

(Fois & Gaetani 1984; De Zanche et al. 1993; Senowbari-Daryan et al. 1993). The Anisian outcrops of the Prags/Braies Dolomites have been famous in the palaeontological literature since the 19th century, mainly on account of the Anisian brachiopods and ammonoids of the "alpiner Muschelkalk" (Loretz 1875; Mojsisovics 1879, 1882; Bittner 1890) and calcareous algae (Pia 1937), while plant remains have remained almost unnoticed (e.g. Pia 1937). The only illustrations of Anisian plants from this area were published by Bechstädt & Brandner (1970; pl. 8, fig. 4; pl. 10, fig. 1).

The preliminary taxonomic analysis of the numerous and well reserved specimens is based on both macro-morphology and some cuticles and *in situ* spores; a very diverse terrestrial plant assemblage emerges which has no comparison with the scarce data hitherto available regarding the Anisian macroflora of the Dolomites, which only mentions rare terrestrial plant remains (e.g. Mojsisovics 1879; Pia 1937; Ogilvie Gordon 1934). The Kühwiesenkopf flora is the first rich Triassic flora of the Dolomites.

The aim of the report is to present the high diversity of this Anisian plant assemblage which contains new taxa both at generic and specific level. In addition, the results of the foraminiferal study of the stratigraphical segment including the plant horizon are also presented.

Stratigraphical setting and age

The plant horizon crops out for several hundred metres along the steep gullies furrowing the western slope of Monte Prà della Vacca / Kühwiesenkopf, inside the Braies/Prags Natural Park (Fig. 1). It occurs in the lower part of the Anisian basinal succession (Fig. 1), now named the Dont Formation of the Braies Group (Pisa et al. 1978; Fois & Gaetani 1984; De Zanche et al. 1993; Senowbari-Daryan et al. 1993; Delfrati et al. 2000). This unit is considered a hemipelagic carbonate-terrigenous sequence of a marginal basin environment (Senowbari-Daryan et al. 1993).

In this section, well-known through the detailed study of Bechstädt & Brandner (1970), the Dont Formation is more than 200 m thick. The plant-bearing beds are situated about 75 m above a massive carbonate platform (sample K3, enclosure 2 of Bechstädt & Brandner 1970; Fig. 1A), previously known as the Algenwellenkalk by Bechstädt & Brandner (1970), and now attributed to the Gracilis Formation (De Zanche et al. 1992; Senowbari-Daryan et al. 1993). The lower part of the Dont Formation is considered to be as an equivalent

of the Voltago Conglomerate of the Dolomites and the "VOLTZIA beds" of Recoaro (De Zanche et al. 1993).

The plant horizon is about one meter thick and situated just above bed K11 of Bechstädt & Brandner (1970, enclosure 2) (Fig. 1A). Plants are concentrated in some centimetres-thick layers of siltstone, marly siltstone and carbonate siltstone. The fossiliferous layers are lens-shaped. Therefore, their number and thickness may change laterally. They alternate with silty and marly limestone layers, in which only sparse terrestrial plant remains occur. Marine biota (bivalves, brachiopods, ammonoids, gastropods and fishes) are present, but not abundant, throughout the horizon. Occurrence and preservation of terrestrial (plants and reptiles) and marine fossils are presumably related to very rapid burial events caused by gravity flows within a marine basin, connected with heavy storms in the terrestrial domain (Tintori et al. 2001; Broglio Loriga et al. 2002).

At the base of the deposit a layer of carbonate siltstone, about 30 cm thick, represents a marker bed, easily recognizable because its upper surface is rich in roughly N-S oriented trunks (trunk bed; Fig. 1B). Large but rare plant remains (trunks) are also present at the top of a limestone bank situated at about two metres below (brachiopod bed, Fig. 1B). This unit of nodular and massive wackestone and packstone contains a rich foraminiferal assemblage. At the top of the bank, byssate bivalves (*Mysidiopora*) and brachiopods [e.g. *Punctospiriferella fragilis* (Schlotheim) and *Angustothyris angustaeformis* (Böckh)] are frequent (Tintori et al. 2001). This brachiopod bed was already noticed by Bechstädt & Brandner (1970), who named it Brachiopodenhorizont 2, and is characterized by the occurrence of *Mentzelia mentzeli* (Dunker) and *Coenothyris vulgaris* (Schlotheim).

The Dont Formation of the Dolomites is traditionally considered Pelsonian-Illyrian in age (Delfrati et al. 2000, with references). In the lower part of the Dont Formation, Upper Bithynian ammonoids have been cited in the Braies area (Rio Schade - Belvedere sections; De Zanche et al. 1993; Gianolla et al. 1998).

The Anisian formations of the Prags/Braies area were dated by Bechstädt & Brandner (1970) mostly on the basis of the brachiopod assemblages; ammonoids, crinoids and conodonts were also considered. However, the stratigraphic distribution of these latter groups was not reported in detail, but referred only to their lithostratigraphic units. According to the above cited authors, the *Algenwellenkalk* interfingers with the *siltitische Mergel und Knollenkalke* and its upper boundary ranges from the late Bithynian (eastward, where it may lacking)

Fig. 1 - Stratigraphical setting of the plant deposit from Kühwiesenkopf / Monte Prà della Vacca. A - General column adapted and modified from Bechstädt & Brandner (1970; enclosure 2). B - Detail of the segment bearing the plant deposit. Symbols: FS - Foraminifer samples; BH - Brachiopod horizons (from Bechstädt & Brandner 1970); K3, K11 - bed numbers from Bechstädt & Brandner (1970, enclosure 2) column.

THE ANISIAN MACROFLORA FROM THE NORTHERN DOLOMITES (MONTE PRÀ DELLA VACCA / KÜHWIESENKOPF, BRAIES): A FIRST REPORT

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Riassunto. Le conoscenze sulla macroflora triassica delle Dolomiti riguardano principalmente il Ladinico, mentre sono scarsi in letteratura i dati relativi a quella anisica. Questa lacuna viene qui colmata con la scoperta di un giacimento a piante a Monte Prà della Vacca / Kühwiesenkopf (Dolomiti di Braies), località già nota in letteratura soprattutto per le faune a brachiopodi e le flore a dasycladali. Le piante si trovano all'interno di un orizzonte, spesso circa 1 metro, posto nella parte inferiore della Formazione di Dont, un'unità bacinale formata prevalentemente da sedimenti emipelagici, terrigeno-carbonatici di età pelsonico-illirica. L'orizzonte a piante si inserisce in un segmento stratigrafico con foraminiferi e brachiopodi tradizionalmente riferiti al Pelsonico. I macroresti vegetali, numerosi e ben conservati, comprendono fronde, corpi fruttiferi, rizomi e legni.

