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The Devonian/Carboniferous boundary in the Grüne Schneid section

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Locality *- In the eastern side of Grüne Schneid (Cresta Verde) at coordinates N 46°36'33", E 12°55'27".*
Lithostratigraphic unit *- Pal Grande Fm.*
Age *- Famennian – Tournaisian (Upper Devonian-lower Carboniferous);* Bi. ultimus *(= Upper* expansa*) Zone to* Si. duplicata *Zone.*
What to see *- Devonian/Carboniferous boundary.*

How to get there

The Grüne Schneid section can be reached along path n. 147, with about 1.5 hours hike from Plöckenpass/Passo di Monte Croce Carnico. It is located at an altitude of 2142 m on the northern side of the crest forming the Austrian/Italian border, about 25 m west of marker point n-129 which is west of Mt. Cellon (Fig. 1).

Historical outline

The Grüne Schneid section is a classical section for the Devonian/Carboniferous boundary in the Carnic Alps since von Gaertner (1931), and it was candidate as GSSP in the 1990s. Comprehensive papers were published by Schönlaub et al. (1988, 1992) and Schönlaub (1993), reporting data on conodonts, ammonoids and trilobites. Later, Kaiser (2005) resampled the section for conodonts, and geochemical data were presented by Schönlaub et al. (1994), Kaiser (2005, 2007), Kaiser et al. (2006) and Kumpan et al. (2014).

Figure 1. Location map of the Grüne Schneid section.

Lithology and fossil content

The measured and analysed section has a total thickness of about 6 metres, and exposes a sequence of well-bedded light gray to reddish micritic limestones of the Pal Grande Fm. Clays are only represented as thin partings separating individual beds. Bed thickness varies from 10 to 80 cm. In the boundary interval, beds have been further subdivided in order to achieve a more precise biostratigraphic subdivision.

Beside conodonts, ammonoids (24 taxa; Korn in Schönlaub et al. 1992) and trilobites (22 taxa; Feist in Schönlaub et al. 1992) are abundant; in the thin sections ostracodes, gastropods, cephalopods, trilobites, crinoids, brachiopods and bivalves can be observed.

Figure 2. View of the Grüne Schneid section. **A.** Prof. Willi Ziegler at the section in second half of the 1990s. **B.** Detail of the Devonian/Carboniferous boundary interval.

