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The quest for the uniform Oxfordian/Kimmeridgian boundary

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Object: "The Kimmeridgian Stage was named by d'Orbigny at the half of the XIX century after the village of Kimmeridge on the Dorset Coast, but it was SALFELD (1913) who first defined the base of the Stage at the base of the Kimmeridge Clays corresponding to a marked change in the Aulacostephanidae ammonite family lineage – from the genus *Ringsteadia* to the genus *Pictonia*. According to that definition - the older genus *Ringsteadia* was indicative of the Pseudocordata Zone of the uppermost Oxfordian whereas the appearance of the genus *Pictonia* defined the base of the Baylei Zone of the lowermost Kimmeridgian. Although the definition seems perfect, it has born some inconveniences, however: (1) ammonites of the family Aulacostephanidae defining the boundary in question show limited palaeogeographic distribution being known mostly from a fairly small Subboreal Province of NW Europe; (2) the transition between genera *Ringsteadia* and *Pictonia* in the Dorset Coast is not continuous because of a stratigraphical gap at the base of the Kimmeridge Clays– hence a part of the succession at the Oxfordian-Kimmeridgian junction is not represented in these sections. Marked differences between the coeval ammonite faunas between the Subboreal ammonite succession in northwestern Europe and the Submediterranean and Mediterranean ammonites successions in middle and southern Europe resulted also in erroneous correlation of the Oxfordian-Kimmeridgian boundary standard in the past, which additionally complicated the problem. It should be remembered that the currently accepted Oxfordian-Kimmeridgian boundary in the Submediterranean-Mediterranean successions (base of the Platynota Zone or the Silenum Zone) runs about two ammonite zones higher (about 1.3 Ma) than the Subboreal standard (see Ogg et al., 2012, and the references given therein) " (Matyja and Wierzbowski, 2014).

The study undertaken in the Flodigarry section at Staffin Bay on the Isle of Skye, Scotland showed the continuous succession of the Subboreal and Boreal ammonites across the Oxfordian/Kimmeridgian boundary enabling recognition both the current standard Subboreal and Boreal zonations (Matyja et al., 2006; Wierzbowski et al., 2006). The study resulted in recognition of the boundary between the Oxfordian and Kimmeridgian stages at the Pseudocordata/Baylei zonal boundary (Subboreal) which corresponds precisely to the Rosenkrantzi/Bauhini zonal boundary (Boreal): this boundary corresponds to a newly distinguished *flodigarrienis* horizon which is characterized by the appearance of the first

Pictonia (*P. flodigarrienis* Matyja, Wierzbowski, Wright) together with first *Prorasenia* replacing an older assemblage of *Ringsteadia-Microbiplices* (Subboreal); the base of the horizon is also characterized by the first appearance of small-sized *Amoeboceras* (*Plasmatites*) (Boreal). Both the section and the horizon in question have been proposed as the site of the Global Stratotype Section and Point (GSSP) for the Oxfordian/Kimmeridgian boundary. It should be remembered, however, that the Oxfordian/Kimmeridgian boundary on the Dorset Coast runs somewhat higher (due to stratigraphical gap covering the *flodigarriensis* horizon) – at the base of the *densicostata* horizon which is characterized by appearance of a younger *Pictonia* species – *P. densicostata* (Salfeld). This horizon has been also recognized above the *flodigarriensis* horizon in the Flodigarry section on Skye (Matyja et al., 2006; Wierzbowski et al., 2006).

Formal arrangements (after documents): "The basal boundary of the Kimmeridgian Stage has been historically difficult problem because of faunal provincialism so that it became clear some time ago that the traditional Boreal/Subboreal boundary was significantly older than the Submediterranean/Mediterranean boundary…. Therefore, a vote was held within the Working Group, convenor Andrzej Wierzbowski, to use the Subboreal base of the Kimmeridgian as the level at which the GSSP should be placed and this was approved by a strong majority (67%) of the members of the Working Group. I decided that to avoid any future problems, the same proposition should be put to the Voting Members of the Jurassic Subcommision and was approved by even larger majority (77%)… Therefore, the base of the Kimmeridgian Stage should be defined at the base of the Baylei Zone" (Morton, 2007).

"Two successive votes were arranged in April 2007 within the KWG to resolve the two questions. The first vote asked "Do you accept the Flodigarry section at Staffin Bay of Skye (Scotland) as the Global Stratotype Section and Point for the base of the Kimmeridgian?". The results were as follows…. yes (77.7%), no (14.8%), abstain (7.4%). Following the result of the vote, the Flodigarry section at Staffin Bay of Skye has been accepted by the Kimmeridgian Working Group as the Global Stratotype Section and Point for the base of the Kimmeridgian. The second vote, concerning selection of the faunal horizon defining the base of the Baylei Zone, has not been unequivocally resolved" (Wierzbowski, 2007).

To summarize the current situation: "**The Kimmeridgian Working Group and the International Subcommision on Jurassic Stratigraphy have accepted the Subboreal base of the Kimmeridgian Stage (the base of the Baylei Zone) as the primary standard of the Stage – i.e. the level at which the base of the Kimmeridgian will be defined at the Global**

Stratotype Section and Point (both votes in November/December 2006). Subsequently the Kimmeridgian Working Group (vote in April 2006) accepted the Flodigarry section at Staffin Bay in northern Scotland, as location of the Global Stratotype Section and Point for the Kimmeridgian Stage. These are our achievements and in these points we are on firm ground" (Wierzbowski, 2008).

"The second vote concerning the selection of the faunal horizon defining the base of the Baylei Zone, i.e. the base of the Kimmeridgian Stage (April 2008), gave similar results to the first vote on that matter in April 2007, and it has not been unequivocally resolved. The proposed horizon (the *flodigarriensis* horizon) once more received a majority of votes (53.85%), but less than the preferred minimum (over 60%)... I do not see any chance in near future, however, to obtain a compromise in selection of the faunal horizon defining the base of the Baylei Zone. This is related with the main controversy – which of the two faunal horizons under question – the *flodigarriensis* horizon or the *densicostata* horizon has the better correlation potential" (Wierzbowski, 2008).

Selection of the horizon defining the base of the Kimmeridgian Stage: The recognition of the both indicated ammonite horizons (*i.e.* the *flodigarriensis* horizon and the *densicostata* horizon) as defined in the Flodigarry section of the Staffin Bay in Skye) has been done in many sections representing the Boreal and the Subboreal successions (*e.g.* in cores of the Nordkapp Basin in Barents Sea – Wierzbowski and Smelror, 1993; in the Mikhalenino and Makariev sections on the Russian Platform – Meseznikov et al., 1989; Głowniak et al., 2010). The position of the faunal horizons can be also approximately established on the basis of study of the Subboreal and Boreal ammonites occurring in the Submediterranean succession in central Europe (especially in Poland and southern Germany – see Matyja and Wierzbowski, 1994; Schweigert and Callomon, 1997; Matyja and Wierzbowski, 1997; Schweigert, 2000; Wierzbowski et al., 2010) as follows: (1) the *flodigarriensis* horizon corresponds to the lowermost part of the Bimammatum Subzone and Zone; (2) the *densicostata* horizon corresponds to some lower parts of the Hauffianum Subzone of the Bimammatum Zone.

The problem of selection of the most appropriate horizon for defining the base of the Kimmeridgian Stage can be solved in an unequivocal way only if one will prove which of the two Submediterranean levels shown above has a wider correlation potential: that close to the base of the Bimammatum Subzone and Zone, or that near the base of the Hauffianum Subzone of the Bimammatum Zone. It should be remembered that a marked change in the aspidoceratid faunas is recognized close to the boundary of the Hypselum Zone and the

Bimammatum Zone (Oloriz et al., 1999; Bonnot et al. 2009; Wierzbowski and Matyja, 2014 a,b): the assemblage of aspidoceratids typical of the Hypselum Zone represented by numerous *Euaspidoceras* and *Neaspidoceras* as well as earlier representatives of *Epipeltoceras* is replaced in upper part of this zone by a new assemblage with *Clambites*, and then in the Bimammatum Zone by *Aspidoceras*, *Physodoceras*, as well as last representatives of *Epipeltoceras.* On the other hand the base of the Hauffianum Subzone shows only minor changes in the oppeliid fauna having a smaller correlation potential. It results from the aforegoing that the *flodigarriensis* horizon as correlated with the base of the Bimammatum Zone has a wider correlation potential and may be treated as a more convenient for the recognition of the uniform Oxfordian/Kimmeridgian boundary, than the base of the *densicostata* horizon correlated with a lower part of the Hauffianum Subzone. It should be also remembered that "the recent study of the Subboreal aulacostephanids from southern England – i.e. their "home area" (Wright, 2010) – evidences the incompleteness of the succession at the boundary of the Oxfordian and Kimmeridgian in these sections, but indicates the presence of the *flodigarriensis* horizon in some basinal sections of the area, such as the Wessex Basin. Thus, the previously supposed local occurrence of an index species – the *Pictonia flodigarriensis* of the *flodigarriensis* horizon in northern Scotland only – used as argument against wider recognition of the base of the *flodigarriensis* horizon as a uniform Oxfordian/Kimmeridgian boundary, is not substantiated" (Wierzbowski, 2010a).

Assuming the results obtained:"although the detailed palaeontological and stratigraphical study of these ammonites in the crucial interval still needs further efforts, the results obtained so far are important for wider correlations. We need, however, new section documenting in detail the ammonite succession from the Hypselum to Bimammatum zones in the Submediterranean and Mediterranean areas, such as e.g. southern Spain, southern France, Italy or Romania. The necessity of such studies reveals the recent stratigraphical research on Spiti Shales in Nepal by Enay (2009) who recognized ["the endemic character of the Indo-SW Pacific forms which reduces possibilities for correlation and dating referring to the zonal standard scale established for Mediterranen Tethys and adjacent areas (op. cit., p.14)"]. It should be remembered, however, that the forms in common with Submediterranean and Mediterranean areas, appearing there (see Enay, 2009) are mostly aspidoceratids such as *Euaspidoceras*, *Clambites*, *Aspidoceras*, *Pseudowaagenia* and *Physodoceras* " (Wierzbowski, 2010a). This shows once more that the Oxfordian/Kimmeridgian boundary should be based on the horizon which offers possibility of wide correlation on the basis of phylogenetical changes within the aspidoceratid lineage, **and hence obviously favours the *flodigarriensis* horizon over the *densicostata* horizon.**

Recent results: The study of two sections in the Wieluń Upland (central Poland) – the Katarowa Góra section and the Bobrowniki section (Wierzbowski and Matyja, 2014 a,b) supported the correlation between the Submediterranean succession and the Boreal succession suggesting the correlation of the Hypselum/Bimammatum zonal boundary (Submediterranean) with the Rosenkrantzi/Bauhini zonal boundary (Boreal) – which corresponds to the base of the Kimmeridgian Stage. The Subboreal ammonites recorded in these sections indicate in their lowermost Kimmeridgian part strong similarity to those known from the Pomerania sections of in northern Poland – shown by common occurrence of such ammonite genera as *Vineta* and *Vielunia* (see Wierzbowski et al. 2010; Wierzbowski and Matyja, 2014 b; cf. also Dohm, 1925). These Subboreal ammonites are counterparts of the *Pictonia* ammonites known from NW part of the Subboreal Province – and the development of two parallel lineages of Subboreal Aulacostephanidae has been the consequence of a separation of north-western and south-eastern parts of the Subboreal Province during earliest Kimmeridgian (Enay, 1980, Wierzbowski, 2010 b). The recent study of the core sections from north-eastern Poland – the Peri-Baltic Syneclise – because of large number of ammonites collected – gives the basis for the stratigraphical interpretation and correlation of the Oxfordian and Lower Kimmeridgian deposits (Wierzbowski et al., 2015, in press). The study indicates the fluctuations in character of ammonite faunas (Boreal, Subboreal, Submediterranean) and makes possible the recognition of the Oxfordian/Kimmeridgian boundary.

