Stop 2

The Silurian and Early Devonian of the Rauchkofel Boden Section, Southern Carnic Alps, Austria.

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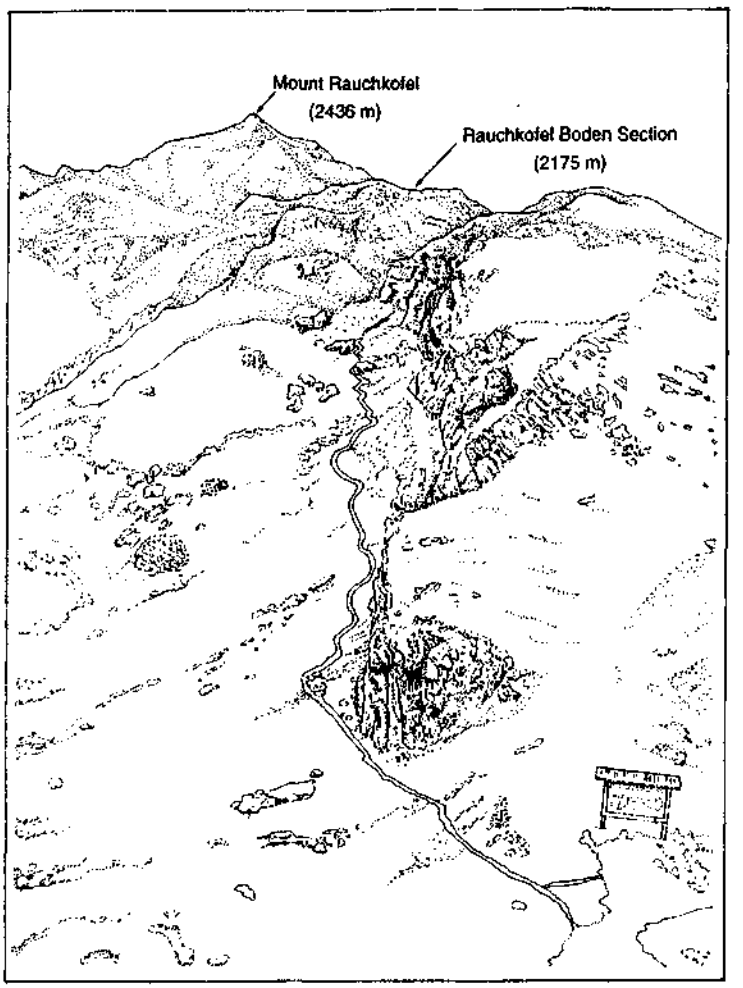

Fig. 6 - General view of Mount Rauchkofel and of the Rauchkofel Boden Section.

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The Rauchkofel Boden section, located on the southwestern slope of Mount Rauchkofel (Fig. 6), exposes a 28 m calcareous succession of the "Wolayer facies" (see SCHÖNLAUB & HISTON this volume for environmental setting) documenting the Late Ordovician (Ashgillian)-Early Devonian (Pragian), but with a significant Early Silurian gap (Fig. 7). Various studies of this section has been carried out during this century, both with general papers (e.g. GAERTNER, 1931; SCHÖNLAUB, 1970, 1980) and monographic works dealing, for example, with orthoconic nautiloids (RISTEDT, 1968), trilobites (HAAS, unpublished), bivalves (KRIZ, 1979, 1999) and conodonts (eg. SCHÖNLAUB, 1980).

