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Dinocyst Morphotype Groups Versus Sequence Stratigraphy of the Upper Jurassic Sediments of the Northern Switzerland Sedimentary Basin

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Abstract

Variations in ratios of chorate (C) dinoflagellate cysts to proximo-chorate (P), proximate (P) and cavate (C) forms recovered from the Rhodano-Swabian sedimentary basin in northern Switzerland have been correlated with sequence boundaries and sedimentary cycles established for this basin. The variations in these ratios and abrupt increases and decreases in the number of recorded species from the same strata corroborate closely the sequence boundaries established by Gygi *et al.*, (1998) using other parameters such as lithology and macrofossil content of the sediments. Highstands of sea level are marked by an abrupt increase in species diversity and in C: PPC ratio. In contrast, lowstands are indicated by rapid decline in the abundance of species and a decrease in C: PPC ratios.

Keywords**:** *Dinoflagellate cyst, morphotype groups, Sequence stratigraphy, Upper Jurassic, Switzerland.*

ZUSAMMENFASSUNG

Schwankungen im Verhältnis von choraten (C) Dinoflagellatenzysten zu proximochoraten (P), proximaten (P) und cavaten (C) Formen, welche aus dem Rhodano-Schwäbischen Ablagerungsraum in der Nordschweiz geborgen worden sind, wurden mit in diesem Becken festgestellten Sedimentationszyklen und Sequenzen korreliert. Die Schwankungen in diesen Verhältnissen sowie starke Zu- und Abnahmen der Anzahl der gefundenen Arten in diesen Schichten bestätigen die Sequenzgrenzen, welche Gygi *et al.*, (1998) festgelegt haben, unter Benützung von anderen Parametern wie Lithologie und

Makrofossil-Vergesellschaftungen. Hochstände des Meeresspiegels sind durch ein starkes Ansteigen der Artenvielfalt der Dinoflagellaten und des C: PPC-Verhältnisses gekennzeichnet. Tiefstände werden dagegen angezeigt durch eine starke Abnahme der Artenvielfalt und eine Abnahme im C: PPC-Verhältnis.

Introduction

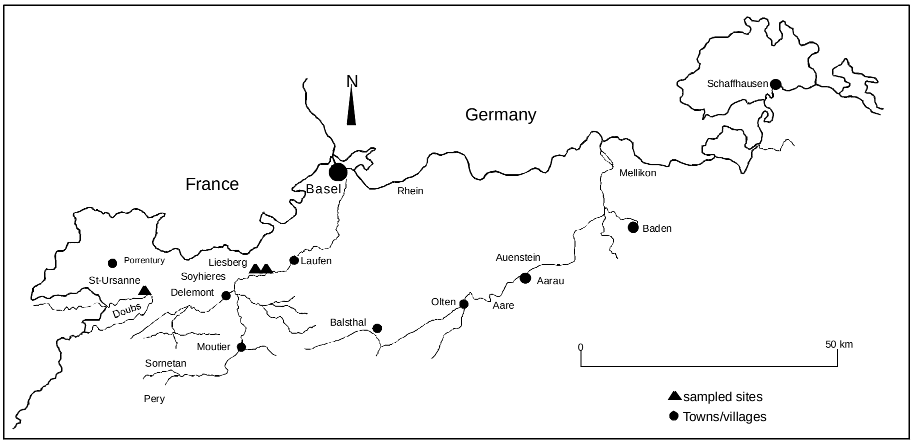
In 1998 sequence stratigraphy of the Upper Jurassic sediments of the Rhodano-Swabian basin of northern Switzerland was established by Gygi and his colleagues (*Gygi et al.,* 1998). Later it was confirmed that absolute abundance and species diversity of dinoflagellate cysts closely corroborate the sequence boundaries identified in these sediments (Ghasemi-Nejad, 1999). In this article, the results obtained from variations in the ratios of four morphotype groups of dinoflagellate cysts, i.e. the ratio of the chorate group to the proximo-chorate, proximate and cavate forms (C: PPC ratios) are re-examined and correlated with the sequence boundaries erected by Gygi *et al.*, (1998), who used other parameters such as lithology and paleontology, and with those confirmed by the author (Ghasemi Nejad, 2001), who used increases and decreases in number of species to confirm the sedimentary cycles.

For this purpose, data obtained from 22 samples taken from three different sections in the proximal area of the basin (Fig.1), were re-examined. In these strata four sequence boundaries were shown previously by Gygi *et al.,* (1998) who used such parameters as lithology and ammonite contents of the sediments (Fig.2).

Stratigraphy

The northern Switzerland sedimentary basin was an epicontinental sea adjacent to the Tethys, shallower in the northwestern and deeper in the southeastern part (Gygi, 1990).

