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Echinoderms from the Middle Triassic Sina Formation (Aghdarband Group) in NE Iran*)

By EDITH KRISTAN-TOLLMANN**)

With 4 Text-Figures and 5 Plates

NE Iran
Aghdarband
Middle Triassic
Sina Formation
Holothurians
Pelagic Crinoids
Stem Crinoids

Contents

Zusammenfassung

Aus dem obersten Ladin der Aghdarband Group (Shale Member der Sina Formation) in NE-Persien wird die Echinodermenfauna beschrieben, die sich vor allem aus Stiel- und Schwebcrinoiden, untergeordnet aus Holothurien-Skleriten sowie Ophiuren zusammensetzt. Die Fauna wird im Makrobereich von der Stielcrinoide *Traumatocrinus caudex* beherrscht; für die Mikrofauna bestimmend ist die Schwebcrinoide *Osteocrinus saklibelensis*. Die seltenere Schwebcrinoide *Osteocrinus aghdarbandensis* ist neu. Nahezu sämtliche artlich bestimmbaren Faunenelemente haben Leitwert für Oberladin/Unterkarn und sind im gesamten Bereich der Tethys weit verbreitet. *Traumatocrinus caudex* ist darüber hinaus auch im peripazifischen Raum nachgewiesen.

Abstract

A description is given of the echinoderm fauna collected in the uppermost Ladinian of the Aghdarband Group (Shale Member of the Sina Formation) in NE Iran. The fauna mainly comprises stem-crinoids and stemless pelagic crinoids, and to a minor extent sclerites of holothuroids and ophiuroids. The macrofauna is dominated by the stem-crinoid *Traumatocrinus caudex*; the marker fossil of the microfauna is the pelagic crinoid *Osteocrinus saklibelensis*. The newly established species *Osteocrinus aghdarbandensis* occurs comparatively rarely. Almost all fauna components are in the category of guide fossils of the Upper Ladinian/Lower Carnian; they occur over the entire Tethys realm. *Traumatocrinus caudex* has also been proven to occur in the Peripacific realm.

1. Introduction

The echinoderm-fauna of the Triassic of Aghdarband studied was obtained from samples (macrofossil-samples as well as marl-samples) which were collected by A. RUTTNER in 1956/57 and 1975/76 in the Aghdarband area in NE-Iran (Khorassan), that is located about 100 kilometers east of Mashhad close to the USSR-border (for more details see A. RUTTNER [1984, and this vol.]).

The major part of this fauna was found in the Faqir Marl Bed (= "Fossil Horizon 2") of the Sina Formation, Shale Member (see A. RUTTNER, this vol.). This horizon

*) Published within the framework of the IGCP Programmes Nos. 4 and 205.
**) Author's address: Univ.-Doz. Dr. EDITH KRISTAN-TOLLMANN, Scheibenbergstraße 53/6, A-1180 Wien.

is proved by the presence of ammonites to be Late Ladinian (Langobardian, *Frankites regoledanus* zone, see F. TATZREITER & L. KRYSTYN [this vol.]); it is characterized in particular by the abundance of the crinoid *Traumatocrinus caudex* (DITTMAR), as was already determined by R. SIEBER in 1960 (see R. OBERHAUSER, 1960, p. 13). Some layers of the Bed are crowded with stem fragments of that characteristic crinoid, which is present in the Upper Ladinian/Lower Carnian of the entire Tethys realm. Apart from these, a few columnalia of *Holocrinus* ? *quinqueradiatus* (BATHER), *Balanocrinus* sp. and *Entrochus* sp. were recognized – the first species being also typical of the Upper Ladinian/Lower Carnian.

Echinoderm fragments, obtained by washing the samples collected from the Faqir Marl Bed, proved to be of particular interest. Apart from juvenile trochites of *T. caudex*, numerous isolated arm fragments of that crinoid and, in addition spinules of the axillary (Axillardornen) were obtained – the latter not being described in the literature so far. Both the arm fragments and the spinules were identified to belong to *T. caudex* by means of comparison with specimens from China (including a crown fragment) at my disposal. Preliminary documentation is shown in plates 4 and 5. A dorsal cup belonging to a theca of *T. caudex*, found in the Aghdarband area, is also of special interest, as knotty ligament facets of the radialia are shown for the first time. An individual status of the genus *Traumatocrinus*, as compared with the genus *Encrinus* is proved by the findings (partly enumerated above) which were obtained from the Iranian and Chinese material. A separate publication on this subject is being planned.

The samples obtained by washing from the Faqir Marl Bed contain also numerous parts of pelagic crinoids, as well as a few sclerites of holothuroids and some unclassified discs of ophiuroids – though poorly preserved, fragmented and badly weathered. The species of the Holothuroidea and Roveacrinida, and their peculiarities are discussed in the particular chapters. All species as recognized in these samples are marker fossils of the Upper Ladinian/Lower Carnian, except for the newly found species *Osteocrinus aghdarbandensis* and the holothuroid *Kaliobullites umbo*; the latter was previously only recognized in the Rhaetian.

A small number of isolated columnalia and two short parts of stems of *Isocrinus* aff. *rollieri* (LORIOL) (see Pl. 5, Figs. 10–13) were collected in upper levels of the Shale Member of the Sina Formation and are considered to be also Ladinian/Carnian in age (see A. RUTTNER, this vol.).

The specimens of echinoderms coming from the "Collection RUTTNER – Aghdarband" are stored at the paleontological department of the Geological Survey of Austria, Vienna; those described in this paper having inventary numbers 1985/6/1 – 1985/6/43. Specimens collected in Austria, South Tyrol and Turkey are described for comparison and form part of the "Collection KRISTAN-TOLLMANN" at the Geological Department of the University of Vienna.

I wish to express my gratitude to Dr. A. RUTTNER for making the material available for the investigation and to Dr. R. OBERHAUSER for allowing me to review the washed samples obtained from RUTTNER's first collection (1956). The scan-photos were carried out at the Geological Survey of Austria, for which I am indebted to HR Dr. H. STRADNER and M. F. ALLRAM.

2. Holothuroidea

2.1. General Remarks

The extremely meagre assemblage of holothuroids presented in this paper is derived entirely from samples collectd by A. RUTTNER from the Faqir Marl Bed (= "Fossil Horizon 2"), at the base of the Shale Member of the Sina Formation (Upper Ladinian, *Frankites regoledanus* zone). The faunule merits attention because it proved to be determinable despite its fragmented and poorly preserved condition, and could thus be used at a synopsis of the distribution of the holothuroids within the Tethys realm; its composition also shows some interesting aspects. The assemblage consits of the following five species:

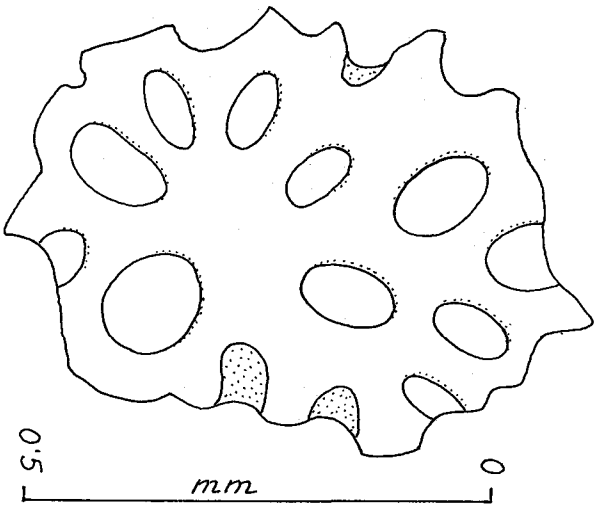
Eocaudina guembeli FRIZZELL & EXLINE (Pl. 1, Figs. 1–4)
Eocaudina cassianensis FRIZZELL & EXLINE (Fig. 1)
Achistrum triassicum FRIZZELL & EXLINE (Pl. 1, Figs. 7,8)
Acanthotheelia spinosa FRIZZELL & EXLINE (Pl. 1, Figs. 5,6)
Kaliobullites umbo KRISTAN-TOLLMANN (Pl. 1, Fig. 9)

All but the last of the species listed in the above order were first described by FRIZZELL & EXLINE (1956), all of them after pictorial and summary reviews by C. W. GÜMBEL (1869, Pl. 5) who first reported the presence of sclerites in Cassian Beds (lowermost Lower Carnian), St. Cassian, South Tyrol. These four species form part of the most commonly occurring and most typical holothurian sclerites of Cassian marls; with other newly discovered species they were restudied and revised by E. KRISTAN-TOLLMANN (1963) based on new material from South Tyrol. In the meanwhile, these species have been located at various sites in rocks of Upper Ladinian–Lower Carnian age in Europe, although not elsewhere (the sclerites designated by F. GRAMANN as *Acanthotheelia spinosa* FR. & EXL. from the Thigaungdaung limestone of Burma [Middle Triassic?] do not belong to this species). The proof of their occurrence in the uppermost Ladinian of Aghdarband in Iran shows once again that many typical Triassic fauna components occur over wide areas of the Tethys realm.

