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Artikel: Mineralostratigraphy, litho- and biostratigraphy combined in correlation of the Oxfordian (Late Jurassic) formations of the Swiss Jura range

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Balderum-Bänke of GEYER & GWINNER (1962, Fig. 22). The lower boundary of sequence 5 on the platform may be marked by biostromes of hermatypic corals near Porrentruy and elsewhere (see Pl. 1B). The probable upper boundary is marked by horizons with well-developed prism cracks near Glovelier (Pl. 1B). However, neither horizons with corals nor with prism cracks can be correlated in the lower Reuchenette Formation over greater distances.

Sequence 6 of the "basin" is a lithologically well-defined succession of marl to marly limestone with siliceous sponges. The total thickness is about 12 m, but there are as yet no diagnostic ammonites. The marl may be equivalent to a very fossiliferous marly limestone with some glauconite between Glovelier and Porrentruy. The marl in the lower part of sequence 7 in the "basin" can be assigned to Weissjura delta 2 on the strength of *Aspidoceras acanthicum* (see above). The same ammonite taxon very probably occurs in the limestone directly below the Banné marl. This is evidence that the Banné marl in the lower part of sequence 7 (Plate 1B, left side) is equivalent to Weissjura delta 2 in southern Germany.

4.4 Comparison with adjacent France

Mineralostratigraphy as calibrated with the biochronologic ammonite zonation and combined with sequential analysis is a tool to establish time-stratigraphic datum planes in shallow-water facies with few or without ammonites. Our correlations go as far northwest as Courgenay and Bressaucourt near Porrentruy. The lithostratigraphic units differentiated in the Ajoie region near Porrentruy can easily be recognized in the area around Montbéliard across the French border.

In adjacent France, there is great uncertainty about the age of lithostratigraphic units, from the equivalents of the Terrain à Chailles Member upward to the equivalents of the lower Reuchenette Formation. For instance, the equivalents of the Vorbourg Member are included in the "Rauracien" of the Middle Oxfordian in the Note explicative of the Carte géologique 1:50,000 Damprichard XXXVI-23 by GOGUEL (1965). On sheet Montbéliard 1:50,000 XXXV-22 by KERRIEN (1973), the Vorbourg Member is called Calcaire à Natices, and this is assigned an early Kimmeridgian age.

A generalized stratigraphic column is included in the sheet Montbéliard where the lithostratigraphic units can be unambiguously identified. The St-Ursanne Formation, which is now known to be of the Transversarium Chron (Middle Oxfordian), has the symbols j6 and j7a in this column and is interpreted to be partly of Late Oxfordian and partly of early Kimmeridgian age. The friable white limestone of the latest Oxfordian as indicated on the left side of our Plate 1A has the symbol j7d on sheet Montbéliard. The upper boundary of this unit is indicated to be the boundary between the lower and the upper Kimmeridgian. According to our correlations, this boundary at Montbéliard is between the Oxfordian and the Kimmeridgian Stages.

5. Conclusions

As a result of measuring sections and of collecting a great number of ammonites from in situ in recent years, it is possible to demonstrate that the Oxfordian and the Kimmeridgian Stages of northern Switzerland include a complete succession of thick, non-condensed sediments. These sediments can be subdivided into depositional sequences. All ammonite zones and subzones currently used in Central Europe can be recognized from the Late Callovian Lamberti Zone to the middle Kimmeridgian Acanthicum Zone. Thick sediments in cephalopod facies from the base of the Oxfordian to the Middle Oxfordian Antecedens Subzone (sequence 1) are restricted to the northwest (canton Bern and canton Jura). Non-condensed sediments in cephalopod facies from the upper boundary of the Antecedens Subzone to the Bimammatum Subzone (mostly of sequence 2) occur in canton Aargau. Late Oxfordian sediments with cephalopods of sequence 3 occur in canton Schaffhausen. Most of the sediments in cephalopod facies of the Middle and Late Oxfordian are gently sloping, progradational sigmoid bodies or clinothems (RICH 1951), which are to a large extent juxtaposed to each other in parallel belts. In western canton Schaffhausen, the ammonite succession is complete and non-condensed from the Bimammatum Zone across the Oxfordian/Kimmeridgian boundary to the middle Kimmeridgian Acanthicum Zone. We conclude from ammonites and from other observations (see GYGI 1986) that sequence boundaries are quasi-isochronous stratigraphic datum levels.

