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Workshop on the base of the Oxfordian Stage in the Subalpine Basin, France, 30th September to 2nd October 2013

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In order to examine new advances for the Callovian-Oxfordian boundary, and to provide further information for the selection of an Oxfordian GSSP, a workshop of three days was conducted in the French Subalpine Basin by the Groupe Français d'Étude du Jurassique (GFEJ) at the end of September 2013. The choice of a reliable section to define a Global boundary Stratotype Section and Point (GSSP) for the base of the Oxfordian Stage is rendered difficult in western European basins, due to: 1) the scarcity of available ammonite-rich continuous sedimentary successions that allow precise ammonite biostratigraphy and integration of ammonite taxa from various palaeobiogeographic provinces, and; 2) the presence of frequent hiatuses or condensed levels through the Callovian-Oxfordian transition. Among possibilities are the Subalpine Basin (SE France), where the Callovian-Oxfordian boundary is well identified and characterised in the Terres Noires Formation, and the Oxford Clay Formation near Weymouth (England), where more condensed sections show all biohorizons bracketing the boundary. Many years ago, the Savournon-Thuoux sections in the Subalpine Basin, and the Redcliff Point/Ham Cliff section near Weymouth (UK) were proposed as two potential candidates for the Callovian-Oxfordian GSSP (Page *et al.,* 2009; Fortwengler *et al.,* 2012), but no consensual decision has yet been taken (see detail of discussions in previous ISJS newsletters, *e.g.* Meléndez 2003, 2004, based on previous meetings organised in the Subalpine Basin in 1993, by the Groupe Français d'Étude du Jurassique (GFEJ), and by the then Oxfordian Working Group (OWG) of the International Subcommission on Jurassic Stratigraphy (ISJS) in 1994 (Atrops *et al*., 1993; Atrops, Meléndez, 1994).

This new excursion and workshop on the Callovian-Oxfordian boundary in the Subalpine Basin has permitted renewed discussions on several important points, including ammonite biostratigraphy, nannofossil biostratigraphy, palynological biostratigraphy, sedimentology, geochemistry, and geophysics, with the participation of Jurassic stratigraphers from various specialities. About twenty researchers were present, including members of the present Oxfordian Task Group and ISJS: C. Chateau (Univ. Bourgogne), P.Y. Collin (Univ. Bourgogne), G. Egoroff (Mus. Hist. Nat. Paris), R. Enay (Lyon), D. Fortwengler (La Bégude de Mazenc), B. Galbrun (Univ. Paris 6), S. Gardin (Univ. Paris 6), S. Hesselbo (Univ. Exeter), V. Huault (Univ. Lorraine), D. Marchand (Nice), G. Meléndez (Univ. Zaragoza), M. Martinez (Univ. Pau), N. Morton (Vogüé), K. Page (Univ. Plymouth), J. Pàlfy (Univ. Eötvös), Pierre Pellenard (Univ. Bourgogne), G. Price (Univ. Plymouth), J. Thierry (Dijon), J. Wright (Royal Holloway, Univ. London).

The objective of this field workshop was to revisit the previously studied Savournon and Thuoux sections, with reliable ammonite stratigraphic frameworks, proposed as potential GSSP candidates, together with two new sections in the Subalpine Basin (Saint-Pierre d'Argençon and Lazer), where the boundary and bracketed biozones are particularly well preserved. In the Subalpine Basin, the Middle to Late Jurassic transition, including tectonic, sedimentological,

