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The Upper Carboniferous of the San Giorgio basin

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LOCALITY	San Giorgio basin, near Iglesias
STRATIGRAPHIC UNIT	Informal unit San Giorgio formation
AGE	Upper Carboniferous, Westphalian D – Early Stephanian

LOCATION

The section crops out close to the by-pass road S.S. N.130, about 2.5Km SSW from the centre of Iglesias town.

HISTORICAL OUTLINE

Early studies on the San Giorgio basin date back to the end of the 19th century, when Gambera (1897) and Arcangeli (1901) described the Upper Palaeozoic deposit yielding plants near Iglesias. Later on, Novarese (1917) and Novarese & Taricco (1923), on the basis of the occurrence of *Annularia stellata, Cordaites* cf. *principalis*, *Walchia piniformis* and *Walchia filiciformis*, assigned the fossil flora to the Autunian. More information was

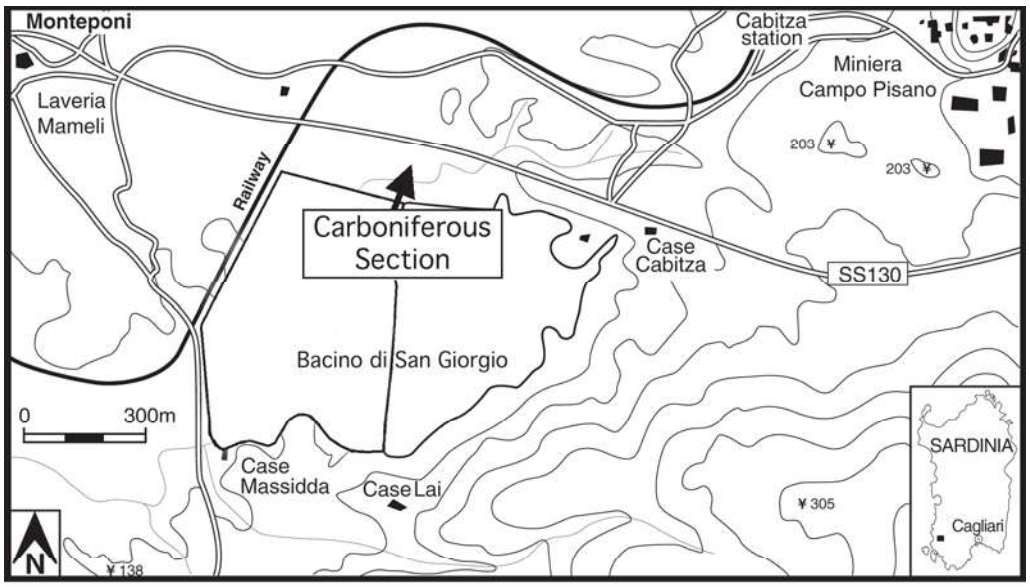

Fig. 1 - Location map of the Upper Carboniferous San Giorgio Section.

