Middle Permian Conodonts from Oman

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This paper is to report the joint occurrence of *Mesogondolella aserrata*, the conodont index species of the Wordian Stage, and *Mesogondolella siciliensis* in ammonoid-bearing Wordian rocks of the Rustaq and Wadi Wasit sections, Oman.

In the Sultanate of Oman, the best Neotethyan outcrops of the entire Tethys are present. In the Hawasina nappes good Permian and Triassic outcrops are present, which were visited by the excellently guided excursions A01 and B01 on the very successful International Conference on the Geology of Oman, Pangaea Symposium and Field Meeting, January 2001. B.R. Wardlaw as Chairman of the SPS asked H.W. Kozur as one of the participants to sample the ammonoid-bearing red limestones overlying pillow lava in the sections Rustaq and Wadi Wasit. These sections are Wordian based on a well preserved, rich, Sosio-type ammonoid fauna identified by the top specialists of Guadalupian ammonoids and stratigraphy Prof. Dr. W.M. Furnish, Prof. Dr. B.F. Glenister and Prof. Dr. W.W. Nassichuk in Blendinger *et al*. (1992), Pillevuit (1993) and Baud *et al*. (2001a,b). Preliminary conodont determinations by Kozur an Krystyn in Blendinger *et al*. (1992) and Baud *et al*. (2001a,b) from the ammonoid horizons yielded mainly *M. siciliensis* as in the famous Rupe del Passo di Burgio block of Sosio Valley, Sicily.

The aim of these investigations was to find in a continuous section, a further anchor point for the conodont correlation of the Wordian Sosio type ammonoid faunas (important for the recognition of the Wordian in the open sea Tethys) with the type Wordian in the Delaware Basin. A second aim was to show, again in a continuous section, well dated as Wordian by ammonoids, the typical Wordian conodont fauna of the Tethyan Conodont Province. The Wordian ammonoid dating of Oman is accepted by all Tethyan workers, not only by the ammonoid specialists, and is based on an up to date ammonoid taxonomy, worked out by three top specialists of the Wordian ammonoid taxonomy and biostratigraphy (see above). This second aim is important because Mei *et al.* (1999a, 1999b) and Mei & Henderson (2001) questioned the Wordian age of the Sosio-type ammonoid fauna which is the best anchor point for correlation of the type Wordian with the Wordian in the huge Tethyan area. They correlated the conodont fauna of the Wordian Sosio type ammonoid fauna of Rupe del Passo di Burgio block in different papers with different Kungurian conodont zones from the base to the top of the Kungurian. Mei & Henderson (2001) even questioned the stratigraphic importance of *Waagenoceras* and regarded this genus as a long-ranging late Kungurian to early Lopingian genus. By the dating of the late Wordian ammonoid fauna of Sosio type and the contemporaneous lower Midian fusulinid fauna from the Rupe del Passo di Burgio stratum typicum of the type species of *Waagenoceras* as lower or upper Kungurian, Mei *et al.* (1999a,b) and Mei & Henderson (2001) did not only reject well established Tethyan Guadalupian biostratigraphic correlations, but also caused Leven (2001) to even question the use of the Guadalupian stages for the Tethys. To provide Mei and Henderson with a well dated Wordian conodont fauna from the Tethyan Conodont Province, the sampling by Kozur from the Wordian ammonoid horizons of the sections Wadi Wasit and Rustaq was duplicated by Dr. B. Beauchamp to make sure that Mei and Henderson got the same samples that we have investigated. The sampling by Kozur and Beauchamp was very much supported in the field by A. Baud, F. Béchennec and J. Marcoux, top specialists of the Permian stratigraphy in Oman. By this, it was guaranteed that the conodont samples were taken exactly from the points from where the Wordian ammonoids had been collected.

