confusion between the terms “Auernig Formation” sensu SELLI (1963) and the term “Auernig Formation” used herein, the term “Gugga Member” was proposed by SCHÖNLAUB & FORKE (2007) as analogous replacement for the “obere kalkreiche Schichtgruppe” sensu HERITSCH et al. (1934). The Trögl-Creta di Rio Secco Member was introduced by FORKE et al. (2006) to describe a carbonate succession at Rosskofel (Monte Cavallo), directly overlying folded Devonian–lower Carboniferous limestones.

VENTURINI (1990) and VAI & VENTURINI (1997) proposed a revised stratigraphic subdivision of the upper Carboniferous clastic/carbonate succession of the Auernig Group, consisting of five formations and excluded the basal breccias and conglomerates as Bombaso Formation (Waidegg Formation in the ASC 2004 and Collendiaul Formation of SCHÖNLAUB & FORKE, 2005, respectively). This scheme was adopted by most following authors (KRAINER, 1990a, 1991, 1992, 1995; KRAINER & DAVYDOV, 1998; DAVYDOV & KRAINER, 1999).

However, due to the strong faulting and complex tectonics it is often difficult to find sections allowing a definition of the base and top of stratigraphic units. Up to now, a complete succession with composite sections has never been reconstructed, individual sections have neither lithologically, nor faunistically been successfully correlated, and a definition of stratigraphic units after the “Recommendations (guidelines) of the usage of stratigraphic nomenclature” (STEININGER & PILLER, 1999) has never been undertaken.

Furthermore, the proposed stratigraphic subdivision of the “Auernig Group” into formations would require distinguishing the formations as mappable units in the field. However, the formations are neither traceable for longer distances, nor presentable in geological maps.

There are several reasons to keep the upper Carboniferous succession as Auernig Formation and to give informal names for the different investigated sections:

1. The “untere kalkreiche Schichtgruppe” (or the equivalent “Pizzul Formation”) consists of two parts (Waschbühel Schichten and Watschiger Schichten), which have never been successfully correlated. Moreover, the base of the formation has never been defined after the revision of FENNINGER et al. (1971). The alternatively proposed type section (after the locality Monte Pizzul) is neither lithologically, nor biostratigraphically sufficiently investigated for correlation.

2. The “untere kalkarme Schichtgruppe” (or the equivalent “Meledis Formation”) in its original type section (Waschbühel ridge) is composed of two units bounded by tectonic contacts. Biostratigraphic data are available only from the northern (“lower”) part (so-called “Waidegger Fauna” of HERITSCH et al., 1934; METZ, 1936; GAURI, 1965). In the alternatively proposed type section (section Rio Cordin east of the Casera Meledis) the base of the formation is not exposed and the succession is overlain directly by the Middle Permian Gröden Formation. Moreover, KRAINER & DAVYDOV (1998) described an “early Gzhelian” (more probably late Kasimovian) fauna from this section, although the overlying (?) Pizzul Formation is partly older (middle-late Kasimovian fauna of the Waschbühel ridge).

Complementary references: -

Untere Pseudoschwagerinen-Formation / Lower Pseudoschwagerina Formation

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

HANS P. SCHÖNLAUB

Validity: First denomination by KAHLER (1947) and later formalized by KRAINER (1995) who renamed the former Lower Pseudoschwagerina Limestone following international recommendations into Schulterkofel Formation (= valid).

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

Type section: The lower boundary and main part of the Schulterkofel Formation is exposed at the section along the northwestern edge of the cliff of the Mountain Schulterkofel (N 46°35’24” / E 13°10’09”).
Remarks: The upper boundary of the Schulterkofel Formation and transition to the basal Grenzland Formation is best exposed above the trail from Rattendorfer Schneid to Cordin Alm in a section forming peak 1,997 m ranging from the base of the cliff to south of peak 1,997 m.

Reference section(s): -

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

Synonyms: Unterer Schwagerinenkalk (HERITSCH et al., 1934: p. 176); Unterer Pseudoschwagerinenkalk (KAHLER, 1947: p. 61); untere Pseudoschwagerinen Schichten (E. FLÜGEL, 1975); untere Pseudoschwagerinen-Formation (SCHÖNLAUB et al., 1988).
Remarks: Due to changes in the fusulinid systematics, KAHLER (1947) changed the original Lower Schwagerina Lst. of HERITSCH et al. (1934) to Lower 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 Lower Pseudoschwagerina Formation (Schulterkofel Formation) is predominantly a carbonate succession with subordinate fine sand- and siltstones. Siliciclastic beds are often intercalated with fossiliferous horizons, grading from calcareous sandstones to sandy limestones with tempestitic beds, rich in smaller foraminifers, echinoderm fragments, brachiopods and gastropods.

