12th International Symposium on Fossil Cnidaria and Porifera

Permian limestones with sponges and corals in the Ba'id area

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1 -The Permian reef boulders of the Wadi Wasit area, an introduction (A. Baud).

(A one day field trip; the Wadi Wasit with the Permian-Triassic Al Jil Formation section was examined during previous field trips (Baud et al., 2001, 2010) and the data presented here are modified part from the concerned sections of these guide books and modified part from Richoz et al., 2014, chap. 4).

1.1 -Routing (Fig. 1)

Starting in the morning February 5 from Muscat we will move to Ba'id village following first the Muscat-Nizwa highway up to Bidbid and then the road in direction of Sur to Wadi Tayn crossing and follow the Wadi Tayn road to Ba'id, turn at the Wadi Wasit entrance, and cross the Naqsi village for first stops, 500m North of the village (Fig. 2).

Figure 1: Google Map with road itinerary in red

Figure 2: Google Earth picture of the outcrops area in the Wadi Wasit, with in red, the road itinerary and the 6 stops of the day (N direction in the left down corner).

1.2 -Geological introduction

The Ba'id tectonic window is located in the Central Oman Mountains, to the south of the autochthonous units of the Arabian platform in the Saih Hatat and below the Samail ophiolite (Figure 3). It forms an anticline with a roughly N-S trending axis that exposes imbricate slices of the Hawasina sedimentary and volcanic units. The Wadi Wasit area provides one of the best and the most extensive exposures of Permian and Triassic deep-water sediments (Baud et al. 2001) in the Hawasina allochthon.

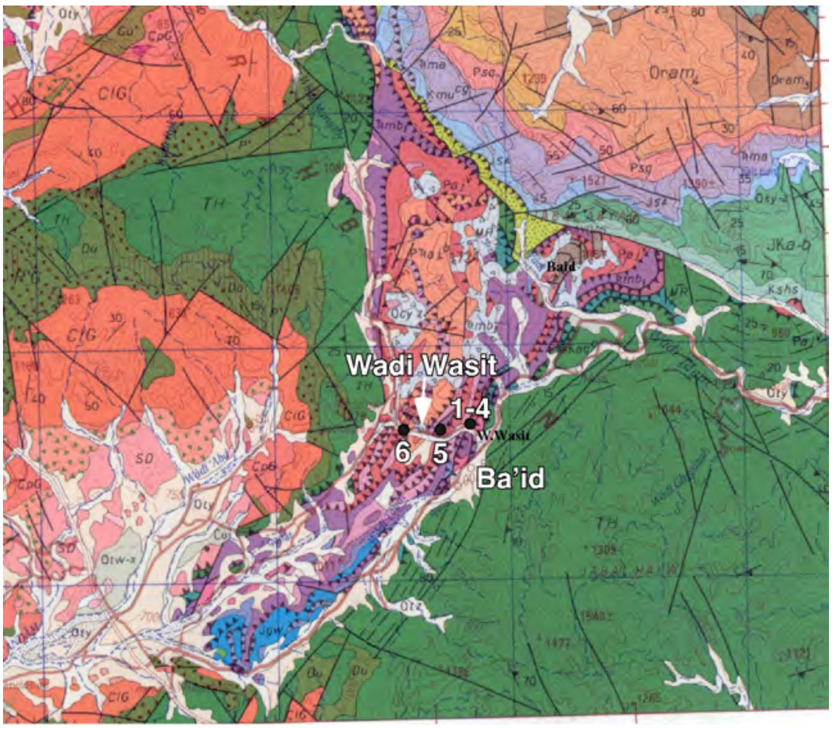

Figure 3: Geological map of the Wadi Wasit area (from Béchenec et al., 1992b). 1-4 Wadi Wasit section (stops1to 4) and 5-6 places of last stops.

The general stratigraphy of the Ba'id window (Permian and Triassic Al Jil Formation, sensu Béchennec, 1988; 1992a) consists of a 250 thick Middle Permian volcano-sedimentary sequence (Pillevuit et al., 1997) of pillow basalt with 4 main intercalations, 10 to 30m thick, of cherts, of volcanic breccia, of calcareous gravity flow deposits with Lower and Middle Permian shallow shelf or reef boulders and of cephalopod lime wackestones (Fig. 4).

