

the transgressive phase of the Lower Pseudoschwagerina Formation cyclic limestone sequence (SAMANKASSOU, 1997). Thick mounds, resulting from increased accommodation space, indicate that mounds kept pace with sea-level. Mound growth was terminated by drowning through sea-level rise (SAMANKASSOU, 1999). Bedded, bio- and lithoclastic limestones on top of the cycles indicate forced regression and erosion of the underlying dark limestones.

The Lower Pseudoschwagerina Formation, representing about one fusulinid zone (*bosbytauensis-robusta* Zone), is composed of four cycloths (HOMANN, 1969; SAMANKASSOU, 1997). The mean duration of one fusulinid zone is estimated as 1–1.5 ma (ROSS & ROSS, 1995), implying a mean duration of 300 to 400 ka for each single cyclothem.

**Chronostratigraphic age:** Uppermost Gzhelian.

**Biostratigraphy:** The index fossil *Daixina (Bosbytauella) postgallowayi* (= ex *Occidentoschwagerina alpina* KAHLER & KAHLER, 1941, megalospheric form) is the diagnostic species of the *bosbytauensis-robusta* Zone, but is not present throughout the section. The lowermost part yields species of *Ruzhenzevites*, *Dutkevitchia* (known also from the underlying Auernig Group), and the *Schwageriniformis perstabilis* group. Species of the *Rugosofusulina stabilis* group and of *Rugosochusenella* have their first appearance in the middle and upper part of the section, which is primarily characterized by the occurrence of the highly inflated species of the genus *Daixina* (subgenus *Bosbytauella*). In the uppermost part *Daixina (Bosbytauella)* disappears and is replaced by species of *Schwagerina* and *Dutkevitchites* in the topmost layers.

The lowermost assemblage of the Lower Pseudoschwagerina Formation may still belong to the *Daixina sokensis* Zone, whereas the main part of the sequence can certainly be correlated with the *bosbytauensis-robusta* Zone. The base of the following *vulgaris-fusiformis* Zone cannot be precisely correlated, as a fusulinoidean assemblage with intermediate characteristics occurs in the topmost layers of the Lower Pseudoschwagerina Formation. Therefore, the boundary between the Carboniferous and Permian systems, defined by the First Appearance Datum (FAD) of *Streptognathodus isolatus* (approximately coinciding with the base of the *vulgaris-fusiformis* Zone) is slightly vague in the Carnic Alps, and spans an inferred interval from the topmost layers of the Schulterkofel Formation to the basal limestone beds of the Grenzland Formation.

**Thickness:** The thickness in the type section is 136 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Auernig Formation.

**Overlying unit(s):** Grenzland Formation.

**Lateral unit(s):** The more than 130 m thick type section decreases in thickness laterally within rather short distances of some 2 km at Pian di Lanza (Lanzenboden) to less than 60 m.

**Geographic distribution:** Carnic Alps, mainly west of Naßfeld crossing the Austrian/Italian border (Schulterkofel, Ringmauer, Pian di Lanza, Rudnigalm, Tressdorfer Höhe, Garnitzenalm).

**Remarks:** In the ASC 2004 the old lithostratigraphic term "Lower Pseudoschwagerina Formation" was printed by a regrettable mistake in place of the term Schulterkofel For-

mation. KRAINER (1995: p. 689) already formalized and renamed the unit in Schulterkofel Formation after the mountain Schulterkofel (2,091 m; Italian name: Creta di Lanza) in the central Carnic Alps west of Rattendorfer Alm.

Italian name of the Schulterkofel Formation: Creta di Lanza Formation.

**Complementary references:** SCHÖNLAUB & FORKE (2007)

### Grenzland-Formation / Grenzland Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; first denomination as "Grenzlandbänke" by HERITSCH et al. (1934: p. 178).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** Not yet designated.

**Remarks:** No complete section of the Grenzland Formation exists. The base is exposed below peak 1,997 m (see Lower Pseudoschwagerina Formation/Schulterkofel Formation). The lower part of the Grenzland Formation is exposed along the border between Austria and Italy south of Rattendorfer Alm. The top of the Grenzland Formation and transition to the overlying Zweikofel Formation is located in the ravine between the mountains Zweikofel (peak 2,059 m) and Zuckerhütl (2,034 m).

