Stop 7 – Wolayer "Glacier" Section

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The continuous Devonian sedimentary record of the Rauchkofel Nappe in the Carnic Alps consists of an up to 230 m thick succession of mostly pelagic and periplatform limestone deposits. Distal turbiditic limestone intercalations only occur at a few levels. They are derived from a peritidal carbonate platform and related slope-apron settings of the Kellerwand and Cellon Nappes, respectively (SCHÖNLAUB, 1971, 1985, 1992; BANDEL, 1969, 1972; KREUTZER, 1990, 1992).

The locality Wolayer Glacier is located halfway between Valentintörl and Lake Wolayer where the south-dipping Devonian strata are exposed forming a 20 m high cliff. The whole section reflects a strongly condensed sequence of pink nodular and greyish to reddish Flaser limestones commonly named cephalopod limestones. They have been deposited in a pelagic off-shore environment testified by radiolarians, foraminifera, dacryoconarids, styliolinids, ostracods, conodonts, trilobites and few goniatites.

The continuous section ranges from the Emsian to the Famennian. Of particular interest is the Frasnian/Famennian boundary, the sedimentology, conodont biostratigraphy and isotope geochemistry which has been studied by GÖDDERTZ & SCHÖNLAUB (1980, 1985), JOACHIMSKI et al. (1994) and HÜNEKE (2001, 2004 in press).

Biostratigraphy

According to the above cited authors continuous carbonate sedimentation started in the Lower Devonian and ranges to the *australis* Zone at the end of the Eifelian Stage. The succeeding equivalents of the Givetian are separated from the Eifelian by a gap in sedimentation which supposedly spans the interval from the *kockelianus* to *ansatus* conodont Biozones. The thin limestone beds of the Givetian represent the *latifossatus/semialternans* and *hermanni-cristatus* Zones.

In contrast to the approx. 6 m thick condensed deposits of the Eifelian, the equivalents of the Givetian are extremely reduced and comprise only 11 cm of limestone deposits. The latter are terminated by a distinct gap in sedimentation lasting from the *disparilis* to the *punctata* Zones. The overlying 10 cm thick limestone bed contains abundant phosphorite nodules, fish remains and mixed conodont faunas ranging from the *transitans* to the *hassi* Zones. Apparently, the youngest elements of this stratigraphic admixture, i.e. *Palamtolepis hassi* and *Ancyroides coeni*, represent the proper age of the formation. In fact, sedimentary structures and microfacies indicate a short accumulating event within the Early *hassi* Zone.

The conodont fauna of the following limestone bed contains *Ancyrognathus triangularis* which suggests the Late *hassi* Zone. This bed is overlain by condensed limestones of the *jamieae* to *crepida* Zones. Overall, the sediments of the late Frasnian do not exceed 1.8 m.

Description of facies

At the passage from the Emsian to the Eifelian the uniformly developed reddish and pink Findenig Lst. grades into the greyish Valentin Lst. The latter represent bioclastic wackestones and rarely packstones characterized by a typical pelagic fauna consisting of small trilobites, styliolinids, ostracods, cephalopods, bivalves, remains of crinoids and rugose corals. In particular in the limestones of the *australis* Zone iron-coated bioclasts and micritic oncoids occur abundantly. The sediment is strongly bioturbated and more or less homogenous. Indication of bedding is mostly obliterated or can be inferred by faint layers of fossil debris. Also, the amount of silty limestones in the matrix varies between individual beds.

