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PALYNOLOGY AND CHEMOSTRATIGRAPHY OF MIDDLE TRIASSIC SUCCESSIONS IN NORTHERN SWITZERLAND (WEIACH, BENKEN, LEUGGERN) AND SOUTHERN GERMANY (WEIZEN, FREUDENSTADT)

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APPENDIX - Core and outcrop description

1. Weiach well

The following lithological subdivisions are present in the Weiach well (after Matter et al. 1988a, b) (Figure A1).

Buntsandstein (981.83 m–991.50 m)
Plattensandstein: 981.83 m–983.40 m
Grobsandstein mit Anhydritknollen (= Karneolhorizont): 983.40 m–985.22 m
Zyklische Sandsteine und Konglomerate: 985.22 m–991.50 m

After the Permian–Carboniferous continental infill of graben structures and peneplain formation, the Triassic succession unconformably overlies clastic Oberrotliegendes (Matter et al. 1988a, b). The base of the Triassic at Weiach consists of a sequence of white, partly red, green or violet quartzose sandstones and conglomerates, i.e., Zyklische Sandsteine, deposited in an alluvial environment (Matter et al. 1988a). This clastic unit is partly altered by soil processes forming silcrete geodes interpreted as Karneolhorizont. The overlying Plattensandstein, representing the top of the Buntsandstein, consists of white, platy sandstone with two sets of cross-bedded dunes and intercalated shales containing marine invertebrate burrows (pers. comm A. Wetzel, Dept. of Environmental Sciences, University of Basel). The depositional environment of this sandstone most likely corresponds to a coastal plain with supra- to intertidal conditions indicated by bioturbation of marine origin. A minor hiatus separates the Plattensandstein from the overlying Lower Muschelkalk.

Lower Muschelkalk (944.56 m–981.83 m)
Orbicularis Mergel: 944.56 m–950.35 m
Wellenmergel: 950.35 m–973.32 m
Spiriferina-Bank: 957.69 m–958.39 m
Wellendolomit: 973.32 m–981.83 m

The Lower Muschelkalk consisting of the above mentioned units was traditionally termed Wellengebirge with the Orbicularis Mergel laying on top. The Wellendolomit is interpreted as an intertidal to shallow subtidal dolomitic sequence (Matter et al. 1988a). Subtidal shallow marine conditions are also inferred for the overlaying Wellenmergel, a carbonate-rich claystone with occasional bioclastic/sandy erosive layers, probably representing storm events. A 70 cm thick carbonate bed within the Wellenmergel has been interpreted as equivalent of the Spiriferina-Bank. A distinct hiatus separates the Wellenmergel from the Orbicularis Mergel.

The following approximately 5 m thick Orbicularis Mergel has a variable composition with an erosive shelly siltstone at the base, followed by a massive anhydrite layer and bituminous marls on the top. Relict selenite bundles indicate a subaqueous basin-floor formation of the sulfates (Matter et al. 1988a).

Middle Muschelkalk; Anhydritgruppe (887.90 m–944.56 m)
Sulfatschichten: 897.66 m–944.56 m
Dolomit der Anhydritgruppe: 887.90m–897.66 m

The Sulfatschichten represent deposits of hypersaline subaqueous pools, lagoons or intertidal to supratidal and sabkha environments comprising five sedimentological cycles (VI to II) each reflecting an increase in salinity with common erosional features at the top of the cycles (Matter et al. 1988a; Dronkert et al. 1990). The lowest cycle VI reflects a time of increasing salinity in a tidal flat (upper intertidal to supratidal) environment with dolomites showing the typical stromatolithic fabric. Cycles V and IV.B are absent from the Weiach core and the following cycle IV.A is characterized by chaotic breccias at the base with components of laminated dolomite, clays or anhydrite in a clay/anhydrite matrix. The comparison with the Sulfatschichten from the Schafisheim well indicates a significant dissolution event of subaqueous precipitated halites in the Weiach core at the base of cycle IV.A (Matter et al. 1988b). Thus, the absence of cycles V and IV.B represents a hiatus caused by dissolution of halite. Cycle III.B is characterized by a sequence of alternating finely laminated layers of anhydrite and subordinately dolomite and shale. The occurrence of desiccation cracks, intraformational breccias and tepee-structures indicates an intertidal environment with periods of reworking and syn-sedimentary desiccation effects. Cycle III.A has a similar appearance except for the presence of current and climbing ripples and the presence of one anhydrite horizon with selenite crystals indicating a subaqueous origin. Cycle II starts with intraformational breccias followed by a sequence of clays, alternating with stromatolithic dolomite and anhydrite with indications of subaquatic precipitation, and an oolithic bioclastic arenite. Thus, sedimentological structures indicate a deepening-upwards sequence from intertital to subtidal conditions. The overlying cycle I, named Dolomit der Anhydritgruppe, is characterized by finely laminated dolomicrite with anhydrite nodules, fenestral pores, flat pebble conglomerates, desiccation cracks and one silicified oolithic layer. All these sedimentological features are typical for an intertidal depositional environment with a tendency to supratidal conditions in the upper part.