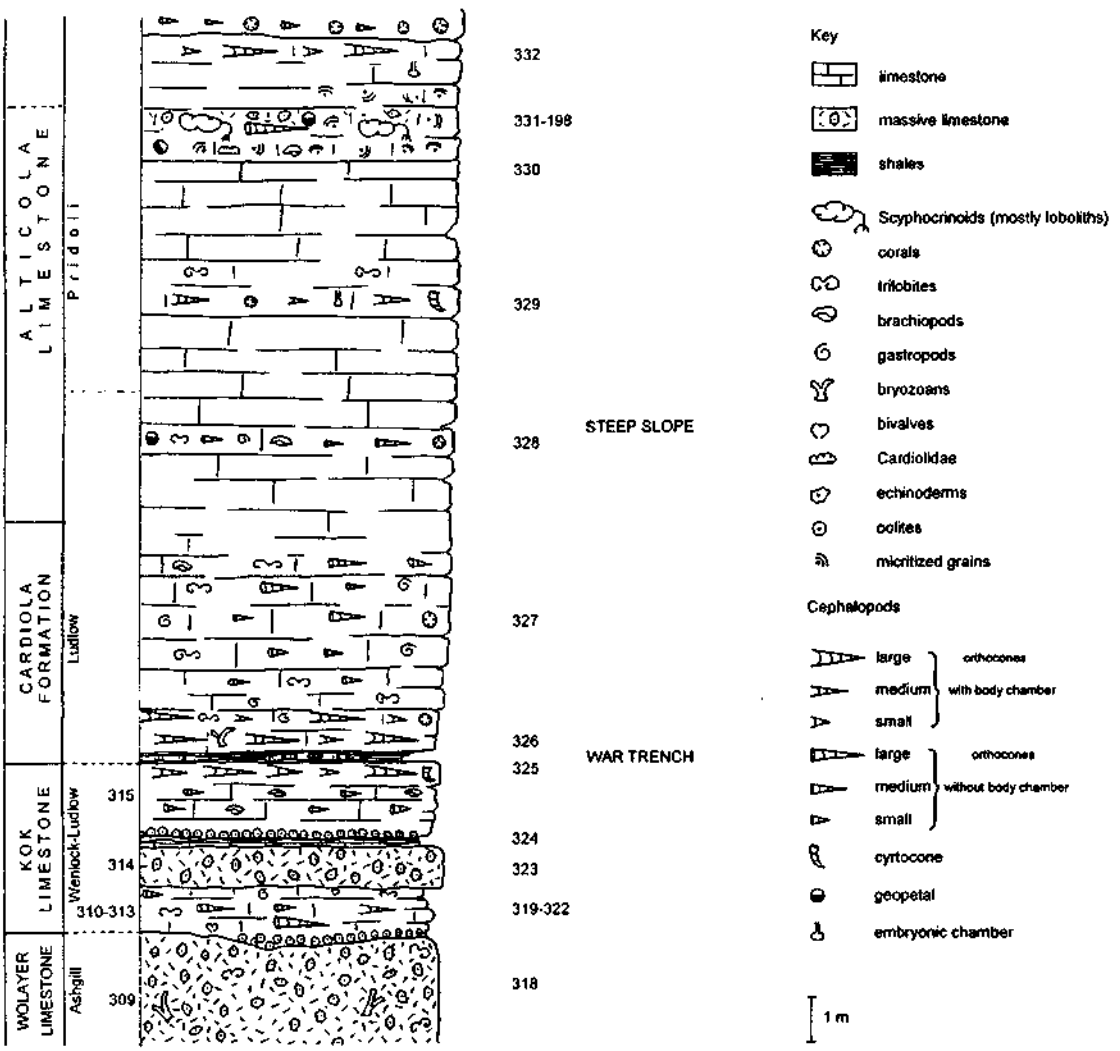

Fig. 7- Stratigraphic column of the Rauchkofel Boden Section.

The Late Ordovician is represented by a 8.6 m thick white massive limestone, the **Wolayer Limestone** (n. 304-309 and n. 316-318), dated by conodonts of the *A. ordovicicus* Zone to the Ashgill, the final series of the Ordovician. Thin section observation reveals a packstone almost entirely represented by echinoderm debris, associated with rare bryozoans and trilobites. DULLO (1992) suggested for this formation a shallow water deposition in a low energy environment in a moderate climatic setting.