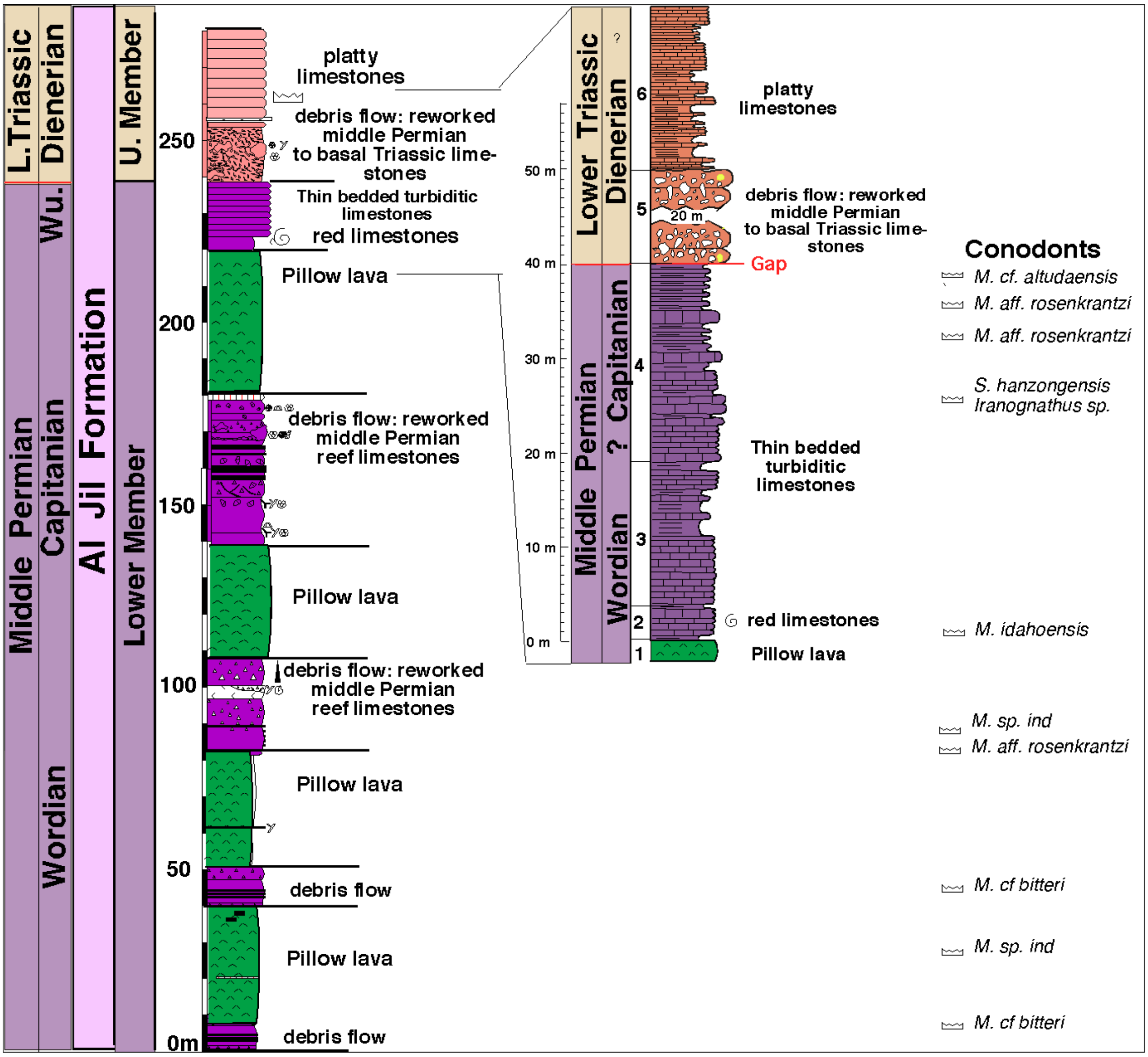

Figure 4: Wadi Wasit composite section (modified from Pillevuit et al. 1997); Conodonts determined by C. Henderson and A. Nicora.

Overlying are nodular, cherty and turbiditic (allodapic) limestones, which contain after a stratigraphic gap of nearly 10 my, the lower Triassic record begins with breccias of Dienerian age. These are followed by platy limestone's of late Dienerian to Smithian age, dated at different places by condones such as *N. waageni, Platyvillosus costatus, Neospathodus cristagalli* (det. L. Krystyn in Baud et al., 2001).

The breccia sandwiched between Permian turbiditic and lower Triassic platy limestone, are of variable thickness and are very widespread. They are channelized, clast-supported debris flows deposits, which cut deeply into the underlying calcareous or volcanic rocks of Middle Permian age

(Blendinger 1988, 1995; Pillevuit, 1993; Pillevuit et al., 1997), and some tectonic slices show dolomitized breccia of characteristic brown color.

These debris flow deposits consist mostly of Guadalupian reefal blocks, which originally formed the margin of the Permian carbonate platform (see Fig. 5). The reef biota of the Permian reef boulders deposited in these deep-water sediments has been compared with the El Capitan reference section of West Texas. Calcareous and dolomitic parts of the breccia tend also to be silicified, making paleontological studies difficult, as fossils are difficult to extract.

A team from the Erlangen Paleontological Institution studied these mid-Permian reef boulders and biota intensively and also compared them with the El Capitan reference section and facies of W Texas (Flügel in Blendinger and Flügel, 1990, Senowbari et al., 1992; Weidlich, 1996a; Weidlich, 1996b; Weidlich et al., 1993; Weidlich and Flügel, 1995; Weidlich and Senowbari, 1996).

A unique, entirely calcareous breccia, which occurs 1 km south of the middle part of Wadi Wasit, includes several small-sized blocks of lowermost Triassic bivalve-bearing limestones. The largest one, with a size of about 200 m^3, the Wasit block have been the subject of detailed studies of Krystyn et al, 2003 and a synthesis by Twitchett et al., 2004 and published with some changes in the Baud & Bernecker (ed.) guide book 2010.

2 -Permian reef blocks – paleogeography, facies and systematic paleontology

(O. Weidlich).

Permian reefs of Oman help to understand biologic processes in the southern Tethys during the Permian see Fig. 5. The reefs occur in different tectonic and stratigraphic units, respectively the Arabian Platform (Saiq Formation), the Hawasina Nappes (Al Jil and Ba'id Formations), and the Sumeini Group (Maqam Formation). Blocks of Permian reefs have been reported from Jebel Qamar (Dibba Zone, UAE), Jebel Nahkl at the northern flank of Jebel Akhdar, Ba'id area (eastern Oman Mountains), and the Batinah coast (e.g. Qararai Limestone, Shackleton *et al.* 1990). From these sites, blocks of the Batinah coast provided additional informations from Lower Permian reefs.

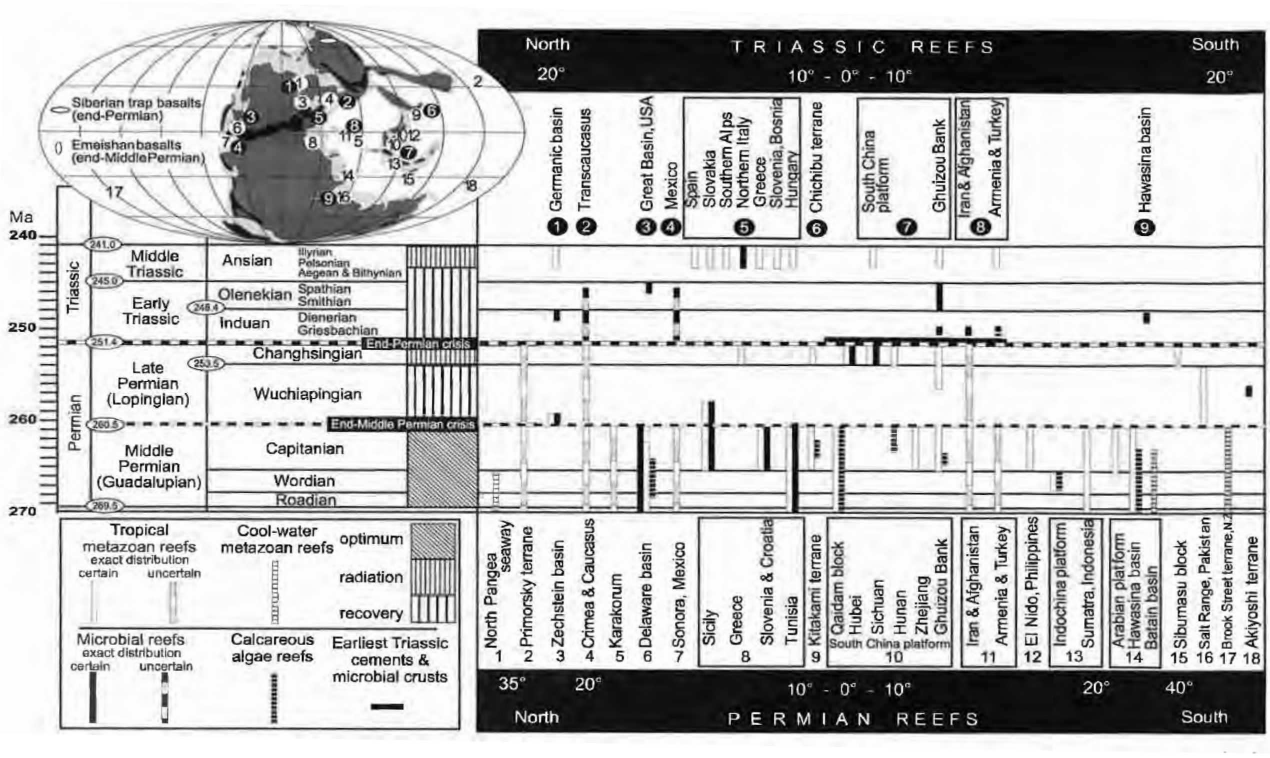

Figure 5: Middle Permian – Middle Triassic chronostratigraphic and stratigraphic ranges of reefs plotted against paleolatitude. Inset map is a Late Permian paleogeographic reconstruction. (14) Arabian platform and Hawasina basin; after Weidlich et al. (2003)