Upper Muschelkalk (819.13 m –887.90 m)
Hauptmuschelkalk (Platten- and Trochitenkalk): 857.05 m–887.90 m
Trigonodus Dolomit: 819.13 m–857.05 m

The lower part of the Hauptmuschelkalk (i.e., Plattenkalk) is represented at the base by a biopelsparite with cm-sized algal oncolites and anhydrite nodules followed by monotonous bioturbated micrites with a couple of bioclastic event-beds (Matter et al. 1988a, b). The upper part of the Hauptmuschelkalk (i.e., Trochitenkalk) is mostly micritic, partly dolomitic and contains crinoidal event-beds. The Hauptmuschelkalk documents a deepening-up succession from intertidal to subtidal conditions. The overlaying Trigonodus-Dolomit is a shallowing-up sequence of dolomitic limestones and marls with bioclastic event-beds at the base and in the upper part of dolomitic limestones with dissolution pores mostly involving bivalves.

Keuper (704.32 m–819.13 m)
Lettenkohle: 814.08 m–819.13 m

The Lettenkohle at the top of the studied profile is an approximately five meter thick unit of dolomitic limestones with anhydrite nodules and an interlayered shale unit representing a regressive cycle from shallow marine to intertidal mudflat conditions.

2. Core B3/13 (Weizen)

Core B3/13, drilled near Weizen (S-Germany; Gauss-Krüger coordinates: R 3460611, H 5292360) comprises a 25 m thick sequence that is lithostratigraphically closely comparable to the Wellendolomit - Wellenmergel-succession (pers. com. E. Nitsch, Regierungspräsidium Freiburg, Landesamt für Geologie, Rohstoffe und Bergbau, Baden-Württemberg, Deutschland) observed in the Weiach core (Becker et al. 1997). The base of the core includes claystones with sandy layers overlain by carbonate-rich claystones and marls with intercalated bioclastic, sandy layers. In the upper part of the section (18.40 m–18.44 m) a bioclastic limestone with brachiopods, assigned to the Spiriferina-Bank, can be correlated with a similar horizon in the Weiach core between 957.69 m and 958.39 m, probably also corresponding to the interval between 956 m and 957 m in the Benken well.

3. Outcrops in the vicinity of Freudenstadt

Abandoned quarry Glatten

The outcrop of the Glatten quarry (Gauss-Krüger coordinates: R 3462675, H 5369130) shows the transition from the Buntsandstein (Plattensandstein and Rötton Formations) to the Lower Muschelkalk ("liegende Dolomite" of Freudenstadt Fm.). At the base, reddish, fine-grained bedded sandstones of the Plattensandstein Fm. are overlain by reddish claystones of the Rötton Fm. (Hagdorn & Nitsch 2009). The overlying basal part of the Freudenstadt Fm. consists of bedded dolomites and dolomitic marls of the basal marine Muschelkalk transgression onto the Rötton playa sediments (Mundlos 1966; Hagdorn & Nitsch 2009).

Abandoned clay pit Haas

The abandoned clay pit at Haas (Gauss-Krüger coordinates: R 3461050, H 5368800) represents the type section of the Freudenstadt Fm. and comprises the following four members - Mergelige Schichten, Rauhe Dolomite, Schichten mit Homomya albertii, and Deckplatten (Hagdorn & Nitsch 2009). The approx. 18 m exposed section contains mostly dolomitic marls with a unit of nodular bedded dolomitic limestone in the middle part of the section (Hagdorn & Nitsch 2009).