The Silurian starts with a 3,9 m thick grey/reddish micritic limestone, the **Kok Formation** (n. 310-315 and n. 319-325). The contact with the Ordovician is strongly irregular and undulated in outcrop, with local basal "pockets" infilled by a thin horizon of ooidal ironstone. This oolitic grainstone, dated to the *P. amorphognathoides* Zone, reveals the establishment of high/energy conditions. Echinoderm elements seem to be the most common coated nuclei.

The following beds (Wenlock in age) are represented by strongly recrystallized cephalopod wackestone to packstones, with cephalopod conchs embedded in a sorted micritic matrix rich in fragmentary trilobites, echinoderms, disarticulated bivalve shells, ostracodes, brachiopods and gastropods. In the Late Wenlock and Ludlow conodonts are fairly abundant. A rich fauna representing the *O. sagitta* Zone occurs from the Ordovician / Silurian boundary up to sample no. 313, i.e. 1.20 m above the base (Fig. 7). Although richly resampled not a single specimen of *Ozarkodina bohemica* has yet been found in that interval. In sample no. 314 *Kockelella variabilis* first occurs suggesting the base of the Ludlow Series by comparison with Bohemia (SCHÖNLAUB in KRIZ et al. 1993).

A 1 m thick massive encrinitic limestone is present towards the middle part of the formation (n. 323/314). The first abundant nautiloid fauna (base 324/mid 314) occurs just above this horizon and is followed by thin layers of bioclastic accumulations and oolitic grainstones separated by thinly laminated iron/rich layers or crusts. A rich nautiloid fauna is preserved, the nautiloids sometimes being apparently trapped within the crusts revealing strong dissolution of the conch wall (Fig. 8). Juvenile nautiloids, associated with equidimensional articulated brachiopods and gastropods, are visible as pinkish horizons towards the top of the formation (top 324-315) and are better visible in the middle part of the outcrop. Species of *Sphaerorthoceras*, *Merocycloceras* and *Parasphaerorthoceras* were described by RISTEDT (1968) from these levels.

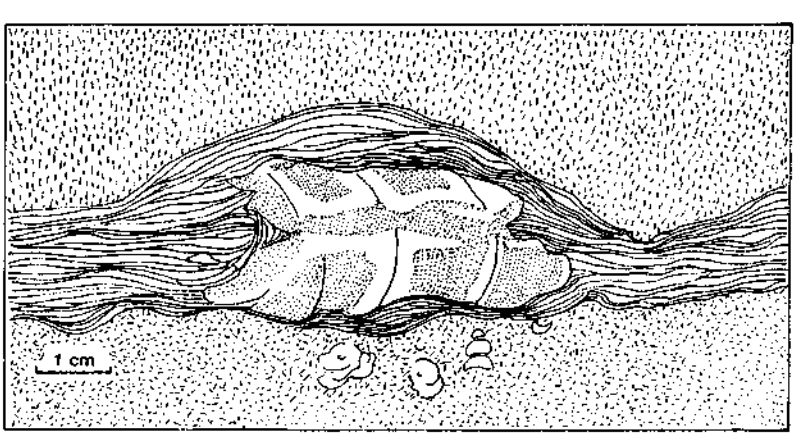

Fig. 8 - Intensive dissolution of a cephalopod shell "trapped" within iron-rich crusts (Kok Formation).

Spectacular cephalopod limestone beds ("*Orthoceras*" limestones) are exposed at the internal border of the war trench (beds n. 325 and 315) just at the top of the Kok Formation. The lighter grey colour and the variety of the cephalopod fauna easily help in identification. The limestone is represented by a cephalopod-trilobite-brachiopod wackestone to packstone with gastropods, echinoderms, trilobites, bivalves and ostracodes. No sorting or gradation was observed.

