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Dating and depositional environment of the Tredian Formation, western Salt Range, Pakistan

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Abstract

The presence of age diagnostic spores and bissacate pollen preserved in the Tredian Formation of the Nammal Gorge and Zaluch Nala sections represent an Anisian age. The comparative study of the spores and pollen taxa of the Nammal and Zaluch gorges reveal weak correlation. This weak correlation can be explained by limited number of samples and low resolution sampling. The palynofacies analysis of the Nammal and Zaluch Gorge sections suggests heterolithic proximal oxic shelfal depositional settings for the Tredian Formation, however the presence of amorphous marine organic matter, sporangial mass and absence of woody matrix in the Zaluch Gorge section, suggests marine incursion and therefore relatively deeper settings as compared to the Nammal Gorge section. The deepening of the Tredian facies in Zaluch section suggest progradation towards south west in the western Salt Range.

Keywords: Playnomorphs; Palynofacies; Progradation; Fluvio-deltaic; Tredian Formation; Salt Range; Pakistan.

1. Introduction

The Tredian Formation is composed of a thick clastic succession, deposited in the fluvial dominated progradational delta. This clastic unit is deposited in the western Salt Range and Trans Indus Ranges. The lower contact is conformable with marine succession of Mianwali Formation and the dolomite sequence of the Kingriali Formation conformably overlies the Tredian Formation. Based on palynoflora middle Triassic age has been assigned to the Tredian Formation in Salt Range and Surghar Range (Balme, 1970). Hermann et al. (2012) has documented rich palynoflora from the Tredian Formation at Chitta-Landu stratigraphic section. Based on this taxa Anisian (middle Triassic) age has been assigned. The aim of this study is to date the Tredian Formation specifically in western Salt Range i.e. Nammal Gorge and Zaluch Gorge using palynoflora. The palynoflora of the two stratigraphic sections will be correlated to unravel the possibility of provincialism in closely spaced stratigraphic. Previously the depositional setting of the Tredian Formation is considered to be a prograding deltaic system (Iqbal et al., 2013). In this study however palynofacies data will be used to critically evaluate the suggested depositional settings.

2. Regional geology

Pakistan occupies an important position in the tectonic setup of the western Indian Plate. The Indo-Gangetic foreland basin was formed as a result of collision of Indian plate with Eurasian Plate during early Eocene or late Paleocene time (Molnar and Tapponier, 1975). This collision shortened the crust and has developed an extensive system of southward directed thrust and associated folding (Coward et al., 1982; Greco et al., 1989). Amongst these thrusts the Salt Range Thrust (SRT) runs along the southern margin of the Salt Range between Jhelum and Indus Rivers and has pushed the older strata of the Salt Range Formation upon the less deformed quaternary sequence of the south-lying Jhelum plain. Thick sedimentary successions from Precambrian to quaternary, with intervening major unconformities are exposed along the SRT. The Nammal and Zaluch Gorge sections are an integral part of the Salt Range (Fig. 1).

3. Methodology and methods

In field two pristine samples are collected from shale horizon in each stratigraphic section. For the preparation of the slides, the shale was grinded into two millimeter size fragments. In order dissolve the carbonates, the grinded were treated with 10% diluted HCl. The samples were left to react till the effervescence stopped. The supernatant was sieved through 10 micron nylon sieve. To dissolve the silicates the left over residue in the sieve was treated 60% HF in a Teflon beaker. The samples were left overnight to react. The supernatant was sieved again through 10 micron sieve. The wet organic residues of each sample was strewed on the glass slides using glycerin jelly and were cover slipped with epoxy resin at the Department of Geology, University of Peshawar.

4. Results

4.1. Palynostratigraphy

The fossils palynoflora are best preserved in those depositional settings where the degradation processes are retarded or suspended. The overall preservation of palynomorphs in the Tredian Formation is good. The recorded palynomorphs taxa are shown in plates 1-6. The distribution of spores and pollen of the Tredian Formation in Zaluch and Nammal Gorge sections are shown in Figures 2 and 3.

The spores reported from the Nammal Gorge section Deltoidospora sp, Monosaccite, Reticuloidosporites warchianus, Leiotriletes sp, Lundbladispora brevicula, Calamospora sp, (see plate 1) Cyclogranisporites arenosus, (see plate 2 and 3) while the pollen taxa of the same section include Araucriates australus, Alisporites landianus, (see plate 1,4 and 5), Taeniasesporites sp, (see plate 1), Microcachryidites daubingeri, Sulcatisporites ovatus, Pinuspollenites thoracatus, Platysaccus queenslandi, Lunatisporites pellucidus, Podocarpidites sp (see plate 2), Falcisporites stabilis, (see plate 2, and 4), Cuneatisporites sp, (see plate 2) Vitriesporites pallidus, , Klausipollenites schaubergeri, (see plate 2), and Decussatisporites sp, (see plate 5).

