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A NEW MIDDLE TRIASSIC (PELSONIAN) PLANT LOCALITY IN THE NON VALLEY (TRENTINO, NORTHERN ITALY)

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With 3 Figures and 2 Plates

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Abstract
This is the first description of Anisian plant fossils from the Non Valley (Val di Non, Trentino, northern Italy). The small flora is housed in the collections of the Geoscience Centre of the University of Göttingen and is probably derived from the Pelsonian Voltago Limestone. The flora is composed of sphenophytes *(Equisetites conicus)*, ferns *(Neuropteridium elegans, Gordonopteris lorigae)*, cycads (*Dioonitocarpidium* sp.) and conifers (*Voltzia recubariensis* and perhaps *Voltzia walchiaeformis*). This flora corroborates the position of the western coast of the emerged land that covered part of the Dolomites during the Anisian.

1. Introduction

The majority of Triassic floras in the Southern Alps come from basinal sediments of Middle Triassic age with most of the literature devoted to the Ladinian (for more details see Kustatscher & Van Konijnenburg-van Cittert, 2005 and references therein). Plant fossils of Anisian age were found so far mostly in the northern Dolomites (e.g., Kühwiesenkopf/Monte Prà della Vacca, Piz da Peres; e.g., Broglio Loriga et al., 2002; Todesco et al., 2008; Kustatscher et al., 2010), although minor findings occurred also in the Vallarsa Valley (Selli, 1938) and in the San Lucano Valley (Kustatscher et al., 2011). Additionally, the historical locality Recoaro in the Vicentinian Alps (e.g., Catullo, 1847; Schauroth, 1855; De Zigno, 1862; Schenk, 1868; Gümbel, 1879) yielded late Permian and Anisian plant fossils. So far the only Anisian plant remains mentioned from the western Southern (Italian) Alps are some poorly defined conifer shoot fragments from the Besano Formation of Monte San Giorgio, which are considered of uppermost Anisian to lowermost Ladinian age (for more details see Stockar & Kustatscher, 2010 with references therein). From the Non Valley plant fossils were only described from lower Permian sediments (Tregiovo/Trompia Tal, Remy & Remy, 1978), although Van Hilten (1960) mentioned *Voltzia recubariensis* Schenk, 1868 at the top of the Richthofen Conglomerate (late Anisian) of the Non Valley (without any further indications). Thus, the discovery of Anisian plant fossils from the Non Valley in the collections of the Geoscience Centre of the University of Göttingen is of special interest. It shows a more complete picture of the Anisian floras of the western Southern (Italian) Alps and adds important information on the distribution of the emerged land in the Southern Alps during this time period.

2. Material and methods

A collection of about 40 Triassic plant fossils from the Southern Alps has been discovered at the Geoscience Centre of the University of Göttingen. The collection, labelled by the former curator Hermann Schmidt (1892–1978; at Göttingen University 1922 - 1963) has apparently been collected in summer of 1927 and spring 1928 by Rolf Teichmüller (1904–