An important feature in both the Kok Formation and the Alticola Limestone is that many organisms show regular iron-rich laminated coatings, involving the most prominent part of the shell (e.g. the trilobite represented in Fig. 9) or the entire individual (e.g. as a continuous structure all around the shell of cephalopods). Indeed these coatings are most commonly noted on trilobites and cephalopods, but they have also been observed on brachiopods. The high iron content of the limestone sequence is in general remarkable both in the form of (a) frequent iron staining of the shells (more frequent in the Kok Formation) with microborings for example in cephalopod and bivalve shells being infilled or echinoderm pores being impregnated by the iron-oxides or (b) of regular laminated iron-rich coatings (abundant at the top of the Kok Formation).

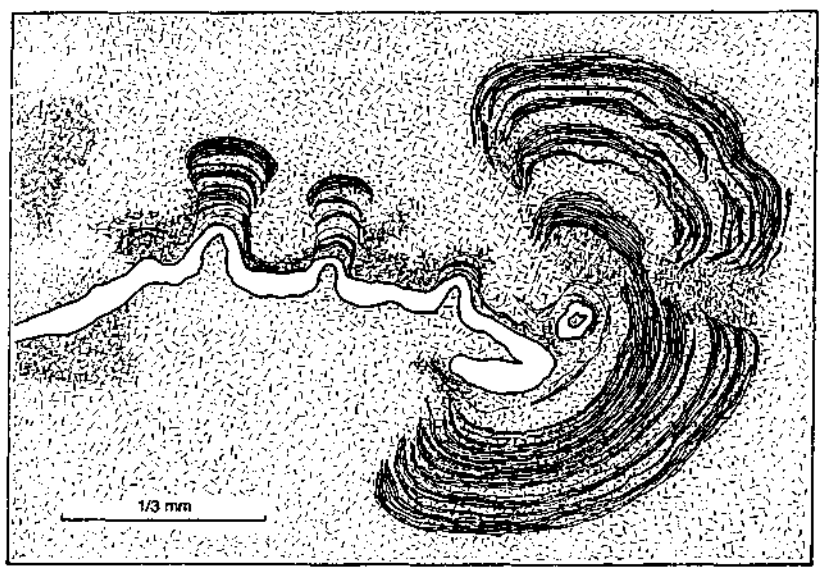

Fig. 9 - Iron-banded coating of a trilobite shell. Note how these covers proceed from the most elevate parts of the shell (Kok Formation; redrawn from a thin-section).

Apart from the species described by RISTEDT (1968), citations by GARTNER (1931) and a faunal list by BOGOLEPOVA (1998) a detailed systematic study of the nautiloid fauna has not yet been published for this section. A revision of the material described by HERITSCH (1929) from the Carnic Alps has been carried out (HISTON 1999a, In press) but only one specimen from this section was included in that monograph. The base of the formation is

relatively barren in nautiloid fauna with respect to the upper beds. A specimen of *Phragmoceras* has been found in Bed 319 and specimens of *Plagiostomoceras*, *Michelinoceras* and *Arionoceras* are common in the Wenlock. The variety of fauna increases noticeably in the Ludlow with again a dominance of *Michelinoceras*, *Plagiostomoceras*, *Arionoceras*, *Geisonoceras* and horizons of juvenile specimens of *Sphaerorthoceras*, *Merocycloceras* and *Parasphaerorthoceras* complete with embryonic chambers as well as elements of Oncocerida represented by *Oonoceras* sp. in beds 315, 325.