The spores reported from the Zaluch Gorge section include Cyclogranisporites arenosus, (see plate 2 and 3), Cythidites australis, Concavissimisporites sp, Osmundacidites sp, (see plate 3), Convolutispora sp, (see plate 4), Grebespora rimulata, Lundbaldispora willmotti (see plate 5) while the pollen taxa of the same section include Cycadophites sp, (plate 1), Cycadophites sp (see plate 3), Vitriesporites pallidus, (see plate 2, 3), Klausipollenites schaubergeri, (see plate 3 and 4), Alisporites radialis, (see plate 3), Falcisporites stabilis, Monosaccite (see plate 4,5), Sulcatisporites sp, Striatopodocarpites auriculatus, Taeniasesporites sp, (plate 4), and Praecolpatites sinuosus, (see plate 5).

Based on the reported spores and pollen taxa the age of the Tredian Formation assigned in this study is Triassic. palynological

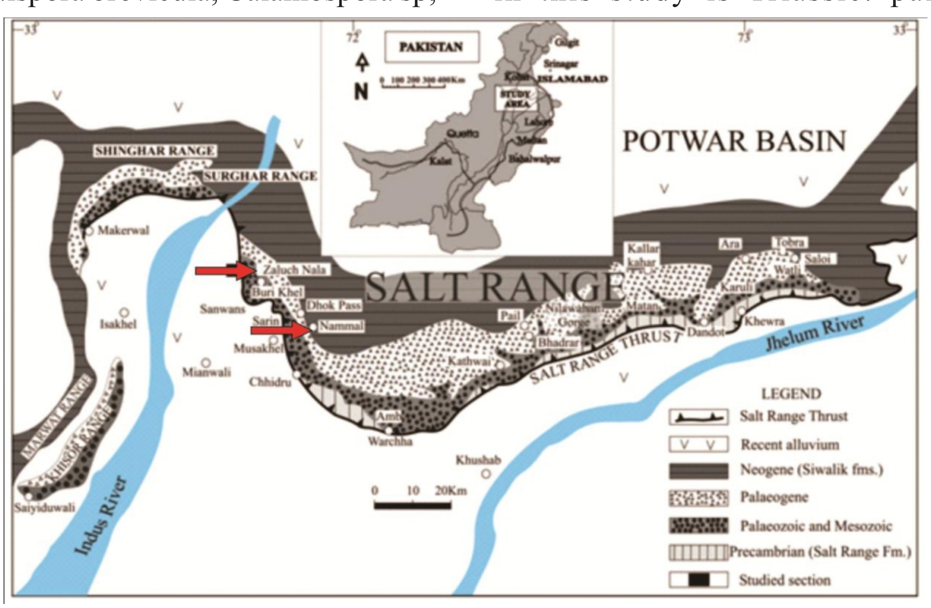


Fig. 1. Showing the locations of the study area (after Jan and Stephenson 2011).

4.2. Age of the Tredian Formation

The palynoflora preserved in the Nammal and Zaluch Gorge sections represent a Triassic age (e.g. Balme 1970; Vijaya et al 1988; Shu and Norris, 1999; Hammad, 2004; Peng et al. 2006; Tripathi et al. 2006; Boniset al., 2009; Hermann et al. 2012; Schneebeli-Hermann et al., 2012; Seyfullah et al., 2013; Dawit, 2014; Tewari et al., 2014). The low number of samples has hampered the erection of the local/global biozones; nevertheless the accumulated literature as mentioned has helped in establishing a Triassic age for the Tredian Formation. The presence of spores e.g. Lundbladispora brevicula (plate 1) and pollen e.g. Lunatisporites pellucidus, (plate 2) Sulcatisporites sp. (plate 4) in the Nammal Gorge Section, Osmundacidites (plate 3) spores and Alisporites, (plate 3) Falcisporites, (plate and 4) Klausipollenites, (see plate 3 and 4) Striatopodocarpites (plate 4) assemblages in the Zaluch Gorge Section suggest Anisian age (middle Triassic) for the Tredian Formation. This age is assigned by comparing this taxa with the similar taxa assemblages of the Hermann et al. (2012) who documented it in the Tredian 1 biozone, from the Tredian Formation, at Chitta-Landu stratigraphic section.

4.3. Palynofacies and depositional environments

The palynofacies identified from the Tredian Formation in the Nammal Gorge Section include phytoclasts; playnomorphs, woody matrix, amorphous marine organic matter, leaf epidermal tissues, and sporangial mass (Plate 6). Such parameters are important for establishing the depositional environment for a characteristic unit.

The Nammal Gorge Section is comprised of 65-67% phytoclasts, 30-32% palynomorphs, and 1-3% woody matrix. The high abundance of phytoclasts with woody tissues suggest clear proximal signature. The palynofacies percentage abundances suggest heterolithic proximal oxic shelf (Tyson, 1995) for the deposition of the Tredian Formation in the Nammal Gorge section (Fig. 4).

The Zaluch Gorge Section is composed of 45-50% phytoclasts, 35-30% playnomorphs, 5-10% amorphous organic matter and 5-10% with rare occurrences of sporangial mass and leaf epidermal tissues. These palynofacies also suggest heterolithic proximal oxic shelf. However the presence of amorphous marine organic matter, sporangial mass and absence of woody matrix, suggests marine incursion and therefore relatively deeper settings as compared to Zaluch Gorge section (Tyson, 1995) (Fig. 4).