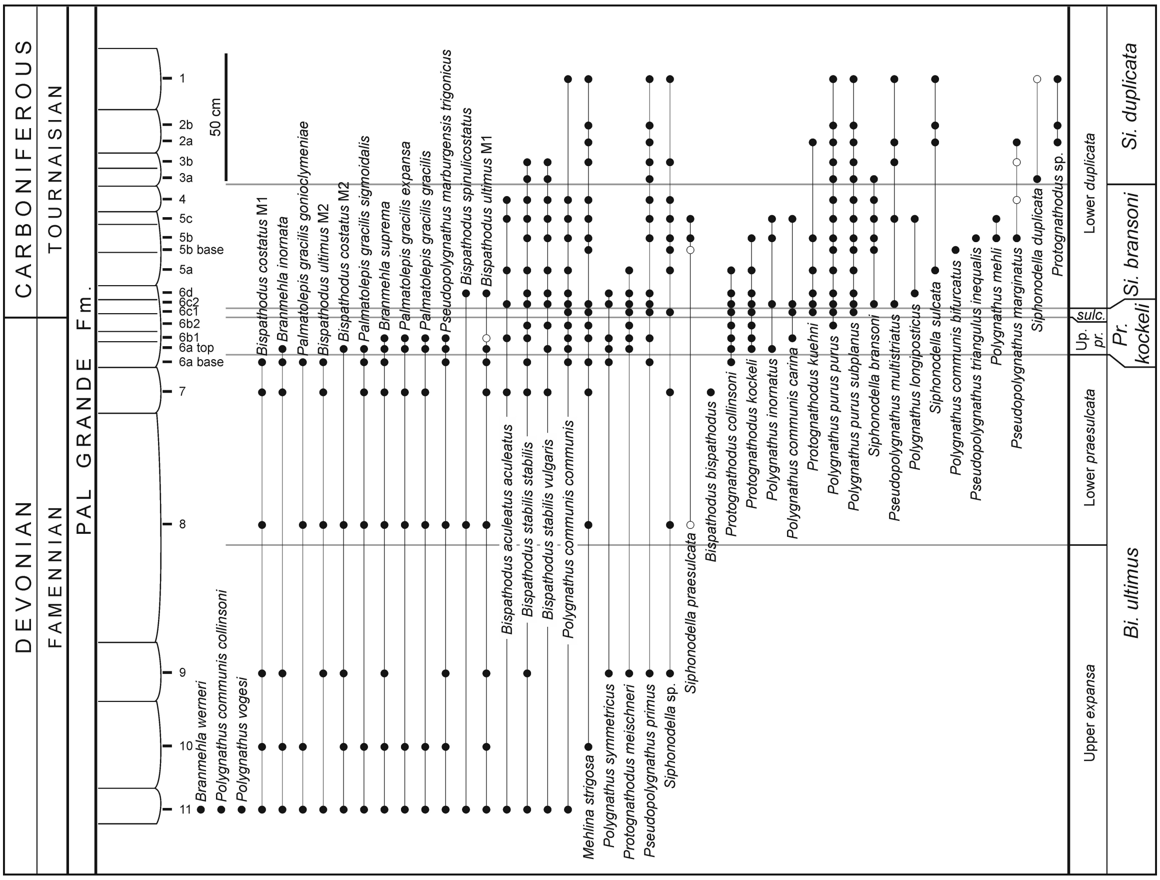

Figure 3. Stratigraphic column of the Grüne Schneid section and conodont distribution. Conodont biozones after global standard (left - Sandberg et al. 1978 and Ziegler & Sandberg, 1990) and present zonation (right – Corradini et al., 2016 and Spalletta et al., 2017).

Palaeonvironment

Pelagic environment.

Conodonts

Conodonts are very abundant and well preserved throughout the whole section. Forty-three taxa belonging to 8 genera (*Bispathodus*, *Branmehla*, *Mehlina*, *Palmatolepis*, *Polygnathus*, *Protognathodus*, *Psudopolygnathus* and *Siphonodella*) were discriminated (Fig. 3). *Palmatolepis*,

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Polygnathus and *Bispathodus* are dominant in the Devonian part of the section, *Protognathodus* is common in the boundary beds, whereas *Polygnathus* is largely dominant in the basal Carboniferous. Representatives of the genus *Siphonodella* are rarely occurring.

Biostratigraphy

The lower part of the section can be attributed to the *Bi. ultimus* (= Upper *expansa*) Zone. The base of the former Lower *praesulcata* Zone is tentatively placed below sample 8, where a questionable specimen of *Si. praesulcata* has been found; the datum is confirmed by the occurrence in sample 9 of *Pr. meischneri*, which FAD is just below the entry of *Si. praesulcata* (Corradini et al., 2011).
Protognathodus kockeli enters in bed 6a top, indicating the base of the *Pr. kockeli* (= Upper *praesulcata*) Zone. The base of the former *sulcata* Zone is indicated in sample 6c1 by the occurrence of *Pr. kuehni*, just below the entry of *Si. bransoni* in sample 6c2, that marks the base of the *Si. bransoni* Zone (= lower part of Lower *duplicata* Zone). The occurrence of *Si. duplicata* in sample 3a allows to attribute the upper part of the section to the *Si. duplicata* Zone (= upper part of the Lower *duplicata* Zone).

