

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 *Zellia* 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 foraminifer-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 northwestern areas.

**Fossils:** Fusulinids (*Zellia*, *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-bottom 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 section is 135 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

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

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

**Lateral unit(s):** See above in chapter “Origin, facies”.

**Geographic distribution:** Carnic Alps, west and northeast of Naßfeld (Zweikofel Massif, Zottachkopf, Rudnig Kar, Rudnigalm, Reppwand, upper Garnitzen gorge).

**Remarks:** In the ASC 2004 the old lithostratigraphic term “Upper Pseudoschwagerina Formation” was printed by a mistake in place of the term Zweikofel Formation. KRAINER (1995: p. 689) already formalized and renamed the unit in Zweikofel Formation after the mountain Zweikofel (2,059 m) between Rattendorfer and Rudnig Alm.

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

### Trogkofelkalk / Trogkofel Limestone

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by GEYER (1898: p. 252) to designate this limestone complex as an equivalent of the Permian Artinskian Stage and not as Triassic as suggested previously by FRECH (1894b).

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

**Type section:** Not defined.

**Reference section(s):** -

Remarks: The section at the Trogkofel mountain (2,280 m) along the Überlacher trail (N 46°34'10" / E 13°13'05") or at the westernmost edge of the steep cliff may serve as type section in the future. Additional sections are exposed at the Reppwand cliff and in the upper Garnitzen gorge.

**Derivation of name:** After the mountain Trogkofel (2,280 m) between Rattendorfer and Rudnig Alm.

**Synonyms:** Trogkofel Schichten (SCHELLWIEN, 1898: p. 279).

**Lithology:** The Trogkofel Limestone is mainly composed of massive, light-colored, partly reddish carbonates. Large parts correspond to a *Tubiphytes/Archaeolithoporella*-cement boundstone. Dolomitization is common and ranges from isolated euhedral dolomitic rhombs to a complete replacement. Boundstones may occur as clasts and boulders, probably representing syndimentary breccias. Indistinctly bedded, well preserved dasycladacean grainstones with a spotty distribution of fusulinids can be found in the upper part of the Trogkofel Mountain along the Überlacher trail. The bedded, ruditic limestones with shale intercalations represent an exceptional lithofacies in the Zweikofel section.

**Fossils:** Fusulinids, smaller foraminifers, conodonts, crinoids, bryozoans, corals, sponges, dasycladacean algae, microproblematica (*Tubiphytes*, *Archaeolithoporella*).

**Origin, facies:** The Trogkofel Limestone includes reefs that differ from those of the previous formations as being interpreted as shelf margin reefs (FLÜGEL, 1981). These types are the thickest reefs of the Upper Paleozoic sequence in the Carnic Alps. They are characterized by the interaction of encrusting organisms (algae, sponges, bryozoans) and syndimentary cementation, supported by microbial and algal activities forming an organic framework. Other lithofacies types within the Trogkofel Limestone point to platform sediments (limestones with dasycladaceans and fusulinids) and upper slope (breccias) deposits. No detailed reconstruction of the stratal patterns in the Trogkofel Lime-

stone has been elaborated so far. However, similar platform – reef – slope geometries are known from carbonate platform systems in northwestern Spain (BAHAMONDE et al., 2000), which may serve as a model for the Trogkofel Limestone.

**Chronostratigraphic age:** Late Artinskian.

**Biostratigraphy:** Rare occurrences of *Robustoschwagerina spatiosa* together with a single conodont taxon (*Neostreptognathodus* cf. *pequopensis*) from the ruditic limestones indicate upper Artinskian for the Trogkofel Limestone.

**Thickness:** Maximum thickness at Trogkofel approx. 400 m, at Reppwand and Garnitzen gorge 200 to 300 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

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

**Overlying unit(s):** Trogkofel Conglomerate (not indicated in the ASC 2004), Tarvis Breccia, Gröden Formation.

**Lateral unit(s):** The locally occurring Tressdorf Limestone in the Naßfeld area (a polymict limestone breccia) and the Goggau Limestone occurring along the old road from Tarvisio to the village Goggau (KAHLER & KAHLER, 1980) and in the western Karavanke mountains of Slovenia (pers. comm. FORKE and NOVAK) may represent lateral equivalents of the Trogkofel Limestone.