Massive limestones form up to 20 m high, almost monospecific (*Anthracoporella spectabilis*) mounds with a sparse associated fauna of rare smaller foraminifers, ostracods and gastropods embedded in a micritic-peloidal matrix. Medium- to thick-bedded limestones occur at the base and in between individual mounds composed of a higher diverse fauna with foraminifers, phylloid algae and others.

Mounds and bedded limestones are overlain by dark, nodular limestones (partly with shale interlayers) with chert nodules containing thick-shelled brachiopods, cephalopods and solitary corals.

Fossils: Fusulinids, smaller foraminifers, phylloid algae, dasycladacean algae (*Anthracoporella*), microproblematica (*Tubiphytes*).

Origin, facies: Siliciclastics at the base represent shoreface deposits. Bedded and massive limestones occur below the storm wave base, but within the photic zone during

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 cyclothems (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 Formation. 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 oncolithic 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).

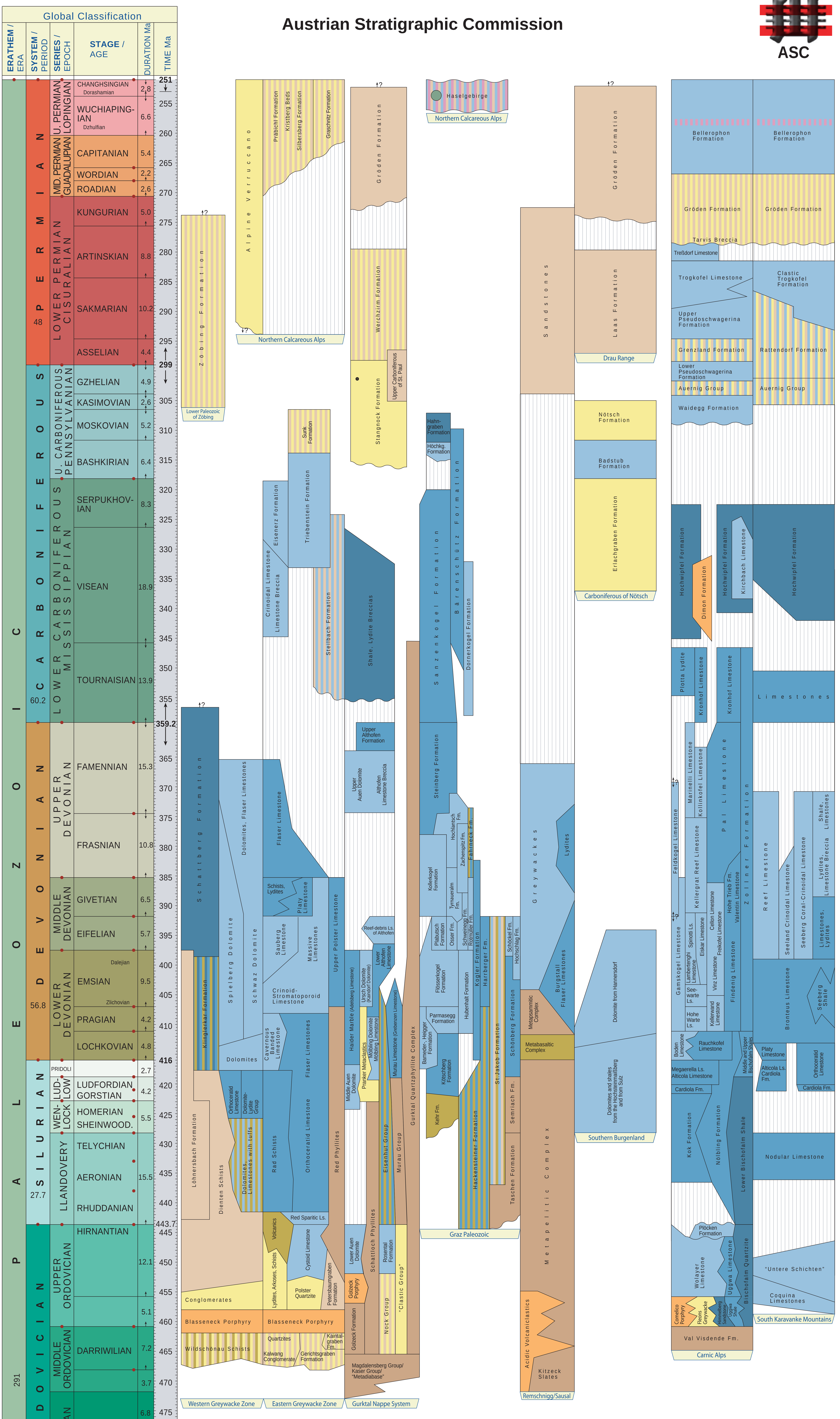
The Grenzland Formation is likewise characterized by cyclic deposits. Individual cycles of up to 10 m thickness with conglomerates and sandstones at the base, overlain by transitional clastic-carbonate deposits with a diverse fauna are followed by oncoidal limestones.