The study of the stratigraphical interval at the Oxfordian/Kimmeridgian boundary in the Peri-Baltic Syneclise shows drastic changes in facies and thickness of deposits following the condensation and/or stratigraphical hiati, which bear witness to tectonic movements during the earliest Kimmeridgian (Wierzbowski et al., 2015, in press). Similar phenomena are reported over wider areas of northern Europe generally corresponding to the Subboreal Province – including the appearance of land barriers along the London-Brabant Massif and Ringkøbing-Fyn High which have been responsible for separate development of two branches of the Aulacostephanidae during earliest Kimmeridgian as discussed above. It should be mentioned that stratigraphical gaps at the Oxfordian/Kimmeridgian boundary as known from the Dorset Coast and Normandy sections are possibly related with the same tectonic event. In the sequence stratigraphical scheme – this unconformity seems close to the key-transgressive surface TS 23 in the Danish Basin and the Fennoscandian Border Zone, as well as possibly to the base of the genetic sequence stratigraphic unit J62 in the North Sea, showing thus a high correlation potential. What seems somewhat strange on the first moment – the presence of the same tectonic event can be recognized in the Wieluń Upland (central Poland). The event is marked here in a rather subtle way – but nevertheless a possible smaller stratigraphical gap at the Oxfordian/Kimmeridgian boundary - marked by abnormally high values of several chemical elements, but also manganese crusts found on the ammonite shells - is well proved. It occurs in the Bobrowniki section at the contact of beds C (uppermost Oxfordian) and bed B - in which lowermost part the Subboreal lowermost Kimmeridgian ammonites *Vineta* and *Vielunia* do occur (see Wierzbowski and Matyja, 2014a). This feature additionally confirms the value of the Submediterranean sections from the Wieluń Upland for recognition of the uniform base of the Kimmeridgian Stage.

Other stratigraphical data important for recognition of the uniform Oxfordian/Kimmeridgian boundary: There are several geological requirements important for defining the uniform boundary of the stages and their GSSP. The bulk of them in relation to the Oxfordian/Kimmeridgian boundary have been presented by Wierzbowski et al. (2006). Some of them are discussed separately in relation to new discoveries in the separate presentations during the Meeting (dinoflagellate stratigraphy by M. Barski; palaeomagnetism by J.Grabowski; isotope stratigraphy by H. Wierzbowski, as well as chemostratigraphy and palaeoecostratigraphy in relation to climatostratigraphy by J.Grabowski, K.Sobień, H.Wierzbowski, et al., and A. Wierzbowski, B.A.Matyja, J.Smoleń). Additionally, it should be mentioned that the Rhenium-Osmium (Re-Os) dating of black shale of the proposed Global Stratotype Section and Point for the Oxfordian/Kimmeridgian boundary placed at the base of the *flodigarriensis* horizon yields an age of 154.1+/- 2.2 Ma (Selby 2007).

References:

Bonnot A., Marchand D., Courville P., Ferchaud P., Quereilhac P., Boursicot P.Y., 2009 – Le genre *Epipeltoceras* (Ammonitina, Perisphinctaceae, Aspidoceratidae) sur le versant parisien de seuil du Poitou (France): faunes ammonitiques, biostratigraphie et biozonàtion de la zone à Bimammatum *pars* (Oxfordien supérieur). *Revue de Palébiologie, Genéve*, **28**, 2: 371-411.

Dohm B., 1925 – Ueber den oberen Jura von Zarnglaff i.P. und seine Ammonitenfauna. *Abhandlungen des Geologisch-Paläontologischen Instituts der Universität Greifswald*, **4**: 1-140.

Enay R., 1980 – Indices d'émersion et d'influences continentales dans l'Oxfordien supérieur – Kimméridgien inférieur en France. Interprétation paléogéographie et consequences palébiogéographiques. *Bulletin de la Sociéte Géologique de France, série 7*, **22** (4): 581-590.

Enay R., 2009 – Le faunes d'ammonites de l'Oxfordien au Tithonien et biostratigraphie des Spiti-Shales (Callovien supérieur – Tithonien) de Thakkhola, Népal Central. *Documents des Laboratoires de Géologie, Lyon*, **166.**

Głowniak E., Kiselev D.N., Rogov M., Wierzbowski A., Wright J.K., 2010 – The Middle Oxfordian to lowermost Kimmeridgian ammonite succession at Mikhalenino (Kostroma District) of the Russian Platform, and its stratigraphical and palaeobiogeographical importance. *Volumina Jurassica*, **8**: 5-48.

Matyja B.A., Wierzbowski A., 1994 – On correlation of Submediterranean and Boreal ammonite zonations of the Middle and Upper Oxfordian: new data from central Poland. *Geobios M.S.*, **17**: 351-358.

Matyja B.A., Wierzbowski A., 1997 – The quest for a unified Oxfordian/Kimmeridgian boundary: implications of the ammonite succession at the turn of the Bimammatum and Planula zones in the Wieluń Upland, central Poland. *Acta Geologica Polonica*, **47** (1/2): 77-105.

Matyja B.A., Wierzbowski A., 2014 – On the Oxfordian-Kimmeridgian (Upper Jurassic) boundary – current state of knowledge. *Beringeria Spec. Issue*, **8**: 111-112.

Matyja B.A., Wierzbowski A., Wright J.K., 2006 – The Sub-Boreal/Boreal ammonite succession at the Oxfordien/Kimmeridgien boundary at Flodigarry, Staffin Bay (Isle of Skye), Scotland. *Transcactions of the Royal Society of Edinburgh, Earth Sciences*, **96**: 387-405.

Mesezhnikov M.S., Azbel A.J., Kalacheva E.D., Rotkyte L.M., 1989 – The Middle and Upper Oxfordian of the Russian Platform. *Academy of Sciences of USSR, Stratigraphical Committee Transactions*, **19**: 1-158 (in Russian).

Morton N., 2007 - Chairman's Report, *International Subcommission on Jurassic Stratigraphy Newsletter*, **34**/2: 2.

Oloriz F., Reolid M., Rodriguez-Tovar E.J., 1999 – Fine-resolution ammonite biostratigraphy at the Rio Gazas – Chórro II Section in Sierra de Cazorla (Prebetic Zone, Jaén Province, southern Spain). *Profil*, **16**: 83-94.

Ogg J.G., 2012 – Jurassic: In: Gradstein F.M., Ogg J.G., Schmitz M., Ogg G. (eds): The Geologic Time Scale 2012: 731-794. Elsevier B.V.

Salfeld H., 1914 – Certain Upper Jurassic strata of England. *Quarterly Journal of the Geological Society of London*, **69**: 423-432.

Schweigert G., 2000 - Immigration of Amoeboceratids into the Sub-Mediterranean Upper Jurassic of SW Germany. *GeoResearch Forum*, **6**: 203-209.

Schweigert G., Callomon J.H.. 1997 – Der *bauhini*-Faunenhorizont und seine Bedeutung für die Korrelation zwischen tethyalem und subborealem Oberjura. *Stuttgarter Beiträge für Naturkunde, Serie B*, **247**: 1-69.

Selby D., 2007 – Direct Rhenium-Osmium age of the Oxfordian-Kimmeridgian boundary, Staffin bay, Isle of Skye, U.K. and the Late Jurassic time scale. *Norwegian Journal of Geology*, **87**: 291-299.

Wierzbowski A., 2007 - Kimmeridgian Working Group Report, *International Subcommission on Jurassic Stratigraphy Newsletter*, **34**/2: 18.

Wierzbowski A., 2008 - Kimmeridgian Working Group Report, *International Subcommission on Jurassic Stratigraphy Newsletter*, **35**/2: 15.

Wierzbowski A., 2010 a – On the Oxfordian/Kimmeridgian boundary and its GSSP – current state of knowledge. *Volumina Jurassica*, **8**: 177-181.

Wierzbowski A., 2010 b – Ammonites of the Subboreal Province in Europe at the turn of the Oxfordian and Kimmeridgian – *Earth Sciences Frontiers, spec. issue.*, **17**: 28-29.

Wierzbowski A., Matyja B.A. 2014a – On the proposed Oxfordian-Kimmeridgian (Upper Jurassic) boundary stratotype and its potential for correlation. In: R.Rocha et al. (eds): Strati 2013 – First International Congress on Stratigraphy, Lisbon 2013. At the cutting edge of stratigraphy: 287-290. Springer V.

Wierzbowski A., Matyja B.A. 2014b – Ammonite biostratigraphy in the Polish Jura sections (central Poland) as a clue for recognition of the uniform base of the Kimmeridgian Stage. *Volumina Jurassica*, **12** (1): 45-98.

Wierzbowski A., Smelror M., 1993 – Ammonite succession in the Kimmeridgian of southwestern Barents Sea, and the *Amoeboceras* zonation of the Boreal Kimmeridgian. *Acta Geologica Polonica*, **43** (3/4): 229-249.

Wierzbowski A., Coe A., Hounslow M., Matyja B.A., Ogg J.G., Page K., Wierzbowski H., Wright J.K., 2006 – A potential stratotype for the Oxfordian/Kimmeridgian boundary: Staffin Bay, Isle of Skye, U.K. *Volumina Jurassica*, **4**: 17-33.

Wierzbowski A., Głowniak E., Pietras K. 2010 – Ammonites and ammonite stratigraphy of the Bimammatum Zone and lowermost Planula Zone (Submediterranean Upper Oxfordian) at Bobrowniki and Raciszyn in the Wieluń Upland, central Poland. *Volumina Jurassica*, **8**: 49-102.

Wierzbowski A., Smoleń J., Iwańczuk J. 2015 – The Oxfordian and Lower Kimmeridgian of the Peri-Baltic Syneclise (north-eastern Poland): stratigraphy, ammonites, microfossils (foraminifers, radiolarians), facies and paleogeographic implications. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, July 2015 (in press).

Wright J.K., 2010 – The Aulacostephanidae (Ammonoidea) of the Oxfordian/Kimmeridgian boundary beds (Upper Jurassic) of southern England. *Palaeontology*, **53** (1): 11-52.

New data on the Kimmeridgian ammonite succession of the Boyarka section (north of Central Siberia) and the Arctic perspectives of the tracing Oxfordian – Kimmeridgian boundary

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The Levaya Boyarka section has been chosen as a reference for the Siberian Kimmeridgian and served for substantiation of ammonite, belemnite, bivalve and foraminiferal zonal successions (Sachs et al., 1969), which are later became a part of the Boreal Zonal Standard (BZS - Zakharov et al., 1997; Shurygin et al., 2011). However after 60^{th} this section was not re-studied in details and published data about ranges of fossils (especially ammonites) are controversial (Wierzbowski, Rogov, 2013). It should be noted that since the early studies by Mesezhnikov (1967, 1968) the Ox/Km boundary applied for the Siberia (and as a part of BZS for the whole Panboreal Superrealm) has been drawn at the base of the Kitchini Zone, which considered as coincided with the base of the Involuta Zone. Such a position of this boundary differ from those used in other Boreal Regions, which is lies one zone lower, at the base of the Bauhini (or Baylei) zone. Moreover, ammonite zonal succession used by Mesezhnikov (1969, 1984) for the Boyarka is partially based on eudemic and poorly known aulacostephanid taxa, and generally could not be used even in relatively nearby sections (coastal sections at the Laptev Sea and Western Siberia core sections). Figured ammonites providing possibilities for establishing of the cardioceratid succession of the Boyaka section, which is well corresponding to those of other Arctic areas (Wierzbowski, Rogov, 2013), but some details of cardioceratid succession remains unclear due to imprecise information about stratigraphic position of taxa and absence of any figured cardioceratids from the topmost part of the section. Here new results received from field works held in the year 2014 are summarized. Lowermost part of the section 22 including Oxf/Km boundary is inaccessible due to intensive covering of lower part of the section by glacial boulders, but some interesting ammonites were found in loose concretions, including *?Amoeboceras schulginae* and *Plasmatites* aff. *bauhini*. Upper half of the bed III (bed numbers are given after Sachs et al., 1969 if possible) is characterized by *Pictonia (Mesezhnikovia) ronkinae* and *Amoebites subkitchini*, the latter are also co-occurred with *P. (M.) involuta* and *P. (M.)* sp. nov. in the bed IV. Bed V and overlying Kimmeridgian strata are represented here by nearly homogenous member of dark-green sandstone. Lower portion of the bed V is characterized by succession *Amoebites* cf. *mesezhnikovi* - *A.* cf. *pingieforme*, which is well corresponding with known ranges of these species in Western Arctic; aulacostephanid ammonites co-occurred with these *Amoebites* belonging to eudemic Siberian species which could not used for direct correlation with other areas. Upper Kimmeridgian succcession was studied in the section 23. If its lowermost part is rich in ammonites (*Amoebites kitchini – Zenostephanus sachsi* assemblage), upwards concretions are mainly crowded by bivalves and/or fossil wood and devoid of ammonites, and aulacostephanids are entirely missing above the Mutabilis Zone. Uppermost part of the Kimmeridgian (Eudoxus and partially Taimyrensis Zone of Mesezhnikov) is characterized by cardioceratid assemblage including *Nannocardioceras anglicum* and, *Hoplocardioceras decipiens*, which could be easily compared with topmost cardioceratid assemblage of the Subboreal Eudoxus Zone of England, Polish Lowland and the Volga area. Unfortunately Km/Vlg transitional beds were covered by numerous landslides and boulders, and top of the "Taimyrensis Zone" was not sampled. New results derived from the Levaya Boyarka section have revealed two possibilities for the Ox/Km boundary: the first, appearance of *Plasmatites* which is used for this boundary in Western Arctic and Subboreal areas, could be easily traced eastwards to Western and Northern Siberia and should be preferred as easy traceable. Second widely correlated level, which is usually used as Ox/Km boundary by Siberian colleagues (Nikitenko et al., 2015), the base of the Kitchini / Involuta Zone, is also well-traced throughout the Arctic (including such areas as NE Russia, Russian Far East, and Alaska) by occurrence of small-sized semi-evolute *Amoebites bayi*, but in Subboreal succession this boundary fall within upper part of the Baylei Zone. This study has been supported by RFBR grants 15-05-03149 and 15-05-06183 as well as by the Programm of the Presidium of RAS no.II.3.

