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Ichnofossils of the Ressen Formation in Gosau (Campanian, Upper Gosau Subgroup, Upper Austria)

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5 Text-Figures, 4 Plates

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Northern Calcareous Alps
Calcareous nannofossils
Upper Gosau Subgroup
Palaeoenvironment
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Lebensspuren der Ressen-Formation in Gosau (Campanium, obere Gosau-Subgruppe, Oberösterreich)

Zusammenfassung

Aus feinkörnigen Sand- und Silt/Mergelsteinen der Ressen-Schichten des Vorderen Glaselbachgrabens auf der Gosauer Sonnseite wird erstmals eine gut erhaltene Lebensspuren-Vergesellschaftung beschrieben. Diese umfasst sowohl Bewegungsspuren von kleinen Bivalven *(Protovirgularia)* als auch Ruhespuren *(Lockeia)*. Auch die typischen Flysch-Ichnofossil-Taxa *Arthrophycus* und *Scolicia* sowie eine spezielle Erhaltungsform von *Scolicia* vom Typ *„Bolonia"* und auch der Fazies überschreitende *Planolites* isp. konnten beobachtet werden. Die Spurenfossilien-Vergesellschaftung ist charakteristisch für gut durchlüftete, mäßig dynamische Ablagerungsräume im Mittelabschnitt eines Turbiditfächers. Mit Hilfe von kalkigem Nannoplankton konnte die stratigraphische Reichweite der Ressen-Schichten dieses Vorkommens auf höheres Untercampanium bis Obercampanium (Zonen-Intervall UC14dTP–UC15) eingeengt werden. Dieses Alter wird durch den Nachweis von Hungaropollis-Pollen untermauert, die erstmals im frühen Campanium auftreten.

Abstract

A well preserved assemblage of ichnofossils is described for the first time from grey turbiditic fine-grained sand- and silt/marlstones of the Ressen Formation in Gosau, Upper Austria. The ichnofossil-assemblage comprises locomotion *(Protovirgularia)* and resting *(Lockeia)* traces of minute bivalves. Also the typical flysch ichnotaxa *Arthrophycus* and *Scolicia* occur as well as a specific preservation variety of *Scolicia* (type *"Bolonia"*) and the facies-crossing form *Planolites* isp. The ichnofossil-assemblage is characteristic for well-oxygenated, moderately dynamic settings in the middle part of a turbidite fan. Calcareous nannofossils confirm an age range of these "flyschoid" sediments from the upper part of the Lower Campanian up to Upper Campanian, zone interval UC14dTP–UC15. This age is also supported by Hungaropollis pollen, which show their FO in the Early Campanian.

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Lithology and Palaeoenvironment of the Ressen Formation

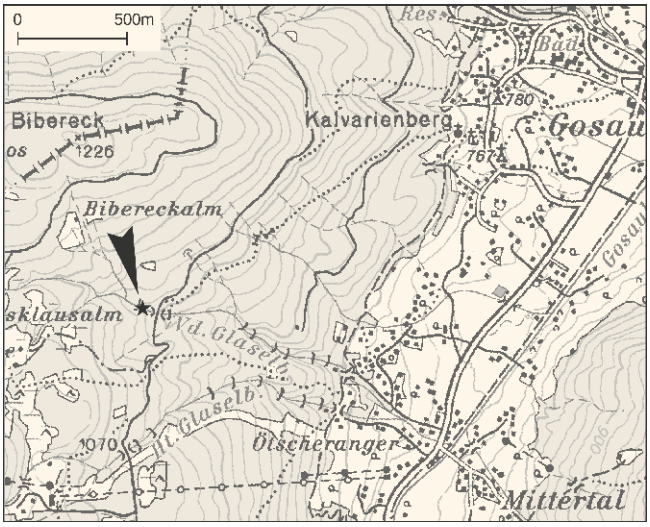
The classical region of the Gosau Group sediments is the surroundings of Gosau village. The Lower Gosau Subgroup is characterized by various continental and shallow marine sediments of Middle Turonian to Upper Santonian age. In the Lower Campanian, however, the sedimentary regime changed to deeper marine conditions with flyschoid sedimentation (e.g. FAUPL, 1978; FAUPL et al., 1987, FAUPL & WAGREICH, 1992a, b, 2000; WAGREICH, 1988, 2002; WAGREICH et al., 2000). This event marks the beginning of the Upper Gosau Subgroup. The "flyschoid" Ressen Formation is characterized by grey turbiditic sand- and siltstones with conglomeratic intercalations, which are bedded in a cm–dm scale. The classical locality of the Ressen Formation is situated on the upper part of Mt. Ressen (or Löckenmoosberg) in Gosau, Upper Austria. This formation is transgressively overlying a palaeokarst-relief of Upper Triassic lagoonal Dachstein Limestone.