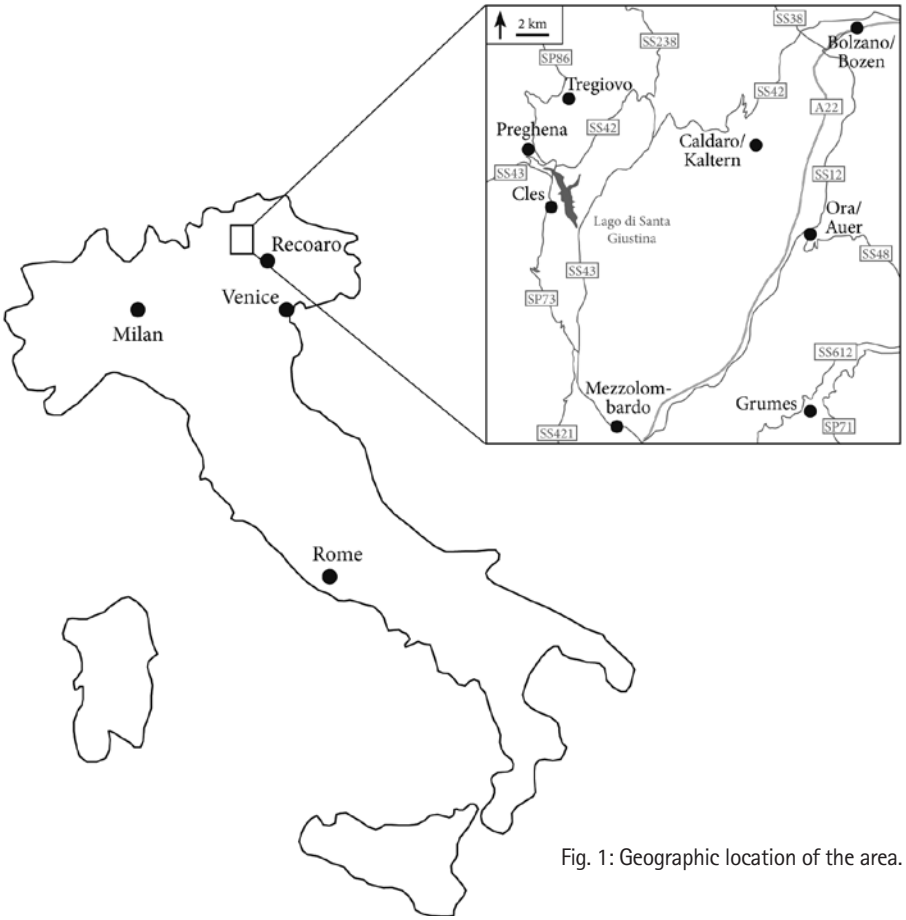

Fig. 1: Geographic location of the area.

1983) during fieldwork in the Southern Limestone Alps for his dissertation. This doctor's thesis (supervised by H. Stille) which was devoted to the tectonics, geology and stratigraphy of the Southern Alps has been defended in 1928, and published one year later (Teichmüller, 1929). Most of the material was collected, accordingly to the labels, in "Val di Rumo, Nonsberg", "Val di Non, Südtirol" and "Preghena (Nonsberg; see fig.1)". Additionally, some plant fossils" (13 specimens) are from the historical "Muschelkalk" of "Recoaro" (Northwest of Vicenza, Veneto, Italy). The plants are preserved as compression fossils, but in most cases no cuticle has been preserved. Only the male cones from Recoaro yielded in situ pollen. Although the only chronostratigraphic definition on the labels is "anisisch" (Anisian), it agrees well with the composition of the flora.

Photography was accomplished with an EOS 550D digital camera following the proposals of Kerp & Bomfleur (2011). The plant fossils are stored at the Geoscience Centre of the University of Göttingen, Museum (Germany).

3. Geological setting and historical background

On the eastern slope of the Monte Avert, between Rumo and Preghena, Anisian sediments crop out (geological map 026 Eppan/Appiano; Bosellini, 2007; Fig 2). They belong to the Carniola di Bovegno, the Angolo Limestone, the Voltago Conglomerate and the Giovo Formation (bottom to top). The Carniola di Bovegno is composed of centimetre thick beds of dolomitic limestones and dolomites of yellowish-greyish colour alternated with thin siltitic layers and decameter- or meter-thick breccias composed of angular clasts of laminated dolomite and greenish limestone. This formation has been related to a coastal marine environment with subtidal and intertidal circulation in a hot and arid climate (sabkha; Avanzini et al., 2007). The Angolo Limestone is composed in the lower part of centimetre thick beds of microcrystalline limestone, dolomites of dark grey to black colour and bioclastic calcarenites rich in crinoids. In the upper part of the formation, centimetre-thick beds of black limestone alternate with laminated mudstones rich

