Cardiola Formation

ANNALISA FERRETTI, HANS-PETER SCHÖNLAUB, CARLO CORRADINI, MARIA G. CORRIGA,
MONICA PONDRELLI, LUCA SIMONETTO & PAOLO SERVENTI

Österreichische Karte 1:50.000
Blatt BMN 197 Kötschach

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Foglio 018 Passo di Monte Croce Carnico
Foglio 031 Ampezzo
Foglio 032 Tolmezzo

Definition

Alternating black nautiloid limestone (wackestone-packstone), marl and shale.

Description

The Cardiola Formation is constituted by dark gray to black shales with limestone intercalations as thin, planar to hummocky-laminated fine-grained calcareous levels and calcisiltites. Orthoconic nautiloid conchs are quite abundant and commonly oriented parallel to bedding surface. A distinctive and spectacular *Cardiola*-dominated molluscan fauna, for which the formation was originally named, developed in association with cephalopods.

Fossil content

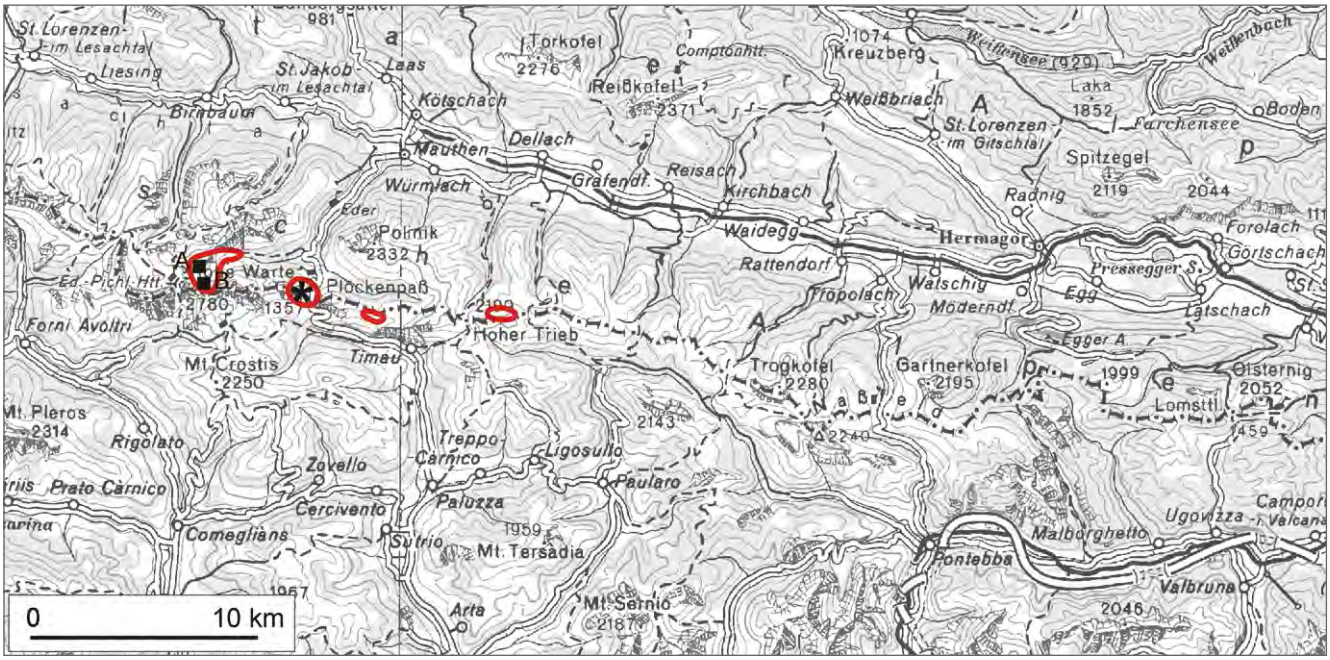
Acritarchs, bivalves, brachiopods, cephalopods, chitinozoans, conodonts, corals, graptolites, radiolarians, trilobites.