L'analisi preliminare, basata sulla macromorfologia, su cuticole e su spore *in situ*, ha permesso di identificare 17 generi. Il maggior numero di taxa appartiene alle Pteridophyta (*Anomopteris*, *Neuropteridium*, *Cladophlebis*, *Crematopteris*, ?*Marattiopsis*); seguono le Cycadophyta (*Bjuvia*, *Taeniopteris*, *Dioonitocarpidium*, *Pterophyllum* / *Nilssonina*). Alle Coniferophyta appartengono *Voltzia*, ?*Voltzia* ed *Albertia*; quest'ultimo genere è segnalato nel Triassico medio delle Dolomiti per la prima volta. Due generi appartengono alle Lycophyta (?*Isoetites*, Lycophyta nuovo taxon) e tre alle Pteridospermae (?*Sagenopteris*, *Scytophyllum* e *Peltaspermum*), un genere alle Sphenophyta (*Equisetites*).

Questa flora rappresenta la prima ricca documentazione della vita vegetale terrestre dopo l'estinzione permo-triassica nel Sudalpino.

Abstract. The knowledge of Triassic macroflora from the Dolomites mostly concerns the Ladinian, while literature data on Anisian plants are scarce. This gap is filled by the discovery, reported here, of a rich plant deposit from Monte Prà della Vacca / Kühwiesenkopf (Prags/Braies Dolomites). The fossils occur in a horizon, about 1 m thick, from the lower part of the Dont Formation, a basinal unit mostly constituted by hemipelagic, terrigenous-carbonatic sediments of Pelsonian - Illyrian age. The stratigraphic interval with the plant horizon is Pelsonian in age.

A preliminary systematic analysis of the numerous and well preserved specimens has allowed the identification of at least 17 genera. The taxa belong primarily to the Pteridophyta (*Anomopteris*, *Neuropteridium*, *Cladophlebis*, *Crematopteris*, ?*Marattiopsis*), subordinately

to the Cycadophyta (*Bjuvia*, *Taeniopteris*, *Dioonitocarpidium*, *Pterophyllum* / *Nilssonina*). Coniferophyta are represented by *Voltzia*, ?*Voltzia* and *Albertia*; the latter genus is recorded herein for the first time in the Middle Triassic of the Dolomites. Besides, two Lycophyta genera (?*Isoetites*, Lycophyta new taxon), three Pteridospermae genera (?*Sagenopteris*, *Scytophyllum* and *Peltaspermum*), and one Sphenophyta genus (*Equisetites*) have also been recognized.

Introduction

Triassic macrofloras of the Dolomites are rare, and the majority of the literature refers to Ladinian plants. After the sparse, vague citations of the pioneering researchers (e.g. Wissmann & Münster 1841; Mojsisovics 1879; Ogilvie Gordon 1927; Mutschlechner 1932), followed by the first monograph of Leonardi (1953) and brief updatings (e.g. Leonardi 1967; Calligaris 1986), the biodiversity of the Ladinian terrestrial plants has been presented in a recent systematic work by Wachtler & v. Konijnenburg - van Cittert (2000) and Kustatscher (2001). The latter two papers are mostly based on the discovery by one author (M. Wachtler) of new Ladinian plant deposits within the La Valle/Wengen Formation from the Braies/Prags area and Badia Valley. This material, now housed in the Museo di Scienze Naturali dell'Alto Adige (Bolzano), was identified using both macromorphology and cuticular analysis. Further plant collections of the Cortina d'Ampezzo and Ortisei Museums have been also considered.

More recently, M. Wachtler discovered a new and rich Anisian plant deposit located in the western slope of Monte Prà della Vacca / Kühwiesenkopf (Braies/Prags Dolomites). The fossils occur in a basinal unit, which has been variously named in the literature: *Pragser Schichten* by Pia (1937); *siltitische Mergel und Knollenkalke* (Bechstädt & Brandner 1970); Dont Formation

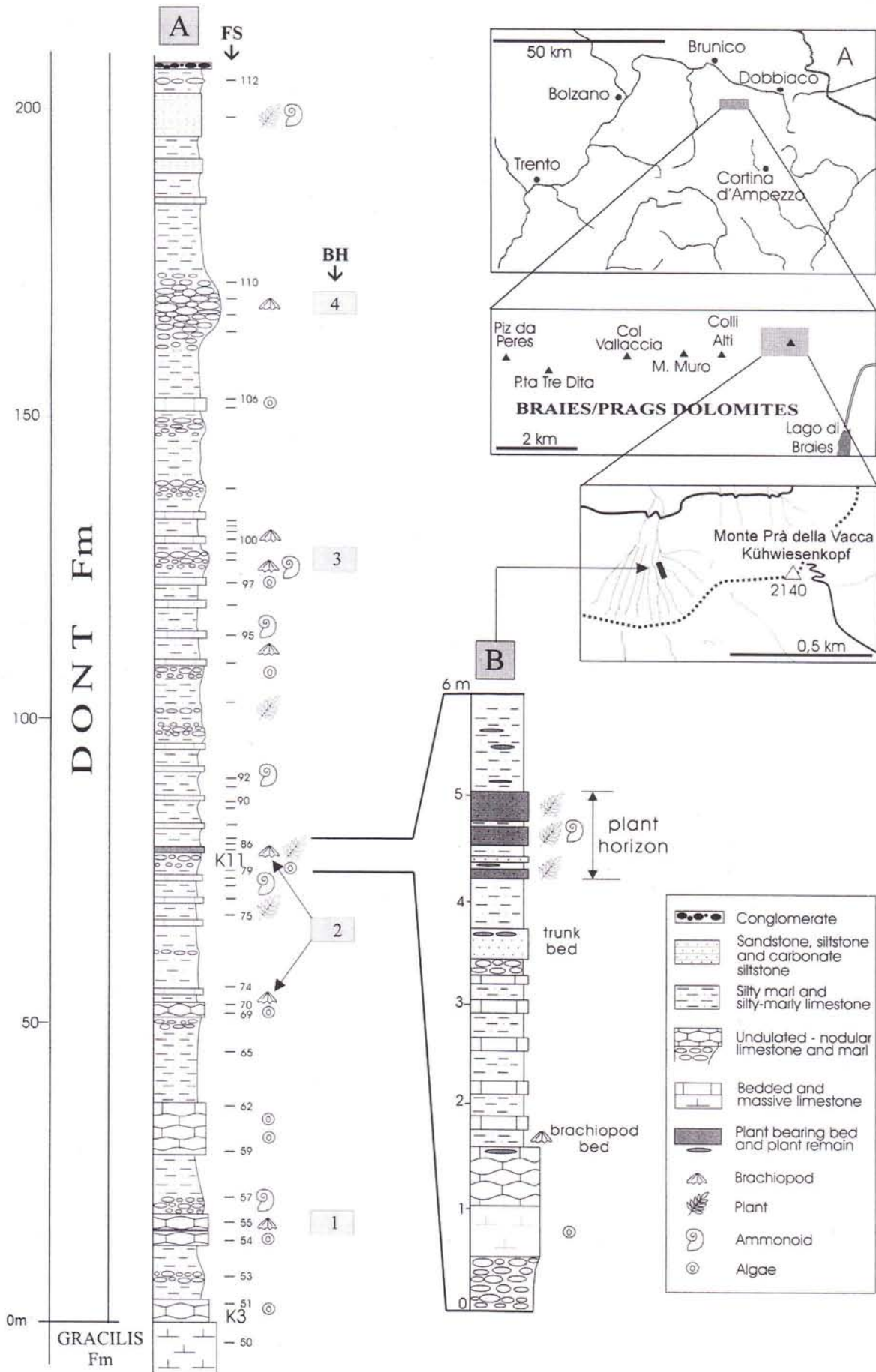
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Kühwiesenkopf / Monte Prà della Vacca section



