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Asteroids from Barremian calciturbidites of the Serre de Bleyton (Drôme, SE France)

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(With 10 figures, 1 plate and 2 tables)

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Abstract

A suite of isolated ossicles of Barremian age (Early Cretaceous) collected at Serre de Bleyton allows the description of eight taxa, of which seven represent species. The most common families in the fossil record of Jurassic and Cretaceous asteroids are documented: *Coulonia neocomiensis* for the Astropectinidae, *Aspidaster* sp. for the Stauranderasteridae, *Comptoniaster* cf. *godeti*, *Calletaster barremicus* nov. sp. and an undetermined species for the Goniasteridae, *Valettaster stipes* nov. sp. for the ? Sphaerasteridae, *Asteriaceros papulosus* for a clade of Valvatida of uncertain affinities, and digitate skeletal elements probably representing Forcipulatida. The taxonomic composition demonstrates continuity between the Jurassic and Late Cretaceous faunas. The recorded species fill the Early Cretaceous gap in the range of *Valettaster* and significantly extend the range of genera formerly restricted to the Jurassic (*Aspidaster*, *Asteriaceros*) and to the Late Cretaceous (*Caletaster*).

Keywords: Asteroidea, new taxa, Early Cretaceous, isolated ossicles.

Introduction

Although well-documented in the Mesozoic, the fossil record of asteroids remains scanty and extremely poor from Lower Cretaceous rocks with only 16 taxa documented from Western Tethys regions (Table 1) and a few more from North America (BLAKE & REID 1998). VILLIER & KUTSCHER (1999) and VILLIER ET AL. (2007) suggest that the scarcity of Lower Cretaceous occurrences does not necessarily reflect a diversity depletion but rather derives from geological and investigative biases: 1) an uneven sampling of the sedimentary record focused on Europe, 2) a sedimentary record dominated by lithofacies unfavorable to preservation of entire asteroid individuals, 3) a literature restricted to

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publication of occasional well-preserved fossils, 4) the omission of the information provided by isolated ossicles, 5) a difficult taxonomy inherited from the nineteenth century. Skeletal elements of asteroids are common and can be collected easily from unlithified or poorly lithified rocks. Despite limitation of taxonomic assignment, they provide valuable information on diversity that would otherwise go unnoticed (Villier & Kutscher 1999). Even in localities where good material has been recovered, investigation of isolated ossicles can complement the taxon lists (e.g. Schulz & Weitschat 1971; Breton 1992; Jagt 2000; Villier et al. 2009). Several faunas have been entirely described from fragmentary material in the Upper Cretaceous (Mercier 1936; Müller 1953; Breton & Decombe 1997; Smith et al. 1988; Néraudeau & Breton 1993; Žítt et al. 2006; Breton & Néraudeau 2008) and the Jurassic (Villier et al. 2004; Villier 2008), but none from the Lower Cretaceous.

So far, few authors have describes ossicle suites from the Lower Cretaceous (e.g. Breton 1992; Radau 1992). The material collected by G. Moosleitner at the Serre de Bleyton of-

Table 1. List of taxa reported from the Lower Cretaceous of Europe and North Africa.

Family Goniasteridae
Comptoniaster comptoni (Forbes, 1848) Albian to Cenomanian, Southern England (UK), Paris Basin [Spencer 1905, Gale in Smith et al. 1988, Breton 1992]
Comptoniaster destombesi Breton, 1988 Albian, Normandie (France) [Breton 1988, 1992]
Comptoniaster godeti Breton, 1992 Hauterivian, Isère (France) [Breton 1992]
Nymphaster ? *arduennensis* (Péron, 1887) Albian, Ardennes (France) [Breton 1992]
Nymphaster ? *dutempleanus* (d'Orbigny, 1850) Albian, Ardennes (France) [Breton 1992]
Comptonia ? *wightensis* Breton, 1992 Albian, Isle of Wight (UK) [Breton 1992]
Comptonia elegans Gray 1840 Albian, Devon (UK) [Forbes 1850; Spencer 1905; Breton 1978, 1992]
Pentetagonaster malbosii d'Orbigny 1850 Lower Neocomian, Berrias (France) [d'Orbigny 1850; Cottreau in Boule 1935]
Pycinaster sp. Hauterivian, Isère (France) [Breton 1992]
Family Chaetasteridae
Chaetasterina gracilis Hess, 1970, Hauterivian, Saint-Blaise (Switzerland) [Hess 1970]
Family Ophidiasteridae
Protothyraster priscus (de Loriol, 1874), Hauterivian, Saint-Blaise (Switzerland) [de Loriol 1874; Hess 1970]
Family Sphaerasteridae (?)
Sphaerasteridae indetermined, Barremian, Hautes-Alpes (France) [Cherbonnier & Roman 1974]
Family Astropectinidae
Coulonia neocomiensis de Loriol, 1874, Hauterivian, Neuchâtel (Switzerland) [de Loriol, 1874; Hess 1955, 1970]
Coulonia platispina Hess & Blake, 1995 Barremian, Tamanar coast (Morocco) [Hess & Blake 1995]
Pentasteria (*Pentasteria*) *carthusiae* (Hérenger, 1944), Valanginian, Grande-Chartreuse (France) [Hérenger 1944].
Prothrissacanthias africanus Villier et al., 2007, Berriasian, Tlemcen (Algeria) [Villier et al. 2007]
Pentasteria sp., Hauterivian, Saint-Blaise (Switzerland) [Hess 1970]
Pentasteria sp., Hauterivian, Engelbostel (Germany) [Neumann 2010]
Family Benthopectinidae
Benthopectinidae indet. Hauterivian, Isère (France) [Breton 1992]

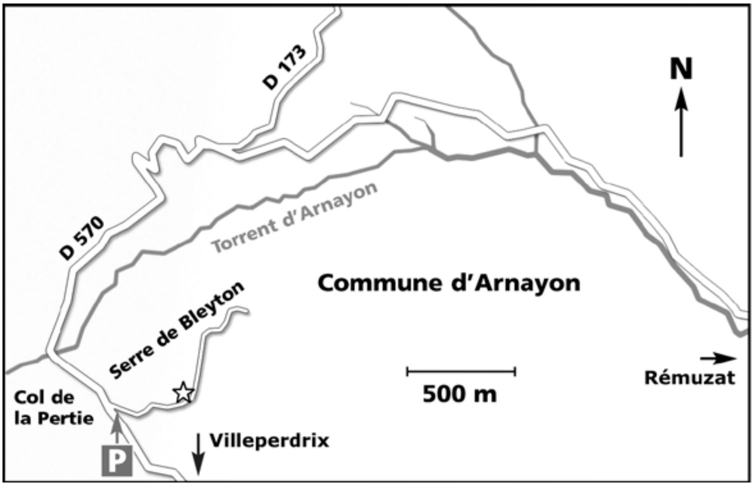

Fig. 1. Location of map of studied sites at Serre de Bleyton. The star indicates the position of the studied section.

fers an unexpected opportunity to study asteroid diversity in the Barremian of SE France that is generally represented by compact Urgonian limestones on shelves and deep water marls in the basins, both facies very poor in asteroid remains. Eight taxa are described at varying detail depending on material availability. Comparison with other Mesozoic faunas allows revision of some poorly known taxa and further allows comparison of Jurassic and Late Cretaceous faunas.

Material and method

The Serre de Bleyton locality is exposed on a hill crest 2 kilometers southwest of the village of Arnayon in the department Drôme (Fig. 1). The two very close sampled sites are located along a track on the west side of the Serre de Bleyton at 44°28'55'' N 05°18'03'' E. In this area, the Urgonian series is represented from base to top by a thick unit of bioclastic grainstone (Barremian), a lithified marl unit (Upper Barremian), and an upper bioclastic unit assigned to the Early Aptian (Bedoulian). The marl unit is interbeded with calcarenitic beds that can be extremely rich in small fossils near their base and that are interpreted as calciturbidite sequences derived from occasional exports of material from a nearby carbonate platform into upper offshore, muddy environments (MOOSLEITNER 2007, KROH et al. 2010). Many carbonate shells and skeletal remains were partially silicified and now altered calciturbidites can form bioclastic sand rich in partially silicified shells. This sand crops out only at the two very limited sites that were sampled. Washed and sieved in the laboratory, the sand samples provided a total of 343 asteroid ossicles, picked under a binocular microscope. Approximately one-half of the ossicles are well-enough preserved or show sufficient diagnostic characters to be identified. Eight taxa are recognized that likely represent species (Tab. 2).

The descriptions of isolated ossicles follow the general terminology of SPENCER & WRIGHT (1966), complemented by BLAKE (1973, 1976) for the axial elements and by GALE (1987) and BRETON (1992) for the marginal ossicles.

The asteroid material from the Serre de Bleyton described in this paper is deposited at the "Musée de Paléontologie de l'Université de Provence" (MPUP).