Both in the Wadi Wasit and in the Rustaq section, a thick pile of pillow lava with interpillow intercalations of red pelagic limestone, partly with Guadalupian ammonoids is overlain by red pelagic limestones, partly in the facies of ammonitico rosso (Rustaq). The Wordian ammonoids in Blendinger *et al.* (1992), Pillevuit (1993) and Baud *et al*. (2001a,b) were from the lower 3 m of these limestones in the Wadi Wasit section and from two 1 m and 1.1 m thick very ammonoid-rich red limestone separated by 1.10-1.80 m thick dolomite in the Rustaq section. In Wadi Wasit the red ammonoid-bearing limestone is overlain by about 30 m of limestones, at first red micritic siliceous limestone, toward the top increasingly grey limestone intercalations, allodapic limestones and shales. All limestones are strongly siliceous. Then follows 5.2 m thick coarse calcarenites with a 3 m intercalation of red and orange shales containing some thin limestone beds. In the upper 5 m red, there are red, subordinately grey or greenish-grey shales, with thick and thin grey, partly graded cherty limestone banks and chert. This sequence is followed by a breccia (Baud *et al*., 2001a). One sample with ammonoids was taken by Beauchamp 0.5 m above the pillow lava (sample KW 10A/2001) and given half of the sample to Kozur. Kozur has taken a further sample 0.4 m above the pillow lava (sample KW 10B/2001) and 9 further samples from the ammonoid-free part of the section up to 40.4m above the pillow lava for investigations outside the scope of the present contribution (samples KW 1-9/ 2001).

In the Rustaq section, the Wordian ammonoids were found in two thick beds of red pelagic limestones with several layers rich in crinoids (Baud *et al*., 2001b). Numerous, well preserved Wordian ammonoids were found in several levels of both beds. The 1 m thick lower bed begins about 0.5 m above the pillow lava and consist of red pelagic limestones with numerous ammonoids and crinoids. These two beds were sampled by Kozur and the sample points were marked in the field and a few days later re-sampled in exactly the same sampling points by B. Beauchamp. Sample KR 2/ 2001 was taken from the base of the lower bed, sample KR1/2001 15 cm higher, sample KR3/2001 from the upper 10 cm below the 1.1-1.8m thick dolomite intercalation. The upper ammonoid-bearing bed is 1.1m thick and consists of Hallstatt Limestone. It is subdivided into 4 beds, from which the uppermost one is partly flaser-bedded. Sample KR 4/2001 was taken 0.15 m above the base of the limestone, sample KR 5/2001 at 0.35 m above the base, sample KR 6/2001 at 0.7 m above the base, and sample KR 7/2001 at the top of the upper limestone bed immediately below about 10 m of dolomites.

The samples KW 10A,B/2001 from the Wadi Wasit section contains numerous silicified ostracods (Kozur, in prep.). They consist mainly of shallow-water ostracods, such as sculptured Bairdiidae and Kirkbyidae and ostracods that occur both in shallow- and deep-water, such as smooth Bairdiidae. In addition, palaeopsychrosphaeric deep-water ostracods are never dominating but rather common. Such an ostracod fauna indicates water depth below the storm-wave base around 100 m to shallower than 200 m. Furthermore, they indicate that the area had full connection to nearby cold bottom-water currents. The conodont fauna consists almost exclusively of smooth *Mesogondolella*, mainly *M. siciliensis,* with rarer primitive specimens of *M. omanensis* n. sp., transitional from *M. siciliensis*. *M. omanensis* evolved from *M. siciliensis* and is distinguished from this species by the outline either with subparallel sides (in primitive forms) or distinctly triangular (advanced specimens). *M. aserrata* (*J. aserrata*) is rarely present, and is very smooth. The highest occurrence of smooth *M. aserrata* is in sample KW8/2001, about 34 m above the pillow lava. In the entire interval an open connection to cold bottom-water currents is indicated by the ostracods, and by the conodonts because all *Mesogondolella*, including *M. aserrata*, are basically unserrated.

In the lower part of the lower ammonoid-bearing limestone at Rustaq, the same ostracod fauna is present, but with fewer palaeopsychrosphaeric ostracods. The conodont fauna is the same as in KW 10A,B/2001. Also in KR1/2001 and KR2/2001 all conodonts, including a few *M. aserrata* are smooth. The ostracod fauna with fewer palaeopsychrosphaeric forms indicates a little shallower environment than that at Wadi Wasit, but within the same depth range as indicated for Wadi Wasit. A distinct change is observed in KR 3/2001, immediately below the dolomite intercalation. There, the same species occur, but *M. aserrata* is not so rare and besides the basically smooth forms, serrated forms are common. In rare specimens, weak serration is even developed in *M. siciliensis* and *M. omanensis*. However, in the lower part of the upper ammonoid-bearing limestone, 15 cm above the dolomite (sample KR4/2001), smooth forms dominate again with only one weakly serrated *M. aserrata*. All other specimens of the rare *M. aserrata*, and of the common *M. siciliensis* and *M. omanensis* are smooth. In sample KR5/2001 all *Mesogondolella* (dominated *M. siciliensis* and *M. omanensis* with very rare *M. aserrata*) are smooth and palaeopsychrosphaeric ostracods re-appear. This indicates a re-opening of the connection to the cold bottom water currents and a correlation between palaeopsychrosphaeric ostracods and completely smooth *Mesogondolella*s. Near the upper thick dolomite, the palaeopsychrosphaeric ostracods disappear again and several specimens of both *M. siciliensis* and *M. omanensis* show faint serration of the anterior platform margin. This feature is especially well developed in sample KR7/2001 immediately below the upper thick dolomite. Thus, two times, typically smooth *Mesogondolella* exhibit faint serration when the open connection to the cold bottom water currents was interrupted. In sample KR6 and 7/2001 *M. siciliensis* is progressively more replaced by *M. omanensis*, which is represented by more and more advanced forms with triangular outline.