5. Discussion

The aim of this study is to establish the ages for the clastic unit of the Tredian Formation in Nammal and Zaluch Gorge sections. Based on the current palynoflora Triassic age is established in this study. More specifically Anisian (middle Triassic) age is established for the Tredian Formation after comparing the palynofloral assemblages with the Tredian 1 biozone of the Tredian Formation at Chitta-Landu stratigraphic section (e.g. of the Hermann et al., 2012). In addition the paper deals to address the reliability of depositional settings of the Tredian Formation, previously considered as a prograding deltaic system (Iqbal et al., 2013). The Tredian Formation is composed of interbedded shale, planer and trough cross bedded sandstone having slumps, and dolomite, representing deposition in prograding deltaic system dominated by fluvial-continental settings, delta topsets/channels with marine incursions (Iqbal et al., 2013).

The interpretation of palynofacies data is carefully made because various factors may cause problems e.g. the dominance of spores infers at least seasonally humid conditions and the dominance of gymnosperms indicates dry conditions. Warm climates with increased humidity would enhance the relative enrichment of spores in a depositional site (Schrank, 2010).

The spores and pollen behave differently during transportation and deposition. Also sea level changes might also influence the composition of the palynomorphs assemblages e.g. bissacate pollens have higher buoyancy and their abundance dominate the spores during a sea-level rise (Tyson 1995). Various sea level changes are documented for the Permian-

Triassic stratigraphic section of Pakistani based on the composition of particular organic matter assemblages (Hermann et al., 2012). The weathering process may cause selective degradation of organic matter; evidenced by blackening of pollen, spores and loss of some organic components. The sparse phytoclasts suggest low organic input from terrestrial sources (Tewari et al., 2014).

The comparative study of the spores and pollen taxa of Nammal and Zaluch Gorge Section reveals weak correlation. Although certain bissacate pollen are common in both sections therefore this weak correlation may not be strictly taken as evidence for provincialism in such a closely spaced stratigraphic sections. This negative correlation can be explained by limited number of samples and low sampling resolution.

The palynofacies data in current study is very limited; nevertheless it proved very helpful in addressing the depositional settings of the Tredian Formation in Nammal and Zaluch Gorge sections. The palynofacies analysis of the Nammal and Zaluch Gorge sections suggests heterolithic proximal oxic shelf for the deposition of Tredian Formation, however the presence of amorphous marine organic matter, and sporangial in the Zaluch Gorge section suggests marine incursion and therefore relatively deeper settings as compared to the Nammal Gorge section. The deepening in the Zaluch section suggest progradation towards the south west from the Zaluch Gorge section. This progradation established in this study is in coherence with Iqbal et al. (2013).

