Microfauna and nannoplankton below the Paleocene/Eocene transition in hemipelagic sediments at the southern slope of Mt. Nanos (NW part of the Paleogene Adriatic carbonate platform, Slovenia)

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Abstract

This paper describes deeper water clastic to hemipelagic sediments from the Adriatic microcontinent, at the contact zone between the Adriatic and Dinaric carbonate platforms. The flysch section from Mt. Nanos contains a sedimentary sequence deposited close to the Paleocene/Eocene boundary. We dated this section biostratigraphically, reconstructed the paleoenvironments, and established a correlation with the northern part of the central Tethys. Samples were studied for calcareous nannoplankton, planktonic foraminifera, small and large benthic foraminifera, and ostracods. Calcareous nannoplankton assemblages of the Nanos section belong to the *Discoaster multiradiatus* zone NP 9 in the uppermost Paleocene. Planktonic foraminiferal assemblages allow the assignment to the biozone *Morozovella velascoensis* (P 5) in the uppermost Paleocene as well. Both nannoplankton and planktonic foraminifera are consistent with a period of global warming in the latest Paleocene just below the PETM. Nannoplankton assemblages are relatively rich in discoasters which suggests that they were deposited in a warm oligotrophic environment. Planktonic foraminifera indicate oligotrophic habitats, warm surface water and a well stratified water column with stable thermocline. Predominance of planktonic foraminiferal species and the presence of the deep-sea ostracod species *Cytherella* sp suggest sedimentation in deeper open-sea environments. A peculiar sphaerical benthic foraminifer – *Aberisphaera* sp., which has been found in the NE Himalayas and in the Nanos section, possibly indicates a connection between these two geographically remote areas.

1. Introduction

The Paleocene/Eocene (Pc/E) boundary is associated with an episode of major global warming (Zachos et al., 2001, 2003). Biotic and abiotic characteristics recorded in sediments from this time span are a useful tool for reconstructing environmental conditions. Microfossil assemblages may indicate a range of climatic conditions. Preliminary unpublished data of some of the authors of this article indicate that a sedimentary sequence of hemipelagic clastic deposits in the area of Mt. Nanos in NW Slovenia (Fig. 1) contains the Pc/E boundary interval. The research presented in this article focused on various microfossil groups from this stratigraphic sequence. Micropalaeontological studies of planktonic and benthic foraminifera, calcareous nannoplankton and ostracods were performed to allow a biostratigraphic dating and to illuminate the palaeoenvironmental conditions during the time of deposition of the studied section.

Previous studies already highlighted the occurrence of a succession of Mesozoic and Cenozoic beds at Mt. Nanos (Fig. 2). The age of the (flysch) sediments in the wider study area was assigned to the Late Cretaceous and Paleocene (Podsabotin beds) and to Early Eocene (Pavšič and Pavlovec, 2009; Drobne et al., 2009). In the Vipava Valley these beds form a sync-

Figure 1: Panoramic view of the southern slope of Mt. Nanos with indicated positions of Nanos (this paper) and Vrhpolje (Drobne et al., 2012) sections.

line, which was filled in periodically with large scale turbidites originating from the south. In the north the flysch is overthrust by Cretaceous limestones (Fig. 3, left). It is interesting that in Goriška Brda we found sediments ranging in age from the Cretaceous/Paleogene (K/T) boundary to Late Cuisian (top of Ypresian), while in the Vipava Valley we found no sediments of Ilerdian age (lower part of Lower Eocene) and all studied outcrops were assigned to the Cuisian (Upper Ypresian) on the basis of nummulitides, alveolines and sea urchins (De Zanche et al., 1967; Cimerman et al., 1974; Mikuž and Pavlovec 2002; Mikuž, 2006; 2007; Drobne and Bačar, 2003; Pavlovec, 2006). The flysch beds have been studied by V. Krašeninikov et al. (1968) as well as S. Buser and J. Pavšič (1976), Pavšič (1997), Pavšič and Dolenec (1995, 1996), Pavšič and Pavlovec (2008), who used calcareous nannoplankton and planktonic foraminifera to determine the Paleocene age of the sediments. Other fossil groups have not been studied before.

2. Geological setting

The research area lies in the Adriatic microcontinent, at the contact zone between the Adriatic and the Dinaric carbonate platforms including Goriška Brda and Vipava Valley and continuing to Friuli towards the west and to Postojna and further towards the east (Fig. 2). Goriška Brda and Vipava Valley are a part of the BiosZ 1 biosedimentary zone or the megazone between the Adriatic and Dinaric carbonate platforms (Drobne et al., 2009; M. Herak personal communication). Several limestone clasts occur in the turbidite bodies within this zone, and