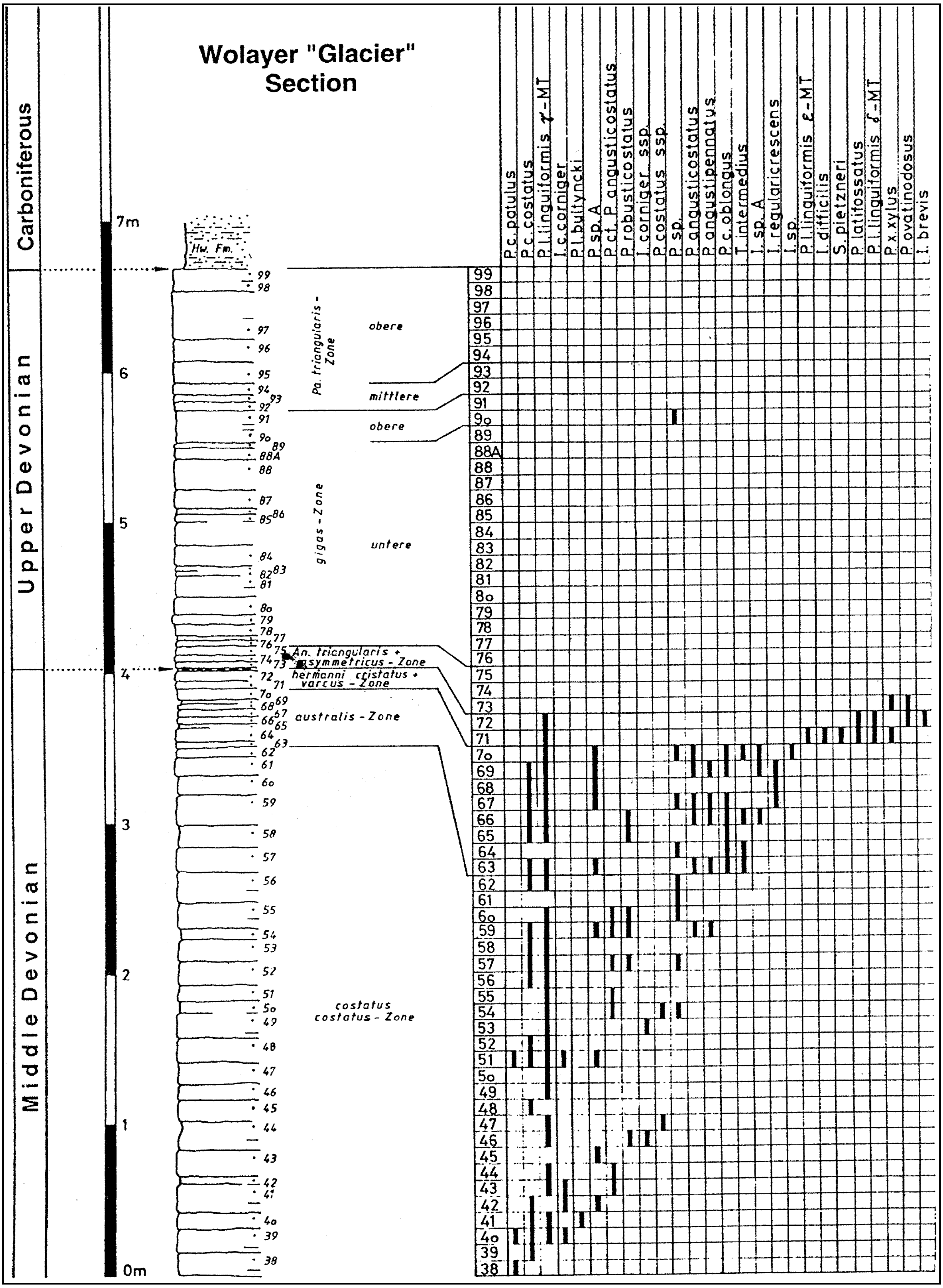
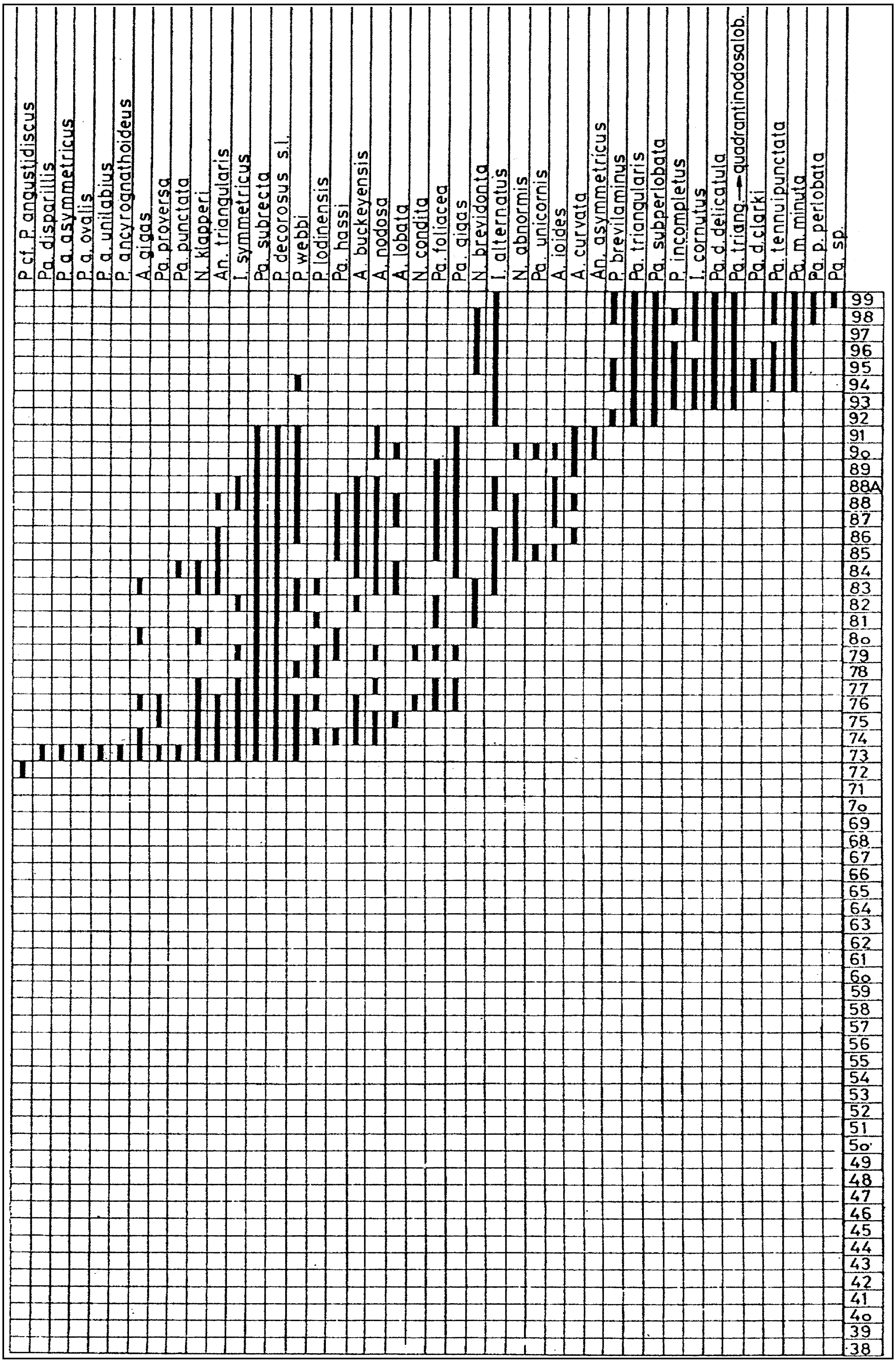


