Geo.Alp, Vol. 8, S. 146–155, 2011

PLANT FOSSILS IN THE CASSIAN BEDS AND OTHER CARNIAN FORMATIONS OF THE SOUTHERN ALPS (ITALY)

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Mit 16 Abbildungen und 3 Tabellen

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Introduction

Triassic macrofloras in the Southern Alps are rare, and the majority of literature data is devoted to Ladinian plants. The first plant remain from the Southern Alps, a not better defined "fern fragment", has been illustrated by Wissmann and Münster (1841). Later, several authors mentioned and figured plant fossils from the so-called "Buchensteiner Schichten", "Wengener Schichten" and *"alpiner Muschelkalk"* of the Dolomites (e.g., Mojsisovics, 1879; Ogilvie Gordon, 1927, 1934; Leonardi, 1953; for an overview see Wachtler & van Konijnenburg-van Cittert, 2000). Only Koken (1913) indicated badly preserved plant remains from the Heiligkreuz Schichten without describing or figuring them. Outside the Dolomites, only two more localities rich in Triassic plant remains were known: the Anisian flora of Recoaro (e.g., De Zigno, 1862; Schenk, 1868) and the Carnian flora of Raibl/Cave del Predil (e.g., Bronn, 1858; Schenk, 1866-7, Stur, 1868, 1885).
In the last few years several outcrops were found, yielding well-preserved plant fossils, some of them are Carnian in age such as Dogna in the Julian Alps, Stuores near Corvara, Heiligkreuz near Badia and Rifugio Dibona section near Cortina in the Dolomites. These floras, together with the Raibl flora, give a nice overview on the Carnian floras of the Southern Alps.

The floras

2.1 Heiligkreuz (Dolomites)

The plant remains from Heiligkreuz were collected from the horizon described by Bosellini as Strati di Santa Croce (Bosellini e Largaiolli, 1965): The plant remains belong to the Heiligkreuz Formation which means a Carnian (late Julian - early Tuvalian) age. The Tanatocenosis of the strata with the plant fossils contains *Unionites munsteri* and *Ptychostoma pleurotomoides* as well as *Renngartenella sanctaecrucis*. Two specimens represent leaf sheets (up to 53 mm long and 16 mm wide) with the typical fused leaf teeth belonging to *Equisetites* (Pl. 1, Fig. 1). Seven plant fragments were collected from this site. Small conifer shoot fragments are up to 30 mm long and 10 mm wide (Pl. 1, Fig. 2). The leaves are rhomboidal (4.5 x 3.5 mm) with distinct costae.

2.2. Stuores Wiesen (Dolomites)

The plant remains from Stuores were collected during an excavation of a nothosaurid skeleton in a calcareous layer of the San Cassian Formation. This gives the flora an early Carnian (Julian) age. Disarticulated mollusks were also found as well as teeth of other vertebrates such as *Cymadontoidea*, *Colobodus*, *Hybodus* and *Paleobates* (Bizzarini et al., 2001).

Fig. 1: Location of the various plant localities in the Dolomites.

Small conifer shoot fragments are up to 65 mm long and 9.5 mm wide (Pl. 1, Fig. 3). The leaves are rhomboidal (4.5 x 3.5 mm) with distinct costae.