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geochemical and biostratigraphical aspects, has been studied over several decades, in numerous well-exposed outcrops in the Diois, the Baronnies and the Buëch valley (*e.g.* Artru, 1972; Tribovillard, 1989; Dardeau *et al.*, 1994; Graciansky *et al*., 1999; Fortwengler, Marchand, 1994a–d; Fortwengler *et al*., 1997; Pellenard, 2003; Pellenard, Deconinck, 2006; Courtinat, 2006; Boulila *et al.*, 2008; Giraud *et al*., 2009; Boulila *et al*., 2010; Fortwengler *et al*., 2012; Pellenard *et al.,* 2013a). In many sections of this domain, numerous well-preserved ammonites provide an accurate biostratigraphy for the Middle to Late Jurassic transition. The four outcrops selected for the three days of the workshop (Thuoux, Saint-Pierre d'Argençon, Lazer and Savournon) are easy accessible, not affected by tectonics (major faults are absent) or strong diagenesis and metamorphism, and allow all ammonite biohorizons and subzones of the uppermost Callovian Lamberti Zone and basal Oxfordian Mariae Zone to be clearly identified. New data about micropaleontology (nannofossils, dinoflagellates), geochemistry ($CaCO_3$, $\delta^{13}C$, $\delta^{18}O$), physical stratigraphy (spectral gamma-ray measurements, magnetic susceptibility), and cyclostratigraphic interpretations based on analyses of these data have been presented for the Thuoux, Savournon, Saint-Pierre d'Argençon sections, allowing a detailed integrated stratigraphy around the Callovian-Oxfordian boundary to be proposed (Fig. 1).

The major stratigraphic features considered as advantages for a GSSP in the Subalpine Basin and discussed during the workshop are as follows:

Ammonite biostratigraphy: for the four sections presented, but also for other sections in the Subalpine Basin, where biostratigraphic features are similar and correlations easy, the biostratigraphic framework is accurately based on the succession of different ammonite species and genera. For all four sections, this precise biostratigraphic framework is shown in relation to the lithology (Fig. 1). Within the Lamberti Zone – Lamberti Subzone and the Mariae Zone – Scarburgense Subzone, which bracket the boundary, the corresponding biohorizons are clearly identified:

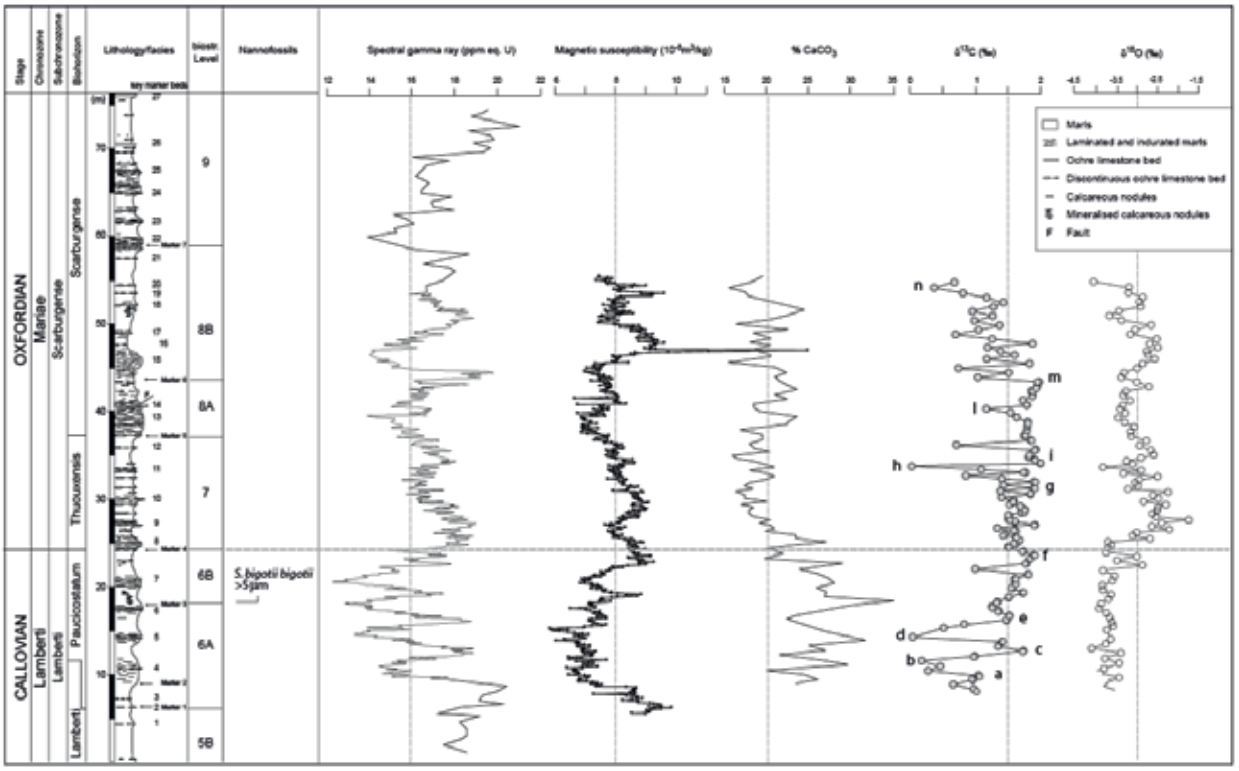

Fig. 1. Example of an integrated stratigraphy at Thuoux around the Callovian/Oxfordian boundary, including biostratigraphy, lithology, physical stratigraphy, and chemostratigraphy

Fig. 2. Photographs of the Callovian-Oxfordian boundary at Thuoux (left), and at Lazer (right), a new potential GSSP section, where participants actively debate on the boundary

1) the upper part of the Callovian (*lamberti* horizon) is characterised by scarce *Kosmoceras* and *Distichoceras* and always the clear presence of *Quenstedtoceras lamberti* (Sowerby), *Hecticoceras punctatum* Lahusen and *Poculisphinctes poculum* (Leckenby);

2) the uppermost part of the Callovian (*paucicostatum* horizon) is characterised by the total disappearance of Kosmoceratidae and the cohabitation of the last *Quenstedtoceras* cf. *lamberti* (Sow.) with the first *Cardioceras paucicostatum* Lange. In the upper part of that horizon, we notice abundant *Hecticoceras paulowi* (de Tsytovitch) and the first appearance of *Peltoceratoides eugenii* (Raspail);

3) The basal Oxfordian is characterised by the isochronal first appearance of true *Cardioceras scarburgense* (Y. & B.), *Hecticoceras* (*Brightia*) *thuouxensis* Fortwengler *et al.,* and *Peltoceratoides eugenii* morphe *eugenii.* This fauna characterises the *thuouxensis* horizon, the first biohorizon of the Scarburgense Subzone;

4) above, several changes in shell ornamentation are used to characterise the basal Oxfordian, in particular the secondary ribs of *Peltoceratoides eugenii* suddenly bifurcate lower on the flanks, and Hecticoceratinae macroconchs have softer ornamentation;

5) the first morphs close to *C. woodhamense* Arkell appear at the top of the Scarburgense Subzone. This species is not found with *C. scarburgense.*

Nannofossil biostratigraphy: The potential of nannofossil biohorizons as useful proxies for the Callovian-Oxfordian boundary has been tested by quantitative analysis and biometric measurements of key taxa. Results indicate that the marker species *Stephanolithion bigoti maximum*, defined as having "measurements exceeding 6x3µm", is not present in the boundary interval, although an increase in size reaching 5.50/5.60 µm of rim length occurs from the Paucicostatum Subzone, in coincidence with a positive carbon-isotope excursion. Thus, the recognition and utility of *S. bigoti maximum* as a marker for dating and correlating the C/O boundary interval depends on accurate biometric measurement.