Systematic paleontology

Class Asteroidea DE BLAINVILLE, 1830

Order Paxillosida PERRIER, 1884

Family Astropectinidae GRAY, 1840

Genus Coulonia DE LORIOL, 1874

Coulonia neocomiensis DE LORIOL, 1874

(Fig. 2; Pl. 1, Figs a-e)

1874 *Coulonia neocomiensis* DE LORIOL, p. 13-16, pl. 2 fig. 1
1955 *Cuneaster hauteriviensis* HESS, p. 61, figs 16-22
1966 *Cuneaster hauteriviensis* HESS – SPENCER & WRIGHT, p. U45, fig. 44.2
1970 *Coulonia neocomiensis* DE LORIOL – HESS, p. 1078-1081, figs 7-8, pl. 3 figs 1-2, pl. 4 figs 1-2
1975 *Coulonia neocomiensis* DE LORIOL – HESS, p. 34, pl. 8 figs 15-16

Table 2. Material.

Taxon	Site 1	Site 2	Sum	
Coulonia neocomiensis	21	2	23	
Aspidaster sp.	16	6	22	
Goniasteridae indet., nov. spec.	7	5	12	
Caletaster barremicus nov. spec.	52	5	57	
Comptoniaster cf. *godeti*	2	3	5	
Valettaster stipes nov. spec.	16	1	17	
Asteriaceros papulosus	23	5	28	
Forcipulatida indet.	4	2	6	
Indeterminate	134	39	173	
Total	275	68	343	(50% received taxonomic assignment)

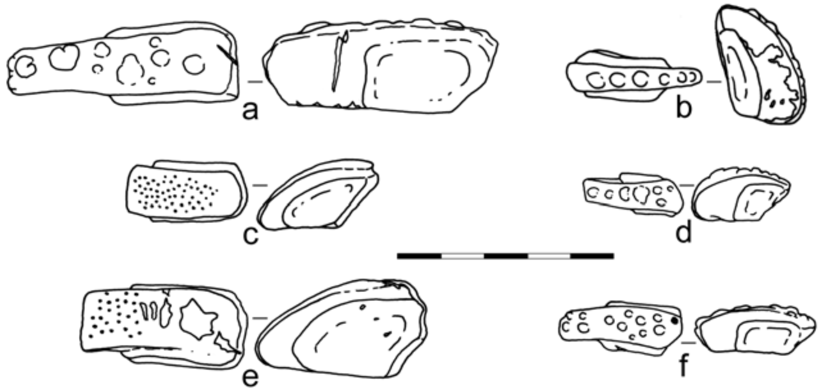

Fig. 2. *Coulonia neocomiensis* DE LORIOL, 1874; a: inferomarginal ossicles MPUP VILL001; b: inferomarginal ossicles MPUP VILL002; c: superomarginal ossicles MPUP VILL003; d: inferomarginal ossicles MPUP VILL004; e: superomarginal ossicles MPUP VILL005; f: inferomarginal ossicles MPUP VILL006. Scale bar equals 5 millimetres.

Material: 21 marginal ossicles (8 inferomarginal and 13 superomarginal) from Site 1 of KROH et al. (2010), plus 2 ossicles from site 2. All available material housed at the Musée de Paléontologie de l'Université de Provence, Marseilles, the figured specimens with numbers MPUP VILL001-006, VILL042-043, and the additional material VILL052-054.

Description: In proximal/distal view, the superomarginal ossicles look approximately triangular with a regularly curved outer face (Figs 2c, e; Pl. 1a). They are rectangular in abactinal view, the lateral faces jutting slightly and asymmetrically over lateral sides and extending to an adradial stepped edge. The lateral faces are flat to slightly concave, and have a profile parallel to that of the ossicle, being only a bit shorter on the abradial side (Figs 2c, e; Pl 1a). Thus, fascioles are shallow, becoming deeper on the outer margin. The external face has an ornament of dense, weakly impressed pits for attachment of granules or spines (nearly 20 per square millimeter, Figs 2c, e).

The inferomarginal ossicles are more variable in size and shape than the superomarginal. Ossicles of the disc and arms are rectangular in both proximal and external profiles (Figs 2a, f; Pl. 1c, d) whereas those of the interradius are shorter and cuneate (Figs 2b). The rectangular arm ossicles have a horizontal external side that becomes rounded abradially. The cuneate interbrachial ossicles have a triangular profile with regularly arched external face. In both morphologies of inferomarginal ossicles, the lateral faces for articulation with the adjoining ossicles are reduced, concave with an external rim, and let space for a fasciolar groove (Pl. 1d). Shallow along the oral side, the fascioles become abruptly deeper on the abradial side, to represent from 1/3 to 2/3 of the ossicle width. The deeper fasciolar grooves on inferomarginal ossicles suggest that the corresponding superomarginal ossicle was smaller in size, the inferomarginal ossicle row shaping the ambitus. The ornament is made up of irregular, low, rounded spine-bearing tubercles (Figs 2a, b, d, f; Pl. 1c, d). Arranged in a single row on the cuneate ossicles, the tubercles are sparsely distributed on the rectangular ossicles with a constant development of two close tubercles on the abradial margin.

Remarks: Hess & Blake (1995: 785) proposed an emended diagnosis of *Coulonia* based on a new species from the Barremian of Morocco. The marginal frame is defined with "inferomarginals very wide on disc, with deep intermarginal channels; the abradial margin of inferomarginals with prominent fringe of spines and superomarginals narrower than inferomarginals", which is considered as a fairly distinctive character sets. Only *Aldebarania* has similar marginal ossicles, which differ however by processes for articulation on the lateral faces and a distinct distribution of spines on the abradial ridge of the inferomarginal ossicles (Blake & Sturgeon 1995; Blake & Jagt 2005). The isolated marginal ossicles from Serre de Bleyton, perfectly fit the definition of *Coulonia*, and likely belong to this genus, despite the general difficulties for taxonomic assignment of isolated ossicles of Astropectinidae.

Several forms have been referred to *Coulonia*, ranging from the Valanginian (Radau 1992) to the Eocene (Rasmussen 1972). The material described by Radau (1992) has distinctive superomarginal ossicles with ornament of tiny tubercles. *Coulonia parva* (Neumann & Hess, 2001) differs by the lack of spines on the inferomarginal ossicles. *Coulonia platispina* has two sizes of tubercles on outer face of the inferomarginal ossicles, the larger ones bearing robust, short, flattened spines, two of which are inserted on the abradial ossicle margin (Hess & Blake 1995). The type species *Coulonia neocomiensis* is defined with inferomarginal ossicles bearing a stack of 5-8 flattened spines on the abradial side (de Loriol 1874). Further revisions of the species (Hess 1955, 1970) demonstrated that some of the inferomarginal ossicles have a rough, irregular, spine-bearing tubercle. Thus, size, development of the fasciolar grooves, and ornament are comparable to the material of Serre de Bleyton.

Occurrences: Hauterivian of the Neuchâtel area (Switzerland) and Barremian of Serre de Bleyton.

Order Valvatida Perrier, 1884

Family Stauranderasteridae Spencer, 1913

Genus *Aspidaster* de Loriol, 1884

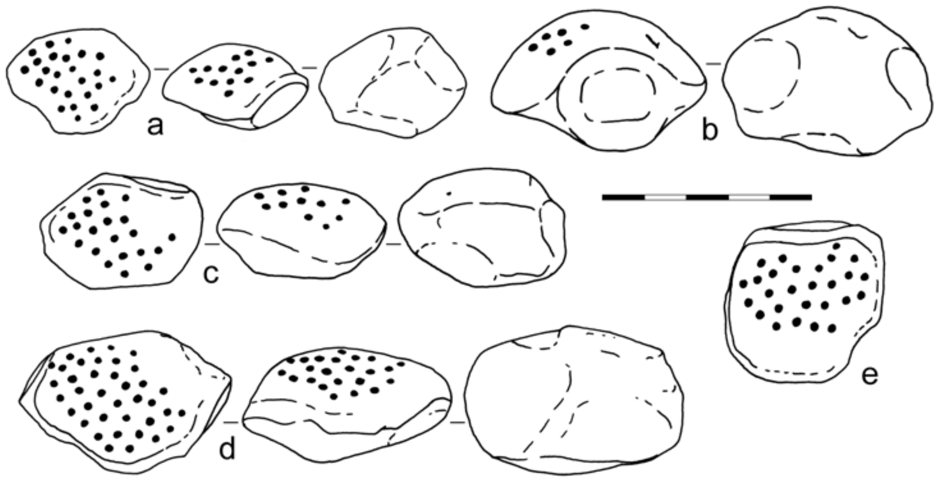

Fig. 3. ? *Aspidaster* sp.; a-e: isolated arm ossicles (radial and marginal ossicles), MPUP VILL007-VILL011. Scale bar equals 5 millimetres.

? *Aspidaster* sp.
(Fig. 3; Pl. 1, Figs f-g)

Material: 16 ossicles that likely represent marginal and abactinal ossicles. All available material housed at the Musée de Paléontologie de l'Université de Provence, Marseilles, collection numbers MPUP VILL007-011 and VILL045 for figured ossicles and MPUP VILL044, VILL055 for the additional material.