The Ba'id area provides excellent data of Middle and Upper Permian facies via blocks (up to 200 m in diameter) and calciturbitides reflecting the compositional variation of reef and platform carbonates. Reef blocks of the Wadi Wasit area (Fig. 6) are dominated by algal cement reefs and coral reefs occur abundantly, while bryozoan reefs occur subordinately. Reef blocks from this area contain, as reef building organisms, coralline sponges, chaetetids, rugose and tabulate corals, richthofeniid brachiopods, uncertain stromatoporoids, and crinoids. Smaller reefbuilders were calcimicrobes including *Shamovella* and *Archaeolithoporella*, bryozoans, *Lercaritubus*, dasycladaceans, solenoporaceans, phylloid algae, and foraminifera. In addition, brachiopods, molluscs, trilobites and ostracodes are present.

Figure 6: reef block type of the Ba'id area.

The main organic reef constituents of the reef blocks comprise sphinctozoan sponges, inozoan sponges, chaetetids, rugosa and tabulate corals and crinoids. Low growing and incrusting organisms comprise Tubiphytes, Archaeolithoporella, Lercaritubus, bryozoans, algae (solenoporaceans, dasycladaceans, problematical dasycladaceans and phylloid algae). Rare richthofenid brachiopods. Sphinctozoan sponges include 14 genera and 25 species (Weidlich and Senowbari-Daryan, 1996). The described fauna exhibits close relationships to sphinctozoan faunas known from the Middle and Late Permian of China and Tunisia. The following genera have been described, see Figs. 7-10: *Amblysiphonella*, *Colospongia*,, *Parauvanella*, *Imbriticatocoelia*, *Salzburgia*, *Preverticillites*, *Welteria*, *Intrasporeocoelia*, *Rhabdactinia*, *Rhabahthalamia*, *Thaumastocoelia*, *Sollasia*, *Girtyocoelia* and *Spica*.

Rugose corals are represented by 7 genera, including *Yokoyamella*, *Monothecalis*, *Wentzelella*, *Wentzelloides*, *Multimurinus*, *Lonsdaleiastraea*, *Praewentzelella* (Figs 11 – 14). Tabulata are represented by *Multithecopora*.

Reefs blocks consist of (1) Bioclastic float/rudstone, (2) Bryozoan cementstone and float/rudstone, (3) Sponge-bryozoan bafflestone, (4) Sponge-calcimicrobe framestone with bryozoans, (5) Coral calcimicrobe framestone, (6) Chaetetid framestone and (7) Richthofeniid boundstone. Rugose corals are locally abundant and formed communities, including the *Praewentzelella* community, the Cerioid coral community, and the *Waagenophyllum* community.

The climax of reef growth on the Arabian Plate and in the Hawasina Basin is documented from the reef blocks of the Al Jil and Ba'id Formations (Hawasina Complex), which might have formed both the shelf margin reefs of the Arabian platform or reefs florishing on isolated platform or seamounts representing the optimum of reef growth. Reef blocks of the Hawasina basin represent the optimum of Middle and Upper Permian reef growth due to a great diversity of reefbuilders (on

high taxonomic level and species level) and the abundance massive corals which contributed to reef building processes and show similarities to their counterparts in China.
Sponge and coral communities were able to construct reef cavities which where filled to some extent with coprolite grainstone, see Fig. 15.

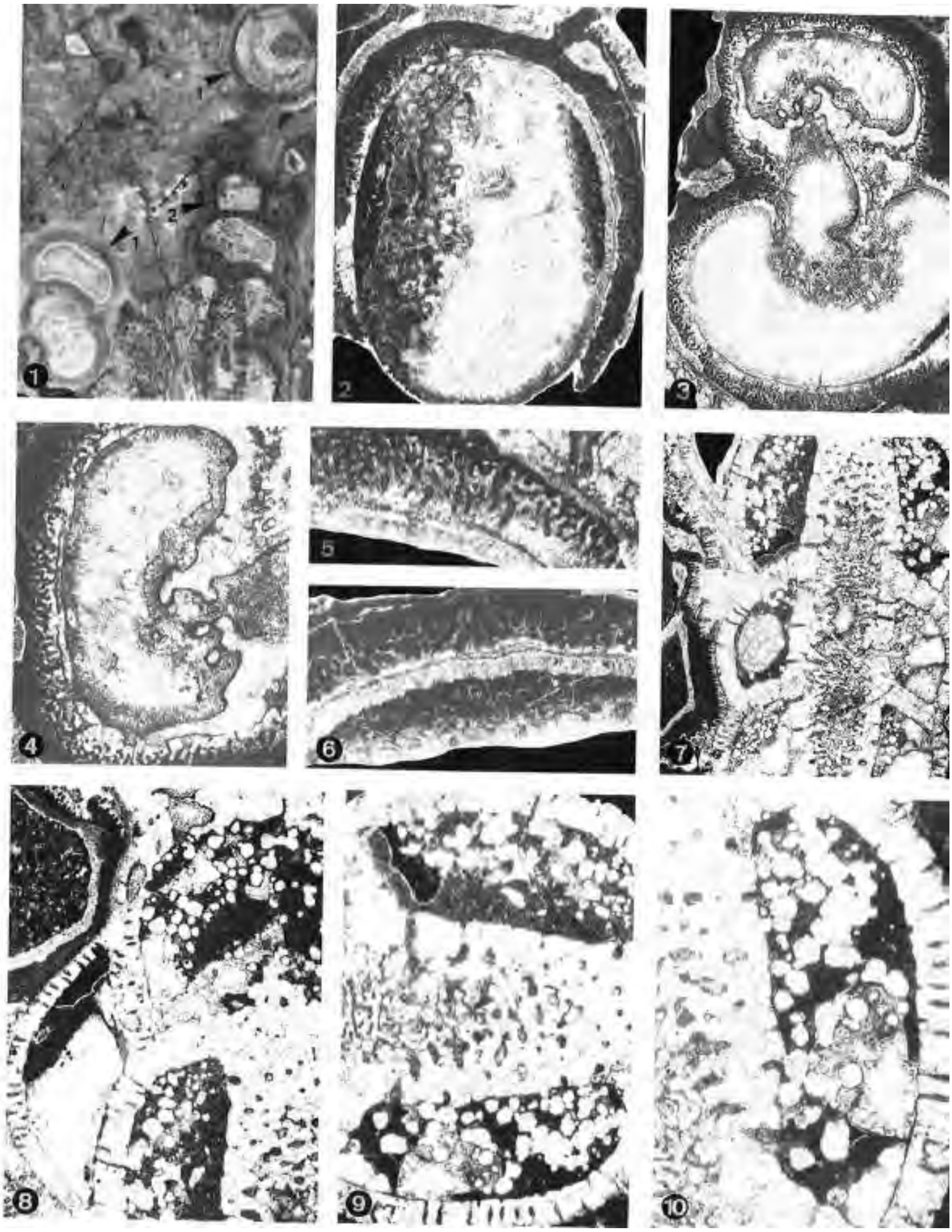

Figure 7: Salzburgia irregularis and Rahbahthalamia bullifera. Fig 8.1, sample with Salzburgia (1) and Rahbahthalamia (2), x 1,3. Figs 8.2-8.6, photomicrographs of S. irregularis showing the central tube and chambers; exowalls with labyrinthine pores. Figs 8.7-8.10, photomicrographs of R. bullifera showing porate chambers with bubble-like filling structure and a central tube. See Weidlich & Senowbari-Daryan (1996) for details.