In the early Campanian enormous quantities of clay and angular mineral grains and – somewhat less – crystalline rock fragments were transported by turbidity currents from the mainland into proximal pelagic environments and formed the coarse mass flow and turbiditic sand/silt/marlstone fan deposits of the Ressen Formation. The turbidites are thinning out in northwestern direction towards the Hornspitz-Bibereck region within a few kilometers (WAGREICH, 2002). Therefore the Ressen Formation of Vorderer Glaselbach creek on Mt. Bibereck, where our outcrops are situated, does not show more coarse grained sandstone-conglomerate sequences than on Mt. Ressen, but is generally much more finegrained (Pl. 1, Fig. 1; Text-Figs. 3–5).

The angular mineral grains (predominantly quartz) and rock fragments of the Ressen sandstones probably resulted from long-lasting, intensive rock weathering on the mainland. Due to a rising sea level repeated marine transgressions transported tremendous amounts of angular broken mineral- and rock-debris from the mainland via turbidity currents into deeper marine environments. Due to different specific weight and floating properties the material was separated into coarse, medium and fine grain sizes. Layers enriched in heavy minerals are characteristic for bottoms of the beds, while floating coaly plant debris often is spread on the bedding surfaces. Macrofossils occur only very scarcely.

Conspicuous sedimentary structures are rather scarce. Occasionally small-scale ripple marks can be observed on the silt/marlstone bedding surfaces (Text-Fig. 5).

The collection site of our samples is located in Vorderer Glaselbach creek in an altitude of about 1020 m, just below the waterfall (Text-Figs. 1–2; Pl. 1, Fig. 1).



Text-Fig. 1.
Topographic sketch of the surroundings of Gosau village.
Asterisk shows the Vorderer Glaselbach site.

Text-Fig. 2.
In the foreground settlements of Gosau Mittertal village.
The wooded ridge in the center of the photo with Mt. Bibereck (1226 m) consists in the higher part of deep(er) marine sediments of the Upper Gosau Subgroup (Ressen, Bibereck and Nierental Formations). Arrow points to location of the Vorderer Glaselbach site.
The high mountain in the background, Mt. Gamsfeld (2027 m), is built up by Upper Triassic Dachstein Limestone.

Text-Fig. 3.
Cm-bedded silt/marlstones alternate with dm-bedded sandstones, middle part of the turbidite fan of the Ressen Fm.

Early Exploration

The classical area of the Ressen Formation are the surroundings of the grindstone quarries ("Schleifsteinbrüche") on Mt. Ressen south of Gosau village. Already in the time of the Austro-Hungarian monarchy the grindstone was repeatedly the subject of scientific investigations. The famous German geologist Leopold von Buch visited the Salzkammergut along with Alexander von Humboldt in 1797. He defined the lithology of the Gosau grindstone as "red and white quartz pieces in a yellow-brown clayey matrix" (BUCH, 1802). The Bohemian natural scientist August Emanuel Reuss described in 1854 the "grindstone layer" even more precisely as fine-grained sandstone, consisting of angular and sharp quartz grains, which are bound by clayey-calcareous cement. The paper by ŠVÁBENICKÁ et al. (2003) deals with the lithology and biostratigraphy of the Ressen Formation on the classical locality of the "Schleifsteinbruch" on Mt. Ressen and with the transition of the Ressen Formation into the variegated coloured Nierental Formation in the profile of Asterbach creek near our outcrops.