In addition to the ammonoids, conodonts and ostracods, reef debris is present in the Wadi Wasit section, and some silicified fusulinids were found in the insoluble residues from Rustaq. Colonial reef corals and numerous sculptured Bairdiidae indicate tropical warm-water conditions. This suggests the presence of reefs (close to Wadi Wasit) and a small carbonate platform (Rustaq) similar to deposition near atolls today.

The above mentioned results show the extraordinary importance of the Rustaq and Wadi Wasit sections for the correlation of the Tethyan stratigraphy and above all for the correlation with the type Wordian in the Delaware Basin which make them to a critical anchor point for the Wordian of the Tethys. The main results are:

1) The Tethyan Wordian key ammonoid fauna of Sosio type in the Wadi Wasit and Rustaq sections contains dominantly smooth *Mesogondolella* (*M. siciliensis*, *M. omanensis*), but this conodont fauna is accompanied by very rare to moderately common *M. aserrata* (*J. aserrata*), the index species of the type Wordian in the Delaware Basin. This confirms also by conodonts the Wordian age of the Sosio-type ammonoid fauna which is accepted by all Tethyan Permian stratigraphers since Miller (1933, Heritsch (1933, 1940) and Kahler (1939).

2) The co-occurrence of *M. siciliensis* and *M. aserrata* confirms by conodonts the Wordian age of the *M. siciliensis* conodont fauna within the Wordian Sosio-type ammonoid fauna.

3) Guadalupian conodont faunas of open sea Tethyan environment with open connection to the cold bottom water currents contain in situ only smooth *Mesogondolella*. Even *M. aserrata* in this environment is typically unserrated. When the open connection to the cold bottom water currents is interrupted, *M. aserrata* displays common serrations and generally smooth forms such as *M. siciliensis* and *M. omanensis* also exhibit faint serrations of the anterior platform.

A very interesting parallel evolution can be observed in the

Phosphoria Basin of western North American and in Oman. In the upper Wordian Retort Phosphatic Shale, *M. phosphoriensis* with a platform widest in or around the middle part, in which triangular forms appear very rare in the upper part of its range changes into parallel-sided to triangular forms of *M. retortensis* n. sp. In Oman *M. siciliensis*, with a platform widest in front or around the middle of the platform changed into the parallel-sided or triangular *M. omanensis*. Both new species are very similar to each other. This suggests that *M. phosphoriensis* and *M. siciliensis* are very closely related to each other.

Mei & Henderson (2001, p.252) suggest that the Oman conodont faunas are transitional between *M. siciliensis* and *J. nankingensis* (based on only three samples collected by Dr. Beauchamp). Our material from Rustaq and Wadi Wasit contains only advanced *M. aserrata* without similarity to *M. nankingensis*. *M. aserrata* of the type which we have found in Oman are also in the Delaware Basin and distinctly younger than *M. nankingensis* and do not occur with *M. nankingensis* or its forerunner. *M. siciliensis* belongs to a different lineage than *M. nankingensis* which retains the carina denticulation and the low blade of *M. idahoensis*, whereas *M. siciliensis* and all species of the *M. siciliensis* lineage up to the Capitanian always have a high, highly fused blade and a different denticulation pattern of the posterior carina. Lambert *et al.* (2000) and Lambert and Wardlaw (1996) have clearly shown that *M. (Jinogondolella) nankingensis* evolved from *M. idahoensis* not *M. siciliensis*. Further, a word of caution, our current investigation suggests that faint serrations can develop in many species of *Mesogondolella* given the proper environmental conditions and the presence of just serration does not indicate the presence of *M. (J.) nankingensis*.

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