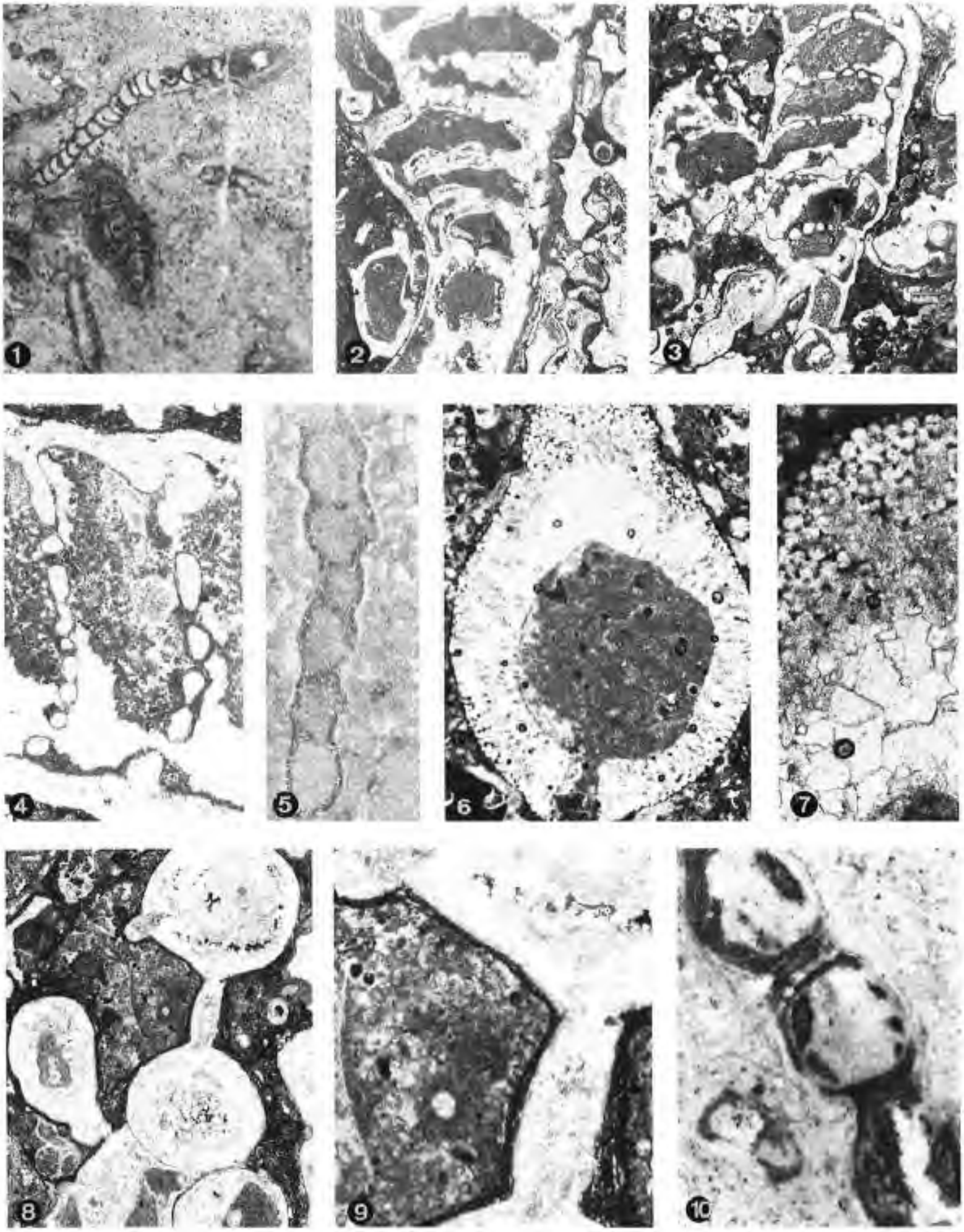

Figure 8: Thaumastocoelia and Sollasia. 1-5, various specimen of T. irregularis and T. sp. showing variability of chambers with respect to chamber shape, dimensions and morphology. 6-8.10, S. ostiolata and S. absita, showing details like chamber morphology, ostia and spherulitic microstructure of chamber walls. See Weidlich & Senowbari-Daryan (1996) for details.

localities	species [%]	genera [%]
China (West Hubei, Guangxi)	40	64
Tunisia (Jebel Tebaga)	36	72
Sicily (Pietra di Salomone)	20	36
U.S.A. (Guadalupe Mountains)	16	36

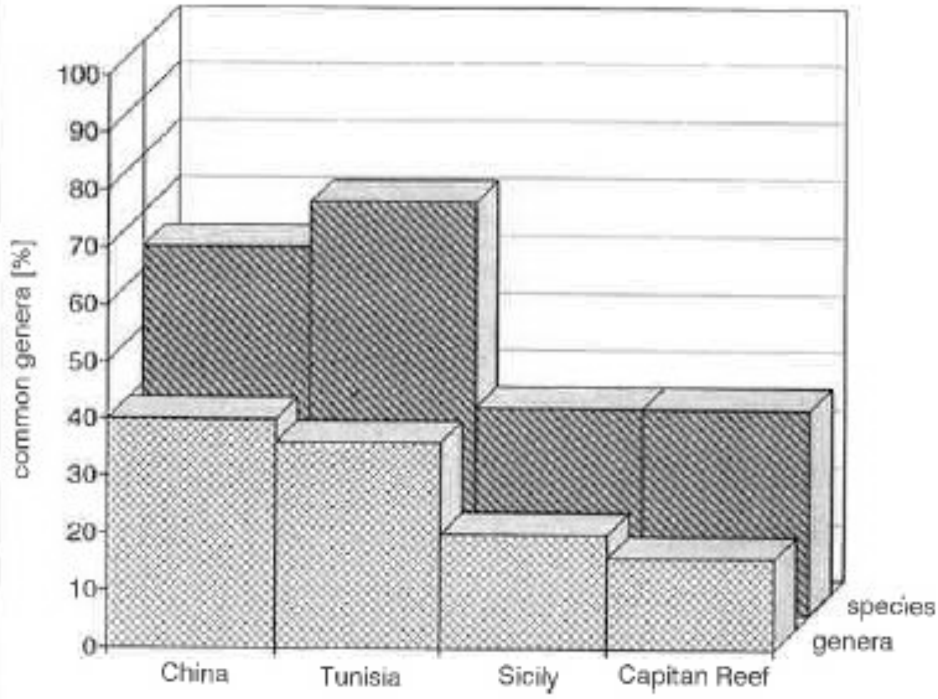

Figure 9: Percentage of sphinctozoan genera from samples and thin sections of the Ba'id area as compared to sphinctozoan associations from China, Tunisia, Sciliy and Texas/New Mexicoa (Capitan Reef). Most abundant are Sollasia and Amblysiphonella that occur in more than 30% of the samples.