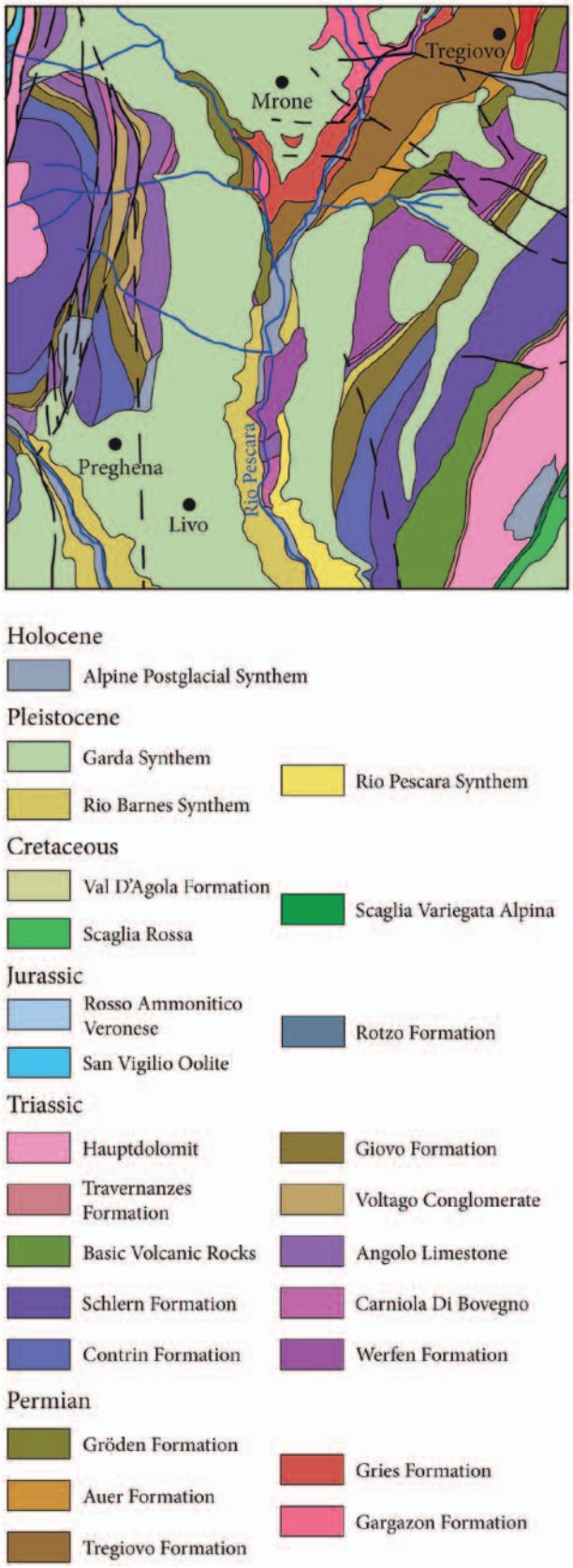

Fig. 2: Redrawing of the geological map with the supposed horizons of the plant fossils (from Bosellini et al., 2007, mod.).

in mica. Ripple marks are often observed. In these beds also brachiopods *(Tetractinella trigonella)*, bivalves, gastropods, ostracods, fragments of crinoids *(Dadocrinus gracilis, Encrinus liliiformis)*, calcareous algae (dasycladaceae) and foraminifera (*Glomospirella*; Avanzini et al., 2007) occur. At the base the Voltago Conglomerate is composed of decimetre to metre thick siltitic limestones and arenaceous bioturbated dolomites of reddish or greyish colour, alternating with decimetre thick levels of siltstone and sandstone (Pisa et al., 1979; Avanzini et al., 2007). The upper part the Voltago Conglomerate is composed of fine to medium-grained sandstones alternating with bioturbated siltstones of reddish and greyish colour. In these horizons also up to 2 m thick conglomerates are intercalated. These conglomerates are massive and poorly sorted in the lower part and show cross-bedding in the upper part. In the uppermost part the formation is characterised by stromatolitic dolomites alternating with arenaceous and evaporitic dolomites, greyish-reddish siltstones and smectite mudstones related to alternated ceneritic levels. The Voltago Conglomerate yielded ripple marks, mud cracks and bioturbation. The foraminifera are probably reworked from the Werfen Formation (e.g., *Glomospira*, *Meandrospira pusilla*). Tetrapod footprints have been observed (*Parasynaptichnium gracilis, Synaptichnium pseudosuchoides;* Avanzini & Renesto, 2002) as well as fragments of *Voltzia* (Avanzini et al., 2007). The Giovo Formation is characterised by carbonates and clastic deposits of various grain size deposited in a marine environment. Three different members are distinguished (in ascending order): The Gampenpass/Passo Palade Member is composed of yellowish-greyish arenites with carbonatic cement and cross-bedded conglomerates containing plant remains and crinoids (e.g., *Encrinus liliiformis, Dadocrinus gracilis*) alternating with greyish and bioturbated pelites rich in plant remains (Avanzini et al., 2007). In the lower part, the Kurtatsch/Cortaccia Member is characterised by dark grey siltstones and marls with plant remains alternating with limestones and greyish-yellowish arenaceous siltstones; the strata are of variable thickness (5-20 cm) and are often characterised by strong bioturbation (e.g., *Rhizocorallium*) giving a nodular structure to the rock (Avanzini et al., 2007). The carbonate horizons increase upwards and yield plant fossils, calcareous algae *(Diplopora)*, ostracods, crinoids (e.g., *Encrinus liliiformis, Dadocrinus gracilis*), foraminifera *(Glomospira)*, brachiopods (e.g., *Tetractinella trigonella, Rhynchonella decurtata, Coenothyris*

vulgaris), corals (*Montlivaltia, Thamnasteria* cf. *silesiaca*) and tetrapod footprints (*Rhynchosauroides, Synaptichnium, Chirotherium*; Avanzini et al., 2007).

The Monte Ozol Member is characterised by dolomites and bioclastic limestones (crinoids) of grey-black colour and arenaceous limestones grading upwards into microcrystalline dolomites (Avanzini et al., 2007). The Carniola di Bovegno is attributed to the late Olenekian-early Anisian, the Angolo Limestone to the Bithynian-lower Pelsonian and the Voltago Conglomerate and the Giovo Formation to the Pelsonian.

The fossil plant specimens are preserved in fine-grained sandstone to siltstone of grey to dark grey colour. Thus, the plant remains discussed here are probably derived from either the upper part of the Voltago Limestone, or – more probably – from the pelitic levels in the Gampenpass/Passo Palade or the Kurtatsch/Cortaccia Member of the Giovo Formation.