Fig. 34: Conodont ranges across Lower/Middle and Middle/Upper Devonian boundaries …



… at the Wolayer Glacier section.

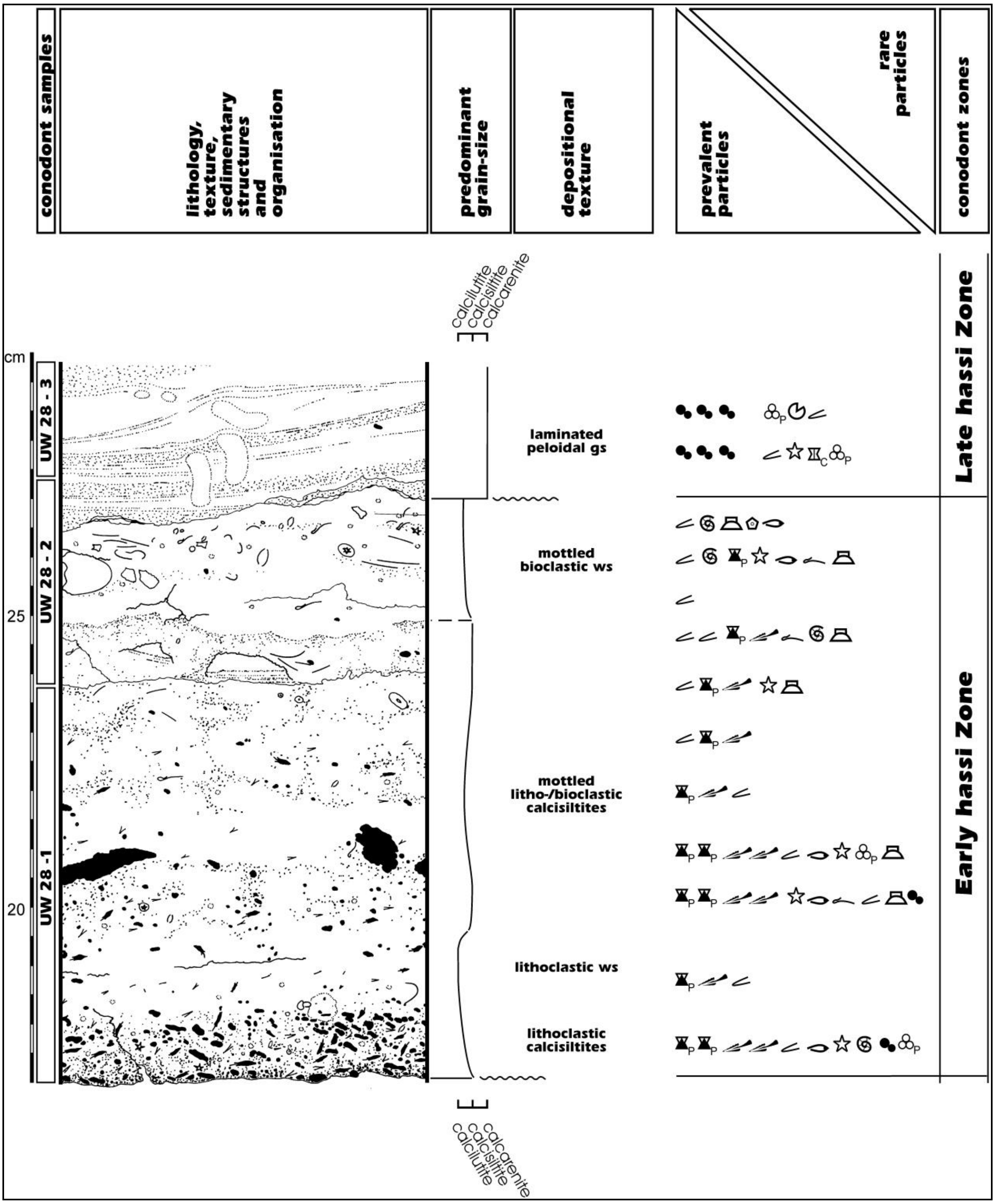
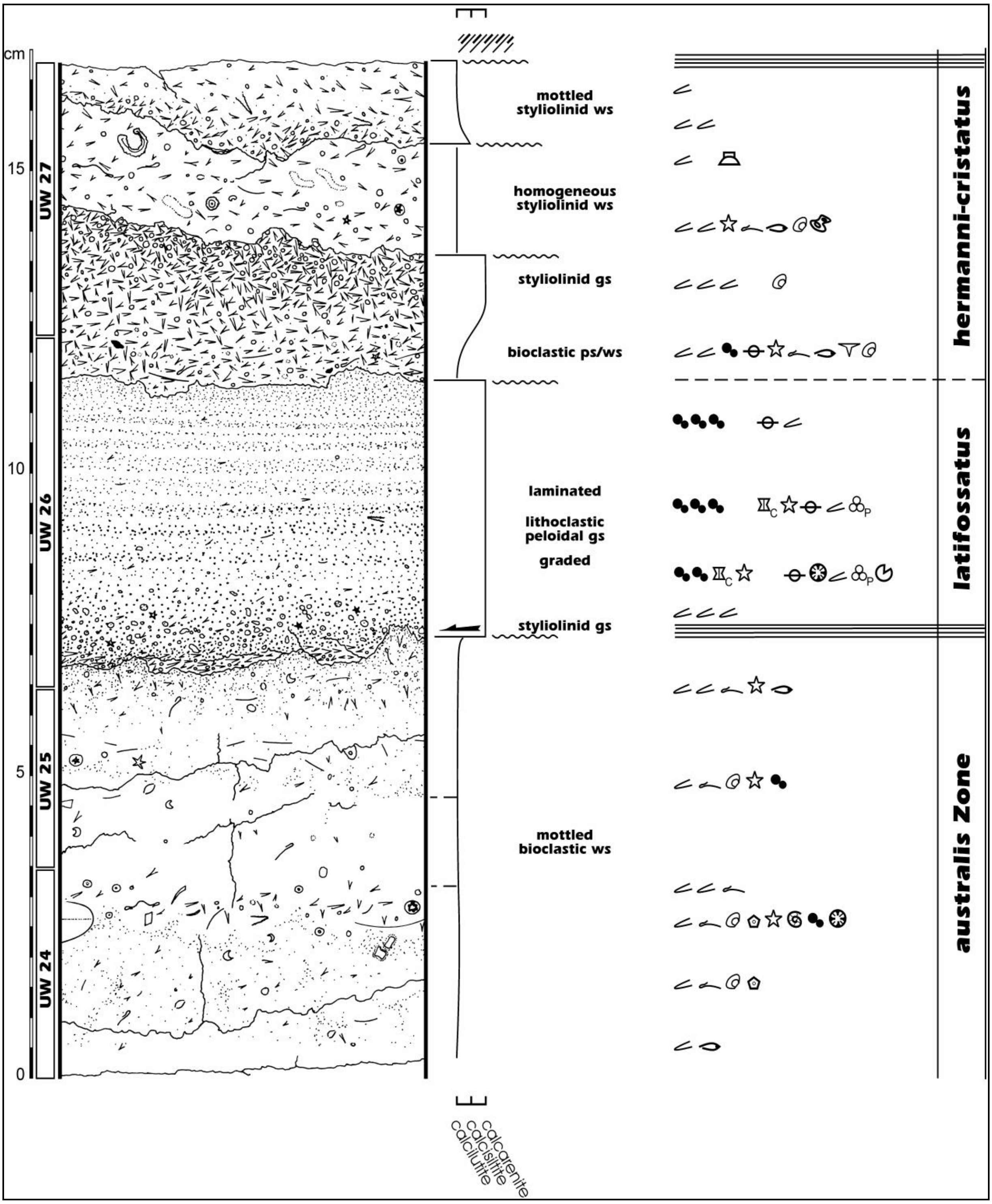


Fig. 35: Lithology, sedimentary texture and organic content of the late Givetian to early …



… Frasnian portion of the Wolayer Glacier section (from HÜNEKE, 2001).