2.3. Dogna (Julian Alps)

The flora from Dogna in the Julian Alps has been collected from the Rio del Lago Formation and is, thus, also early Carnian in age (Roghi et al., 2006a). Preliminary studies had permitted to distinct at least six different taxa. A few stem impressions (45 mm long and up to 2 mm wide) with distinct vascular bundles belong to equisetalean stem fragments. A few frond fragments belong to the fern genus *Danaeopsis* Heer ex Schimper 1869. The fragments (up to 20 mm long and 35 mm wide) are characterized by secondary veins arising acutely (50°) from the stout midrib, forking at least once near the midrib (Pl. 1, Fig. 4). The almost complete absence of anastomosing veins near the margin and a low number of vein bifurcations within the lamina suggests a resemblance with the species *D. angustifolia* (Kustatscher et al., submitted). Several frond fragments belong to *Ptilozamites sandbergeri* (Schenk) Kustatscher & Van Konijnenburg-van Cittert, 2007 (Pl. 1, Fig. 5). This seed fern is characterized by simple pinnate leaves, up to 120 mm long and 30 mm wide. The axis is slightly striate (2-4 mm), the sub-rectangular to sub-triangulate pinnules (6-22 mm long and 3-8 mm wide) are inserted perpendicularly and with an expanded basis. Each pinna displays 6–8 parallel veins, and a distinct margin.

The most abundant group are the conifers with at least three different taxa distinguished by their leaf shape and cuticles (Roghi et al., 2006a). The first type (Pl. 2, Fig. 3) is characterized by up to 15 cm long and 3-4 cm wide shoots covered by spirally arranged rhomboidal leaves (7-8.5 mm long and 4-6 mm wide). The leaves are too strongly carbonised to yield cuticles. This taxon resembles the specimens described by Dobruskina et al. (2001, pl. 15, figs. 1-3) as *Voltzia haueri* Stur.

The second conifer type (Pl. 2, Fig. 1) has smaller shoots (up to 4 cm long and 1 cm wide), bearing more delicate leaves (2-2.5 x 3-3.5 mm) with a rhomboidal shape and an obtuse apex. The thick cuticle shows stomata arranged in short rows. The walls of the 4-6 subsidiary cells are thickened on the inner side, while the large papillae cover partially the stomatal pit resembling the cheirolepidiaceous. The last type consists of up to 10 cm long and 0.6 cm wide shoot fragments with slightly falcate, spirally and closely arranged leaves (3.5-4 mm long and 2.5 mm wide) (Pl. 2. Fig. 2). The dicyclic stomata with circles of 8-10 thickened subsidiary cells are arranged in short longitudinal rows. Papillae cover the stomatal pit.

2.4. Rifugio Dibona (Dolomites)

The flora of Dibona is mostly famous because of the amber drops which were found, partly together with plant remains, in the sediments of the Heiligkreuz Formation, being thus of upper Carnian age. Macroremains are seldom found in the sediments. They belong to equisetalean stem fragments and conifer shoots (Pl. 2, Fig. 4) probably of the genus *Voltzia*. Of particular interest are the dispersed leaves (Pl. 2, Fig. 5) that have been found in the same horizon of the amber drops. Those are wide triangular to rhomboidal in shape, with an obtuse apex (4.5-6 x 3-4.5 mm). The stomata are arranged in short rows and are characterized by a circle of 4-6 subsidiary cells.