Eocaudina guembeli FR. & EXL. is the most frequent species from Aghdarband: Five fragments of this species are at hand; they show clearly the rows of hexagonal holes. On one fragment (Fig. 2 of Pl. 1, bottom right) even the decrease in size of the holes towards the edge is evident. In contrast to its frequency only one fragment of *Eocaudina cassianensis* was preserved in the samples from the Faqir Marl Bed. This relationship, i. e. between *E. guembeli* and *E. cassianensis*, is contrary to that found in the Cassian Beds of the Pralongia Mountain in South Tyrol; from the latter beds only one fragment of *E. guembeli* and numerous fragments of *E. cassianensis* were obtained (comp. E. KRISTAN-TOLLMANN, 1963, Pl. 2, Figs. 3–7).

Eocaudina cassianensis FR. & EXL. is characterised by its radially arranged holes, which are roundish to oval shaped, and by the rather large intervals between the holes. This is even observable in the small fragment available from Aghdarband.

Two fragments of *Achistrum triassicum* FR. & EXL. were found; their heads are preserved, although their peaks are broken off. Both hooks are poorly preserved; however, the socket to the central bridge is clearly observable in both heads. There is a considerable variation in



Text-Fig. 1.
Eocaudina cassianensis FR. & EXL., fragment, from the latest Ladinian from Aghdarband 100 km east of Mashhad in NE Iran.
Sample Ruttner 75/6; 1985/6/5.

the shape of the heads, which may be broad to narrow and unilateral to symmetrical, showing mostly two to three holes. This was noted and documented by E. KRISTAN-TOLLMANN (1963, Pls. 5–7), and is based on observations on the material from Cassian Beds of the Pralongia Mountain, South Tyrol.

Two specimens of *Acanthotheelia spinosa* FR. & EXL. are also at hand, one of them (Pl. 1, Fig. 5) being attached to a rock fragment. Both wheels are weathered to such a degree that the usually characteristic teeth or spinules are indistinct; rudiments of them are best preserved at the upper right edge of the sclerite, as shown in fig. 6. Nine and ten wheel-spokes respectively are counted at our two flat wheels. Nine to eleven, predominantly ten spokes are characteristic of the specimens of that species frequently found in the Cassian Beds of South Tyrol.

The discovery of one single specimen of *Kaliobullites umbo* KR.-TOLLM. is noteworthy, since this species is rarely found so far in the Rhaetian of Europe only. Proof of its presence in the Upper Ladinian of Aghdarband in Iran extends our knowledge regarding its stratigraphic and regional distribution considerably.

3. Crinoidea

3.1. General Remarks

The fossiliferous Upper Ladinian Faqir Marl Bed of the Sina Formation ("Fossil Horizon 2") is particularly characterized by the abundance of the stem-crinoid *Traumatocrinus caudex*. Individual layers of that Bed, each with a thickness of 20–50 centimeters, consist almost entirely of stem-fragments of that species (see A. RUTTNER, this vol., Fig. 21). Besides of the large number of stem-fragments, A. RUTTNER collected also a dorsal cup of a theca with the columnal still attached and (in 1956) a complete crown, which unfortunately could not at this time be located in the collections of the Geological Survey. Numerous juvenile columnalia were obtained by washing samples and in addition pinnulae and a great many of the characteristic axillary spinules of that species (see below). Columnalia of other species were also found, i. e. single trochites of juvenile individuals of the species *Holocrinus ?quinqueradiatus, Entrochus* sp. and *Balanocrinus* sp. Except for the columnal of *H. ?quinqueradiatus* all of these are poorly preserved and badly weathered to such a degree that a species-determination was not possible.

In addition, the washing of samples yielded abundant single parts of pelagic crinoids, although these were also in an extremely poor state of preservation. Centralia, radialia and brachialia could mostly be assigned to two species; the classification of a few radialia and brachialia remains uncertain.

To summarize, up to the present the following crinoid species are recognized in the Faqir Marl Bed at the localities sampled:

- Stemless pelagic Crinoids
  - *Osteocrinus saklibelensis* KRISTAN-TOLLMANN (Pl. 1, Figs. 11–13; Plate 2, Figs. 7–13)
  - *Osteocrinus aghdarbandensis* n. sp. (Pl. 2, Figs. 1–5)
  - *Osteocrinus rectus*? (not shown, several corroded fragments of brachialia)
  - *Osteocrinus* sp. (Pl. 1, Fig. 10)
- Stem Crinoids
  - *Traumatocrinus caudex* (DITTMAR) (Pl. 4, Figs. 1–9; Pl. 5, Figs. 1–7)
  - *Holocrinus ? quinqueradiatus* (BATHER) (Pl. 5, Fig. 8)
  - *Balanocrinus* sp. (1 columnal, not shown; pinule Pl. 5, Fig. 9)
  - *Entrochus* sp.

Lastly mention should be made of several columnalia and two somewhat longer stem fragments, collected southwest of the Aghdarband village in shales of the Shale Member of the Sina Formation (fossil locality 33a, see geol. map, Pl. 1 in A. RUTTNER, this vol.). These shales overlie the Faqir Marl Bed and are assigned to a Ladinian/Carnian age (see A. RUTTNER, this vol., chapter 3.2.3.2.). The appearance of the fragments corresponds to that of a crinoid known from the Upper Jurassic:

- *Isocrinus* aff. *rollieri* (LORIOL) (Pl. 5, Figs. 10–13).

3.2. Observations on the species

3.2.1. Pelagic Crinoids

Order: Roveacrinida SIEVERTS-DORECK, 1952
Family: Roveacrinidae PECK, 1943
Subfamily: Somphocrininae PECK, 1978
Genus: *Osteocrinus* KRISTAN-TOLLMANN, 1970

***Osteocrinus saklibelensis* KRISTAN-TOLLMANN, 1975**

(Pl. 1, Figs. 11–13; Pl. 2, Figs. 7–13; Pl. 3, Figs. 1–9)

*1975 *Osteocrinus saklibelensis* n.sp. – KRISTAN-TOLLMANN, p. 330ff., Pl. 7, Figs. 2,3,6,8; Pl. 8, Figs. 5,8–10,12,13; Fig. 30.

Observations: *Osteocrinus saklibelensis* was found for the first time in the Upper Ladinian/Lower Carnian Hallstatt Limestone at Saklibeli in the Taurus Mountains, Turkey. There, this rather frequently found

species is documented by several rather well preserved centralia, radialia, and long fragments of the centrale spine respectively. By contrast, brachialia are predominant in the Faqir Marl Bed; they are characterized by the same reticular groove sculpture at both edges, as they are typical both for the upper part of the centrale and the dorsal side of the radiale. Centralia are very rare in the Iranian material, only the slim upper parts being preserved; the long, thin, needle-shaped spines joining with these upper parts are broken off. At Saklibeli such spine-fragments are not rare; they are absent completely in the Faqir Marl Bed at Aghdarband.

On the whole, isolated elements of *Osteocrinus saklibelensis* are by far the predominating ones from pelagic crinoids in samples from the Faqir Marl Bed; considerably less elements of *Osteocrinus aghdarbandensis* are to be recognized and only a few arm fragments of *Osteocrinus rectus* (being badly weathered and, therefore, not positively ascertainable) were found in those samples – against which, however, the latter species occurs in abundance in beds of the same age at numerous other localities. Finally, two or three radialia (Pl. 1, Fig. 10) found in the samples belong to a further species of *Osteocrinus*.

Distribution: The floating crinoid *Osteocrinus saklibelensis* occurs with widely varying frequency throughout Upper Ladinian and Lower Carnian sedimentary rocks over the Tethys realm in Europe and Asia. Two occurrences of this species, at Saklibeli in the Taurus Moutains of Turkey (Upper Ladinian/Lower Carnian Hallstatt limestone) and with this paper the occurrence at Aghdarband near Mashhad in Iran (Upper Ladinian tuffaceous shale) are published so far. In addition I have specimens from two European localities on hand which for comparison are shown in Pl. 3, because of their better preservation in marls. They are isolated elements derived from this species which originate in Upper Ladinian Seeland Beds ("Seelandbach", 3 kilometers NW Schluderbach, South Tyrolian Dolomites, Italy) and in the Lower Carnian Halobia Shales of "Steiglweg" close to the lake "Vorderer Gosausee", Upper Austria.

Osteocrinus aghdarbandensis n. sp.

(Pl. 2, Figs. 1–5,6; Fig. 2)

Derivatio nominis: Named after the locality of the find (Aghdarband).

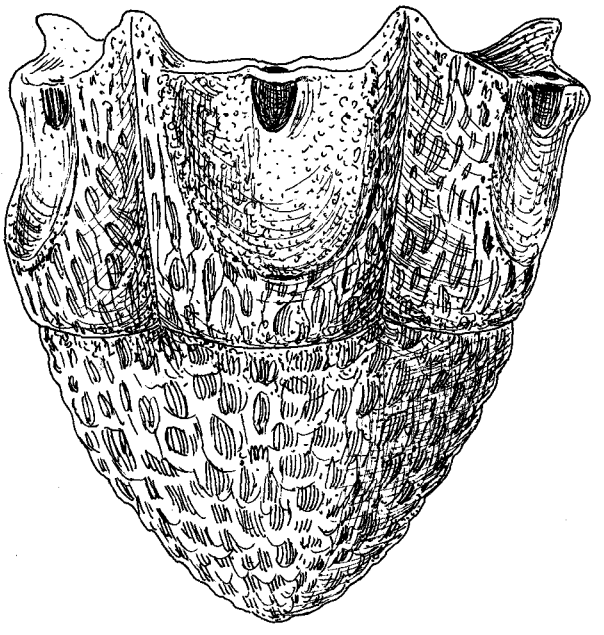
Holotypus: Central, Pl. 2, Fig. 1, Geol. B.-A. No. 1985/6/15.

