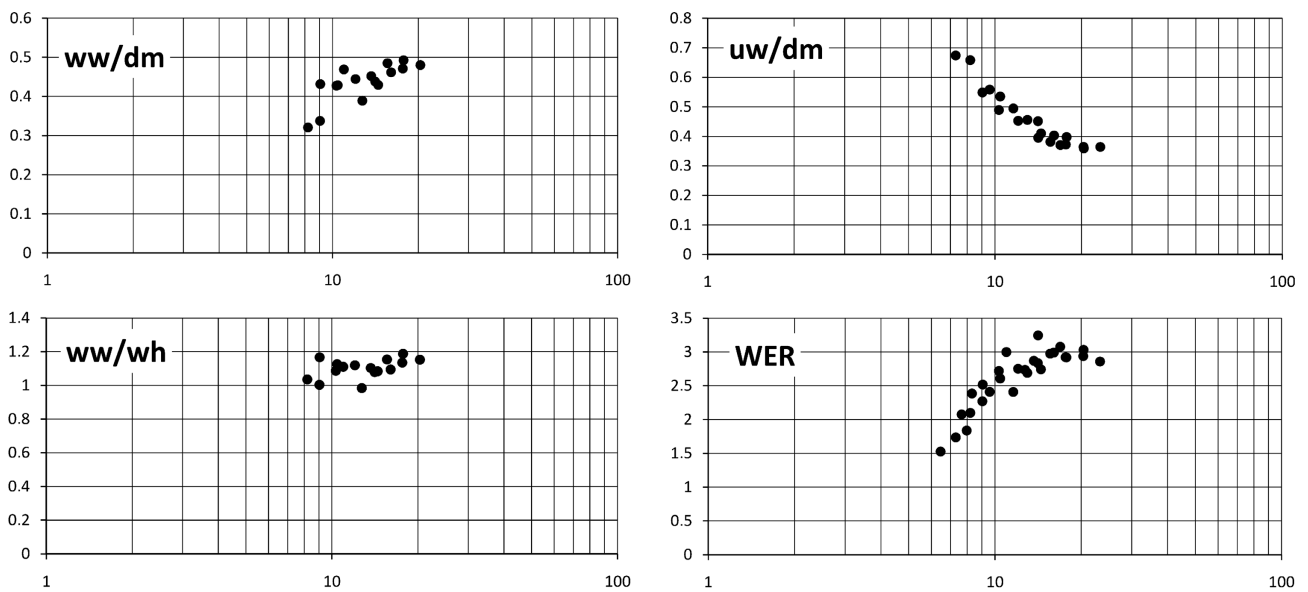


Figure 3. Ontogenetic development of conch parameters for *Pictetia astieriana* from Japan (Miyako Group) including all available specimens, top left: CWI, top right: UWI, bottom left: WWI, bottom right: WER against the diameter (mm).

Pictetia was found from the Aketo Formation that contains abundant orbitolinids. These lines of evidence indicate that *Pictetia* was dwelling in warm water conditions.

Pictetia astieriana d'Orbigny, 1842

Material. – IPMM 62949–62975, 63272–63273 (IPM: Iwate Prefectural Museum, Japan), a total number of 29 specimens from the Miyako Group were studied. For synonymy see Hoffmann *et al.* (2009).

Description. – The shell is very small to fairly small and varies between 14–39 mm in diameter with criocone coiling throughout ontogeny. The whorl section is circular to subcircular depressed without an umbilical shoulder. Juvenile parts of the shell show a low whorl height expansion. The best-preserved specimen (IPMM 62960; Fig. 2G) retains its juvenile conch. The lowest recorded whorl height is 0.4 mm, reaching 1.2 mm after 180° and 3.5 mm after completion of one whorl. Also, the more or less pronounced dorsal impression is present. For the ontogenetic trajectories of WER, WWI, UWI, and CWI see Fig. 3. The umbilicus is moderately wide. The convex flanks converge to a broad rounded venter. Ornamentation consists of fine, irregularly spaced ribs of similar magnitude crossing the venter without weakening. Ribs starting at the dorsal area are strongly rursiradial. They become radial at about mid-flank and cross the venter in a slightly projected direction. From about 30 ribs per ¼ whorl, some ribs are bifurcated on the lower flank. A weak strigation on the shell surface is only visible in sided light. The juvenile suture line is visible only in a single specimen (Fig. 2H). At wh = 0.8 mm, this specimen shows a quadrilobate suture line with a trifid I, a bifid U₁ and a broad trifid A. Following Schindewolf (1961), the small impression in the saddle I/U is regarded as incision and not as a lobe (Fig. 2Ha). Saddles are bifid throughout ontogeny with decreasing length from external to internal side. The suture line shows the tendency of trifid lobes and bifid saddles (Fig. 2Hb). The base of U₁ is slender and shorter than I, becoming asymmetric in shape. The base of A is broad, trifid and of similar depth like I and deeper than E. At wh = 1.25 mm, all lobes are trifid. A-lobe is asymmetric bifid and the saddle E/A becomes increasingly complex (Fig. 2Hc). The body chamber is not preserved.