Depositional environment

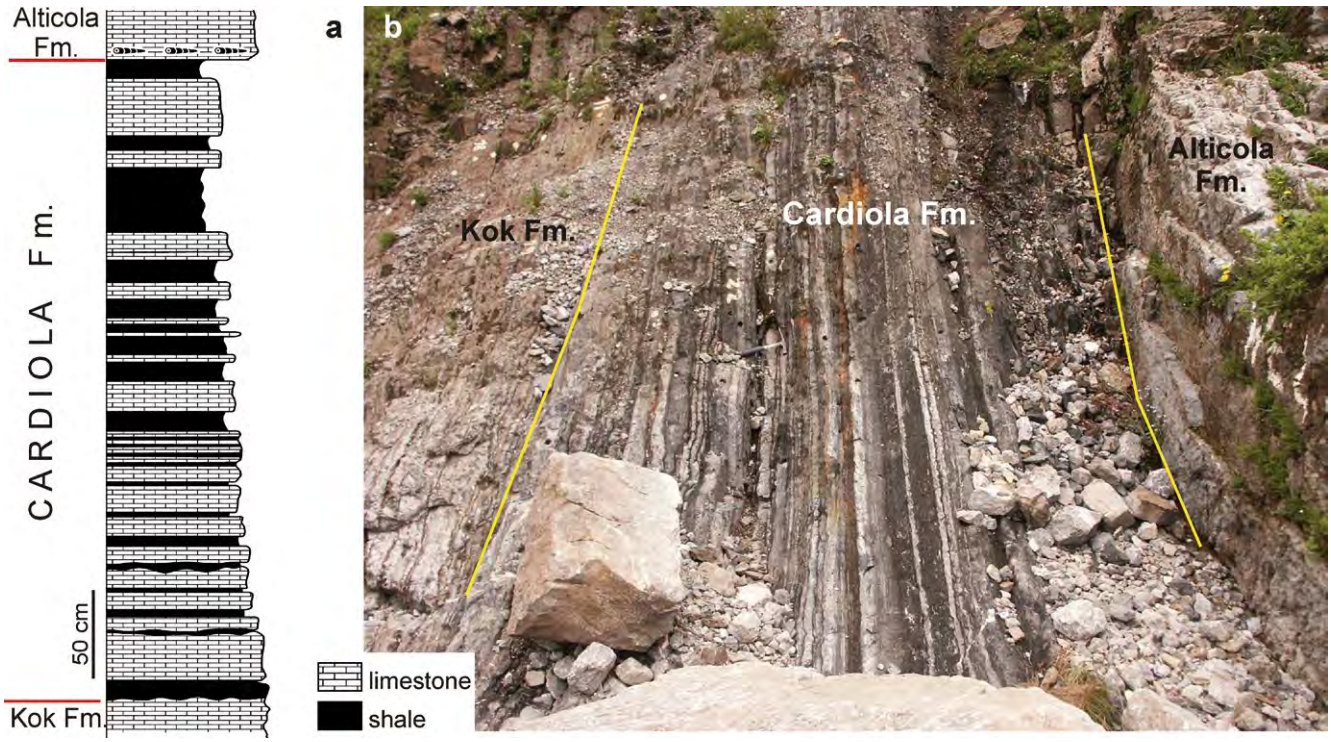
Moderately deep shelf.

Stratotype

Cellon Section (beds 20-24A in WALLISER, 1964), located in the eastern slope of Mt. Cellon/Creta di Collinetta, at coordinates N 46°36'32", E 12°56'30".



Main areal distribution of the Cardiola Formation in the Western Carnic Alps with indication of the stratotype (asterisk) and of the reference sections (squares). Asterisk: Cellon Section; A: Rauchkofel Boden Section; B: Lower Seewarte Base Section.