The rate of sediment supply was close to zero just before the end of the Middle Jurassic. Consequently, a starved basin was existing from



mid Callovian to earliest Oxfordian time. Sedimentation recommenced slowly at the beginning of the Oxfordian and produced a thin, widespread marker bed of iron-oolitic marl of the uppermost Herznach Formation (Gygi, 2000).

Figure 1. Location map of the studied area and the sampled sites.

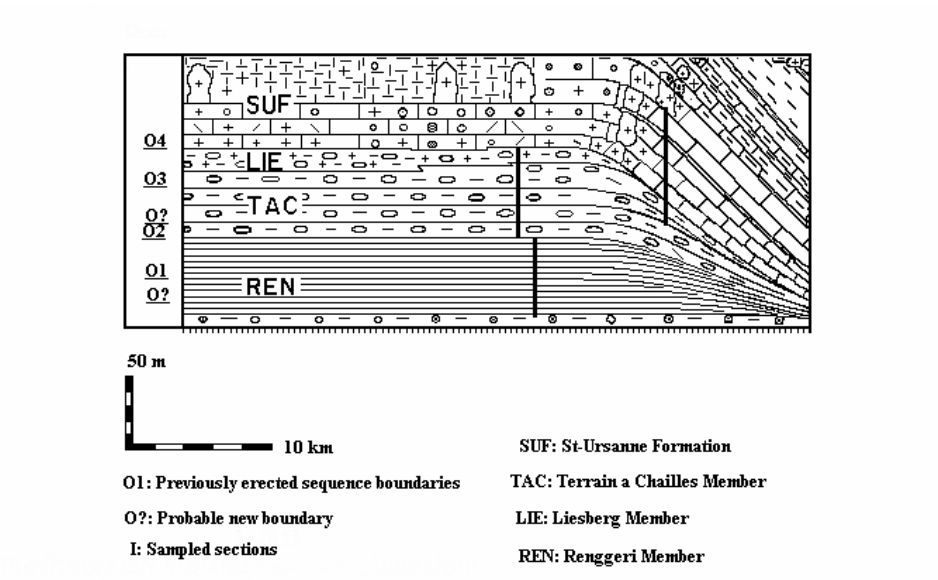


Figure 2. A synthetic cross-section of the platform strata of the Oxfordian stage in northern Switzerland with previously established sequence boundaries (O1 – O4), and probable new boundaries (O?) (redrawn from Gygi et al., 1998).

Gygi (1986) concluded that, from a paleodepth of about 80 meters downward, cephalopods constituted more than 80% of the macrofauna. The macrofauna of the iron-oolitic horizon at the base of the Renggeri Member near Péry is constituted by 84% cephalopods (Gygi & Persoz, 1986). These iron ooides and the cephalopod fauna dominating this layer therefore indicate a water depth of less than 100 meters (Gygi, 1981; Gygi & Persoz, 1986).

The abundance of iron ooids decreases towards the top of the marker bed and fades away completely at the base of the Renggeri Member as a result of an increasing rate of sedimentation where the blue-gray marls and clays of the member begin. The boundary between the Middle and Upper Jurassic in northern Switzerland is therefore placed within the ferruginous marls and clays below the Renggeri Member (Gygi *et al.,* 1998, Ghasemi-Nejad *et al.*, 1999).

The thin ferruginous layer is overlain by a mass of blue-gray marl-clay of the Renggeri Member that is several tens of meters thick in the Clay Pit at Ampthil near Liesberg (Fig. 3). The macrofauna of the lower Renggeri Member consists mostly of cephalopods, although other organisms such as bivalves, gastropods, brachiopods and crinoids have also been reported (Gygi 1986, Gygi & Persoz 1986).

In northwestern Switzerland, the Renggeri Member is overlain by the Terrain à Chailles Member, composed of 40 to 50 meters of gray marls with bands of limestone concretions and, in some areas, bands of marly limestone (Gygi *et al.,* 1998).

The gray marls, with bands of limestone concretions, of the Liesberg Member overlie the Terrain à Chailles Member. The Liesberg Member differs from the Terrain à Chailles in having less interspace between the nodule bands and in the irregular shape of the nodules (Gygi & Persoz 1986).

The carbonate platform deposits of the St-Ursanne Formation, whose thickness varies between 35 and 95 meters in different areas, overlie the Liesberg Member. At the distal margin, the formation contains coral bioherms that are in turn replaced further basinward (eastward) by a succession of well-bedded limestones and lime mudstones of the Pichoux Limestone. The Pichoux limestone, a slope sediment, is transitional between the platform deposits of the St-Ursanne Formation with corals and the basinal Birmenstorf Member that belongs to the ammonite facies (Gygi 1986). The Birmenstorf Member in the east is a biostrome of siliceous sponges with abundant ammonites and has an average thickness of about 5 meters (Gygi 1992, Gygi & Persoz, 1986).

