GSSP and Stratotypes

Redefining the Devonian-Carboniferous boundary: overview on problems and possible solutions

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The discussion where the Devonian-Carboniferous boundary (DCB) should be placed has a long tradition. The current boundary criterion and the GSSP at La Serre have become under critics already when they were defined, and the work of the last two decades have highlighted several problems. Findings of supposed Carboniferous taxa in Devonian strata (including the guide fossil) and taxonomic problems with the conodont lineage to define the DCB revived the discussions in the last years not only on the suitability of the GSSP section, but also on the criterion itself. Several diverging approaches exist for the definition of a DCB, but none of them offers an easy solution. Future work has to focus on detailed biostratigraphic work in different groups and should respect stratigraphic stability for the DCB. The profound changes in the latest Devonian – earliest Carboniferous biosphere culminated in the Hangenberg Event, which is found below, but not too far from the DCB. It is easily recognizable in many sections without specific knowledge in the taxonomy of a specific fossil group. Hence, the Hangenberg interval offers not only an alternative for a more or less accurate placement of the DCB, which is sufficient for many geologists, but the extinctions and appearances around the level offers a great potential for detailed biostratigraphic zonations, and thus a precise definition of the DCB.

Keywords: Devonian-Carboniferous boundary, Hangenberg event, conodont biostratigraphy.

High-resolution Carbon-isotope stratigraphy of the Cambrian–Ordovician GSSP: an enhanced international correlation tool

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Isotope curves delineating the $\delta^{13}C_{carb}$ and $\delta^{16}O$ variations across the Cambrian–Ordovician boundary at Green Point, western Newfoundland (Canada) are presented. The $\delta^{13}C_{carb}$ profile of the section reveals a composite (3 peaks) negative shift of ~ 6.0 ‰ and starts immediately at the base of bed 23 of the Broom Point Member. The $^{13}C_{carb}$ profile ties to conodont and graptolite zones and indicates that the lowest occurrence of planktic graptolites in Bed 25 largely coincides with the *C. lindstromi s.l.* conodont Zone i.e. below the *Iapetognathus*? conodont Zone.

Keywords: $^{13}C_{carb}$ isotope curve, trace-element geochemistry, Green Point Formation, Cambrian–Ordovician GSSP**.**

The Montalbano Jonico section (Southern Italy): a candidate for the GSSP of Ionian Stage (Lower-Middle Pleistocene boundary)

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The Early-Middle Pleistocene Subseries boundary and the Ionian Stage still lack formal ratification. The use of the name 'Ionian' as Stage of the Middle Pleistocene basically follows CITA *et al*. (2006; 2008) and GIBBARD *et al.* (2009). GSSP of the Ionian Stage should be defined at a point *close* to the Matuyama-Brunhes (M/B) reversal, in a marine section exposed on land. However, magnetic reversal is considered as *only one* of multiple criteria that may be used for GSSP's definition (HEAD *et al*., 2008). The Montalbano Jonico (Southern Italy) is a marine marly-clayey continuous succession, well exposed and astronomically calibrated, which extends from 1.24 Ma to 0.645 Ma (CIARANFI *et al*., 2010). It spans the interval from Marine Isotope Stage (MIS) 37 to 17/16 and covers, together with the Vrica section, the sedimentary record of the entire Calabrian Stage. The section encompasses MIS 19, whose base closely corresponds to the M/B boundary (LISIECKI & RAYMO, 2005); unfortunately the paleomagnetic reversal M/B was not identified in the Montalbano sediments (SAGNOTTI *et al.*, 2010). The isotopic signals are considered acceptable for definition of boundary stratotype (REMANE *et al*., 1996) and its practice has been recently adopted for the definition of the GSSP of the Serravallian Stage (HILGEN *et al*., 2009). The interval including MIS 19 is chronologically well constrained and a maximum flooding surface, evidenced by the occurrence of *Neopycnodonte* paleocommunity and the mesopelagic tropical-subtropical Atlantic teleostean *Bonapartia pedaliota* marks the base of the interglacial. Evidences of glacio-eustatic sea level rise, correlated with MIS 19 and M/B boundary, are well known in several geographic areas, supporting the wide traceability of this oxygen isotope shift. The onset of MIS 19 in the Montalbano Jonico section may represent an appropriate stratigraphic horizon for the definition of the GSSP of the Ionian Stage, also fulfilling additional indication of REMANE *et al.* (1996) for boundary stratotype definition, such as continuous sedimentation, high sedimentation rate, absence of synsedimentary disturbance and good preservation and protection of the section.