**Reference section(s):** -

**Derivation of name:** Name expresses the location of the section along the state border between Austria and Italy.

**Synonyms:** Grenzlandbänke ("Grenzland Beds") (HERITSCH et al., 1934: p. 178).

**Lithology:** Clastic marine sequence characterized by oncoidal limestone intercalations containing large (0.5–1 cm) spherical fusulinids. Quartz conglomerates are less common and comparably thinner than in the Auernig Group. More common are thick calcareous sandstones with quartz grains exhibiting dissolution features on top with brecciation and dissolved fossil remains, often filled with a red matrix. Siltstones display common bioturbation and sediment structures (slumping, convolute bedding and load casts), as well as ichnofossils (*Zoophycos*).

In addition to the oncoidal limestones, bioclastic limestones with a diverse fauna, as well as reddish limestones with dissolution features and brecciation occur in the Grenzland Formation.

**Fossils:** Fusulinids, smaller foraminifers, ostracods, crinoids, bryozoans, brachiopods, phylloid algae, dasycladacean algae (*Epimastopora*), oncoids, trace fossils, microproblematica (*Ramovsia*, *Tubiphytes*) and megaplants (FRITZ & KRAINER, 2004).

**Origin, facies:** Provenance analysis of the clastics indicates magmatic and metamorphic source areas (TIETZ, 1974; MADER & NEUBAUER, 2004). Microfacies of the limestones points to high-energy nearshore deposits (E. FLÜGEL, 1975).

The Grenzland Formation is likewise characterized by cyclic deposits. Individual cycles of up to 10 m thickness with conglomerates and sandstones at the base, overlain by transitional clastic-carbonate deposits with a diverse fauna are followed by oncoidal limestones.

Paleosols, fracture fillings and collapse breccia occur within sections exposed at mountain Zweikofel, proofing intervals of subaerial exposure (VENTURINI, 1990a, b; SAMANKASSOU, 1997).

**Chronostratigraphic age:** Originally correlated to the middle Asselian, the Grenzland Fm. seems to represent the entire Asselian plus part of the Sakmarian (FORKE, 2002). In comparison with the much thicker Auernig Group, however, non-deposition and erosion have to be considered in this sequence suggesting a much longer time interval although clear sedimentological hints have not been found yet.

**Biostratigraphy:** To date, limestone beds with fusulinids have been investigated only in the lower and uppermost parts of the Grenzland Formation. Based on the occurrence of *Sphaeroschwagerina carniolica* and *Pseudoschwagerina extensa* the faunal assemblages of the lower part indicate an early? to middle Asselian age. The upper part yields *Sphaeroschwagerina asiatica*, i.e., a species of the *Paraschwagerina nitida* group, and first primitive *Zelia* and *Robustoschwagerina*, indicating a Sakmarian age (FORKE, 2002).

**Thickness:** As no continuous section exists, the maximum thickness is estimated at about 120 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Pseudoschwagerina Formation (Schulterkofel Formation).

**Overlying unit(s):** Upper Pseudoschwagerina Formation (Zweikofel Formation).

**Lateral unit(s):** -

**Geographic distribution:** Carnic Alps, mainly west of Naßfeld crossing the Austrian/Italian border (Schulterkofel, Ringmauer, Rattendorfer Schneid, Pian di Lanza, Rudnigalm, north of Kühweger Alm).

**Remarks:** Italian name of the Grenzland Formation: Val Dolce Formation

**Complementary references:** -

### Obere Pseudoschwagerinen-Formation / Upper Pseudoschwagerina Formation

[recte: Zweikofel-Formation / Zweikofel Formation (KRAINER, 1995)]

HANS P. SCHÖNLAUB

**Validity:** First denomination by KAHLER (1947) and later formalized by KRAINER (1995: p. 689) who renamed the former Upper *Pseudoschwagerina* Limestone following international recommendations.

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia (N 46°34'47" / E 13°13'12").

**Type section:** Originally the section at Zottachkopf was chosen as type section by HERITSCH et al. (1934). However, at this section only less than half of the succession is exposed.