Locus typicus: Aghdarband, 100 kilometers east of Mashhad, Khorassan, NE-Iran.

Stratum typicum: Faqir Marl Bed at the base of the Shale Member of the Sina Formation, latest Ladinian (Langobardian "three", *Frankites regoledanus* zone).

Sample material: Three centralia, two radialia and several brachialia form the Locus typicus; in addition a complete wheel of radialia (Pl. 2, Fig. 6) obtained from the Upper Ladinian Cassian Marls at the big landslide 2.2 kilometers WNW of St. Leonhard-Abtei above the Pedraces village, South Tyrolian Dolomites, Italy (sample x 81).

Diagnosis: A species of the genus *Osteocrinus* KRISTAN-TOLLMANN, 1970, which is characterized as follows: It is a small delicate species, whose extremely small, short and funnel-shaped centrale is pointed, with the blunt point distalward, terminating at the upper end with a broad, flat and slightly pentagonal-shaped rim. The small radials have a nearly rectangular contour; they are very flat and only slightly narrower at their base than at their upper part. The slightly curved ligament fossa is almost vertical and exceptionally large. It occupies nearly the entire width of the dorsal face of the radial and two-thirds of its length. The slender, thin, elongated brachials show the same fine irregular retiform sculpture dorsally at their broadened ends as do the centrals and radials at their outer walls.



Text-Fig. 2.
Osteocrinus aghdarbandensis n. sp., reconstruction of the theca.
Diameter on the upper rim 0.35 mm.

Description: In general this is a very small and delicate species, having long, slender arms. The extremely short, funnel-shaped centrale, with a rounded, pentagonal-shaped contour, narrows rapidly downwards and terminates in a blunt point. The plane, rounded upper rim is uniform in width. The radialia are also very small and have a straight and plane base; they are joined to the centrale over its entire width. The contour of the radiale is nearly rectangular as the latter increases only slightly in width upward. The shallow ligament fossa occupies about two thirds of the similarly flat dorsal side of the radiale. The broad arch of the ligament fossa becomes somewhat narrower downwards. As this large ligament-fossa is about vertical, it is assumed that the arms extend at right angles to the theka. The brachialia are long and extremely thin; they are particularly delicate and smooth – only the broadened ends of their dorsal sides are covered with a fine reticular relief. The same delicate irregular relief covers both the outer walls of the centralia and those parts of the radialia not covered by the finely crinkled surface marking the aboral ligament fossa.

Dimensions of the holotype: Diameter of the centrale at the upper edge: 0.36 mm; length: 0.25 mm. Specimen from South Tyrol (for comparison): Diameter of the wheel of radialia: 0.36 mm; hight: 0.25 mm.

Relationship to other species: The following species have short cup-shaped centralia: *Osteocrinus glaber* (MOSTLER, 1973), *Osteocrinus globosus* (MOSTLER, 1973), *Osteocrinus depressus* KRISTAN-TOLLMANN, 1976, and *Osteocrinus brevis* KRISTAN-TOLLMANN, 1976. All of them differ from our species in diverse ways.

O. glaber, whose centrale bears the greatest resemblance to our species, has no relief, but shows a smooth to extremely fine-grained texture, whereas the surface of our species is covered by a fine retiform sculpture. No information is available of the radialia of *O. glaber* and therefore, no comparison with the radialia of our species can be made.

O. globosus also has a smooth to longitudinally grooved surface; in addition, both the centrale and the radialia are differently shaped from those of our species.

The centrale of *O. depressus* is not funnel-shaped, but has a flat knobular form. The radialia of this species are not flat, but protrude, the ligament fossa being particularly prominent.

The radialia of *O. brevis* also protrude considerably with their small ligament fossa, in contrast to our species, where the large ligament fossa shows close alignment with the radiale. In addition, the centrale of *O. brevis* tapers to a point longitudinally and shows coarsely irregular longitudinal ribbing on the surface.

Distribution: *Osteocrinus aghdarbandensis* is considered to have been distributed over the whole Tethys realm; however, the occurrence of this species has until now been proven at one locality in Europe and one in Asia, i. e. in the upper Ladinian tuffaceous shales of Aghdarband near Mashhad in Iran and in the Upper Ladinian Cassian marls at St. Leonhard-Abtei, near Pedraces in the South Tyrolian Dolomites (Italy).

3.2.2. Stem-Crinoids

Order: Cladida MOORE & LAUDON, 1943
Family: Traumatocrinidae MU, 1949
Genus: *Traumatocrinus* WÖHRMANN, 1889

Comments: Judging by its characteristics, e. g. the presence of only three infrabasalia (W. KLIKUSCHIN, 1983, fig. 1), or the presence of interradialia and interbrachialia, or the biserial isotomous-endotomous arms, *Traumatocrinus* remains classified as an entirely "Paleozoic" genus, much more than *Encrinus*. It was a serious error to regard the genus *Traumatocrinus* synonymously with the genus *Encrinus* – thus uniting these two genera – as was done in the new Treatise on Invertebrate Paleontology, Part T, 1978. *Traumatocrinus* differs in so many essential characteristics from *Encrinus* that A.T. MU – after having studied numerous crowns – not only confirmed the independence of the genus *Traumatocrinus*, but also established a new family Traumatocrinidae as far back as 1949. Prior to that time only stems and one single root of that genus were known. Unfortunately, the type material of MU was not accessible to me for review during my stay in China in 1980; I was therefore unable to clear up several important particulars which would have furnished a more reliable coordination, including the order level. Thus, assignment to the order Cladida – as done here – is entirely provisionary as is the still incomplete list of synonyms of the genotype *Traumatocrinus caudex*.

In 1956, A. RUTTNER collected a complete crown of *Traumatocrinus*, apart from numerous stem-fragments, at Aghdarband, all of which were assigned to the Geological Survey, Austria. As soon as this crown – described to have been in excellent condition – is relocated, a detailed study comprising this crown and stem-fragments from the entire Tethys-Panthalassa realm is expected to help in clearing up questions which are still open.

Traumatocrinus caudex (DITTMAR, 1866)

(Pl. 4, Figs. 1–9; Pl. 5, Figs. 1–7)

*1866 *Porocrinus caudex* Dittm. – DITTMAR, p. 394, Tab. 20, Figs. 1,2.
·1866 *Porocrinus reticulatus* Dittm. – DITTMAR, p. 395, Tab. 20, Figs. 3–5.
·1866 *Porocrinus ornatus* Dittm. – DITTMAR, p. 395, Tab. 20, Figs. 6–8.
·1889 *Traumatocrinus caudex* Dittmar sp. – WÖHRMANN, p. 190, Tab. 5, Figs. 7,7a.
·1915 *Encrinus hyatti* Clark, n.sp. – CLARK & TWITCHELL, p. 22, Pl. 1, Figs. 3a–b.
v·1929 *Traumatocrinus timorensis* n. sp. – BATHER, p. 220, Pl. 257, Figs. 4a–c.
1949 *Traumatocrinus hsui* sp. nov. – MU, p. 86, Pl. 1, Figs. 1–7; Pl. 2, Figs. 1–4.
1949 *Traumatocrinus hsui* var. *enormis* var. nov. – MU, p. 89, Pl. 2, Fig. 5.
·1949 *Traumatocrinus uniformis* sp. nov. – MU, p. 89, Pl. 2, figs. 10,11.
·1949 *Traumatocrinus kueichouensis* sp. nov. – MU, p. 90, Pl. 2, Fig. 7.
·1949 *Traumatocrinus* sp. aff. *T. timorensis* BATHER – MU, p. 90, Pl. 2, Fig. 6.
·1949 *Traumatocrinus* sp. – MU, p. 91, Pl. 2, Figs. 8,9.
v·1973 *Traumatocrinus* n. sp. *rumerlensis* – ZARDINI, p. 5, Pl. 2, Figs. 13–14.
1973 *Encrinus granulosis* Münster – ZARDINI, p. 5, Pl. 1, pars: Figs. 34a,b; ?Fig. 26.
·1983 *Traumatocrinus caudex* (Dittmar, 1868) – KLIKUSCHIN, p. 85, Figs. 1–3.

Remarks:

Genotype: A. DITTMAR classified the new species *caudex, reticulatus* and *ornatus* in his new genus *Porocrinus*, although not defining neither a holotype nor a genotype. Type designations are not to be found in the paper of S. WÖHRMANN (1889) either, who introduced the name *Traumatocrinus*, because the genus name *Porocrinus* had already been conferred on an Ordovician crinoid genus by BILLINGS in 1857. It was only in 1929 that F.A. BATHER concentrated on our genus again, establishing lectotypes for all three species – though he questioned whether they are independent species (rightly so, see below!) – and he designated *T. reticulatus* to be the genotype. He selected this form because it seemed to him to be the most frequent and normal of all types – that is the middle region of the stem of a normal adult individual.

The possibility considered by BATHER has now become a certainty through the study of a rich material collected in Europe and Asia, i. e. that *T. caudex* and *T. ornatus* should be regarded as stem-fragments respectively of old or young, proximal or distal forms of one and the same species; *T. reticulatus*, however, represents the middle stem-section of an adult, normally preserved specimen. All three forms described by DITTMAR are part of a single species (see below) to which the name *caudex*, owing to page priority, applies. Therefore, the genotype of *Traumatocrinus* can not be named *T. reticulatus*; the genotype of *Traumatocrinus* is *Traumatocrinus caudex* (DITTMAR, 1866) which is the only species so far known of this genus.