The ammonite fauna of the *bimammatum* biohorizon in SW Germany and its correlation value between Subboreal and Submediterranean biozonations

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The type of the microconchiate ammonite *Epipeltoceras bimammatum* (Quenstedt), the index of the Oxfordian Bimammatum Zone in the Submediteraneam biozonation and an important tool for long-distance correlations, comes from the Upper Jurassic of Swabia. Although its exact position within the sections was unknown for long time, a locality with a rich fauna of this age was found in the Danube valley near the small town of Mühlheim an der Donau. It was a single thin, slightly glauconitic limestone bed within a series of spongiolithic rocks. This bed and its fauna was termed as "Bimammatum-Horizont" already in the late 19th century and mainly exploited by several amateur palaeontologists. In the 1990ies this bed was rediscovered. Subsequently the *bimammatum* biohorizon was located in the section of the large Plettenberg quarry near the town of Balingen. There, this horizon comprises two subsequent limestone beds rich in ammonites. Thanks to this richness and intensive sampling acivities the ammonite diversity of the *bimammatum* horizon is well-known now and was recently described in a regional journal (Jantschke 2014). Concerning ammonoid diversity it is one of the richest horizons of the Upper Jurassic of Southern Germany. Predominant ammonoids are perisphinctids (*Orthosphinctes*, *Pseudorthosphinctes*, *Praeataxioceras*), oppeliids (*Taramelliceras*, *Lingulaticeras*, *Ochetoceras*, *Glochiceras*) as well as aspidoceratids (*Clambites*, *Epipeltoceras*, *Epaspidoceras*, *Aspidoceras*, *Pseudhimalayites*) of (Sub-)Mediterranean affinity. Besides (Sub-)Boreal faunal elements such as amoeboceratids and raseniids and, more rarely, even Tethyan phylloceratids (*Sowerbyceras*, *Holcophylloceras*) occur. The former are mainly represented by microconchs and a few macroconchs which can be determined as *Amoeboceras praebauhini* (Salfeld) and *A. rosenkrantzi* (Spath), respectively. They both morphologically and phyletically link the long-known amoeboceratid immigration of the elder *semimammatum* horizon of the Hypselum Subzone with that of the younger *bauhini* horizon of the Hauffianum Subzone. In addition, *Ringsteadia* and its microconchiate partner (*Microbiplices/Prorasenia*) are still present in this fauna. Coeval beds in Poland are much poorer in fossils and therefore these elements were thought to be already extinct or partly assigned to the new genus *Vielunia*. However, if *Ringsteadia* and *Microbiplices* from older beds of the Swabian Jurassic are accepted as truly representing these genera, there is no reason to suggest that the slightly younger forms of the *bimammatum* horizon should belong to different, palaeogeographically disjunct genera. Comparing amoeboceratids and raseniids from the *bimammatum* horizon with those of (Sub-)Boreal faunas, we do not agree with the actual suggestion of an Early Kimmeridgian age for the *bimammatum* horizon and older biostratigraphic levels in the Submediterranean.

References:

Jantschke, H., 2014 – Ammoniten aus dem *bimammatum*-Faunenhorizont im Weißjura (Malm, Oxfordium) der Schwäbischen Alb. – *Jahreshefte der Gesellschaft für Naturkunde in Württemberg*, **170** (1): 205-243.

Ammonite biostratigraphy of the Oxfordian – Kimmeridgian transitional beds of Moscow, Kaluga and Ivanovo regions (central part of the European Russia)

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Central part of the European Russia and especially the Moscow region are well-known as a source of some types of ammonite taxa, which characterized the uppermost Oxfordian and lowermost Kimmeridgian (*Prorasenia mniovnikensis*, *Plasmatites zieteni*, *P. tuberculatoalternans*, *P. praebauhini* and *Amoeboceras rectinatoalternans*), but detailed information concerning the Oxfordian-Kimmeridgian transitional beds of this area is poorly known, and descriptions of key sections are not published yet. Here preliminary data about the ammonite distribution in three reference sections (Mocow region – Rybaki; Kaluga region – Lipitsy; Ivanovo region – Yakimikha) are presented. The full succession of the Ox/Km transitional beds is recognized in the Rybaki and Yakimikha sections, while in the Lipitsy section Kimmeridgian overlying Oxfordian with a gap.

Uppermost Oxfordian is relatively poor in ammonites, which are mainly small-sized (microconchs are strongly prevailed) and including the both late *Amoeboceras* (*A. freboldi, A. tuberculatoalternans* auct. non Nikitin) and aulacostephanids (*Ringsteadia/Microbiplites*). The beginning of the Kimmeridgian is marked by appearance of *Plasmatites*, which are mainly represented by specific morphotype characterized by poorly developed secondaries (*P. zieteni*) and could be tentatively ascribed to as *zieteni* horizon. These ammonites are co-occurs with uncommon *Plasmatites* close to *P. bauhini* and *P. praebauhini*. Typical *P. tuberculatoalternans* also could be found in this horizon. Aulacostephanid ammonites are mainly represented by inner whorls of *Pictonia* (Yakimikha) or *Prorasenia* (Rybaki and Lipitsy), while poorly preserved pieces of big-sized ammonites recovered from the same beds could be ascribed to as *Pictonia (Pomerania).* Above *Plasmatites* with poorly developed secondaries are missing, while typical *P. bauhini* and/or finely ribbed *P. lineatum* became common. In the strongly condenced Lipitsy succession Bauhini Zone is directly overlying by the uppermost Lower Kimmeridgian glaukonite sands with *Crussoliceras*, while Rybaki and Yakimikha sections are shown transition from Bauhini to Kitchini zones. The lowermost part of the Kitchini Zone is characterized in these sections by appearance of early *Amoebites* (*A. bayi*).

It should be noted that in all studied sections as well as in Mikhalenino (Glowniak et al., 2010) cardioceratids from the Ox/Km boundary beds and especially from the lowermost

Kimmeridgian are represented by small-sized specimens, sometimes occurred in abundance. Such mass ammonite records could be caused by Lilliput effect and/or reflect widespread changes in sedimentation leads to stratigraphic condensation.

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New Upper Oxfordian Localities in Moscow Region, Central Russia

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The study of the evolution and geographical distribution of Boreal Upper Oxfordian ammonites (especially cardioceratids) is difficult by the fact that the shells of ammonites are often preserved as flattened imprints. At the end of the XIX century in the Moscow region were several localities (Mnevniki, Myachkovo), which were known as a source of pyritized three-dimensional moulds of Upper Oxfordian ammonites (Iloviasky, 1903; Nikitin, 1916), but now these outcrops are not available for study. However, in the Moscow region in the vicinity of the town of Bronnitsy there are two new Upper Oxfordian localities, in which ammonites are represented by pyrite internal moulds with well-preserved aragonitic shell layers. This type of preservation allows us to study not only the sculpture and the cross-section of ammonite shells, but also rarely preserved details of the ammonites such as muscle scars and wrinkle layer. Aragonite from these shells is suitable for the study of paleotemperatures.

The first locality is near the village of Markovo on the left bank of the Moscow River, 3.5 km upstream from the bridge at Bronnitsy. It is available for study only in the winter, when the water level drops sharply due to the dams on the river. Upper Oxfordian clays of the Amoeboceras alternoides Zone crop out at the boundary of the winter water level in the river. Slightly below the water level bituminous shales belonging to its lower subzone (Ilovaiskii subzone, ca. 0,2 m) occurred.. There are numerous imprints and shells of *A. ilovaiskii* and *Subdiscosphinctes* spp in these layers. These bituminous shales are covered with dark weakly bioturbated shales, overlying by a layer of dense slightly micaceous clays contains numerous pyritized shells of ammonites *A.alternoides, A. transitorium, A.*cf. *alternans* and *Subdiscosphinctes* spp. The thickness of this layer which belongs to the A.alternoides Subzone does not exceed 20 cm, but the concentration of ammonites in it is very large. There are also belemnite rostra, shells of bivalves (*Grammatodon* spp., *Trautscholdia cordata*), gastropods (*Bathrotomaria, Dicroloma, Pictavia* и т.д.) and scaphopods (*Laevidentalium* spp.). This outcrop is located only 17 km from Myachkovo village, from which the holotype of *Amaltheus alternoides* (*Amoeboceras alternoides*) was described by S.N. Nikitin (1878). Ammonites from Markovo are almost identical to the holotype of *Amoeboceras alternoides* and stratigraphic position of this species is irrefutable. Therefore, the author considers it necessary to name the ammonite zone containing these ammonites precisely as the Amoeboceras alternoides Zone instead of Amoeboceras glosense.

The second outcrop is located 2 km upstream from the first, also on the left bank of the Moscow River near the village of Rybaki. Younger Upper Oxfordian deposits are exposed here, ranging from the Amoeboceras serratum Zone to the Oxfordian-Kimmeridgian boundary. A.serratum Zone is also available for study in the winter only, whereas overlying sediments including the Oxfordian-Kimmeridgian boundary can be studied throughout the year. The A.serratum Zone is composed of gray clays with a thickness exceeding 1 m. This locality is unusual not only due to very well preservation of ammonites (pyritized phragmocones with phosphorite body chambers), but also due to a high concentration of Aspidoceratidae (*Euaspidoceras* [M] and *Mirosphinctes* [m]). These ammonites are extremely rare in the boreal Upper Oxfordian. Their aptychi with a thick calcitic layer can be found together with these ammonites. Perisphinctids *Dichotomoceras* sp., which are ordinary to the A.serratum Zone in many localities (e.g. Mikhalenino in Kostroma region) are rare. In both localities near Bronnitsy microfossils are numerous, especially foraminifera.

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Dinoflagellate cyst biostartigraphy of Oxfordian/Kimmeridgian boundary in Central Poland- preliminary report

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Organic walled Dinoflagellate cyst were used as supporting biostratigraphical tool to approach Oxfordian/Kimmeridgian boundary along Łobodno and Bobrowniki sections in the Wieluń Upland, central Poland. This group of marine microfossils has promising capacity to recognize the stratigraphic boundaries due to tight correlation of marker species ranges with ammonite fauna, especially for Boreal Province (e.g. Riding and Thomas, 1992; Poulsen and Riding 2003).

Since several palynological samples collected from limestone layers of section in question were barren, selected samples from cherts had been finally studied. Two samples from the uppermost part of Łobodno section and one from the lowermost part of Bobrowniki section yielded well preserved, relatively diversified and moderately abundant Dinoflagellate cyst assemblages including important stratigraphical taxa.