Description: All available ossicles are of similar size (3 to 7 millimeters) and shape so that marginal, carinal and other abactinal ossicle types cannot be distinguished. In external view the outline of the ossicles vary from coarsely quadrate to hexagonal (Figs 3a, c-e). One or the two corners of the proximal side are truncated to provide space for the papular area. The proximal margin is more or less projected in an articulation process made of an external rim prolonged internally by an oblique, slightly concave face (Fig. 3b). The distal face is more flattened, vertical or slightly oblique and slightly concave. The lateral faces develop in large oblique planes that extend downward and give the internal face a faceted aspect. On all ossicles, the ornament of the external face consists of few sparsely distributed (5-7 per square millimeter), large and deeply impressed granule pits, on a poorly delineated raised central area (Figs 3 a, c-e; Pl. 1f, g). Neither spine bases nor pedicellariae pits are recognized on the external face.

Remarks: Assignment to the family Stauranderasteridae has no ambiguity considering the association of: 1) an ornament with granule pits on a raised central area (a pattern also known in Goniasteridae); 2) the indentation at some ossicle corners for papulae (also in Pycinasteridae and Oreasteridae); 3) the robust ossicles with regularly convex outer face (also in some Goniasteridae, Pycinasteridae and Oreasteridae); 4) the differentiated processes for articulation on the proximal sides (unique to several Stauranderasteridae); and 5) weakly differentiated shape of ossicle rows in the arm and the disc (rare in forms with large size ossicles). In *Aspidaster*, *Manfredaster*, and *Stauranderaster*, the ossicles of the arms slightly imbricate and develop distinct processes for articulation on distal and proximal sides similar to those described in the material from Serre de Bleyton (designated as kidney-like processes by VILLIER et al. 2004). Diagnostic features of *Manfredaster* are the enlarged ossicles in the disc and the distal part of the arm. The marginal ossicles are numerous on an individual, preserve well in the fossil record and are likely being sampled as isolated elements. Although limited, the material of Serre de Bleyton suggests similar size and shape for the ossicles of the arm and the disc, without occurrence of obviously hypertrophied ossicles, which make unlikely an assignment to *Manfredaster*. The type and only available specimen of *Aspidaster delgadoi* is poorly preserved and comparisons remain difficult, so that VILLIER et al. (2004) considered isolated marginal ossicles from the Oxfordian of France to complement the coding for cladistic analysis. Thus, *Aspidaster* could be distinguished from *Stauranderaster* by a low density of large and deeply impressed granule pits, primary ossicles in the disc similar in size to those of the arm, lack of pedicellariae pits, of grooves for papulae and of pits on the lateral faces. The material from Serre de Bleyton fairly fits the description of *Aspidaster* proposed by VILLIER et al. (2004) and is therefore tentatively assigned to this genus pending thorough revision of the type specimen.

Occurrence: Barremian of Serre de Bleyton, but ossicles with close morphologies also occur in Upper Jurassic rocks of France and Germany (unpublished data).

Family Goniasteridae FORBES, 1841

Genus *Comptoniaster* BRETON, 1984

Comptoniaster cf. *godeti* BRETON, 1992

(Fig. 4; Pl. 1, Figs h-i)

1992 *Comptoniaster godeti* BRETON, p. 231-238, figs 7-8, pl. 25
1997 *Comptoniaster godeti* BRETON – BRETON, p. 137

Material: 6 marginal ossicles, 2 from site 1 and 4 from site 2 of KROH et al. (2010). All available material housed at the Musée de Paléontologie de l'Université de Provence, Marseilles, collection numbers MPUP VILL012-015 for figured ossicles and MPUP VILL056, VILL057 for the additional material.

Description: All marginal ossicles are robust and block-like, varying in proportions from 1/3 wider than long to equidimensional (Fig. 4). The shortest and tallest ossicle corresponds to a distal position in short blunt arms and its vertical flattened adradial face indicates contact of the two ossicle rows close to the arm tip (Fig. 4b). The proximal

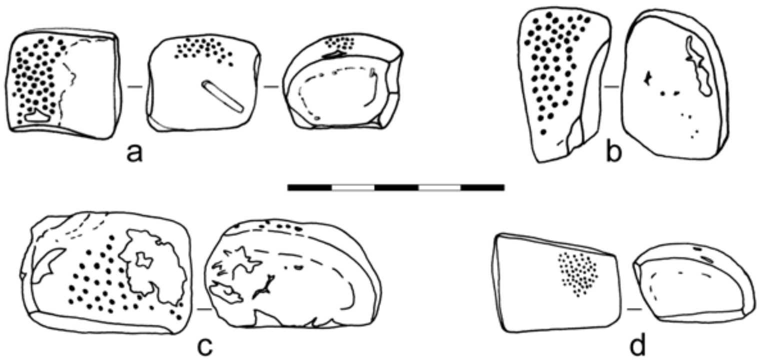

Fig. 4. *Comptoniaster* cf. *godeti* BRETON, 1992; a-d: marginal ossicles, MPUP VILL012-VILL015. Scale bar equals 5 millimeters.

profile shows a convex regularly curved external face that varies from horizontal on the adradial to vertical on the abradial margins (Figs 4a-d). The adradial side of the ossicles is vertical, and nearly equally divided into the internal face and the faces for articulation with the ossicle of the body walls (abactinal or actinolateral). The lateral faces are approximately parallel, flat or slightly concave with a poorly differentiated rim along the edge of the external face. The ornament is made up of dense granule pits (15-25 per square millimeter) that draw a polygonal network (Pl. 1h, i). One of the ossicles has a one 1.2 millimeter long, slit-like pedicellariae pit positioned obliquely on the abradial margin (Fig. 4a, Pl. 1h).

R e m a r k s : The basic construction of block-like marginal ossicles, the regularly curved external face, the ornament of regularly distributed granule pits, the absence of fasciolar grooves are considered a combination of primitive characters of the Goniasteridae (BRETON 1992, VILLIER et al. 2004), and taxa with such marginal ossicles are generally diagnosed with few apomorphies. This is found with slit like pedicellariae pits only in some Cretaceous species assigned to the genus *Comptoniaster* (*C. comptoni* (FORBES, 1848), *C. godeti* BRETON, 1992, *C. peetersorum* JAGT, 2000), *Ophryaster* spp. and *Tomidiaster sulcatus* SLADEN, 1891.

The genus *Ophryaster* can be differentiated from isolated material because of proportionally longer marginal ossicles, well demarcated granule pits, generally lacking on the adradial margin of the external face and occurrence of numerous pedicellariae pits, especially on inferomarginal ossicles (BRETON 1992). *Tomidiaster sulcatus* also has numerous pedicellariae pits and its interbrachial marginal ossicles are proportionally wider, with a marked angular profile. Among the Cretaceous species of *Comptoniaster*, only the paedomorphic *C. godeti* combines elongate pedicellariae and marginal ossicles similar in size and shape to the material from Serre de Bleyton. However, the pedicellariae pits seem more frequent and longer in the type material of *C. godeti* (BRETON 1992). Therefore, the new Barremian material is only tentatively assigned to that species, pending verification from additional material.

Occurrences: Early Hauterivian and Barremian, on the margins of the Alpine Basin, in France.

Genus *Caletaster* Breton, 1988

***Caletaster barremicus* nov. spec.**
(Fig. 5; Pl. 1, Figs j-l)

Derivatio nominis: Name derived from the Barremian age of the type locality.

Holotype: Marginal ossicle illustrated on figure 5a and plate 1j, housed at the Musée de Paléontologie of the Université de Provence, Marseilles, collection number MPUP VILL016.

Paratypes: Six marginal ossicles housed at the Musée de Paléontologie of the Université de Provence, Marseilles, collection numbers MPUP VILL017-VILL020, VILL046, VILL047.

Additional material: Batch of ossicles MPUP VILL058 and VILL059.

Locus typicus: Site 1 of Kroh et al. (2010), Serre de Bleyton, 2 km SW to Arnayon village, Drôme department, France.

Stratum typicum: Shelly grainstone (calciturbidites) interbeded with marls, Late Barremian.

Diagnosis: A species of *Caletaster* with a distinctive proximal/distal profile of the marginal ossicles, the external face being slightly sunken on its adradial margin and arched at its abradial side. Associated with this profile, the outline of the body margin is flat or slightly depressed. Ornament of dense fine granule pits, associated in some ossicles with tiny rounded tubercles. Pedicellariae unknown.