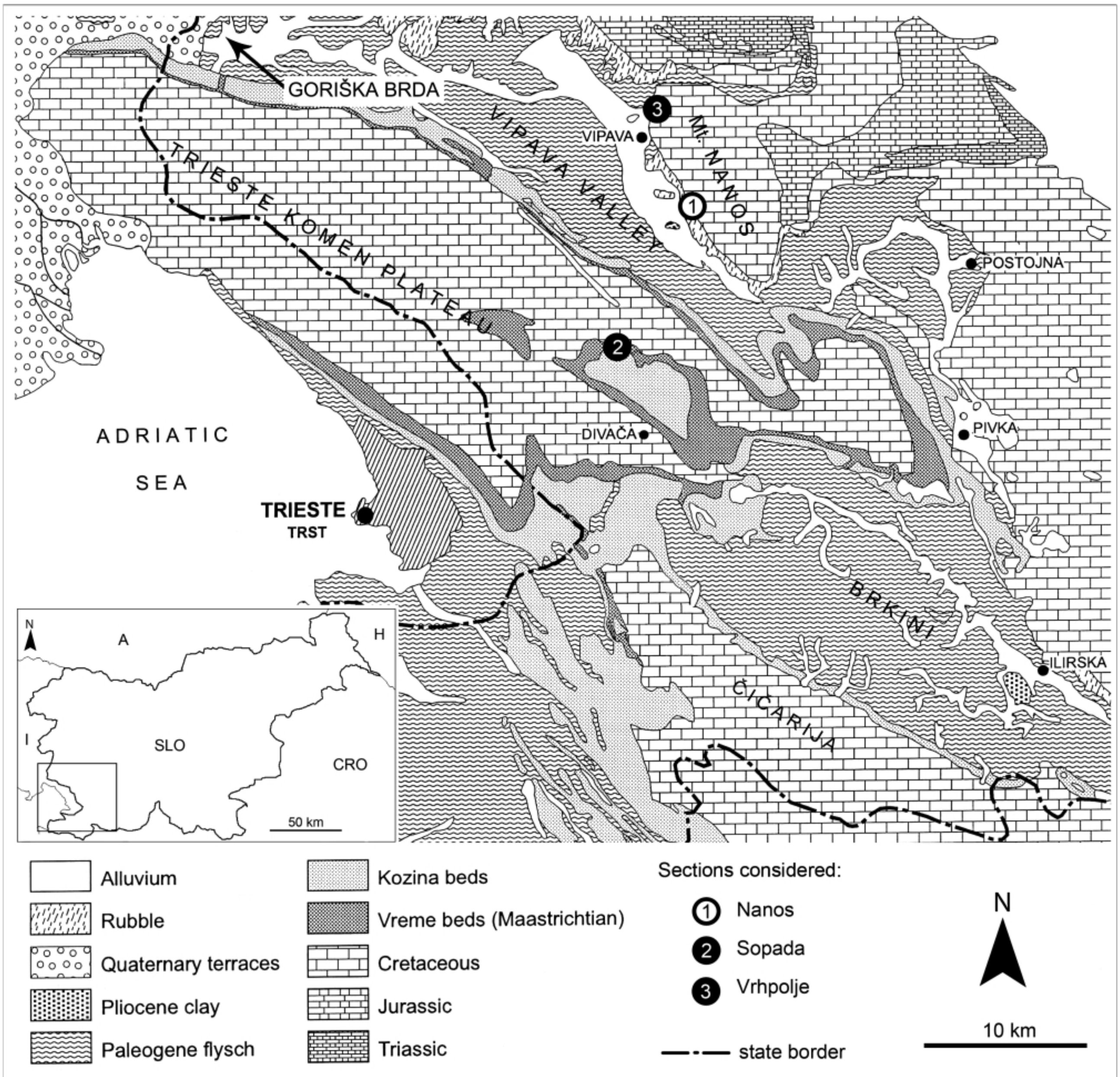

Figure 2: Geological map of the study area with indicated positions of studied sections. The wider geographical area is shown in the bottom left corner. The empty circle marks the section consisting of flysch sediments, while full circles mark sections consisting of limestones. The Nanos section is discussed in this article, while Sopada and Vrhpolje sections are discussed by Drobne et al. (2011).

these breccias contain Paleocene and Ilerdian genera of foraminifera and corals. They originated from gravity flows bringing material into the basin from the southern edge of the platform, which means that these fossils are reworked (Turnšek and Košir, 2004).

The contact zone between the Adriatic and the Dinaric carbonate platforms contains a strip of deeper water clastic-hemipelagic sediments. Flysch beds are present at the southern slope of Mt. Nanos. The Nanos section, discussed in this paper, is situated at the slope of Rebrnica below the overthrust of Upper Cretaceous sediments of Mt. Nanos (Fig. 1). The youngest strata are of Maastrichtian age (Jež, 2011) and lie on the SE tip of the ridge in a recumbent fold. The plateau behind the ridge is approximately 1000 m high. There are several outcrops of flysch sediments in the steep slope, where they occur between overthrust Cretaceous limestones (Fig. 3, left). The studied section lies 540 m above sea level (coordinates Y: 422567, X: 73212) along the road between Podnanos and the top of Mt. Nanos (Fig.1).

3. Material and methods

The studied section is approximately 8 m thick. It was first sampled in 1992 and then sampled again for the purpose of this research in 2009 (samples Nanos 1-5) and resampled in 2011 (two series Nanos I: 14-7, Nanos II: 6-1) (Fig. 3, right).

For micropalaeontological analyses the microfauna was determined from washed samples. Samples were soaked in water with hydrogen peroxide and then washed under running water through 63 µm, 125 µm, 160 µm and 630 µm sieves. From each fraction foraminifera were picked out. Microfossil associations were examined using a stereo microscope; in addition a detailed study of benthic and planktonic foraminifera was performed on scanning electron microscope (SEM; see Plates 1 and 2). Nannoplankton analyses required the preparation of smear slides and examination under a light microscope. Micropalaeontological analyses were qualitative - at this point we were primarily interested in obtaining a reliable biostratigraphic age information and data on the composition of microfossil assemblages.

4. Results and discussion

The studied outcrop consists largely of sandy marls. The grain size decreases towards the top of the section with increasing predominance of harder marls containing a higher carbonate content.

4.1 Calcareous nannoplankton

Calcareous nannoplankton assemblages in the samples from the Nanos section are poorly to moderately preserved with 8 to 20 species identified per sample. The assemblages contain several species of the genera *Fasciculithus*, *Toweius* and *Discoaster* (*D. multiradiatus* Bramlette and Riedel, *D. binodosus* Martini, *D. mohleri* Bukry and Percival etc.), most of them with ranges spanning the uppermost Paleocene and lowermost Eocene. Most samples contain rare specimens of *Zygrablithus bijugatus* (Deflandre in Deflandre and Fert) Deflandre. This species is usually reported from the Eocene (Perch-Nielsen, 1985; Wise et al., 2004). However, it is also occasionally mentioned in assemblages from the uppermost Paleocene - e.g. in the samples from the section spanning the Pc/E boundary interval in the nearby Nozno section (Dolenec et al., 2000a, b). The nannoplankton assemblages allowed the biostratigraphic