The most abundant taxa within Dinoflagellate cyst assemblages includes: *Systematophora areolata, Dingodinium tuberosum, Pareodinia ceratophora, Barbatacysta* sp., *?Occisucysta balios, Cribroperidinium globatum, Glossodinium dimorphum, Cribroperidinium granuligerum, Leptodinium subtile, Scriniodinium crystallinum, Scriniodinium galeritum, Aldorfia dictyota, Gonyalucysta jurassica jurassica, Tubotuberella apatela, Epiplosphaera gochtii.*

The ages of the samples are constrained through comparisons with well known Dinoflagellate cyst ranges (e.g. Riding and Thomas, 1992; Poulsen and Riding 2003; Barski et al.2005). According to stratigraphical distribution of selected age diagnostic Dinoflagellate cyst species, the samples can be assigned to the uppermost Oxfordian-lowermost Kimmeridgian and represent the Pseudocordata/Rosenkrantzi to Baylei/Bauhini zones interval of Subboreal/Boreal zonal scheme.

However absence in studied samples of *Tenua hystrix, Egmontodinium polyplacophorum* and *Senoniasphaera jurassica*, which are typical for Baylei Zone, could tentatively indicate position of uppermost Oxfordian. It should be also noted that the latter species inception occurs within precisely defined by ammonite fauna Baylei Zone in Bartoszyce IG 1 and Kcynia IG 4 from northern Poland (Barski et al.2005).

Other palynological samples from cherts are characterized by scarce recovery and poor preservation. It consists of few no age diagnostic terrestrial palynomorph taxa.

References:

Barski M., Matyja B.A., Wierzbowski A., 2005 – The ammonite-dinocyst subdivisions correlation at the Oxfordian/ Kimmeridgian boundary in the Bartoszyce IG 1and Kcynia IG IV cores from northern Poland. – *Tomy Jurajskie*, **3**: 87-96 (in Polish).

Poulsen N.E., Riding J.B., 2003 – The Jurassic cyst zonation of Subboreal Northwest Europe. *Geological Survey of Denmark and Greenland Bulletin* **1**: 115-144.

Riding J.B., Thomas J. E., 1992 – Dinoflagellate cysts of the Jurassic System. In: Powell, A. J. (Ed.), A stratigraphic index of dinoflagellate cysts. Chapman and Hall, London, pp. 7-97.

Magnetostratigraphy of the Oxfordian/Kimmeridgian boundary and investigations in Polish sections

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Magnetostratigraphy is a method which might be very helpful in correlating sedimentary rocks from different faunal realms (see Grabowski 2011 for review). However, the pattern of magnetic reversals around the Oxfordian/Kimmeridgian boundary is poorly recognized. The problem arises from poor quality record and low amplitude of linear magnetic anomalies in oceans , especially between M25 to M29 (Tominaga and Sager 2010). The low amplitude anomalies are very numerous in that interval and there are even doubts if they represent true reversals of geomagnetic field or rather paleointensity fluctuations (Cande et al. 1978; Tominaga et al. 2008). The presence of reversals were finally proved from land sections data (Ogg et al. 1984; Przybylski et al. 2010), however, duration of magnetozones is extremely short: between 0.1 and 0.3 My, which requires sections with sufficiently high sedimentation rate, as a goal for magnetostratigraphic study. The boundary is situated at the top of M27n which is correlated with the Pseudcordata/Baylei zonal boundary (Subboreal) and the Rosenkrantzi/Bauhini zonal boundary (Boreal). This boundary has been correlated with the upper part of Submediterranean Bimammatum ammonite Zone after Przybylski (2010) who studied the sections from the Wieluń Upland, Poland, including especially the Bobrowniki section. The problem with identification of the boundary in question arises, however, additionally from the fact – that there are common stratigraphical gaps at the Oxfordian/Kimmeridgian boundary in the Subboreal province; additionally in well recognized and complete section of the Staffin Bay in Isle of Skye, Scotland (treated as the potential candidate for the GSSP of the Oxfordian/Kimmeridgian boundary) – the crucial interval directly at the boundary was unfortunately not sampled for magnetostratigraphic studies. Thus, assumed polarity pattern around the Oxfordian/Kimmeridgian boundary in the Subboreal-Boreal areas showing dominating normal polarity below, and the reversal polarity above (Przybylski et al. 2010)is not complete as it does not represent the whole stratigraphical interval at the boundary in question. To supplement the general knowledge on the palaeomagnetic pattern we studied the sections from the Wieluń Upland, central Poland which yielded ammonites showing the presence of the uppermost Oxfordian-lowermost Kimmeridgian. We report preliminary magnetostratigraphic results from the sections: Katarowa and the lowermost part of Bobrowniki quarry, which has not been studied by

Przybylski et al. (2010). The rocks reveal, however, extremely weak magnetization and diamagnetic magnetic susceptibility. The results of thermal demagnetization, rock magnetic properties as well as anhysteretic and isothermal remanent magnetization logs will be discussed at the background of geochemical data.

References:

Cande S.C., Larson R.L., Labrecque J.L., 1978 – Magnetic lineations in the Pacific Jurassic quiet zone. *Earth Planet. Sc. Lett.*, **41**: 434-440.

Grabowski J., 2011 – Magnetostratigraphy of the Jurassic/Cretaceous boundary interval in the Western Tethys and its correlation with other regions: a review. *Volumina Jurassica*, 9, 105-128.

Gradstein F.M, Ogg J.G., Smith A., 2004 – *A Geologic Time Scale 2004*. Cambridge University Press, 589 pp.

Ogg J.G., Steiner M.B., Oloriz F., Tavera J.M., 1984 – Jurassic magnetostratigraphy, 1. Kimmeridgian-Tithonian of Sierra Gorda and Carcabuey, southern Spain. *Earth and Planetary Science Letters*, **71**: 147-162.

Przybylski P.A., Ogg J.G., Wierzbowski A., Coe A.L., Hounslow M.W., Wright J.K., Atrops F., Setteles E., 2010 – Magnetostratigraphic correlation of the Oxfordian-Kimmeridgian boundary. *Earth and Planetary Science Letters*, **262**: 267-288.

Tominaga M., Sager W.W., 2010 – Revised Pacific M-anomaly geomagnetic timescale. *Geophysical Journal International*, **182**: 203-232.

Tominaga M., Sager W.W., Tivey M.A., Lee S.M., 2008 – Deep-tow magnetic anomaly study of the Pacific Jurassic Quiet Zone and implications for the geomagnetic polarity reversal time scale and geomagnetic field behavior. *J. Geoph. Res.* 113.

Magnetostratigraphy of the proposed GSSP Flodigarry section: detailed data from bed 35, the Pseudocordata- Baylei boundary

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1) The base of magnetozone F2n.2n (correlated base of anomaly chron M27n, Fig. 3) is located between 235cm and 260cm below the base of bed 36. This interval coincides (within the sampling resolution) with the top of the R. pseudocordata Subzone at 240cm below bed 36.

2) The base of magnetozone F2r (base of correlated marine anomaly chron M26r; Figs. 3and4) is located between 128 and 148cm below the base of bed 36 (Fig. 5). The base of the P. densicostata Subzone (FAD of P. flodigarriensis) is located at 122cm below bed 36, so these two events are within less than ~25cm of each other. Using the marine magnetic anomaly scale in the 2012 timescale, this equates to an age difference of no more than ~30kyrs.

3) Therefore, the base of magnetozone F2r (and its correlated base of chron M26r) provide an ideal secondary marker for the base of the Kimmeridgian, allowing high-resolution correlation in marine and non-marine strata to this boundary interval.

Seawater temperatures and variations in $\delta^{13}C$ values of marine carbonates in European basins during and after the Middle–Late Jurassic transition (Late Callovian–earliest Kimmeridgian)

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Stable isotope values of well-preserved and stratigraphically well-dated carbonate fossils and bulk-carbonates from the Upper Callovian–Lower Kimmerdgian of the Polish Jura Chain, Russian Platform and the Isle of Skye in Scotland have been analyzed and compared with the published results. Similar $\delta^{18}O$ values of coeval belemnite rostra and benthic fossils point to the necto-benthic habitat of the belemnites studied (Wierzbowski, 2002; Wierzbowski et al., 2013). Belemnite $\delta^{18}O$ values show relatively constant temperatures (ca. 12°C) of bottom waters in the Polish Jura Chain basin during a major part of the Late Callovian–Middle Oxfordian, except for a short-term cooling (to ca. 9°C) at the Callovian–Oxfordian transition (Wierzbowski, 2002; Wierzbowski et al. 2009). Similar temperatures and the cooling in the earliest Oxfordian are reported from the Isle of Skye in Scotland (Nunn et al. 2009). The cooling is regional phenomenon, which is linked to the incursion of a cold bottom current during a sea-level rise. It is not observed in the area of the Russian Platform, where temperatures of bottom waters were lower (5-8.5°C) and relatively constant during the whole Late Callovian–Middle Oxfordian (Wierzbowski et al. 2013) . A significant increase in the bottom water temperatures calculated (by 4 to 9.5°C) is noted in all the basins studied during the Submediterranean Late Oxfordian or its time equivalent i.e. the Boreal Late Oxfordian–earliest Kimmeridgian. This phenomenon is linked to both the shallowing of the basins and the global climate warming. Significant admixture of freshwater input to the Middle Russian Sea may have also accounted for the overestimation of the Late Oxfordian–Early Kimmeridgian temperatures calculated from $\delta^{18}O$ values of Russian belemnite rostra (Wierzbowski et al., 2013).

New and published belemnite and brachiopod carbon isotope data point to the presence of metabolic fractionation of carbon isotopes in belemnite skeleton, which results in a depletion of belemnite calcite in ^{13}C isotope (Wierzbowski, 2002). Despite significant vital effect, belemnite rostra are considered to be a valuable tracer of temporal variations in the carbon isotope composition of oceanic dissolved inorganic carbon (DIC). Belemnite $\delta^{13}C$ data show the presence of two positive excursions in the Polish Jura Chain record – in the Upper Callovian and the Middle Oxfordian ($\delta^{13}C$ increase during these events to ca. 2‰ and ca.

1.5‰ VPDB, respectively; Wierzbowski, 2002; Wierzbowski et al. 2009). The excursions are divided by a Lower Oxfordian interval characterized by decreased $\delta^{13}C$ values (to. 0.5‰ VPDB). This is most likely a regional feature of peri-Tethyan and Tethyan isotope records not known from the (Sub)Boreal basins, where a long-term positive carbon isotope excursion comprising the entire Upper Callovian–Middle Oxfordian interval is observed (Nunn et al. 2009; Wierzbowski et al., 2013). The decrease in carbonate $\delta^{13}C$ values in the Lower Oxfordian of European Tethyan region is interpreted to have been caused by upwelling, which may have carried waters enriched in the ^{12}C isotope. The appearance of a mixed cold- and warm-water radiolarian assemblage as well as the presence of a diversified ammonite fauna in central European basins at that time confirms intensified seawater circulation (Matyja and Wierzbowski, 1995; Smoleń, 2002). Low belemnite $\delta^{13}C$ values, despite a difference in absolute values, are observed in the lower part of the Submediterranean Upper Oxfordian (in the upper part of Bifurcatus Zone and the Hypselum Zone) of the Polish Jura Chain and its chrostratigraphic equivalent i.e. the Boreal Upper Oxfordian (from the upper part of the Glosense Zone to the Rosenkrantzi Zone) in the Isle of Skye and the Russian Platform (Nunn et al. 2009; Wierzbowski et al. 2013). The low $\delta^{13}C$ values are linked to the well-mixed state of seawater in all the basins studied. The discussed time-period is characterized by a short-term migration event of Boreal ammonites into the Submediterranean ammonite province and mass-occurrences of small necto-pelagic haploceratid ammonites and radiolarians, which might have thrived in eutrophic waters (Matyja and Wierzbowski, 2000; Smoleń et al., 2014; Wierzbowski and Matyja, 2014).