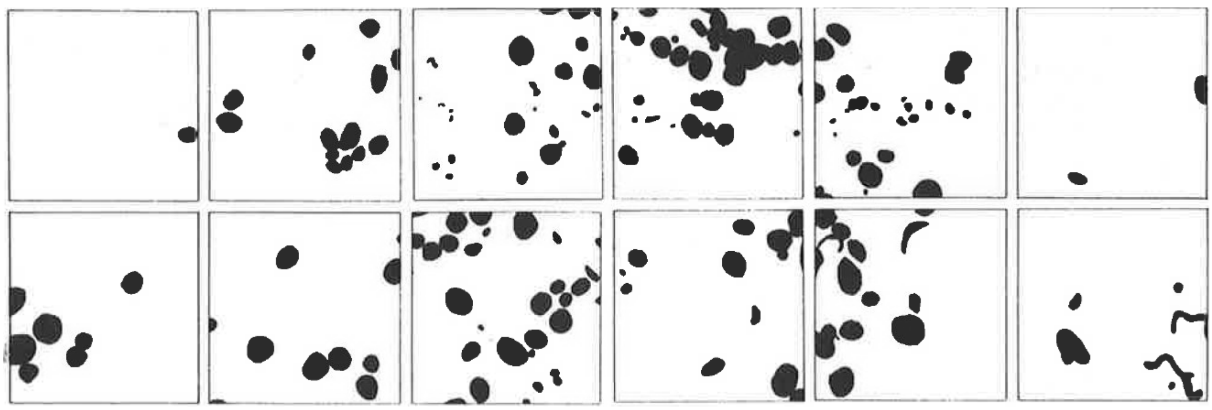

Figure 10: Cross section through the Praewentzelella coral community, showing its monospecific character.The quadrats have a length of 20 cm. See Weidlich et al. (1993) for details.

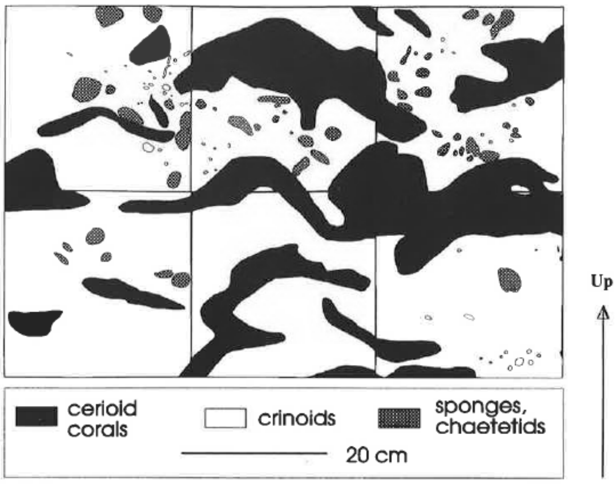

Figure 11: Field data of a vertical cut through the cerioid coral community. Most colonies exhibit a pronounced vertical aggradation with fairly steep flanks, providing cryptic cavities cavities. See Weidlich & H.W. Flügel (1995) for details.

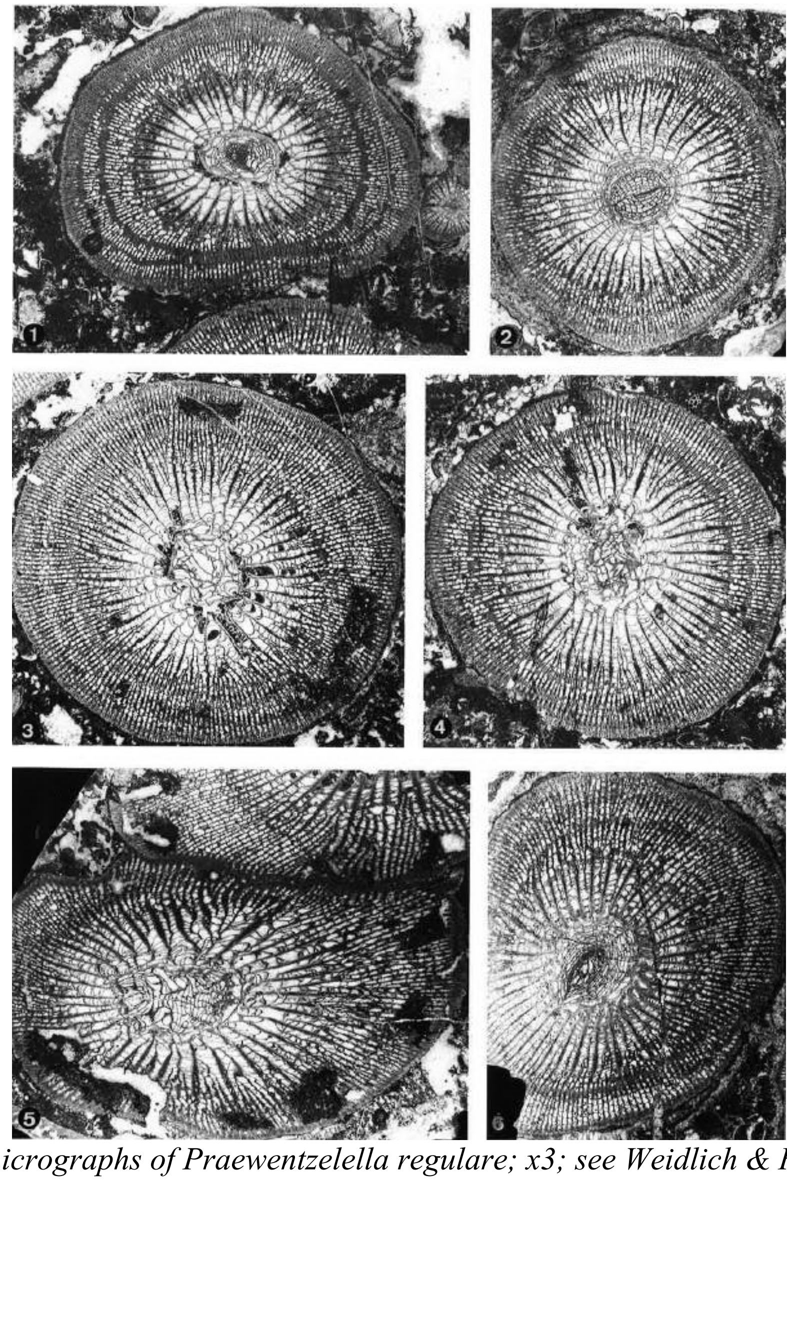

Figure 12: Photomicrographs of Praewentzelella regulare; x3; see Weidlich & H.W. Flügel (1995) for details.