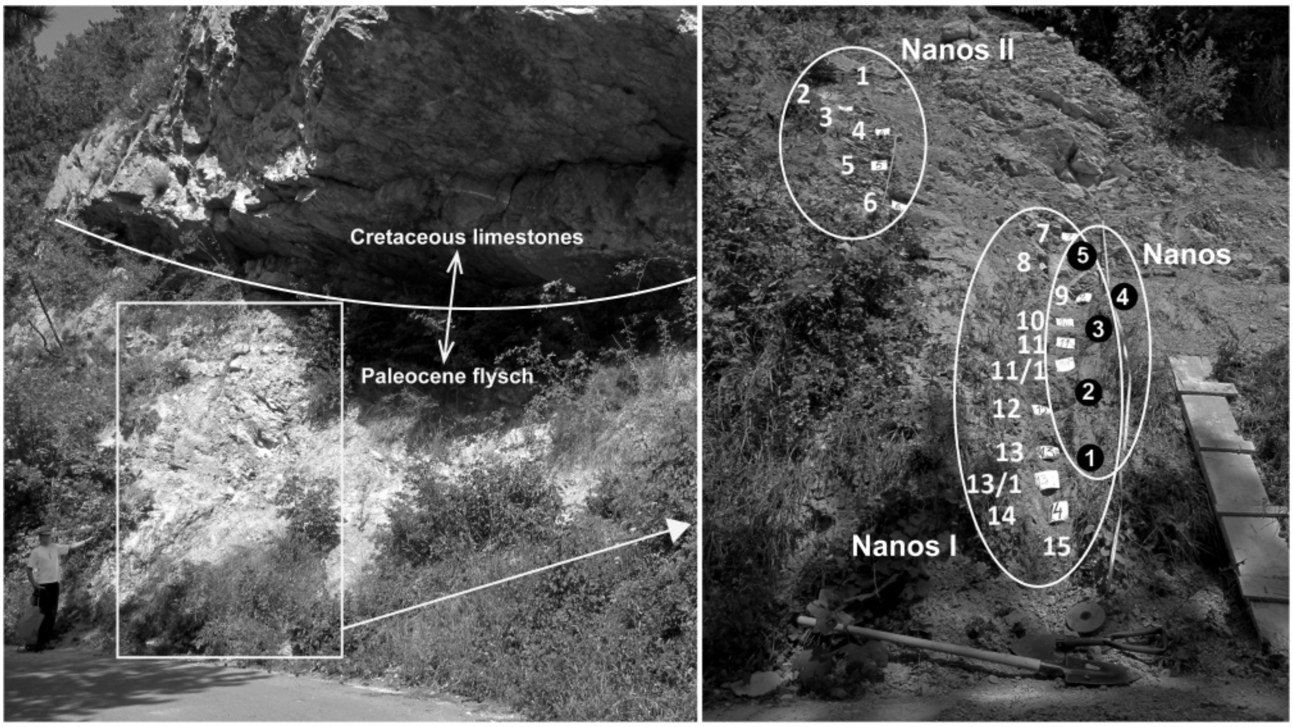

Figure 3: Nanos section below overthrusted Cretaceous and Jurassic limestones (left) and position of samples (right).

assignment of the studied interval to the *Discoaster multiradiatus* biozone NP9 of Martini (1971) in the uppermost Paleocene. Selected stratigraphically significant species of calcareous nannoplankton are presented in Plate 1.

The assemblages are relatively rich in discoasters which suggests warm oligotrophic environment in general (Chapman and Chepstow-Lusty, 1997). This would be consistent with environmental conditions characterising the Paleocene-Eocene Thermal Maximum (PETM). However, the assemblages studied in samples from Mt. Nanos are not similar to the *Rhomboaster-Discoaster* assemblage (RD), which, according to Aubry et al. (2007), is characteristic for the PETM, as no specimens of the genus *Rhomboaster* were observed. Therefore, the assemblage could be assigned to NP 9 below the onset of the PETM. Additional evidence for such an age is the presence of *Fasciculithus alanii* Perch-Nielsen, the range of which is limited to the lower part of NP 9 (NP9a and NP9b below the carbon isotope excursion, Perch-Nielsen, 1985). Specimens assigned to *F.* cf *alanii* (Pl. 1, Fig. 22) - somewhat questionable due to poor preservation - were found throughout the studied interval, from sample Nanos II 5-1 to sample Nanos I-14. Sample Nanos I-15 was barren of nannoplankton.

The nannoplankton assemblages from the Nanos section (though not typical PETM assemblages) are consistent with warm water environment. The relatively high abundance of discoasters in poorly preserved assemblages could also be attributed to selective dissolution. Dicoasters are relatively resistant to selective dissolution and can be concentrated in partially dissolved assemblages while holococcoliths are reportedly highly prone to dissolution (Bukry, 1981). The presence of several species of holococcoliths in the studied assemblages (Pl. 1, Figs. 14-17, 20, 21) suggests that selective dissolution did not have an important effect on the composition of the studied nannoplankton assemblages.

4.2 Planktonic foraminifera

Planktonic foraminiferal assemblages of the Nanos section are rich and highly diversified. The muricate planktonic foraminiferal genus *Morozovella* dominates microfossil assemblages with the following species: *Morozovella aequa* (Cushman and Renz), *Morozovella velascoensis* (Cushman), *Morozovella subbotinae* (Morozova), *Morozovella acuta* (Toulmin), *Morozovella occlusa* (Loeblich and Tappan) and *Morozovella pasionensis* (Bermúdez), (Pl. 2, Figs. 3-12).

Other species that are frequent in the assemblages include *Subbotina velascoensis* (Cushman), *Acarinina coalingensis* (Cushman and Hanna), and *Globanomalina chapmani* (Parr). In addition, *Acarinina soldadoensis* (Brönnimann), *Igorina tadjikistanensis* (Bykova) and *Subbotina triangularis* (White) also occur. Microperforate species are represented by *Chiloguembelina crinita* (Glaessner), *C. wilcoxensis* (Cushman et Ponton), *Zeauvigerina aegyptica* Said et Kenawy, and *Zeauvigerina lodoensis* (Martin).

Planktonic foraminiferal assemblages indicate the uppermost Paleocene zone of *Morozovella velascoensis* (P 5) after Berggren and Pearson (2005) and Wade et al. (2011). The diversity and high percentage of warm water muricate taxa *(Morozovella*, *Acarinina* and *Igorina*) indicate oligotrophic habitats, warm surface water and a well stratified water column with a stable thermocline. All mentioned data confirm an period of global warming in the latest Paleocene and tropical to subtropical climate in the research area (Shackleton et al,1985; D'Hondt et al., 1994; Bralower et al., 1995; Kelly et al., 1998; 2001; Olsson et al.,1999; Berggren and Pearson, 2006; Alegret et al., 2009). The predominance of the planktonic foraminifera (97%) in the microfossil assemblages indicates sedimentation in outer shelf to upper slope environments. Very similar planktonic foraminiferal assemblages have also been observed in several localities in the Palmyride area in Syria (Hernitz-Kučenjak et al., 2003).