The carbon isotope record of bulk carbonates from the Polish Jura Chain differs from those of belemnites and brachiopods probably because of a strong increase in carbonate production during the Oxfordian and changes in the origin of carbonate mud. As the Oxfordian acceleration of carbonate production is widely observed in Tethyan and peri-Tethyan basins, it may have affected carbon isotope record of bulk carbonates in this region.

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References:

Matyja, B.A., Wierzbowski, A., 1995 – Biogeographic differentiation of the Oxfordian and Early Kimmeridgian ammonite faunas of Europe, and its stratigraphic consequences. *Acta Geol. Pol.*, **45**: 1–8.

Matyja, B.A., Wierzbowski, A., 2000 – Biological response of ammonites to changing environmental conditions: an example of Boreal Amoeboceras invasions into Submediterranean Province during Late Oxfordian. *Acta Geol. Pol.,* **50**: 45–54.

Nunn, E.V., Price, G.D., Hart, M.B., Page, K.N., Leng, M.J., 2009 – Isotopic signals from Callovian–Kimmeridgian (Middle–Upper Jurassic) belemnites and bulk organic carbon, Staffin Bay, Isle of Skye, Scotland, *J. Geol. Soc. Lond.*, **166**: 633–641.

Smoleń, J., 2002 – Radiolarian faunas from the Late Callovian and Early Oxfordian deposits of the Kraków–Wieluń Upland, South Poland. *Ann. Soc. Geol. Pol.,* **72**: 145–161.

Smoleń, J., Wierzbowski, A., Iwańczuk, J. 2014 – Radiolarian horizon in the lowermost Kimmeridgian of the Peribaltic Syneclise and its palaeogeographic significance. In: A. Feldman-Olszewska and A. Wierzbowski (Eds): Jurassica XI Abstracts, Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, Warszawa, 59–60. [in Polish]

Wierzbowski, H., 2002 – Detailed oxygen and carbon isotope stratigraphy of the Oxfordian in Central Poland. *Int. J. Earth Sci. (Geol. Rundsch.)* **91**: 304–314.

Wierzbowski, A., Matyja, B.A., 2014 – Ammonite biostratigraphy in the Polish Jura sections (central Poland) as a clue for recognition of the uniform base of the Kimmeridgian Stage. *Vol. Jur.* **12**; 45–98.

Wierzbowski, H., Dembicz, K.. Praszkier, T., 2009 – Oxygen and carbon isotope composition of Callovian–Lower Oxfordian (Middle–Upper Jurassic) belemnite rostra from central Poland: a record of a Late Callovian global sea-level rise? *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **283**: 182–194.

Wierzbowski, H., Rogov, M.A., Matyja, B.A., Kiselev, D., Ippolitov, A., 2013 – Middle–Upper Jurassic (Upper Callovian–Lower Kimmeridgian) stable isotope and elemental records of the Russian Platform: Indices of oceanographic and climatic changes. *Global and Planetary Change* **107**: 196–212.

Palaeoenvironmental changes across the Oxfordian/Kimmeridgian transition (Upper Jurassic, Wieluń Upland, Central Poland): evidences from rock magnetism and inorganic geochemistry

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The results of an integrated magnetic and geochemical study of the Oxfordian/Kimmeridgian boundary interval in the Polish Jura Chain are presented. The deposits studied are bedded limestone-marly limestones of the sponge megafacies deposited in the deep neritic northern Tethyan shelf. The succession studied (two sections: Katarowa Góra and Bobrowniki), 24 m thick, is well dated based on ammonites mostly of Submediterranean affinity, with important contribution of Sub-Boreal and Boreal species at some levels. Magnetic susceptibility (MS), anhysteretic remanent magnetization (ARM) and isothermal remanent magnetization (IRM) were measured with high resolution along the succession. Additionally, contents of main, minor, trace elements and REE were determined. The study aimed to identify palaeoenvironmental perturbations related to Boreal ammonite excursions.

The content of non-carbonate material is very low. Al content typically varies between 0.04 – 0.15% only. The rocks studied are also extremely weakly magnetic. MS values are mostly negative (usually between -4 and -2 x 10^{-9} m^3/kg). Dominant magnetic mineral is magnetite, occasionally hematite and goethite are also present. MS correlates positively with lithogenic elements (Al, Ti, Zr and others) which indicates that it is mostly of detrital origin. Correlation of ARM and IRM with lithogenic proxies is a bit worse. This might account for authigenic origin of a part of magnetic minerals. Despite that a long term trend of decrease of detrital supply is clearly visible on both magnetic and geochemical curves. The trend is broken only at the Oxfordian/Kimmeridgian boundary represented by tectonically enhanced omission surface, with extremely high content of terrigenous elements and magnetic minerals.

Relatively high input of terrigenous material is observed in the intervals rich in Boreal and Subboreal ammonites (e.g. "*Amoeboceras* layer") which occur in the lower and upper part of the Hypselum Zone. These intervals reveal also relatively high values of ARM as well as Th/U and P/Al ratios, which points to oxic conditions of the bottom water and increased productivity. The observations are in good agreement with palaeoecological observations, which show mixed ammonite assemblage and suggest important influx of nutrient-rich waters. The latter resulted in the development of radiolarians. Within the upper part of the succession, in the uppermost part of the Hypselum and in the Bimammatum Zone, a marked decrease of detrital influx is observed. It is accompanied by lower values of magnetic indexes and stepwise oxygen depletion of bottom water (decrease of Th/U ratio). Productivity index (P/Al) reveals here high variations and attends its maximum values. It is concordant with the increased number of Submediterranean ammonites and abundance of Tethyan radiolaria. These phenomena might be related to diminished mixing of seawater and increased carbonate production either as a result of the long term warming trend, which is documented on the basis of belemnite $\delta^{18}O$ values, or local shallowing of the Polish Jura basin.

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The palaeobiological factors as a clue for recognition of the environmental-climatic conditions at the Oxfordian/Kimmeridgian transition (Upper Jurassic, Wieluń Upland, Central Poland)

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The studies at identifying the uniform boundary of the Oxfordian and Kimmeridgian stages within the Boreal, the Subboreal, and the Submediterranean successions in Europe have concentrated so far mostly on the precise correlation of the relevant ammonite zonal schemes. Recent study of two sections (Katarowa Góra and Bobrowniki) in the Wieluń Upland (central Poland) beside showing that the boundary in question lies close to the Submediterranean Hypselum/Bimammatum zonal boundary, has yielded new data on the variations in composition of the succeeding faunal assemblages. These variations seem to be environmentally/climatically controlled and are correlated with variations observed in elemental geochemistry being the subject of an independent presentation.

The deposits studied are the bedded limestone-marly limestone deposits of the sponge megafacies of the deep neritic northern Tethyan shelf. The ammonite faunas occurring here are mostly of the Submediterranean character, but the Boreal ammonites (Cardioceratidae: *Amoeboceras*) and bivalves (*Buchia*) as well as the Subboreal ammonites (Aulacostephanidae) become quite common at some levels. The longer term, as well as the shorter term faunal variations in the assemblages studied may be recognized –the former are especially well visible – and are commented herein. A prominent maximum of occurrence of the colder-water Boreal-Subboreal faunas is observed in the middle of a lower part of the succession (about 6-7 meters thick) of the Hypselum Zone of the uppermost Oxfordian – around the "*Amoeboceras* layer" (over 70% of Boreal cardioceratids). Another similar in thickness interval displaying increase (but a weaker one) in number of the Boreal-Subboreal faunal elements is recognized in the upper part of the Hypselum Zone. The deposits studied show also the occurrence of the radiolarian faunas – mostly of the Tethyan origin – but the representatives of the Boreal *Paravicingula* assemblage do occur in the "*Amoeboceras* layer". The occurrence of the Boreal-Subboreal ammonite assemblages in the Hypselum Zone of the uppermost Oxfordian could be related with activity of the sea-currents which additionally brought the nutrient-rich waters which enabled the development of the radiolarian assemblages. Action of sea currents along the existing sea-ways between the northern and southern areas of Europe, were stimulated by contrasted climate changes during the latest Oxfordian. The recognized fine siliciclastic supply – which is generally higher below, and declining upwards - within the uppermost Oxfordian studied - is in general agreement with such interpretation.

A marked change in faunal assemblages is observed in the upper part of the succession in question – in the lowermost Kimmeridgian (Bimammatum Zone). It corresponds to decline of a colder-water Boreal-Subboreal faunas, and the dominance of a warmer-water Submediterranean ammonites (Oppeliidae). Their dominance follows mostly a well developed tectonically enhanced omission surface – which is recognized also at the Oxfordian/Kimmeridgian boundary over vast areas of northern Europe – delimiting there two contrasted environmentally faunal assemblages. The dominant oppeliids are mostly small-sized necto-pelagic forms which occurrence along the Tethyan radiolarians indicate the presence of nutrient-rich waters, but also diminished mixing of seawater and partly anoxic conditions at the sea-bottom. It is in general accordance with a markedly decreasing siliciclastic material supply, general increase in the biogenic phosphorus content, as well as a decrease in the Th:U ratio, when compared with underlying uppermost Oxfordian deposits.

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Middle and Upper Jurassic record in the Western Sicily successions

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Middle-Upper Jurassic successions cropping out in western Sicily have been the subject of detailed sedimentological, stratigraphic and palaeontological studies over the last 15 years based on the analysis of ammonite associations. Studies are preferentially focused on the Bathonian-Tithonian chronostratigraphic interval. Some studied successions represent the type-locality of many ammonite species defined by G.G. Gemmellaro, while others have been known only in Sicilian geological literature.

The examined sequences were sedimented in different depositional environments (moderately deep external carbonate platform) called Domains, more precisely, the Trapanese and Saccense Domains (TP, Trapanese Domain and TD, Saccense Domain), which during the Middle-Upper Jurassic were located in the western sector of the Tethys. The Sicilian studied sequences may be regarded as highly condensed, Ammonitico Rosso facies, developed on epioceanic environments similarly as Baetic Chains (Sequeiros, 1974), Transdanubian Central Range in Hungary (Főzy and Meléndez, 1996; Főzy et al., 1997) and Western Greece.

The compared study of Callovian - early Tithonian ammonite successions in pelagic carbonate sequences across West Sicily show clear palaeobiogeographical differences not only between the Trapanese and Saccense domains, but also within the latter.

All the successions of the TD (Rocce del Calderaro, Sant'Anna and Erice Ter at Mt. Erice) and the SD (C.da Diesi, Cava Capraria, Stretta Arancio and Vallone San Vincenzo) show a Mediterranean-type fauna. It includes common representatives of suborder Phylloceratina and, among Ammonitina, the bulk of recorded associations is formed by representatives of Mediterranean subfamilies such as Passendorferiinae, Euaspidoceratinae and Peltoceratinae with a minor representation of family Oppeliidae.

The ammonite recorded associations from the C.da Diesi succession, belonging to the Saccense Domain, show a typical assemblage, ranging from lower to early middle Oxfordian (Antecedens Sub-Biozone, Plicatilis Biozone), composed by a reduced number of specimens but showing a clear predominance of representatives of subfamily Perisphinctinae over Passendorferiinae. Especially noteworthy are representatives of genus *Platysphinctes* and, in the last association of this assemblage, of *Tornquistes* spp. The low share of representatives of the typical tethyan group Phylloceratina marks a clear difference with similar associations from other near areas belonging to the Trapanese Realm where these typical tethyan groups are dominant. The upper assemblages instead show a typical mediterranean fauna, even if there are some dubious specimens of Perisphinctinae and, for the first time in the Sicilian faunas, a representative of genus *Clambites* has been found.

In all the studied sections the Middle Jurassic, recorded from the Upper Bajocian (Contrada Monzealese) throughout the Callovian (Vallone San Vincenzo), is characterized by the same Bositra limestone facies and reaches its maximum thickness at Vallone San Vincenzo and Cava ex-Capraria sections, whilst in the sections of Contrada Diesi and Stretta Arancio, instead, the sequences show a remarkeble reduction in thickness.

The Callovian-Oxfordian transition in Sicily was marked by a wide stratigraphic gap ranging presumably from Upper Callovian to Middle Oxfordian (upper Plicatilis Zone, Antecedens Subzone). However, this gap is not homogeneous and sometimes is more expanded and involves the entire Callovian (Stretta Arancio section) (Cusumano *et al.*, 2013).