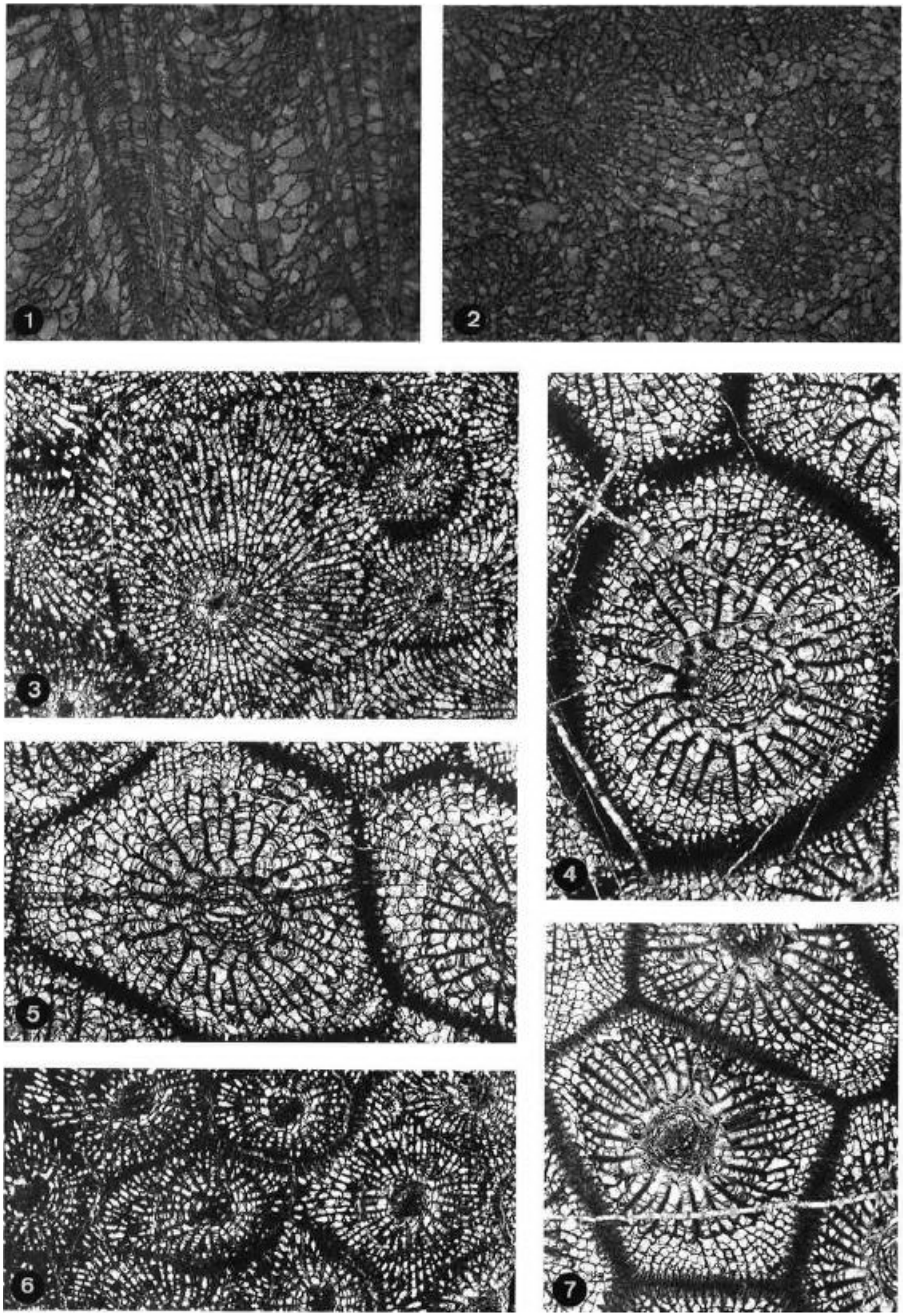

Figure 13: Photomicrographs of cerioid corals. 14.1-14.2, Monothecalis minor. 14.3-14.5, 14.7 Wentzelella katoi magna. 14.6 Wentzelelloides sp. x 6; see Weidlich & H.W. Flügel (1995) for details.

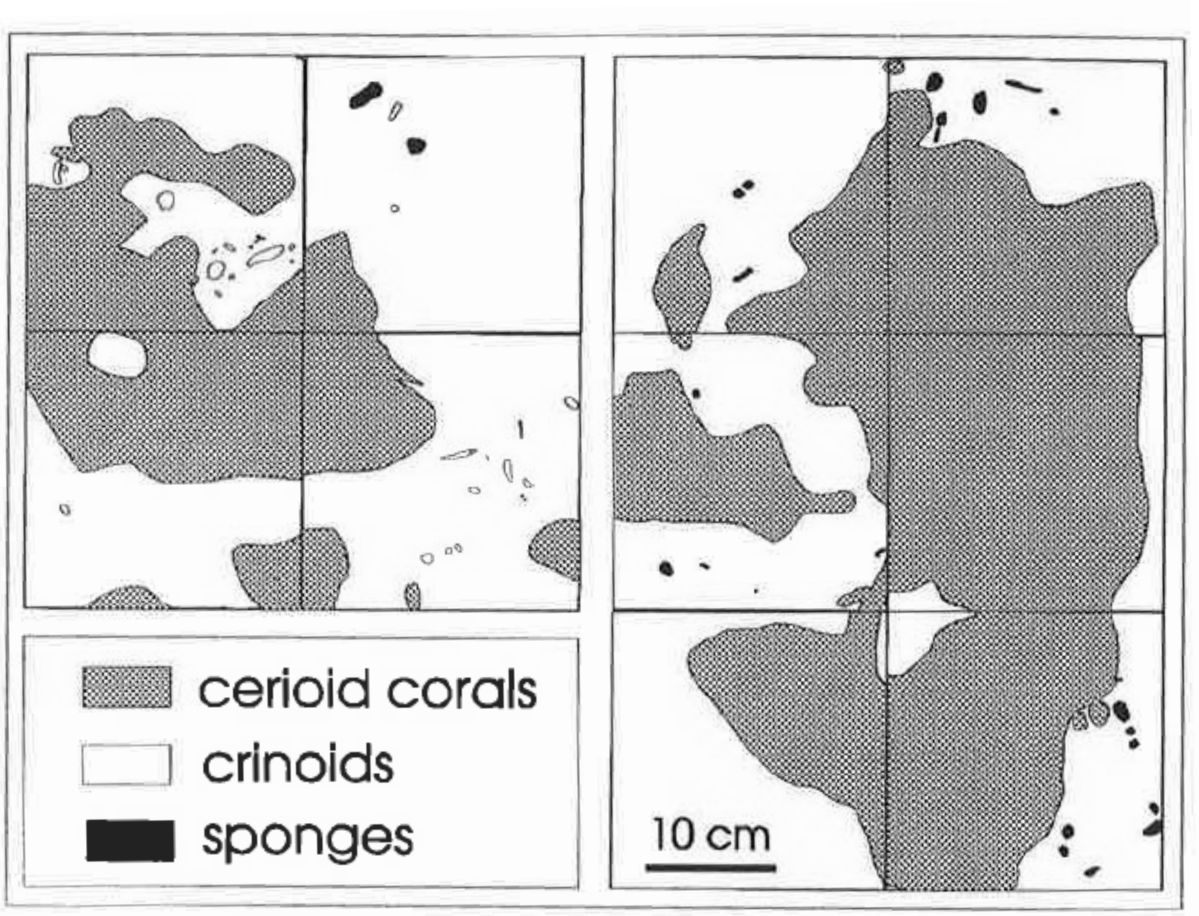

Figure 14: Horizontal section through the cerioid coral community. The corals are in growth position. Comples colony outlines and growt6h framework pores provided cryptic habits. See Weidlich & H.W. Flügel (1995) for details.