WEIGEL (1937) mentions already "Kriechspuren". BRINKMANN (1934) postulates a second intergosavian tectonic phase between his middle and upper Gosau, which he called "Ressenphase". According to WEIGEL (1937) these movements took place after the late Early Campanian, but considerably earlier as the Maastrichtian, however, tectonics is not the topic of this paper.

Ichnology

Three rock samples were collected for the ichnologic study: 1, a fine-grained sandstone/siltstone slab around 30 mm thick; 2, a fine-grained sandstone/siltstone slab ca 26 mm thick; 3, a siltstone slab ca 25 mm in thickness. Sample 1 is covered on one side (= lower bedding plane according to the preservation of ichnofossils) with (mostly) well preserved, clearly defined specimens of trace fossils. Among them, *Planolites* cf. *P. beverleyensis* (BILLINGS), *Protovirgularia* isp., *Lockeia* isp. and *Arthrophycus linearis* were determined. *Protovirgularia* and *Lockeia* represent locomotion (*P.*) and resting (*L.*) traces of minute bivalves. The sample shows a clear example of *Protovirgularia* connected with *Lockeia*; this situation upholds both the determination of the traces and the assumption of their common tracemaker. The fine-grained sandstone/siltstone slab (2) bears in its upper surface minute parallel ripples. The lower bedding plane preserved (in "sharp", minute hyporeliefs) the trace fossils of the ichnogenera *Protovirgularia* and *Arthrophycus* and large, poorly preserved (washed-out) ?*Scolicia* isp. and *Lockeia* isp. (Pl. 1, Figs. 2–4).

The second sample is a siltstone slab partly reworked by in-fauna (primary parallel lamination is preserved ca. from 50 %; thereby, the ichnofabric index = 3). Beside a "general reworking" (i.e., undeterminable spots), conspicuous traces with a prominent active backfill, 20 to 30 mm wide, are present. The backfill corresponds in minor parts of the traces to the "classical" meniscate backfill of the ichnogenus *Taenidium*; more often, the "menisci" reach only half of the trace width. In the trace axis, a zig-zag suture/pattern can be seen. Such a suture is typical, e.g., for the ichnogenus *Polykampton* which is a complex spreiten-structure with two size orders of laminae/lamellae; these, however, cannot be observed on the studied sample. Therefore, the only plausible determination of the traces is putting them to the ichnogenus *Scolicia* (relatively deeply subsurface burrows made by heart urchins and probably also some mollusk tracemakers) in a specific preservation variety (type *"Bolonia"*).

The above-mentioned features of ichnofabrics were proved by the study of thin sections of the siltstone slab (see Pl. 3 and its explanations).

All the above-mentioned ichnotaxa have already been found in the Cretaceous flysches (e.g., UCHMAN, 1999); the most common of them, i.e., *Planolites* isp., is a facies-crossing form. Also *Arthrophycus* and *Scolicia* have been reported manifold; they can be considered typical flysch ichnofossils of post-Jurassic strata. Bivalve traces (*Protovirgularia*, *Lockeia*) are not frequent in Cretaceous flysches; if present, they occur rather in middle parts of turbidite fans, in well-oxygenated, moderately dynamic settings. Ichnologically, it can be excluded that the samples come from distal turbidite sequences; these are, as a rule, characterized by the occurrence of graphoglyptids – the Nereites ichnofacies in a classical ichnofacies schedule (e.g. SEILACHER, 1967).

Calcareous Nannofossils

Generally, sediments provided very poor and poorly preserved nannofossils. Placoliths are etched and mostly in fragments.

Text-Fig. 4.
Cm-bedded silt/marlstones from the middle part of the turbidite fan of the Ressen Fm.