to the Pelsonian (westwards).

In the *siltitische Mergel und Knollenkalke* of Monte Prà della Vacca/Kühwiesenkopf section, five brachiopod horizons were reported by Bechstädt & Brandner (1970) (Fig. 1A). The horizons 1 to 3 were considered Pelsonian in age, the horizon 4 Pelsonian - early Illyrian, while the horizon 5, occurring about 15 m above a thin bed of conglomerate (at the top of section in Fig. 1A), was dated to the early Illyrian. More recently, Senowbari-Daryan et al. (1993) suggested a Pelsonian age also for the brachiopod assemblage of the horizon 4, because the same species are present throughout the Recoaro Formation in the Braies Dolomites, where late Pelsonian ammonoids have been cited in the upper part (De Zanche et al. 1992).

Therefore, according to Bechstädt & Brandner (1970), the plant horizon can be referred to the Pelsonian as it occurs between the brachiopod assemblages 2 and 3.

The benthic foraminifera of the examined section are mainly represented by agglutinated, microgranular and porcelaneous species belonging to Ammodiscidae and Cornuspiridae.

The most significant species are *Meandrospira dinarica* Kochansky-Devidé & Pantic, *Pilamina densa* Pantic, *Pilaminella semiplana* (Kochansky-Devidé & Pantic), *Paulbronnimannia judicariensis* (Premoli Silva), and *Paulbronnimannella whittakeri* Rettori. The majority of these taxa are well known from several areas of the Tethys domain and their acme has been traditionally referred, sometimes by means of ammonites and conodonts, to the Pelsonian (e.g. Premoli Silva 1971; Gadzicki et al. 1975; Salay et al. 1988; De Zanche et al. 1992; Angiolini et al. 1992; Rettori et al. 1994; Rettori 1995; Zaninetti et al. 1994).

In particular, *Pilamina densa* shows the widest vertical distribution in the sections. Up to about 50 m from the base of the Dont Formation, the above quoted species is associated with *Meandrospira dinarica* and *Pilaminella semiplana*; this foraminiferal association is typically recognized in the Tethys realm as indicative of Pelsonian. The plant horizon is included in the stratigraphical interval bearing this association.

It is worth noting that *Paulbronnimannia judicariensis* occurs already in the lowest part of the section (samples 65, 66) together with *Pilamina densa* and before the appearance of *M. dinarica*. According to liter-

ature, *Paulbronnimannia judicariensis*, a species first discovered in the "orizzonte a binodosus s. str." (Premoli Silva 1971, p. 316), is generally recorded after the disappearance of *M. dinarica* even if their coexistence has not to be excluded (e.g. Premoli Silva 1971; Gadzicki et al. 1975; Trifonova 1979; Oravec-Scheffer 1987; Rettori et al. 1994; Angiolini et al. 1994; Zaninetti et al. 1994). This record consequently enables the stratigraphic distribution of *P. judicariensis* to be lowered. All these taxa are still occurring in the upper part of the section (which includes the brachiopod horizons 3 and 4) in which *Paulbronnimannia judicariensis* becomes the dominating species (samples 97 to 110). *Paulbronnimannella whittakeri*, which is considered a late Pelsonian marker (De Zanche et al. 1992; Zaninetti 1994), occurs only in the sample 110.

The macroflora

A preliminary systematic analysis of the terrestrial plants contained in more than 1000 samples, has made it possible to determine at least 17 genera belonging to the following divisions: Lycophyta, Sphenophyta, Pteridophyta, Pteridospermae, Cycadophyta and Coniferophyta. The fossil plant association is dominated by ferns, conifers and cycadales, while horse-tails and seed-ferns are rarer.

The Lycophyta are represented by two genera. One genus (?*Isoetites*, Tab.1; Pl. 1, Fig. 2) is characterized by elongated leaves, similar to *Isoetites* Münster. It is also represented by nearly complete individuals with still articulated roots, stem and elongated leaves covered, at least on one side, by thin hairs (trichomes). The genus *Isoetites* is also known from the Lower Triassic of Germany (Kelber & Hansch 1995) and China (Wang Z.1996).