4. The flora of the Non Valley

?Equisetoid stem fragments

Some of the fragments on the rock slabs are small and elongated with impressions of vascular bundles (e.g., GZG.PB.5204, Pl. 1, Fig. 1). These fragments probably represent equisetalean stem fragments, even if they are too small and nodes are not preserved.

Equisetites conicus Sternberg, 1833

The stem fragments (GZG.PB.5208, 5225, Pl. 1, Fig. 2-3) are up to 85 mm long and 16 mm wide. The stem is longitudinally divided by delicate costae (distance of 3 mm). The leaf sheath at the node is 9 mm high and composed probably of 8-9 microphylls (4 are visible on one side). Each microphyll is cuneate, 8 mm long, 4 mm wide and fused almost over the entire length; only the 1.5-2 mm broad apical part of the microphyll (leaf teeth) with a slightly rounded apex is free. Although this is a small stem fragment, the shape and size of the microphylls and the narrow stem suggest an attribution to the species *Equisetites conicus*. So far the only Anisian *Equisetites* species is *Equisetites mougeotii*, first described by Brongniart (1828, p. 137, pl. 25, figs. 4-5) as *Calamites mougeotii*, then transferred to the genus *Equisetum* by Schimper (1869, p. 278, pls 12, 13, figs 1–4) and finally to *Equisetites* by Wills (1910, p. 282-4). Unfortunately, the fossil record only consists of stem fragments with impressions of the vascular bundles but without leaf sheaths (e.g., Brongniart, 1828; Schimper & Mougeot, 1844; Compter, 1894) and isolated strobili (e.g., Kustatscher et al., 2007). The primary shoot is however much broader in *Equisetites mougeotii*. The specimens of the Non Valley also differ from *Equisetites arenaceus* (Jäger) Schenk, 1864, the most common *Equisetites* species of the Ladinian (late Middle Triassic) of Europe and the Upper Triassic of Germany (Kelber & van Konijnenburg-van Cittert, 1983), by the lower number of microphylls, the narrower shoot and the broader microphylls with less pointed apices. Grauvogel-Stamm (1978, *Equisetites* sp., pl. 1, fig. 1) figures a similar stem fragment with a leaf sheath, although the stem is slightly bigger and the microphylls show a more acute apex than in the remains from the Non Valley, but that might be due to preservation. Also isolated *Equisetites* cones *(Equisetostachys verticillata)* with *in situ* spores of the *Calamospora tener* type, that could perhaps belong to *E. mougeotii*, have been described from the Anisian of the Vosges (Grauvogel-Stamm, 1978, p. 71, pl. 14, figs. 1-10; Grauvogel-Stamm and Lugardon, 2009).

Equisetites conicus, originally described from the Keuper of Abschwind (Austria; Sternberg, 1833), is known also from the late Ladinian of the German Basin (Lettenkeuper/Erfurt Formation; Kelber & Hansch, 1995) and from the Carnian flora of Lunz (Austria; Krasser, 1909; Pott et al., 2008) and Neuewelt (Switzerland; Kräusel & Leschik, 1959). Schweitzer et al. (1997) described this species also from the Norian of Iran.

Neuropteridium elegans (Brongniart) Schimper, 1879

The two small frond fragments (GZG.PB.5195, 5203, Pl. 1, Fig. 4) are up to 20 mm long and 15 mm wide, with a 3 mm wide rachis. The pinnae fragments are 6-8 mm long and 6-7 mm wide. The venation is typically neuropterid with a clear midrib and secondary veins that diverge and fork up to three times. Although the specimens are only fragmentarily preserved, the characteristic pinnule shape and dimension nonetheless permit to attribute them to this species which occurs in the Anisian of the Dolomites (Van Konijnenburg-van Cittert et al., 2006) and in the Buntsandstein of the Vosges and Germany (e.g., Brongniart, 1828; Grauvogel-Stamm, 1978; Mägdefrau, 1931; Sander & Gee, 1994).

Gordonopteris lorigae Van Konijnenburg-van Cittert et al., 2006

The single frond fragment (GZG.PB.5206, Pl. 1, Fig. 5) is characterised by a narrow rachis (3.5 mm) and small, roundish pinnules (2.5-3 x 1.5-2 mm). Although the preservation is bad, the organisation of the leaf and the shape of the pinnules is typical for this species.

This species seems to be so far restricted to the Middle Triassic of the Southern Alps (for more details see Van Konijnenburg-van Cittert et al., 2006).

Dioonitocarpidium sp. cf. *Dioonitocarpidium pennaeformis* (Schenk) Rühle von Lilienstern, 1928

The only fragment of *Dioonitocarpidium* (GZG.PB.5215, Pl. 1, Fig. 6) is about 20 mm long and 7 mm wide. Although only the upper, sterile part has been preserved, the pinnate structure of the macrosporophyll is typical for this genus. Similar macrosporophylls have been found in the Anisian (middle-late Pelsonian) flora of Kühwiesenkopf/Monte Prá della Vacca (e.g., Broglio Loriga et al., 2002).