The ***Gosau 1-I sample*** (fine-grained sandstone slab No 1, upper portion): smear slide contained rarely fragmented nannofossils specimens (±1/1 field of view of the microscope), some of them could not be identified. The assemblage is formed by *Reinhardtites levis, Broinsonia parca constricta, Hexalithus gardetae, Eiffellithus eximius, E. gorkae, Chiastozygus litterarius, Cyclagelosphaera margerelii, Prediscosphaera crenulata, P. grandis* (fragments of the broadly elliptical specimens), *Zeugrhabdothus bicrescenticus, Z. diplogrammus, Gartnerago obliquum, Watznaueria barnesae, Cribrosphaerella ehrenbergii, Calculites obscurus, Retacapsa crenulata, Broinsonia-Arkhangelskiella* (outer rims of large specimens), *Biscutum constans, B. coronum, Microrhabdulus attenuatus, Tranolithus orionatus*. The assemblage points to the upper part of the Lower Campanian up to Upper Campanian, zone interval UC14dTP–UC15 (Burnett, 1998) according to the common occurrence of *Reinhardtites levis, Broinsonia parca constricta* and *Eiffellithus eximius*.

The ***Gosau 2-I sample*** (upper portion of the mudstone slab) provided very rare and extremely badly preserved calcareous nannofossils (1–5 fragmented specimens / 10 fields of view of the microscope). Following species have been identified: *Broinsonia parca constricta, Arkhangelskiella cymbiformis, Watznaueria barnesiae, Zeugrhabdothus diplogrammus, Micula decussata, Retacapsa crenulata, Eiffellithus turriseiffelii, E. eximius, Cribrosphaerella ehrenbergii, Prediscosphaera cretacea, Gartnerago obliquum*. The assemblage confirms the Campanian age, zone interval UC14–UC15 (sensu Burnett, 1998) according to the common occurrence of *Broinsonia parca constricta* and *Eiffellithus eximius*.

The ***Gosau 3–I sample*** (lower portion of the mudstone slab) provided rare and badly preserved nannofossil assemblages with *Broinsonia parca parca-constricta* (fragments), *Arkhangelskiella* sp. (fragment), *Eiffellithus turriseiffelii, E. eximius, E. gorkae, Watznaueria barnesiae, Cribrosphaerella ehrenbergii, Zeugrhabdothus bicrescenticus, Z. diplogrammus, Retacapsa crenulata, Micula decussata, Hexalithus gardetae, Chiastozygus litterarius, Prediscosphaera* sp., *Cribrosphaerella-Psyktosphaera*? (one fragment of the large and broadly elliptical specimen), *Gartnerago obliquum, Calculites obscurus*. The assemblage points to the Campanian, zone interval UC14–UC15 (sensu Burnett, 1998) according to the common occurrence of *Broinsonia parca constricta* and *Eiffellithus eximius*.

Palynology

Gosau 1-I: The fine-grained sandstone sample provided a poor and mostly badly preserved palynomorph assemblage. The assemblage consists of pteridophyte spores – *Gleicheniidites senonicus* Ross, *Bikolisporites toratus* (Weyland & Greifeld) Srivastava, *Verrucosisporites* sp., triporate angiosperm pollen from the Normapolles group: *Trudopollis* sp.,

Text-Fig. 5.
Small-scale ripple marks on a siltstone bedding surface. The currents probably came from the left upper side.

Oculopollis sp., *Complexiopollis* sp. and dinoflagellate cysts *Odontochitina operculata* (O. WETZEL) DEFLANDRE & COOKSON, *Pervosphaeridium pseudhystrichodinium* (DEFLANDRE) YUN, *Dinogymnium* cf. *albertii* CLARKE & VERDIER and *Spinidinium* sp.