Dinoflagellate, foraminifer and ostracod biostratigraphy: first results show the good quality of preservation and the very high richness of the organic residue, with abundant dark charcoal particles, but also spores and pollen, acritarchs, rare foraminifer linings and numerous dinoflagellate cysts. The Callovian-Oxfordian boundary is well defined, using dinoflagellate cysts, by the disappearance of *Durotrigia filapicata* Gocht at the top of the Callovian, and the occurrence of *Wanaea fimbriata* Sarjeant at the base of the Oxfordian. Investigations of dinoflagellate cyst assemblages in Thuoux follow the global trend described elsewhere in Europe. The richness of the samples in the Thuoux section and their good correlation with ammonite biozones could be of major interest to provide an additional biostratigraphic marker. Only two stratigraphically significant species of foraminifers have been identified:

Fig. 3. Some of the participants during the field workshop in the Subalpine Basin at the Lazer section (from left to right: Grégoire Egoroff, Mathieu Martinez, Jozsef Pálfy, Guillermo Meléndez, Kevin Page, Silvia Gardin, Pierre Pellenard, Pierre-Yves Collin, Didier Marchand, Bruno Galbrun, Dominique Fortwengler, Nicol Morton, Raymond Enay, Steve Hesselbo, John Wright, and Gregory Price; photograph by Vincent Huault)

Ophthalmidium compressum Ostenfeld and *O. strumosum* Gümbel. *O. compressum*, which disappeared during the *thuouxensis* Biohorizon, was replaced by *O. strumosum*, which appeared during the *paucicostatum* Biohorizon, and persisted into the *scarburgense* Biohorizon (Poulsen and Jutson, 1996). New data is currently under analysis for the Thuoux and Savournon sections. Preliminary research shows that ostracods are rare but nevertheless observed at Savournon (Tesakova, 2008).

Chemostratigraphy: the marlstone bulk-carbonate $\delta^{13}C$-record at the Thuoux section shows marked fluctuations, with values from 0‰ to 2‰ (Fig. 1). Although the values are quite scattered in some intervals, significant trends across the MLJ (Middle–Late Jurassic) boundary are discernible. This general pattern of the $\delta^{13}C_{carb}$ curve does not correlate with carbonate content and oxygen-isotope values, therefore mirroring, at least in part, the primary environmental signal. The ~1.5‰ increasing $\delta^{13}C_{carb}$ trend around the Callovian/Oxfordian boundary has already been documented in other sections and boreholes in France, Switzerland and elsewhere (Pellenard *et al*., 2013b). The $\delta^{13}C_{carb}$ positive shift to maximum values can thus be used as an auxiliary marker of the Callovian/Oxfordian (and MLJ) boundary.

Physical stratigraphy: high-resolution analysis of magnetic susceptibility and field spectral gamma ray measurements were performed on 700-m-thick Early-Middle Oxfordian marine marl of the Terres Noires Formation. Sub-Milankovitch to Milankovitch cycles are clearly identified, with the long-term eccentricity (405 kyr and 2 myr) being the most prominent. The 405 kyr cycle was used as a high-resolution geochronometer for astronomical calibration of this poorly constrained interval of Late Jurassic time. The astronomical calibration of the Mariae Zone indicates a duration of ~2.2 myr in this basin (Boulila *et al*., 2010). New high-resolution magnetic susceptibility analysis (every 8 cm) and spectral gamma-ray measurements (every 12 cm) spanning the Callovian-Oxfordian transition of the Thuoux and Saint-Pierre d'Argençon sections will allow astronomical calibration of the associated ammonite sub-zones and horizons, and assessment of variations in sedimentation rate. These physical parameters, combined with biostratigraphy, allow precise correlations within the Subalpine Basin and potentially with other sedimentary basins (*e.g*. Paris Basin).

Before preparing a proposal for the base-Oxfordian GSSP, the participants of the Terres Noires workshop plan to visit the English sections, especially Redcliff Point/Ham Cliff in the Weymouth district, during spring 2014 as proposed by K. Page and G. Meléndez. In parallel, members of the Oxfordian task group plan to make new investigations during spring 2014 on the Lazer section in the Subalpine Basin, little studied until now, in order to provide a detailed, accurate biozonation of ammonites, dinoflagellates, ostracods and nannofossils, completed by physical and geochemical studies. This latter section could be considered as the best place to define a GSSP in the Subalpine Basin. All interested researchers are cordially invited to provide contributions for this promising new section.

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