The richness of the assemblages suggests that the sediments sampled in the section predate the PETM which caused an extinction of approximately 18 % of the foraminiferal species

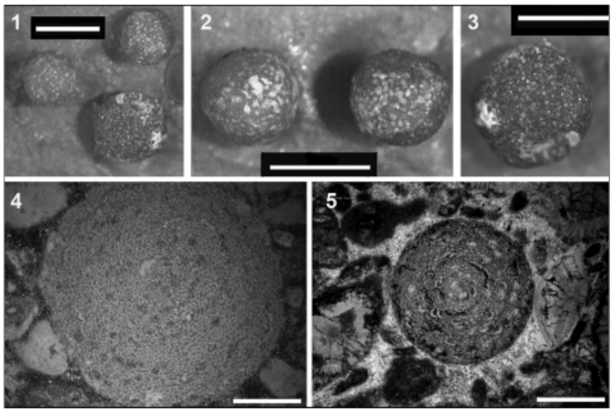

Figure 4: Spherical foraminifera from the Nanos section and NE Himalayas: Figs. 1-3; Figs. 4, 5 *Aberisphaera* sp. 2, thin sections, NE Hymalayas, Meghalaya region. Scale bars – 1 mm.

due to extremely high temperatures (Alegret et al., 2009). The biostratigraphic consideration of nannoplankton and planktonic foraminifera indicates that the exact stratigraphic position of the studied section is at the top of the Paleocene just below the PETM.

4.3 Ostracods and benthic foraminifera

The ostracod fauna is very poor; it is exclusively represented in some samples by *Cytherella* sp. (samples Nanos 1, 2 and 3). This species can be considered autochthonous because both juvenile and adult specimens co-occur in the assemblages. Thus, its occurrence confirms the palaeoenvironmental interpretation based on planktonic foraminifera. Actually, *Cytherella* sp. indicates an open shelf/deep water environment. Moreover, in agreement with Whatley (1990, 1991), this infaunal filter-feeder genus may also suggest hypoxia.

The preservation of small benthic foraminifera in the samples Nanos 1-5 (Pl. 3, 4) varies greatly – even within a single sample, but in general preservation is very poor. The few big specimens are damaged, sometimes beyond recognition - obviously by transportation. The above indicates that the benthic foraminifera assemblage is largely reworked. It seems most likely that it was redeposited from the nearby carbonate platforms into the basin.

The studied Orthophragminae association consists of small (2-3 mm large) A - forms. Flattened specimens dominate over inflated tests with well developed granules. The outer morphology of the foraminifera is well preserved and does not show evidences of taphonomic alteration, except rare breakage of outer parts, but preparation of equatorial sections reveals severe recrystallization of the internal structures. Based on the identification of *Orbitoclypeus schopeni ramaraoi* Less and *Discocyclina seunesi* aff. *karabuekensis* Less and Özcan, the section is Thanetian in age, and belongs to the shallow benthic foraminiferal zone SBZ 4-6 (Less et al., 2007). Although there is very little morphological evidence of reworking, we assume that the orthophragmininid fauna has been transported post-mortem based on the presence of only A-forms and strong size selection.

In the Meghalaya region in the NE Himalayas a spherical species *Aberisphaera* sp.2 (Fig. 4) was found (Tewari, personal communication), with individual specimens reaching up to 3 mm in diameter. A very similar spherical species (but smaller, with individual specimens reaching up to 1 mm) with a largely similar structure of the main and supplement chambers, has been found in the Nanos section and is mentioned from several localities in the Mediterranean. This confirms the hypothesis of a possible connection between these two geographically remote areas, the Himalayas and the Adriatic area.

5. Conclusions

The Nanos section was dated as Late Paleocene. The nannoplankton assemblages allowed the biostratigraphic assignment of the studied interval to the *Discoaster multiradiatus* zone NP 9 of Martini (1971) in the uppermost Paleocene. This corresponds well to the assignment to the uppermost Paleocene P 5 Zone (*Morozovella velascoensis*) of Berggren and Pearson (2005) and Wade et al. (2011) based on planktonic foraminifera. The detailed biostratigraphy based on calcareous nannoplankton and planktonic foraminifera suggests that the exact stratigraphic position of the studied section is at the top of the Paleocene, just below the PETM.

The nannoplankton assemblages from the Nanos section (though not typical PETM assemblages) are consistent with warm water environments as also indicated by the rich and highly diversified planktonic foraminiferal assemblages. Predomination of the planktonic foraminiferal species indicates sedimentation in an open-ocean environment. The ostracod fauna is very poor, but indicates an open shelf/deep water environment and possibly suggests the presence of hypoxia. The assemblage of small benthic foraminifera is largely reworked from the adjacent carbonate platform.

The sphaerical benthic foraminifer *Aberisphaera* sp., which has been found in the NE Himalayas and in the Nanos section, possibly indicates a connection between these two geographically remote areas.

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Plate 1:

Calcareous nannoplankton from the Nanos section

Figure 1: *Toweius eminens* (Bramlette & Sullivan, 1961) Perch-Nielsen 1971; XPL: 0°; sample Nanos II-6.

Figure 2: *Prinsius bisulcus* (Stradner, 1963) Hay & Mohler 1967; XPL: 0°; sample Nanos II-3.

Figure 3: *Prinsius bisulcus* (Stradner, 1963) Hay & Mohler 1967; XPL: 45°; sample Nanos II-3.

Figure 4: *Campylosphaera* cf *eodela* Bukry & Percival 1971; XPL: 0°; sample Nanos I-14.

Figure 5: *Chiasmolithus bidens* (Bramlette & Sullivan 1961) Hay & Mohler 1967; XPL: 0°; sample Nanos I-8.

Figure 6: *Zygodiscus plectopon*s Bramlette & Sullivan 1961; XPL: 45°; sample Nanos I-14.

Figure 7: *Zygodiscus sheldoniae* Bown 2005; XPL: 0°; sample Nanos I-7.

Figure 8: *Zygodiscus sheldoniae* Bown 2005; XPL: 0°; sample Nanos I-9.

Figure 9: *Neocrepidolithus grandiculus* Bown 2005; XPL: 0°; sample Nanos II-1.

Figure 10: *Neochiastozygus chiastus* (Bramlette & Sullivan 1961) Perch-Nielsen 1971; XPL: 0°; sample Nanos I-9.