**Reference section(s):** Complete sections occur on the western part of Zweikofel and in the upper Garnitzen gorge.

**Derivation of name:** After the genus *Pseudoschwagerina*, a fusulinid foraminifer.

**Synonyms:** Oberer Schwagerinenkalk (HERITSCH et al., 1934: p. 178); oberer Pseudoschwagerinenkalk (KAHLER, 1947); obere Pseudoschwagerinen Schichten (E. FLÜGEL, 1975); obere Pseudoschwagerinen-Formation (SCHÖNLAUB et al., 1988).

**Remarks:** Due to changes in the fusulinid taxonomy, KAHLER (1947) changed the original Upper Schwagerina Lst. of HERITSCH et al. (1934) to Upper Pseudoschwagerina Lst. However, since the genus *Pseudoschwagerina* is missing in this section, KRAINER (1995) recommended a change of the name according to the international usage of lithostratigraphic nomenclature.

**Lithology:** The Zweikofel Formation is mainly composed of carbonates characterized by bedded, oncoidal and foraminiferal-algal limestones. Small, highly diverse mounds, reddish, bioclastic crinoidal limestones and oolites are present in the lower part. Siliciclastic input with quartz pebbles and sandstone lenses is restricted to northwest-ern areas.

**Fossils:** Fusulinids (*Zelia*, *Robustoschwagerina*, *Paraschwagerina*, "Pseudofusulina", *Pseudochusenella*), smaller foraminifers, conodonts (*Sweetognathus* aff. *whitei*, *Diplognathodus*, *Mesogondolella bisselli*), crinoids, bryozoans, corals, brachiopods, phylloid algae, dasycladacean algae (*Epimastopora*), microproblematica (*Tubiphytes*).

**Origin, facies:** Siliciclastics retreat in the Zweikofel Formation and a complex carbonate platform developed with high-energy ooid bars (Zweikofel area), subtidal, oncoid limestones (Zottachkopf area) and small mounds (Trogkar area). Variations in microfacies, biotic associations and geochemical composition have been pointed out by E. FLÜGEL (1975). The lateral variations in cyclic patterns could be explained by a differentiated shelf and sea-bot-tom morphology at time of deposition. High-frequent sea-level fluctuations are superposed on these morphological variations (SAMANKASSOU, 1997).

**Chronostratigraphic age:** According to FORKE (1995b, c, 2002) the Zweikofel Formation has a late Sakmarian to early Artinskian age.

**Remarks:** Due to the three-fold subdivision of the Asselian (lower-middle-upper) and the disappearance of "inflated schwagerinids" at the beginning of the Sakmarian in the type sections of the Urals, the Zweikofel Formation has long been correlated with the upper Asselian by KAHLER (1986a).

According to FORKE (1995a, b, 2002) geographic barriers and/or changes in the oceanographic circulation pattern are responsible for the impoverished fusulinoidean faunas of the Urals. The co-occurrence of "inflated schwagerinids" with Sakmarian/Artinskian conodonts has demonstrated that these groups have much longer stratigraphic ranges in the Tethyan faunal realm.

**Biostratigraphy:** Based on fusulinids and conodonts.

**Thickness:** Maximum thickness in the Zweikofel type sec-tion is 135 m.

**Lithostratigraphically higher rank unit:** -

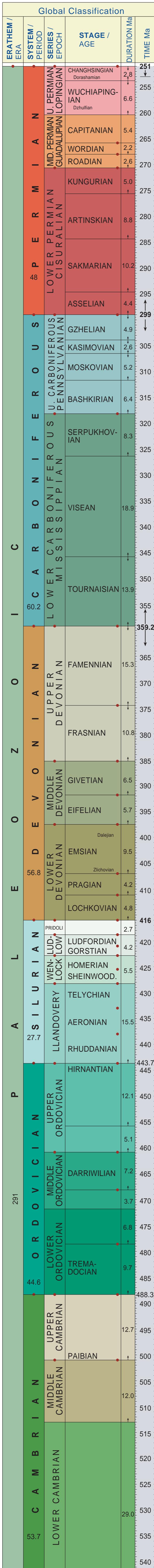
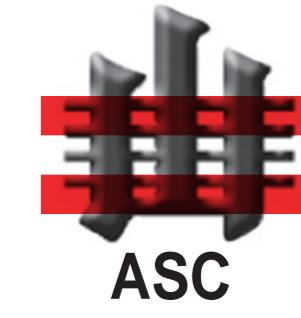
**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Grenzland Formation.

