

The Hangenberg Crisis at the Devonian-Carboniferous Boundary (DCB) – a “bottleneck” for conodonts

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Highly diverse and abundant conodont faunal assemblages characterize the pre-Hangenberg Crisis phase in the *praesulcata* conodont Zone. Besides a stepwise faunal decline among several conodont taxa, sudden mass extinctions also can be recognized in the *costatus-kockeli* Interregnum (*ckl*), correlative with the global deposition of the Hangenberg Black Shale (KAISER et al. 2009). In pre-crisis times, around the boundary of the *expansa* and *praesulcata* zones, the conodont genus *Protognathodus*, the first representative of the family Idiognathodontidae, and the genus *Siphonodella*, the first representative of the family Elictognathidae, have their first appearance datum (FAD).

Siphonodella praesulcata, as well as rare *Protognathodus meischneri* and *Pr. collinsoni*, first occur during pre-crisis time. In impoverished protognathodid biofacies within pelagic limestone successions, the most abundant associated species are *Polygnathus purus purus* or *Po. communis*, marking the extinction-based *ckl*. *Protognathodus kockeli* and *Pr. kuehni* are important biostratigraphic markers found in limestones from different paleotectonic settings at the DCB. *Protognathodus kockeli*, whose precise FAD in the *kockeli* (= Upper *praesulcata*) Zone was recently discussed (CORRADINI et al. 2017; HARTENFELS & BECKER 2018; KAISER et al. 2019), phylogenetically evolved to *Pr. kuehni* at the DCB in the *sulcata/kuehni* (= *sulcata*) Zone.

A recent, detailed study of the ornamentation of the platform (cup), and shape (outline) of the cup of the early protognathodids (KAISER et al., work in progress) indicates a phyletic lineage among the typical morphotypes and their transitional forms, as suggested previously (ZIEGLER 1973; CORRADINI et al. 2011). However, the morphological complexity especially in intermediate forms between the four species has to be considered (KAISER et al. 2019). Furthermore, atypical morphologic characteristics among all four species exist regarding shape and ornamentation of the cup. For example, almost all diagnostic features regarding the typical shape of cup of one taxon can be applied to all other “ornamentation-types.” Similar problems concerning highly morphologic variability at the DCB were previously recognized for the siphonodellids (FLAJS & FEIST 1988). Therefore, seven morphotypes of *Si. praesulcata* and *Si. sulcata* were established (KAISER & CORRADINI 2011) in order to enable correlations and determinations based on conodont biostratigraphy at the DCB.

Morphotype groups, as previously established for the siphonodellids, also could be an important tool for the classification of early protognathodids. Morphotype groups and their correlative potential could be easily recognized in the recent study of KAISER et al. (in progress) of the protognathodids, and could serve as a basis for further discussions about a stable future criterion for the DCB GSSP.

Protognathodus kockeli, *Pr. kuehni* and *Siphonodella sulcata* can have a relatively wide geographic distribution (KAISER & CORRADINI 2011; CORRADINI et al. 2011; KAISER et al. 2019), but at the current state of knowledge, a conodont-based DCB definition requires an evaluation of the biozonation concepts proposed for example by CORRADINI et al. (2016) as well as further taxonomic studies due to rare, alternate or

diachronous first occurrences (FO) of index conodonts in some regions, but also due to a high spectrum of variable morphotypes. However, a fine-biostratigraphic subdivision of the Famennian-Tournaisian transition is needed in order to untangle the ultimate causes of major environmental changes and mass extinctions at the DCB. While the lineage of *Si. praesulcata* to *Si. sulcata* at the current GSSP La Serre (Montagne Noire, France) is probably an artifact created by reworked sediments (ZIEGLER & SANDBERG 1996; KAISER 2009), the lineage of *Pr. kockeli* to *Pr. kuehni* can be readily recognized in several undisturbed pelagic successions in the Rhenish Massif, Carnic Alps and Graz Paleozoic. Most importantly, maintaining a joint *sulcata/kuehni* conodont Zone is well applicable especially when one or the other taxon is missing (KAISER et al. 2019).