The specimen resembles *Dioonitocarpidium pennaeformis* (Schenk, 1864) Rühle von Lilienstern, 1928, a typical element from the late Ladinian of the German Basin (e.g., Schenk, 1864; Schönlein & Schenk, 1865; Rühle von Lilienstern, 1928; Kustatscher & Van Konijnenburg-van Cittert, 2010). The macrosporophylls of *Dioonitocarpidium moroderi* (Leonardi) Kustatscher et al. (2004) from the Ladinian of the Dolomites are much bigger (about 65 mm long with a 5 mm wide rachis) than the here described fragment.

Voltzia sp. cf. *Voltzia walchiaeformis* Fliche, 1908

Several specimens (GZG.PB.5208, 5219, 5221, 5226, 5230-33, Pl. 1, Fig. 7) show small conifer shoot fragments up to 200 mm long and 5 mm wide. Small, falcate leaves (3-5 x 0.7-1 mm) with a pointed apex are inserted in a close helix on a narrow axis (< 1 mm).

Fliche (1908, p. 198) originally described the species as *Voltzia valchiaeformis*. Since in the text the author uses also *"Valchia"* instead of *"Walchia"*, the Permian conifer genus which the author thought the conifer resembled most, this is no simple printing error (pers. comm. Gea Zijlstra, 2012). On the other hand, this writing error was corrected in Fliche (1910b), the book that collected all paper written by Fliche (1908) as well as those written by Ph. Guinier and M.R. Zeiller after Fliche died based on his notes (Fliche, 1910a). The correct version of the name to use is *"walchiaeformis"*, according to the genus *Walchia*, the author referred it to, but with the correct spelling.

Although *Voltzia walchiaeformis* has been described from the Upper Buntsandstein of the Vosges (Fliche, 1910b), it is rather rare in this formation. Grauvogel-Stamm (1978, p. 31) considers this species to be restricted to the base of the Grès à Voltzia which is Bithynian, i.e. early Anisian in age, on the basis of conchostracans (Kozur et al. 1993). From the Alpine Area this species has been mentioned before only from the middle-late Pelsonian flora of Kühwiesenkopf (e.g., Broglio Loriga et al., 2002; Kustatscher, 2004).

Voltzia recubariensis Schenk, 1868

The biggest part of the flora is composed of this species (e.g., GZG.PB.5196, 5203, 5205, 5218, 5226). The shoots fragments are up to 75 mm long and 15 mm wide (e.g., GZG.PB.5203, Pl. 1, Fig. 8-9). Falcate to triangular leaves arise from the stout axis (3-7 mm wide) in a wide helix. The single leaves are very leathery with a median ridge. The proximal margin is inclined at an angle of approximately 45° while the distal margin arises almost perpendicularly from the axis. The leaves are 6-10 mm long and 2-4 mm wide.

Voltzia recubariensis is a typical element of the Anisian of the Southern Alps and has been found in the "Strati di Voltzia" of Recoaro (Schenk, 1868), the Anisian flora of Kühwiesenkopf (e.g. Broglio Loriga et al., 2002; Kustatscher, 2004), Piz da Peres (Todesco et al., 2008) and Agordo (Kustatscher et al., 2011).

Scale

One conifer of ovuliferous scale (part and counterpart, GZG.PB.5207, Pl. 1, Fig. 10) is about 10 mm long and 5.5 mm wide with a long stalk (12 mm) and three lobes with a slightly rounded apex and a broad basis (6 x 4 mm).

5. Plant remains from Recoaro at the Museum of the Geoscience Center

Apart from the small flora of the Non Valley also some other Anisian plant fossils from the Southern

Alps were found at the Geoscience Centre of the University of Göttingen.

As in the Non Valley, the flora of Recoaro is dominated by *Voltzia recubariensis* (about 10 specimens). Shoot fragments of various levels and male cones represent this taxon. The shoots are up to 50 mm long and 15 mm broad, with triangular leaves (3-6 x 1-2.5 mm) inserted in a wide helix and almost with perpendicular distal margin on the up to 4 mm wide axis. Sometimes, the shoots are very coarse with up to 9 mm long and 3 mm wide and very falcate leaves with a pointed apex, and 8 mm long and 5 mm wide leaf cushions (GZG.PB.5216, Pl. 2, Fig. 1, 3). A fragmentary ovuliferous scale (14 x 10 mm) has been found (part and counterpart, GZG.PB.5216-7, Pl. 1, Fig. 2) showing a long axis (7 x 4 mm) and three lobes (8 x 3.5 mm) with pointed apices. It is unclear to which conifer this scale belongs. The male cones (e.g., GZG.PB.5214, 5216, Pl. 2, Fig. 1, 5) are up to 35 mm long and 11 mm wide with an axis of 1.5-2 mm in diameter and seem at least in one case (GZG.PB.5216, Pl. 2, Fig. 1) attached to the shoot. They seem to be similar to the cones assigned to *Willsiostrobus* sp. that have been described in the Anisian of eastern France (Grauvogel-Stamm, 1978).

