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Devonian shallow water carbonates of the Carnic Alps – current state of knowledge and future prospects

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Shallow water carbonates in the Central Carnic Alps span the entire Devonian period but are best developed from Pragian to Frasnian and exposed in several tectonic units ranging from forereef, reef and backreef facies to deposits of restricted lagoons.
This contribution is an attempt to document the work conducted up to now on the shallow water carbonates and to point out were future work is particularly required.
The most continuous and best documented successions occur at Mts. Hohe Warte, Seewarte and the peaks of the upper Kellerwand massif (VAI 1963 and 1967, BANDEL 1969 and 1972, SCHÖNLAUB & FLAJS 1975, POHLER 1982, SCHÖNLAUB & KREUTZER 1984, KREUTZER 1990, SCHÖNLAUB *et al*. 2004, SUTTNER 2007 and others).
KREUTZER (1992a, b) introduced a number of formation names for the successions of the shallow water carbonates of the Central Carnic Alps beginning with the neritic Rauchkofel Limestone, followed by Hohe Warte Ls. (Pragian crinoidal grainstones and rudstones and reef limestones), Seewarte Ls. (Pragian to Emsian?), Lambertenghi Ls. (largely Emsian, dolomitized laminites and grainstones), Spinotti Ls. (Eifelian to Givetian crinoidal grainstones, loferites and *Amphipora* Ls.), Kellergrat Reef Ls. (Givetian to Frasnian Reef ls.) and Kollinkofel Ls. (Famennian lithoclastic and brachiopod ls.). A different late Devonian facies (loferite) occurs in an abandoned quarry below Marinelli Hut for which KREUTZER (1992: p. 271) coined the term Marinelli Ls.
The facies development in the Hohe Warte region is quite distinctive and the different formations can be easily distinguished as far west as Mt. Seekopf (Capo di Lago) as noted by KREUTZER (1992a) when climbing to the top of the mountain. Further to the west (Biegengebirge) the facies become more lagoonal and dolomitic. KREUTZER (1992a) measured a section through the Biegengebirge at Austriascharte and commented on the similarity of this facies to the "Zebragrat" of Mt. Mooskofel and the carbonates of Mt. Gamskofel in the northeast. He therefore summarized carbonates of the Biegengebirge west of Mt. Seekopf and those of Mt. Gamskofel as Pragian to Givetian? Gamskofel Limestone. In his correlation of the various sections (KREUTZER 1992a: Abb. 2) he illustrated the Austriascharte section ending with loferites of possibly late Eifelian or early Givetian age.
To the west of Biegengebirge lies the Cima Ombladet succession. Its geology and facies development was documented by GALLI (1984, 1985). The 250 m thick shallow water limestone succession consists of reefal and lagoonal facies comprising crinoidal detrital limestones, crinoidal stromatoporoid ls, detrital brachiopod ls, *Amphipora* ls and others of late Givetian to Frasnian age. GALLI (1985: p. 106) felt that the facies development at Cima Ombladet was different from adjacent shallow-water limestones of the Carnic Alps and believed that they belonged to a different isolated "atoll" in a cluster of shallow platforms situated in a major carbonate complex.
Further to the northeast are located the Weidenwände and Mt. Plenge. Both are probably of shallow water origin but are too metamorphosed for facies analyses (SCHÖNLAUB 1985, HUBICH *et al.* 2000).
The Gamskofel Massif to the east of the Biegengebirge (north of Hohe Warte and Kellerwand Massif) is poorly known. BANDEL (1972) measured a short (21.4 m) section on the SW side of Gamskofel, presumably the older part of the succession whereas KREUTZER (1992a)

measured a 45 m long section on the NE side near Raimunda Törl where probably younger limestones are exposed. Both sections comprise intercalated beds of stromatolitic bindstones (laminites) intercalated with loferites (birdseye ls), lithoclastic ls and dark *Amphipora* ls., all with varying degrees of dolomitization. Deposition in inter- to supratidal water depths in a sheltered lagoonal environment is interpreted for these facies types and BANDEL (1972: p. 33) stressed the cyclic nature of the sequences. KREUTZER (1992b) suggested the name Gamskofel Limestone for the Pragian to Givetian succession which he estimated to be at least 800 m thick. Thinsection from the upper Gamskofel Limestone show deformed albeit recognizable coral stromatoporoid bafflestones and *Amphipora* limestones with *Stringocephalus* from the younger (Givetian?) part of the succession.