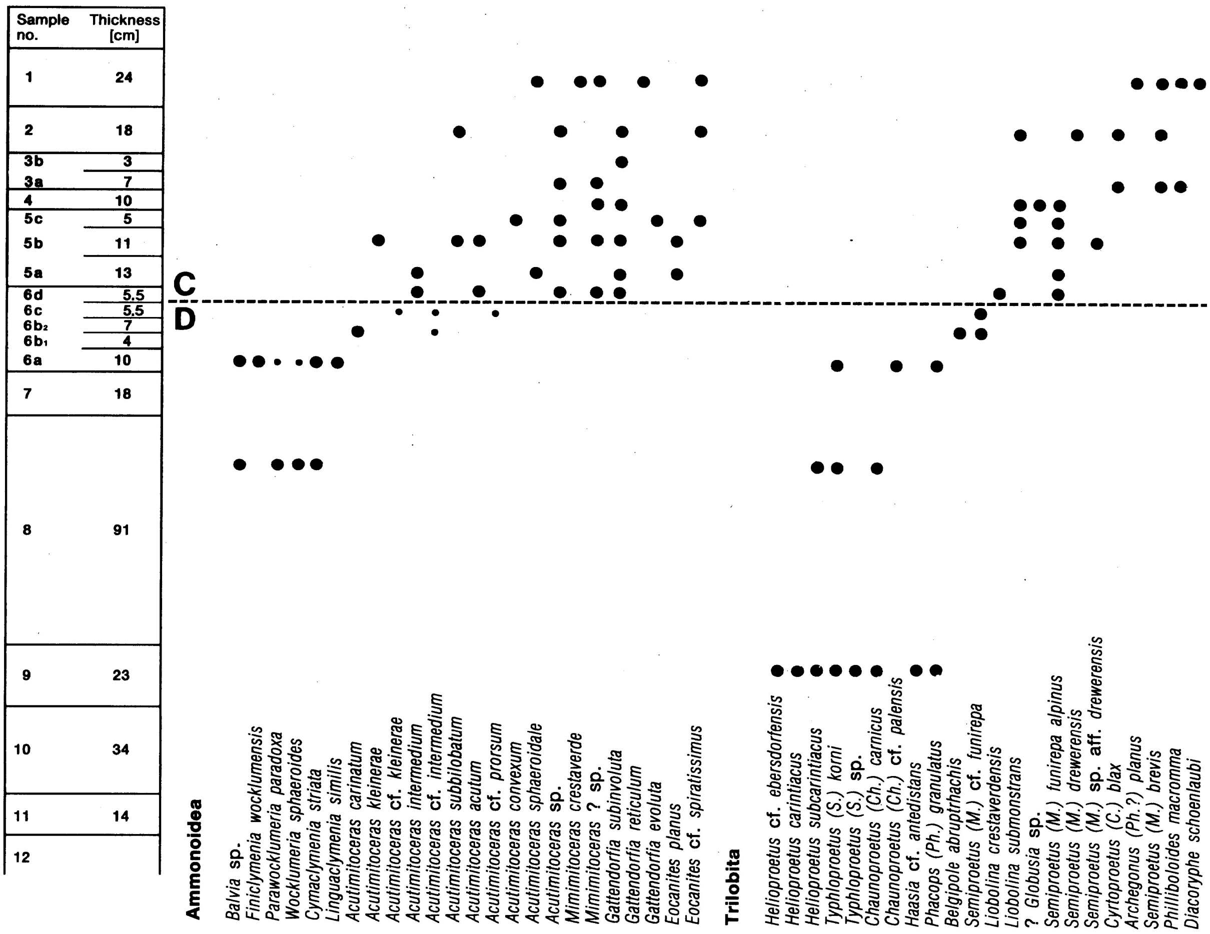

Figure 4. Occurrence of ammonoids and trilobites in the Grüne Schneid section (after Schönlaub et al., 1992).

Additional remarks

The position of the Devonian/Carboniferous Boundary

The D/C boundary was placed by Schönlaub et al. (1988, 1992) at the base of bed 6d, where ammonoids indicating the base of the "*Gattendorfia* stage" (*Gattendorfia subinvoluta* and *Acumitoceras acutum*) occur, and *Si. sulcata* was found. The conodont collection of Kaiser (2005, 2007), and the recent revision (C. Corradini) of the conodont collection of Schönlaub indicate that the true *Si. sulcata,* according to the present taxonomic attribution (Kaiser & Corradini, 2011), enters slightly higher (bed 5a), whereas many specimens with intermediate features between *Si. praesulcata* and *Si. sulcata* (indicated as *Siphonodella* sp. in Fig. 3) occur in lower beds, already starting in bed 9. It is also important to note that two specimens of *Si. bransoni* occur in sample 6c2 in the Schönlaub collection stored at the Austrian Geological Survey.

Kaiser (2005, 2007) proposed to place the D/C boundary at the base of bed 6c1, where *Pr. kuehni* first occurs: at other places it has been demonstrated that this species enters at the very base of the Carboniferous (Kaiser at al., 2009; Corradini et al., 2011).

The D/C boundary has now been under revision, and the new criterion for the boundary definition, voted by the ICS Working Group for the redefinition of the Devonian/Carboniferous Boundary (Montpellier, September 2016), not yet ratified, is the '*base of kockeli Zone, beginning of radiation & top of major regression (top of HSS) and end of mass extinction*'. Therefore, the D/C boundary will be placed in a lower position when the new criterion will be better precised and ratified.

In the Grüne Schneid section we register unusual data in this interval that needs further investigation. *Pr. kockeli* enters in both Schönlaub and Kaiser collections in bed 5a (sample 5a top of Kaiser) with taxa that elsewhere are extinct during the Hangenberg crisis. In general, *Pr. kockeli* is occurring only after the end of the extinction, in association with the survivors to the crisis (Lower *Protognathodus* fauna of Ziegler). The early occurrence at Grüne Schneid of *Pr. kockeli* could be explained by lack of documentation from sections where a black shale interval deposited in correspondence with the Hangenberg Event. Conodonts are very rare if not absent in black shales and *Pr. kockeli* is often documented in the first limestone bed above the shales. However, in the Grüne Schneid section the limestone sedimentation persisted across the D/C boundary, and the sequence is continuous, even if condensed.

The Hangenberg Event was evidenced by an increasing of argillaceous material in the lower part of bed 6b (sample 6b1) (Schönlaub et al., 1992), by a facies change from bioclastic wackestones to mudstones in 6b1, and a conodont biofacies change in 6b1. The carbon isotopes ($\delta^{13}C_{carb}$) start to increase in the upper part of bed 6a and have a clear shift within bed 6b1 indicating enhanced C_{org} burial at this level (Kaiser 2007).

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