The Oxfordian, represented always by *Protoglobigerina* limestone, is almost always poorly expanded in SD (approximately, 3 m at Cava ex-Capraria to about 40 cm at Stretta Arancio) and often indistinct due to the lack of markers. Only at Vallone San Vincenzo the Upper Oxfordian is clearly reported (Bifurcatus and Bimammatum Biozones). On the contrary in C.da Diesi and in all the successions of TD the ammonite record of Middle and Upper Oxfordian was more or less complete, whilst the sedimentary record shows the presence of frequent small stratigraphic gaps (D'Arpa, 2003; D'Arpa and Meléndez, 2006).

Based on the taphonomic study of the ammonites, a major discontinuity at the Oxfordian-Kimmeridgian boundary at Cava ex-Capraria has been recognized. It revealed the presence of a stratigraphic gap affecting the Platynota, Strombecki and the lower part of Divisum Biozones.

Even the Kimmeridgian, represented in all the Saccense Domain sequences by Saccocoma limestones, shows some variability in relation to the measured thickness, from, approximately, 9 m at Vallone St. Vincent to about 55 cm at Stretta Arancio, and a (relatively) greater abundance of specimens. It has been also possible to identify the Lower and the Upper Kimmeridgian at Contrada Diesi and at Cava ex-Capraria. In particular, in the latter location the recorded ammonite associations have allowed recognizing the top of the Divisum Biozone (upper part of the Lower Kimmeridgian) and the Acanthicum Biozone (basal part of the Upper Kimmeridgian).

The Tithonian, finally, is represented by more expanded deposits than those beneath, with abundant cephalopods but characterized by a considerable lateral variability. The maximum thickness is reached at Vallone San Vincenzo (23 m) and at Cava ex-Capraria (8.5 m) while at Stretta Arancio, the measured thickness of the unit does not overpass 40 cm. In these sequences the first appearance of calpionellids (*Calpionella alpina*, *Crassicollaria* sp.) marks the Lower-Upper Tithonian limit (Crassicollaria Zone).

The wide/significant vertical variations and the rapid lateral thinning of the layers, which are recorded in the studied localities (opp. in the localities under exam), may be linked to a different palaeotopographic position within the Saccense Platform, confirming the suggestion by Marino et al. (2002) based on a distribution of the pelagic sediments known as "panettone" model (Santantonio et al., 1996).

The data set out above, combined with the presence of angular unconformities or paraconformities present in corrispondence of the contact with the Inici Fm. deposits (and, thus, at the beginning of the drowning of the platform), suggest a fairly articulated structure of the Jurassic plateau composed/formed/made up of distinct sub-environments (Cusumano, 2012).

As it is known the western area of the Tethys, interested by carbonate sedimentation, was the subject of a general regression during the Callovian-Oxfordian transition and during the lower Oxfordian (Callomon, 1964). The presence of a sedimentary and paleontological record at the C.da Diesi section indicates that the Sciacca area was located in the outer area of the platform, only marginally affected by the regression.

The Mt. Erice succession has been instead interpreted as the expression of a distal sector of a ramp adjacent to the Trapanese carbonate platform, where subsequent changes in the sedimentary dynamic of the inner part of the ramp (a deepening or an emersion) would have enabled a pelagic sedimentation and where topographical differences, which occurred after the lower part of the Middle Oxfordian, would have caused lithological and taphonomic variations on a local scale (Martire and Pavia, 2002).

References:

Callomon J.H., 1964 – Notes on the Callovian and Oxfordian stages. Coll. Juras. Luxembourg, 1962; C.R. et Mem. Inst. Gd. Duc, Sect. Sci. Nat. Phys. et Math.: 269-291.

Cusumano A., 2012 – Sistematica, tafonomia e paleobigeografia delle associazioni ad ammoniti del Giurassico Medio e Superiore della Sicilia Occidentale, con particolare riferimento all'intervallo Calloviano-Kimmeridgiano. Tesi di Dottorato. Dipartimento di Scienze della Terra e del Mare (Di.S.T.e.M.), Università degli Studi di Palermo: 1-281.

Cusumano A., D'arpa C., Di Stefano P., 2013 – Biostratigraphical study of the Middle-Upper Jurassic ammonite association of Stretta Arancio's section (Southern Sicily, Italy). Progressive Palaeontology. Leeds 22nd-24th may 2013. Programme & abstracts.

Cusumano A., D'Arpa C., Di Stefano P., Melèndez G., 2012 – Jurassic ammonite associations from a section near Sambuca di Sicilia (Sciacca, Sicily). Giornate di Paleontologia XII edizione, Catania 24-26 maggio 2012. Volume dei riassunti.

D'Arpa C., 2003 – Studio delle associazioni ad ammoniti dell'Oxfordiano della Sicilia Occidentale. Tesi di Dottorato. Dipartimento di Geologia e Geodesia, Università degli Studi di Palermo: 1-258.

D'Arpa C., Meléndez G., 2006 – Oxfordian ammonites from Contrada Diesi (Sciacca, Sicily) a historical locality studied by Gemmellaro. Quad. Mus. G.G. Gemmellaro, **9**: 63-74.

Fözy I., Meléndez G., 1996 - Oxfordian ammonite from Hungary. *GeoResearch Forum*, 1-2: 187-194.

Fözy I., Peréz-Urresti I., Meléndez G., 1997 – Middle and Upper Oxfordian ammonite successions from the Transdanubian Central Range and from the Mecsek mountains (Hungary). Biostratigraphy and Palaeobiogeographic affinities. Comunicatión 4° Congreso de Jurásico de España. Alcaniz (Abstract volume): 69-72.

Marino M.C., Baldanza A., D'Arpa C., Nicosia U., Pallini G., Parisi G., Petti F.M., 2002 – Middle Jurassic/Lower Cretacicous pelagic sediments from the Sciacca area (Monte Magaggiaro, western Sicily). Abstract of the VI International Symposium on the Jurassic System, 12-22 September 2002, p. 117.

Santantonio M., Galluzzo F., Gill G., 1996 – Anatomy and palaeobathymetry of a Jurassic pelagic carbonate platform/basin system. Rossa Mts, Central Appenines Italy). Geological implications. *Palaeopelagos*, **6**:123-169.

Sequeiros L., 1974 – Paleobiogeofrafia del Calloviense y Oxfordiense en el sector central de la Zona Subbetica (II): Estudio paleontologico de los ammonites del Calloviense y Oxfordiense en el sector central de la Zona Subbetica. PhD Thesis, Univ. Granada: 1-359.

FIELD EXCURSION TO WIELUŃ UPLAND

19-20.05.2015r.

Katarowa Góra section

The abandoned quarry at the top of Katarowa Góra hill, south-east of Łobodno-Górki village, yields a complete well exposed succession of bedded limestones, especially in the eastern and southern faces of the northern part of the quarry (denoted as A-sections). The additional sections (B and C) in the central and southern parts of the quarry are generally poorly exposed, but nevertheless they are also described because they yield additional information on the upper, poorly fossiliferous part of the succession (Fig. 1). The quarry has been mentioned by Malinowska (1972a), and some ammonites found here were described and illustrated therein, but without any succession given.

The sections of the northern part of the quarry (A) are exposed along its eastern face – where the beds show a dip 15° towards the south-east (coordinates of the middle part are: N 50°55'54.4", E 19°00'43.7"), and on its southern face (coordinates of the middle part are: N 50°55'52.9", E 19o00'43.6") – where the beds show a dip 10° towards the east. Both sections differ somewhat in the development and thickness of particular beds, and both are described below. The following section is exposed along the eastern face of the quarry from the base:

Bed 1 (0.7 m seen, base not exposed) – limestone layer with rare cherts, except the topmost part where flattened chert nodules are common; at the top a thin marly seam.

Bed 2 (0.85 m) – limestone layer with rare cherts; in the uppermost part flattened chert nodules occur commonly; at the top a thin marly seam.

Bed 3 (0.25 m) – limestone layer with rare cherts except in the topmost part where flattened chert nodules are common; at the top a thin marly seam.

Bed 4 (0.65 m) – massive limestone layer; cherts appear at the top, below a well marked upper boundary of the layer; ammonites include: *Amoeboceras ovale* (Quenstedt) – upper part of the bed, *Microbiplices procedens* (Oppenheimer) – from uppermost part of the bed, *Ringsteadia* sp.

Bed 5 (0.60 m) – massive limestone layer with fairly abundant ammonites: *Ochetoceras* (*Ochetoceras*) sp., *Amoeboceras ovale* (Quenstedt), *Microbiplices procedens* (Oppenheimer) (lowermost part of the bed), *M. microbiplex* (Quenst.) – (lower part), *Ringsteadia* cf. *pseudoyo* Salfeld (Pl. 3: 2), *Ringsteadia* sp., *Neaspidoceras tietzei* (Neumayr) – (lower part).

Bed 6 (0.04 m) – marly intercalation containing rounded limestone nodules.

Bed 7 (0.33 m) – limestone layer with rare cherts which become more common in the topmost part; ammonites include: *Microbiplices* cf. *microbiplex* (Quenst.), *Graefenbergites idoceroides* (Dorn).

Bed 8 (0.02 m) – marly intercalation.

Bed 9 (0.78 m) – limestone layer with fairly common cherts; ammonites include: *Taramelliceras* (*Taramelliceras*) *externnodosum* (Dorn) forma *mediocris* (Hőlder, 1958), *Graefenbergites idoceroides* (Dorn).

Bed 10 (0.10 m) – limestone nodules in the marly matrix; ammonites include: *Amoeboceras ovale* (Quenstedt).

Bed 11 (1.0 m) – limestone layer with rare cherts; the lowermost part of the bed, 0.18 m in thickness and indistinctly separated by fracture from the rest of the layer, represents the lower *Amoeboceras layer* (see description of the sections above) – the ammonites include: *Amoeboceras ovale* (Quenstedt) – very numerous, *Microbiplices* cf. *microbiplex* (Quenst.); also bivalves *Buchia concentrica* (Sowerby).

Bed 12 (0.01–0.02 m) – marly intercalation.

Bed 13 (0.20 m) – limestone layer.

Bed 14 (0.01 m) – marly intercalation.

Bed 15 (1.08 m) – limestone layer; a well defined horizon with common flattened chert nodules occurs in the topmost 0.15 m of the layer; the ammonites include: *Ringsteadia* sp., *Orthosphinctes* sp.

Bed 16 (0.01 m) – marly intercalation.

Bed 17 (1.80 m) – massive limestone layer with cherts sparsely placed; the ammonites include: *Ringsteadia* cf. *pseudoyo* Salfeld; moreover *Ringsteadia* cf. *salfeldi* was found in a loose block coming from beds 16–17.

Bed 18 (0.14 m) – marly-limestone layer.

Bed 19 (0.95 m) – massive limestone layer; a horizon with flattened chert nodules occurs 0.25 m above the base of the layer.

Bed 20 (0.10 m) – marly-limestone layer with rare small rounded cherts.

Bed 21 (0.75 m) – massive limestone layer with rare rounded cherts; at the top of the layer the cherts become common.

Bed 22 (0.30 m) – soft limestone layer with abundant micritic matrix, bordered from the base and the top by thin marly seams.

Bed 23 (0.75 m) – massive limestone layer, more friable in its lowermost (0.20 m) part; the top part of the layer (0.20 m thick) contains common flattened cherts.

Bed 24 (0.30 m) – soft limestone layer with abundant micritic matrix, flaggy weathered and containing occasional small rounded cherts; the limestone layer is bordered at the base and top by thin marly seams. Ammonites and belemnites are fairly common in the topmost part of the limestone layer: *Clambites* sp.

Bed 25 (at the top of the section seen to 0.80 m) – massive limestone layer.