The Cellon Section. a) detailed log of the Cardiola Formation (modified after BRETT et al., 2009); b) overview photo of the Cardiola Formation (photo H.P. SCHÖNLAUB).

Reference sections

Lower Seewarte Base Section (SCHÖNLAUB, 1980), located in the southern flank of Wolayer valley at coordinates N 46°36'48", E 12°52'45", where a shallow-water facies is better exposed.

Rauchkofel Boden Section (SCHÖNLAUB, 1980) located on the southern slope of Mt. Rauchkofel at coordinates N 46°36'53.5", E 12°52'33.0", exposing contacts with underlying and overlying units in a shallow-water context.

Type area

Central Carnic Alps.

Main outcrop areas

The unit has been documented in Mt. Rauchkofel-Valentintörl, Mt. Cellon, Freikofel and Hoher Trieb areas.

Thickness

Thickness is variable, with a maximum value of ca. 3-4 m.

Boundaries

Underlying units – Kok Formation (conformable, sharp contact).

Overlying units – Alticola Formation (conformable, sharp contact).

Lateral units – Nölbling Formation.

Derivation of name

After the bivalve Genus *Cardiola* BRODERIP (in MURCHISON, 1839).

Synonymy

Untersilurische Schichten [partim]: STACHE (1874).
Cardiola-Horizont: STACHE (1874).
Grauer Plattenkalk: FRECH (1887).
Cardiola-Niveau: GEYER (1894).

Detail of the planar laminated fine-grained calcareous levels of the Cardiola Formation exposed in the Cellon Section (photo H.P. Schönlaub).

Cardiola-Schichten: Geyer (1894).
Bunte Flaser- oder Bänderkalke und Kalkphyllite des Obersilur [partim]: Geyer (1899).
Cardiolaniveau: Gaertner (1931).
Cardiola Beds: Schönlaub (1970).
Cardiola Beds: Schönlaub (1980).
Calcari a *Cardiola*: Vai et al. (2002).
Livello a *Cardiola*: Carulli (2006).

Chronostratigraphic age

Silurian: Ludlow (Ludfordian).

Biostratigraphy

Conodonts. – *Ancoradella ploeckensis-Polygnathoides siluricus* zones (Walliser, 1964; Corradini et al., 2015 and references therein).

Graptolites. – *M. bohemicus* group (Jaeger, 1975).

Chitinozoans. – ?*Angochitina elongata* Zone (Priewalder, 1997) (see remarks below).

Complementary references

Sequence stratigraphy. – Brett et al. (2007, 2009).

Taphonomy, sedimentology and microfacies analysis. – Flügel (1965); Kreutzer (1992); Ferretti & Histon (1997); Histon (2012, and references therein).

Paleocommunities. – Vai (1999).

Geochemistry. – Tietz (1976).

Isotopes. – Schönlaub (1994); Wenzel (1997); Jeppsson et al. (2012).

Remarks

The name Cardiola has been used for a long-time for this formation to document its peculiar bivalve association. Adaptation to the unique Silurian environment of the cephalopod limestone biofacies led in fact to the evolution of the Praecardiidina bivalves (*Cardiola* in primis), which became cosmopolitan in northern peri-Gondwana (Bohemia, Sardinia, Spain, Montagne Noire, etc.; Cope & Kříž, 2013). The paleogeographic significance of *Cardiola*-dominated communities makes the Cardiola Formation a distinctive marker interval for precise correlations outside the Carnic Alps (Jaeger, 1976).

Priewalder (1997) only tentatively referred the chitinozoan association from the upper part of the Kok Formation and the Cardiola Formation to the *Angochitina elongata* Zone (most of taxa were identified in open nomenclature).