Synonymy, stem: It was previously pointed out (E. KRISTAN-TOLLMANN et al., 1983, pp. 197) – based on personal knowledge of a wealth of material collected in Europe and Asia (particularly at Aghdarband, Timor and China) – that, on one hand the appearance of the stem of *Traumatocrinus caudex* differs from the proximal to the distal part and, on the other hand that the external sculpture of the stem of this species differs, depending on its preservation, i. e. grade and depth of weathering ("pseudo-outside-sculpture"). Furthermore, it was possible to show that almost all "species" as listed above were categorised on the basis of misinterpretation of the stem sculpture.
Thus, already the first author reporting on our genus was misled by differences in the shape of the stem, whether young or old specimens were concerned, and by differences between proximal and distal parts of the stem, as well as by differences in the preservation of the stem, and so had applied various stem-sections and stems of various ages to three different "species". Actually the following specimens were studied by him:
T. caudex (Pl. 20, Figs. 1,2, DITTMAR 1866) is a long and large stem-fragment from the distal region of a large adult individual. Typical for such a distal section are columnalia having all the same size, being of low height but having a large diameter, as the genotype (Fig. 1) clearly shows. The external sculpture differs, dependig on the grade of weathering; the less weathered parts seem to have smooth surfaces, whereas lattice-like structures appear in the strongly weathered parts (on top and at lower half of the stem, middle right in the same figure) which results from the weathering of the wall above the rows of pores along the articular facets. It turns out that the surface of entirely unweathered columnalia is irregularly sculptured by low spinules.
"P. reticulatus" (Pl. 20, Figs. 3–5) is the name given by DITTMAR to three stem-fragments of juvenile specimens of the species *T. caudex*. Two of them (Figs. 3 and 4) are derived from middle stem-sections; Fig. 5, on the other hand, shows a well preserved end of a stem with roots.
Finally, *"P. ornatus"* (Pl. 20, Figs. 6,7 and 8) is the name given to two stem-fragments, being in fact parts of proximal (Fig. 8) and most proximal (Figs. 6,7) stem-sections belonging to juvenile specimens of *T. caudex*. The nodalia are still clearly visible in this proximal section of the stem (as shown especially on Fig. 8), whereas they become more and more indiscernible in the distal sections. The typical lattice-like appearance (Fig. 8) is the result of strong weathering of the stem's outer wall. This appearance inspired A.T. MU (1949, p. 90) to the appropriate comparison with two sets of teeth chewing on another; it also led him to an (unjustified) nomination of the new species *T. kueichouensis*. However, S. WÖHRMANN (1889, p. 100) had already noted: "Durch eine starke Verwitterung nimmt die Oberfläche des Stammes von *T. caudex* eine gitterartige Beschaffenheit an" (i. e.: "the surface of the stem of *T. caudex* acquires a lattice-like texture through strong weathering").
Though BATHER (1929, pp. 218) had suspected that DITTMAR's specimens were derived from only one species, the stem-fragments originating from various stem-sections and of different ages, being (wrongly) classified into three species, he did not presume to propose a retraction. On the contrary, he established a special lectotype for each of these and enlarged the synonymy by a further species, i.e. *T. timorensis* which is derived from the Carnian Hallstatt Limestone of Bihati, Timor. The fragment in question is part of the middle to subproximal section of the stem, as was correctly stated by BATHER, its outer wall having been reduced by weathering to a smooth surface, with the spinules eroded, but the lattice-like structure remaining hidden. BATHER cited, as distinguishing criteria, the divergence in the dimensions and in the proportions of the columnalia from those of the holotype of *T. caudex* as well as the absence of sculpture as a marking difference from *T. reticulatus* and *T. ornatus*; but he still recognized both of these as separate species. Since then, it became known that the proportions of the stem depend on the age of the individual as well as on the stem-section from which a stem-fragment is derived, and that the texture of the external sides of the stem depends on the grade of preservation. I may add that several specimens of stem-fragments of the material collected by myself in the Carnian Hallstatt Limestone of Bihati – apart from other specimens in excellent preservation – show well preserved surfaces with spinules of *T. caudex* on one side of the stems, but resemble *"T. timorensis"* on the other side of the stems, because they are weathered there to a smooth surface.
The stem-fragment designated as *Encrinus hyatti* by W. B. CLARK (1915, p. 22) and originating from the Upper Triassic of California is undoubtedly a fragment of *T. caudex*, having a similar position and grade of preservation as the mentioned above *"T. timorensis"*. Perfectly similar to *"T. timorensis"* is *T. rumerlensis*, described by ZARDINI (1973) which was collected in the Cassian Beds in Italy, and the holotype (Fig. 11) of *"T. uniformis"* MU, 1949, derived from the Halobia Beds of Kueichou, China. The remaining new species of *Traumatocrinus*, which were unjustifiedly categorised by MU are (among others) the subject of a paper published in 1983 (KRISTAN-TOLLMANN et al., 1983, pp. 198). All stem-fragments described and figured by him are identical with the well known stem-fragments of *Traumatocrinus caudex* – with those being published as well as with those being to my hand – differing only in age, or in the grade of preservation, or in their position on the stem.

Articular facets: Some authors have argued that features of articular facets of the columnalia could also be used in species classification. However,

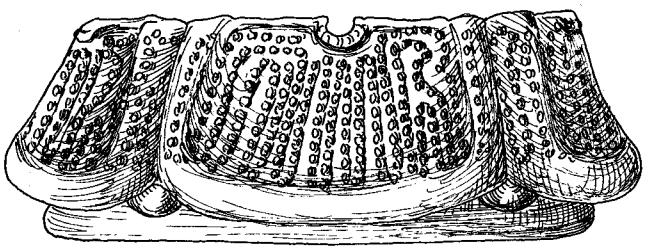
there are not many diagnostic features along individual stems, particularly features that could be regarded as suitable for species differentiation and characterization.

The relief shown in the articular facets of *T. caudex* is characteristical as follows: The entire surface is covered by radially arranged, plaited ribs, which branch outwardly to varying degrees corresponding to the diameter (i.e. age) of the columnalia; in juvenile specimens they show no such ramification. At the trochites of most proximal stem positions the indivicual ribs may be arranged more loosely and at narrow intervals in the central region; the ribs may even be curved to some extent there. The plait-like elements of this central region may be horizontally arranged instead in the shape of a V. Only close to the circumference of the trochites of these columnalia the ribs are packed closely together; there, they are separated from each other by narrow, straight, radial grooves, and the plait-like elements are V-shaped with outward opened legs. Example for this are our Fig. 8 of Pl. 4 (upper part well preserved), or the excellent photo on Fig. 34a, Pl. 1 of ZARDINI (1973), or – very typically – the photos d and e, Fig. 3 of KLIKUSHIN (1983). In contrast to these features being charcteristic for the articular facets of the proximal columnalia, all other sub-proximal, middle and distal stem-sections show the common standard features of the articular facets: plait-like elements arranged in narrow, strictly straight lines and being V-shaped also in the central part of the facet. Examples for these are: Fig. 4, Pl. 257 of BATHER (1929); Figs. 13,14, Pl. 2 of ZARDINI (1973); photo g in Fig. 3 of KLIKUSHIN (1983). These two variants of articular facets as described above are analogous as a general principle of all specimens studied so far. They are in agreement with all forms as published by various authors and as coming from extremely diverse localities; they render no specific discriminating character whatsoever. It may be added that the pore-canals of proximal columnalia are relatively large in diameter and, therefore, clearly visible; excellent examples for that are the Figs. 3d and 3e in KLIKUSHIN (1983). The pores of the articular facets of all other stem-sections, however, are hardly perceptible except for the most central regions of the articular facets.