The other form is represented mostly by specimens with stems and elongated leaves, covered, at least on one side, by very thin hairs (trichomes). At first they were thought to belong to *Pleuromeia sternbergii* (Münster) Corda (Kustatscher, van Konijnenburg - van Cittert & Wachtler 2002), a typical plant of the Anisian of the Vosges and the Germanic Buntsandstein (Grauvogel-Stamm, 1978; Sander & Gee 1994); this species is known from corm, leaves and undivided stem remains with elongated scars up to 1 cm in length, giving the stem

LYCOPHYTA	SPHENOPHYTA	PTERIDOPHYTA	PTERIDOSPERMAE	CYCADOPHYTA	CONIFEROPHYTA
? <i>Isoetites</i>	<i>Equisetites</i>	<i>Anomopteris</i>	? <i>Sagenopteris</i>	<i>Bjuvia</i>	<i>Voltzia</i>
Lycophyta		<i>Neuropteridium</i>	<i>Scytophyllum</i>	<i>Taeniopteris</i>	? <i>Voltzia</i>
new taxon		<i>Cladophlebis</i>	<i>Peltaspermum</i>	<i>Dioonitocarpidium</i>	<i>Albertia</i>
		<i>Cremaopteris</i>		<i>Pterophyllum</i>	
		? <i>Marattiopsis</i>		<i>Nilssonina</i>	

Tab. 1 - Preliminary list of the fossil plant genera discovered in the plant horizon from Kühwiesenkopf /Monte Prà della Vacca.

a more or less reticulate structure. However, recent findings at Kühwiesenkopf of thick rhizomes giving off the stems and stem fragments which show an apparent division now make this attribution impossible as *Pleuromeia* is characterized by a four-lobed corm and an undivided stem. The present material will probably have to be assigned to a new genus (Lycophyta new taxon, Tab. 1). The way the rhizome divides is characteristic for e.g. primitive Lycophytes but can also still be found in living *Lycopodium*.

The division Sphenophyta is documented by some stems, generally with only the internodes, isolated strobili and rare microsporophylls belonging to *Equisetites* Schimper, a genus well known all over the Triassic of Europe (i.e. Germany, Kelber & Hansch 1995).

The Pteridophyta contain five genera: *Anomopteris* Brongniart, *Neuropteridium* Schimper, *Crematopteris* Schimper & Mougeot, *Cladophlebis* Brongniart and ?*Marattiopsis* Schimper (Tab. 1). The fern genus *Anomopteris* is probably represented by two species; one is *A. mougeotii* Brongniart, formerly cited in the Buntsandstein of Vosges (Grauvogel-Stamm 1978, Grauvogel-Stamm & Grauvogel 1980) and of the German Basin (Sander & Gee 1994), in the Muschelkalk of France (Depape & Doubinger 1963), in the Early Triassic of China (Wang Z. 1996) and in the Ladinian of the Dolomites (Wachtler & van Konijnenburg - van Cittert 2000). Its leaves may reach 70 cm in length and bear both sterile and fertile pinnules. The other, probably a new species of *Anomopteris* (Pl. 1, Fig. 5), is rather similar on first sight to *A. mougeotii* but differs in the absence of aphaebia; moreover, it is probably tripinnate whereas *A. mougeotii* is bipinnate.

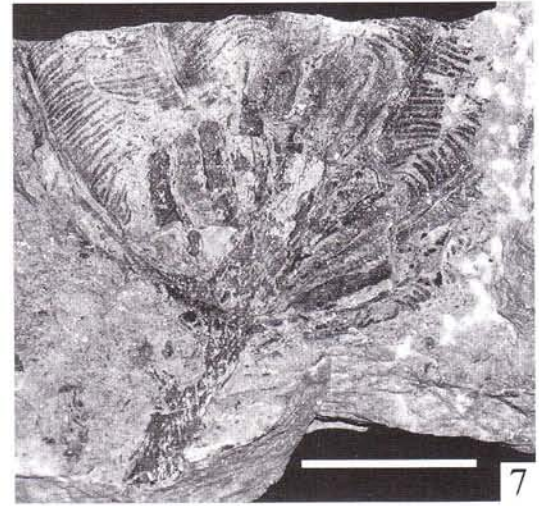
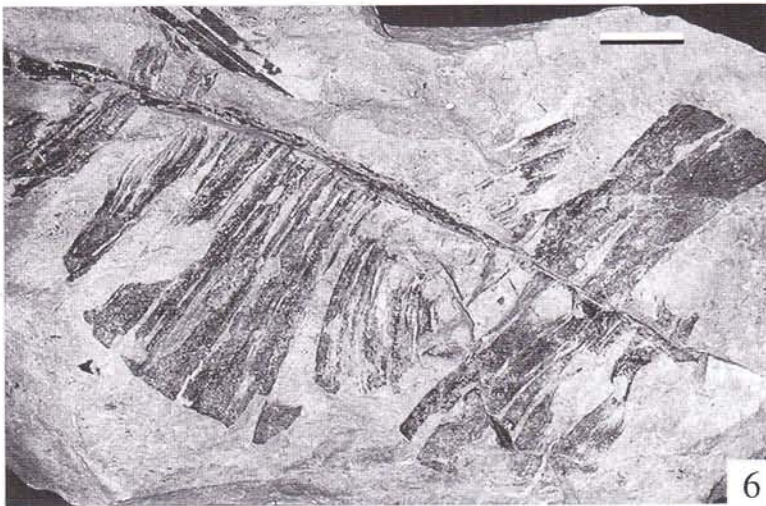
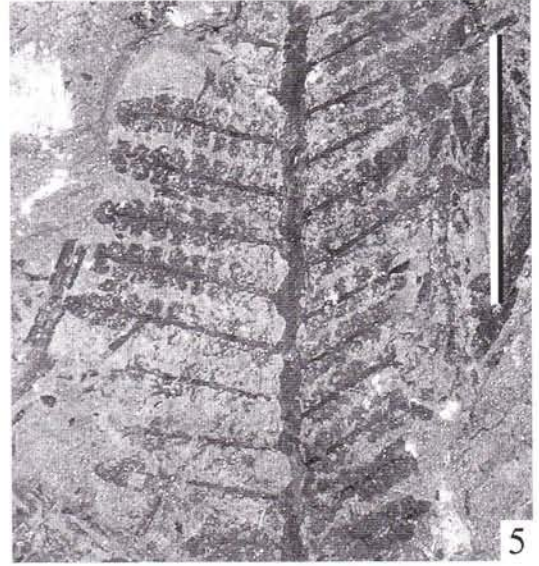
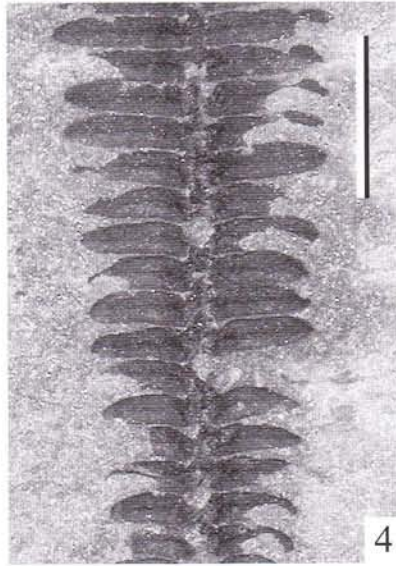
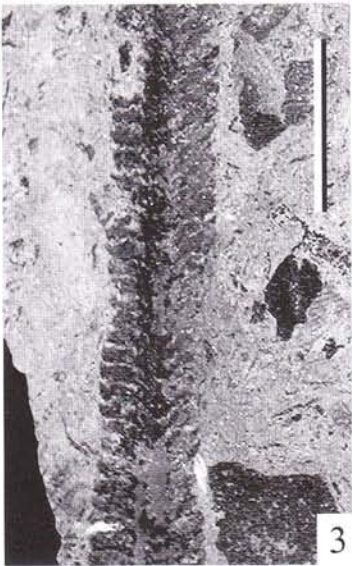
Neuropteridium (Pl. 1, Fig. 4) is represented by a large number of specimens. According to the literature they could be assigned to at least four species [*N. elegans* (Brongniart) Schimper & Mougeot, *N. intermedium* Schimper & Mougeot, *N. voltzii* (Brongniart) Schimper & Mougeot and *N. bergense* Blanckenhorn]. *N. elegans* is characterized by diverging and forking veins and pinnules as wide as they are long, while *N. intermedium* is characterized by a fusiform disposition of the pinnules, with the widest located in the middle part. In *N. voltzii* the two lobes, which cover the rachis, are asymmetrical, while *N. bergense* has very large pinnules attached to a rachis broader than in the other *Neuropteridium* material. However, the occurrence of specimens with transitional characters at least between the first three species suggests they should be considered as a single species. Further analysis will be necessary to resolve these taxonomical questions. *Neuropteridium* has also been described from the Upper Buntsandstein of the Vosges (Gall & Grauvogel-Stamm 1999), Germany (Blanckenhorn 1885; Sander & Gee 1994) and the Lower Triassic of China (Wang Z. 1996). *Crematopteris* (Pl. 1, Fig. 3) is a genus for fertile, once pinnate fern-leaves that had in