Gosau 2-I: The mudstone sample (upper part of the mudstone slab) provided rare palynomorphs, relatively better preserved than the previous one (see Pl. 4). The palynomorph assemblage yielded fern spores *Gleicheniidites senonicus* ROSS, *Plicifera delicata, Cyathidites minor* COUPER, *Echinatisporites varispinosus* (POCOCK) SRIVASTAVA, *Camarozonosporites ambigens* (FRADKINA) PLAYFORD, *Cicatricosisporites* sp., mostly triporate angiosperm pollen from the Normapolles group *Plicapollis* sp., *Hungaropollis* sp., *Suemegipollis triangularis* GÓCZÁN, *Interporopollenites* sp., *Krutzschipollis* sp. and dinoflagellate cysts *Pervosphaeridium truncatum* (DAVEY) BELOW, *Spiniferites multibrevis* (DAVEY & WILLIAMS) BELOW, *Surculosphaeridium? longifurcatum* (FIRTION) DAVEY et al., *Circulodinium distinctum* (DEFLANDRE & COOKSON), *Florentinia* sp., *Isabelidinium* sp., *Spiniferites ramosus* (DAVEY & WILLIAMS) LENTIN & WILLIAMS, *Achomosphaera ramulifera* (DEFLANDRE) EVITT, *Pterodinium cingulatum* (O. WETZEL) BELOW, *Spinidinium* sp. Chitinous foraminiferal linings appear as well. Fungal spores are relatively common.

The redeposited bisaccate pollen *Labiisporites granulatus* were originally described by LESCHIK (1956) from the Zechstein deposits in Neuhof near Fulda (Upper Permian) (determined by J. Drábková, Czech Geological Survey). KLAUS (1963) rarely recovered this species from black shales of the Upper Permian age from the Dolomites, Southern Alps (Grödener Sandstein and Bellerophonschichten). It is clear, that the Upper Permian pollen in our sample are redeposited from the nearby Haselgebirge deposits. Biostratigraphically important are *Hungaropollis* pollen with their first occurrence in Early Campanian (GÓCZÁN et al., 1967).

Gosau 3–I: The mudstone sample (lower part of the mudstone slab) provides very rare and badly preserved plant microfossils. Despite the fact that the assemblage comes from the same sample, bad preservation is probably caused by weathering. The palynomorph assemblage consists of the pteridophyte spores *Echinatisporites varispinosus* (POCOCK) SRIVASTAVA, *Plicatella* sp., *Zlivisporis* sp., *Gleicheniidites senonicus* ROSS, *the* rare fungal spores *Pluricellaesporites psilatus* CLARKE and dinocysts *Odontochitina* aff. *O. porifera* COOKSON, *Spiniferites crassipellis* (DEFLANDRE & COOKSON) SARJEANT, *Spinidinium* sp., *Pervosphaeridium pseudhystrichodinium* (DEFLANDRE) YUN. No angiosperm pollen occurred.

Discussion and Conclusions

A well preserved assemblage of ichnofossils is described for the first time from grey turbiditic fine-grained sand- and siltstones of the Ressen Formation in Gosau, Upper Austria. The ichnofossil-assemblage comprises locomotion (*Protovirgularia*) and resting (*Lockeia*) traces of minute bivalves. Also the typical flysch ichnofossil taxa *Arthrophycus* and *Scolicia* occur as well as a specific preservation variety of *Scolicia* (type *"Bolonia")* and the facies-crossing form *Planolites* isp. The ichnofossil assemblage is characteristic for well-oxygenated, moderately dynamic settings in the middle part of a turbidite fan. Ichnologically, it can be excluded that the samples come from distal turbidite sequences; these are, as a rule, characterized by the occurrence of graphoglyptids – the Nereites ichnofacies in a classical ichnofacies schedule (e.g., SEILACHER, 1967). Calcareous nannofossils confirm an age range of the upper part of the Ressen Formation ranging from the upper part of the Lower Campanian up to Upper Campanian, zone interval UC14dTP–UC15 (BURNETT, 1998). This age is also supported by *Hungaropollis* pollen, which show their FO in the Early Campanian.

Plate 1

Fig. 1: View of the collection site “Vorderer Glaselbach”.
Ressen Formation showing alternation of silt/marlstones with scarce sandstone layers of the middle part of a turbidite fan.
Dr. Gerhard W. Mandl for scale.

Fig. 2: Mudstone slab, *Scolicia* isp. in various taphonomic forms.