Remarks. – Following the revision by Hoffmann *et al.* (2009), the Japanese material, which is characterized by a circular whorl cross-section and a weak dorsal depression, represents *P. astieriana*. The best-preserved specimen is about 23 mm in diameter and has its earliest whorls with a wh = 0.4 mm preserved (Fig. 2Ha). It is therefore adopted that only a small portion of the whorl is missing and *Pictetia* has a postembryonic umbilical opening of about 4.5 mm

in diameter. For comparison of the new findings, we figure (Fig. 4) here the lectotype of *P. depressa* (Pictet & Campiche, 1861) designated by Casey (1960, p. 4) from Perte du Rhône and housed at the natural history museum of Genève (Switzerland). Records of *Pictetia* from Japan were listed by Obata (1967, p. 67, 1969, p. 173, 1973, p. 312) as *Pictetia* sp. for the Aketo Formation but neither described nor figured. Since it was never indicated where Obata's material was stored, its actual location remains unclear [pers. comm. S. Toshimitsu (Tsukuba) 2008]. A fragmented lytoceratid ammonite, later assigned to ?*Pictetia* by Matsu-moto (1980), was reported by Katto & Obata (1975) from the Lower Cretaceous (Upper Aptian–Middle Albian) Shimantogawa Group of the Shimanto Belt of Shikoku, southwest Japan. The assignment of that specimen to *Pictetia* was refuted by Hoffmann *et al.* (2009). Nevertheless, Toshimitsu & Hirano (2000) used these records for the database of Cretaceous ammonoids in Japan.

Age. – Early Albian of Japan (Miyako Group, Aketo Formation).

Discussion

The material from Japan can be assigned to *Pictetia astieriana* unequivocally. For the first time, a specimen revealed details of the earliest sutural ontogeny of *Pictetia*. A quadrilobate suture line was reported by d'Orbigny (1840–1842), Pictet & Campiche (1861–1864), Casey (1960) and Schindewolf (1961, p. 45/679). These documentations of a quadrilobate juvenile suture line (wh = 0.8 mm, Fig. 2Hb) led us to the assumption that *Pictetia* retains four lobes (EAUI) throughout ontogeny.

The exclusion of *Pictetia* from the Lytoceratoidea and the assignment to the Ancyloceratina is now substantiated by the knowledge of the early juvenile suture line development and is in agreement with Hyatt (1900), Schindewolf (1961), Hoffmann *et al.* (2009), and Hoffmann (2010) but in contrast to the assignment presented by Wright *et al.* (1996). Owing to the trifid I, U₁ and A (Fig. 2Hb) and the lack of a septal lobe, a character that constitutes the monophylum Lytoceratoidea, besides loose coiling supports the exclusion of *Pictetia* from the Lytoceratoidea. All morphological similarities between *Pictetia* and the Lytoceratoidea (ornamentation, constrictions, coiling and whorl shape) are regarded as plesiomorphic or homoplastic characters apparently unsuitable for higher systematic assignment (Hoffmann *et al.* 2009).

Since the major contributions to ammonoid systematics by Arkell *et al.* (1957), Schindewolf (1961–1968) and Wiedmann (1966), it is widely accepted that the superfamily Ancylocerataceae was derived from the lytoceratid stock and subsequently, the Turrilitaceae was derived from



Figure 4. A–D – lectotype of *Pictetia depressa* from the lower Albian of Perte du Rhône, subsequent designated by Casey (1960), original of Pictet & Campiche (1861, pl. 45, figs 3a–d); A – lateral view, B – ventral view, C – dorsal view, D – lateral view. Housed at the Muséum of Natural History in Genève (coll. No.: AIV-96-17544).