Description: The marginal ossicles reach a relatively large size, up to six millimeters in width, three in height and length. On the available ossicles, the length/width ratio ranges with size from 0.4 (Fig. 5a) in the largest ossicle to 0.7 in the smallest (Fig. 5e). This suggests that the relative length of the marginal ossicles increases from the interradius to the arm tip. In external view, the ossicles look quadrangular with lateral faces parallel or convergent to the abradial side and with a straight or angular adradial margin (Figs 5a, b). In proximal/distal view, the ossicles look approximately rectangular to triangular (Pl. 1k, i). The intermarginal face is markedly developed and accounts for 3/4 or more of the ossicle width. The internal face (that in contact with the body cavity) varies from flattened, oblique in the smaller ossicles to concave in the larger ones. The lateral faces are generally flat, although the faces of some ossicles have a slight thickened rim along

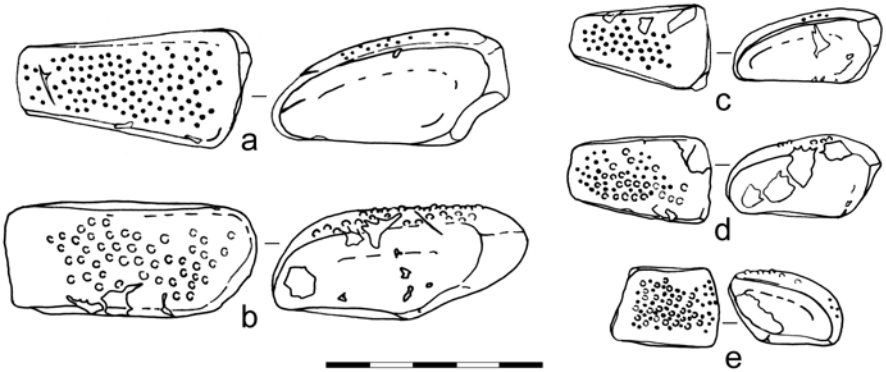

Fig. 5. *Caletaster barremicus* nov. spec.; a: holotype, isolated marginal ossicle MPUP VILL016; b-e: paratypes, isolated marginal ossicle MPUP VILL017-VILL020. Scale bar equals 5 millimetres.

the external face. The external face is flat to slightly convex (more developed in the ossicle's plane of symmetry) and well-delineated on the lateral sides by truncated ridges. In proximal/distal view, this latter ridge is oriented vertically or strongly curved abradially, becoming nearly horizontal or slightly curved on most of the ossicle width, and slightly sunken near the adradial margin (Figs 5b-d, Pl. 1k, l). The ornament is composed of 20-30 granule pits per square millimeter (Pl. 1j), associated on some ossicles with tiny rounded tubercles inserted between granules. No pedicellariae pits have been recognized.

Comparison: BRETON (1988, 1992) grounds the diagnosis of *Caletaster* mostly on characters of the marginal ossicles that are described as often "tordues" (= bent lateral faces), typically short, wide, with a triangular, slightly convex profile, and the superomarginal ossicles meeting at mid length of the arms. External faces are described with an ornament of well demarcated granule pits and/or tiny tubercles, and rare pits for insertion of pedicellariae. The description of the material from Serre de Bleyton matches fairly well Breton's definition of the genus.

So far, three species are assigned to *Caletaster* that differ sufficiently from the material of Serre de Bleyton to justify erection of the new species. The marginal ossicles of *C. girardi* can be distinguished by a constantly flattened external face with a smooth surface or dense, poorly impressed granule pits (BRETON 1992: Pl. 39.4). *C. decombei* has more robust, relatively longer and taller marginal ossicles with a constant ornament of large granule pits (10 to 15 per square millimeter) and relatively common pedicellariae pits. *C. romani* is a highly variable species so that (BRETON & NÉRAUDEAU 2008) define two morphotypes. The profile of the external faces may vary from convex to flat, and their ornament from smooth to covered with fine granule pits and/or tiny rounded tubercles. Combination of granule pits and tiny tubercles also occur in material from Serre de Bleyton, but, on average, *C. romani* has a lesser density (10 to 20 granule pits per square millimeter). Several structures are reported as occasional in *C. romani* that have not been observed in the new Barremian material: pedicellariae pits and ball and socket processes for articulation of adjoining ossicles. *C. romani* also differs by the proximal/distal profile of the marginal ossicles that looks more regularly arched in typical *C. romani* and more triangular in its morph *dominae* than in any ossicle of *C. barremicus* nov. sp.

Occurrence: Only known from the type locality, the Barremian calciturbidites of Serre de Bleyton.

Goniasteridae indet., nov. spec.

(Figs 6a-e; Pl. 1, Figs m-o)

Material: 12 marginal ossicles (7 from the site 1 and 5 from the site 2 of Kroh et al. (2010). All available material housed at the Musée de Paléontologie de l'Université de Provence, Marseilles, collection numbers MPUP VILL021-025, VILL048 for figured ossicles and MPUP VILL060, VILL061 for the additional material.

Description: The limited material does not allow separation of supero- from inferomarginal ossicles. All marginal ossicles are robust, quadrate elements ranging from 3.2 to 5.5 millimeters in their greatest dimension. The length and width are similar except in few ossicles that are elongated in the proximal-distal axis (Fig. 6). The ossicle's profile is characterized by a limited angle between the intermarginal and the adradial sides (100 to 140°), a regularly curved or angular external face that forms a vertical abradial margin of the ossicle (Fig. 6; Pl. 1n). The internal face and the faces for articulation with the ossicles of the body wall (abactinal or actinolateral ossicles) represent each approximately half the height of the adradial side. The occurrence of three to four quadrate faces demonstrates that each superomarginal was in contact with three or four abactinal ossicles, or actinolateral in the case of inferomarginal ossicles. A more or less developed convexity bulges out the external face, and is oriented either to the abradial side or in the dorso-ventral axis (Fig. 6; Pl. 1m-o). This convexity can be a simple and regular elevation above the lateral margins or correspond to a well-defined, raised bump. The external face looks integrally smooth, so that neither evidences of granule pits nor pedicellariae pits are recognized (Pl. 1m, o). The lateral faces have a coarsely rectangular or arched profile more or less parallel to the ossicle outline. The lateral faces are relatively flattened with a slightly thickened external rim, and the two faces of an ossicle are grossly oriented parallel or converging to the abradial side. These differences in orientation of the lateral faces suggest that the curvature of the body outline varies from the disc to the arms. Intermarginal side shows two articulation faces of very different sizes, which indicates that every individual ossicle was in contact with 2 ossicles of the other marginal row; a pattern generally described as alternating ossicles (i.e. in staggered rows).

Remarks: The large, robust, block-like construction of the marginal ossicles is indicative of the Goniasteridae. For comparison, the other groups of valvatidan asteroids with large marginal ossicles also have enlarged abactinal ossicles that are likely being sampled

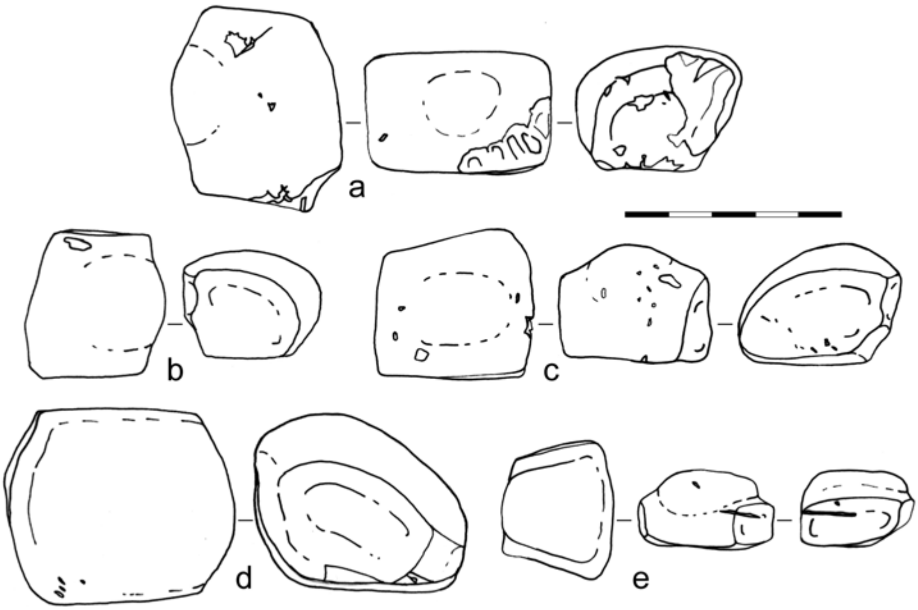

Fig. 6. Goniasteridae indet., nov. spec.; a-e: isolated marginal ossicles, MPUP VILL021-VILL025. Scale bar equals 5 millimeters.

together with the marginal (Oreasteridae, Stauranderasteridae) and/or have distinctive processes for articulation on the lateral faces (Pycinasteridae, Stauranderasteridae).

Several genera of Goniasteridae both extant and fossil are known to develop an abactinal bulge, among which few forms have a reduced ornament. The shape of the marginal ossicles from Serre de Bleyton is fairly similar to those found in some taxa of the *Pentagonaster* clade (*sensu* MAH 2007) and closely related forms. However, none have marginal ossicles completely lacking traces of accessories and the available material is insufficient for the thorough comparisons that would be necessary for a precise identification. The *Pentagonaster* clade is documented as fossil in the Paleogene (BLAKE & ARONSON 1998; MAH 2007) and if it could be demonstrated that the material from Serre de Bleyton belongs to this clade, its first occurrence date would move backward in time for 80 million years.

Occurrence: Only known from the Barremian calciturbidites of Serre de Bleyton.