**Geographic distribution:** Carnic Alps (Trogkofel, Zweikofel Massif, Rudnigalm, Reppwand, upper Garnitzen gorge, northeast slope of Col Mezzodi near Forni Avoltri). At the latter locality the boundary between the Zweikofel Formation and the overlying Trogkofel Limestone is not precisely known yet), Karavanke Mountains, Slovenia.

**Remarks:** -

**Complementary references:** -

### Treßdorfer Kalk / Treßdorf Limestone

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by HOMANN (1969: p. 278) to designate isolated occurrences of polymict limestone breccias in the surroundings of the Treßdorf Alm northeast of Naßfeld.

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

**Type section:** No reference section exists since the main occurrence WNW of Treßdorf Alm is only some meters in thickness (N 46°34'42" / E 13°15'28").

**Reference section(s):** -

**Derivation of name:** After Treßdorf Alm located closely to this limestone unit (see SCHÖNLAUB & FORKE, 2007).

**Synonyms:** -

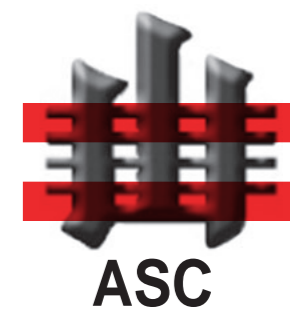
**Lithology:** According to HOMANN (1969) and FLÜGEL (1968) the Treßdorf Limestone represents a clast-supported stylonbreccia. The cm-sized angular and subrounded clasts reflect different types of microfacies which are supposedly derived from the Trogkofel Limestone and the underlying Zweikofel Formation. The majority of the clasts are light-greyish *Tubiphytes-Archaeolithoporella*-cement boundstones and thus resemble the typical Trogkofel Limestone