The following section is exposed in the southern face of quarry (the bed numbers correspond to those of the eastern face of the quarry):

Bed 17 (1.80 m seen, base not exposed) – chalky limestones with fairly abundant chert nodules generally randomly placed in the bed, subdivided into four layers (from the base): a well defined limestone layer (0.75 m in thickness) with common flattened chert nodules in its topmost part; and three younger layers, 0.60 m, 0.25 m, and 0.20 m in thickness, respectively; a horizon with flattened chert nodules occurs at the top of the bed; ammonites include: *Ochetoceras* (*Ochetoceras*) *hispidiforme* (Font.), *Microbiplices microbiplex* (Quenst.), *Passendorferia* (*Enayites*) cf. *gygii* (Brochwicz-Lewiński et Różak) (lower part of the bed), *Ringsteadia* sp., *Ringsteadia teisseyrei* (Siemiradzki) (about one meter below the top), *Orthosphinctes* (*Orthosphinctes*) sp., also bivalves *Buchia concentrica* (Sowerby)1.

Bed 18 (0.35 m) – soft, friable limestones with abundant micritic matrix showing flaggy weathering which are subdivided into two limestone layers (0.15 m and 0.20 m in thickness); thin marly intercalations occur at the base of the bed, in between the limestone layers, and at the top of the bed – the latter marks irregularities at the top of the bed ranging up to 0.05 m in height; ammonites include: *Taramelliceras* (*Richeiceras*) cf. *pichleri* (Oppel), *Amoeboceras rosenkrantzi* Spath, *Microbiplices microbiplex* (Quenst.), *M.* cf. *microbiplex* (Quenst.), also bivalves *Buchia concentrica* (Sowerby).

Bed 19 (0.77 m) – limestones subdivided into two layers (from the base): 0.37 m, and 0.40 m in thickness; the chert nodules occur commonly at the top of the lower limestone layer; rare chert nodules are encountered in the upper limestone layer; thin marly intercalations occur at the base of the bed, in between the limestone layers, and at the top of the bed – the latter is the most pronounced.

Bed 20 (0.40 m) – soft, friable limestones with rare spongy mummies and small rounded cherts, with abundant micritic matrix showing flaggy weathering; the limestones are subdivided into three layers (from the base): 0.12 m, 0.10 m, and 0.18 m in thickness; thin marly intercalations occur at the boundaries of the limestone layers (including the top and the base of the bed); ammonites include: *T.* (*Taramelliceras*) cf. *externnodosum* (Dorn), *Glochiceras* (*Coryceras*) cf. *microdomum* (Oppel), *Amoeboceras rosenkrantzi* Spath, *A. tuberculatoalternans* (Nikitin), *A.* cf. *tuberculatoalternans* (Nikitin), *Microbiplices microbiplex* (Quenst.), *Ringsteadia* cf. *pseudoyo* Salfeld, *R.* cf. *salfeldi* Dorn, *Orthosphinctes* sp., *Praeataxioceras* sp. nov., also bivalves *Buchia concentrica* (Sowerby) – *B.* cf. *concentrica* (Sowerby).

Bed 21 (0.40 m) – hard, massive limestone layer; the spongy mummies and rare small cherts are present; ammonites include: *Microbiplices microbiplex* (Quenst.) and *Taramelliceras* (*Taramelliceras*) cf. *externnodosum* (Dorn) found in a loose block – almost certainly coming from that bed.

Bed 22 (0.40 m) – soft, friable limestones with rare spongy mummies and small rounded cherts, with abundant micritic matrix showing flaggy weathering, which are subdivided into two layers (from the base): 0.23 m and 0.17 m in thickness; thin marly intercalations occur at the base of the bed, in between the limestone layers, and at the top of the bed; ammonites include: *Taramelliceras* (*Richeiceras*) *lochense* (Oppel), *T.* (*R.*) cf. *lochense* (Oppel), *T.* (*R.*) *pichleri* (Oppel), *T.* (*R.*) *jaeggii* Quereilhac, *Amoeboceras* cf. *rosenkrantzi* Spath, also bivalves *Buchia concentrica* (Sowerby) – *B.* cf. *concentrica* (Sowerby).

Bed 23 (0.70 m) – more hard limestone layer; a horizon with chert nodules occurs about 0.20 m above the base of the bed; bivalves *Buchia concentrica* (Sowerby).

Some ammonites were found in the rubble and they cannot be precisely located in the section beyond the general statement that they come from beds 17–23. They include: *Taramelliceras* (*Taramelliceras*) cf. *externnodosum* (Dorn) – this may come from beds 17, 19, 21 or 23 (after the lithology of the matrix); *Epipeltoceras* cf. *semiarmatum* (Quenstedt) – this may come from beds 18, 20 or 22 (after the lithology of the matrix).

Bed 24 (0.40 m) – soft, friable limestones with abundant micritic matrix showing flaggy weathering; the following succession is recognized from the base: 0.01 m – marly intercalation, 0.25 m – limestone layer, a thin marly seam, 0.05 m – limestone layer, 0.02 m – marly intercalation, 0.05 m – limestone layer, a thin marly seam. The fauna includes: ammonites – *Taramelliceras* (*Richeiceras*) cf. *lochense* (Oppel), *T.* (*R.*) cf. *jaeggii* Quereilhac, aulacostephanid microconch (*Microbiplices* or *Prorasenia*), *Praeataxioceras virgulatus* (Quenstedt), *Orthosphinctes* sp.; also bivalves *Buchia concentrica* (Sowerby).

Bed 25 (0.75 m) – a further hard limestone layer with rare cherts.

Bed 26 (0.30 m) – nodular limestones with abundant micritic matrix; at the base and the top – thin marly intercalations.

Bed 27 (0.85 m) and bed 28 (at the top of the section visible up to 0.77 m) – massive limestones with cherts possibly forming originally one thick layer; the limestones show marked splitting at the top of quarry due to their weathering – which part is distinguished as bed 28.

The central part of the quarry (denoted as B) shows the following section (numbers of beds correspond to those of the A-part of the quarry, but the local numbers are given in brackets; the beds show a dip 12° towards south-east):

Bed 20 (bed B1) (0.30 m seen, base not exposed) – soft friable limestones with abundant micritic matrix, showing flaggy weathering; ammonites include: *Taramelliceras* (*Richeiceras*) cf. *lochense* (Oppel).

Bed 21 (bed B2) (0.80 m) – hard, massive limestone layer.

Bed 22 (bed B2/B3) (0.25 m) – soft friable limestones with abundant micritic matrix, showing flaggy weathering; ammonites include: *Taramelliceras* (*Richeiceras*) *lochense* (Oppel), *T.* (*R.*) cf. *lochense* (Oppel), *T.* (*R.*) *pichleri* (Oppel), *T.* (*R.*) cf. *pichleri* (Oppel), *T.* (*T.*) aff. *externnodosum* (Dorn), *Microbiplices* cf. *anglicus vieluniensis* Wierzbowski et Matyja subsp. nov., *Praeataxioceras virgulatus* (Quenstedt), *Orthosphinctes* sp., *Neaspidoceras* cf. *radisense* (d'Orbigny); also bivalves *Buchia concentrica* (Sowerby) – *B.* cf. *concentrica* (Sowerby).

Bed 23 (bed B3) (0.7 m) – hard, massive limestone layer.

Bed 24 (bed B4) (0.4–0.5 m) – soft friable limestones with abundant micritic matrix, showing flaggy weathering; a thin marly intercalations and cherts occur in the middle part of the bed; ammonites include: *Glochicers* (*Lingulaticeras*) sp.

Bed 25 (beds B5–B6) (at the top of the section visible up to 0.7–0.8 m) – massive limestones, at the top showing flaggy weathering.

The southern part of the quarry (denoted as C – coordinates: N 50°55'50.0", E 19°00'43.4") shows a fragment of the succession whose correlation with those exposed in parts A and B is less clear due to a larger distance and poor exposure. Nevertheless the beds denoted here from C1 to C7 possibly correlate with beds 19 to 27 from the A-part of the quarry (see chapter on stratigraphy). The beds show a dip 15° towards south-east. The following section is recognized here (from the base):

Bed C1 (1.10 m, base not exposed) – limestones with common spongy mummies, cherts occur commonly at about 0.70 m below the top of the bed.

Bed C2 (0.86 m) – massive limestone layer; a thin (0.1 m) marly limestone layer at the top yielded ammonites: *Amoeboceras rosenkrantzi* Spath, *A.* cf. *rosenkrantzi* Spath; about 0.4 m below the top – *Passendorferia* (*Enayites*) sp.

Bed C3 (0.92 m) – subdivided into several layers (from the base): a – marly limestone layer (0.1 m) yielding the ammonites: *Amoeboceras* cf. *rosenkrantzi* Spath; b – limestone layer (0.14 m); c – limestones with common spongy mummies (0.16 m); d – limestones with common spongy mummies (0.36 m); e – marly limestone layer (0.16

m); other ammonites in the bed include: *Glochiceras* (*Coryceras*) cf. *canale* (Quenstedt), *Passendorferia* (*Enayites*) sp.

Bed C4 (0.16 m) – soft friable limestones with abundant micritic matrix, showing flaggy weathering; ammonites include: *Glochiceras* (*Coryceras*) *canale* (Quenstedt). ?*Microbiplices* sp., *Orthosphinctes* sp.

Bed C5 (1.04 m) – subdivided into several layers (from the base): a – marly limestone layer (0.04 m), b – marly limestone layer (0.10 m), c – limestone layer (0.11 m), d – limestone layer (0.79 m); the horizon with flattened chert nodules occurs about 0.2–0.3 m below the top of the bed.

Bed C6 (0.22 m) – marly layer (0.04 m) followed by soft friable limestones with abundant micritic matrix (0.18 m).

Bed C7 (0.54 m) – (at the top of the section visible up to 0.54 m) – limestones showing flaggy weathering; cherts common at the base of the bed.

Bobrowniki section

A large abandoned quarry, about 0.5 km to the north of the main road in Bobrowniki village (denoted as Pj 92) was described in detail by Wierzbowski et al. (2010), and presents the succession of beds 1–8, about 9.5 m in thickness (Fig. 1). A newly exposed part of the succession shows the older beds, about 4 m in thickness. These are described below (from the base):

Bed F (visible down to 0.2 m) – hard limestone layer.

Bed E (0.1 m) – consisting of the following layers (from the base): marly layer (0.02 m), limestone layer with sponge mummies, nautiloids and numerous ammonites (0.06 m), thin marly layer (at the top of the bed); ammonites include: *Taramelliceras* (*Taramelliceras*) cf. *costatum* (Quenstedt), *Glochiceras* sp., *Microbiplices anglicus vieluniensis* Wierzbowski et Matyja subsp. nov., *M.* cf. *anglicus vieluniensis* Wierzbowski et Matyja subsp. nov.

Bed D (0.55 m) – hard, fine-grained limestones with a monotonous fauna (small haploceratid ammonites, crabs) and rare rounded cherts; ammonites include: *Glochiceras* sp., *Taramelliceras* (*Taramelliceras*) *costatum laterinodosum* Karvé-Corvinus.

Bed C (0.20 m) – limestone layer overlain and underlain by thin marly intercalations (the upper one is a more pronounced) with an abundant fauna (ammonites, nautiloids, brachiopods, gastropods); the fossils are covered with thin dark manganese coatings; sponge mummies occur commonly in a lower part of the limestone layer. Ammonites include: *Glochiceras* (*Glochiceras*) *tectum* Ziegler, *G.* (*Coryceras*) *canale* (Quenstedt), *G.* (*C.*) cf. *canale* (Quenstedt), *Taramelliceras* (*Taramelliceras*) *costatum laterinodosum* Karvé-Corvinus, *Taramelliceras costatum* (Quenstedt), *Glochiceras* (*Lingulaticeras*) cf. *bobrownikiense* Wierzbowski et Głowniak, *G.* sp., *Amoeboceras subcordatum* (d'Orbigny, 1845) sensu Salfeld (1916), *Microbiplices anglicus vieluniensis* Wierzbowski et Matyja subsp. nov., *M.* cf. *anglicus vieluniensis* Wierzbowski et Matyja subsp. nov., *Ringsteadia*/*Vielunia* sp., *Passendorferia* (*Enayites*) sp.