Figure 11: *Ellipsolithus distichus* (Bramlette & Sullivan 1961) Sullivan 1964; XPL: 45°; sample Nanos II-1.

Figure 12: *Ellipsolithus macellus* (Bramlette & Sullivan 1961) Sullivan 1964; XPL: 45°; sample Nanos I-14.

Figure 13: *Chiasmolithus consuetus* (Bramlette & Sullivan) Hay & Mohler 1967; XPL: 20°; sample Nanos I-8.

Figure 14: *Semihololithus biskaye* Perch-Nielsen 1971; XPL: 20°; sample Nanos II-1.

Figure 15: *Semihololithus biskaye* Perch-Nielsen 1971; XPL: 20°; sample Nanos II-5.

Figure 16: *Semihololithus tentorium* Bown 2005; XPL: 0°; sample Nanos II-1.

Figure 17: *Lanternithus simplex* Bown 2005; XPL: 0°; sample Nanos 3.

Figure 18: *Discoaster multiradiatus* Bramlette & Riedel 1954; PPL; sample Nanos II-1.

Figure 19: *Discoaster nobilis* Martini, 1961; PPL, sample Nanos II-1.

Figure 20: *Zygrhablithus bijugatus* (Deflandre in Deflandre & Fert 1954) Deflandre 1959; XPL: 0° ; sample Nanos 3.

Figure 21: *Zygrhablithus bijugatus* (Deflandre in Deflandre & Fert 1954) Deflandre 1959; XPL: 0°; sample Nanos 1.

Figure 22: *Fasciculithuscf alanii* Perch-Nielsen 1971; XPL: 0°; sample Nanos 3.

Figure 23: *Discoaster multiradiatus* Bramlette & Riedel 1954; PPL; sample Nanos I-11.

Figure 24: *Discoaster mohleri* Bukry & Percival 1971; PPL; sample Nanos II-2.

Figure 25: *Discoaster mohleri* Bukry & Percival 1971; PPL; sample Nanos II-2.

Figure 26: *Fasciculithus richardii* Perch-Nielsen 1971; PPL; sample Nanos 2.

Figure 27: *Fasciculithus tympaniformis* Hay & Mohler 1967; XPL: 0°; sample Nanos 5.

XPL – cross polarized light

PPL – plane polarized light

Scale bar – 5 μm.

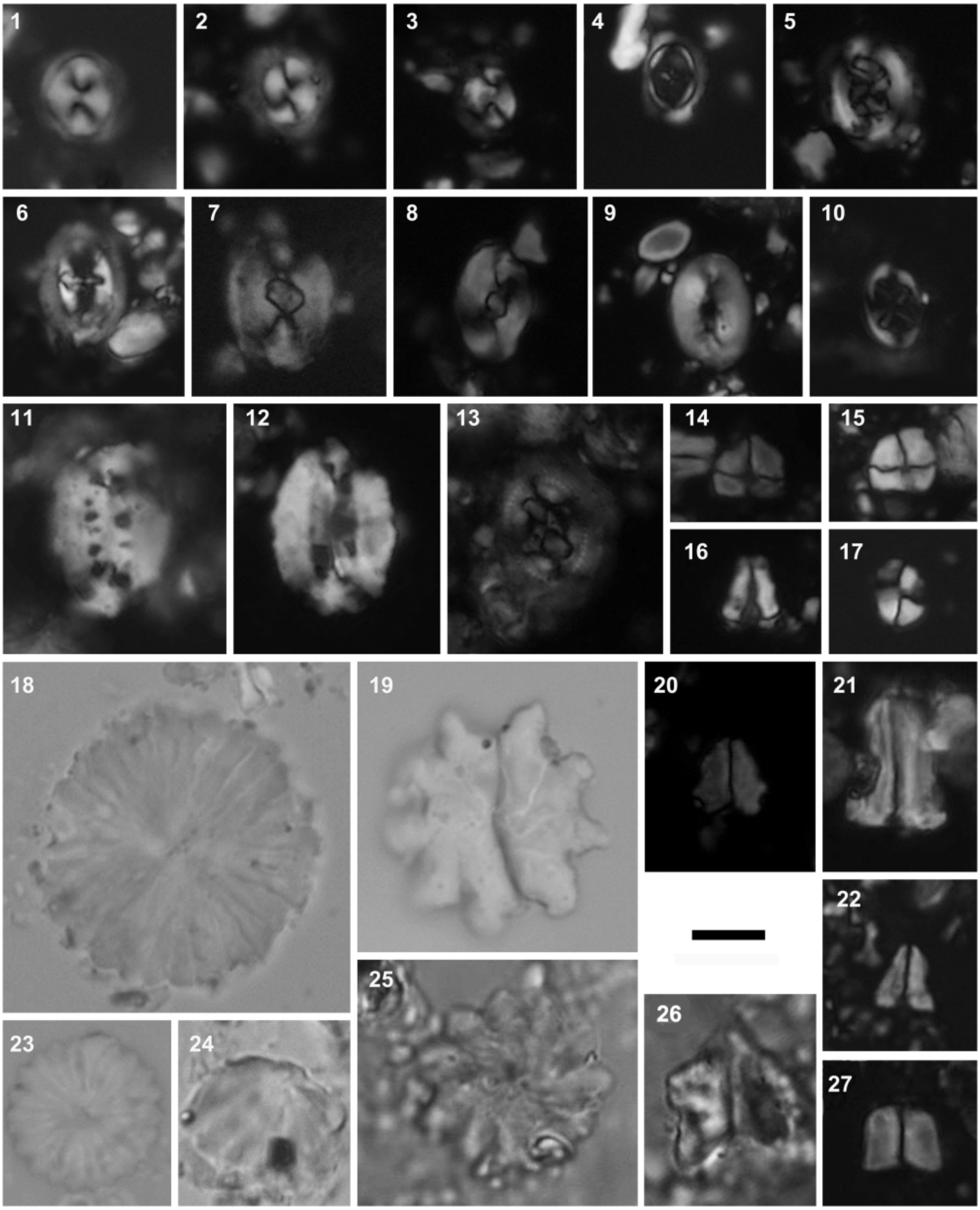
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Plate 2:

Planktonic foraminifera from the Nanos section

Figure 1: *Subbotina velascoensis* (Cushman), sample Nanos I-14.