? Sphaerasteridae SCHÖNDORF 1906a

Genus *Valettaster* LAMBERT, 1914

Remarks: *Valettaster* is generally classified together with the Jurassic *Sphaeraster* and *Testudinaster* and the extant *Podosphaeraster* in the family Sphaerasteridae because they all share a hemispherical to globular body shape (SPENCER & WRIGHT 1966). Several authors recognize that the body shape of sphaerasterids may be only superficially similar and that the construction of the skeletons is distinctive among genera (BLAKE 1984; BRETON 1985). *Valettaster* is characterized by multiple granular ossicles embedded in a thick dermal layer (BRETON 1985). *Podosphaeraster* has a globular body shape and no clear pattern in the distribution of the thin, tabulate extraxial ossicles (ROWE 1985; FUJITA & ROWE 2002). *Sphaeraster* and *Testudinaster* share a hemispherical, tessellate, dorsal surface, with ossicles arranged in rows (HESS 1983, 1994; BLAKE 1984). Thus, the Sphaerasteridae is in need for a full reassessment, and assignment of *Valettaster* to the family is here just conventional.

***Valettaster stipes* nov. spec.**
(Fig. 7; Pl. 1, Figs p-r)

Derivatio nominis: From the Latin "*stipes*" (= tree stump) for its morphological similarity with a cut trunk with radiating root bases.

Holotype: Holotype, isolated primary ossicle housed at the Musée de Paléontologie of the Université de Provence, Marseilles, collection number MPUP VILL026.

Paratypes: isolated primary ossicles housed at the Musée de Paléontologie of the Université de Provence, Marseilles, collection number MPUP VILL027-VILL029, VILL049-VILL051.

Additional material: Batch of ossicles MPUP VILL062 and VILL063.

Locus typicus: Site 1 of KROH et al. (2010), Serre de Bleyton, 2 km SW to Arnayon village, Drôme department, France.

Stratum typicum: Shelly grainstone (calciturbidites) interbeded with marls, Late Barremian.

Diagnosis: A species of *Valettaster* with primary ossicles characterized by a low, flattened shape and an irregular, slightly digitate outline. The external surface is a flat and rounded surface without ornament. Lateral faces are marked by shallow grooves and processes for articulation with adjoining ossicles (digitations or bulges) commonly with a central pit.

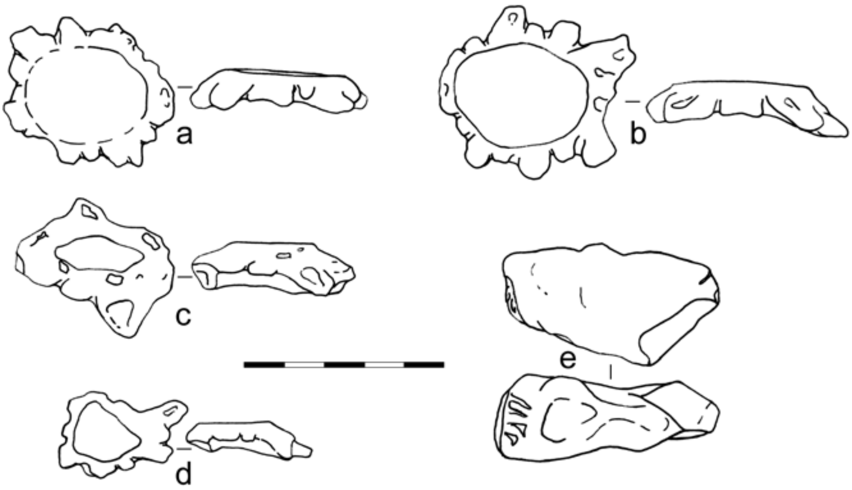

Fig. 7. *Valettaster stipes* nov. spec.; a: holotype, isolated primary ossicle MPUP VILL026; b-d: paratypes, isolated primary ossicles MPUP VILL027-VILL029; e: ambulacral ossicle MPUP VILL030. Scale bar equals 5 millimeters.

Description: The 15 primary ossicles available are tabulate with a height of nearly one millimeter for a larger dimension varying from 3 to 6 millimeters. The external face is always smooth and flattened (Pl. 1p, q). The lateral sides are oblique and develop complex outlines with grooves, bulges and digitations (Figs 7a-d). The digitations are often pitted and truncated in their upper side, which correspond to articulation processes with the adjoining ossicles or granules. The internal face, slightly convex, develops smooth undulations that connect to the lateral processes (Pl. 1r). The shape of the ossicles varies with size from approximately rounded to elliptical or irregularly polygonal (Fig. 7). Larger ossicles have a more rounded outline and are proportionally lower. The external face is broader and more rounded in larger ossicles whereas it is relatively smaller and irregular in smaller ossicles. The outline of the small ossicles also looks more digitate.

A short, compressed ambulacral ossicle is assigned to the species by comparison with that of *V. argus* illustrated by BRETON (1985). It looks trapezoidal in axial view with a reduced, squared, ambulacral head and a projecting keel-like ambulacral body (Fig. 7e). The articulation with the adambulacral ossicles develops large flattened surfaces for insertion of muscles. In median part of the ambulacral ossicle, the constrictions for passage of the podia are shallow, symmetrical, and the abradial blade forms narrow spaces for the ampulae. The adradial side of the ambulacral head articulate with the symmetrical ossicle through four reduced teeth, continuing on the same plane by a reduced area for attachment of a dorsal ligament. The open angle (120°) between the interradial articulation and the furrow side suggests an open ambulacral groove in living conditions.

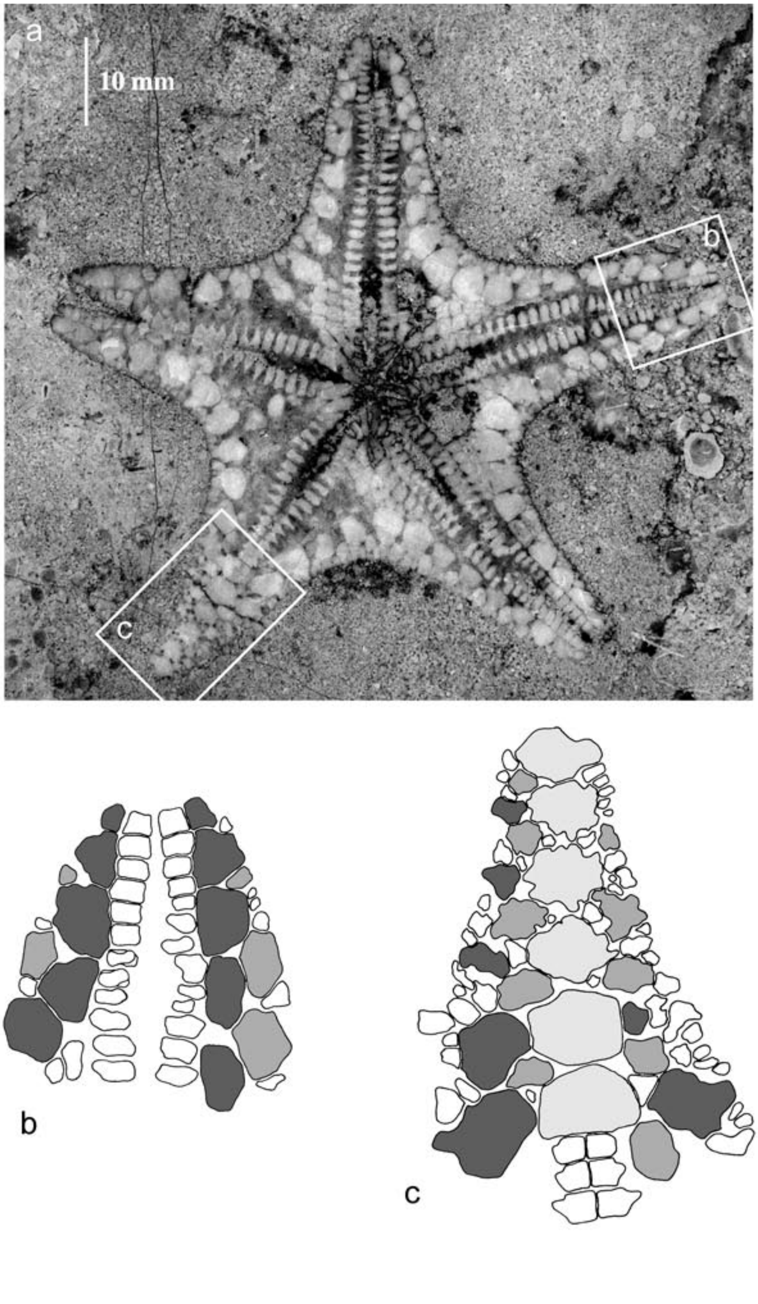

Fig. 8. *Leptaster martinii* Loriol 1880; a: Grainstone slab cutting transversally a specimen of *Leptaster martinii*, Bathonian, Quarry of Comblanchien, Côte d'Or, collection of the Université de Bourgogne. b: line drawing of an arm tip showing the contact between inferomarginal (dark gray) and adambulacral ossicles. c: line drawing of an arm section that shows the arm construction with inferomarginal (dark gray), superomarginal (median shade) and radial (light gray) ossicle rows.

C o m p a r i s o n : There are five species traditionally assigned to *Valettaster*: two from the Jurassic, *V. dangeardi* MERCIER, 1935 and *V. digitatus* (QUENSTEDT, 1858); two from the Upper Cretaceous, *V. argus* (SPENCER, 1907) and *V. ocellatus* (FORBES, 1848); and one from the Paleogene, *V. granulatus* BRÜNNICH-NIELSEN, 1943. The primary ossicles of the body wall (undifferentiated marginal, abactinal and actinal ossicles) are diagnostic for every species and thus allow a direct comparison with the material from Serre de Bleyton (SPENCER 1913; BRETON 1985).