Further to the east follows Mt. Mooskofel which is separated by a major fracture from Gamskofel (SCHÖNLAUB 1985). Very little is known about this mountain. Debris found at the eastern end at Hinterjoch yields dolomitic limestones and dolostones very similar to those from Gamskofel, i.e., loferitic and laminitic lithologies with minor lithoclastic carbonates. Cursory investigation suggests that the rocks of Mt. Mooskofel are more dolomitized than those from Gamskofel. BANDEL (1972) thought that both were deposited in a similar environment in close proximity to each other. KREUTZER (1992a, b) found *Palmatolepis* in carbonates from Mt. Mooskofel indicating a younger age for the top than at Mt. Gamskofel. He felt that the Mooskofel lithologies are closer to the Polinik carbonates and assigned both to a “Northern Shallow Water Nappe” which is thought to encompass deposits of a different carbonate platform than the Southern Shallow Water Nappe (or Kellerwand Nappe).

At Mt. Polinik, located to the east of Mt. Mooskofel, BANDEL (1972) measured several sections and also assessed slope debris derived from inaccessible parts of the mountain. His sections were more than 180 m long and he estimated that another 500 m of section were not accessible for meassuring. BANDEL (1972: p. 33) wrote that laminites, birdseye limestones/dolostones and *Amphipora* limestones found at Mt Polinik were quite similar to those from Gamskofel. KREUTZER (1992: p. 266) re-visited the section previously described by BANDEL. He noticed finer lamination and darker colour in the Polinik laminites (algal stromatolites), common ostracod-parathuraminacean packstone and quartz-rich dolosparites which he did not find at Gamskofel and the scarcity of birdseyes which are common in the Gamskofel succession. This led him to dispute BANDEL’S conclusion that both mountains belong to a similar carbonate platform and to establish a separate unit – the Feldkogel or Northern Shallow Water Nappe mentioned above. The Feldkogel limestones are thought to range from Eifel to early Famenne although BANDEL found echinoderm biosparites at the base of the Polinik section for which he suggested an Emsian age. Famennian conodonts were found in one sample from the eastern side of Mt. Polinik by one of us (SMLP, 2002). It should also be noted that BANDEL (1972: p. 101) commented on the frequent occurence of authigenic quartz crystals in *Amphipora* ls. and laminites from Polinik and Gamskofel but also in various other samples of Middle to Upper Devonian age. In fact the quarry at Monumenz closed because the sharpness of these crystals consistently damaged the rock sawing mechanism. SUTTNER (pers. obs., 2008) also noticed numerous quartz crystals in limestones near Cima Plotta. Consequently their occurrence cannot support a separate platform origin for rocks of the Feldkogel Complex.

A number of smaller outcrops of shallow water carbonates occur in quarries on the Italian side of Plöcken Pass, but the most extensive shallow water succession is exposed on Mt. Zermula. The geology of Mt. Zermula is more complex than that of the Kellerwand Complex. According to SELLI (1963) and FERRARI & VAI (1965) the Devonian carbonates consist of several overturned nappes. Givetian to Frasnian Limestones are biostromal whereas neritic to infraneritic sediments formed from Late Devonian to early Caboniferous. The Devonian shallow water limestone succession illustrated by FERRARI & VAI (1965) is at least 250 m thick. At Passo di Lanza a horizon with *Stringocephalus burtini* suggests a Givetian age which is supported by recent work of C. CORRADINI, M. PONDRELLI & T. SUTTNER in the region. The fossil content with regard to reef and biostrome building organisms is quite well known from this region based on works of GORTANI (1907), VINASSA DE REGNY (1918),

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FERRARI & VAI (1965) and others. The section at Passo di Lanza exhibits numerous horizons with *Amphipora* biostromes and appears to be quite similar to the upper part of the succession at Mt. Seewarte.

The picture that is emerging from literature review is a darce of data from the extreme shallow water successions (Gamskofel, Mooskofel, Biegengebirge, Polinik) and an insecurity about how similar or different the various limestone successions are. To resolve both problems detailed measuring of sections and analyses of facies via microfacies analyses is required. The sections published in previous work by BANDEL and KREUTZER suggests that both, the Gamskofel and Feldkogel limestones contain distinctive units to warrant further sub-division.

Regional mapping might answer the question whether the Cima Ombladet is truly different from the Hohe Warte section or whether it is a structurally separate continuation of the Biegengebirge succession which ends prematurely in the late Eifelian or early Givetian.

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