Two shoot fragments (GZG.PB.5213, 5216, Pl. 2, Figs. 4, 6) seem to belong to the species *Voltzia heterophylla* Brongniart, 1828. The up to 60 mm long and 20 mm wide long shoot fragments are characterised by elongated leaves (8-9.5 x 2 mm) with a slightly rounded apex arising in a loose helix from the 1.5-2.5 mm wide axis.

The "Voltzia beds" of the Recoaro limestone have been attributed to the early Pelsonian (e.g., De Zanche et al., 1992). The flora is dominated almost completely by the conifer *Voltzia recubariensis*. Additional conifers mentioned in the literature are stems with leaf scars attributed to the genus *Endolepis* (e.g., Schenk, 1868), some additional conifer shoots (*Taxodites saxolympiae* De Zigno, 1862 in Schenk, 1868) and a fern frond fragment interpreted as "*Neuropteris gaillardotii* Brongniart" by Schenk (1868).

6. Conclusions

This is the first description of Anisian plant remains from the Non Valley as well as some considerations about those of Recoaro. The knowledge about the floras from the Pelsonian is important in the reconstruction of the biotic recovery of the floras after the end

Fig. 3: Palaeogeographic reconstruction of the area during the late Anisian (after Petti et al., in press, mod.).

Permian mass extinction event. The flora of Kühwiesenkopf/Monte Prá della Vacca of middle to late Pelsonian age is one of the oldest examples for the full recovery of the ecosystems after the end-Permian mass extinction (Grauvogel-Stamm & Ash, 2005). It shows a highly diversified vegetation dominated by ferns, cycadophytes and conifers. "Modern" Mesozoic taxa are represented by the fern *Chiropteris*, the seed ferns *Scytophyllum* (with its ovuliferous organ *Peltaspermum*), *Sagenopteris* and perhaps *Ptilozamites*, the cycadophytes *Bjuvia* and *Nilssonia* and the conifer *Voltzia* (Schenk, 1868; Broglio Loriga et al., 2002; Kustatscher et al., 2010). Typical Anisian elements from the floras of the Southern Alps are the osmundaceous ferns *Neuropteridium, Anomopteris* and *Gordonopteris*, the lycophyte *Annalepis* and the conifers *Albertia* and *Aethophyllum* (Schenk, 1868; Broglio Loriga et al., 2002). The abundance of lycophytes is also of particular interest, with dm to m long stems (e.g. *Lycopia, Isoetites*), although without secondary wood (Kustatscher et al., 2010).

Although the plant fossils from the Non Valley are very fragmentary and not very well preserved, they contain, however, some of the typical Anisian elements from the Southern Alps such as the ferns *Gordonopteris lorigae, Neuropteridium elegans* and the conifers *Voltzia recubariensis* and *Voltzia walchiaeformis*. The cycadophyte megasporophyll *Dioonitocarpidium* is common in the Anisian of the Southern Alps but

appears in the German Basin only in the Ladinian (e.g., Rühle von Lilienstern, 1928; Kustatscher & Van Konijnenburg-van Cittert, 2010). Similarly *Equisetites conicus* which was so far only known from the Ladinian of the German Basin and the Carnian of the Alpine Area (Lunz and Neuewelt), represents the first record of this species from the Anisian. It is worth to note that some of these plants (*Neuropteridium elegans, Anomopteris mougeotii, Albertia, Aethophyllum* and *Voltzia walchiaeformis*) are also characteristic of the early Anisian (Bithynian) of the German Basin (Grauvogel-Stamm, 1978).

The new flora of the Non Valley increases not only our knowledge of the composition of the Anisian floras in the Southern Alps, but it adds also a new piece in the puzzle on the distribution of the emerged land during the Pelsonian (Anisian, Middle Triassic). With a mixture of sphenophyte, fern and conifer remains this flora corroborates the position of the western coast of the emerged land (Fig. 3) that covered part of the Dolomites during the Anisian (e.g., Petti et al., in press) because such a flora could not have been transported over long distances. Hopefully, the findings of other Anisian floras will enable us to get even more information on the palaeogeographic distribution of the emerged land during this period.