Keywords: GSSP of Ionian Stage (Lower/Middle Pleistocene boundary), Montalbano Jonico section (Southern Italy).

Stratigraphic distribution of the brachiopods in the proposed Toarcian GSSP at Peniche (Portugal)

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Brachiopods are abundant and diverse across the section of Ponta do Trovão (Peniche Peninsula, Portugal) that has been proposed as GSSP of the Toarcian Stage. They have been mentioned and partially described by several authors since the 19th century, but they were never described in detail. Exhaustive sampling in this section in the

last years allow the identification of 25 species belonging to four orders of brachiopods, ranging from the Spinatum Zone (Hawskerense Subzone) of the Pliensbachian to the Levisoni Zone of the Toarcian.
The taxa recorded in the Hawskerense Subzone are of clear NW European affinities. In the levels with *Pleuroceras hawskerense* (Young & Bird), the recognized brachiopods are *Liospiriferina rostrata* (Schlotheim), *Prionorhynchia serrata* (Sowerby), *Gibbirhynchia northamptonensis* (Davidson) and *Lobothyris punctata* (Sowerby). The presence of *P. serrata* is noteworthy, because this species is only known from South England but belongs to a typical Mediterranean genus that occurs occasionally in the NW European Province. In the beds with *Emaciaticeras-Canavaria-Tauromeniceras*, *L. rostrata* persists and *Quadratirhynchia* cf. *quadrata* Buckman, *Homoeorhynchia acuta* (Sowerby), *Lobothyris subpunctata* (Davidson) and *Zeilleria quadrifida* (Lamarck) appear. In the last levels below the Pliensbachian-Toarcian boundary and in the Mirabile Subzone, several species with a more restricted geographic distribution appear, such as *Cisnerospira* nov. sp., *Gibbirhynchia* aff. *reyi* Alméras & Fauré, *Gibbirhynchia cantabrica* García Joral & Goy or *Lobothyris arcta* (Dubar).
The most important episode or renewal takes place at the base of the Semicelatum Subzone, coinciding with the limit between the Lemede and the Cabo Carvoeiro formations, associated with a flooding event recorded in the basin. The response of the brachiopod fauna to this change is a marked decrease in the size of the taxa. Spiriferinids, for example, are all minute, and it is difficult to determine if they are separated species or miniaturized specimens of morphologically similar taxa known in neighboring basins, such as *L. falloti* (Corroy). Apart from spiriferinids, the most abundant and representative species are *Cirpa fallax* (Deslongchamps), *Zeilleria culeiformis* Rollier, *Nannirhynchia pygmaea* (Morris), *Koninckella liasina* (Bouchard) and *Pseudokingena deslongchampsi* (Davidson), the last being typical components of the so-called "Koninckella Fauna" often associated with organic-rich facies in several localities of Southern England and Normandy.
Diversity becomes very low in the top of the Semicelatum Subzone and brachiopods disappear from the record close to the Polymorphum – Levisoni zonal boundary, as happens in many other places in the Western Tethys. Their renewal is marked by the scarce record of *Soaresirhynchia bouchardi* (Davidson) several meters above that limit. Above this record, brachiopods are extremely scarce until the uppermost Bifrons Zone.

