

## Paleogeography of the Permian in the Southern Alps

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Sedimentological, paleontological and geochemical studies of the Permian sediments in South Tyrol, in the Carnic Alps and in the Karawanken (BUGGISCH 1976, BUGGISCH et al. 1976, E. FLÜGEL 1975, 1977) indicate the following paleogeographical evolution

The basement of the Permian rocks are Variscan quartzphyllites in the Dolomites. In the area between the western Carnic Alps and Slovenia Upper Carboniferous Auernig beds are exposed. These cyclic deposits are overlain by the Lower Permian Rattendorf formation.

In the western area (Dolomites) locally continental coarse-grained clastics (Waidbruck conglomerate resp. Verrucano alpino) are sedimented during the transition from the Carboniferous to the Permian. Thick volcanic rocks (Bozener Quarzporphyr) are formed during the Lower Permian in South Tyrol.

The Lower Permian Rattendorf and Trogkofel formations of the Carnic Alps and the Karawanken are characterized by a shelf- and shelf-edge sedimentation. During the Rattendorf stage (Asselian) three lithological units can be recognized.

The Lower Pseudoschwagerina limestones were deposited cyclically in a near-coast inner-shelf area by alternating transgressive and regressive phases.

The erosion of metamorphic and acid volcanic rocks and the increasing sedimentation of clastics in a near-coast high-energy environment with intertidal to subtidal conditions is responsible for the genesis of the sandstones and silty shales of the Grenzland group. For the upper part of this group an additional source area with acid plutonites is indicated by heavy mineral analysis (TIETZ 1975).

The Upper Pseudoschwagerina limestones show a regular recapitulation of microfacies sequences, which together with the medium to high biotic diversity give evidence to a repeated shifting of ecological zones from very shallow water areas to off-shore environments in an open-marine shelf lagoon with normal water circulation.

This outer-shelf platform facies continues during the Trogkofel stage in the western parts of the Carnic Alps and in the western Karawanken. In contrast to these well-bedded Trogkofel limestones organic buildups with encrusting algae (Tubiphytes MASLOV) and with fenestellid bryozones, brachiopods and crinoids are developed in the Sexten Dolomites in the Carnic Alps (Trogkofel Tarvis) and in the Karawanken.

Besides the Trogkofel area all the Tubiphytes limestones are known only from resedimentated Trogkofel components within the Tarvis beccia. A shelf-edge position of some of these Trogkofel reefs is probable.

The mobile inner-shelf developed in the Carnic Alps and in Slovenia and Croatia is characterized by the "Clastic Trogkofel formation" consisting of up to 2000 m quartz-sandstones, conglomerates, and some limestones. Lithoclastic limestones give hints to a long-lasting period of syndimentary re-sedimentation (KOCHEVSKY-DEVIDE et al. 1973)..

A widespread regression at the end of the Lower Permian is manifested by breccias and conglomerates (Tarvis breccia, Gröden conglomerate). These sediments have been formed in areas of intensive intra-Permian block-faults. A tectonic uplift of some sedimentary regions seems to be responsible for an uniform submarine and subaerial destruction of the Trogkofel limestones in high-energy environments.

The red bed facies of the Gröden formation (Middle Permian) known from South Tyrol to the Karawanken is superimposed discordantly to different Lower Permian or Variscan rocks.

Within the sedimentation area of the Gröden formation two facies units have been observed:

- (A) Coarse-grained and ill-sorted conglomerates and sandstones consisting predominately of reworked material from basement. Typical for this facies are authigenic kaolinite formed by intensive in-situ weathering of feldspars and lack or low content of calcite (no dolomite).
- (B) Fine-grained, medium- to well-sorted, interbedded silt- and sandstones, overlying the facies unit A in the area between the Karawanken and the river Etsch in South Tyrol. Characteristics of this facies are the high feldspar contents (20-30 %) high carbonate content (predominately dolomite) and the occurrence of

chlorite together with the lack of kaolinite

The transition between these two facies is characterized by gyps , coals , enrichment of Pb and by typical clay minerals (montmorillonite , mixed-layers) . Representative sections are situated in the Gröden valley and in the Bletterbach gorge near Radein

A particular Middle Permian facies is exposed in the area of Bled , Julian Alps , consisting of high-energy reef-limestones (RAMOVS 1955)

The attributes of facies A correspond with a deposition in continental environments ; fresh-water algae (Kreuzberg pass Sexten Dolomites) support this interpretation

The transition facies shows characteristics of a coastal region with marginal lagoons . Paleontological data (tetrapod traces drifted cephalopods and foraminifera) are in accordance with this model

Facies Type B is deposited in marine environment (supply of Mg for dolomitization and formation of the chlorits ; enrichment of Mn ; scarce foraminifera , ostracods and gastropods)

In summary the paleogeographical development during the Middle Permian is as follows ;

- Continental sedimentation at the basis
- marine transgression in the western Carnic Alps and in the western Karawanken during the lower Gröden stage ;
- progressive transgression during the middle Gröden stage to the west , with a coast line near the Gröden valley and the Bletterbach gorge and
- a coastline near the River Etsch at the end of the Middle Permian

The increasing transgression during the Upper Permian resulted in the deposition of bituminous sediments and basal evaporites of the Bellerophon formation . In the southwestern near-coast area evaporites are dominating (facies fiammaza , ACCORDI 1958 , sabkha environment) whereas in northeastern South Tyrol gypsum with open marine carbonates prevails (facies badiotica) . The Bellerophon formation of the Carnic Alps indicates connections between the Marine Zazar formation in the Save Folds area and with the limestones and dolomites of the Velebit Mountains