An account of the taphonomy of the nautiloid fauna from this section was given by HISTON (1999b). The orientation of the conchs to bedding and the presence of telescoping may be used as an indication of the energy of the environment in which they were deposited; telescoping being taken as an indication of high energy. Thus a high energy environment may be indicated for beds 319, 324 and some levels of 315. The preservation of the shells where they are relatively intact with body chambers and apexes present may indicate little or no transport of the fauna as may be the case for beds 320, 322, some levels of 315 and 325. Vertical embedded cephalopods are present in beds 311, 312, 324 and 325. The associated fauna of articulated brachiopods, gastropods and solitary corals in these levels may also indicate a low energy setting. The orientation of the nautiloids on the bedding surface varies within individual beds but definite trends may be noted in some cases.
Preliminary measurements and conclusions on the orientation of cephalopod orthocones were proposed by BOGOLEPOVA (SCHÖNLAUB & BOGOLEPOVA, 1994). Three beds in this section were investigated, two respectively at the base and at the top of the Kok Formation, the third in the Alticola Limestone. Two different trends (from SW to NE and from W to E) were recognized at the older level, while a SW to NE orientation (but having diverse angular values) was evidenced at the two upper horizons.
Data for the structural limits of the nautiloids based on a ratio of conch diameter to septal spacing indicates a mixed fauna in the lower beds of the formation becoming dominated by stronger fauna higher in the formation (HISTON 1999b).

In general we can note the changing energy and oxygen levels of the formation from the data given and from the preservation and orientation of the nautiloid fauna that there are many accumulated levels with intermittent changes in sea level particularly towards the top of the sequence.

The **Cardiola Formation** (Ludlow), is badly exposed in the war trench as loose blocks or lenses of dark micritic limestone (about 10 cm thick) which strongly resemble the well known cephalopod limestone of Bohemia and of the northern Gondwana margin. The Cardiola Fm. corresponds to the *P. siluricus* Zone of the stratotype at the Cellon section.

Isoriented cephalopods dominate, being embedded in a matrix of sorted aligned bioclasts, frequently coated by micritic envelopes (Fig. 10). Numerous bivalves of the *Cardiola* Community are reported from here and also from a thin layer immediately above bed 325. According to KRIZ (1979), representatives of *Cardiola* and other genera developed a peculiar living stratagem to adapt to a cephalopod-rich environment. The ventral part of the elongated anterior margin together with the large umbones represented three major points of stability (distributed at the vertices of a triangle) which enabled a stable byssal attachment to cephalopod shells in any position.

The specimens in general are well preserved with body chambers and apexes being present. Geopetal structures have been noted in the body chambers of some specimens oriented

parallel to bedding and an opposed orientation of conchs on the bedding plane is also indicated. Structural data indicates a mixed fauna (HISTON 1999b) and species are similar to those of the upper Kok Formation however, lacking the juvenile elements.

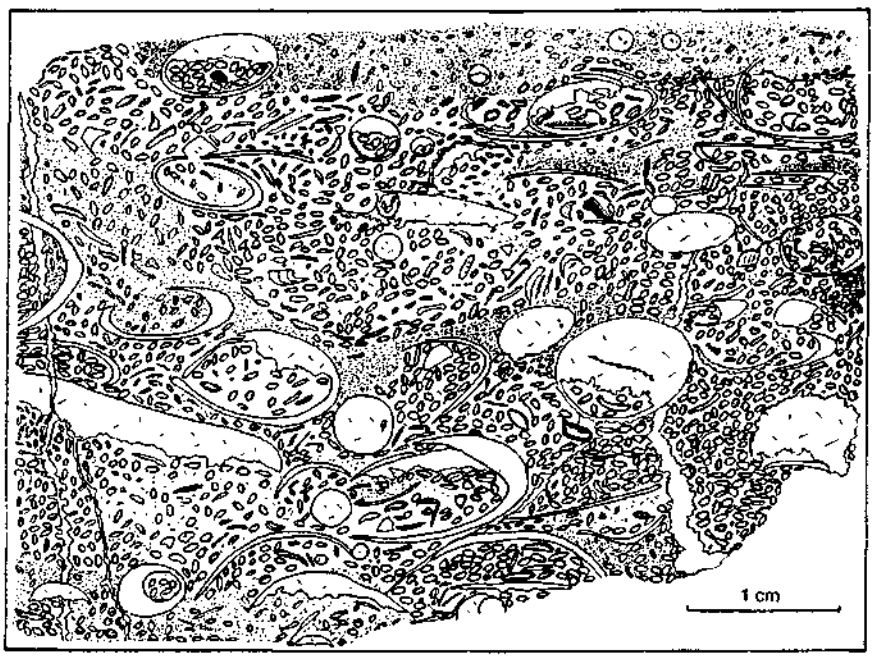

Fig. 10 - Cardiola Formation; cephalopods embedded in a matrix mostly represented by micritized grains (redrawn from a thin-section).