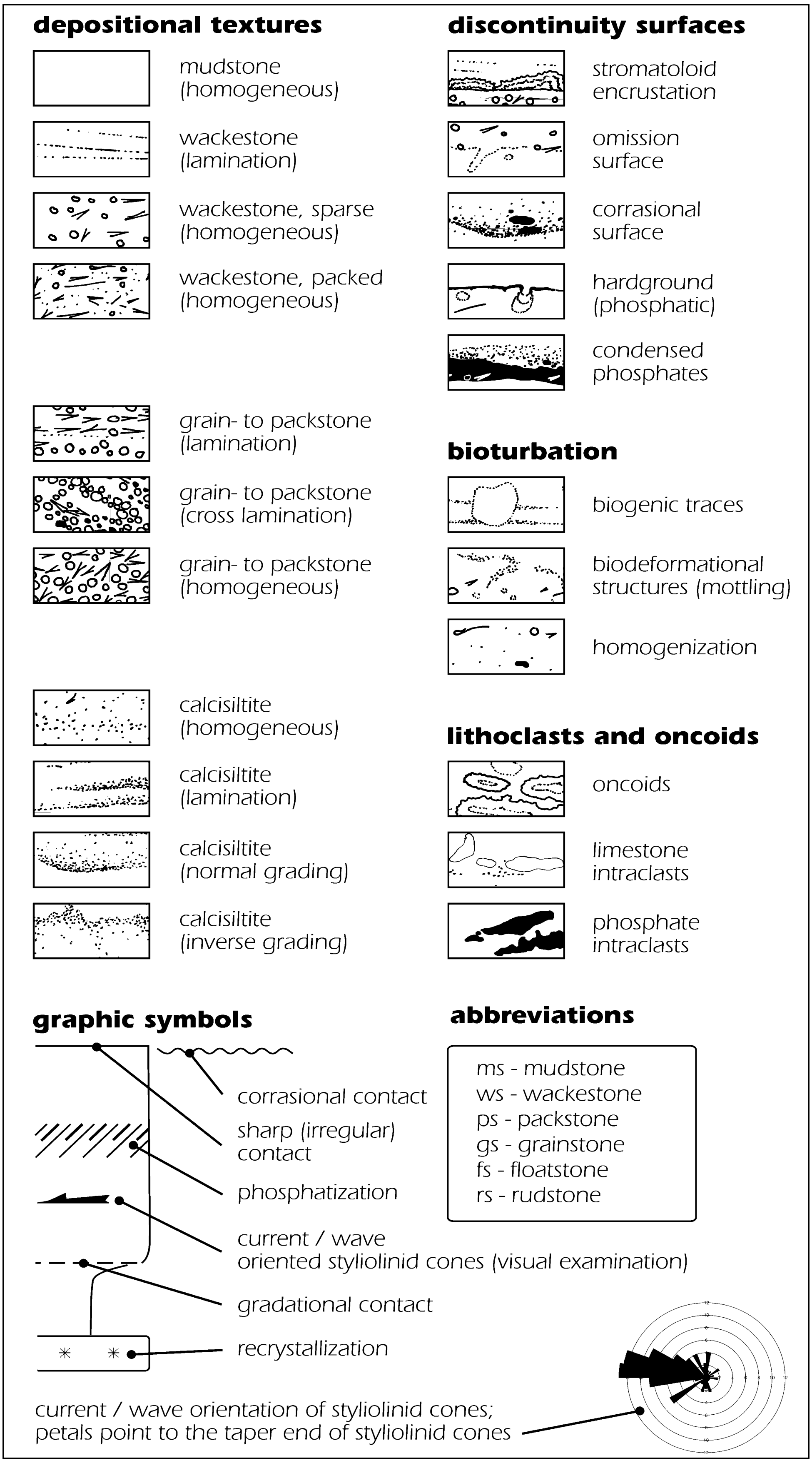


Fig. 36: Depositional textures, discontinuity surfaces, indication of bioturbation and symbols used in the graphics (from HÜNEKE, 2001, 2004 in press).

The small portion of limestones equivalent to the Givetian is well bedded. Immediately above the lower discontinuity surface which suggests erosion during the late Eifelian and early Givetian, thin laminae of styliolinid grainstones and packstones are preserved. This horizon is succeeded by graded layers consisting of peloidal grainstones with crinoids, cortoids, lithoclasts, styliolinids and solitary corals. Above this graded part bioclastic wackestones occur which grade into styliolinid grainstones. They are succeeded by two more beds comprising pelagic styliolinid wackestones with rarely occurring foraminifera, peloids and cortoids.