Early *Protognathodus* conodont faunas started to spread during and just after an episode of major environmental changes near the end of the Famennian, accompanied by mass extinctions among many faunal groups, known as the 1st order Hangenberg Biocrisis. In the *kockeli* and *sulcata/kuehni* zones, faunal recovery and radiations among different fossil groups started and affected are mainly the protognathodid and siphonodellid conodont faunas. Considering the high spectrum of morphotypes of the *Protognathodus* and *Siphonodella* faunas, which rapidly evolved in different regions worldwide during the late phase of the Hangenberg Crisis in the Lower Tournaisian *sulcata/kuehni* (= *sulcata*) Zone, the Hangenberg Crisis at the DCB can be regarded as a "bottleneck" for conodonts during a time of global anoxic events, climate, and sea-level changes.

- CORRADINI, C., KAISER, S.I., PERRI, M.C. & SPALLETTA, C. (2011): Conodont genus *Protognathodus* and its potential as a tool for defining the Devonian/Carboniferous boundary. - *Rivista Italiana di Paleontologia e Stratigrafia*, **117**: 15-28.
- CORRADINI, C., SCHÖNLAUB, H.P. & KAISER, S.I. (2017): The Devonian/Carboniferous boundary in the Grüne Schneid section. - *International Conodont Symposium 4, Valencia, 25-30th, June 2017*: 271-275.
- CORRADINI, C., SPALLETTA, C., MOSSONI, A., MATYJA, H. & OVER, D.J. (2016 online): Conodonts across the Devonian/Carboniferous boundary: a review and implication for the redefinition of the boundary and a proposal for an updated conodont zonation. - *Geological Magazine*, **154** (4): 888-902 [print version 2017, doi.org/10.1017/S001675681600039X].
- FLAJS, G. & FEIST, R. (1988): Index conodonts, trilobites and environment of the Devonian-Carboniferous boundary beds at La Serre (Montagne Noire, France). - In: FLAJS, G., FEIST, R. & ZIEGLER, W. (Eds.), *Devonian-Carboniferous boundary - Results of recent studies*. - *Courier Forschungsinstitut Senckenberg*, **100**: 53-107.
- HARTENFELS, S. & BECKER, R.T. (2018): Borkewehr near Wocklum (northern Rhenish Massif, Germany), a possible future Devonian/Carboniferous boundary GSSP section. - *Abstracts Geo Bonn 2018*: 252.
- KAISER, S.I. (2009): The Devonian/Carboniferous stratotype section La Serre (Montagne Noire) revisited. - *Newsletters on Stratigraphy*, **43**: 195-205.
- KAISER, S.I., BECKER, R.T., SPALLETTA, C. & STEUBER, T. (2009): High-resolution conodont stratigraphy, biofacies and extinctions around the Hangenberg Event in pelagic successions from Austria, Italy and France. - *Palaeontographica Americana*, **63**: 97-139.
- KAISER, S.I. & CORRADINI, C. (2011): The early siphonodellids (Conodonta, Late Devonian-Early Carboniferous): overview and taxonomic state. - *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **261**: 19-35.
- KAISER, S.I., KUMPAN, T. & RASSER, M.W. (2019, accepted): High-resolution conodont biostratigraphy in two key sections from the Carnic Alps (Grüne Schneid) and Graz Paleozoic (Troip) - implications for the biozonation concept at the Devonian-Carboniferous boundary. - *Newsletters on Stratigraphy*.
- ZIEGLER, W. (1973): *Catalogue of Conodonts*. - 504 pp.; Stuttgart (Schweizerbart).
- ZIEGLER, W. & SANDBERG, C.A. (1996): Reflexions on Frasnian and Famennian stage boundary decisions as a guide to future deliberations. - *Newsletters on Stratigraphy*, **33**: 157-180.