V. granulatus can be easily differentiated by occurrence of large scattered granules on the outer surface (BRUNNICH-NIELSEN 1943), whereas it is smooth in V. *stipes* nov. sp. Overall shape of *V. ocellatus* ossicles is similar to that of V. *stipes* nov. sp., the species sharing rounded to lobate primary ossicles, a conical external face with pits on tiny radiating bulges on the lateral slopes. The ossicles of *V. ocellatus* are however thicker than those of *V. stipes* nov. sp. and have a distinctive radiating ornament on the external face. The ossicles of *V. argus* are small, compact with a dome-shaped upper side and develop an internal cavity (BRETON 1985), a rare character among asteroids. The flattened shape and large size ossicles of *V. stipes* nov. sp. clearly differentiate the species from *V. argus*. *V. dangeardi* was defined with overall shape of the ossicle quite similar to *V. argus*, the only difference noted being the lack of pits on the bulges and digitations of the lateral faces (MERCIER 1935). However, the type material is lost and the original illustrations and descriptions are insufficient determine whether *V. dangeardi* is a valid species and if so, if it belongs to *Valettaster*. I hereby follow BRETON (1985) and consider *V. dangeardi* as a *nomen dubium*. Regardless of its identity, the thickness of the ossicles and the lack of pits on the lateral side would differentiate *V. dangeardi* from *V. stipes* nov. sp. Compared to any other species of the genus, *V. digitatus* has larger ossicles (more than 5 millimeters) with expanding digitations, a reduced external surface, and an ornament of dense, very low crater shaped tubercles.

O c c u r r e n c e : Only known from the type locality, the Barremian calciturbidites of Serre de Bleyton.

Clade of uncertain affinities

R e m a r k s : *Asteriaceros*, *Geinitzaster* and *Leptaster* share original features, which would justify there association in a separate clade of Valvatida. However, the phylogenetic position of the group within the Valvatida is unclear and it is treated here as a clade of uncertain affinities.

Asteriaceros has long been considered a problematic genus (SCHÖNDORF 1906b; VALETTE 1932; HESS 1977). The very distinctive isolated ossicles of the type species *Asteriaceros stelliferus* are considered as inferomarginal ossicles of *Sphaeraster* by SCHÖNDORF (1906b), a hypothesis followed by almost all authors until HESS (1991) published a complete body fossil of *Asteriaceros* from the Oxfordian of Switzerland. *Asteriaceros cristatus* is a large stellate asteroid with long cylindrical arms constructed with two marginal rows, a carinal row, and abactinal and actinolateral ossicles only in the proximal part of the arm. Small secondary ossicles occur at the corners of the primary ossicles and are covered in the disc by a thick layer of secondary irregular ossicles and granules. External and lateral faces of the marginal ossicles have more or less developed ridges and grooves, generally radiating and/or bifurcating.

No mention of *Leptaster* was reported since its original description by de Loriol (1880). The type and only known species *Leptaster martinii* from the Bajocian of Burgundy is a large stellate form with a reduced number of ossicle rows consisting of enlarged inferomarginal, alternating superomarginal and carinal ossicles, and additional abactinal ossicles inserted between the carinal and superomarginal (Fig. 8c). Actinolateral fields are developed in the proximal part of the arm and look very similar to the pattern found in the Goniasteridae. The external face of the inferomarginal is relatively flattened and has an ornament of rounded tiny tubercles on which articulate very short conical spines. The adradial part of the marginal ossicles looks triangular in external view and develops grooves along the intermarginal face for articulation with the superomarginal. Superomarginal and carinal ossicles are marked by grooves and ridges on the external face. The whole upper surface of the arms and disc is covered by a thick layer of granular ossicles decreasing in size externally and inserted between the ossicles of the primary skeleton.

Žítt (2005) erected the genus *Geinitzaster* to accommodate very distinctive ossicles initially described as *Oreaster decoratus* by Geinitz (1871) from the Cenomanian deposits of the Bohemian basin (Germany and Czech Republic). The body structure remains unknown due to the variety and morphological peculiarity of the ossicles. However, some of the morphological types of ossicles recognized by Žítt (2005) are comparable with the marginal ossicles of *Leptaster* and *Asteriaceros* with reduced rectangular to triangular intermarginal, proximal and distal faces for articulation with the adjoining marginal ossicles (e.g. Žítt 2005: Figs 6l, 6o), and development of slight grooves along the ossicle sides, some of which bifurcating (e.g. Žítt 2005: Figs 4k, 6d, 8f).

Hess (1991) assigned *Asteriaceros* to the Goniasteridae on the bases of overall body construction, and the adoral face of *Leptaster* also suggests similarities with the Goniasteridae. However, other groups may share the similar body construction (Oreasteridae, Stauranderasteridae) and pavement of the adoral face (Oreasteridae, Sphaerasteridae). *Asteriaceros*, *Geinitzaster* and *Leptaster* are here interpreted as a distinct clade of Valvatida, branching close or within the Goniasteridae, Oreasteridae, Sphaerasteridae or Stauranderasteridae.

Included taxa:

Asteriaceros VALETTE, 1932

Note that the genus is assumed synonym of *Sphaeraster* by SCHÖNDORF (1906b), and synonym of *Valettaster* in the Treatise on Invertebrate Paleontology (SPENCER & WRIGHT 1966).

Asteriaceros stelliferus (GOLDFUSS, 1833), the type by original designation (synonym *Asterias pustulata* QUENSTEDT, 1858)

Asteriaceros cristatus HESS, 1991

Asteriaceros papulosus (DE LORIOL, 1868)

Geinitzaster ŽÍTT, 2005

Geinitzaster decoratus (GEINITZ, 1871), the type by monotypy

Leptaster DE LORIOL, 1880

Leptaster martinii DE LORIOL, 1880, the type by monotypy

Genus *Asteriaceros* VALETTE, 1932

Asteriaceros papulosus (DE LORIOL, 1868)
(Fig. 9; Pl. 1, Figs s-u)

1868 *Astrogonium papulosum* DE LORIOL, p. 81, pl. 7 figs 20-21
1975 «*Astrogonium papulosum*» DE LORIOL – HESS, p. 36
1977 *Lithaster* ? *papulosum* (DE LORIOL) – HESS, p. 329

Type material: The lectotype should be designated as the marginal ossicle illustrated by DE LORIOL (1868: Pl. 7, Figs 20-21) and collected from the Valanginian "Pierre Jaune" at Arzier Quarry, Vaud County, Switzerland. However, the present location of the original material is unknown to the author.

Material: Housed at the Musée de Paléontologie of the Université de Provence, Marseilles, collection numbers MPUP VILL031-VILL037, VILL052 for the figure specimens and MPUP VILL064-VILL065 for additional material.

Diagnosis: Marginal ossicles flattened, rectangular in outlines, two-fold differentiated into a quadrate adradial part on which the adjoining ossicles abut and a more or less prominent, strongly ornamented, abradial extension. External face with ornament of two to four poorly differentiated rows of crater-shaped tubercles. Abradial extension with ridges and grooves on its intermarginal side. Intermarginal face coarsely triangular, reduced to 30% to 50% of the ossicle width. Lateral faces flattened, reduced, and irregular in size and shape. The radial ossicles are wider than long, with ridges and grooves

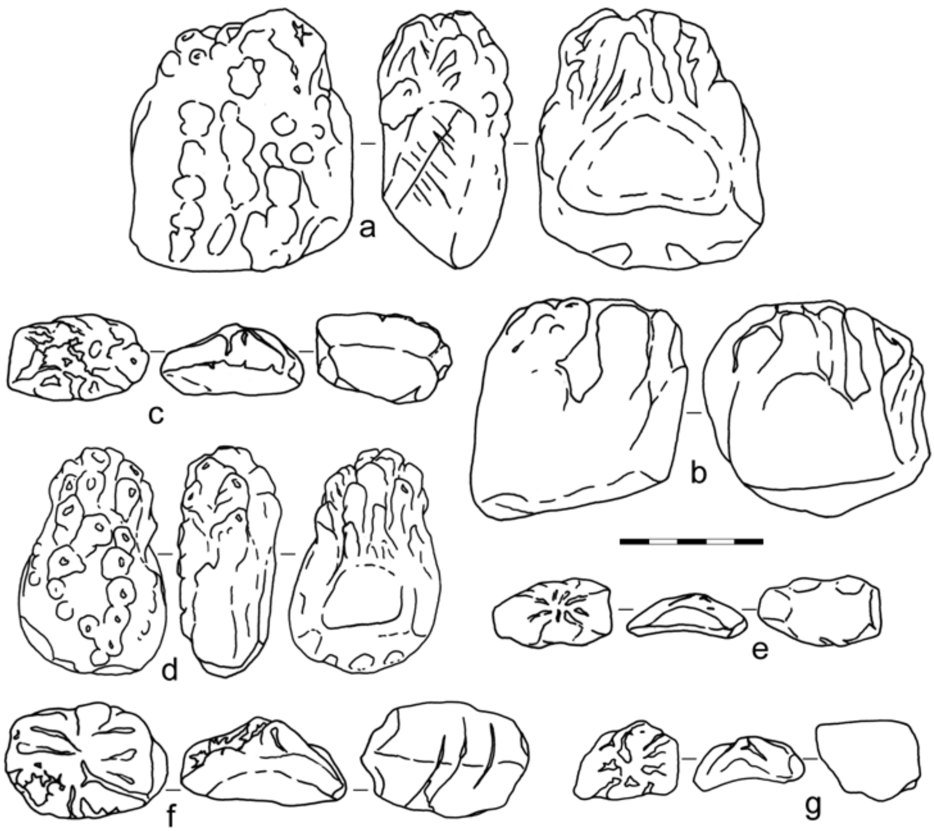

Fig. 9. *Asteriaceros papulosus* (de Loriol, 1868) ; a-c: marginal ossicles, MPUP VILL031-VILL033; d-e: radial ossicles, MPUP VILL034-VILL035; f-g: abactinal ossicles, MPUP VILL036-VILL037. Scale bar equals 5 millimeters.

throughout the external face. Ossicle of the disc large, robust, block like with a similar ornament as other dorsal ossicles.