The **Alticola Limestone** (n. 326-331) documents the final part of the Silurian (Upper Ludlow - Pridoli) and the passage to the Devonian. Lower beds are represented by a cephalopod wackestone to packstone. Magnificent nautiloids, preserving body chambers, are exposed on the external border of the war trench. Solitary corals were recognized in many beds. Trilobites and cephalopods are still showing iron-banded coatings; furthermore, fragments of these coverings are present even in the matrix. Towards the top, the formation grades to darker thin-bedded beds, as a response to a major micrite content and to the presence of micritized grains. Echinoderm debris is quite abundant. A *Scyphocrinites* bed bearing complete specimens caps the formation.
Conodonts from the uppermost part of the black nodular limestones (sample nos. 330. 331) belong to the apparatus of *Oz. r. eosteinhornensis.* In addition, *Oz. ortuformis and Oz. jaegeri* occur at this interval.

The preservation of the nautiloid fauna is similar to that of the Kok Formation but no *'Orthoceras'* bed may be determined within this sequence. The base and top of the formation are marked by the occurrence of large orthocones (*Columenoceras*) oriented both parallel and perpendicular to bedding but which also show definite trends on the bedding surface itself. Current direction has been given as SW-NE for both these points in the formation

(SCHÖNLAUB & BOGOLEPOVA, 1994). The nautiloid fauna is quite well preserved throughout the formation even where a higher energy environmental setting is indicated by telescoping, with body chambers being intact and sometimes showing geopetal structures parallel to bedding which is a good indication of little transport of the fauna. The data for the structural limits of the fauna, even though quite general, show a mixed fauna throughout the formation dominated by weaker fauna in bed 327 and comprised almost entirely of weak fauna in bed 331 at the top of the sequence. This latter indicates the shallowest fauna in the formation with elements of Oncocerida and *Anaspyroceras* being dominant.

The Silurian/Devonian boundary is drawn at the base of grey and blackish platy crinoidal limestones containing *Scyphocrinites* (sample no. 331=198). Bed no. 198 as well as the overlying sample no. 199 yielded common occurrences of *Oz. r. eosteinhornensis* and, more frequently, *Oz. r. remscheidensis.*

The basal part of the overlying Lochkov sequence seems to be extremely condensed (Fig. 11). This interval is represented by well bedded, thin and blackish limestone beds with shaly intercalations (sample nos. 201 b-201 j). The index conodont for the base of the Devonian, *Icriodus woschmidti,* was collected in sample nos. 201 and 201 a. However, as yet only juvenile specimens have been found. Neither at this horizon nor in any other parts of the section have graptolites yet been recorded.

With regard to the Lower Devonian part of this section we refer to Fig. 11 showing its lithology and faunal content. The 40 m thick undisturbed section is subdivided into the following formations:

1.80 m pelagic **Rauchkofel Lmstn.** comprising black limestones interbedded with marls (Lower Lochkovian)

c. 17 m **Boden Lmstn.** comprising greyish coarsely bedded nautiloid bearing limestones rich in conodonts but rare in dacryoconarids and orthoconic and coilded nautiloids (Upper Lochkovian)