Keywords: Pliensbachian – Toarcian boundary, biostratigraphy, Lower Jurassic, Lusitanian Basin.

Thuoux and Saint-Pierre d'Argençon sections (Subalpine Basin, SE France): case studies of ammonite biostratigraphy for the potential candidate Callovian-Oxfordian GSSP

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The Thuoux and Saint-Pierre d'Argençon sections (Subalpine Basin, SE France) display a thick silty-clayey sedimentation with abundant and diversified ammonite faunas, free of detectable hiatuses. The Callovian-Oxfordian boundary is biostratigraphically located between the Lamberti and the Mariae Zones or, more precisely, between the Lamberti Subzone - *paucicostatum* horizon and the Scarburgense Subzone - *thuouxensis* horizon. The mixing of Boreal-Subboreal Cardioceratinae and Submediterranean-Tethyan Hecticoceratinae, Peltoceratinae and Perisphinctinae in this basin allows reliable world-wide correlations which enhance the choice of the Thuoux and Saint-Pierre d'Argençon sections as the Callovian-Oxfordian GSSP candidate.

Keywords: Callovian, Oxfordian, ammonites, biostratigraphy.

Calcareous nannofossil biochronology around the Callovian Oxfordian boundary of three potential GSSP candidate sections: Thuoux, Savournon and Saint-Pierre d'Argençon (SE France)

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A high resolution calcareous nannofossil analysis has been performed on three upper Callovian lower Oxfordian GSSP candiate sections from the subalpin basin (Thoux, savournon, St Perre d'Argençon; SE France) in order to test the reliability and precision of calcareous nannofossils as proxies for the C-O boundary. The results of this study indicate that the zonal marker species Stephanolition bigoti maximum, reported from the upper Lamberti to the Mariae ammonite zones in previous litearature, can be reliably identified only with accurate biometric measurements. In the french sections this subspecies is not occurring till the Precordatum subzone. The size increase of S. bigoti specimens observed across the Callovian-Oxfordian boundary was probably mixed up with genuine S. bigoti maximum, generating confusion in the calibration and correlation of this bio-horizon.

Keywords: Callovian, Oxfordian, GSSP, Subalpine Basin, bio-chronology.

Lower Moscovian conodonts and fusulinids: the position of the lower boundary of the Moscovian Stage (Pennsylvanian)

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The definition of the base of the Moscovian Stage is one of the high priorities of the Subcomission on Carboniferous Stratigraphy. This stage was established in 1890 by S.N. Nikitin in the Moscow Basin (Russia) According to the unified Carboniferous chart of the Russian Platform, the Moscovian consists of four substages: Vereian, Kashirian, Podolskian, and Myachkovian. In the stratotype region, the Lower Moscovian includes the Vereian and Kashirian. Most of the Vereian is a siliciclastic succession, and carbonate marine units occur only at its base and top. The younger Kashirian Substage is represented mainly by shallow water marine carbonates with an abundant and diverse marine fauna. Several subordinate siliciclastic units occur as well. The exact position of the base of the Moscovian cannot be defined properly in its type area, because the basal Vereian unconformably overlies Mississippian limestones or alluvial and lagoonal strata of the Aza Formation (uppermost Bashkirian). Today, the Moscovian Stage constitutes the Middle Pennsylvanian Series of the Carboniferous System, but a biostratigraphic marker and GSSP for it have not yet been designated. The Task Group to establish a GSSP close to the existing Bashkirian-Moscovian boundary suggested several potential markers among foraminifers and conodonts, but now the search for the base of the global Moscovian Stage marker near its traditional base has stalled and the most recent proposals have attempted to shift this boundary to a level within the middle or upper Bashkirian. In contrast, we suggest that it may be more productive to search for FADs of conodont species within the lower part of the traditional Moscovian that may have greater potential for boundary designation and international correlation. We have restudied the distribution of the lower Moscovian (Vereian and Kashirian substages) conodonts and fusulinids from the southwest Moscow Basin and the Oka-Tsna Swell. The greatest change in conodont assemblages does not occur at the base, but higher up in the Moscovian. The platform conodonts of the overlaying Kashirian Substage differ significantly in their morphology and taxonomy from Vereian conodonts. The Bashkirian genera *Declinognathodus* and *Idiognathoides* became exist close to end of the Vereian. The base of the Kashirian Substage, coinciding with the FAD of *Neognathodus bothrops,* would be an easier level for global correlation than the base of the Vereian Substage, the current level of the base of the Moscovian in the Moscow Basin. The analysis of the fusulinid shows that the Kasirian assemblage also differs