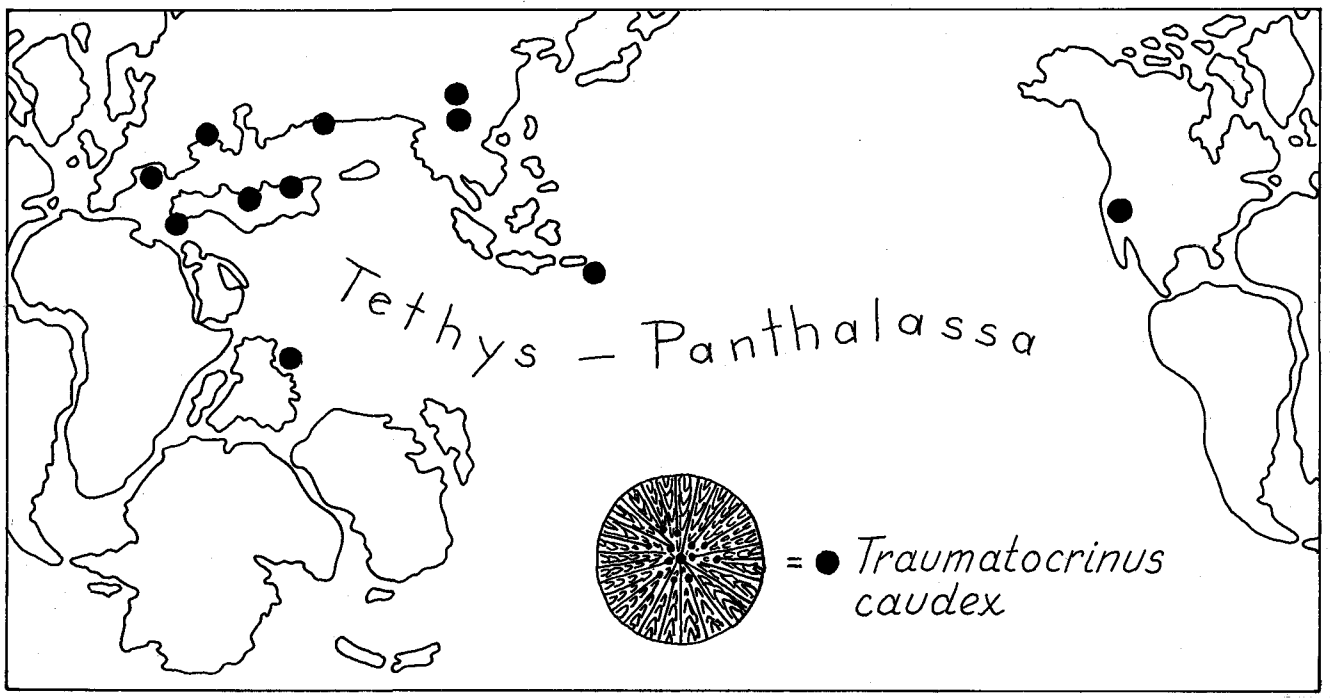
The outer wall of the columnalia may be straight to convex. The nodalia have narrow bulgy outer rims.

For the first time it is possible to show articular facets of isolated brachialia and of axillary spinules (Pl. 4, Figs. 6,7; Pl. 5, Figs. 1–6). The plane facets mostly show short, coarse ribs at their rims.

Of particular interest are the radialia, whose features can be examined through a specimen of the base of a dorsal cup, collected at Aghdarband (Fig. 3; Pl. 4, Figs. 1–5), the only available specimen of this kind. These are trapezoidal and flat and are rather wider than higher; they have extremely large ligament fossae, occupying almost the entire width of the external sides of the radialia; the ligament fields



Text-Fig. 3.
Traumatocrinus caudex **(DITTMAR), lateral view of the lower part of the theca.**
Latest Ladinian from Aghdarband 100 km east of Mashhad in NE Iran.
See also Plate 4, Figs. 1–5, 8.



Text-Fig. 4.
Circumtropic distribution of *Traumatocrinus caudex* (DITTMAR) in the Upper Ladinian/Lower Carnian according to the present knowledge.
Localities: Northern Limestone Alps/Austria and Bavaria; Dolomites/Italy; Taurus/Turkey; Aghdarband/Iran; Krimea and Pamir/USSR; northern Afghanistan; Spiti to Kumaun in Himalaya/India; Guizhou and Sichuan/China; Baun/Timor; California/USA.

– also trapezoidal in shape – terminate on three sides with straight and sharp edges and on their proximal sides with slightly convex, rounded edges. The ligament fossae are scarcely arched, rather flat, and show relief over their entire field: In the central part of the entire ligament field are, radially arranged, densely packed lines of nodules, emanating from the relatively small semicircular ligament pit and extending to the outer edges. On both sides of this central part are parallel arranged lines of nodules which continue, somewhat meandering, beyond the ligament field at the external face of the radiale (see Pl. 4, Figs. 2,3 and Fig. 1). The lower rims of the radialia appear to be somewhat bulbous.

Distribution (Fig. 4): *Traumatocrinus caudex* is a characteristic Upper Ladinian/Lower Carnian crinoid, often frequently (and in many places abundantly) occurring in sedimentary rocks of the basin- and swell-facies of the Tethys realm. The species occurs over the entire realm of the Tethys and, in the habitat of subtropical to tropical latitudes, also at the opposite shore of the Tethys-Panthalassa, now the westcoast of the American continent. This circumtropic distribution is confirmed by the occurrences personally known to the author as well as according to verified literature references as follows:

● Northern Calcareous Alps in Austria, particularly in the "Salzkammergut", E of Salzburg, and in Bavaria (Hallstatt Limestone and Carnian north-alpine Raibl Beds in Tyrol – compare also S. WÖHRMANN, 1889, p. 190);

● Southern Alps: Cassian Beds in South Tyrol (Italy); Central European alpine localities are compiled in the Fossilium Catalogus, W. BIESE (1934, pp. 143);

● Turkey: Carnian Hallstatt Limestone of Erenkolu Mezarlik;

● Iran: Upper Ladinian Shale Member of the Sina Formation at Aghdarband, ESE Mashhad, Khorassan;

● North-Afghanistan: Carnian, river basin of Schela and Chodja-Palur (W. G. KLIKUSCHIN, 1983, pp. 85, Figs. 2, 3)

● Himalaya, India: Daonella Limestone at Spiti, Kágá, Lilang; Lower Carnian crinoid limestone of the Shalshal cliff – (E. MOJSISOVICS & A. BITTNER, 1899; C. DIENER, 1908, pp. 7, 144, Pl. 2, Figs. 12–13; 1909, pp. 1, 38);

● Southern China: Numerous locations in the province Guizhou:
– Anisian (?) Kuanling Beds, W Kuanlingchang, Kuanling district (MU, 1949);
– Ladinian Halobia Beds at Falang (Kualing district), Leishihkuo near Lungchang and Lienhuantzai (Chengfeng district) (MU, 1949);
Author's own collections:
– Lower Carnian Trachyceras Beds, Wayao Subformation, near Yongningzhen, SW of Anshun;
– Lower Carnian limestone in sandstone layer, Longmendong, 10 km W of Emei, Sichuan;
Furthermore:
– Nanchuan (J. DUBOTOLOVA et al., 1959, p. 66);

● Timor: Carnian Hallstatt Limestone, Bihati, near Baun, W. Timor;

● U.S.A.: Carnian; location in the Oscar Tunnel, near Longville, Plumas County, California (W. B. CLARK et al., 1915, p. 22, Pl. 1, Figs. 3a,b);
Moreover:
● Crimea and Pamir Mountains: W. G. KLIKUSCHIN (1983, p. 84) refers to occurrences of our species in these regions;
● Spitzbergen: Abundant *Traumatocrinus* material from the Carnian (oral communication by H. HAGDORN, Ingelfingen, 17. Sept. 1985).

Order: Isocrinida SIEVERTS-DORECK, 1952
Family: Holocrinidae JAEKEL, 1918
Genus: *Holocrinus* WACHSMUTH & SPRINGER, 1886

Holocrinus ? quinqueradiatus (BATHER, 1911)

(Pl. 5, Fig. 8)

1911 *Dadocrinus* ? sp. – BATHER, p. 19, Pl. 1, Fig. 28.
*1911 *Entrochus quinqueradiatus* n. sp. – BATHER, p. 19, Pl. 1, Figs. 29–34.
1927 J 14 columnal, middle stem-section, articular facet [*Encrinus Carnalli* BEYR.] – BIESE, p. 54, Pl. 4, Fig. 10.
v·1973 *Encrinus* n. sp. *raridentatus* – ZARDINI, p. 6, Pl. 2, Figs. 24–25.
v·1975 *Entrochus quinqueradiatus* BATHER, 1911 – KRISTAN-TOLLMANN, pp. 278, Figs. 6–11; Fig. 12, Figs. 1,5; Fig. 19A; Pl. 4, Figs. 1–5.

Remarks: *Holocrinus ? quinqueradiatus* is extremely sparsely represented in the material collected at Aghdarband; but it does occur – in contrast to the finds at the location Saklibeli in the Taurus Mountains (Turkey), where numerous isolated columnalia and parts of the theca were found, so that at the least a preliminary reconstruction of the stem of that species was possible (E. KRISTAN-TOLLMANN, 1975, Fig. 19A). Based on this reconstruction – which yielded a few new essential facts – this species can now be tentatively assigned to the genus *Holocrinus* (diagnosis Treatise 1978, p. T849), with reservation, because no critically important parts of the theca were found.

The following features characterise the stem of the genus *Holocrinus*: Columnals are distally rounded, subproximally pentagonal, proximally pentastellate. The short crenulae are marginal to submarginal, and radially arranged. The columnals of the proximal and, partly, of the middle stem-sections have varying height and width, but are downward more and more uniform; the columnals of the distal stem-sections are generally uniform. The nodals are distinctly larger than the adjacent columnals; they are equipped with cirrus sockets at proximal stem-sections. The cirrus sockets are broad elliptical in shape; articular ridges are reduced to two, thick, bulbous, vertical tubercles.

Distribution: In Cassian Beds (Lower Carnian) of the Bakony (Hungary) and of the Dolomites in South Tyrol (Italy); in Hallstatt Limestone (Upper Ladinian/Lower Carnian) at Saklibeli in the Taurus Mountains (Turkey); in Upper Ladinian tuffaceous beds (Faqir Marl Bed of the Shale Member, Sina Formation) at Aghdarband, near Mashhad, Iran.

Family: Isocrinidae GISLÉN, 1924
Genus: *Isocrinus* MEYER, 1836

Isocrinus aff. *rollieri* (LORIOL, 1886)

(Pl. 5, Figs. 10–13)

*1886 *Pentacrinus Rollieri*, P. de Loriol – LORIOL, Pl. 149, Figs. 9–13.