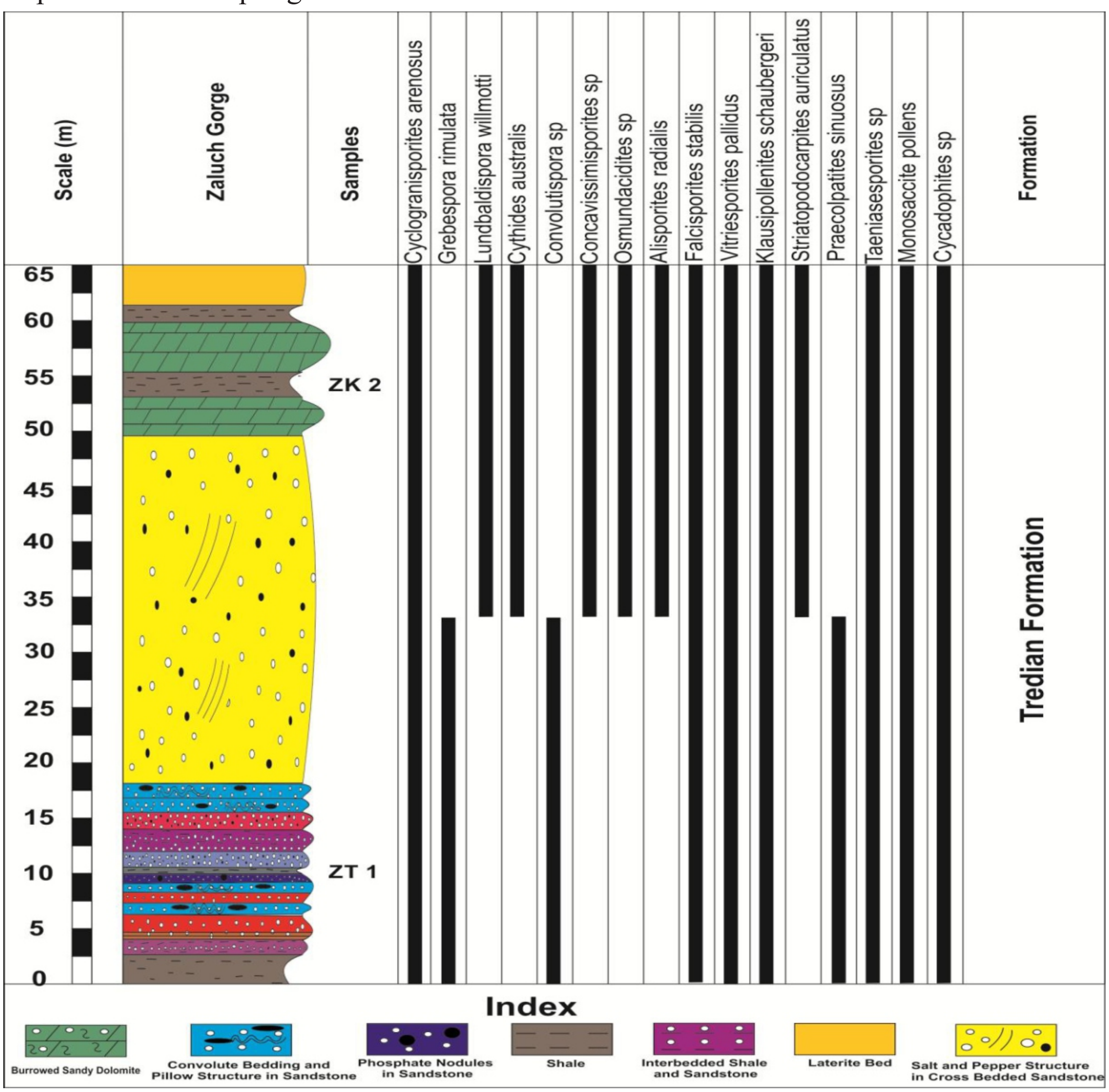


Fig. 2. Palynoflora range chart of the Tredian Formation in Zaluch Gorge section, Salt Range, Pakistan.

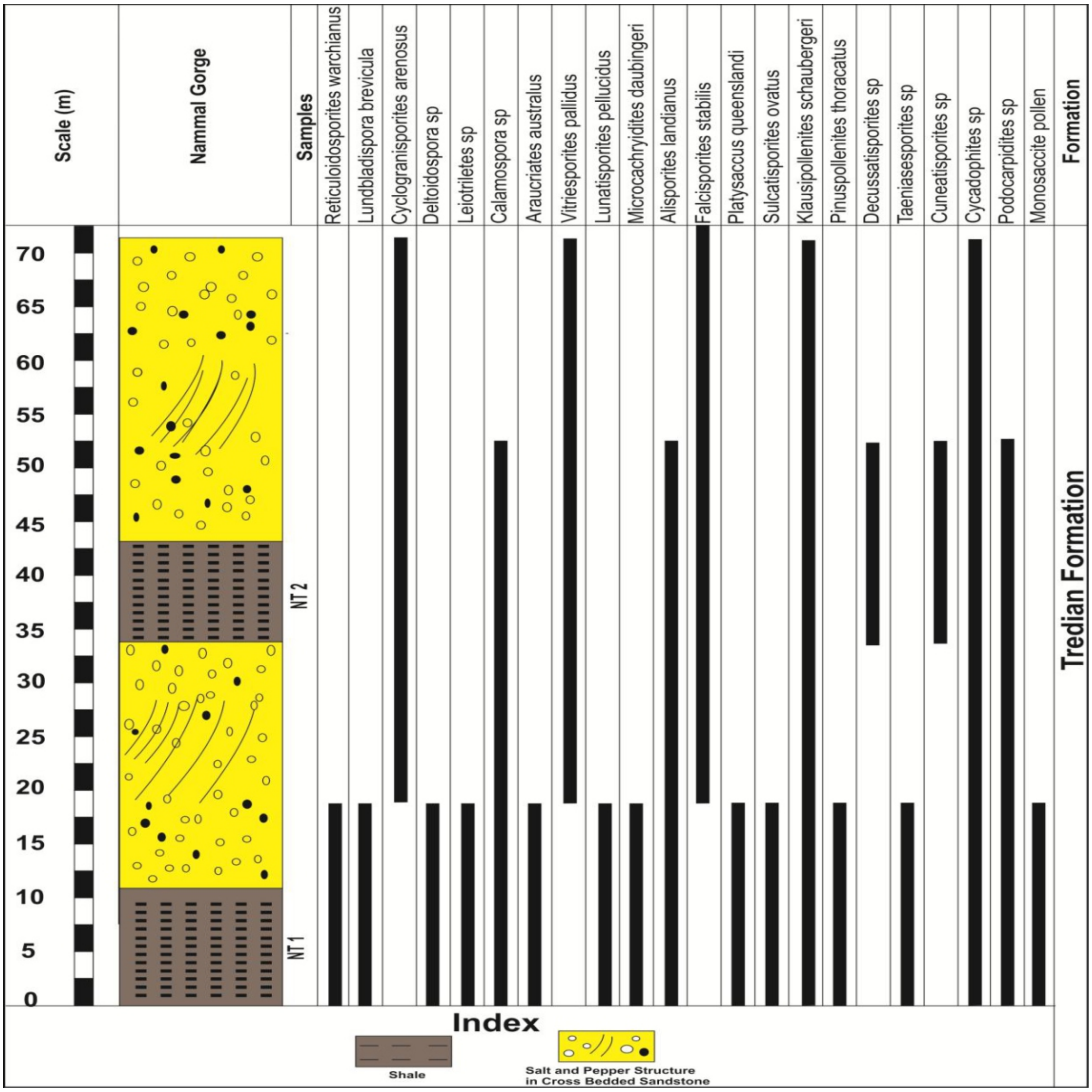


Fig. 3. Palynoflora range chart of the Tredian Formation in Nammal Gorge section, Salt Range, Pakistan