A difficulty of the studied successions in the Carnic Alps is the bedding-parallel orientation of stylolitic seams which usually follow discontinuity surfaces. However, distinct erosional contacts and hardgrounds are preserved in only few cases. Nevertheless, breaks in sedimentation can be recognized by the occurrences of index conodonts. In addition to this section, the succession of the Rauchkofel Nappe west of the Wolayer Lake exhibits interruptions in accumulation during the *kockelianus* to *ansatus* Zones and during the *disparilis* to *punctata* Zones. Thus, on a distance of some hundred metres, biostratigraphic gaps comprise slightly different ranges (GÖDDERTZ, 1982).

The equivalents of the Frasnian Series (Early *hassi* Zone) start at a phosphorite bearing horizon rich in conodonts and fish remains. Supposedly, its base is characterized by a gap in sedimentation spanning the *disparilis* and *punctata* conodont Zones. At the base of this distinct bed phosphorite lithoclasts are densely packed in the matrix consisting of calcisiltite while in the upper part up to 5 cm big clasts occur. Also the amount of calcisiltite varies showing locally internal erosional surfaces or shallow scours followed by well-graded laminated calcisiltites. Fragmented bioclasts are quite abundant representing styliolinids, thin shells of brachiopods, trilobites, cephalopods, ostracods and less abundantly crinoids, calcispheres, forams as well as peloids and cortoids. In addition the whole bed is strongly bioturbated.

The phosphorite horizon is overlain by mostly wavy laminated peloidal packstones and grainstones assigned to the Late *hassi* Zone. In this part of the section gradation and bioturbation rarely occur; bioclasts, however, resemble the underlying beds.

The uppermost portion is characterized by irregularly stratified mottled calcisiltites and bioclastic wackestones. Erosional contacts are rarely preserved. Immediately above such surfaces conodonts are enriched as well as abraded bioclastic shell remains. Interestingly peloids and mica may be found. With the transition to bioclastic wackestones the amount of the well preserved biogens increases consisting mainly of styliolinids, small trilobites, cephalopods, bivalves, ostracods, forams, calcisphaerids and some crinoids. Also, micritic oncoids and peloids occur as well as bioturbation obliterating primary from altered textures.

Interpretation

According to HÜNEKE (2001, 2004 in press) the Eifelian flaser limestones are the product of intensively bioturbated pelagic carbonate muds. Indistinct bedding, however, is still preserved. Occasionally, ferruginous coatings around biogens suggest longer periods of exposition at the sea floor. Abrasion and bottom-current-induced reworking started in the late Eifelian and continued at least until the middle Frasnian. For the Givetian corresponding deposits are only preserved in relics and thus it is difficult to decide whether or not bottom currents prevailed during this time. However, during the early Frasnian the velocity and erosive capacity of currents obviously decreased giving way to ongoing accumulation of a thin but continuous record of bottom-current deposits. Although these sediments include at some stratigraphic levels a high proportion of elements that point to a shallow water source area (peloids, cortoids, crinoids and fragments of rugose corals) they are all interpreted as deposits of bottom currents.

In conclusion, the redeposited calcareous material partly derived from bottom-current redeposited turbidites or periplatform carbonates which were delivered from a shallow water carbonate platform. According to KREUTZER (1990, 1992) such cortoid grainstones and ostracod and parathuramminid packstones occur in the upper part of the nearby Kellerwand and Cellon Nappes. Styliolinid grainstone laminae included at the base of peloidal grainstone layers, erosive down-cutting of bioclastic wackestones to packstones and following inversely graded transitions into styliolinid grainstones argue for deposition from a bottom current in most successions of the Rauchkofel Nappe. The late Frasnian and Famennian record of generally mud-supported limestones is interpreted as intensively bioturbated pelagic deposit without any clear indication of current-induced redeposition. They contain a typical pelagic fauna in which elements from shallow water sources are missing.

The net **accumulation rate** within the Rauchkofel Nappe of the Carnic Alps is deduced from detailed conodont stratigraphic data of SCHÖNLAUB (1980, 1985) and GÖDDERTZ (1982) at this section and additional studies by HÜNEKE (2001). The curve shows a steep incline for the Emsian part of the succession (5-10 m / 10^6 years). Condensation started during the early Eifelian and the net sediment accumulation rapidly decreased below 0.5 m / 10^6 years (*australis* Zone). During late Eifelian to early Frasnian (*kockelianus* to *punctata* Zones), condensation and sediment reworking prevented continuous accumulation. From the late Givetian (*latifossatus* and *hermanni-cristatus* Zones) only thin limestone layers of the bottom-current redeposited facies are preserved immediately below and above the hiatuses. A continuous record without biostratigraphically recognizable gaps persisted until the late Frasnian (Early *hassi* Zone) onwards starting with allochthonous phosphatic sediments and accumulation rates below 0.5 m / 10^6 years. The remaining part of the condensed Frasnian to Famennian succession is characterized by values between 2 and 0.1 m / 10^6 years.