Remarks: This form is a true representative of the genus *Isocrinus* having large recumbent, oval cirrus sockets. Judging by the features of the outer walls of the columnals, it is a typical Liassic crinoid. However, our specimens were collected from the Shale Member of the Sina Formation, just southwest of the Aghdarband village, which is dated as latest Ladinian to earliest Carnian, according to L. KRYSTYN & F. TATZREITER (this vol.) and A. RUTTNER (this vol.). There are only a few single trochites and two stem fragments available; an unobjectionable determination was therefore not possible so far. At present our form is attributed – with reservation – to the species *I. rollieri*, described first from the Upper Liassic.

Relationships: Our species has many common features with *Isocrinus rollieri* (LORIOL), i.e.:

- The development of the trochites' lateral faces is entirely similar in the horizontal middle ridge, which is smooth to nodular, having the larger nodules toward its tip (at the specimen shown in Pl. 5, Fig. 13 most of the nodules have been severed, but their basal remnants are still clearly visible; they are well preserved and are easily discernible in other columnals, e. g. in that shown at Pl. 5, Fig. 12).
- The development of the cirrus sockets, which are recumbent-oval and large; it shows a circumferential depression with a ridge encompassing the entire base, and a long horizontal articular ridge broadening outwardly and terminating at either end in a straight line, thus resembling a large, narrow tied bow.
- The full conformity in the features of the syzygial faces (comp. our columnal shown at Pl. 5, Fig. 12b with that shown at Fig. 12b, Pl. 149 at LORIOL, 1886): broad fields, short flat ribs at wider separations becoming shorter and finally discontinuing towards the center.

The only factor of uncertainty concerns an articular facet of a columnal of *I. rollieri* shown by LORIOL, Pl. 149, Fig. 11a, presumably from a middle or even from a more distal stem-section; according to that drawing, the petalodia of *I. rollieri* appear to be more rounded than those of our material. The latter belongs entirely to proximal stem-sections and shows pointed petalodia. Because of the lack of appropriate specimens to make a comparison, I was not in the position to decide whether the rounding of the petalodia as shown by LORIOL in his Fig. 11A, (Pl. 149) is a general characteristic of the species *I. rollieri* applicable to all stem-sections of this species, or whether it is specific to the central to distal stem-positions only.

The articular facets of our material also very much resemble those of *Isocrinus tyrolensis* (LAUBE), type "var. α" BATHER; however, the outer walls of the columnalia of that species are entirely smooth, straight to slightly concave, and the cirrus sockets are small and round.

Plate 1

Holothuroidea (Figs. 1–9) and Roveacrinida (Figs. 10–13) from the latest Ladinian (Faqir Marl Bed at the base of the Shale Member of the Sina Fm.; Langorbardian 3, *Frankites regoledanus* zone; sample Ruttner 75/36/3) of Aghdarband, 100 km east of Mashhad in NE-Iran.

Figs. 1– 4: ***Eocaudina guembeli*** **Fr. & Exl.**
Small fragments; 1985/6/1 – 1985/6/4.

Figs. 5,6: ***Acanthotheelia spinosa*** **Fr. & Exl.**
Strongly weather-beaten; 1985/6/6,7.

Figs. 7,8: ***Achistrum triassicum*** **Fr. & Exl.**
Spear broken off. At both eyes bar broken; 1985/6/8,9.

Fig. 9: ***Kaliobullites umbo*** **Kr.-Tollm.**
Lower side; 1985/6/10.

Fig. 10: ***Osteocrinus*** **sp..**
Radial from outside; 1985/6/11.

Figs. 11–13: ***Osteocrinus saklibelensis*** **Kr.-Tollm.**
Muscular articulation-end of brachials (fragments); 1985/6/12–1985/6/14.

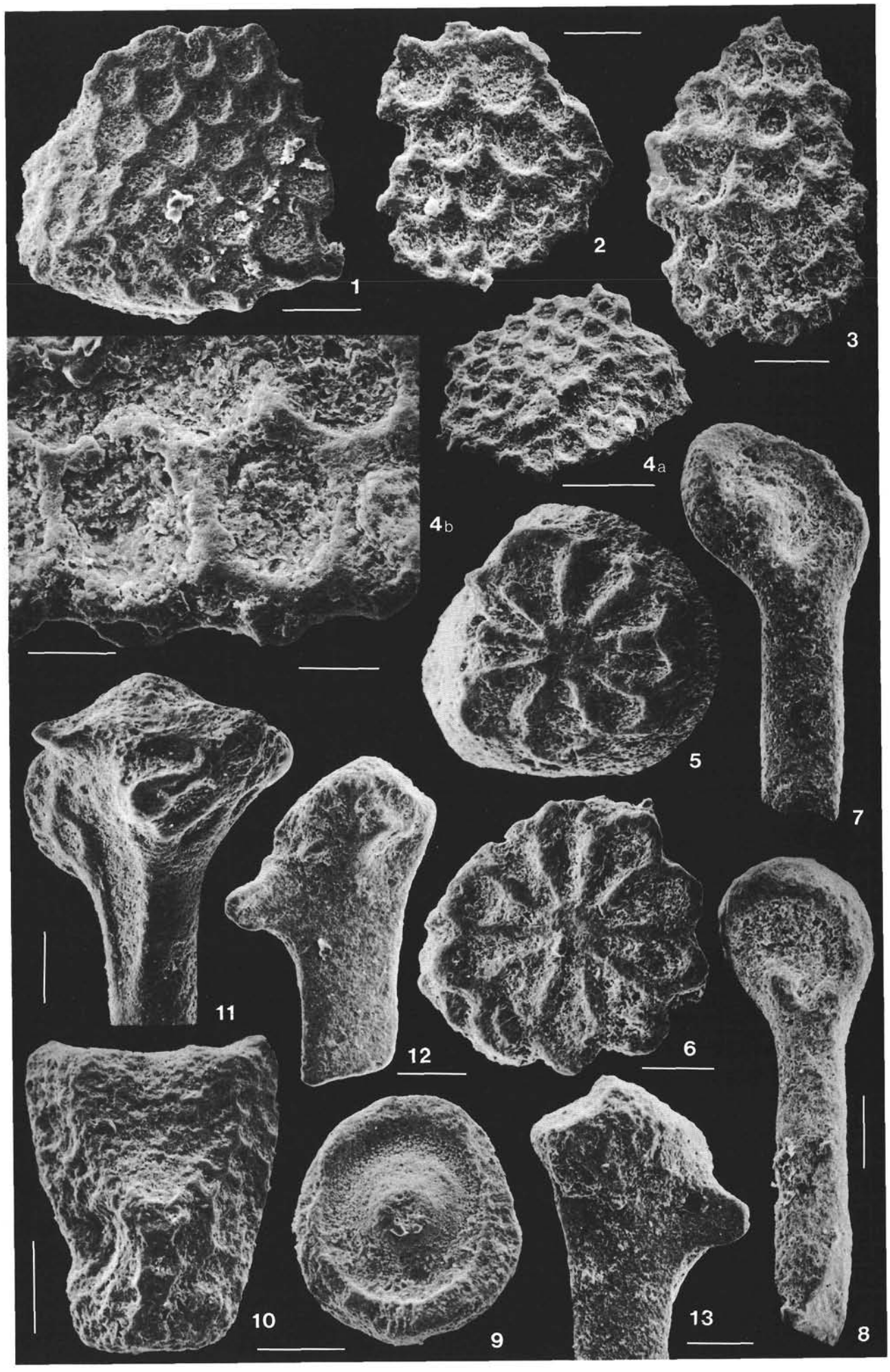

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Plate 2

Roveacrinida from the latest Ladinian (Faqir Marl Bed at the base of the Shale Member of the Sina Fm.; Langobardian 3, *Frankites regoledanus* zone) from Aghdarband 100 km east of Mashhad in NE-Iran (Figs. 1–4,8,11,13: sample Ruttner 75/36/3; Figs. 5,7,9,10,12: sample Ruttner 75/6) and from the upper Ladinian Cassian Marls near St. Leonhard-Abtei above Pedraces, Southern Tyrol, Italy (Fig. 6: sample KR.-TOLLM. x 81).

***Osteocrinus aghdarbandensis* n. sp.**

Fig. 1: Holotype, centrale, lateral view. 1985/6/15.

Fig. 2: Centrale from outside. 1985/6/16.

Fig. 3: Centrale from lateral; ventral border somewhat damaged. 1985/6/17.

Fig. 4: Radial from outside. 1985/6/18.

Fig. 5: PBr_1, proximal part, from outside. 1985/6/19.

Fig. 6: Radial circlet, lateral view.

***Osteocrinus saklibelensis* KR.-TOLLM.**

Fig. 7: Radial, 7a lateral, 7b dorsal. 1985/6/20.

Fig. 8: Radial from outside, ligament fossa encrusted. 1985/6/21.

Figs. 9,10: Centrals in lateral view, the long spine is broken off. 1985/6/22, 23.

Fig. 11: Axillary from the distal arm region. 1985/6/24.

Fig. 12: PBr_1, lower part, from outside. 1985/6/25.

Fig. 13: PBr_1, lower part, lateral view. 1985/6/26.