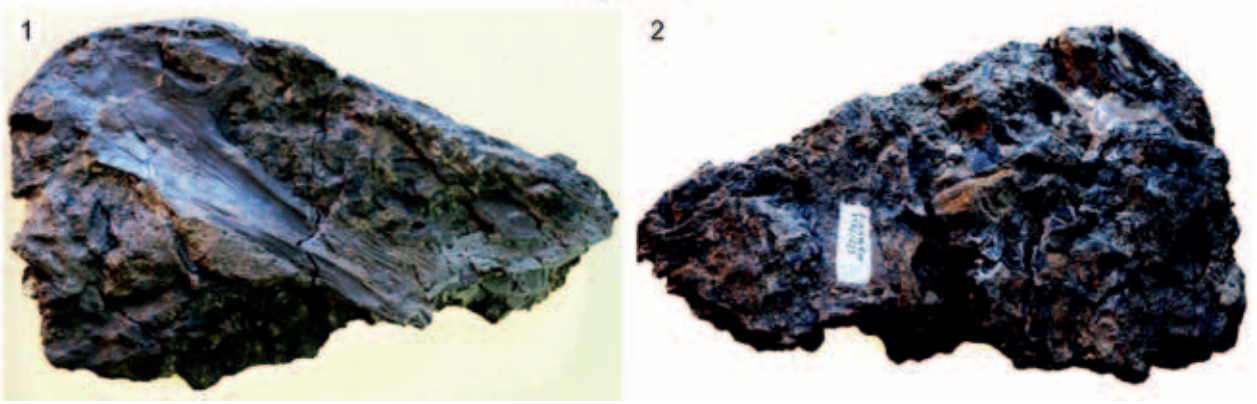

Fig. 2: Charcoal fragments on the back of *Metoposaurus santacrucii* Koken 1913.

2.5. Raibl/Cave del Predil (Julian Alps)

The flora from Raibl is, together with those from Lunz and Neuewelt, one of the most famous Upper Triassic (Carnian) floras in the Alps. It has been attributed to the lower part of the Raibl Formation, corresponding to the Predil Limestone (De Zanche et al., 2000), belonging thus to the lower Carnian. The flora has been studied mostly in the second half of the 19th century (e.g., Bronn, 1858; Schenk, 1866-7, Stur, 1868, 1885); lately Dobruskina et al. (2001) published an overview on the flora, consisting of circa 600-650 specimens.

According to the literature this flora is nicely diversified. The horsetails are represented by *Equisetites arenaceus* (Jaeger) Schenk 1864 although in literature *Calamites raiblensis* Schenk 1865 and *Equisetites strigatum* Stur 1885 are mentioned as well. The latter corresponds to *Phylladelphia strigata* Bronn 1858, an enigmatic fossil (for more details see Kustatscher & Van Konijnenburg-van Cittert, 2008) (Pl.2, Fig. 9). The ferns are represented by frond fragments of taxa well represented in Middle Triassic floras such as *Neuropteridium grandifolium* (Schimper et Mougeot) Compter 1883, *Neuropteridium elegans* (Brongniart) Schimper 1869, *Chiropteris lacerata* (Quenstedt) Rühle von Lilienstern 1931, *Cladophlebis ruetimeyeri* (Heer) Leonardi 1953 (Pl. 2, Fig. 8) and perhaps *Cladophlebis leuthardtii* Leonardi 1953. *Ptilozamites sandbergeri* (Schenk) Kustatscher & Van Konijnenburg-van Cittert, 2007 (Pl. 3, Fig. 2) is numerous. The cycads are represented by *Sphenozamites bronnii* (Schenk) Passoni et al. 2003 (Pl. 3, Fig. 3); probably *Pterophyllum giganteum* Schenk 1865 and *Pterophyllum longifolium* Stur 1885 fall also within its variability. Some entire-leaved cycads might belong to the genus *Macrotaeniopteris* or *Bjuvia*. The conifers are the most abundant group of the flora and several species have been created for this flora such as *Voltzia haueri* Stur 1885, *Voltzia raiblensis* Stur 1885 (Pl. 3, Fig. 6) and *Cephalotaxites raiblensis* Stur 1885. *Pelourdea vogesiaca* (Schimper et Mougeot) Seward 1917 (Pl. 3, Fig. 5) is also abundant in this flora. A modern taxonomic revision of this flora (in progress) will permit to understand how diversified this flora is.

2.6. Additional plant remains

Charcoalified wood, seeds and small conifer shoots have been also collected from Pralongià (com. pers., Helmut Buratti, 2011), Misurina (com. pers., Alexander Nützel, 2011). Additionally, the *Metoposaurus santacrucii* of Koken (1913) shows on the backside of the sample a high frequency of charcoal fragments (Fig. 2). Late Carnian plant remains are also known from Lastoni di Formin in the Dolomites (Heiligkreuz Formation) (Roghi et al., 2006a). Also in this case, the plant remains belong mostly to the conifers (mainly as isolated leaves) while some other fragments belong probably to the sphenophytes.