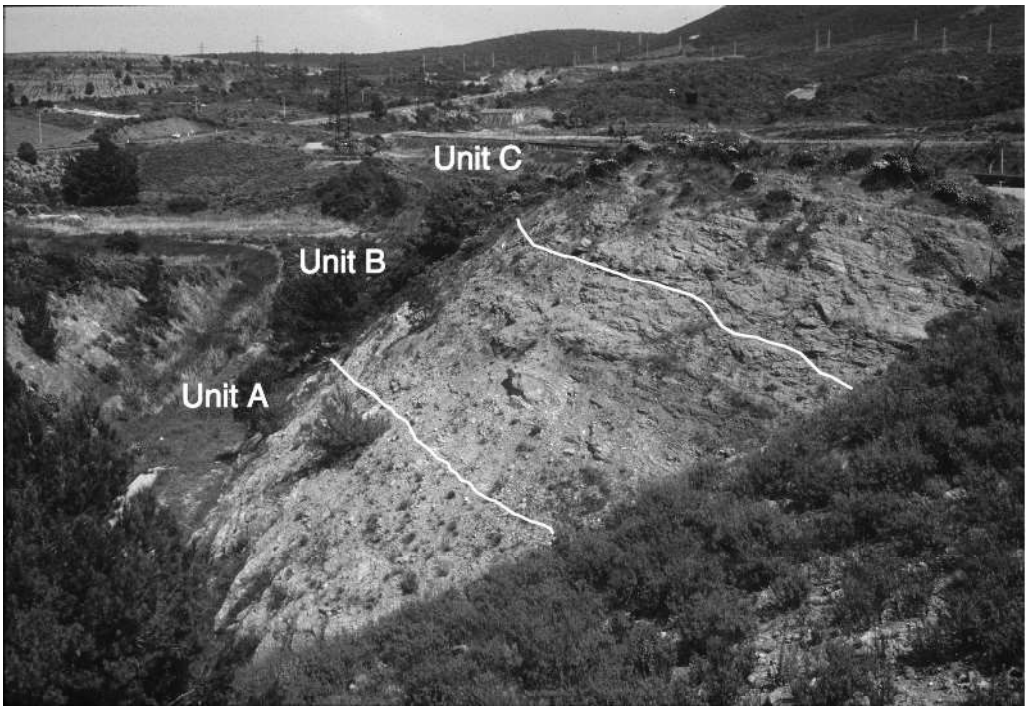

Fig. 2 - View of the best exposed succession of the Upper Carboniferous San Giorgio formation; the boundaries between lithostratigraphic units are indicated by white lines (see text for lithologies).

provided by Cocozza (1967); he described several plant species and proposed an Upper Stephanian age for these remains. The Stephanian age was confirmed after studies on sporomorphs recorded in the sandy layers (Del Rio, 1973; Del Rio & Pittau, 1999; Pittau & Del Rio, 2002), while a late Westphalian (D) age was proposed by Fondi (1980) after the finding of small tetrapod footprints belonging to *Salichnium (Saurichnites) heringi* (Geinitz, 1885).

Due to the peculiar scientific and cultural value in the Sardinian geology and palaeontology, the present day reduced outcrops of the "San Giorgio formation" have been proposed as possible protected area within the UNESCO Geopark (Benedetti *et al*., 2002; Muntoni, 2002).

Lithology

The best continuous Carboniferous section (about 30 m thick) crops out along the waterway drain cut, excavated near to the mine dump, in order to modify the San Giorgio river path (Fig. 1). Unfortunately, the lower portion of the succession is not cropping out here, but only in a few sites not far away.

From bottom to top, three main units can be distinguished (Fig. 2):

Unit A: Heterometric breccias, made up of polygenic carbonatic, angular shaped, heterometric elements, with gray dolomitic cement; this unit may locally be thicker or absent. Thickness: 13 m.

Unit B: Yellow-grey dolomites, with local more or less lenticular conglomerate bodies (well rounded quartz pebbles) and minute well bedded breccias with dolomitic cement,

evolving to platy dolomites, dolomitic siltstones and carbon-rich clays, usually finely laminated, capped by massive sandstones. Thickness: 6 m.

Unit C: Mainly made up of polygenic heterometric conglomerates, interfingering with sandy, flat lenticular deposits, with local concentrations of plant remains and trunks in life position. Thickness: 11 m.

Paleobiological content and Biostratigraphy

Macroflora

On the basis of the list of taxa recorded in previous works by Gambera (1987), Novarese & Taricco (1923), Cocozza (1967), Pittau & Del Rio (2002), the flora compressions display representatives of the following botanical groups:

Sphenopsida

Annularia stellata Schlotheim, *Annularia pseudostellata* H. Potonié, *Sphenophyllum emarginatum* Brongniart, *Calamites cistii* Brongniart, *Calamites gigas* Brongniart, *Calamites* cf. *leioderma* Gutbier, *Calamites suckowii* Brongniart, *Calamites* sp., ferns by *Asterotheca* sp., *Pecopteris arborescens* Schlotheim, *Pecopteris polymorpha* Brongniart, *Sphenopteris rotundiloba* Nemejc, *Sphenopteris* spp.

Pteridospermopsida

Alethopteris cf. *ambigua* Lesquereux emend. Wagner, *Dicksonites pluckeneti* (Schlotheim) f. *sterzeli* Zeiller, *Neurocallipteris planchardii* Zeiller.

Cycadopsida

Testified by the presence of one species of *Taeniopteris* sp.

Gymnosperms

Cordaitales (*Cordaites* sp.) and Voltziales: *Feysia* and *Hermitia*.