the past already been found associated with *Neuropteridium* leaves (Schimper & Mougeot 1844, Blanckenhorn 1885). We are now certain that *Crematopteris* represents the fertile parts of *Neuropteridium*. Although there is almost no macromorphological difference, we may be dealing with 2 species of *Crematopteris* as we found two different types of sporangia. The genus *Crematopteris* has also been cited in the Upper Buntsandstein of Germany (Blanckenhorn 1885; Sander & Gee 1994) and from the Early Triassic of China (Wang Z. 1996). The first species, with small and roundish sporangia, is *Crematopteris typica* Schimper & Mougeot, also known from the Vosges and Germany (Schimper & Mougeot 1844, Blanckenhorn 1885) and belongs to *Neuropteridium elegans* as we have found both attached to the same rhizome. The second species of *Crematopteris* with the larger, oval sporangia probably belongs to *N. bergense* but it has not been found attached to a rhizome. Spores from both *Crematopteris* species are identical trilete globular spores of the type found in the Osmundaceae.

Cladophlebis specimens are very similar to those described in the Ladinian of the Dolomites (Wachtler & van Konijnenburg - van Cittert 2000), from which they differ by their larger pinnules (up to 3 cm in length). Some incomplete specimens with microsporangia may belong to *Marattiopsis* (see e.g. Wang Y. 1999).

At least two leaf genera have been determined within Pteridospermae. One (?*Sagenopteris*, Tab. 1) comprises a few small leaf fragments with dichotomised veins which tend to anastomose, as in *Sagenopteris* Presl or *Neoglossopteris* (Wang Z. 1996). The other genus has pinnate leaves, ranging from elongated to lanceolate, similar to *Scytophyllum* Bornemann; it has been found associated with macrosporophyll heads of *Peltaspermum* Harris indicating that these fossils belong to the pteridosperm order of the Peltaspermales. Some leaves show traces of insect chewing. *Scytophyllum* and *Peltaspermum* are also recorded from the Keuper of Germany (Kelber & Hansch 1995).

At least three genera of Cycadophyte leaves have been recognized. One, with the largest leaves (50 cm long and 20 cm wide), probably belongs to *Bjuvia* Florin (Tab. 1; Pl. 1, Fig. 6); its morphology is close to *B. dolomitica* Wachtler & van Konijnenburg - van Cittert (2000) from the Ladinian of the Dolomites. *Taeniopteris* Brongniart (Tab. 1), a form-genus for undivided cycadophyte leaves, is represented by three species, whose distinction is based on leaf size and outline and on venation; one is *Taeniopteris angustifolia* Schenk also known from the Keuper of Germany (Kelber & Hansch 1995). Moreover, leaves morphologically similar to either the bennettitalean genus *Pterophyllum* Brongniart or the cycadalean genus *Nilssonia* Brongniart have been found; cuticular analysis indicates at least for part of the material a possible attribution to *Nilssonia* which would be



the earliest record of this genus so far (*Pterophyllum* / *Nilssonia*, Tab.1).

Almost complete female fructifications are also present. These consist of a series of macrosporophylls with an apical sterile part, up to 4 cm long, and a basal fertile part that is up to 3 cm long, on which as many as 12 seeds are inserted in two rows. The single scale has a morphology close to *Dioonitocarpidium* Lilienstern (Tab. 1; Pl. 1, Fig. 7) quoted from the Keuper of the Germanic Basin (Rühle von Lilienstern 1928; Kelber & Hansch 1995), Carnian of Lunz (Kräusel 1953) and from the Ladinian of the Dolomites (Leonardi 1953; Wachtler & van Konijnenburg - van Cittert 2000) even if generic names sometimes differ. Other macrosporophylls are similar to those of the recent cycad *Zamia* or the fossil genus *Beania* Carruthers.