Shallow-water facies with hermatypic corals and oolite first developed in the Antecedens Subchron in the northwest. In Oxfordian time, there was an average advance of the coral bioherm facies of 40 km seaward, from the Antecedens Subchron to the Planula Chron or in about 4 m.y. Sedimentation of deposits from very shallow water with few ammonites or from supratidal environments without ammonites continued in the northwest to the middle Kimmeridgian. Previous attempts at correlating between the shallow-water or supratidal facies and the deeper marine cephalopod facies led to controversial results.

Our approach at correlation between different facies is based on the fact that clay minerals (also: phyllites, or phylisites) are ubiquitous in the Oxfordian and in the early Kimmeridgian limestones and marls analyzed. The non-carbonate clay fraction of these rocks consists mainly of illite-micas, kaolinite, mixed-layers, and of some chlorite and smectite. The Oxfordian and the early Kimmeridgian clay mineral assemblages differ from those of the Middle Jurassic and from those of the late Kimmeridgian or the Tithonian mainly in that smectites are normally scarce or absent and that mixed-layers are abundant. There is a short-term variation in the clay mineral assemblages of the Oxfordian and of the early Kimmeridgian. In particular, the major vertical changes in the kaolinite content can be traced from section to section. Distinct highs or lows of kaolinite change little from deposits of the supratidal realm to litoral calcarenites and to mud-grade sediments of the "basin". The absence of a distinct correlation in a given horizon kaolinite content and the depositional environment or lithology is evidence that neither the depositional environment nor diagenesis influenced the kaolinite content substantially. The observation that the vertical variation in the kaolinite content is remarkably constant through different depositional environments and lithologies is evidence that this variation reflects changes in the source area. This made regional stratigraphic correlations based on kaolinite possible. The kaolinite content increases in some cases in the proximal direction. This indicates that the clay mineral assemblages were influenced in the course of sediment transport by differential settling velocities according to the grain or floccule size. The increase of the kaolinite content and the growth of the maximum grain size of detrital quartz in the proximal direction suggest that the source of siliciclastic sediment was in the north.

We chose to discriminate 13 prominent vertical changes in the kaolinite content and lettered them from A to M. Correlation C is subparallel to the upper boundary of sequence 1. Correlation I is very close to the upper boundary of sequence 2, and correlation L runs almost parallel with and close to the base of sequence 4. Since sequence boundaries may be regarded to be isochronous datum levels, we conclude that changes in the source area influenced clay mineral assemblages of northern Switzerland almost simultaneously as compared with the average sedimentation rate, and that our mineralostratigraphic correlations are near-isochronous. The mineralostratigraphic correlations were tied in with the biochronologic ammonite scale by analysis of the clay minerals of the Oxfordian and of the lower Kimmeridgian in cephalopod facies of canton Aargau. The resolution of the mineralostratigraphic correlations is of the order of one ammonite subchron.

The mineralostratigraphic correlations A to C confirmed that the St-Ursanne Formation is time-equivalent to the Birmenstorf Member as was concluded before on the strength of ammonites. The Natica Member is indeed coeval with the Effingen Member just as Bolliger and Burri inferred. The Hauptmumienbank Member is the same age as the Steinibach Beds, and these beds are, according to the mineralostratigraphic correlation I, time-equivalent to the Geissberg Member. Mineralostratigraphic correlation is the only means by which the position of the upper boundary of sequence 2 could be recognized in the shallow water realm. Subdivision of sequence 2 is possible only in the shallow water realm, whereas subdivision of sequence 3 can be done only in the "basin". Correlation L suggests that the boundary between the Balsthal Formation and the Reuchenette Formation almost coincides with the Oxfordian/Kimmeridgian boundary.

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