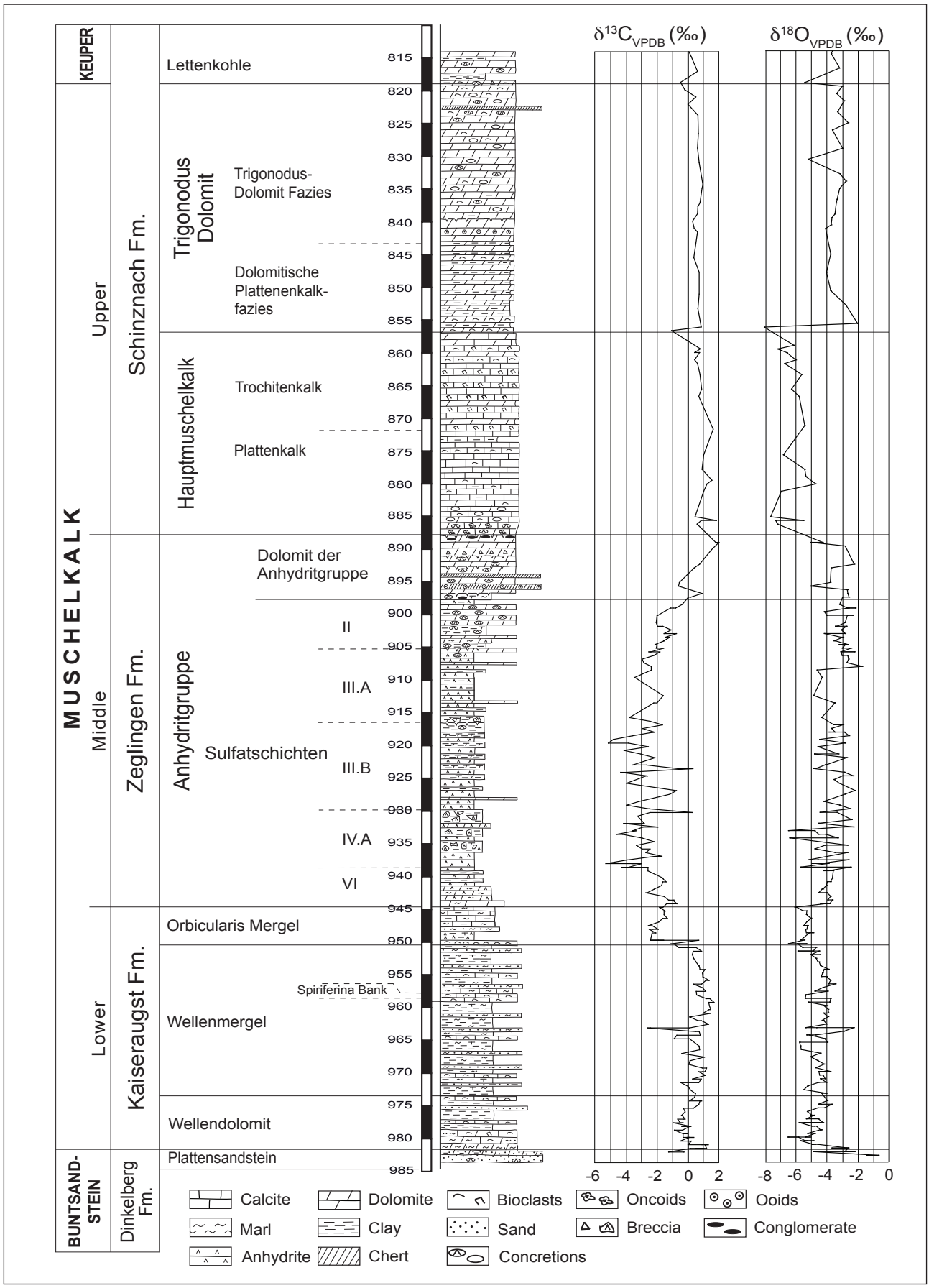

Fig. 1A- Lithostratigraphic column of the upper "Buntsandstein" to "Lower Keuper" in the deep Nagra-borehole at Weiach (Matter et al. 1988 a,b); oxygen and carbon isotopes this study.