Four different forms have been determined among the Coniferophyta. The first (?*Voltzia*, Tab. 1; Pl. 1, Fig. 1) shows a wide variability of leaf outlines, ranging from short needles (1 cm long) with a rounded apex to long needles (3-4 cm long) with a pointed apex. Falciform leaves, strongly diverging from the axis, occur between those two extremities. On the basis of leaf morphology, this material might be attributed to *Voltzia heterophylla* Brongniart known also from the Anisian of Spain (Diez et al. 1996), from the Buntsandstein and the Muschelkalk of Germany (Blanckenhorn 1885; Sander & Gee 1994), and France (Schimper & Mougeot 1844). However, the female cones found in the deposit, with ovuliferous scales divided in several lobes and only slightly fused at the base, show similarities with those of *Pseudovoltzia* Florin, a Late Permian conifer generally reported from Germany (Schweitzer 1962) and the Dolomites (Clement-Westerhof 1987). For this reason, the attribution of these plant remains to *Voltzia* Brongniart is questionable. A second form (*Voltzia*, Tab. 1) is characterized by elongated triangular needles which are inserted perpendicularly to the axes, as in *Voltzia recubariensis* Schenk, well-known from the Anisian flora of Recoaro (Schenk 1868). A third species seems to be identical to *Voltzia walchiaeformis* Fliche (Grauvogel-Stamm 1978). It is not clear if this form is to be considered as belonging to the first conifer species mentioned above, which is characterised by a strong heterophylly, or if it represents a different taxon. Probably only cuticular analysis will provide an answer to this question.

This analysis will be applied to all those taxa in which the cuticle is preserved.

The fourth type of conifer leaves present in the association can be attributed to the genus *Albertia* Schimper (Tab. 1) that is also known from the Anisian flora of the Vosges (Grauvogel-Stamm 1978) and the German Keuper (Kelber & Hansch 1995).

Some male cones have been also found but they are isolated; it is therefore impossible to determine to which conifer they belong. At least two different types of isolated female ovuliferous cones have been found as well.

Research for pollen and spores *in situ* also will be performed too.

Conclusions

The plant assemblage of Kühwiesenkopf/Monte Prà della Vacca is the first important record of the Mesozoic flora from the Dolomites after the Permian-Triassic extinction. It occurs in the lower part of the Dont Formation, a basal unit of Pelsonian-Illyrian age. The Pelsonian age of the stratigraphical interval including the plant horizon, already dated by means of brachiopods (Bechstädt & Brandner 1970), is confirmed by foraminiferal analysis. The material is numerous and well preserved, often yielding cuticles and *in situ* spores.

This assemblage represents an important flora with several new taxa (e.g. Lycophyta new taxon, *Anomopteris* new species) and some other taxa that are recorded for the first time in the Dolomite region (e.g. *Albertia*). In particular, the Lycophytes are found for the first time in the Triassic of the region, whereas in China and in Germany they are already known since the Lower Triassic. Some of the new taxa may even give a better insight in the evolution of certain groups (e.g., Lycophyta new taxon, cycad female fructifications).

The flora has several taxa in common with the Anisian floras of e.g. the Vosges (e.g. Brongniart 1828; Schimper & Mougeot 1844; Grauvogel-Stamm 1978), Recoaro and the German Buntsandstein (e.g. Blanckenhorn 1885; Mägdefrau 1931; Schlüter & Schmidt 1927). In particular, the macroflora reported here is much richer than that of the historical *Voltzia* beds of Recoaro, which are the most famous Anisian plant deposit of the Southern Alps (e.g. Catullo 1827, 1847; v. Schauroth

PLATE I

Some fossil plant specimens from the Anisian of Kühwiesenkopf /Monte Prà della Vacca plant horizon. Scale bar is 2 cm.

Fig. 1) - Primary shoot of conifer bearing secondary shoots, both with spirally arranged leaves; the specimen is macromorphologically similar to *Voltzia heterophylla* Brongniart (KÜH0058). Fig. 2) - ? *Isoetes* Münster, nearly complete individual with roots (below), short stem and long narrow leaves (KÜH0035A). Fig. 3) - *Crematopteris* Schimper & Mougeot, fragment of a simply pinnate fertile fern-leaf (KÜH0642). Fig. 4) - *Neuropteridium* Schimper, leaf-fragment (KÜH0665). Fig. 5) - *Anomopteris* Brongniart, bipinnate leaf-fragment with small oblate pinnules (KÜH0089). Fig. 6) - Specimen of a large Cycad leaf similar to *Bjurgia dolomitica* Wachtler & van Konijnenburg - van Cittert (KÜH0553). Fig. 7) - An almost complete female Cycad fructification with macrosporophylls (KÜH0658) of the *Dioonitocarpidium* Lilienstern - type.

1855; De Zigno 1862; Schenk 1868; Gümbel 1879). Only when the systematic study will be completed, the comparison with the other classical European Anisian floras and Ladinian floras of the Dolomites is possible, also with paleoclimatic aims.