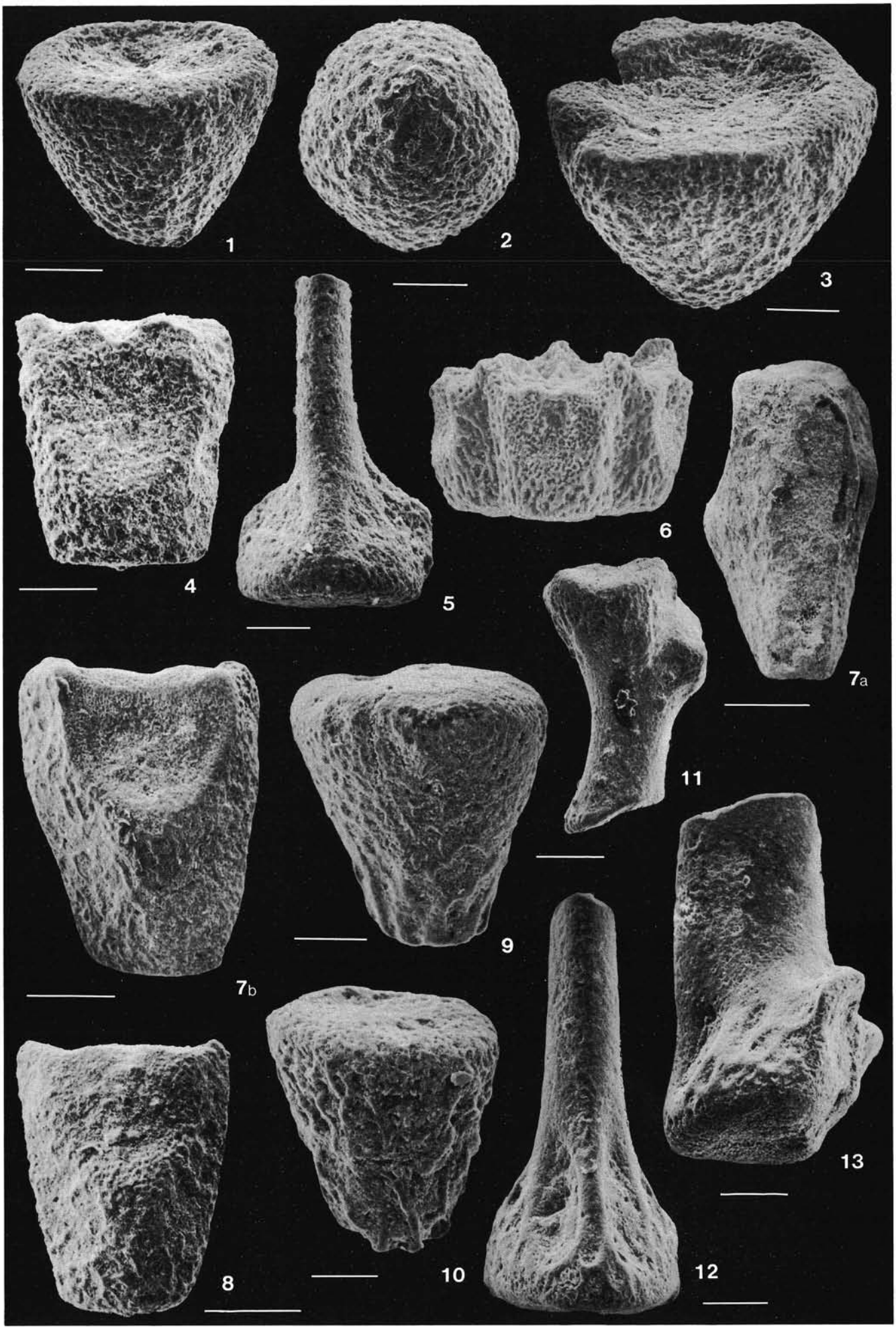
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Plate 3

Osteocrinus saklibelensis KRISTAN.-TOLLMANN
from the type locality in Turkey and from two localities in Europe for comparison with the Iranian material from Aghdarband on Pl. 2, Figs. 7–13.

Figs. 1–3,9: Centrals, lateral view, spine in a longer part preserved, broken off below. Limonit encrusted, dissolved from Hallstatt Limestone.
Lower Carnian Hallstatt Limestone from Saklibeli southwest of Antalya, Taurus Mountains, Turkey.

Figs. 4,5: Radials from outside.
Sample S747 as Fig. 7.

Fig. 7: Centrale in lateral view, spine broken off.
Lower Carnian Halobia schists from the "Steiglweg" near Vorderer Gosau lake in Upper Austria (washed sample S747).

Figs. 6,8: Centrals in lateral view, broken off below.
Upper Ladinian Seeland beds from the Seeland brook near Schluderbach, southern Tyrol, Italy (washed samples, Fig. 6: sample U826; Fig. 8: U836).

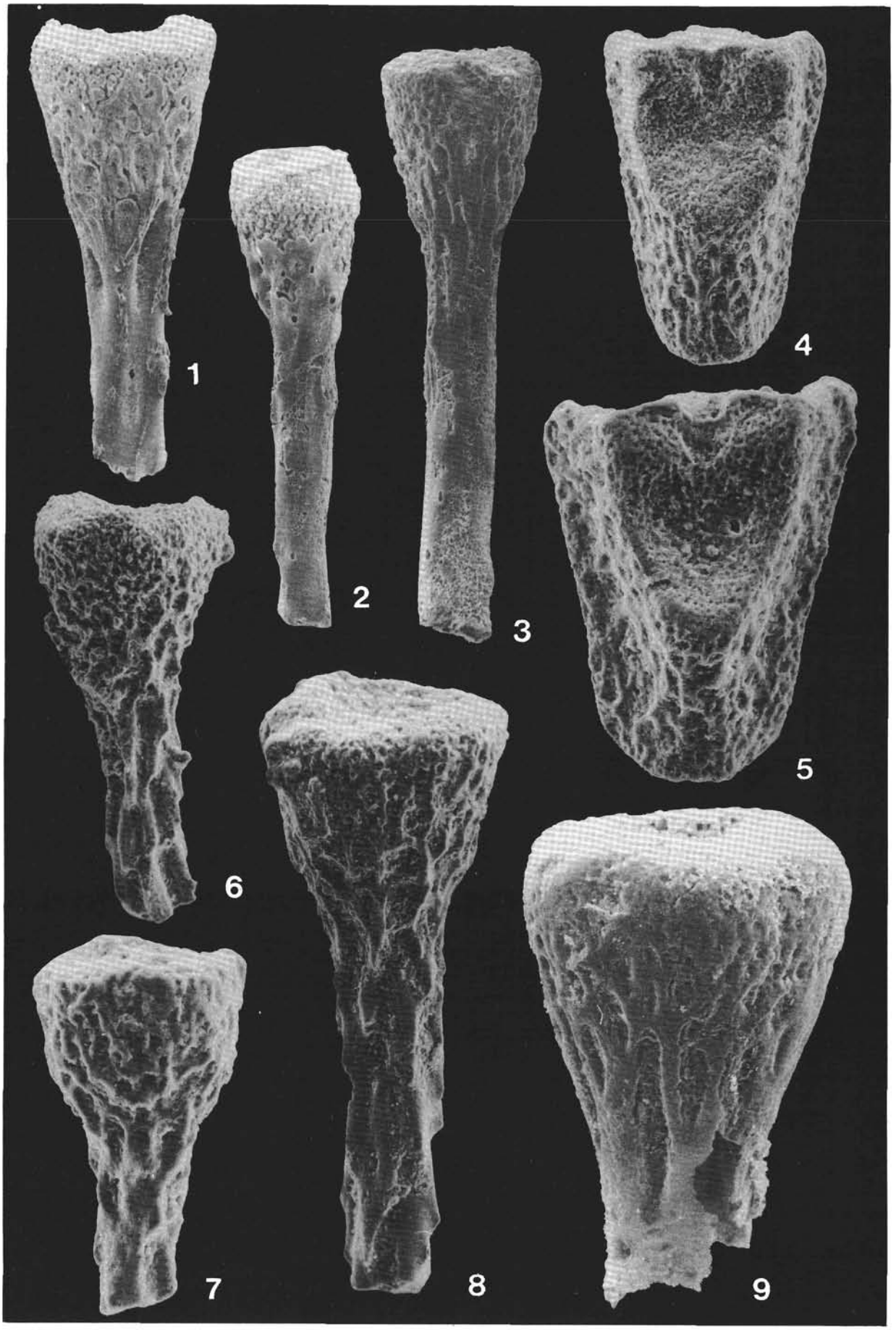
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Plate 4

Traumatocrinus caudex (DITTMAR)
from the latest Ladinian (Faqir Marl Bed at the base of the Shale Member of the Sina Fm.; Longobardian 3, *Frankites regoledanus* zone) of Aghdarband 100 km east of Mashhad in NE-Iran.
(Figs. 1–5,8: sample Ruttner P56/163; Figs. 6,7,9: sample Ruttner 75/6).

Figs. 1–5: Details from the lower part of the theca (see also Fig. 2).
Dorsal view with attached nodal see fig. 8; 1985/6/27).
The scale at Fig. 5 is the same for all five figures.
Fig. 1: One can see in the middle part of the figure two connected radials with their sculptur of rows of knobs.
Fig. 2: Ligament fossa of the right radial from Fig. 1.
Fig. 3: Ligament fossa of the left radial from Fig. 1.
Figs. 4,5: Poorly preserved radials with visible basals between and with a joined stem fragment below.