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Plate 1

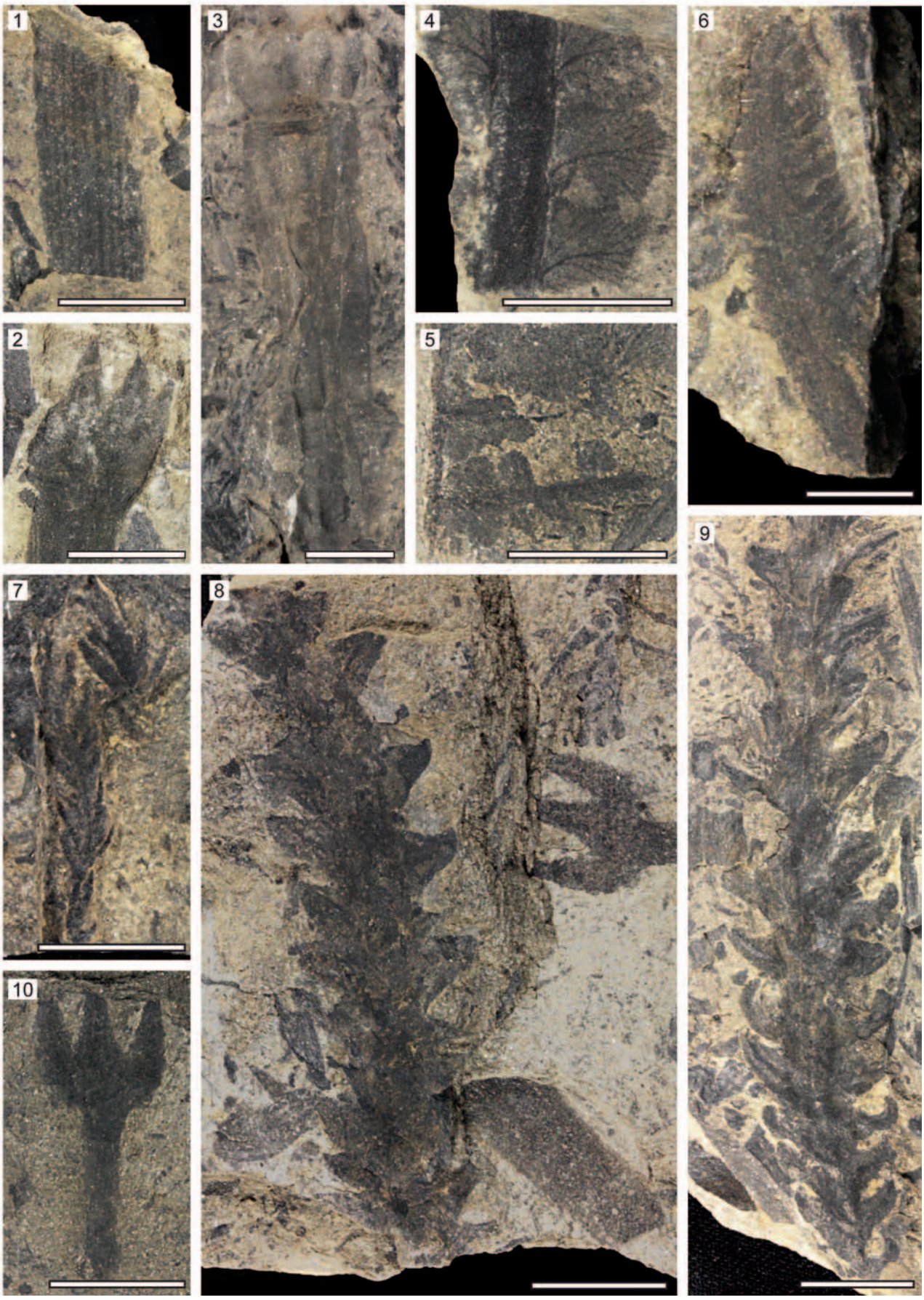

Plate 1 The flora of the Anisian sediments from the Non Valley (scale = 1 cm if not indicated differently)

Fig. 1. *Equisetalean* stem fragment (GZG.PB.5204).
Fig. 2. *Equisetites conicus* Sternberg, 1833, leaf sheet (GZG.PB.5225).
Fig. 3. *Equisetites conicus* Sternberg, 1833, stem fragment (GZG.PB.5208).
Fig. 4. *Neuropteridium elegans* (Brongniart) Schimper, 1879, frond fragment (GZG.PB.5195).
Fig. 5. *Gordonopteris lorigae* Van Konijnenburg-van Cittert, 2006, frond fragment (GZG.PB.5206).
Fig. 6. *Dioonitocarpidium* sp. cf. *Dioonitocarpidium pennaeformis* (Schenk) Rühle von Lilienstern, 1928, fragment of the sterile part of the macrosporophyll (GZG.PB.5215); scale = 0.5 cm.
Fig. 7. *Voltzia* cf. sp. *Voltzia walchiaeformis* Fliche, 1908, shoot fragments (GZG.PB.5219).
Fig. 8. *Voltzia recubariensis* Schenk, 1868, shoot fragment on the left with the typical triangulate, coriaceous leaves and on the right and isolated conifer scale (GZG.PB.5205).
Fig. 9. *Voltzia recubariensis* Schenk, 1868, shoot fragment (GZG.PB.5203).
Fig. 10. Dispersed ovuliferous scale (GZG.PB.5207), counterpart of GZG.PB.5205.