References

BRETT, C., FERRETTI, A., HISTON, K. & SCHÖNLAUB, H.P. (2007): Eustasy and Basin Dynamics of the Silurian of the Carnic Alps (Austria). – Yangtze Conference on Ordovician and Silurian (June, 2007). Nanjing, China, 27 - 30 June 2007, Acta Palaeontologica Sinica, **46** (Suppl.), 43–49, Beijing.

BRETT, C., FERRETTI, A., HISTON, K. & SCHÖNLAUB, H.P. (2009): Silurian Sequence Stratigraphy of the Carnic Alps, Austria. – Palaeogeography, Palaeoclimatology, Palaeoecology, **279**/1–2, 1–28, Amsterdam.

CARULLI, G.B. (2006): Note illustrative della Carta geologica del Friuli Venezia Giulia, scala 1:150.000. – Regione Autonoma Friuli Venezia Giulia, Direzione Centrale Ambiente e Lavori Pubblici, Servizio Geologico Regionale, 44 p., Firenze.

COPE, J.C.W. & KŘÍŽ, J. (2013): The Lower Palaeozoic palaeobiogeography of Bivalvia. – In: HARPER, D.A.T. & SERVAIS, T. (eds.): Early Palaeozoic Biogeography and Palaeogeography. – Geological Society, London, Memoirs, **38**, 221–241, London.

CORRADINI, C., CORRIGA, M.G., MÄNNIK, P. & SCHÖNLAUB, H.P. (2015): Revised conodont stratigraphy of the Cellon section (Silurian, Carnic Alps). – Lethaia, **48**/1, 56–71, Oslo.

FERRETTI, A. & HISTON, K. (1997): Cephalopod Limestones. – In: SCHÖNLAUB, H.P. (ed.): IGCP-421 North Gondwanan Mid-Palaeozoic Biodynamics, Guidebook. – Berichte der Geologischen Bundesanstalt, **40**, 112–116, Wien.

FLÜGEL, H. (1965): Vorbericht über mikrofazielle Untersuchung des Silurs des Cellon Lawinenrisses (Karnische Alpen). – Anzeiger der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, **1965**, 289–297, Wien.

FRECH, F. (1887): Über das Devon der Ostalpen, nebst Bemerkungen über das Silur und einen palaeontologischen Anhang. – Zeitschrift der Deutschen geologischen Gesellschaft, **39**, 659–738, Berlin.

GAERTNER, H.R. von (1931): Geologie der Zentralkarnischen Alpen. – Denkschrift der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, Abteilung 1, **102**, 113–199, Wien.

GEYER, G. (1894): Zur Stratigraphie der pälaozoischen Schichtserie in den Karnischen Alpen. – Verhandlungen der kaiserlich-königlichen Geologischen Reichsanstalt, **1894**/3, 102–119, Wien.

GEYER, G. (1899): Über die geologischen Aufnahmen im Westabschnitt der Karnischen Alpen. – Verhandlungen der kaiserlich-königlichen Geologischen Reichsanstalt, **1899**/3, 89–117, Wien.

HISTON, K. (2012): The Silurian nautiloid-bearing strata of the Cellon Section (Carnic Alps, Austria): Color variation related to events. – In: FERRETTI, A., HISTON, K., MCLAUGHLIN, P.I. & BRETT, C.E. (eds.): Time-specific facies: the colour and texture of biotic events. – Palaeogeography, Palaeoclimatology, Palaeoecology, **367–368**, 231–255, Amsterdam.

JAEGER, H. (1975): Die Graptolithenführung im Silur/Devon des Cellon-Profils (Karnische Alpen). – Carinthia II, **165**, 111–126, Klagenfurt.

JAEGER, H. (1976): Das Silur und Unterdevon vom thüringischen Typ in Sardinien und seine regionalgeologische Bedeutung. – In: Franz Kossmat Symposium. – Nova Acta Leopoldina, NF **224**, 263–299, Leipzig.

