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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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mineralostratigraphic correlations in an area of limited geographic extent. The Oxfordian of the Swiss Jura range was chosen, because on the one hand, these sediments have been investigated at intervals since the beginnings of stratigraphy in this country, and because, on the other hand, no consensus on correlation has been reached to this day in spite of the large amount of work done. We wish to stress that the results presented in this paper are preliminary. Most of the sections measured by R. Gygi are unpublished, and so are most of the ammonites collected by R. and S. Gygi since 1962, on which biostratigraphy and most of the regional correlations of the Oxfordian as presented in this paper are based.

2. Methods

The biochronologic framework for the mineralostratigraphic correlations was provided by sampling three sections for clay mineral analysis in the "basinal" cephalopod facies of canton Aargau (no 9, 10, and 11 in Pl. 1). Ammonite biochronology is well known in the rhodano-swabian "basin" (ENAY 1966) which was a shallow sea on the southern continental shelf of Jurassic Europe. The deeper marine Oxfordian and Kimmeridgian sediments discussed in this paper were laid down in part of this epicontinental sea, which was less than 200 m deep. Therefore, the term basin is referred to with quotation marks in this paper. The other sections sampled for clay minerals include paleoenvironments from the slope, the margin, and the inner part of carbonate platforms, as well as environments of the intertidal and the supratidal zones.

2.1 Lithostratigraphy

The palinspastic cross section of Plate 1 is assembled from sections measured by R. Gygi (Fig. 1). The sections are spaced as closely as possible in order to facilitate correlation. They are arranged in transects perpendicular to depositional strike, or lines of equivalent facies, respectively. Thus, the cross section of Plate 1 is drawn along a line of maximum facies change. One difficulty in preparing the plate was that the slope of the Pichoux limestone between the St-Ursanne Formation and the Birmenstorf Member (see Table 2) varies from transect to transect. Another difficulty is the change of thickness within the St-Ursanne Formation which is from 35 m in the platform interior to more than 100 m at the platform margin. Even greater thickness variance over short distances occurs within the Natica Member at the transition to the Günsberg Member. Thicknesses had to be averaged in order to make Plate 1 interpretable.

When measuring the sections, every recognizable horizon down to a thickness of a few centimeters was sampled individually. Thick-bedded or massive limestones were sampled at intervals of 1 m or less. Some of the thick-bedded or massive shallow-water limestones in the sections done by GYGI (1969) were sampled at larger intervals. Only the limestone samples processed to thin sections or polished slabs, or marls to be washed, are kept in the Museum of Natural History, Basel. Plate 1 is based on more than 2150 thin sections and more than 560 polished slabs from 182 measured sections. The sections were subdivided into shallowing-upward sequences. Rock names for primary mixtures of clay and lime mud are from PETTIJOHN (1957, Fig. 99).

2.2 Biostratigraphy

Ammonites are the fossils most suitable for establishing a biochronology in the "basinal" deposits considered. The ammonites relevant to biochronology and regional correlation as indicated in Plate 1 are mostly from approximately 5000 specimens prepared out of the 8000 collected by R. and S. Gygi since 1962. These were either taken from systematic excavations, or collected from in situ in measured sections. Many an important ammonite included in Plate 1 has been given on loan or as a gift to the Museum of Natural History Basel. Ammonites cited from this museum have an individual number preceded by J or Gy. Paleontologic procedures are described in GYGI (1977). Ammonite zonation is discussed by GYGI & MARCHAND (1982).

2.3 Mineralostratigraphy

The methods of mineralogical analysis and principally those of phyllite minerals discussed in PERSOZ & REMANE (1976) and PERSOZ (1982) are based on the classical works by BROWN (1961) and BRINDLEY & BROWN (1980). The quartz content is measured by X-ray diffractometry with an external standard. It is expressed relative to the total rock. The phyllite percentages are measured on granulometric fractions of less than two microns on oriented samples. The percentage is calculated relative to the sum of all phyllites present. These are measured by the height of the peak, without any corrections at 17 Å (smectites), between 11 and 17 Å (mixed layers), at 10 Å (illite-micas), and at about 7 and 3.5 Å (kaolinite and chlorite).

The estimation of the kaolinite/chlorite ratio is sometimes difficult on the basis of the two peaks at 3.5 Å. In this paper, this uncertainty is without great consequence on the kaolinite content due to the very low values of chlorite percentages, which are generally less than 10%.