Plate 2

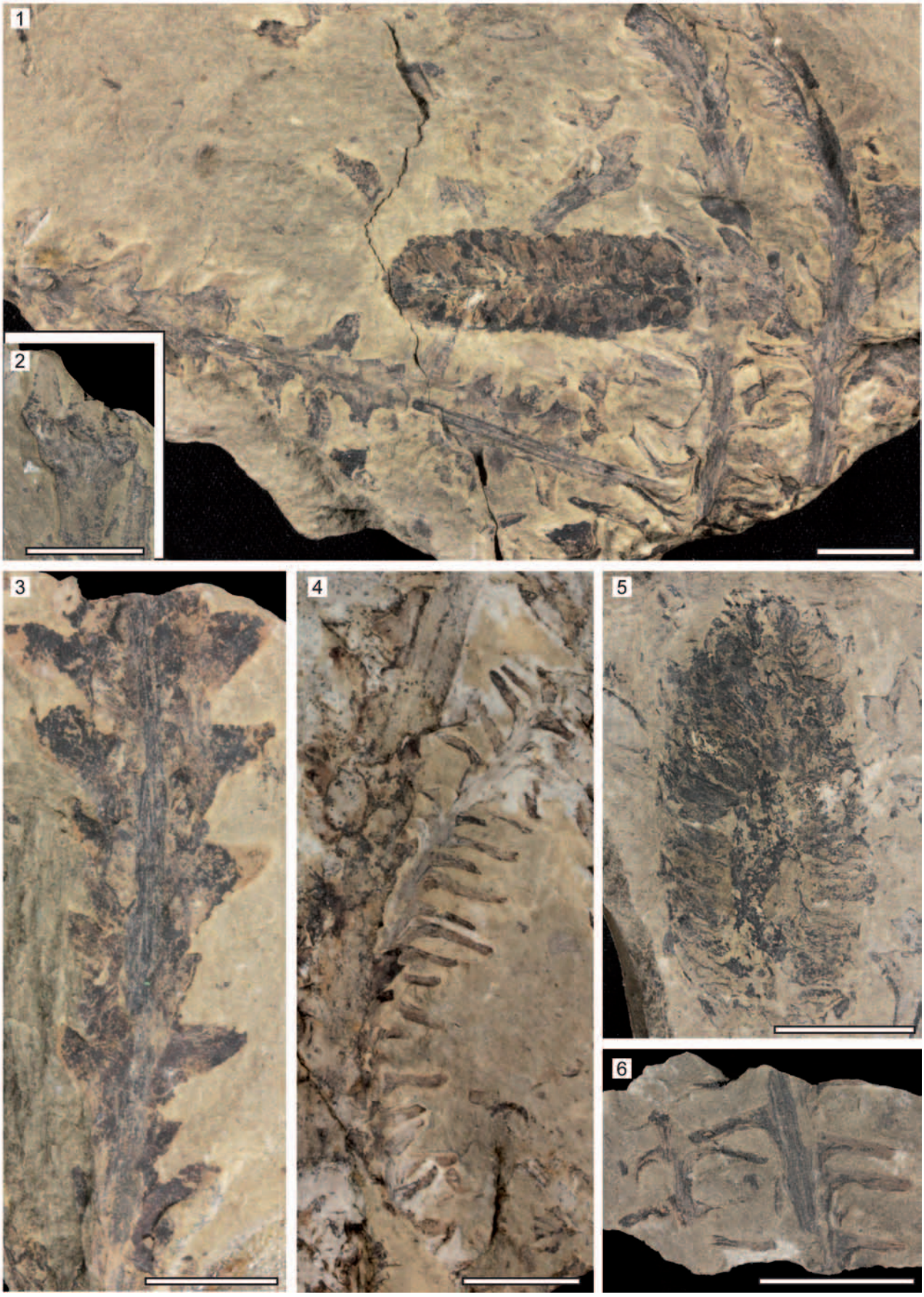

Plate 2 The Anisian flora of Recoaro (scale = 1 cm if not indicated differently)

Fig. 1. *Voltzia recubariensis* Schenk, 1868, shoot fragment with a supposedly attached male cone (GZG.PB.5216).
Fig. 2. Isolated ovuliferous scale (GZG.PB.5217), scale = 0.5cm.
Fig. 3. *Voltzia recubariensis* Schenk, 1868, shoot fragment with coarse leaves and broad, triangular leaf cushions (GZG.PB.5212).
Fig. 4. *Voltzia* sp. cf. *Voltzia heterophylla* Brongniart, 1828, shoot fragment (GZG.PB.5216).
Fig. 5. Isolated male conifer cone (GZG.PB.5214).
Fig. 6. *Voltzia* sp. cf. *Voltzia heterophylla* Brongniart, 1828, shoot fragment (GZG.PB.5213).

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