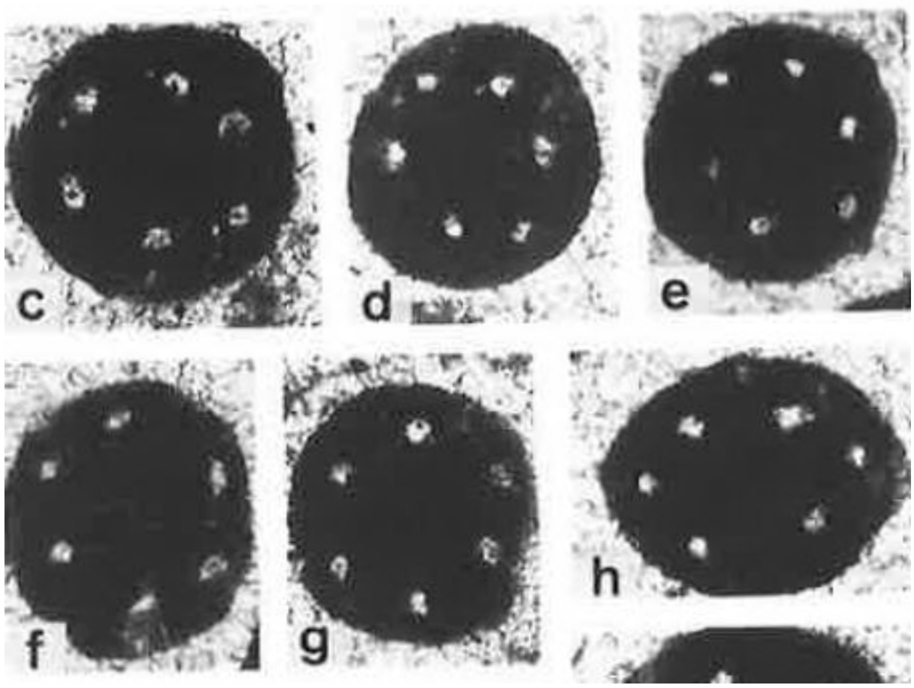

Fig. 15: Photomicrographs of a coprolite grainstone (Palaxius salataenensis) filling a reef cavity. See Senowbari-Daryan et al (1992) for details.

3 - Stops of the day (A. Baud).

3.1 -Stops 1, 2 and 3: stratigraphy of the Al Jil Formation on the left side of the Wadi Wasit (see position on fig. 2) **and reef boulders mass flows.**

We will have a half day look of the complete section that consists of 5 main lithologic units (Al Jil Fm.) from base up (Fig. 16):

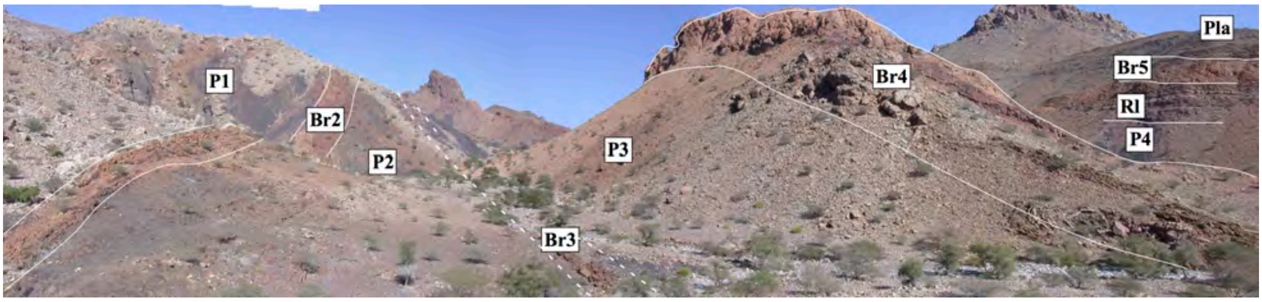

Figure 16: General view on the Wadi Wasit section. The successive units are found in different tectonic slices. The pillow-lavas units are labelled P1 to P4 and the interspersed sedimentary levels Br2 to Br3. Br4 is not present in this view. The upper sedimentary succession on the right comprises the red and allodapic limestone (Rl), the upper Induan breccia (BR5) and the overlying lower Triassic platy limestone (Pla), see Figure 4.

-**Units P1, P2, P3 and P4** are thick volcano-sedimentary sequences made up of alkali pillow basalts WPB-type (Béchennec 1988, Béchennec et al., 1991, Pillevuit, 1993, Maury et al., 2003) and of tuffites with inter-beds of radiolarites. These volcanic rocks are strongly enriched in the most incompatible elements and are typical of high-Ti basalts identical to plume-related alkali basalts from intra-plate continental or oceanic settings.

-Units Br2, Br3, and Br4 will be the main subject of attention of the day. They consist of gravity flows deposits, from 10 to up 50m thick, partly composed of reef boulders re-deposited in the deep water sediments (Fig. 17).

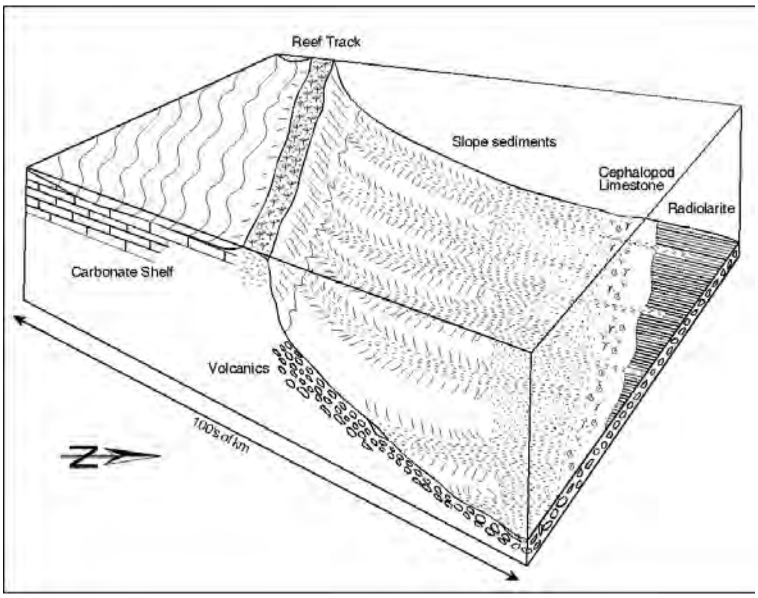

Figure 17: Depositional model for the Middle Permian of the WadiWasit basin margin (modified after Blendinger, 1988).