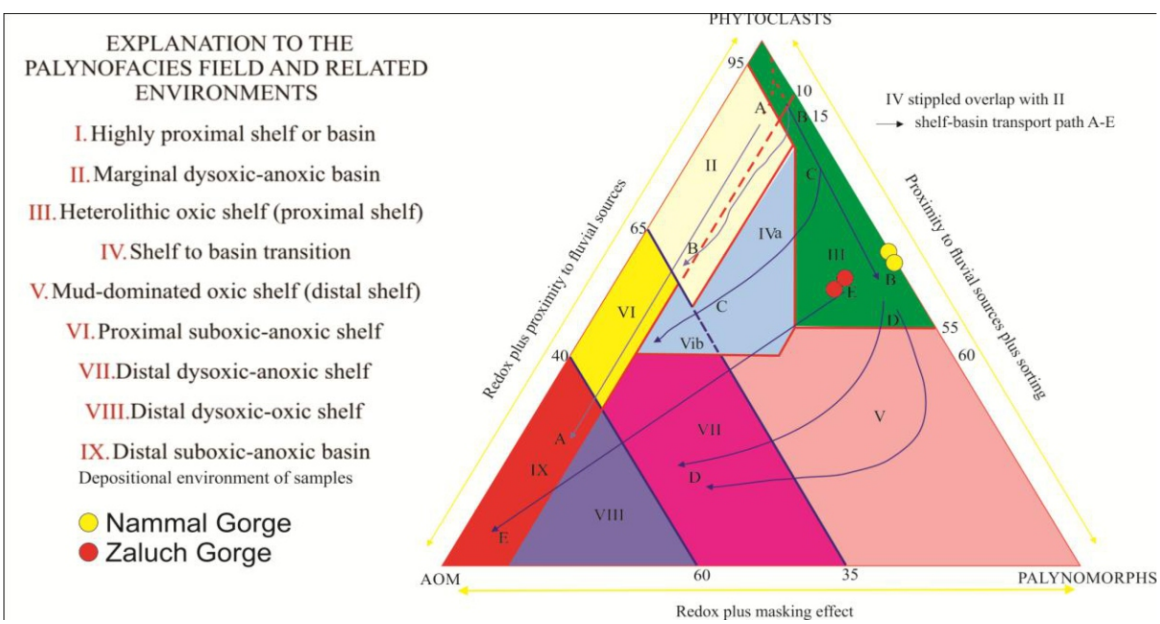
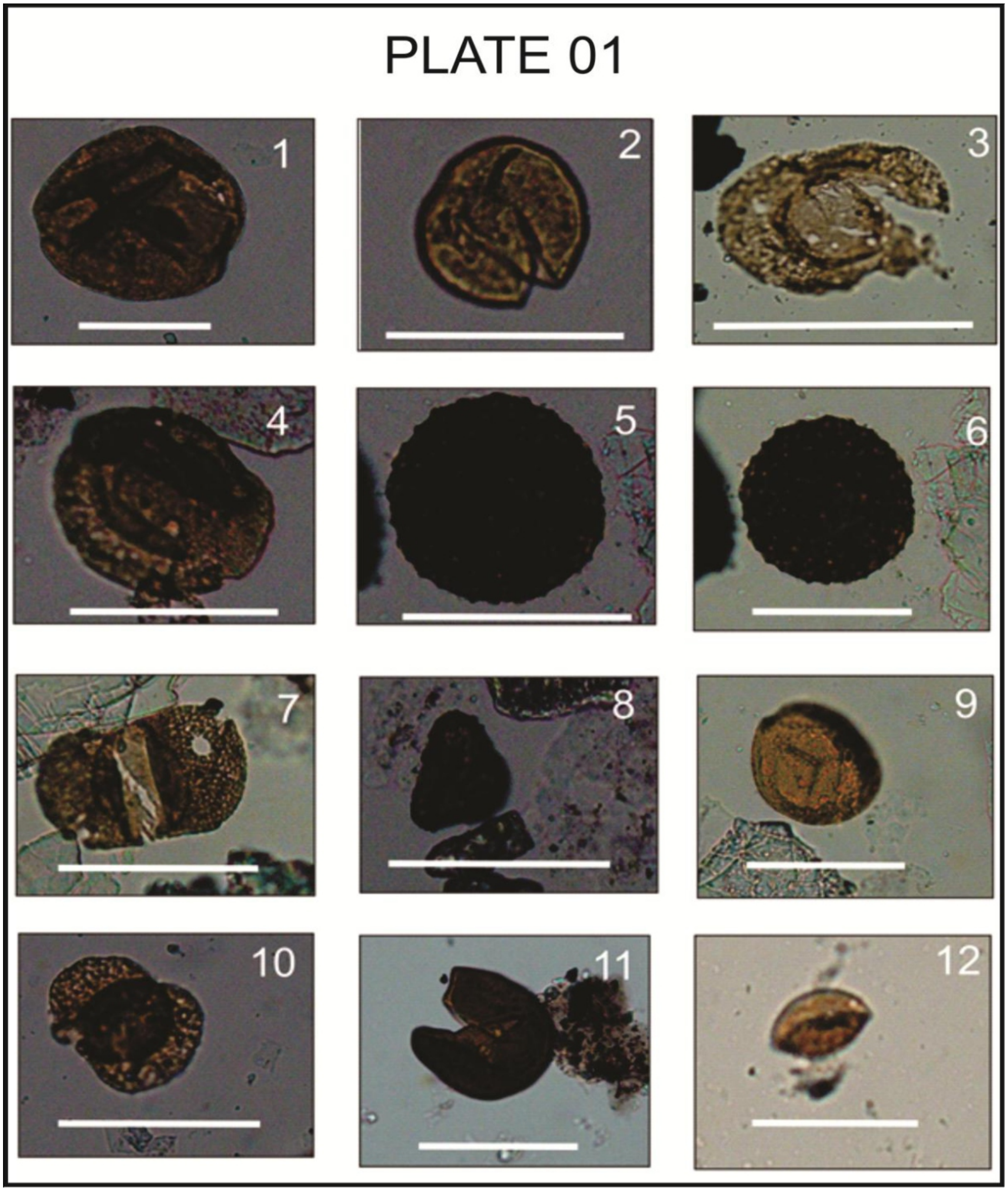