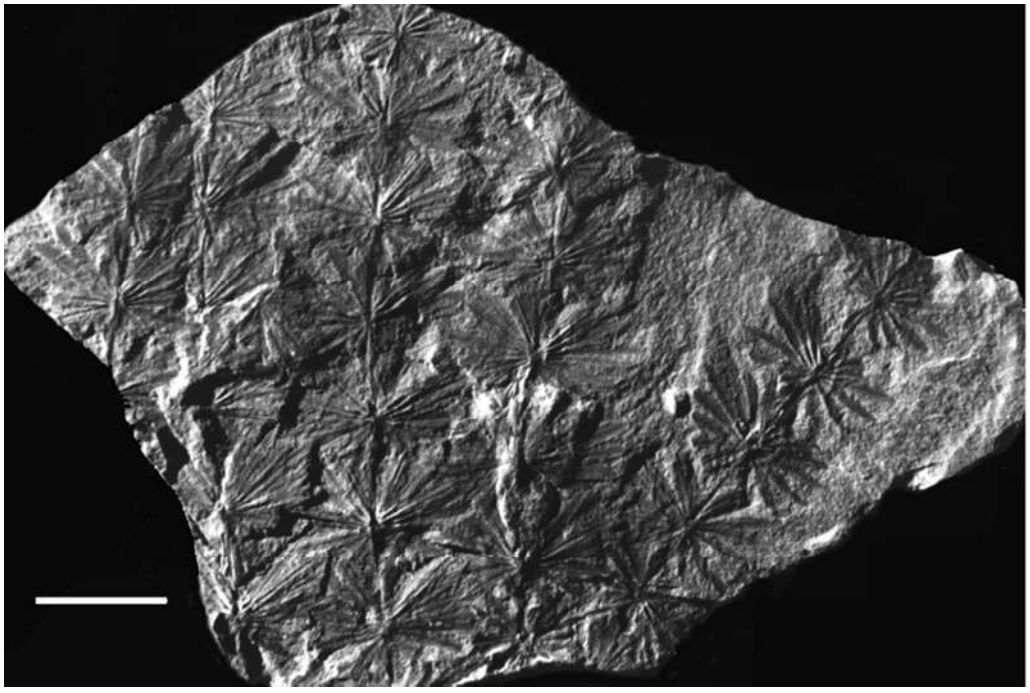

Fig. 3 - Particularly well preserved remains assigned to *Annularia stellata* (Shlotheim) from the highest portion of Unit B. Scale bar = 1cm.

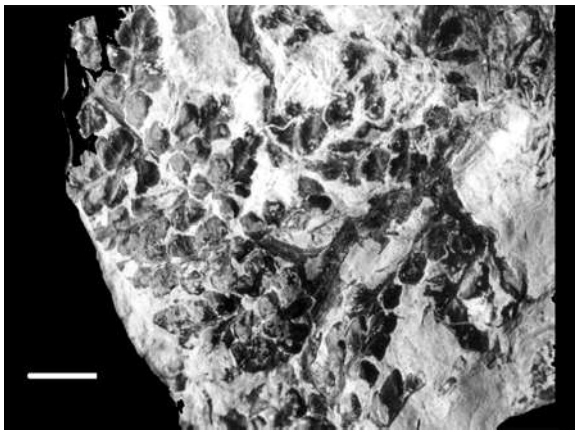

Fig. 4 – Foliage compression of *Sphenopteris rotundiloba* Nemejc. Scale bar = 0,5 cm. (by courtesy of P. Pittau, Univ. Cagliari).

MICROFLORA

In previous works (Del Rio, 1973; Del Rio & Pittau, 1999; Pittau & Del Rio, 2002), the following taxa have been recorded:

Monolete spores

Laevigatosporites vulgaris Ibrahim, 1932, cf. *Latosporites globosus* (Schemel) Potonié & Kremp, 1954, *Punctatosporites granifer* Potonié & Kremp, 1956, *Punctatosporites minutus* Ibrahim, 1933.