greatly from those of the Vereian. The FADs of *Taitzehoella* and *Hemifusulina* coincide with the lower boundary of the Kashirian in the type region of the Moscovian and were fixed almost simultaneously with the appearance of *Neognathodus botrops.* For the correlation purposes, the appearance of these genera is very useful and probably can be used as a markers or additional taxa for the difinition of the lower boundary of the Moscovian Stage.

Keywords: Middle Pennsylvanian, Moscovian Stage, GSSP, conodonts, fusulinids.

A potential Lower–Middle Pleistocene GSSP with excellent magnetostratigraphy along the west Pacific margin: the Chiba section, Central Japan

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The Chiba section in Japan represents a potential global boundary stratotype section and point (GSSP) for the Lower–Middle Pleistocene Subseries/Subepoch. The proposed GSSP is placed at the base of the Byakubi ash bed, a regional marker directly correlated to the Matuyama–Brunhes magnetic reversal which is the primary guide for the Lower–Middle Pleistocene boundary. The Byakubi ash bed occurs within the 2000-m thick Kazusa Group deposited in bathyal to shelf paleoenvironments during the Early and Middle Pleistocene. In addition to the numerous marine stratigraphies already studied, this section offers potential correlation to Chinese loess stratigraphy.

Keywords: Lower–Middle Pleistocene GSSP, Chiba section, Byakubi ash, Matuyama–Brunhes magnetic reversal.

Integrated biostratigraphy of calcareous nannofossils and ammonoids: implication for the definition of the stratotype of the Berriasian/Valanginian boundary (139.4 Ma ago)

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This work aims at identifying the Berriasian/Valanginian boundary (139.4 Ma) in three sections from South-East France (Vergol, Courchons, Berrias) by using an integrated biostratigraphy approach, and supports the proposition of the Vergol section as candidate for the Global Stratotype Section and Point (GSSP; BLANC *et al.,* 1994). The analysis of the distribution of calcareous nannofossils and ammonoids is used to construct a new

biochronstratigraphic frame. We used interval zones for establishing ammonoids and nannofossil biozones. The identification of Berriasian/Valanginian boundary is based on the first occurrence of *Tirnovella pertransiens* (OGG *et al*., 2012). Coccolith bioevents around the boundary are also helpful, like the first occurrence of *Percivalia fenestrata, Calcicalathina oblongata,* and *Zeugrhabdotus trivectis.* Changes in the assemblages of nannofossils and ammonoids are also used to reconstruct paleoenvironmental variations. A *Nannoconus* decline is identified in the Early Valanginian that corresponds to a perturbation of the carbon cycle occurring between the Early and Middle Valanginian.

Keywords: Calcareous nannofossils, Ammonoids, Integrated biostratigraphy, Berriasian/Valanginian boundary.

The advantages of giving the Bedoulian, lower substage of the Aptian, the rank of a full stage

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The amount of information available on the historical sections of the Bedoulian and Aptian *sensu stricto* (the sole Gargasian) and the preliminary results of on-going geochemical analyses on the Bedoulian type-area allow us to push forward our recent proposals of having the Bedoulian defined as a stage on its own, the Aptian reverted to its original definition, and of defining the GSSPs of both aforementioned stages at La Bédoule**.**

Keywords: Barremian, Bedoulian, Aptian, stage boundaries, GSSPs.