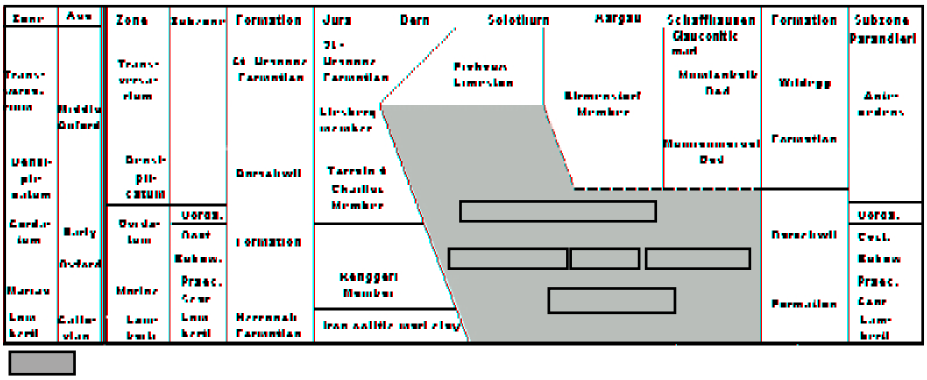


Figure 3. Time-stratigraphic position of Callovian-Oxfordian lithostratigraphic units of the northern Switzerland sedimentary basin (redrawn from Gygi 2000).

Discussion

The carbonate platform evolved in the northwestern Switzerland sedimentary basin by Middle Oxfordian time and continued to exist throughout the Late Jurassic. Recent studies by Gygi *et. al*. (1998) have indicated that the Oxfordian sediments as a whole represent a 2nd-order regression- transgression cycle, punctuated by eight 3rd-order cycles.

The start of the transgression is marked by a decrease in the terrigenous influx and retrogradation of the carbonate facies across the carbonate platform. Maximum flooding is characterized by a slowdown or even termination of the growth of coral reefs on the platform, condensation of the beds and some times by the deposition of a condensed fossiliferous horizon in the basin (Gygi *et al.,* 1998).

The top of the Lamberti Bed in the upper Herznach Formation (Callovian-Oxfordian boundary) is interpreted as a maximum flooding surface because of the rich macrofauna and condensed nature of the bed (Gygi *et al.*, 1998). The overlying 20 cm of calcareous, slightly silty claystone with scattered iron ooids of the uppermost Herznach Formation (Gygi, 2000) directly below the Renggeri Member and the lower part of the overlying slightly silty calcareous claystones of the Renggeri Member comprise the highstand system tract (Gygi *et al.*, 1998). Sample #2 of Ghasemi Nejad *et al.*, (1999) was taken from the calcareous claystone with iron ooids directly below the Renggeri Member and contains 58 species of dinoflagellate cysts. The ratio of C: PPC was calculated 18: 82 for this sample (Fig. 4).

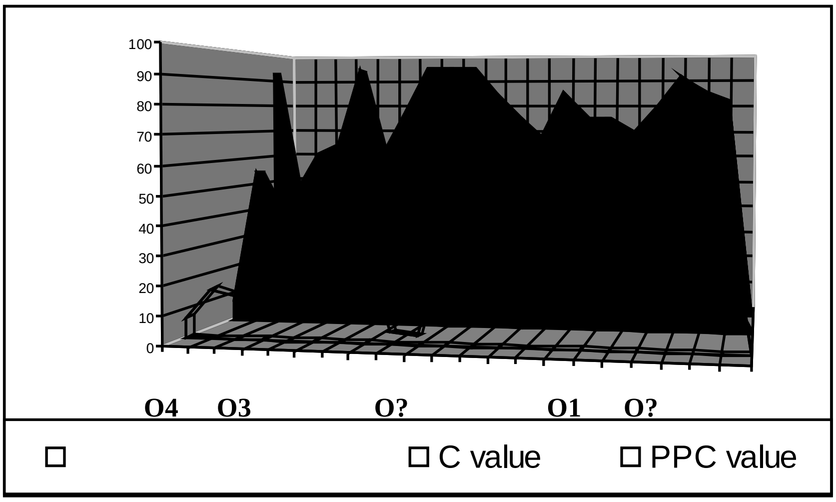


Figure 4. Correlating variations in number of species and ratios of C: PPC dinoflagellate cyst groups with sequence boundaries established for the Oxfordian strata of the northern Switzerland sedimentary basin.
O1 - O4: Previously erected sequence boundaries (Gygi *et al.,* 1998)
O?: probable new boundaries
Sample #2: Iron oolitic unit
Sample #3 - #11: Renggeri Member
Sample #12 - #19: Terrain à Chailles Member
Sample #20 - #21: Liesberg Member
Sample #22: St-Ursanne Formation