Acknowledgements

We wish to thank Alexander Lukeneder and Andreas Kroh (Naturhistorisches Museum Wien) and Irene Zorn and Barbara Meller (Austrian Geological Survey) for the help during the study of the Raibl flora. The project "Taxonomic revision of the Carnian (Upper Triassic) conifers from the historical Raibl flora from Northern Italy " (AT-TAF-2999) received funding through SYNTHESYS, which is made available by the European Community - Research Infrastructure Action under the FP6 „Structuring the European Research Area" Programme.

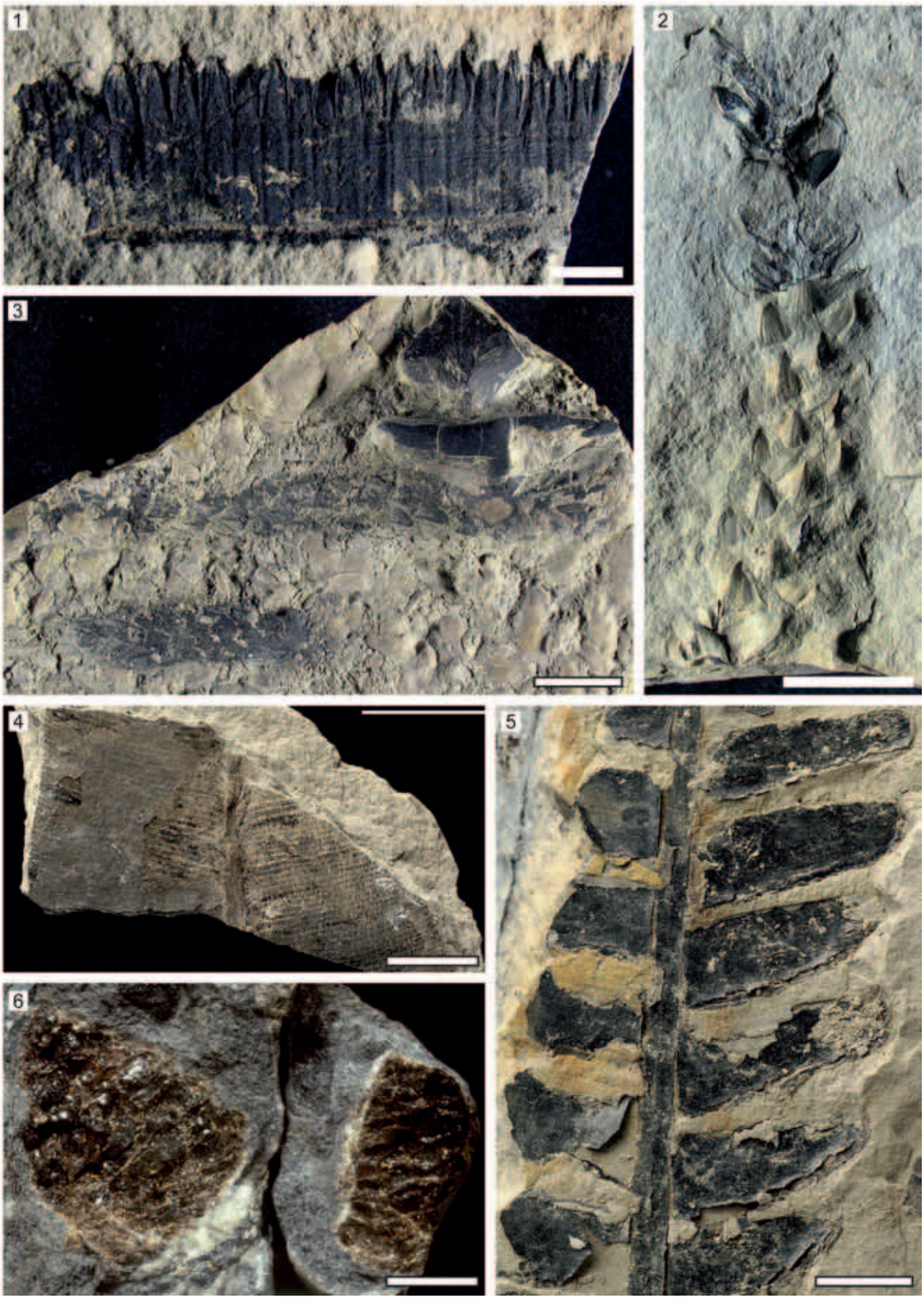

Plate 1 (scale = 1 cm if not indicated differently)

Fig. 1: *Equisetites* sp., leaf sheet, Heiligkreuz, Heiligkreuz Formation.
Fig. 2: *Voltzia* sp., shoot fragment, Heiligkreuz, Heiligkreuz Formation.
Fig. 3: *Voltzia* sp., shoot fragments together with bone fragments, Stuores, San Cassian Formation.
Fig. 4: *Danaeopsis angustifolia* (Kustatscher et al., submitted), frond fragment, Dogna, Rio del Lago Formation (CHIUT 107).
Fig. 5: *Ptilozamites sandbergeri* (Schenk) Kustatscher & Van Konijnenburg-van Cittert, 2007 frond fragment, Dogna, Rio del Lago Formation (CHIUT 104).
Fig. 6: Amber fragment, Dogna, Rio del Lago Formation.

Plate 2 (scale = 1 cm if not indicated differently)

Fig. 1: *Brachyphyllum* sp., shoot fragment, Dogna, Rio del Lago Formation (CHIUT 14), scale = 0.5 mm.
Fig. 2: Shoot of the conifer taxon 3, Dogna, Rio del Lago Formation (CHIUT 11), scale = 0.5 mm.