Description: The material can be separated into three morphological types of ossicles, one corresponding to marginal (13 ossicles), carinal (10 ossicles) and abactinal of the disc (5 ossicles).

Marginal ossicles are flattened, rectangular in outline, and differentiated in a quadrate adradial part on which the adjoining ossicles contact and a more or less developed, strongly ornamented, abradial extension (Figs 9a, d; Pl. 1t, u). It remains unclear whether the marginal ossicles represent both infero- and superomarginal series or only the inferomarginal one. The larger marginal ossicle measures 12.8 mm in width, 7.4 mm in length and 4 mm in height, but most ossicles have a length of 4-5 mm. The external face has an ornament of irregular, crater-shaped tubercles more or less coalescent, organized in two to four rows (Figs 9 a, d; Pl. 1t). Tubercles become denser and less organized in the abradial extension, some being placed at the top of drop like processes that extend to the intermarginal side. Some irregular, bifurcating grooves carve the lateral sides and the intermarginal side of the abradial extension (Figs 9 a, d; Pl. 1u). The faces for articulation with the adjoining ossicles have limited extension: the intermarginal face is coarsely triangular, reduced to 30% to 50% of the ossicle width; the lateral faces are flattened, reduced, and irregular in size and shape. In the inferomarginal ossicles from the arm, the adradial face is oblique, with three or four faces for articulation with the adambulacral ossicles (Figs 9 a, d), whereas it is more rounded and irregular in the ossicles of the disc and/or the superomarginal ossicles.

The abactinal ossicles have a coarsely rectangular outline, about 30% shorter than wide (Figs 9c, f-g). The lower face is dihedral in the larger ossicles (i.e. carinal) and flattened or even slightly concave in the smaller ones (i.e. abactinals of the arm base). There are one or two oblique faces for articulation with the supermarginal ossicles which suggests that abactinal and marginal rows contact in the arm, either alternate or vis-à-vis. The upper side is conical and sculpted by a combination of irregular ridges and deep radiating grooves (Pl. 1s).

Ossicles of the disc are equidimensional to tall and block-like (Fig. 9b). The external face forms a low cone with an ornament similar to that of abactinal ossicles with radiating grooves and ridges. The grooves extend to the lateral faces, except where faces for articulation with adjoining ossicles develop. The internal face is flattened convex, carved by the extension of the grooves.

C o m p a r i s o n s : Ossicles with an external face covered with radiating ridges and grooves are described from several nominal taxa: *Asterias stellifera* GOLDFUSS, 1833, *Pentaceros jurassicus* ZITTEL, 1876, *Pentaceros pustuliferus* FRAAS, 1886, *Asteriaceros cristatus* HESS, 1991 and also occur in *Leptaster martinii* DE LORIOL, 1880. Marginal ossicles with similar low, rectangular shape and ornament characterized by well-demarcated and elevated crater-shape tubercles on the external side and conjunction of ridges and grooves in the abradial expansion have been described as *Asterias pustulata* QUENSTEDT, 1858 and *Astrogonium papulosum* DE LORIOL, 1868.

The body construction of the species from Serre de Bleyton is probably close to that of *Leptaster martinii*, but this latter taxon differs by the ornament of tiny tubercles and the lack of abradial projection of the inferomarginal ossicles (Fig. 8).

A. stellifera was described only from isolated ossicles, of quadrate outline, with a flat base, and an ornament of radiating ridges and grooves on the external face (GOLDFUSS 1833; QUENSTEDT 1858, 1876). SCHÖNDORF (1906b) considered *A. stellifera* as the inferomarginal ossicles of *Sphaeraster*, of which abactinal ossicles occur in the same levels in Germany. VALETTE (1932) described a suite of ossicles from the Oxfordian of Yonne (Eastern France) that associated *A. stellifera* with other ossicles similar to *A. pustulata*, but no *Sphaeraster*. He concludes that *A. stellifera* is a valid species and erects for it the genus

Asteriaceros. In VALETTE's opinion, the ossicles originally described as *A. stellifera* represent dorsal elements and those of *A. pustulata* the marginal ossicles of a single species. The publication of a complete specimen of *Asteriaceros cristatus* allowed HESS (1991) to refute SCHÖNDORF's hypothesis and to validate the genus *Asteriaceros*. *Asteriaceros stelliferus* shares several features with the form collected at Serre de Bleyton: large differentiated marginal with an adradial projection bearing ridges, flattened external face covered with crater shaped tubercles, and rectangular to oval dorsal ossicles with radiating ridges and grooves. However, the shape of the ossicles differs substantially: the marginal are more elongated with parallel lateral faces in *A. stelliferus*, the tubercles are denser and extend on the adradial projection in the material from Serre de Bleyton, and some of the dorsal ossicles of *A. stelliferus* bear tubercles on the ridges of the external face.

HESS (1991) described *Asteriaceros cristatus* with ossicles of similar size and shape throughout the arm and ossicles of reduced size in the disc, characters that do not match the description of the material from Serre de Bleyton.

HESS (1977) proposed a new genus name *Lithaster* for *P. jurassicus*. This taxon is very similar to *Asteriaceros cristatus* in arm construction and ornament of the ossicles, but HESS (1991) considered the two forms as morphologically convergent, evolved independently in the Stauranderasteridae for *Lithaster* and Goniasteridae for *Asteriaceros*. Compared to *A. cristatus*, *L. jurassicus* has robust bloc-like radial ossicles in the disc and lack the secondary layer of ossicles in the disc. The development and ornament of the marginal ossicles exclude assignment of the material from Serre de Bleyton to *Lithaster*.

P. pustuliferus was described from isolated ossicles and a small arm fragment, which was chosen later as lectotype by HESS (1977). The illustrated marginal ossicles are robust, and block-like with a distinct ornament of irregular ridges bearing prominent crater-shaped tubercles (FRAAS 1886; HESS 1977), which is very distinctive from the material from Serre de Bleyton.

In his original description of *A. papulosum*, DE LORIOL (1868) illustrated a single marginal ossicle, which should be considered as insufficient to ground a taxon. However, the given morphological description fully fits that of the material from Serre de Bleyton. Instead of considering *A. papulosum* a *nomen nudum* and defining a new taxon, I prefer a conservative approach and assume the material from Serre de Bleyton and *A. papulosum* to be conspecific. The newly described material deserves emendation of the diagnosis and justifies assignment of *A. papulosum* to the genus *Asteriaceros* because of the numerous characters shared with the type species *A. stelliferus*.

Occurrence: Species recorded from the Valanginian of Vaud Canton (Switzerland) and the Barremian of Serre de Bleyton.

Order Forcipulatida PERRIER, 1884

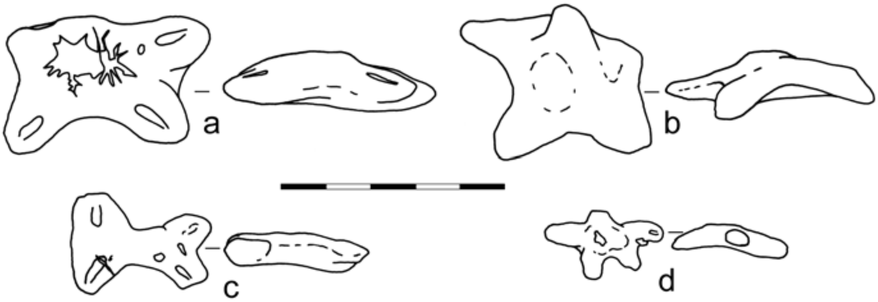

Fig. 10. ? Forcipulatida indet.; a-d: isolated digitate skeletal elements of the body wall. Scale bar equals 5 millimeters.

? Forcipulatida indet.
(Fig. 10)

Material: 4 isolated skeletal ossicles from the site 1 and 2 from site 2 of KROH et al. (2010) housed at the Musée de Paléontologie of the Université de Provence, Marseilles, numbers MPUP VILL038-VILL041, VILL066.