22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
sample number

number of species

The Renggeri Member comprises up to 70 meters of monotonous poorly bedded, silty claystone with scattered ammonites, belemnites, and brachiopods. There is a sharp color change in the middle of the member from a light bluey-gray below to a more uniform light gray above, that is coincident with an increase in silt content and is interpreted as sequence boundary O1 (Gygi *et al.,* 1998). Sample #7 of Ghasemi Nejad *et al.,* (1999) was taken from the layer forming the upper boundary of the first cycle, O1. Only 12 dinoflagellate cyst species were recorded from sample #7, whereas 50 species were found in the preceding sample #6 (Ghasemi Nejad 1999). Although this may confirm the results obtained from lithological and paleontological studies by Gygi *et al.,* (1998), the C: PPC ratio, however, is calculated at 25:75 for the sample. However, sample #5, taken about 13 meters below sample #7 with a C: PPC of 20: 80 and with only nine recorded species could mark another possible boundary (O?) that has not been indicated in previous studies (Fig. 4).

The Renggeri Member is overlain by the more calcareous Terrain à Chailles Member. The sharp change to more carbonate-rich facies at the base of the Terrain à Chailles Member is interpreted as representing the upper boundary of the second cycle, O2 at its correlative conformity (Gygi *et. al*. 1998). Unfortunately, data from the base of the Terrain a Chailles Member were not available for re-examination. However, sample #13 of Ghasemi Nejad *et al.,* (1999) taken from about 13 meters above the border between the Renggeri and Terrain à Chailles Members indicates a sharp decline in number of species from 35 in the previous sample to only three species in this sample. Moreover, the ratio of C: PPC decreases to only 5:95, the lowest amount recorded throughout the whole stratigraphic column and continues to be so in the next two consecutive samples numbered 14 and 15. This, together with the important decrease in the number of species relative to the preceding sample (#12) taken four metes below, in which 35 species have been recorded, may indicate the existence of a new boundary (Fig. 4, O?) that has not been detected by Gygi and his colleagues (1998).

The upper part of the carbonate-rich Terrain à Chailles Member contains several thick, well-defined limestone beds interbedded with marls and clays. The first thick tabular limestone is interpreted as the upper boundary of the third cycle, O3. This boundary corresponds with the layer from which sample #19 was taken. Only nine species of dinoflagellate cysts are recorded from this sample and this corroborates the established boundary. However, the rate of C: PPC in sample number #19 is calculated at 35: 65 and does not seem to confirm the previous works of Gygi (1998) and Ghasemi Nejad (2001). Instead, in sample #18 taken only four meters below the C: PPC ratio decreases sharply to 7:93. The discrepancy of a larger number of species in sample #18 however, remains unresolved and requires involvement of other paleoenvironmental factors and further studies.

Samples #20 and #21 were taken from the Liesberg Member overlying the Terrain à Chailles Member. Only a smooth increase is recorded in the number of dinoflagellate cysts species recovered from these samples. The Liesberg Member is overlain by the St-Ursanne Formation with a basal oncolitic and oolitic grainstone. The base of the St-Ursanne Formation is interpreted as the sequence boundary O4 (Gygi *et al.*, 1998). The lower part of this formation is interpreted as shelf-margin systems tract.

Sample #22 was taken from the base of the St-Ursanne Formation. Only seven species have been recorded in this sample (Ghasemi Nejad et al., 1999). The C: PPC ratio was also calculated at 7:93 for this sample. This also indicates that the base of the St-Ursanne Formation as being the sequence boundary O4.

Conclusions

Increases and decreases in the number of species and in the ratios of chorate to proxim-ochorate, proximate and cavate dinoflagellate cyst species (C: PC ratios) recorded from the Upper Jurassic sediments of the Rhodano-Swabian basin in northern Switzerland can be correlated with sequence boundaries established for these sediments. Increases and decreases in the number of dinocyst species confirm the established boundaries by using other parameters such as lithology and paleontology. Moreover, variations in the C: PPC ratios may also show variations associated with the sequence boundaries established for the basin, although with some displacements. Two more boundaries could be erected by using palynological data; these boundaries have not previously been detected by Gygi *et al.*, (1998) who used characteristics such as lithology and paleontological content of the sediments.

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