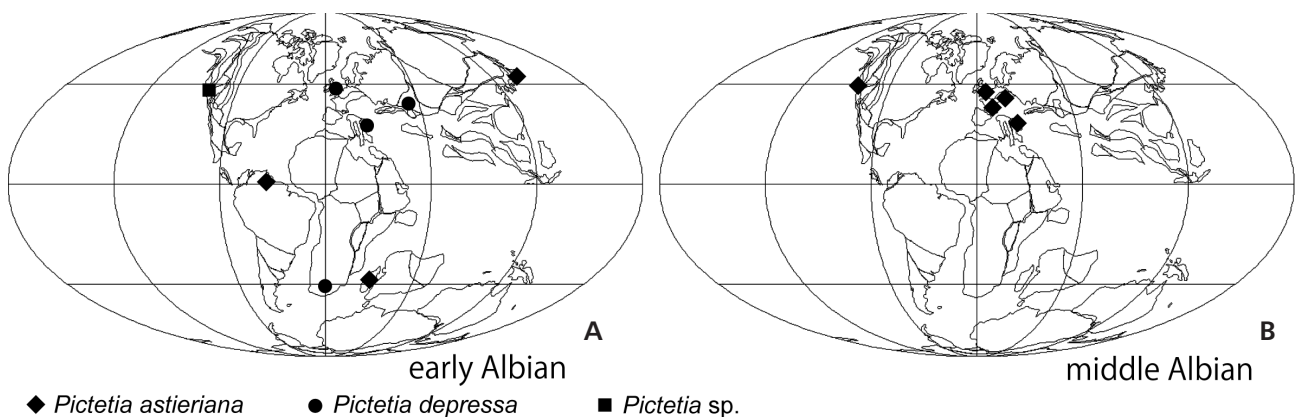


Figure 5. Distribution of *Pictetia astieriana* and *P. depressa* during the early to middle Albian. A – early Albian (110 Ma), B – middle Albian (100 Ma). Paleomap based on Eldridge *et al.* (2000).

the former group. That idea is mainly based on the suture line development concerning the low number of elements becoming more or less strongly slit during ontogeny. Nevertheless, both the Ancylocerataceae, with predominantly trifid lobes, and the Ancyloceratina are recognized as a paraphylum (Szives & Monks 2002).

The number of lobes, four or five, is unstable in the Ancylocerataceae during ontogeny, while only four lobes occur in the Turrititaceae. Due to the fact that not a single genus of Jurassic and Cretaceous Lytoceratoidea (Hoffmann 2010) displays a quadrilobate suture during ontogeny, the hypothesis of direct derivation of the Turrititaceae from the lytoceratid stock (Doguzhaeva & Mikhailova 1982) is rejected. Comparing the superfamilies Ancylocerataceae and Turrititaceae with the diagnostic features now known for *Pictetia* (four lobes throughout ontogeny),

it appears reasonable to place the genus within the Turrititaceae with predominantly bifid lobes.

The oldest representative of the superfamily Turrititaceae is the family Anisoceratidae ?Upper Aptian–Lower Albian (Wright *et al.* 1996). Most of the younger members of the Anisoceratidae show bifid lobes but trifid lobes occur in the older members. A similar suture line configuration with trifid lobes is present in the closely related Lower Albian paraphyletic Hamitidae (Monks 1999, Monks 2002, Szives & Monks 2002). Based on the ontogenetic changes from juvenile trifid lobes to later ontogenetic stages with subsymmetric bifid lobes, *Pictetia* obviously belongs to one of these two groups. The striking similarities between *Pictetia* and these two families might be the reason for re-identification of two species formerly referred to as *Pictetia* (*P. arcuata* and *P. crassecostata*) but

later assigned to *Ephamulina*, a genus belonging to the Anisoceratidae (Collignon 1963, Kennedy *et al.* 2000, Szives & Monks 2002, Szives *et al.* 2007).

Based on the presence or absence of ventrolateral and/or lateral tubercles, members of the Anisoceratidae are distinguished from the Hamitidae. Due to the lack of tubercles in *Pictetia*, it appears appropriate to assign the genus to the Hamitidae. That viewpoint is substantiated by the presence of 5–6 varices per whorl (constrictions visible on the internal mould) and the asymmetric suture line (Schindewolf 1961, Hoffmann *et al.* 2009) in *Pictetia*, both are non-typical for Anisoceratidae.

Furthermore, representatives of the Hamitidae are characterized by a circular to compressed whorl section and annular ribs, all features present in *Pictetia*. Both members of the Hamitidae such as *Hamites* or *Lytohamites* and *Pictetia* share a similar suture line compared to their complexity and particular development with a trifold I lobe, bifid saddles, subsymmetric bifid lobes and a similar median siphonsal saddle of the E lobe.

Conclusions

New material of from Japan revealed poorly known and unknown details of the early suture lines and suture ontogeny. In combination with other morphological details, this allows us to conclude that *Pictetia*, with its first occurrence in the Lower Albian, represents one of the oldest members of the Hamitidae.

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