JEPPSSON, L., TALENT, J.A., MAWSON, R., ANDREW, A., CORRADINI, C., SIMPSON, A.J., WIGFORSS-LANGE, J. & SCHÖNLAUB, H.P. (2012). – Late Ludfordian correlations and the Lau Event. – In: TALENT, J.A. (ed.): Earth and Life, International Year of Planet Earth, 653–675, Berlin-Heidelberg-New York (Springer).

KREUTZER, L.H. (1992): Photoatlas zu den variszischen Karbonat-Gesteinen der Karnischen Alpen (Österreich/Italien). – Abhandlungen der Geologischen Bundesanstalt, **47**, 1–129, Wien.

MURCHISON, R.I. (1839): The Silurian System Founded on Geological Researches in the Counties of Salop, Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester and Stafford; with Descriptions of the Coalfields and Overlying Formations. – John Murray, **32**, 768 p., London.

PRIEWALDER, H. (1997): The distribution of the Chitinozoans in the Cellon Section (Hirnantian – Lower Lochkovian) – A preliminary report. – In: SCHÖNLAUB, H.P. (ed.): IGCP-421 North Gondwanan Mid-Palaeozoic Biodynamics, Guidebook. – Berichte der Geologischen Bundesanstalt, **40**, 74–85, Wien.

SCHÖNLAUB, H.P. (1970): Vorläufige Mitteilung über die Neuaufnahme der silurischen Karbonatfazies der Zentralen Karnischen Alpen (Österreich). – Verhandlungen der Geologischen Bundesanstalt, **1970**, 306–315, Wien.

SCHÖNLAUB, H.P. (1980): Carnic Alps. Field Trip A. with contributions from JAEGER, H., HOUSE, M.R., PRICE, J.D., GÖDDERTZ, B., PRIEWALDER, H., WALLISER, O.H., KŘÍŽ, J., HAAS, W. & VAI, G.B. – In: SCHÖNLAUB, H.P. (ed.): Second European Conodont Symposium, ECOS II, Guidebook, Abstracts. – Abhandlungen der Geologischen Bundesanstalt, **35**, 5–57, Wien.

SCHÖNLAUB, H.P. (1994): Stable Isotope Data. – In: SCHÖNLAUB, H.P. & KREUTZER, L.H. (eds.): Field Meeting Eastern + Southern Alps, Austria, Guidebook + Abstracts. – Berichte der Geologischen Bundesanstalt, **30**, 88–89, Wien.

STACHE, G. (1874): Die paläozoischen Gebiete der Ostalpen. – Jahrbuch der kaiserlich-königlichen Geologischen Reichsanstalt, **24**, 135–274 (Heft II), 333–424 (Heft IV), Wien.

TIETZ, G.F. (1976): Petrographische und geochemische Untersuchungen an einer kondensierten Kalkbank des unteren Silurs der Karnischen Alpen (Österreich). – Verhandlungen der Geologischen Bundesanstalt, **1976**, 207–242, Wien.

VAI, G.B. (1999): Wenlockian to Emsian communities of the Carnic Alps (Austria and Italy). – In: BOUCOT, A.J. & LAWSON, J.D. (eds.): Paleocommunities - a case study from the Silurian and Lower Devonian. – World and Regional Geology Series, **11**, 282–304, Cambridge.

VAI, G.B., VENTURINI, C., CARULLI, G.B. & ZANFERRARI, A. (eds.) (2002): Alpi e Prealpi Carniche e Giulie (Friuli Venezia Giulia). – Guide Geologiche Regionali della Società Geologica Italiana, **9**, 390 p., Milano.

WALLISER, O.H. (1964): Conodonten des Silurs. – Abhandlungen des Hessischen Landes-Amtes für Bodenforschung, **41**, 1–106, Wiesbaden.

WENZEL, B. (1997): Isotopenstratigraphische Untersuchungen an silurischen Abfolgen und deren paläozeanographische Interpretation. – Erlanger geologische Abhandlungen, **129**, 1–117, Erlangen.