With regard to the isotope signal the Wolayer Glacier profile represents a key section. Although anoxic sediments are missing at the F/F boundary the positive $\delta^{13}C$ excursion can clearly be recognized. Consequently, it may be concluded that these isotope excursions are valid on a global scale independent of anaerobic conditions. The positive excursions are explained by changes in the isotopic composition of the marine total dissolved carbon (TDC). The extension of the oxygen minimum zone during a short-term sea-level rise is thought to be responsible for the enhanced deposition of ^{12}C-enriched organic matter of the Kellwasser Horizons. This is recorded by the positive carbon isotope shift. The subsequent negative excursion is explained by erosion and oxidation of previously deposited organic carbon during sea-level fall. In addition, the withdrawal of large amounts of carbon from surface waters will also affect the atmospheric pCO_2 and thus result in climatic alterations with severe implications for the biosphere. According to these explanations, the main reason for the increased amount of organic carbon is not the result of increased productivity, but the beginning of anoxic reducing conditions in the late Frasnian. This view seems to be supported by the predominance of black layered sediments free of bioturbation, an increase in the concentrations of chalcophile elements such as S, Zn, As and Sb.

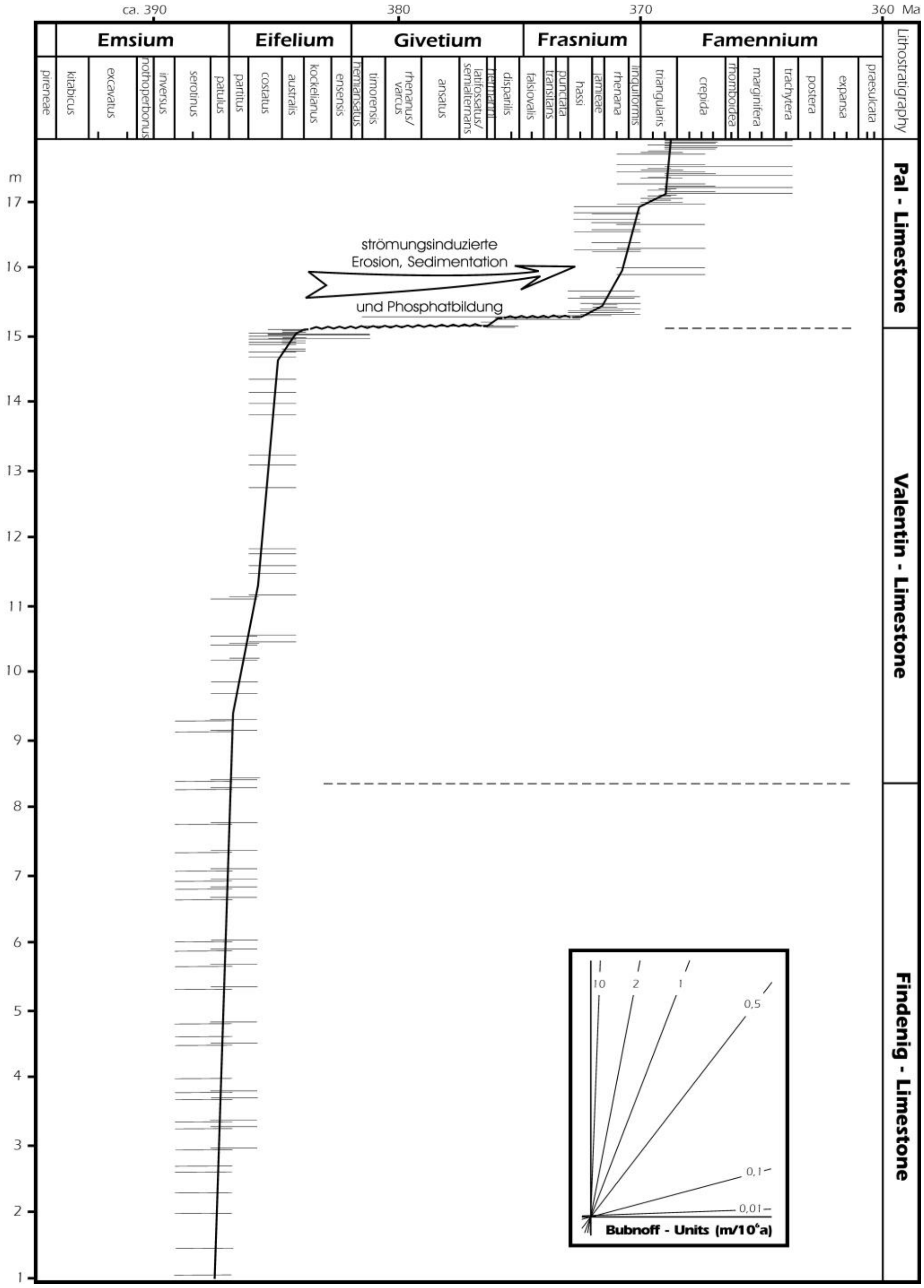


Fig. 37: Periods of condensation reflected in limestones of the Wolayer Glacier section based on accumulation rates versus absolute ages. Horizontal bars indicate conodont biostratigraphic data. Stratigraphic gaps are shown by wavy lines.
From HÜNEKE (2001).