Integrated stratigraphy of the potential candidate Oxfordian GSSP at Thuoux and Saint-Pierre d'Argençon (France)

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The Thuoux and Saint-Pierre d'Argençon sections (Subalpine Basin, SE France) are proposed as a potential GSSP candidate for the Callovian-Oxfordian boundary. Several aspects of stratigraphy that have recently been applied in the two selected sections are discussed, including ammonite and nannofossil biostratigraphy, palynology, physical stratigraphy and cyclostratigraphy.

Keywords: Callovian, Oxfordian, GSSP, Subalpine Basin, biostratigraphy, chemostratigraphy, physical stratigraphy.

Russian GSSP candidate sections for the Jurassic System

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During the last decade three Russian sections were proposed as GSSP candidates for the Callovian, Oxfordian and Tithonian Stages. Comparison of these sections with other GSSP candidate sections in relations with their fulfillment of GSSP requirements has revealed that in some points Russian sections are better studied. The Kimmeridgian/Tithonan (Volgian) boundary transition is especially fully investigated at the Gorodischi section, which could be used as GSSP for the Tithonian Stage and SSSP for the Volgian Stage.

Keywords: Russia, GSSP, Callovian, Oxfordian, Tithonian.

Correlation between the type Chattian in NW Europe and the Rupelian/Chattian candidate GSSP in Italy

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The original type section for the Chattian stage is situated in NW Germany, i.e., in the southern part of the semi-enclosed North Sea Basin. A recent magneto- and biostratigraphic study from the eastern North Sea Basin allows a new correlation between sections in the original Chattian type-area and sections in central Italy. One of the Italian sections is the Monte Cagnero section, a proposed Global Stratotype Section and Point (GSSP) for the Chattian stage.
Our observations from the eastern North Sea and Denmark include a new method to identify NP zones in the mid-Oligocene of the North Sea Basin and confirm previous findings that a mid-Oligocene interval with the dinocyst *Svalbardella* in the North Sea Basin is synchronous with the global Oi-2b isotope cooling event as recognized in the Italian sections. However, we recorded the *Svalbardella* interval within the benthic foraminifera *Asterigerina guerichi guerichi* acme, a prominent North Sea Basin marker horizon. This points to a position of the Oi-2b *within* the lower Chattian deposits in the original type area and contradicts previous assumptions that the Oi-2b event correlates with an unconformity *below* the type-Chattian. Our new correlations are in agreement with recently published absolute datings, calcareous nannofossil zonation and the occurrence of *Svalbardella*. We suggest that the erosional base of the Chattian deposits in NW Europe is most probably synchronous with the global Oi-2a cooling event.

Keywords: *Svalbardella*, the Rupelian/Chattian boundary, the Oi-2a event, the Oi-2b event, GSSP.

On the proposed Oxfordian-Kimmeridgian (Upper Jurassic) boundary stratotype and its correlation potential

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The primary standard of the Oxfordian/Kimmeridgian boundary is the base of the Subboreal Baylei ammonite Zone which corresponds to the base of the Boreal Bauhini Zone as recognized in the proposed GSSP section at Staffin Bay, Scotland. The new data from the Submediterranean succession indicate that the boundary in question may be recognized fairly low within the so called "Submediterranean Upper Oxfordian", not far from the boundary of the Hypselum (Semiarmatum) Subzone/Zone and the Bimammatum Subzone/Zone. This makes progress in detailed correlation between a large part of the "Submediterranean Upper Oxfordian" and a lower part of the Boreal/Subboreal Lower Kimmeridgian which would result in changing of the Oxfordian/Kimmeridgian boundary position in Submediterranean-Mediterranean successions.

Keywords: Oxfordian/Kimmeridgian boundary, ammonites, zonal schemes, correlations.