3.2 -Stop 4 (fig. 18).

It is located on the left and NE side of the Wadi Wasit. It is the upper part of the complete section and consists of five main lithological units (Al Jil Fm.) from base up:

- Unit 1 (only its uppermost part is represented in fig. 18) is a thick volcano-sedimentary sequence made up of alkali pillow basalts WPB-type (Béchennec, 1988, Béchennec et al., 1991, Pillevuit, 1993, Maury et al., 2001) and of tuffites with inter-beds of radiolarites.
- Unit 2, 19m thick, consists essentially of medium bedded red cephalopod limestone with some levels of fine-grained resedimented limestone and red shale inter-beds. Furnish and Glenister in Blendinger et al. (1992) determined the ammonoids of these limestones and gave the following list, named "sicilian species": *Parapronorites konincki*, *Propinacoceras beyrichi*, *Eumedlicottia bifrons, Neogeoceras marcoui*, *Adrianites elegans*, *Aricoceras ensifer*, *Tauroceras scrobiculatum, Stacheoceras sp*. and *Waagenoceras sp*.. *Epadrianites beyrichi* is known from Timor and *Mongoloceras omanicum* is a new species. In the same level as the ammonoid, H. Henderson and A. Nicora founded the conodonts *N. idahoensis*.
- Unit 3-4 (21m thick) consists of depositional sequences mainly of turbiditic lime packstones and red shale, the latter being more abundant in the upper part. The allodapic limestones are represented either by calcarenites or calcirudites and they include occasionally reddish-whitish chert nodules.

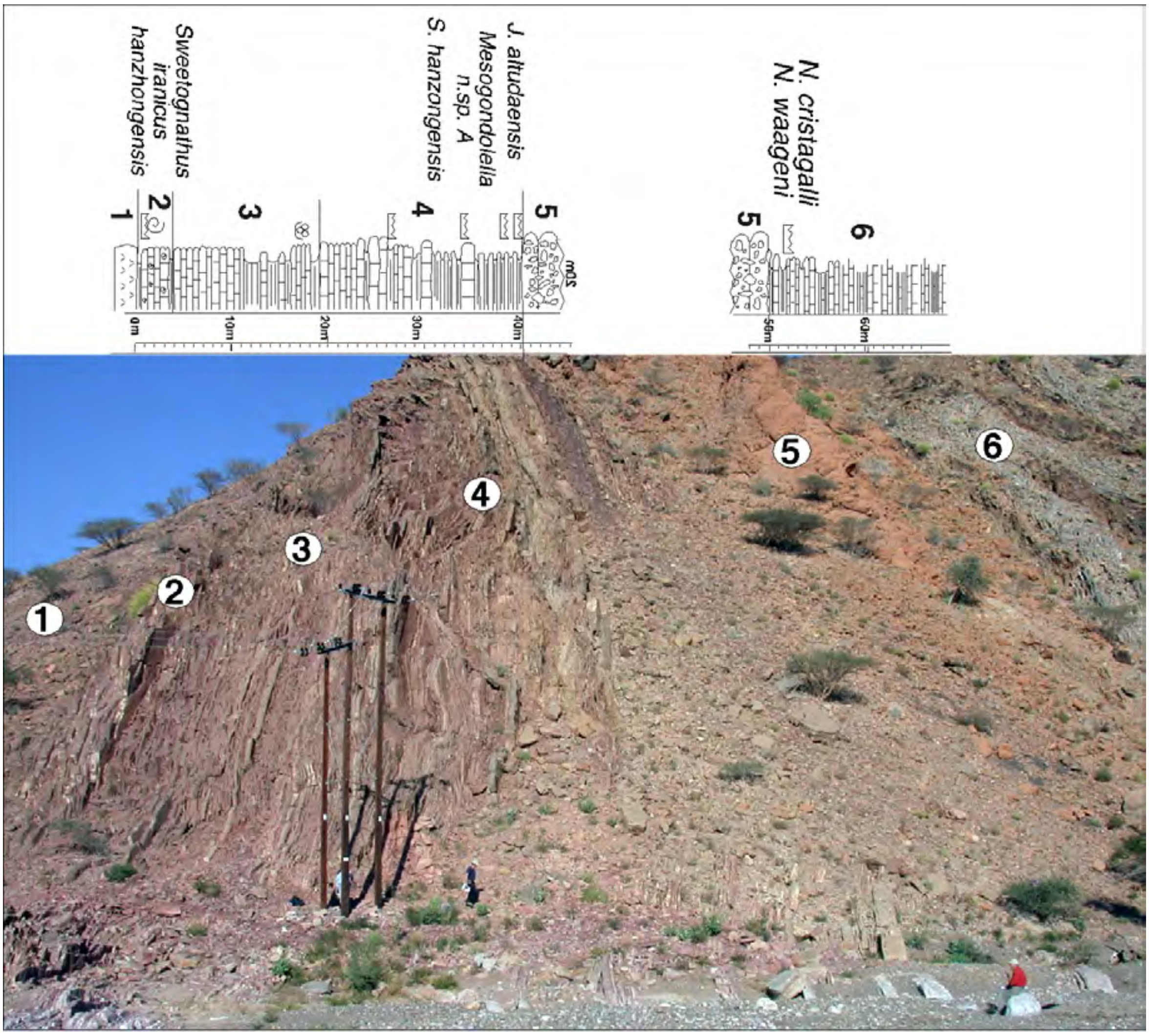

Figure 18, stop 4: view of middle part of the Wadi Wasit section. Lithological section modified from Atudorei (1999). Unit 1 to 4, conodont founded and determined by C. Henderson and A. Nicora. Unit 6, conodont founded and determined by L. Krystyn.

- Unit 5, about 20-30 m thick is represented by a massive dolomitized breccia with blocks of reefal limestones (Weidlich et al., 1993).
- Unit 6 starts with gray platy limestones and thin shales or marlstones interbeds, over a 6 m thickness.

The contact with massive dolomitized breccia is irregular and marked in some depressions by a thin layer of marly shale. Elsewhere the platy limestone unit is overlain by a green shale/fine-grained quartz-sandstone sequence 12 m thick and then by a green/red radiolarian chert series, base of the Matbat Fm.

Stop 5

It is about 1 Km upstream of Wadi Wasit and concerns a lateral outcrop of the Unit Br2 with mid-Permian reef boulders (fig. 19) of different sizes.

Figure 19 : reef boulder with crinoid stems

Stop 6

Spectacular road cut through pillow lava and its deformed sedimentary cover (fig 20)..

Figure 20 : pillow-lava (left) with his folded middle Permian cover (thin bedded limestone and radiolarite, overlain by reef limestone blocks. Mathias back for scale.

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