At the F-F boundary, the positive signal of the stable carbon isotope ratio is overprinted by a short-term negative anomaly. According to JOACHIMSKI & BUGGISCH (1993, 1994) and JOACHIMSKI et al. (1994) this shift reflects a significant decrease of productivity and biomass formation in the upper water layers for which the above mentioned mass extinction is held responsible.

Whether or not the global Frasnian-Famennian biotic crisis may has been caused by oceanic ecosystem destabilization or by a single or by multiple impacts remains controversial and unsettled.

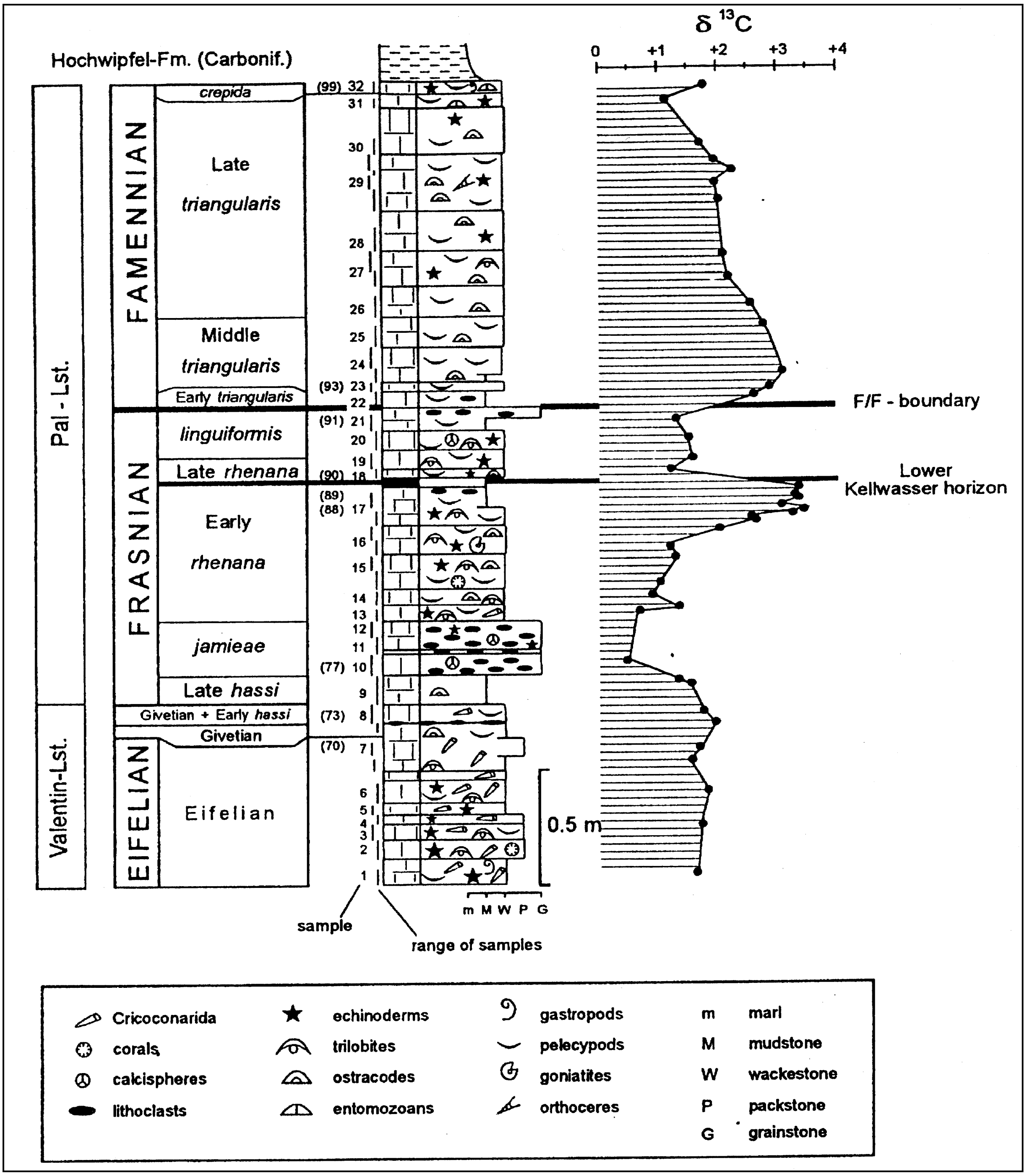


Fig. 38: Carbon isotope pattern across the Frasnian/Famennian boundary at the Wolayer Glacier section (modified from JOACHIMSKI, BUGGISCH & ANDERS, 1994)