Trilete spores

Apiculatisporites abditus (Loose) Potonié & Kremp, 1955, *Calamospora laevigata* (Ibrahim) Schopf, Wilson & Bentall, 1944, *Calamospora pallida* (Loose) Schopf, Wilson & Bentall, 1944, *Convolutispora tessellata* Hoffmeister, Staplin & Malloy, 1955, *Crassispora* sp., *Cristatisporites* sp., *Leiotriletes tumidus* Butterworth & Williams,1958, *Leiotriletes* sp., *Lycospora deforma* Shwartsman *in* Inossova *et al*., 1976, *Lycospora orbicula* (Potonié & Kremp) Smith & Butterwort, 1967, *Microreticulatisporites reticulatus* (Knox) Potonié & Kremp, 1954, *Punctatisporites sinuatus* (Artüz) Neves, 1961, *Pustulatisporites pustulatus* Potonié & Kremp, 1954, *Raistrickia aculeata* Kosanke, 1950,

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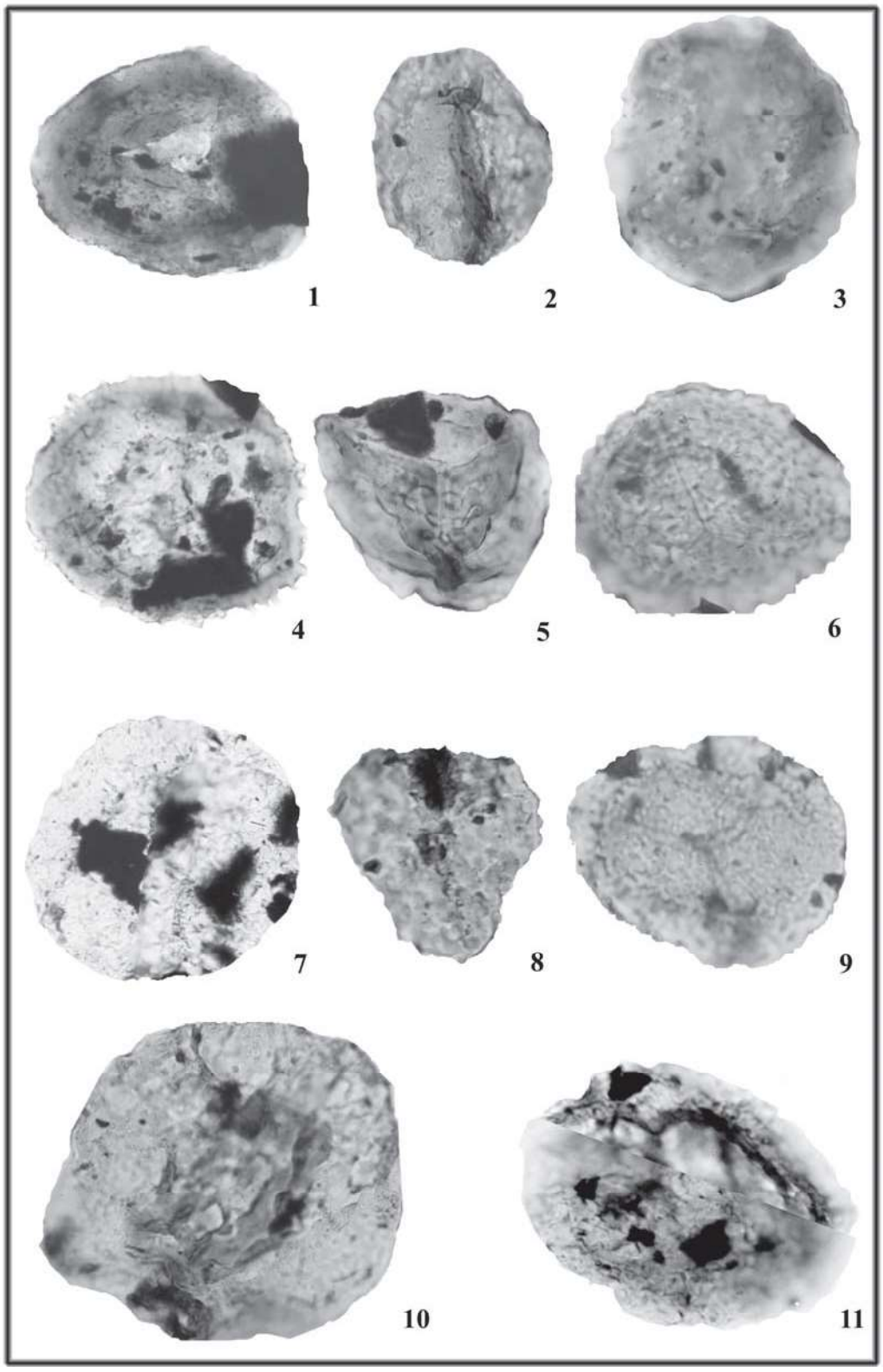
Plate 1

Sporomorphs of the San Giorgio basin.