Fig. 3: *Voltzia* sp., shoot fragment, Dogna, Rio del Lago Formation (CHIUT 84).
Fig. 4: Shoot of the conifer taxon 3, Dogna, Rio del Lago Formation (CHIUT 11), scale = 0.5 mm.
Fig. 5: Dispersed leaves and amber drops from the paleosoil, Dogna, Rio del Lago Formation.
Fig. 6: conifer dwarf shoot, Dibona, Heiligkreuz Formation, scale = 0.5 mm.
Fig. 7: seed, Dibona, Heiligkreuz Formation, scale = 0.5 mm.
Fig. 8: *Cladophlebis ruetimeyeri* (Heer) Leonardi 1953, frond fragment, Raibl/Cave del Predil, Raibl Formation (GBA 2007-072-0012).
Fig. 9: *Phylladelphia strigata* Bronn 1858, enigmatic fossil, Raibl/Cave del Predil, Raibl Formation (NHM 1866 XL 464).

Plate 3 (scale = 1 cm if not indicated differently)

Fig. 1: *Equisetites* sp., Raibl/Cave del Predil, Raibl Formation (NHM 1887 IX 68).
Fig. 2: *Ptilozamites sandbergeri* (Schenk) Kustatscher & Van Konijnenburg-van Cittert, 2007, frond fragment, Raibl/Cave del Predil, Raibl Formation (GBA 2005-0008-004).
Fig. 3: *Sphenozamites bronnii* (Schenk) Passoni et al. 2003, leaf fragment, Raibl/Cave del Predil, Raibl Formation (GBA 2007-072-0060).
Fig. 4: *Voltzia* sp., shoot fragment, Raibl/Cave del Predil, Raibl Formation (GBA 1986-2-06).
Fig. 5: *Pelourdea vogesiaca* (Schimper et Mougeot) Seward 1917, leaf fragment, Raibl/Cave del Predil, Raibl Formation (NHM 2007B0003-0017).
Fig. 6: *Voltzia raiblensis* Stur 1885, shoot fragment, Raibl/Cave del Predil, Raibl Formation (NHM 1864 LII 39).

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