The mixed-layer minerals are generally interstratifications of illite and smectites. These most often form a broad peak on diffractograms. Sometimes one or two discrete lines are present (Fig. 6 and 7). It was impossible to analyze this complex system in routine work.

The term illite-micas was chosen due to the difficulty in discriminating between true micas and illites which are clay grade micas (BRINDLEY & BROWN 1980, and KÜBLER 1984).

The crystallinity index of illite-micas (Fig. 8) is defined by the width of the peak at half of its height, at 10 Å on oriented samples as treated with ethylene glycol (IAGI). This procedure is necessary because of the presence of swelling mixed layers which artificially increase the width of the peak. IAGI is not equivalent to the crystallinity index of KÜBLER (1964, 1966) which is measured in the same manner, but on air-dried samples. IAGI is generally lower than the KÜBLER index except at the base of the anchizone and in the epizone where it approaches the KÜBLER index. In the diagenetic zone, values less than $0.42° 2\theta$ (Neuchâtel calibration), which is for the KÜBLER index the limit between diagenesis and anchimetamorphism, indicate a probable metamorphic or anchimetamorphic origin of illite.

The crystallinity index of kaolinite (IANK) is measured on air-dried samples on the (001) peak at about 7.1 Å. This is possible because of the very low content of chlorite whose (002) peak is also at 7 Å. There is no statistical correlation between IANK and chlorite content except in the Effingen Member of the Reuchenette and Aargau sections (Fig. 9), where the correlation coefficient is significant at 95% of confidence level, but not at 99%. In this case, the chlorite/kaolinite ratio is higher than in all the other members. Another statistical control shows that the variation of the height of the (001) peak of kaolinite has no influence on the IANK values.

Mineralogical analysis was carried out on more than 650 samples from 9 composed sections as measured by GYGI (1969), BOLLIGER & BURRI (1970), and completed by us in the upper part, as well as from sections by BIELER (1972), KETTIGER (1981), PERSOZ & REMANE (1973), and from a section near Courgenay as well as one near Bressaucourt as measured by Gygi (unpublished). The spacing of the samples is indicated in Figures 9 and 10.

2.4 Paleoecology, correlation, and depositional history

The paleobathymetry and paleogeography of northern Switzerland in Early Oxfordian time was worked out by GYGI (1981). Observations on sedimentology, on assemblages of the macrofauna, on the taphonomy of ammonites, and on the regional distribution of the minerals glauconite and chamosite/berthierine led to the conclusion that iron ooids could be accreted on the surface of marine mud at a depth of as much as 100 m. The thin, widespread, and mostly continuous iron-oolitic horizons at the base of the Oxfordian of northern Switzerland are sediments from relatively deep water. The deep water origin of oncoids several centimeters across in a thin glauconitic bed of the Middle Oxfordian in canton Schaffhausen was established by the same methods (GYGI et al. 1979, see Fig. 14).

Shallowing-upward sequences are defined by the type of sediment as identified in thin section or on polished slabs, and by the assemblages of fossils. Broad estimates of paleodepth were made from faunal assemblages according to B. ZIEGLER (1971). Minimum depth may be deduced from the taphonomy of ammonites in some cases. Argillaceous or carbonate mudstone with a macrofauna dominated by ammonites is taken as an indication of a water depth greater than about 50 m (GYGI 1981, p. 245). Biostromes and bioherms of colonial corals were formed in the shallow subtidal or in the lower intertidal zone. Calcarenite with preserved cross-bedding is a sediment from the intertidal and the shallow subtidal zones. Prism-cracked mudstone in itself is not conclusive evidence for the supratidal environment (see HARDIE 1977, Fig. 28). An environment of the upper intertidal or of the supratidal zone must be assumed when there are stromatolites with crinkled fenestrate laminations, and when stromatolites can be observed to pass laterally into mudstone with pebbles. A limestone with rounded or angular pebbles and cobbles of carbonate rock above a hummocky erosion surface of oolitic limestone is considered to be evidence of the supratidal zone.

Correlation was made with ammonites when possible. Lithologic marker beds were used when ammonite zonation was uncertain (see GYGI 1969, Fig. 5). Sequence boundaries as for instance the one between sequence 3 (Court Formation) and 4 (Reuchenette Formation, see Plate 1) were also used for correlation. Part of the correlations depend on the vertical variation in the kaolinite content alone.