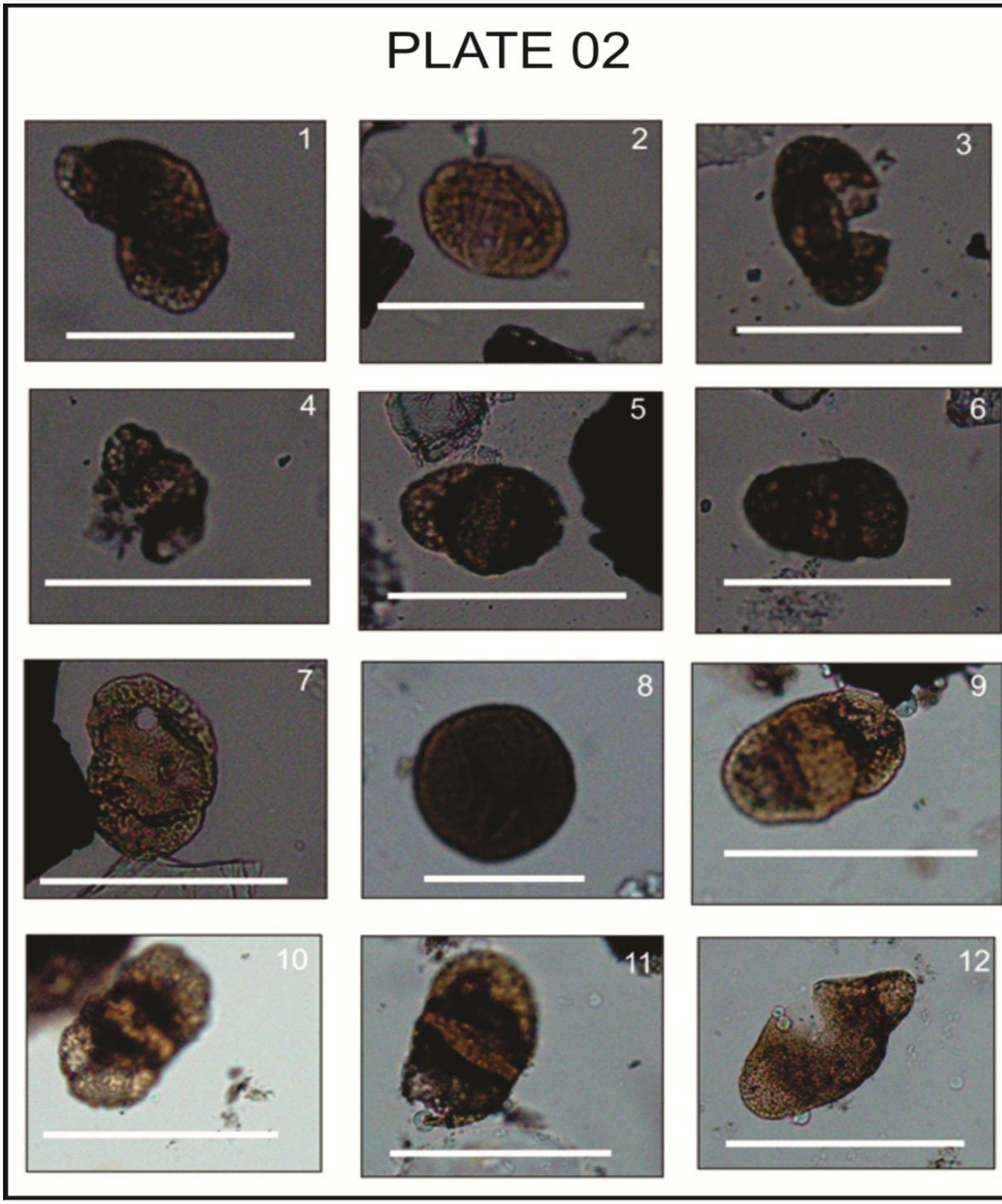
Fig. 4. Palynofacies plot showing depositional environments (After Tyson 1995).