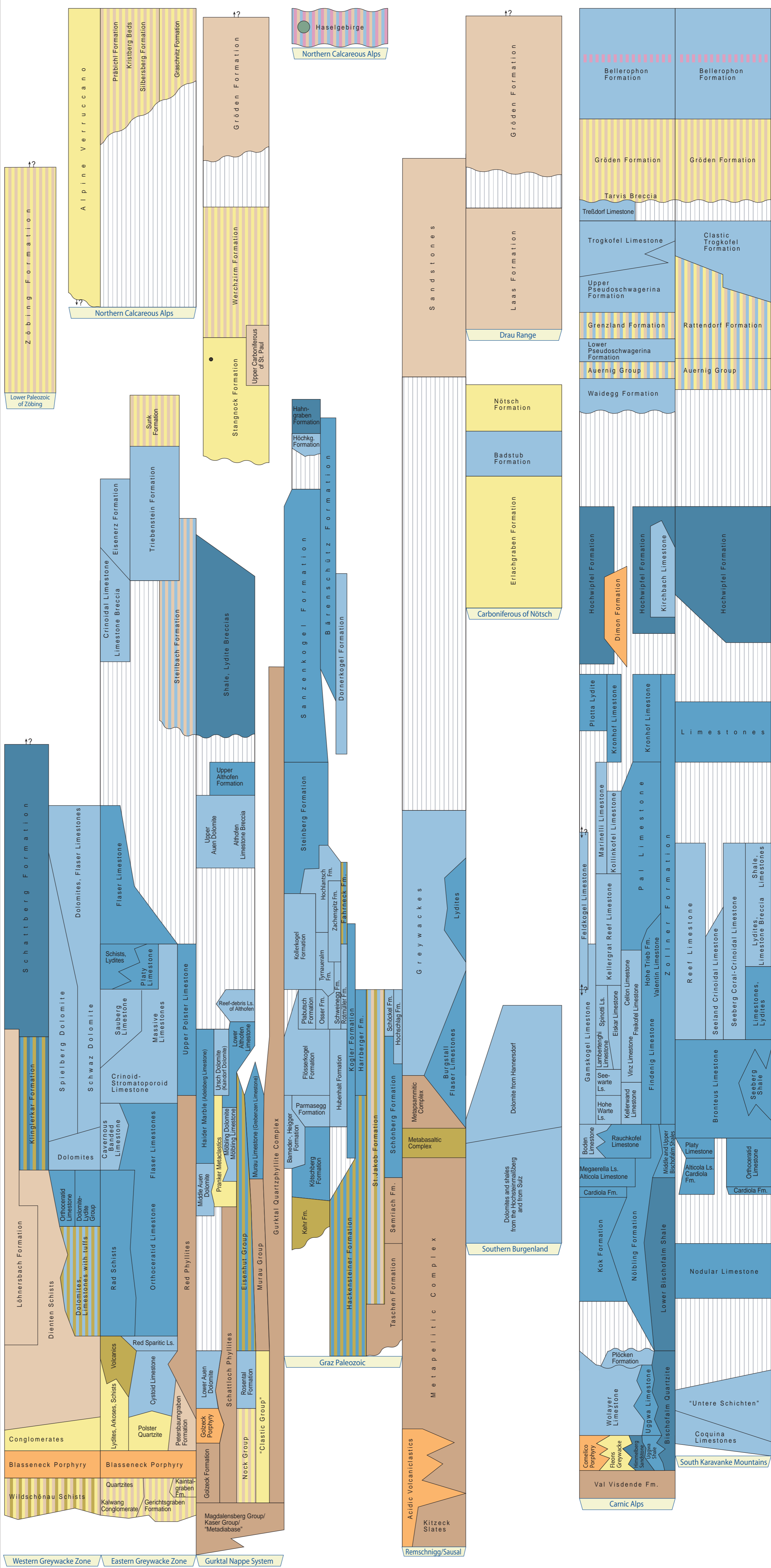
# Austrian Stratigraphic Chart 2004 - Paleozoic

(sedimentary successions)