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REFERENCES

- Angiolini L., Dragonetti L., Muttoni G. & Nicora A. (1992) - Triassic stratigraphy in the Island of Hydra (Greece). *Riv. It. Paleont. Strat.*, 98(2): 137-180, Milano.
- Bechstädt T. & Brandner R. (1970) - Das Anis zwischen St. Vigil und dem Höhlensteintal (Pragser-und Olang Dolomiten, Südtirol). *Festband des Geol. Inst., 300-Jahr-Feier Univ. Innsbruck*, 9-103, Innsbruck.
- Bittner A. (1890) - Brachiopoden der alpinen Trias. *Abb. k. k. Geol. Reichsanst.*, 14: 325 pp., Wien.
- Blanckenhorn M. (1885) - Die fossile Flora des Buntsandsteines und des Muschelkalks der Umgebung von Comern. *Palaeontographica*, 32(6/2): 117-153, Stuttgart.
- Broglio Loriga C., Fugagnoli A., Gaetani M., van Konijnenburg - van Cittert J., Kustatscher E., Mantovani N., Posenato R., Renesto S., Tintori A. & Wachtler M. (2002) - Il giacimento a piante di Kühwiesenkopf / Monte Pra della Vacca (Anisico, Dolomiti di Braies): una proposta di salvaguardia. In: A. Tintori (ed.), *Giornate di Paleontologia 2002 S.P.I., Verona-Bolca-Prabona 6-8/6/2002*, abstracts p. 13.
- Brongniart A.T. (1828) - Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans les diverses couches du globe. I. Dufour et d'Oscagne (eds.), vol. of 488 pp., Atlas I, 166 pls., Paris.
- Calligaris R. (1986) - Geologia della Val di Braies e segnalazione di nuove località fossilifere a vegetali nel Ladinico superiore. Vol. of 63 pp., Tipografia Villaggio del Fanciullo, Trieste.
- Catullo, T. (1827) - Saggio di Zoologia fossile nelle Province Austro-Venete. Vol. of 348 pp., Padova.
- Catullo, T. (1847) - Prodrómo di geognosia paleozoica delle Alpi Venete. Vol. of 157 pp., Tipografia Seminario, Padova.
- Clement-Westerhof J.A. (1987) - Aspects of Permian palaeobotany and palynology. VII. The Majoniaceae, a new family of Late Permian conifers. *Rev. Palaeobot. Palynol.*, 52: 375-402, Amsterdam.
- Delfrati L., Balini M. & Masetti D. (2000) - Formazione di Dont. In: Delfrati L. et al. (eds.), *Carta geologica d'Italia, 1:50.000*, Catalogo delle formazioni, fascicolo I, Unità validate. *Quaderni del Servizio Geologico d'Italia*, ser. 3, 7: 89-99, Roma
- De Zanche V., Franzin A., Gianolla P., Mietto P. & Siorpaes C. (1992) - The Piz da Peres Section (Valdaora-Olang, Pusteria Valley, Italy): A reappraisal of the Anisian stratigraphy in the Dolomites. *Eclogae geol. Helv.*, 85(1): 127-143, Basel.
- De Zanche V., Gianolla P., Mietto P., Siorpaes C. & Vail P. R. (1993) - Triassic sequence stratigraphy in the Dolomites (Italy). *Mem. Sci. Geol.*, 45: 1-27, Padova.
- De Zigno M.E. (1862) - Sulle piante fossili del Trias di Recoaro raccolte dal Prof. A. Massalongo. *Mem. Ist. Ven. Sc. Lett. Arti*, 11: 1-32, Venezia.
- Depape G. & Doubinger, J. (1963) - Flores triasiques de France. In *Colloques sur le Trias de la France et les régions limitrophes, Mém. Bur. Rech. Géol. Min.*, 15: 507-523, Paris.
- Diez J.-B., Grauvogel-Stamm L., Broutin J., Ferrer J., Gisbert J. & Linana E. (1996) - Première découverte d'une paléoflore anisienne dans le faciès "Buntsandstein" de la branche aragonaise de la Cordillère Ibérique (Espagne). *C. R. Acad. Sci.*, sér. IIA, 323: 341-347, Paris.
- Fois E. & Gaetani M. (1984) - The recovery of reef-building communities and the role of Cnidarians in carbonate sequences of the Middle Triassic (Anisian) in the Italian Dolomites. *Palaeontographica Americana*, 54: 191-200, Ithaca/ New York.
- Gazdzicki A., Trammer J. & Zawidzka K. (1975) - Foraminifers from the Muschelkalk of Southern Poland. *Acta Geol. Pol.*, 25(2): 285-298, Warszawa.
- Gall J.C. & Grauvogel-Stamm L. (1999) - Paläoökologie des Oberen Buntsandsteins am Westrand des Germanischen Beckens: Der Voltziensandstein im nordöstlichen Frankreich als deltaische Bildung. In: Hauschke N. & Wilde V. (eds.), *Trias - Eine ganz andere Welt*, pp. 283-298, Verlag Friedrich Pfeil, München.
- Gianolla P., De Zanche V. & Mietto P. (1998) - Triassic sequence stratigraphy in the Southern Alps (Northern Italy): definition of sequences and basin evolution. In: *Mesozoic and Cenozoic Sequence Stratigraphy of European Basins, SEPM*, spec. publ. no. 60: 719-747, Tulsa.
- Grauvogel-Stamm, L. (1978) - La flore du Grès à Voltzia (Buntsandstein supérieur) des Vosges du Nord (France). Morphologie, anatomie, interprétations phylogénétique et paléogéographie. *Sci. Géol. Mem.*, 50: 255 pp., Strasbourg.
- Grauvogel-Stamm L. & Grauvogel L. (1980) - Morphologie et anatomie d'*Anomopteris mougeotii* Brongniart (synonyme: *Pecopteris sulziana* Brongniart), une fougère du Buntsandstein Supérieur des Vosges (France). *Sci. Géol. Bull.*, 33: 53-66, Strasbourg.
- Gümbel C.W. (1879) - Geognostische Mitteilungen aus den Alpen. V. Die Pflanzenreste führenden Sandsteinschichten von Recoaro. *Sitz. Bayer. Akad. Wiss. Math. Phys.*, 9: 33-90, München.