Note: Scale bar represent 50µm for all figures.

PLATE 1

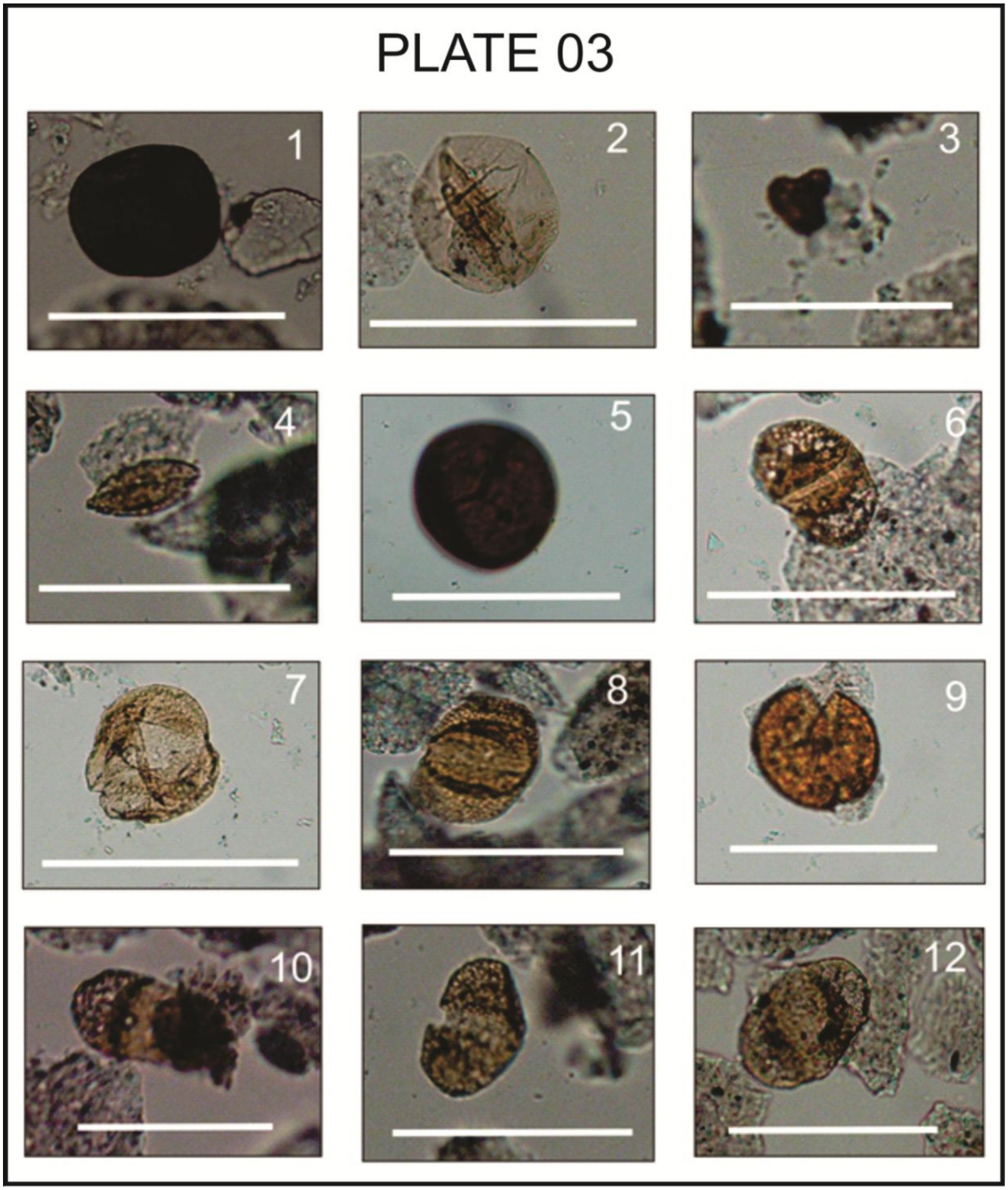
1. Araucriates australus, Nammal section, Sample NT1,
2. Deltoidospora sp., Nammal section, Sample NT1,
3. Monosaccite sp., Nammal section, Sample NT1,
4. Monosaccite, Nammal section, Sample NT1,
5. Reticuloidosporites warchianus, Nammal section, Sample NT1,
6. Reticuloidosporites warchianus, Nammal section, Sample NT1,
7. Alisporites landianus, Nammal section, Sample NT1,
8. Leiotriletes sp, Nammal section, Sample NT1,
9. Lundbladispora brevicula, Nammal section, Sample NT1,
10. Taeniasesporites noviaulensis, Nammal section, Sample NT1,
11. Calamospora sp, Nammal section, Sample NT2,
12. Cycadophites sp, Zaluch section, Sample ZK2



Note: Scale bar represent 50μm for all figures.