Figure 2: *Subbotina velascoensis* (Cushman), sample Nanos I-13.

Figure 3: *Subbotina triloculinoides* (Plummer), sample Nanos I-13.

Figure 4: *Morozovella aequa* (Cushman and Renz), sample Nanos I-13.

Figure 5: *Morozovella aequa* (Cushman and Renz), sample Nanos I-14.

Figure 6: *Morozovella subbotinae* (Morozova), sample Nanos I-14.

Figure 7: *Morozovella acuta* (Toulmin), sample Nanos I-13.

Figure 8: *Morozovella acuta* (Toulmin), sample Nanos 1.

Figure 9: *Morozovella velascoensis* (Cushman), sample Nanos I-14.

Figure 10: *Morozovella occlusa* (Loeblich and Tappan), sample Nanos I-14.

Figure 11: *Morozovella velascoensis* (Cushman), sample Nanos I-14.

Figure 12: *Morozovella pasionensis* (Bermúdez), sample Nanos 1.

Scale bar - 100 µm.

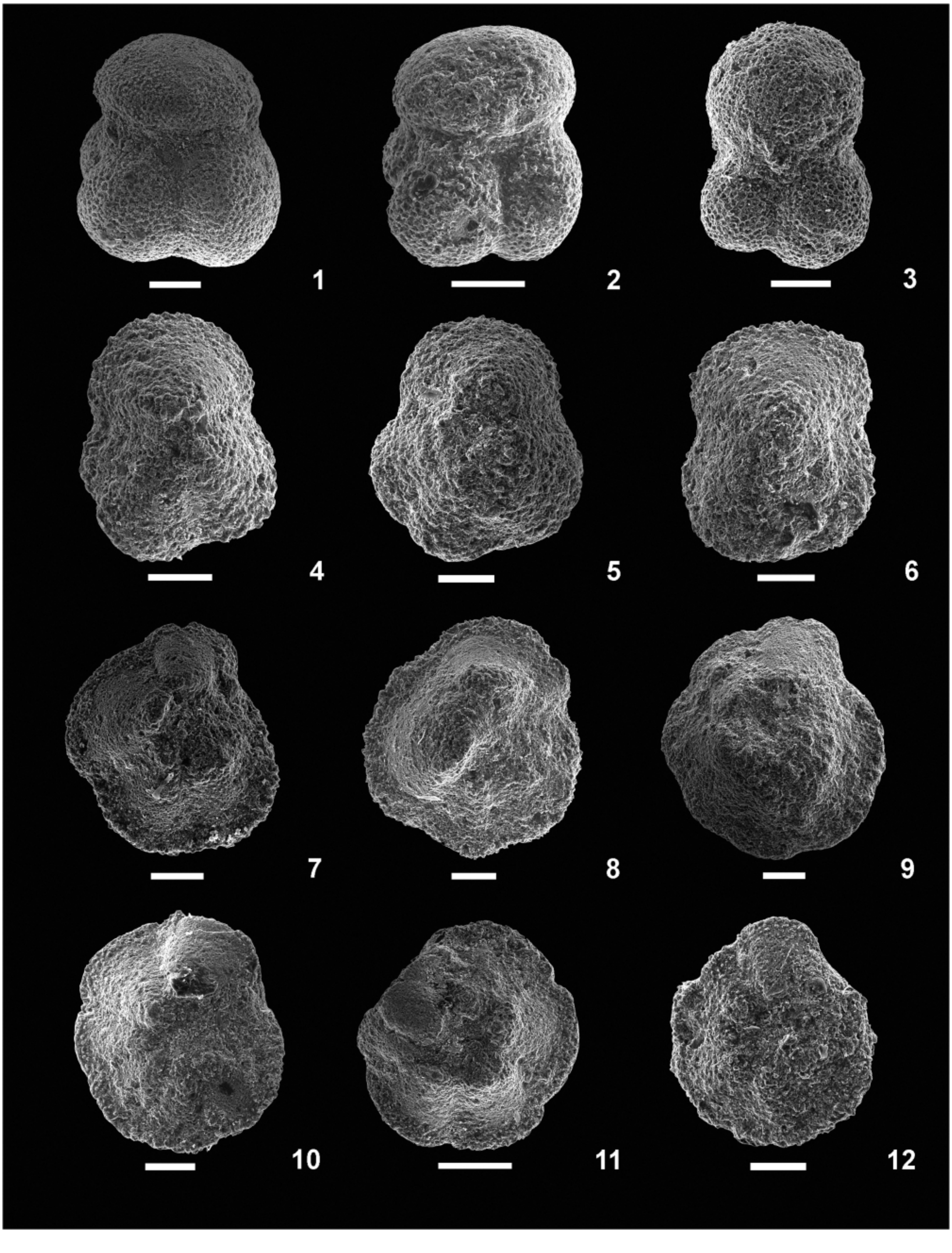
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Plate 3:

Benthic foraminiferal species identified in the Nanos Section

Figure 1: *Anomalinoides* sp., sample Nanos 3
Figure 2: *Anomalinoides darwini* (Hagn & Kuhn, 1989), sample Nanos 5
Figure 3: *Anomalinoides plummerae*, Brotzen, 1942, sample Nanos 3
Figure 4: *Anomalinoides sinaensis*, Said & Kenawy, 1956, sample Nanos 3
Figure 5: *Aragonia aragonensis?*, (Nuttall, 1930), sample Nanos 3
Figure 6: *Astacolus cretaceus*, (Cushman, 1937), sample Nanos 5
Figure 7: *Astacolus gladius*, (Philippi, 1843), sample Nanos 5
Figure 8: *Bulimina salisbergensis*, Hillebrandt, 1962, sample Nanos 2
Figure 9: *Bulimina tuxpamensis*, Cole, 1928, sample Nanos 4
Figure 10: *Ceratobulimina* sp., sample Nanos 5
Figure 11: *Chrysalogonium dickerson*, Cushman & Bermudez, 1936, sample Nanos 2
Figure 12: *Cibicidoides* sp. 1, sample Nanos 5
Figure 13: *Cibicidoides* sp. 2, sample Nanos 3
Figure 14: *Cibicidoides* sp. 3, sample Nanos 2
Figure 15: *Cibicidoides* sp. 4, sample Nanos 4
Figure 16: *Cibicidoides dayi*, (White, 1928), sample Nanos 3
Figure 17: *Cibicidoides grimsdalei*, (Nuttall, 1930), sample Nanos 2
Figure 18: *Cibicidoides havanensis*, (Cushman & Bermudez, 1936), sample Nanos 5
Figure 19: *Cylindroclavulina* cf. *rudislosta*, (Hantken, 1898), sample Nanos 1
Figure 20: *Da* Figure *rbyella* sp. 1, sample Nanos 2
Figure 21: *Darbyella* sp. 2, sample Nanos 2
Figure 22: *Dentalina acuta*, d´Orbigny, 1846, sample Nanos 3
Figure 23: *Dentalina consobrina*, d´Orbigny, 1884, sample Nanos 3
Figure 24: *Dentalina elegans*, d´Orbigny, 1846, sample Nanos 2
Figure 25: *Entsolenia crebra*, (Matthes, 1939), sample Nanos 2
Figure 26: *Eponides* sp., sample Nanos 5
Figure 27: *Gaudryina* sp., sample Nanos 2
Figure 28: *Gaudryina mcleani*, Hofker, 1955, sample Nanos 5
Figure 29: *Globulina lacrima*, Reuss, 1845, sample Nanos 2
Figure 30: *Gyroidina naranjoensis*, White, 1928, sample Nanos 1
Figure 31: *Haplophragmoides* sp. ?, sample Nanos 2
Figure 32: *Karreriella subglabra*, (Cushman, 1926), sample Nanos 2
Figure 33: *Lagena* sp., sample Nanos 2
Figure 34: *Lagena apiculata* var. *elliptica*, Reuss, 1863, sample Nanos 5
Figure 35: *Lagena globosa*, (Montagu, 1803), sample Nanos 5

Lengths of scale bars 0.1 mm, unless stated otherwise

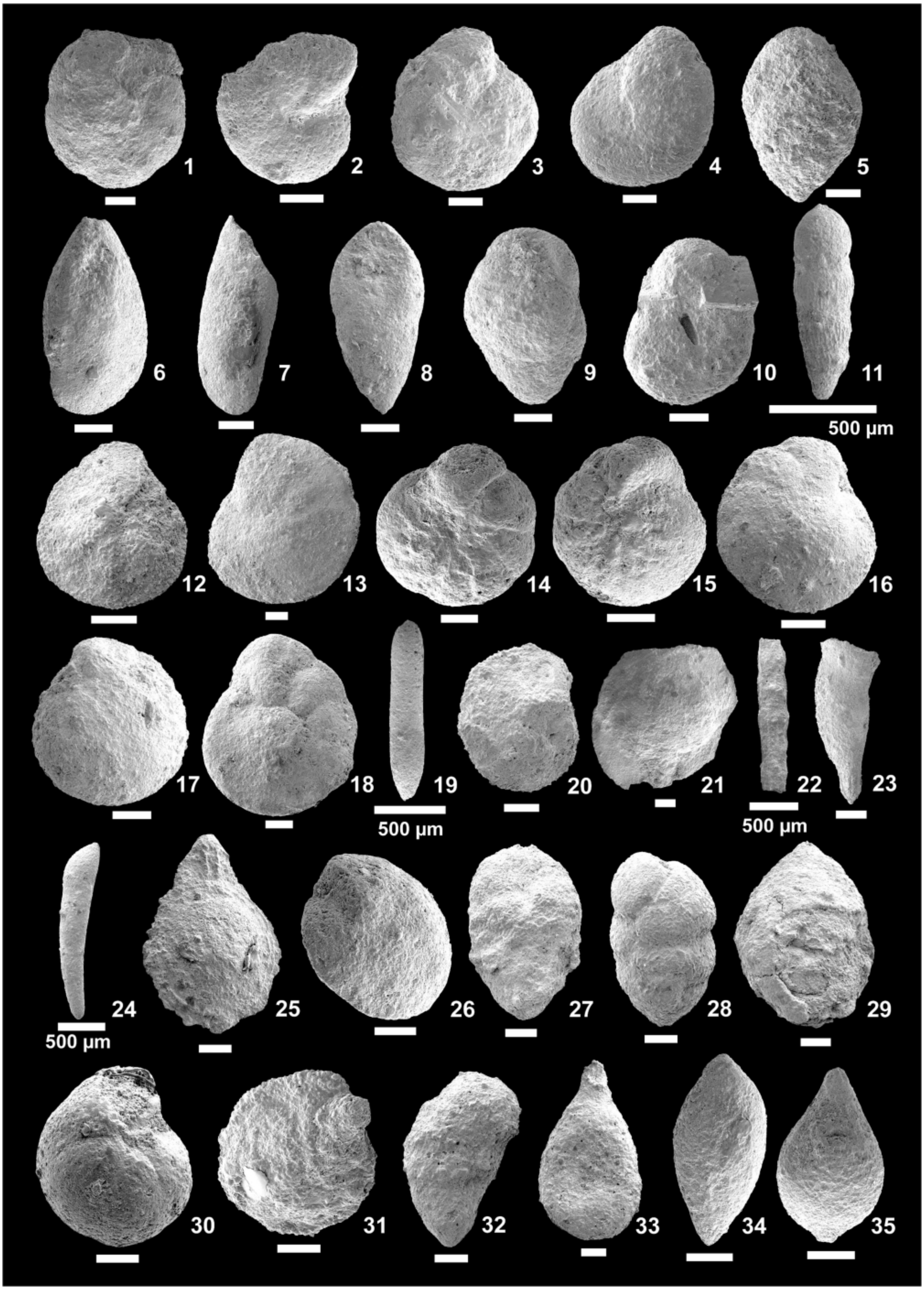
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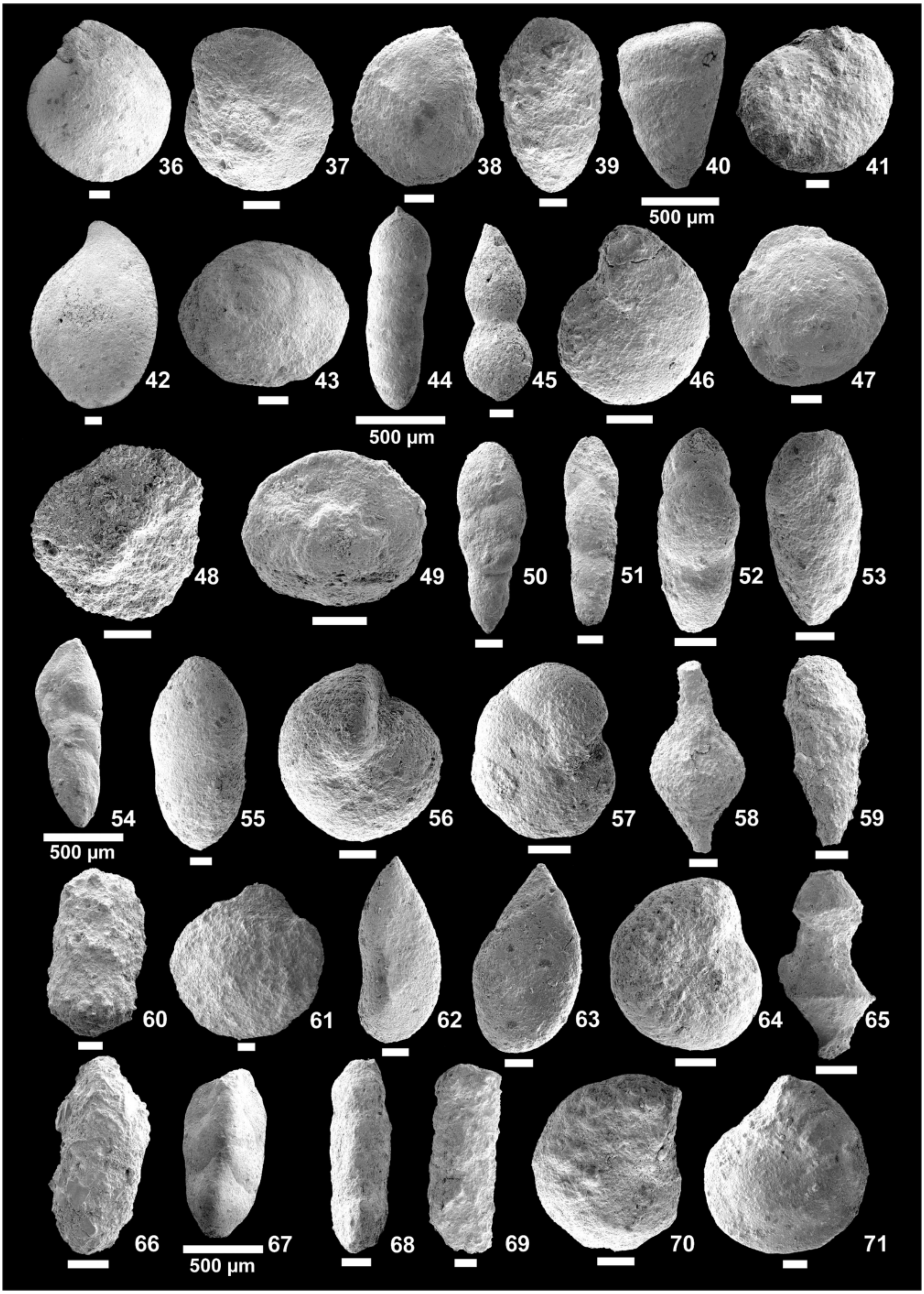
Plate 4:

Benthic foraminiferal species identified in the Nanos Section

Figure 36: *Lenticulina* sp.1, sample Nanos 4
Figure 37: *Lenticulina* cf. *depauperata*, (Reuss, 1851), sample Nanos 3
Figure 38: *Lenticulina inornata*, (d´Orbigny, 1846), sample Nanos 5
Figure 39: *Marsonella* sp., sample Nanos 2
Figure 40: *Marsonella oxycona*, (Reuss, 1860), sample Nanos 3
Figure 41: *Melonis* sp., sample Nanos 2
Figure 42: *Miliolina* sp., sample Nanos 2
Figure 43: *Neoconorbina* sp., sample Nanos 2
Figure 44: *Nodosaria aspera*, Reuss, 1845, sample Nanos 4
Figure 45: *Nodosaria limbata*, d´Orbigny, 1840, sample Nanos 2
Figure 46: *Nonion durhami*, Mallory, 1959, sample Nanos 5
Figure 47: *Oridorsalis plummerae*, (Cushman, 1948), sample Nanos 2
Figure 48: *Osangularia* sp. 1, sample Nanos 2
Figure 49: *Osangularia* sp. 2, sample Nanos 2
Figure 50: *Paleopleurostomella* sp., sample Nanos 2
Figure 51: *Pleurostomella* sp., sample Nanos 5
Figure 52: *Pleurostomella nitida*, (Guembel, 1868), sample Nanos 3
Figure 53: *Pleurostomella paleocenica*, Cushman, 1947, sample Nanos 5
Figure 54: *Pleurostomella velascoensis*, Cushman, 1926, sample Nanos 5
Figure 55: *Pseudonodosaria manifesta*, (Reuss, 1851), sample Nanos 5
Figure 56: *Pullenia coryelli*, (Reuss, 1851), sample Nanos 5
Figure 57: *Pullenia jarvisi*, Cushman, 1936, sample Nanos 2
Figure 58: *Ramulina globulifera* var. *cretacea*, Schacko, 1897, sample Nanos 4
Figure 59: *Reophax* sp., sample Nanos 2
Figure 60: *Rhabdammina* sp., sample Nanos 4
Figure 61: *Rotalia pinarensis*, Cushman & Bermudez, 1947, sample Nanos 2
Figure 62: *Saracenaria* sp., sample Nanos 3
Figure 63: *Saracenaria propinque*, (Hantken, 1875), sample Nanos 5
Figure 64: *Stensioina beccariiformis*, (White, 1928), sample Nanos 2
Figure 65: *Stilostomella* sp., sample Nanos 2
Figure 66: *Textularia* sp., sample Nanos 5
Figure 67: *Tritaxia* sp., sample Nanos 2
Figure 68: *Tritaxia midwayensis*, (Cushman, 1936), sample Nanos 5
Figure 69: *Vaginulinopsis* sp., sample Nanos 2
Figure 70: *Valvalabamina praeacuta*, (Vasilenko, 1950), sample Nanos 2
Figure 71: *Valvulinera beccariiformis*, (White, 1928), sample Nanos 5

Lengths of scale bars 0.1 mm, unless stated otherwise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