- Kelber K.-P. & Hansch W. (1995) - Keuperpflanzen. Die Enträtselung einer über 200 Millionen Jahre alten Flora. *Museo*, 11: 1-157, Heilbronn.
- Kräusel R. (1953) - Ein neues *Dioonitocarpidium* aus der Trias von Lunz. *Senckenbergiana*, 34(1-3): 105-108, Frankfurt.
- Kustatscher E. (2001) - Flora continentale del Ladinico delle Dolomiti. *PaleoItalia*, 4: 2-7, Modena.
- Kustatscher E., van Konijnenburg - van Cittert J.H.A. & Wachtler M. (2002) - La macroflora anisica del giacimento di Kühwiesenkopf / Monte Prà della Vacca (Dolomiti di Braies). In: A. Tintori (ed.), Giornate di Paleontologia 2002 S.P.I., Verona-Bolca-Priabona 6-8/6/2002, abstracts p. 31.
- Leonardi P. (1953) - Flora continentale Ladinica delle Dolomiti. *Mem. Ist. Geol. Min. Univ.*, 18: 1-22, Padova.
- Leonardi P. (1967) - Le Dolomiti. Geologia dei Monti tra Isarco e Piave. Vol. I, 552 pp., Manfrini ed., Rovereto.
- Loretz H. (1875) - Einige Petrefacten der alpinen Trias aus den Südalpen. *Zeitschr. Deutsch. Geol. Gesell.*, 27: 784-841, Berlin.
- Mägdefrau K. (1931) - Die fossile Flora von Singen in Thüringen und die pflanzengeographischen Verhältnisse in Mitteleuropa zur Buntsandsteinzeit. *Beih. Dtsch. Bot. Ges.*, 49: 298-308, Stuttgart.
- Mojsisovics E. (1879) - Die Dolomit-Riffe von Südtirol und Venetien: Beiträge zur Bildungsgeschichte der Alpen. Vol. of 551 pp., A. Hölder Verlag, Wien.
- Mojsisovics E. (1882) - Die Cephalopoden der mediterranen Triasprovinz. *Abh. k. k. Geol. Reichsanst.*, 10: 320 pp., Wien.
- Mutschlechner C. (1932) - Geologie der St. Vigiler Dolomiten. *Jahrb. Geol. Bundesanst.*, 82: 163-273, Innsbruck.
- Ogilvie Gordon M. M. (1927) - Das Grödner- Fassa- und Enneberggebiet in den Südtiroler Dolomiten I-III. *Abh. Geol. Bundesanst.*, 24(1-2): 376 pp., Wien.
- Ogilvie Gordon M. M. (1934) - Geologie von Cortina di Ampezzo und Cadore. *Jahrb. Geol. Bundesanst.*, 84: 215 pp., Wien.
- Oravecz-Scheffer A. (1987) - Triassic foraminifers of the Transdanubian Central Range. *Geol. Hung., Series Palaeont.*, 50: 1-331, Budapest.
- Pia J. (1937) - Stratigraphie und Tektonik der Pragser Dolomiten in Südtirol. Vol. of 248 pp., A. Weger ed., Brixen.
- Pisa G., Farabegoli E. & Ott E. (1978) - Stratigrafia e paleogeografia dei terreni anisici della Conca di Agordo e dell'Alta Val di Zoldo (Dolomiti Sudorientali). *Mem. Soc. Geol. It.*, 18: 63-92, Roma.
- Premoli Silva I. (1971) - Foraminiferi anisici della regione giudicariense (Trento). *Riv. It. Paleont. Strat.*, 77(3): 303-374, Milano.
- Rettori R. (1995) - Foraminiferi del Trias inferiore e medio della Tetide: revisione tassonomica, stratigrafia ed interpretazione filogenetica. *Publ. Dép. Géol. Paléont. Univ. Genève*, 18: 1-147, Genève.
- Rettori R., Angiolini L. & Muttoni G. (1994) - Lower and Middle Triassic foraminifera from Eros Limestone, Hydra Island, Greece. *Journ. Micropal.*, 13(1): 25-46, London.
- Rühle von Lilienstern H. (1928) - "*Dioonites pennaeformis* Schenk" eine fertile Cycadee aus der Lettenkohle. *Paläont. Zeit.*, 10(1): 91-107, Bonn.
- Salay J., Trifonova E., Gheorghian D. (1988) - A biostratigraphic zonation based on benthic foraminifera in the Triassic deposits of the Carpatho-Balkans. *Rev. Paléobiol.*, vol. spéc. 2, Benthos 1986: 153-159, Genève.
- Sander M. & Gee C.T. (1994) - Der Buntsandstein der Eifel. In: Koenigswald W. von & Meyer W. (eds.), Erdgeschichte im Rheinland, pp. 117-124, Friedrich Pfeil Verlag, München.
- Schuroth v. K. (1855) - Übersicht der geognostischen Verhältnisse der Gegend von Recoaro im Vicentinischen. *K. Akad. Wiss.*, 34: 283-356, Wien.
- Schenk A. (1868) - Über die Pflanzenreste des Muschelkalk von Recoaro. *Geognostische paläontologische Beiträge*, 2/1: 58-87, München.
- Schimper W.P. & Mougeot A. (1844) - Monographie des Plantes fossiles du Grès Bigarrés de la chaîne des Vosges. Vol. of 83 pp., Leipzig.
- Schlüter H. & Schmidt H. (1927) - *Voltzia*, *Yuccites* und andere neue Funde aus dem südhanoverschen Buntsandstein. *N. Jahrb. Min., Geol. Paläontol.*, 57B: 12-27, Stuttgart.
- Schweitzer H.J. (1962) - Die Makroflora des niederrheinischen Zechsteins. Fortschritte in der Geologie von Rheinlande und Westfalen, 6: 331-377, Kirefeld.
- Senowbari-Daryan B., Zühlke R., Bechstadt T. & Flügel E. (1993) - Anisian (Middle Triassic) buildups of the Northern Dolomites (Italy): The recovery of reef communities after the Permian/Triassic crisis. *Facies*, 28: 181-256, Erlangen.
- Tintori A., Posenato R., Kustatscher E. & Wachtler M. (2001) - New Triassic fish faunas from paralic environments in the Alps. 3rd International Meeting on Mesozoic Fishes, 26-31 august 2001, Serpiano (CH).
- Trifonova E. (1979) - On the generic status of *Agathammina judicariensis* Pr.-Silva, 1971 (Foraminifera). *Paleont. Strat. Lith.*, 10: 9-10, Sofia.
- Wachtler M. & van Konijnenburg - van Cittert J.H.A. (2000) - The fossil flora of the Wengen Formation (Ladinian) in the Dolomites. *Beiträge zur Paläontologie*, 25: 105-141, Wien.
- Wang Z. (1996) - Recovery of vegetation from the terminal Permian mass extinction in North China. *Rev. Palaeobot. Palynol.*, 91: 121-142, Amsterdam.
- Wang Y. (1999) - Fertile organs and *in situ* spores of *Marattia asiatica* (Kawasaki) Harris (Marattiales) from the Lower Jurassic Hsiangchi Formation in Hubei, China. *Rev. Palaeobot. Palynol.*, 107: 125-144, Amsterdam.
- Wissmann H.L. & Münster G. (1841) - Beiträge zur Geognosie und Petrefactenkunde des südöstlichen Tirol's, vorzüglich der Schichten von St. Cassian. Vol. of 152 pp., Bayreuth.
- Zaninetti L., Rettori R. & Martini R. (1994) - Paulbronnianinae Rettori & Zaninetti, 1993 (Foraminifera, Ammodiscidae) and other Anisian foraminifers from the Piz da Peres section (Valdaora-Olang, Pusteria Valley, Dolomites, NE Italy). *Riv. It. Paleont. Strat.*, 100(3): 339-350, Milano.