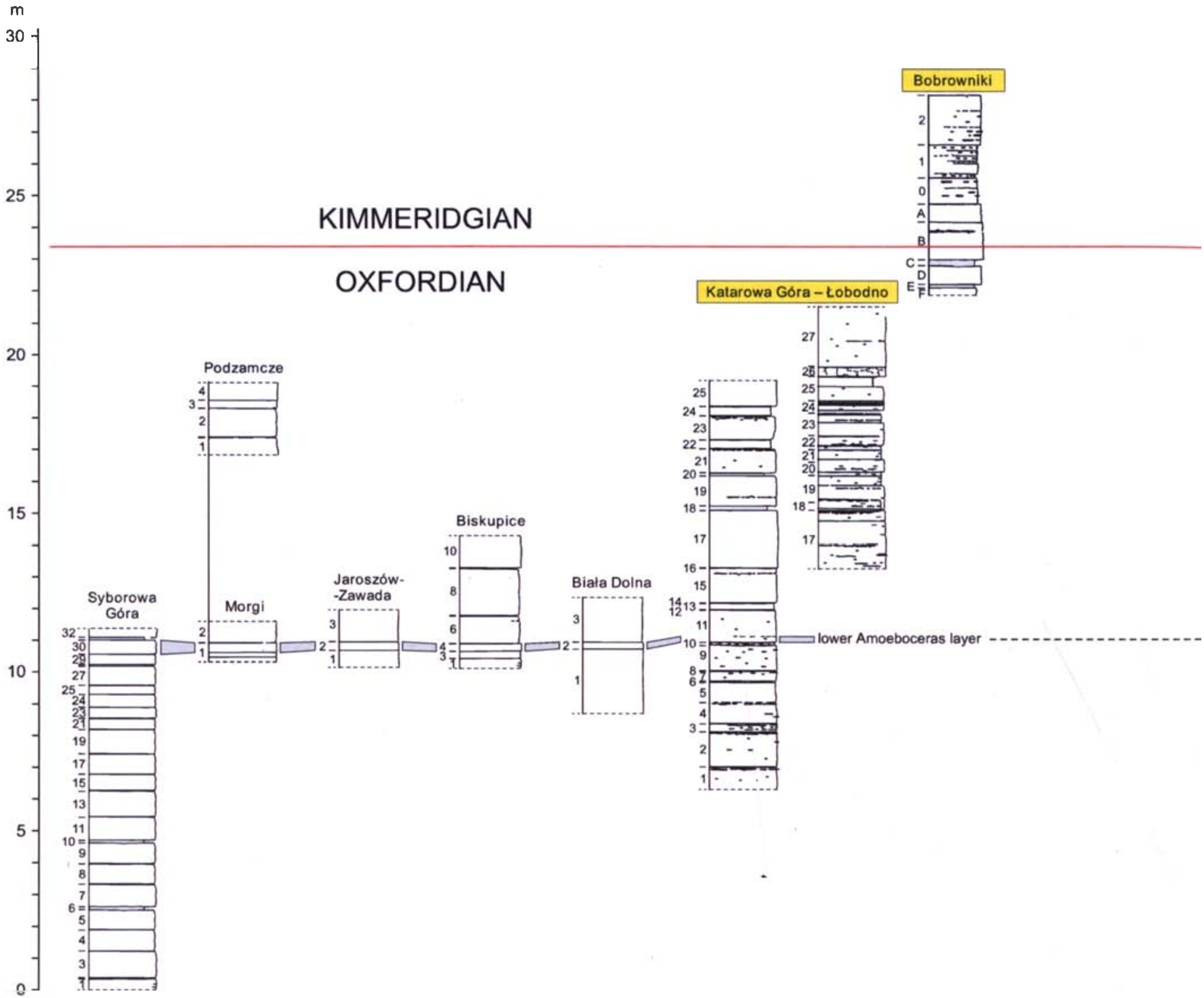
Bed B (1.20 m) – hard, fine-grained limestones with a monotonous fauna (small haploceratid ammonites, nautiloids, brachiopods, bivalves) similar to those of bed D; a well marked chert horizon occurs about 0.3 m below the top of the bed; the ammonites become more common in the topmost part of the bed: *Taramelliceras* (*Richeiceras*) *pichleri* (Oppel), *Glochiceras* (*Coryceras*) *canale* (Quenstedt), *G.* sp., *Prorasenia* cf. *crenata* (Quenstedt).

Bed A (0.58 m) – hard, fine-grained limestones with a monotonous fauna (small haploceratid ammonites, rare sponge mummies) similar to those of beds D and B; ammonites include: *Glochiceras* (*Glochiceras*) cf. *tectum* Ziegler.

Bed 0 (0.80 m) – consisting of two limestone layers with cherts (from the base): b – 0.50 m with ammonites: *Ochetoceras* (*Ochetoceras*) *semifalcatum* (Oppel), *Glochiceras* (*Glochiceras*) *tectum* Ziegler, *T.* (*R.*) cf. *pichleri* (Oppel) ; a – 0.30 m with ammonites: *Taramelliceras* (*Richeiceras*) cf. *lochense* (Oppel), *T.* (*R.*) cf. *pichleri* (Oppel), *Glochiceras* (*Coryceras*) *canale* (Quenstedt), *Taramelliceras* (*Taramelliceras*) *costatum laterinodosum* Karvé-Corvinus, *T.* (*T.*) aff. *Externnodosum* (Dorn), *Glochiceras* (*Lingulaticeras*) *bobrownikiense* Wierzbowski et Głowniak, *G.* (*Glochiceras*) cf. *tectum* Ziegler, *G.* sp.; marly seams occur at the boundaries of the limestone layers.

Bed 1 (1.07 m) – consisting of several layers (from the base): a – limestone layer with cherts (0.12 m), b – hard limestone layer without cherts (0.32 m), c – marly limestone layer (0.07 m), d – friable limestone layer with cherts (0.15 m), e – friable limestone layer

(0.15 m), f – friable limestone layer with cherts (0.16 m). The upper and middle parts of this bed of a total thickness of 0.8 m were distinguished formerly (Wierzbowski et al., 2010) as bed 1; a fragment of this interval, corresponding to bed f as recognized herein, yielded abundant ammonites (Wierzbowski et al., 2010, p. 51, pl. 1: 1, pl. 5: 1–2, pl. 6: 1, pl. 12: 3): *Taramelliceras* (*Taramelliceras*) cf. *costatum laterinodosum* Karvé-Crovinus, *Glochiceras* (*Lingulaticeras*) *bobrownikiense* Wierzbowski et Głowniak, *Taramelliceras* (*Richeiceras*) *lochense* (Oppel), *T.* (*R.*) cf. *pichleri* (Oppel), *T.* (*R.*) *jaeggii* Quereilhac, *Glochiceras* (*Coryceras*) *canale* (Quenstedt), *G.* (*C.*) *microdomum* (Oppel), *Aspidoceras binodum* (Oppel), *Orthosphinctes* cf. *fontannesi* (Choffat), *Prorasenia* sp., *Amoeboceras* (*Plasmatites*) cf. *lineatum* (Quenstedt); moreover in the same stratigraphical position has been found recently *Taramelliceras* (*Taramelliceras*) *costatum costatum* (Quenstedt) forma *aurita*. The ammonites coming from the lower part of the bed (1a–1b) described herein include: *Taramelliceras* (*Richeiceras*) *jaeggii* Quereilhac, *Streblites* cf. *tenuilobatus frotho* (Oppel), *Amoeboceras* (*Plasmatites*) sp.; whereas those of the middle part of the bed (1c) include: *Taramelliceras* (*Taramelliceras*) *costatum costatum* (Quenstedt) and *T.* (*T.*) *costatum laterinodosum* Karvé-Corvinus.



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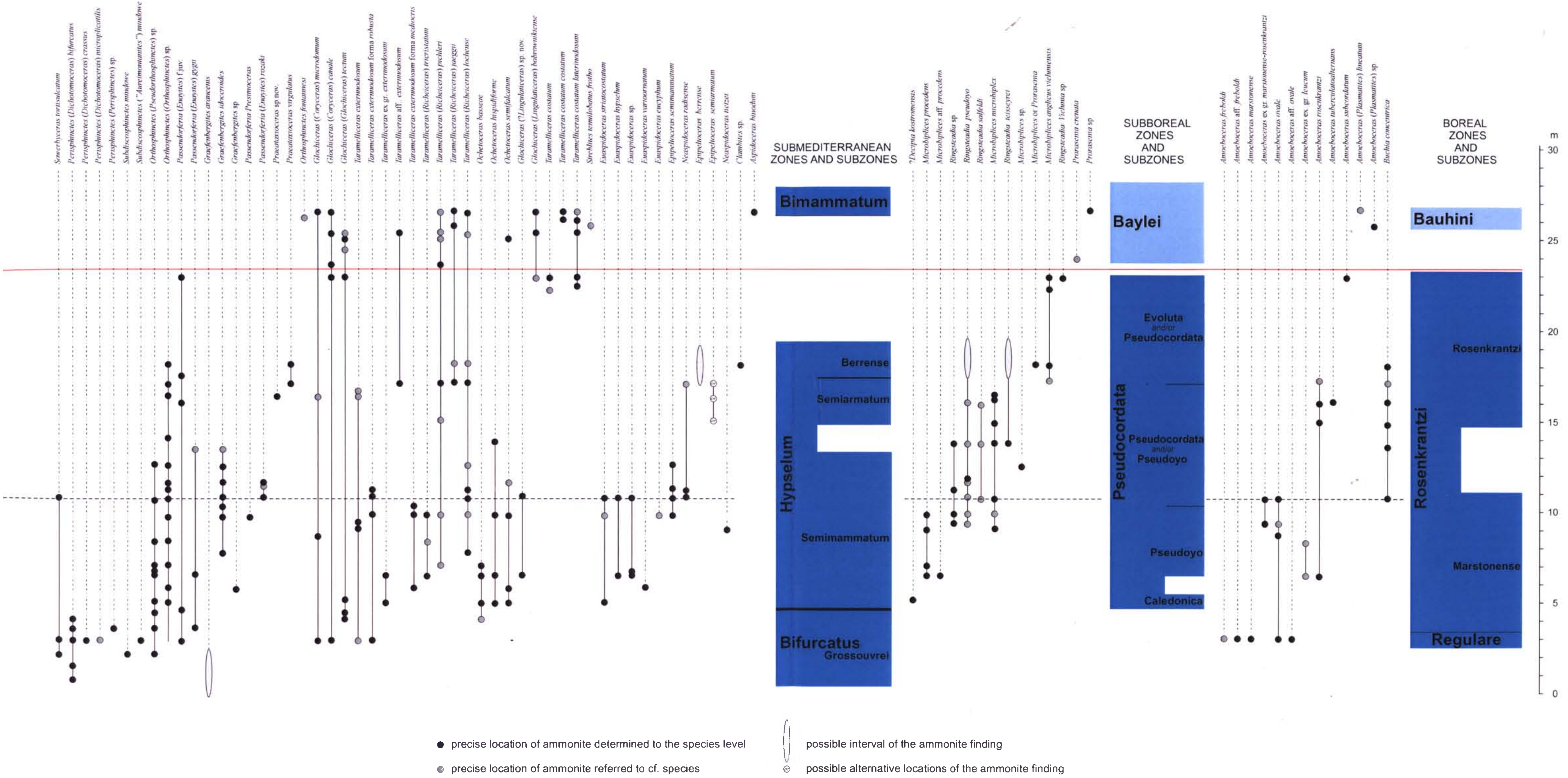
KIMMERIDGIAN
OXFORDIAN
Bobrowniki
Katarowa Góra – Łobodno
Podzamcze
Biskupice
Syborowa Góra
Morgi
Jaroszów-
-Zawada
Biała Dolna
lower Amoeboceras layer



SUBMEDITERRANEAN ZONES AND SUBZONES
SUBBOREAL ZONES AND SUBZONES
BOREAL ZONES AND SUBZONES
m
Bimammatum
Hypselum
Berrense
Semiarmatum
Semimammatum
Bifurcatus
Grossouvrei
Baylei
Pseudocordata
Evoluta
and/or
Pseudocordata
Pseudocordata
and/or
Pseudoyo
Pseudoyo
Caledonica
Bauhini
Rosenkrantzi
Rosenkrantzi
Marstonense
Regulare
30
25
20
15
10
5
0
precise location of ammonite determined to the species level
precise location of ammonite referred to cf. species
possible interval of the ammonite finding
possible alternative locations of the ammonite finding