Description: The few ossicles assigned tentatively to forcipulatid asteroids are robust, digitate elements that likely represent marginal or abactinal ossicles. The size ranges from 2.5 to 5 millimeters in the larger dimension. The central part of the ossicles is relatively thick, but none of the ossicles show a clear tubercle for articulation of a spine. The four or five lobes show slight scars that represent articulation faces to the adjoining ossicles.

Remarks: Clear recognition of Forcipulatida as fossil requires preservation of full bodies. The distinctive ambulacral ossicles can also be indicative, but any other isolated skeletal material must be considered very cautiously. For example, BRETON & FERRÉ (1995) assign to the family Asteriidae (Forcipulatida) several cross-shaped abactinal ossicles, with a central thickened part, frequently bearing a well-developed tubercle for articulation of a spine. Cross-shaped, digitate ossicles are common in other groups (e.g. Velatida, Asterinidae) and BRETON & FERRÉ (1995) ground their recognition of Forcipulatida on varied suites of ossicles including abactinal, marginal, ambulacral, and adambulacral ossicles. Only few and ambiguous elements are available from Serre de Bleyton and they are provisionally assigned to undetermined forcipulatid asteroids, pending collection of a more diagnostic set of skeletal elements.

Occurrence: Forcipulatida is a diverse modern order to which several fossil forms have been assigned, and earliest record date back to the Hettangian (BLAKE 1990). The material from Serre de Bleyton would be the first and only record of Forcipulatida from the Early Cretaceous.

Conclusion

Despite the unavoidable limitation inherent in fragmentary material, the isolated skeletal elements of asteroids allow at least an evaluation of ancient diversity in many localities lacking more complete fossil representation (Villier & Kutscher 1999). It has been possible to recognize 8 taxa based on 343 ossicles collected from Serre de Bleyton, which represents the second comprehensive fauna sampled worldwide in the Lower Cretaceous, after that of the Albian of Texas (Blake & Reid 1998). The newly described taxa document common families in the Jurassic and Cretaceous of Europe, but they significantly modify the recognized stratigraphic ranges of genera and solve some taxonomic problems.

Coulonia neocomiensis, a well-documented species in the Hauterivian of Switzerland, is now extended to the Barremian. It is the oldest species of a genus that occurs frequently in the Upper Cretaceous and the Lower Cenozoic (Jagt 2000).

The Stauranderasteridae was hitherto unknown from the Lower Cretaceous, which weakened the resolution of its phylogeny (Villier et al. 2004). ? *Aspidaster* sp. described here partially close the stratigraphic gap but its morphology remains too poorly understood to help with improving resolution of the existing phylogenetic reconstruction.

Caletaster barremicus nov. spec. predates by 30 million years the oldest formerly representation of the genus (Breton 1992).

Goniasteridae indet. nov. spec. is distinctive but no close Jurassic or Cretaceous relatives are recognized. More precise taxonomic assignment requires additional material.

The sampling of *Comptoniaster godeti* is the second occurrence of the species in the Lower Cretaceous of France, extending its stratigraphic range to the Barremian.

Valettaster stipes nov. spec. is the only record of the genus from the Lower Cretaceous whereas it is common in the Upper Cretaceous and represented in the Upper Jurassic by *V. digitatus*.

The new material of *Asteriaceros papulosus* confirms the validity of the species, and extends the range of the genus by 20 million years (Hess 1991). Its comparison with *Leptaster* and *Geinitzaster* allows recognition of a distinct clade of Mesozoic valvatidans.

The few elements assigned to Forcipulatida indet. indicate that the Barremian fauna of southeastern France included representation of the order. One or more species are present but their skeleton is too light and fragile to be identified at a lower taxonomic level.

Acknowledgments

I am very grateful to Gero Moosleitner for making the material available for study and for offering the opportunity to describe the diversity of an outstanding Lower Cretaceous collection of asteroid ossicles. Many thanks to Andreas Kroh for his editorial work and his patience during gestation of the manuscript. Roger Notonier & Alain Tonetto from the "Service Commun de Microscopie Electronique" of the Université de Provence are acknowledged for the SEM pictures, and Jérôme Thomas, Université de Bourgogne for the photos of *Leptaster martinii*. Reviews by Dan Blake and Andy Gale contributed to significant improvements of the manuscript. I am indebted to them.

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Plate 1

Coulonia neocomiensis de Loriol, 1874

Figs a, b: superomarginal ossicles MPUP VILL003, VILL42

Figs c-e: inferomarginal ossicles MPUP VILL001, VILL043, VILL004

? *Aspidaster* sp.

Figs f, g: isolated arm radial or marginal ossicles MPUP VILL011, VILL045

Comptoniaster cf. *godeti* Breton, 1992

Figs h-i: marginal ossicles MPUP VILL012-VILL013

Caletaster barremicus nov. spec.

Fig. j: holotype, external view of marginal ossicle MPUP VILL016

Figs k, l: lateral views of paratypes MPUP VILL046, VILL047

Goniasteridae indet., nov. spec.

Fig. m: external view of the marginal ossicle MPUP VILL023

Fig. n: lateral view of the marginal ossicle MPUP VILL048

Fig. o: external view of the marginal ossicle MPUP VILL025

Valettaster stipes nov. spec.

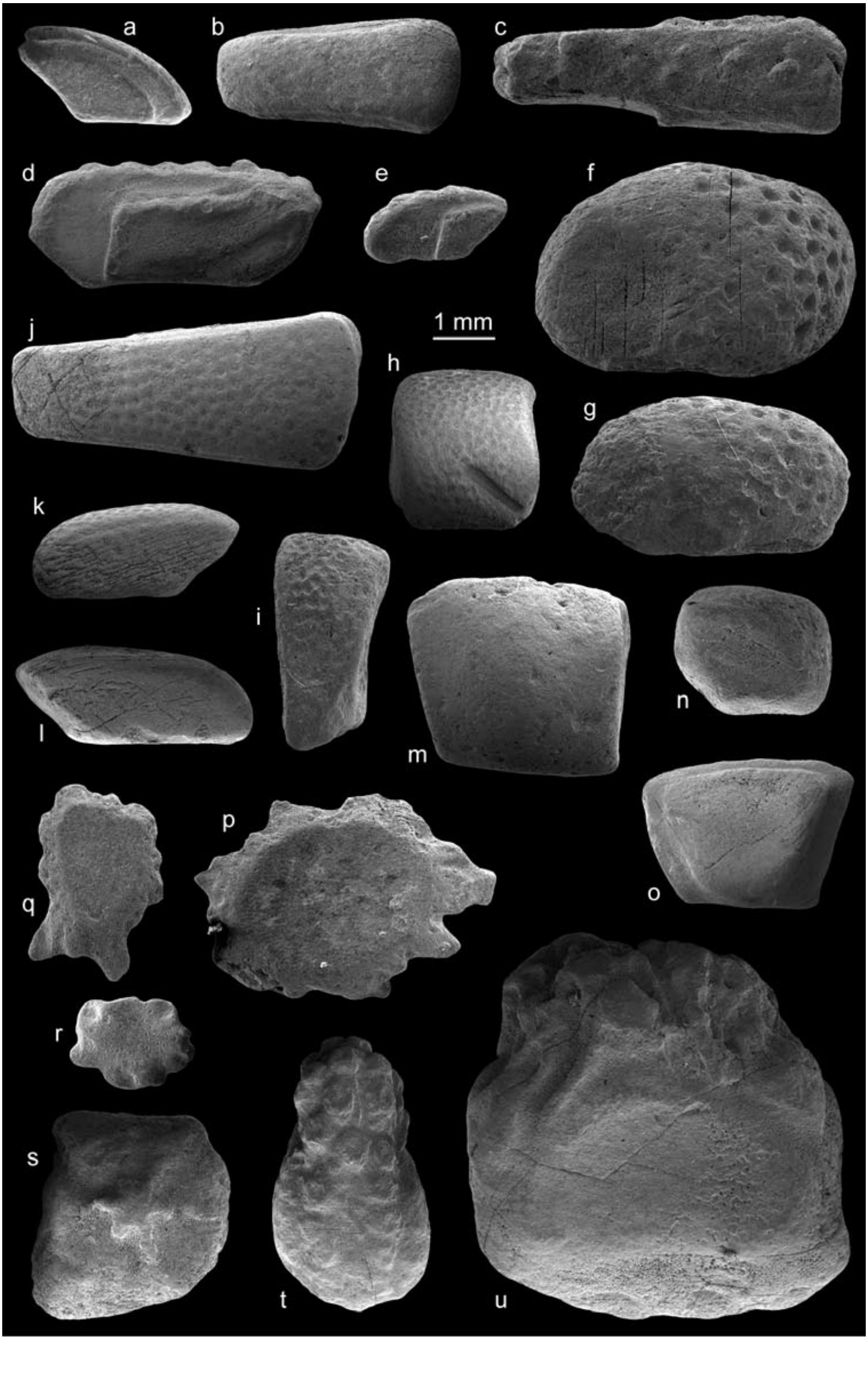
Figs p-r: paratypes MPUP VILL049-VILL051

Asteriaceros papulosus (de Loriol, 1868)

Fig. s: abactinal ossicle MPUP VILL052

Fig. t: marginal ossicles, MPUP VILL032

Fig. u: marginal ossicles, MPUP VILL031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