Fig. 1 - *Densosporites granulosus* Kosanke, 1950; D: 150 µm.
Fig. 2 - *Latosporites vulgaris* Ibrahim, 1933; D: 45 µm.
Fig. 3 - cf. *Latosporites globosus* (Schemel) Potonié & Kremp, 1956; D: 48 µm.
Fig. 4 - *Raistrickia aculeata* Kosanke, 1950; D: 105 µm.
Fig. 5 - *Savitrisporites camptotus* (Alpern) Doubinger, 1974; D:55 µm.
Fig. 6 - *Convolutispora tessellata* Hoffmeister, Staplin & Malloy, 1955; D: 53 µm.
Fig. 7 - cf. *Florinites pumicosus* (Ibrahim) Schopf, Wilson & Bentall, 1944; D: 65 µm.
Fig. 8 - *Triquitrites rugosus* Bharadwaj, 1957; D: 35 µm.
Fig. 9 - *Lycospora orbicula* (Potonié & Kremp) Smith & Butterworth, 1967; 53 µm.
Fig. 10 - *Florinites similis* Kosanke, 1950; D:68 µm.
Fig. 11 - *Cordaitina* cf. *donetziana* Inossova *in* Inossova, Shwartsman, Krusina, 1976; D: 80 µm.

D = diameter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Savitrisporites camptotus (Alpern) Doubinger, 1974, *Savitrisporites cingulatus* (Alpern) Bhardwaj, 1962, *Triquitrites arculatus* Wilson & Coe, 1940, *Triquitrites bransoni* Wilson & Hoffmeister, 1956, *Triquitrites sculptilis* Balme, 1952, *Triquitrites rugosus* Bhardwaj, 1957, *Triquitrites verrucosus* Alpern, 1958, *Triquitrites* sp., *Vestispora fenestrata* (Kosanke & Brokaw) Spode *in* Smith & Butterworth, 1967, cf. *Vestispora laevigata* Wilson & Venkatachala, 1963.

Monosaccate and disaccate pollen grains

Cordaitina cf *donetziana* Inossova *in* Inossova *et al*., 1976, cf. *Cordaitina bractea* Inossova *in* Inossova *et al*., 1976, *Florinites florinii* Imgrund, 1960, *Florinites parvus* Dybovà & Jachowicz, 1957, *Florinites pellucidus* (Wilson & Coe) Wilson, 1958, *Florinites similis* Kosanke 1950, cf. *Florinites pumicosus* (Ibrahim) Schopf, Wilson & Bentall, 1944, *Potonieisporites novicus* Bhardwaj, 1954, *Potonieisporites* sp., *Limitisporites* sp., *Pityosporites reticulatus* Hennelly, 1959, *Pityosporites westphalensis* Williams, 1955, *Vesicaspora* sp., *Wilsonites* cf. *delicatus* (Kosanke) Kosanke,1959, *Wilsonites kosankei* Bhardwaj, 1957, *Wilsonites vesicatus* (Kosanke) Kosanke, 1959.

Megaspores

Calamospora sp., *Laevigatisporites reinschii* Ibrahim, 1932, *Laevigatisporites* sp., *Valvisisporites* sp., *Zonalesporites* sp., *Zonalesporites ovalis* (Stach & Zerndt) Potonié & Kremp, 1955.