Figs. 6,7: Brachials with peripher costate articulation facet.
1985/6/28, 29.

Fig. 8: Dorsal view of the lower part of the theca, with nodal; diameter 16 mm. On the upper rim of the figure one can see the dorsal border of the radials (broad) and of the basals (very small knolls), because they stand out from the nodal. Details of the radials and basals see Figs. 1–5.

Fig. 9: Articulation facet of a very juvenile columnal, badly perserved.
1985/6/30.

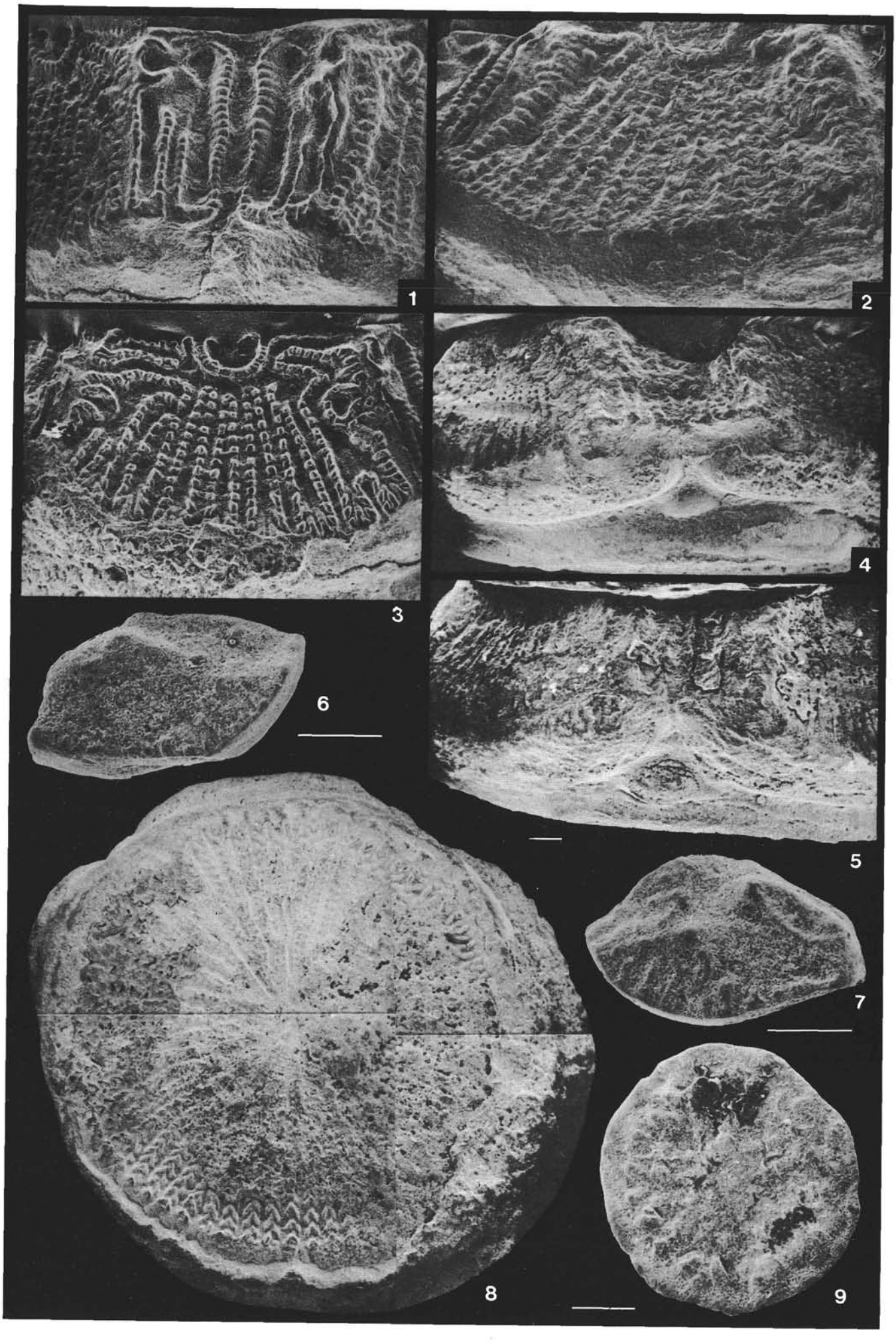
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Plate 5

Crinoids from the latest Ladinian (Figs. 1–9) and the Carnian? (Figs. 10–13) from Aghdarband 100 km east of Mashad in NE-Iran (Figs. 1–4: sample Ruttner 75/6; Figs. 5–9: Ruttner 75/36/3; Figs. 10–13: Ruttner Agh. 75/33a).

Traumatocrinus caudex **(DITTMAR)**

Figs. 1–6: Axillary spines.
1985/6/31–1985/6/36.

Fig. 7: Very juvenile columnal.
1985/6/37.

Holocrinus ? quinqueradiatus **(BATHER)**

Fig. 8: Juvenile columnal.
1985/6/38.

Balanocrinus **sp.**

Fig. 9: Pinnule, ventral view.
1985/6/39.

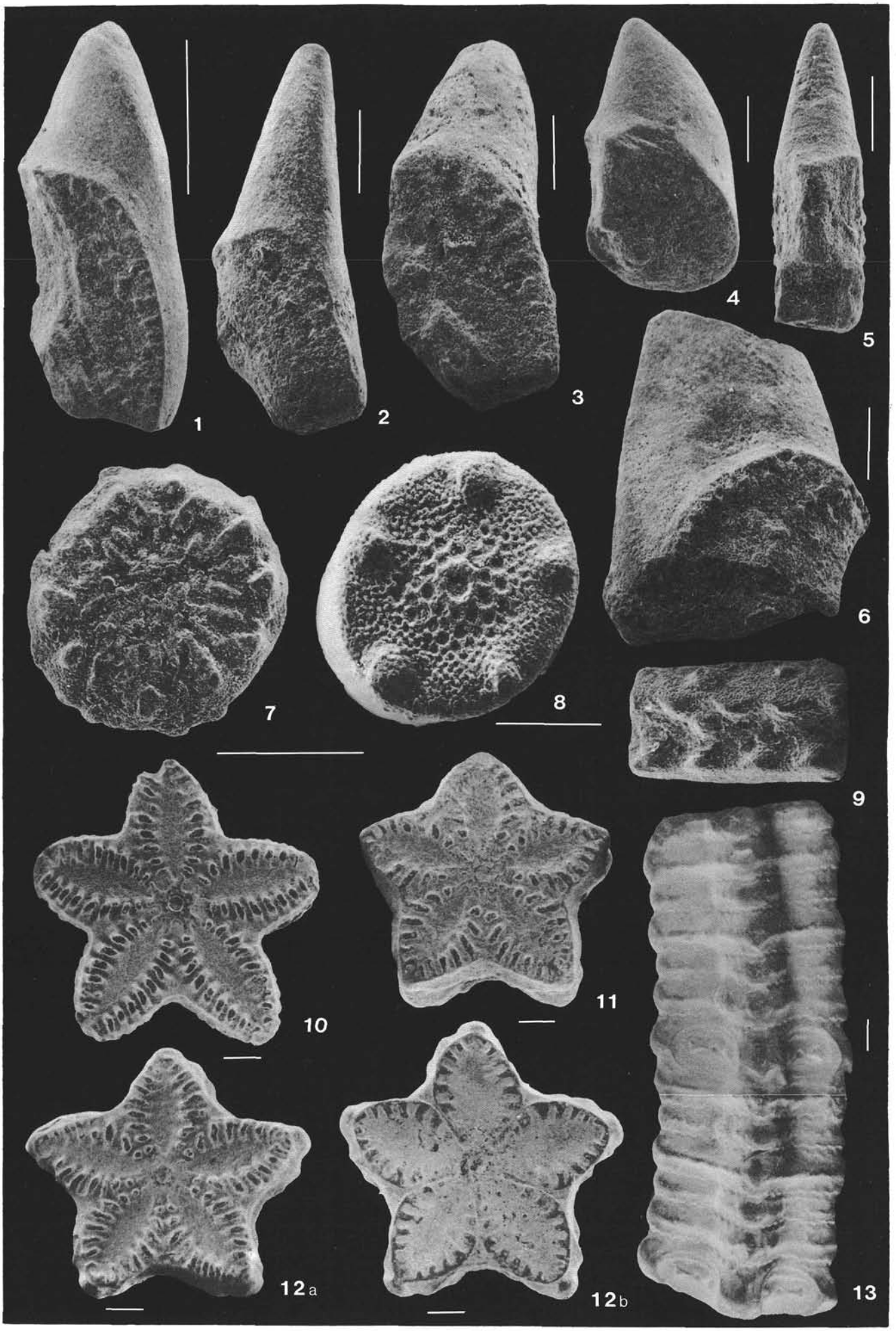
Isocrinus **aff.** ***rollieri*** **(LORIOL)**

Fig. 10: Flat columnal from the proximal part of a stem.
1985/6/40.

Fig. 11: Stem fragment of two columnals, the lower one is a nodal; middle part of a stem.
1985/6/41.

Fig. 12: Nodal, 12b: syzygial articulation.
1985/6/42.

Fig. 13: Stem fragment with a complete intersyzygium below; remarkable the large oval cirrus sockets.
1985/6/43.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