Fig. 3: Overall view of the fine-grained sandstone slab No. 1 (lower bedding plane) with trace fossils *Arthrophycus linearis*, *Protovirgularia* isp. and *Lockeia* isp.

Fig. 4: Detail of the previous image with *Arthrophycus linearis* (middle) and *Lockeia* isp. (randomly spread oval and almond-shaped knobs).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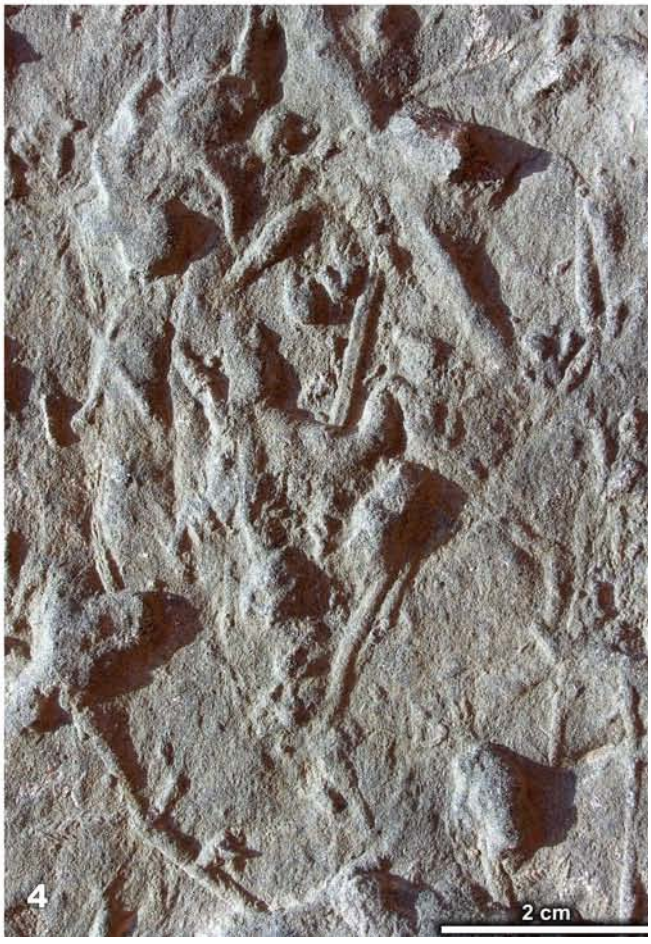
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Plate 2

Fig. 1: Mudstone slab, *"Bolonia"*, i.e. *Scolicia* isp. in a specific way of preservation.

Figs. 2, 3: Detailed views of the fine-grained sandstone slab No. 2 (lower bedding plane) with trace fossils *Lockeia* isp. and poorly preserved *Protovirgularia* isp.

Fig. 4: Detail of the fine-grained sandstone slab No. 1 (lower bedding plane) with well-preserved *Protovirgularia* isp.


1
2 cm
2
3 cm
3
2 cm
4
2 cm

Plate 3

Fig. 1: Mudstone slab, vertically oriented thin section of its lower portion; well-visible ichnofabric (ca 12 % of the material removed; ichnofabric index = 2).

Figs. 2, 7: Mudstone slab, vertically oriented thin section, thin tunnels filled with material enriched in clay minerals.

Figs. 4, 6: Mudstone slab, vertically oriented thin section, clay minerals concentrated in the walls of tunnel-shaped trace fossils.

Fig. 3: Mudstone slab, horizontally oriented thin section, lamination resulted from active backfilling of the trace fossil *Scolicia* isp.

Fig. 5: Mudstone slab, vertically oriented thin section with undisturbed sedimentary laminae.

Fig. 8: Mudstone slab, vertically oriented thin section with foraminifer indet. (*Meandrospira*?).