Austrian Stratigraphic Commission



ERA	SYSTEM / PERIOD / SERIES / EPOCH	STAGE / AGE	DURATION Ma	Global Classification					
				ERATHM / ERA	SYSTEM / PERIOD / SERIES / EPOCH				
PALEOZOIC	PERMIAN	CHANGHSINGIAN / Dorashanian	251	PERMIAN	MID PERMIAN / GUADALUPIAN / LOPINGIAN				
		WUCHIAPINGIAN / Dzhulfian	255						
		CAPITANIAN	260						
		WORDIAN	265						
		ROADIAN	270						
		PERMIAN	LOWER PERMIAN / CISURALIAN			KUNGURIAN	275		
						ARTINSKIAN	280		
						SAKMARIAN	285		
						ASSELIAN	290		
		PERMIAN	TRIAS			GZHELIAN	295	TRIAS	U. CARBONIFEROUS / PENNSYLVANIAN
KASIMOVIAN	300								
MOSKOVIAN	305								
BASHKIRIAN	310								
PERMIAN	LOWER PERMIAN / CISURALIAN			SERPUKHOVIAN	315				
				VISEAN	320				
				TOURNAISIAN	325				
PERMIAN	DEVONIAN			FAMENNIAN	330	DEVONIAN	UPPER DEVONIAN		
				FRASNIAN	335				
				GIVETIAN	340				
		EIFELIAN	345						
		DEVONIAN	LOWER DEVONIAN	EMSIAN	350				
				LOCHKOVIAN	355				
		PERMIAN	DEVONIAN	LUDFORDIAN / GORSTIAN	359.2			DEVONIAN	MIDDLE DEVONIAN
				HOMERIAN / SHEINWOOD	365				
				TELYCHIAN	370				
				AERONIAN	375				
RHUDDANIAN	380								
PERMIAN	LOWER DEVONIAN			HIRNANTIAN	385				
				LLANDOVERY	390				
PERMIAN	DEVONIAN			WEN-LOCK / LOW	395	DEVONIAN	LOWER DEVONIAN		
				WEN-LOCK / LOW	400				
				WEN-LOCK / LOW	405				
		WEN-LOCK / LOW	410						
		PERMIAN	LOWER DEVONIAN	WEN-LOCK / LOW	415				
				WEN-LOCK / LOW	420				
		PERMIAN	DEVONIAN	WEN-LOCK / LOW	425			DEVONIAN	LOWER DEVONIAN
				WEN-LOCK / LOW	430				
				WEN-LOCK / LOW	435				
				WEN-LOCK / LOW	440				
PERMIAN	LOWER DEVONIAN			WEN-LOCK / LOW	443.7				
				WEN-LOCK / LOW	445				
PERMIAN	DEVONIAN			WEN-LOCK / LOW	450	DEVONIAN	UPPER ORDOVICIAN		
				WEN-LOCK / LOW	455				
				WEN-LOCK / LOW	460				
				WEN-LOCK / LOW	465				
		PERMIAN	LOWER DEVONIAN	WEN-LOCK / LOW	470				
				WEN-LOCK / LOW	475				
		PERMIAN	DEVONIAN	WEN-LOCK / LOW	480			DEVONIAN	MIDDLE ORDOVICIAN
				WEN-LOCK / LOW	485				
				WEN-LOCK / LOW	490				
				WEN-LOCK / LOW	495				
PERMIAN	LOWER DEVONIAN			WEN-LOCK / LOW	500				
				WEN-LOCK / LOW	505				
PERMIAN	DEVONIAN			WEN-LOCK / LOW	510	DEVONIAN	LOWER ORDOVICIAN		
				WEN-LOCK / LOW	515				
				WEN-LOCK / LOW	520				
				WEN-LOCK / LOW	525				
		PERMIAN	LOWER DEVONIAN	WEN-LOCK / LOW	530				
				WEN-LOCK / LOW	535				
		PERMIAN	DEVONIAN	WEN-LOCK / LOW	540			DEVONIAN	UPPER CAMBRIAN
				WEN-LOCK / LOW	545				
				WEN-LOCK / LOW	550				
				WEN-LOCK / LOW	555				
PERMIAN	LOWER DEVONIAN			WEN-LOCK / LOW	560				
				WEN-LOCK / LOW	565				
PERMIAN	DEVONIAN			WEN-LOCK / LOW	570	DEVONIAN	MIDDLE CAMBRIAN		
				WEN-LOCK / LOW	575				
				WEN-LOCK / LOW	580				
				WEN-LOCK / LOW	585				
		PERMIAN	LOWER DEVONIAN	WEN-LOCK / LOW	590				
				WEN-LOCK / LOW	595				
		PERMIAN	DEVONIAN	WEN-LOCK / LOW	600			DEVONIAN	LOWER CAMBRIAN
				WEN-LOCK / LOW	605				
				WEN-LOCK / LOW	610				
				WEN-LOCK / LOW	615				
PERMIAN	LOWER DEVONIAN			WEN-LOCK / LOW	620				
				WEN-LOCK / LOW	625				



- 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

© Commission for the Paleontological and Stratigraphical Research of Austria (CPSA) of the Austrian Academy of Sciences and Austrian Stratigraphic Commission

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

The Austrian Stratigraphic Chart 2004 - Paleozoic is a supplement of:  
 Hubmann, B., Ebner, F., Ferretti, A., Kido, E., Krainer, K., Neubauer, F., Schönlaub, H.-P. & Suttner, T.J. (2014): The Paleozoic Era (them), 2<sup>nd</sup> edition. - In: Piller, W.E. (Ed.): The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions) - Vol. 1 - Abhandlungen der Geologischen Bundesanstalt, 66, 9-133, Wien.

Printing: Grasl Druck & Neue Medien GmbH, Bad Vöslau 2014

Landesmuseum Joanneum, OAW, Geologische Bundesanstalt, UNI GRAZ, OGG, Universität Wien, Naturhistorisches Museum Wien