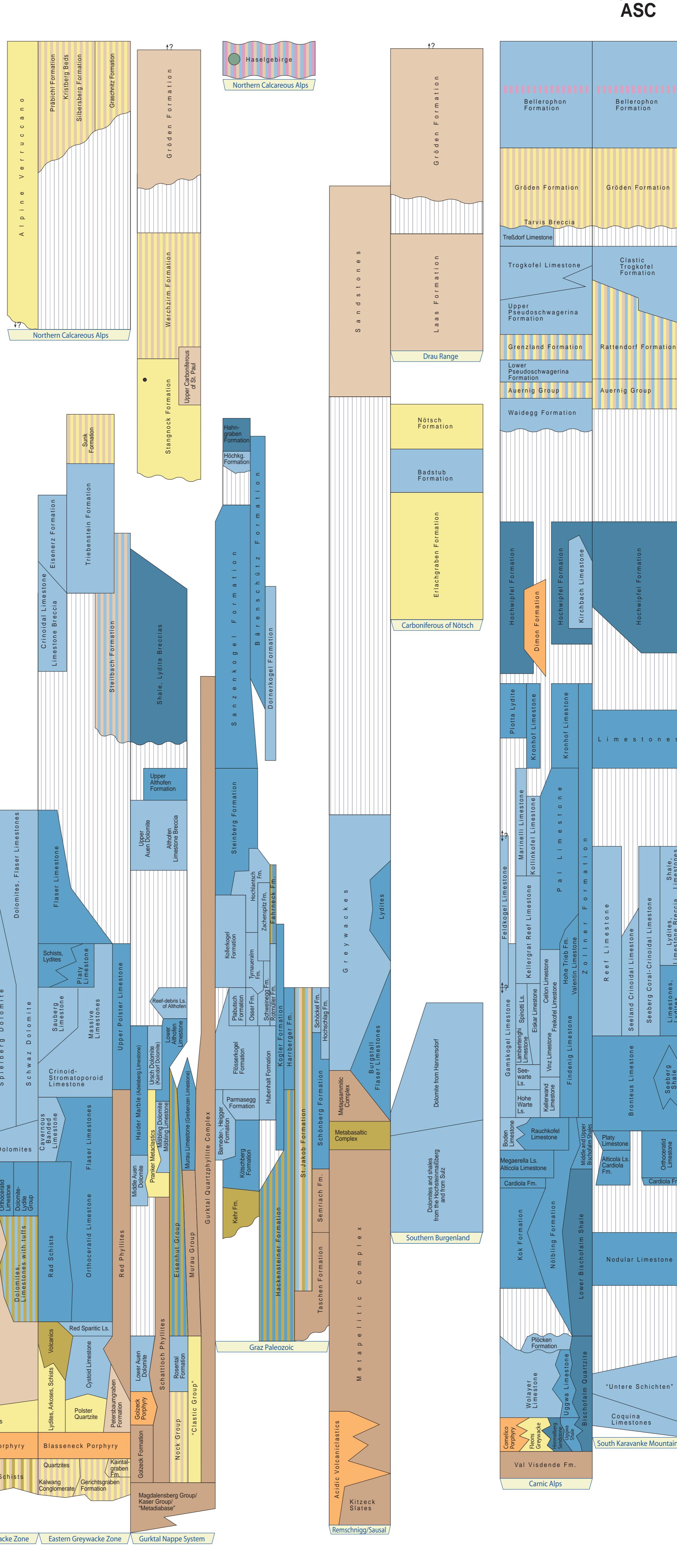
**Overlying unit(s):** Trogkofel Limestone.

# Austrian Stratigraphic Chart 2004 - Paleozoic

(sedimentary successions)



Austrian Stratigraphic Commission



### Legend

- pelagic, offshore, siliciclastic
- pelagic, nearshore, calcareous
- shallow marin, neritic
- terrestrial-continental, coarse clastic
- terrestrial-continental, fine clastic
- evaporite (chloride, sulphate)
- rhyolite, dacite
- (basaltic) andesite, trachyandesite
- basalt
- phyllite
- mixed-facies (in corresponding colors)
- coal (may include several seams)
- position/age doubtful/controversial
- equal units
- older unit left \ younger unit right
- hiatus
- unconformity
- GSSP
- Fm. Formation
- Ls. Limestone

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