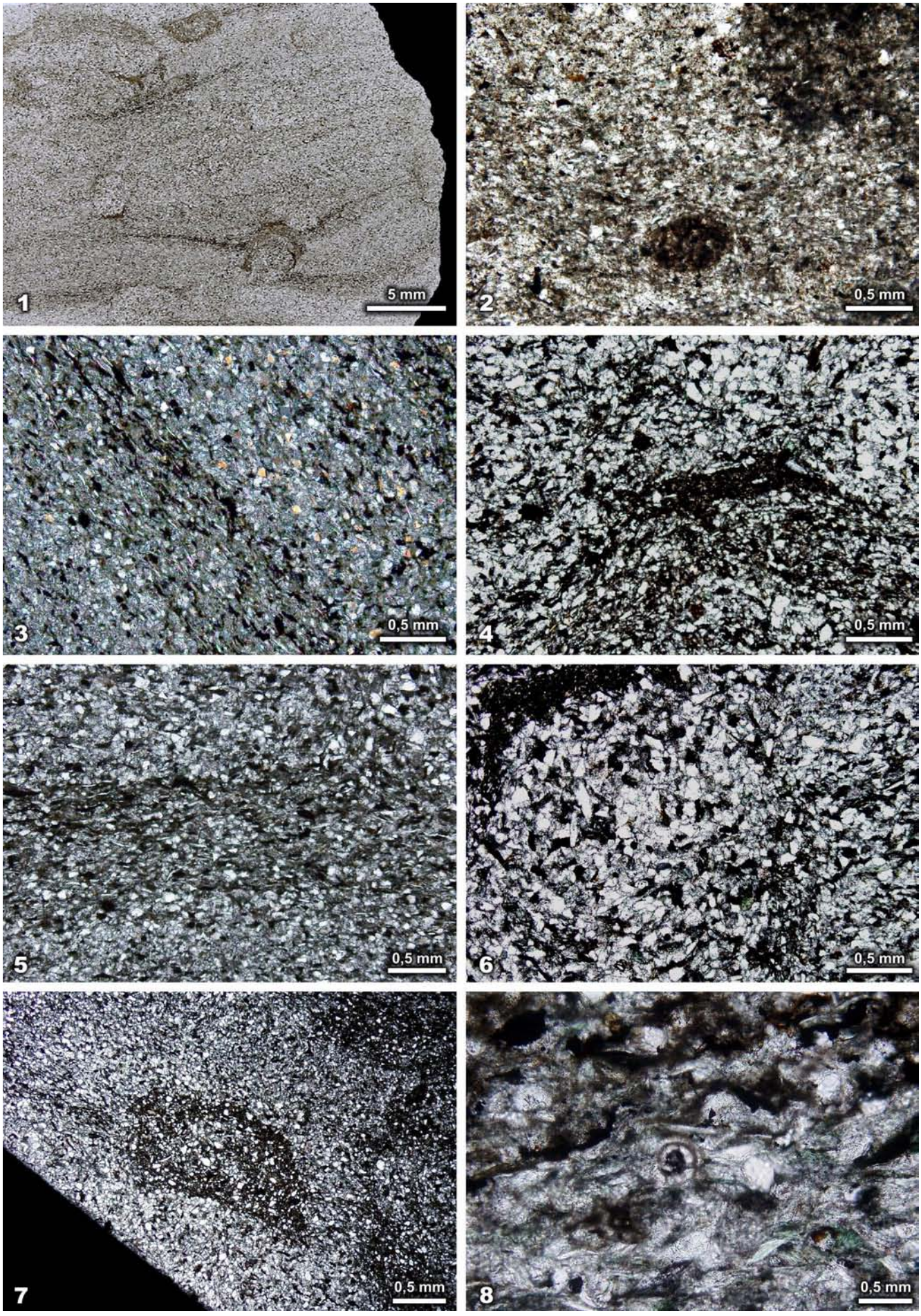
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Plate 4

Palynomorphs. Scale bar 10 µm.

Fig. 1: *Pervosphaeridium* cf. *truncatum* (Davey) Below 1982a.
Sample Gosau 2-I.

Fig. 2: *Achomosphaera ramulifera* (Deflandre) Evitt 1963.
Gosau 2-I.