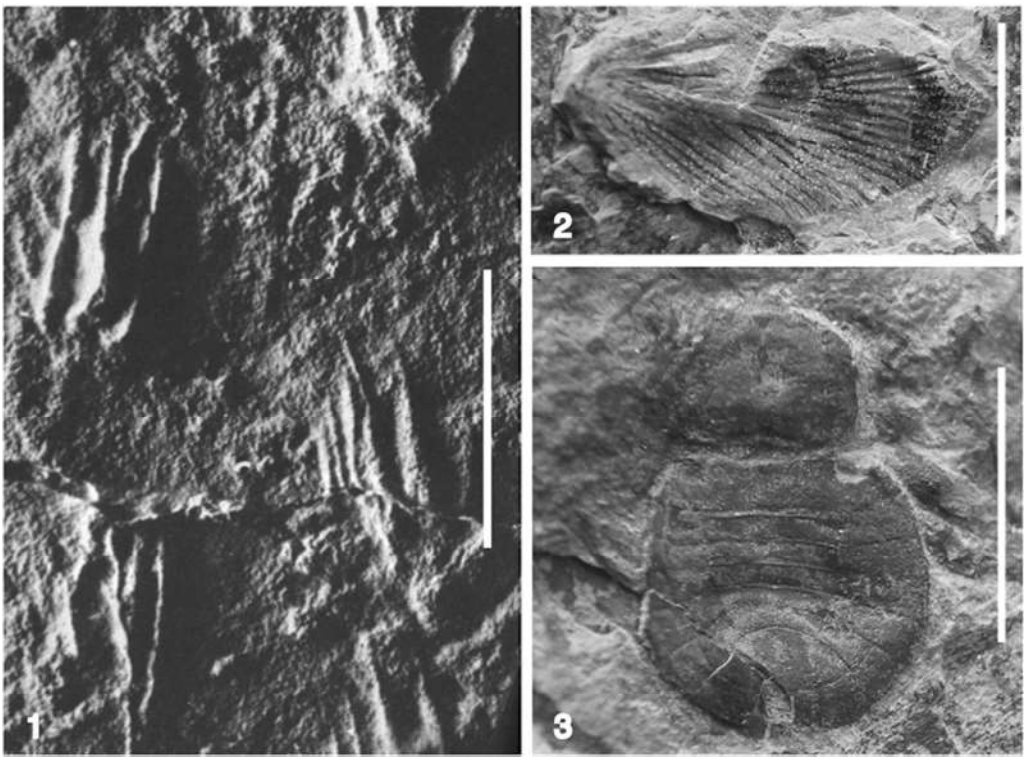

Fig. 5 - (1, 2, 3) - Ichnofossils and arthropods from the San Giorgio formation.. 4. 1) Detail of *Salichnium (Saurichnites) heringi* (Geinitz, 1885), reproduced from Fondi (1980); 4. 2) blattoid wing; dorsal view, upper third of Unit B; 4. 3) Anthracomartid arachnid, dorsal view, upper third of Unit B. Scale bar = 1cm.

Trace and body fossil

As reported above, the only ichnofossil recorded in the Upper Carboniferous of San Giorgio has been assigned to *Salichnium (Saurichnites) heringi* (Geinitz, 1885) by Fondi (1980) and, in all likelyhood, these footprints originates from the lower portion of Unit B. In more recent times, the finding of two arthropods has been published (Benedetti *et al*., 2002). These remains have been collected in the upper third of Unit B, and belongs to arachnids and blattoids. The former is represented by a nearly complete specimen of Anthracomartid, probably belonging to the genus *Anthracomartus*; its body is slightly flattened and legs are only partially visible. The latter consists of an exquisitely preserved blattoid wing (cf. Fig. 5).

In this assemblage, sphenopsid and ferns are abundant; pteridosperms and conifers are rare and *Cycadopsida* very rare. Monolete spores (*Laevigatosporites*, *Latosporites* and *Punctatosporites*) are poorly represented while trilete spores are more diversified; among these, the genus *Cristatisporites* is the most encountered. Significant is the presence of *Vestispora fenestrata* and cf. *Vestispora laevigata, Densosporites, Savitrisporites* and *Triquitrites* suggesting a Westphalian affinity to the microfloral assemblage. *Florinites* and *Potonieisporites* are also present. As concerns the presence of pre-pollen and pollen grains of gymnospermic affinity, *Pityosporites*, reported in the associations, is so far known to be present in the Stephanian of France. In the San Giorgio microfloras the absolute absence of taeniate pollen grains (*Vittatina*) is noticeable. Their appearance in the Northern Hemisphere (Owens, 1996) is considered to be Stephanian B. The above mentioned megaspores (Pittau & Del Rio, 2002) are known in the Westphalian A – C of the coal Ruhr basin (Potonié & Kremp, 1955).

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