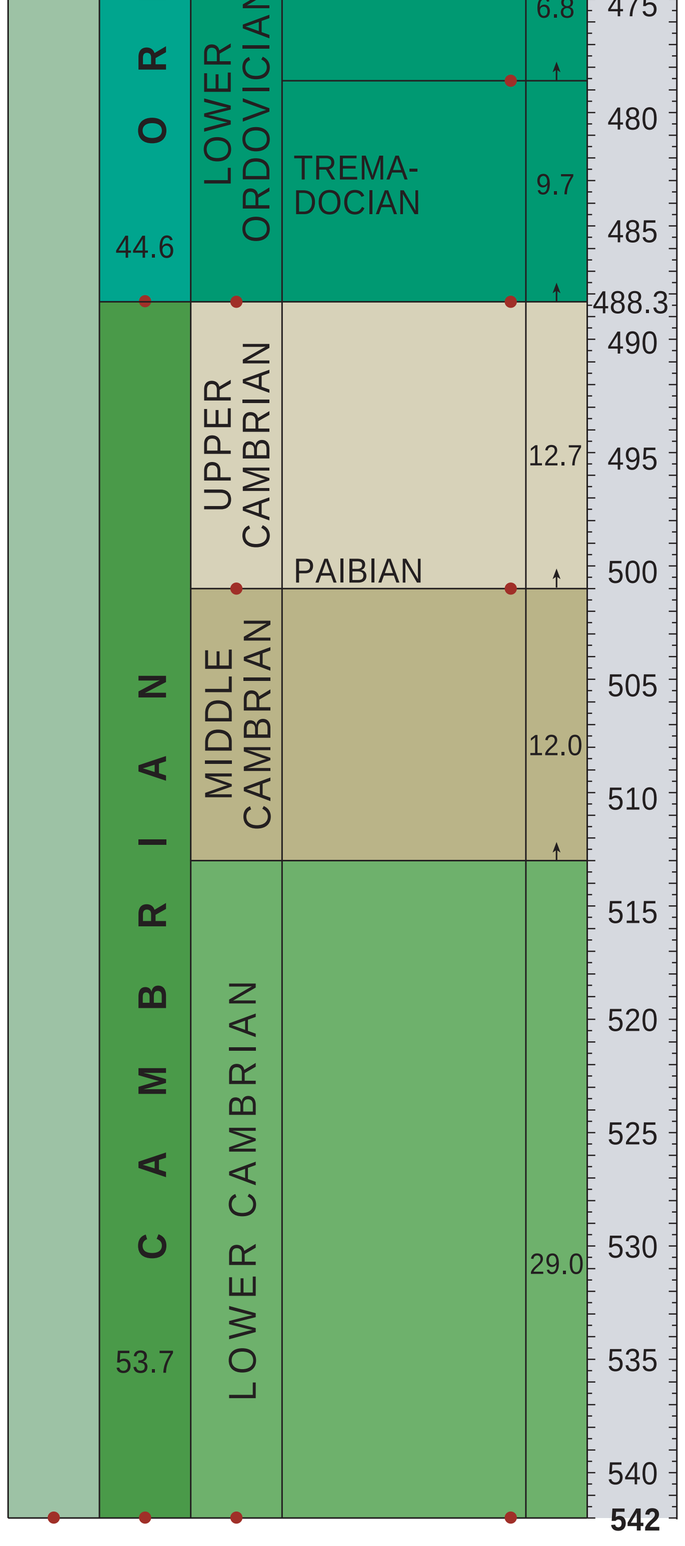
Austrian Stratigraphic Chart 2004 - Paleozoic

(sedimentary successions)

Austrian Stratigraphic Commission

ASC





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

Cutout and English adaptation of the "Die Stratigraphische Tabelle von Österreich 2004": Geological Survey of Austria

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