Fig. 3: *Odontochitina* aff. *O. porifera* Cookson 1956.
Gosau 3-I.

Fig. 4: *Dinogymnium* cf. *albertii* Clarke & Verdier 1967.
Gosau 1-I.

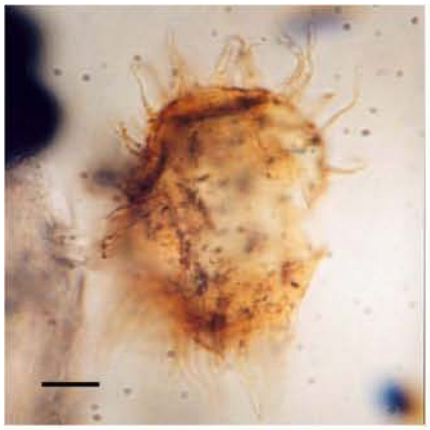
Fig. 5: *Bikolisporites toratus* (Weyland & Greifeld) Srivastava 1975.
Gosau 1-I.

Fig. 6: *Echinatisporis varispinosus* (Pocock) Srivastava 1975.
Gosau 3-I.

Fig. 7: *Suemegipollis triangularis* Góczán 1963.
Gosau 2-I.

Fig. 8: *Krutzschipollis* sp.
Gosau 2-I.

Fig. 9: *Labiisporites granulatus* Leschik.
Gosau 2-I, redeposition from the Upper Permian Haselgebirge.



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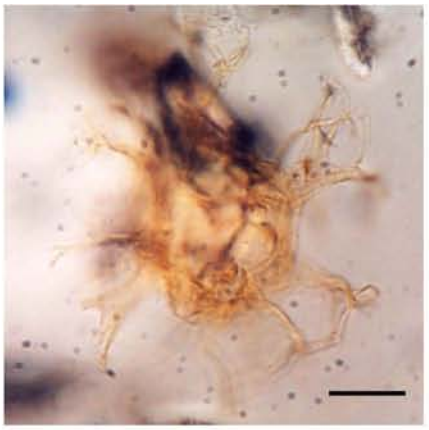

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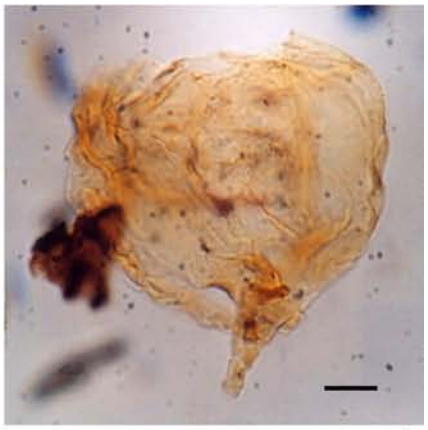

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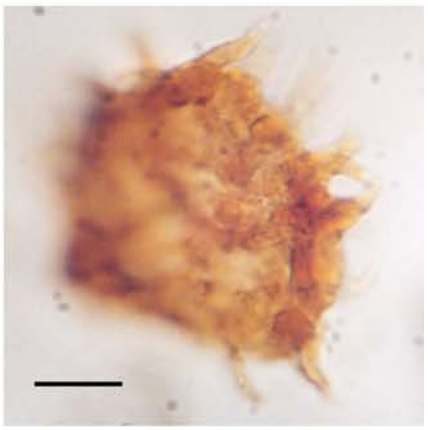

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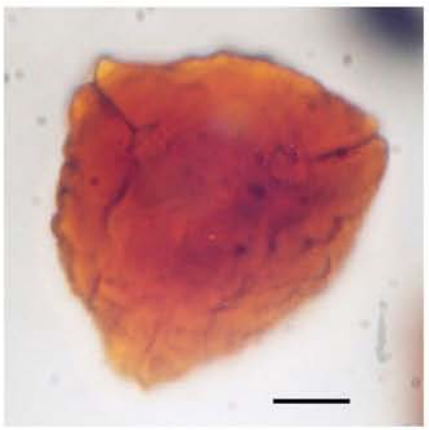

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