20 m nodular pink **Findenig Lmstn.** rich in dacryoconarids

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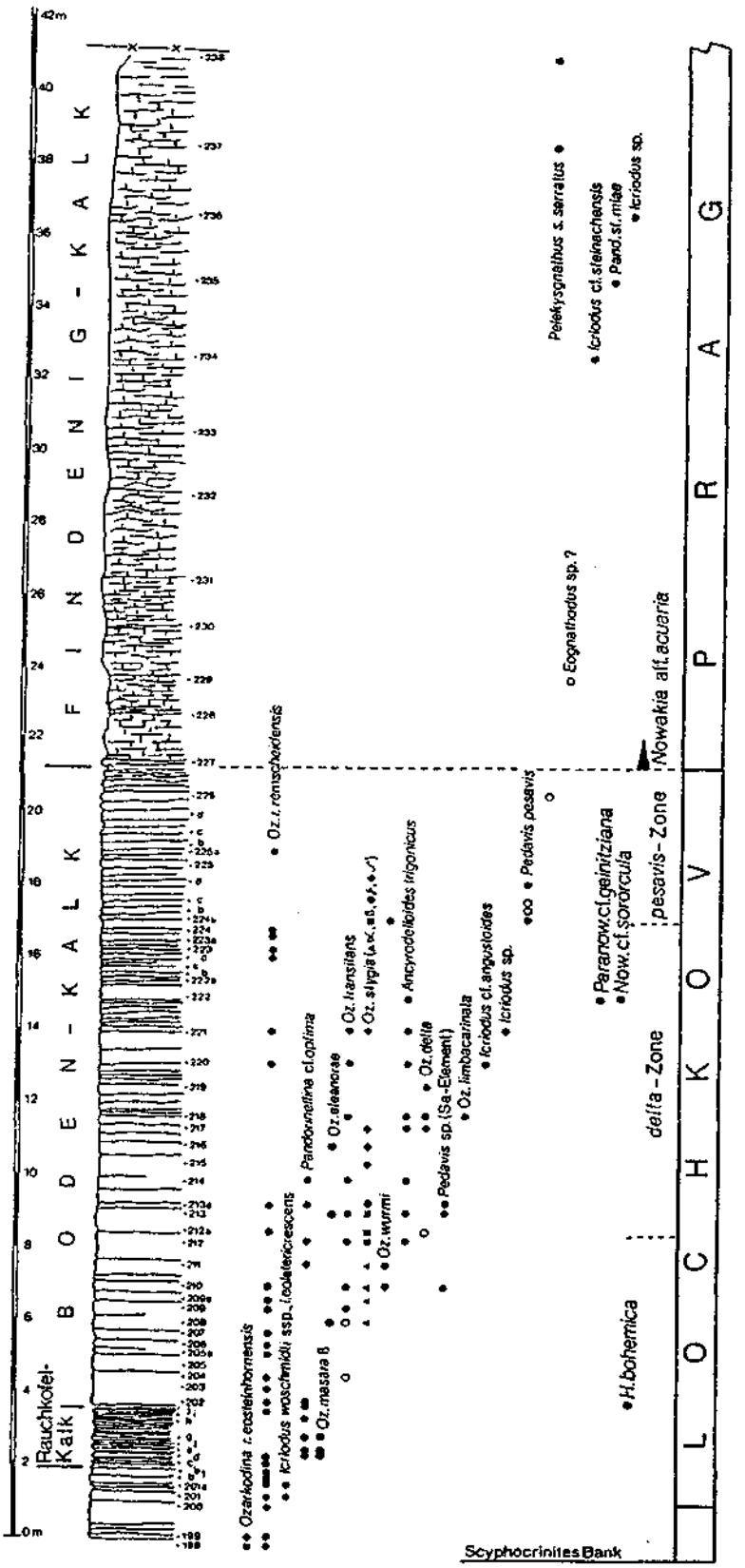

Fig.11 - Rauchkofel Boden section, Lower Devonian part with 1.80 m thick pelagic Rauchkofel Lmstn., Boden Lmstn. and Findenig Lmstn. (after SCHÖNLAUB et al. 1980, modified).