PLATE 2

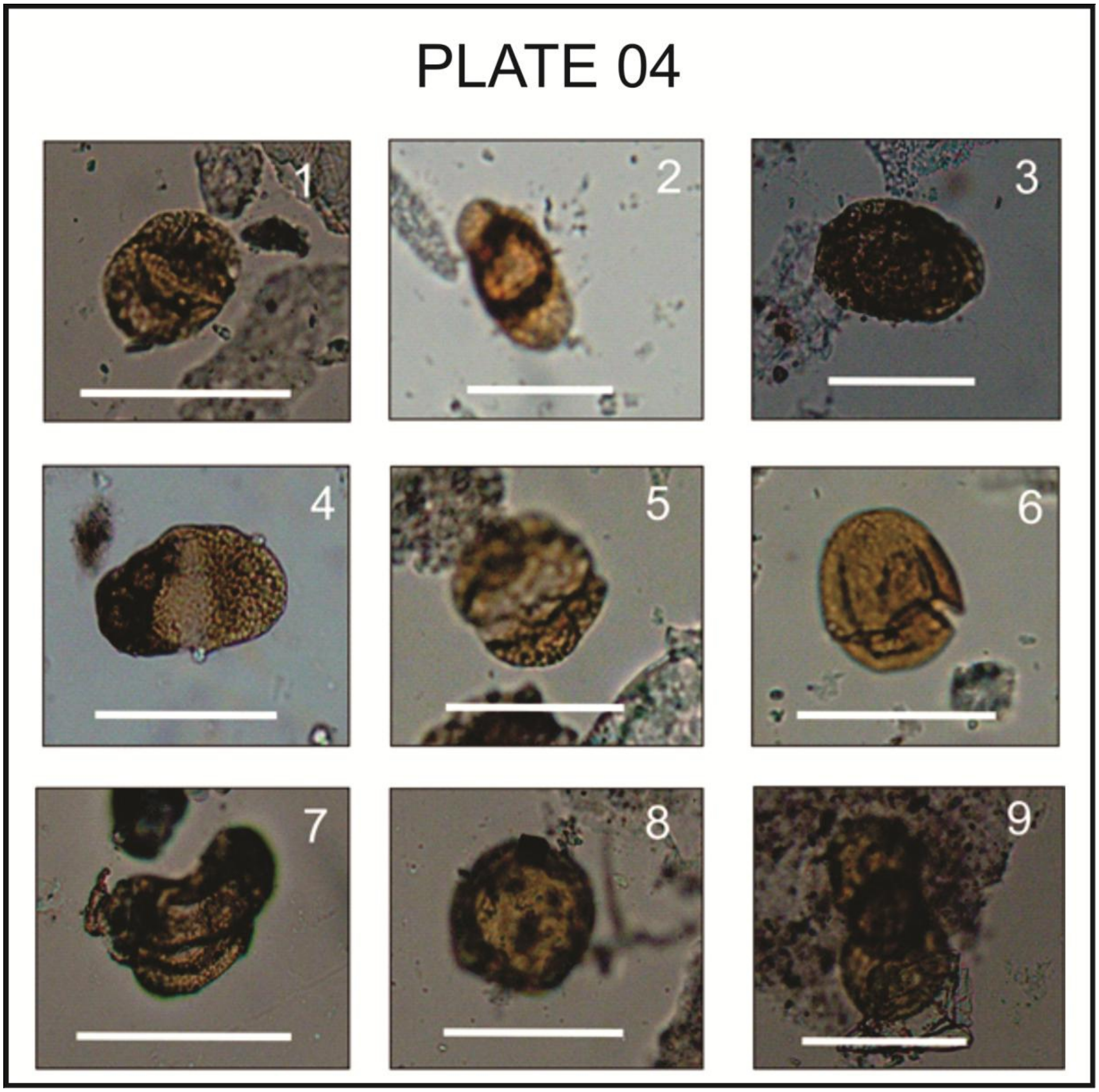
1. Pinuspollenites thoracatus, Nammal section, Sample NT1,
2. Sulcatisporites ovatus, Nammal section, Sample NT1,
3. Microcachryidites daubingeri, Nammal section, Sample NT1,
4. Platysaccus queenslandi, Nammal section, Sample NT1,
5. Lunatisporites pellucides, Nammal section, Sample NT1,
6. Podocarpidites sp., Nammal section, Sample NT1,
7. Podocarpidites sp., Nammal section, Sample NT1,
8. Cyclogranisporites arenosus, Nammal section, Sample NT2,
9. Falcisporites stabilis, Nammal section, Sample NT2,
10. Cuneatisporites sp, Nammal section, Sample NT2,
11. Vitriesporites pallidus, Nammal section, Sample NT2,
12. Klausipollenites schaubergeri, Nammal section, Sample NT2



Note: Scale bar represent 50µm for all figures.

PLATE 3

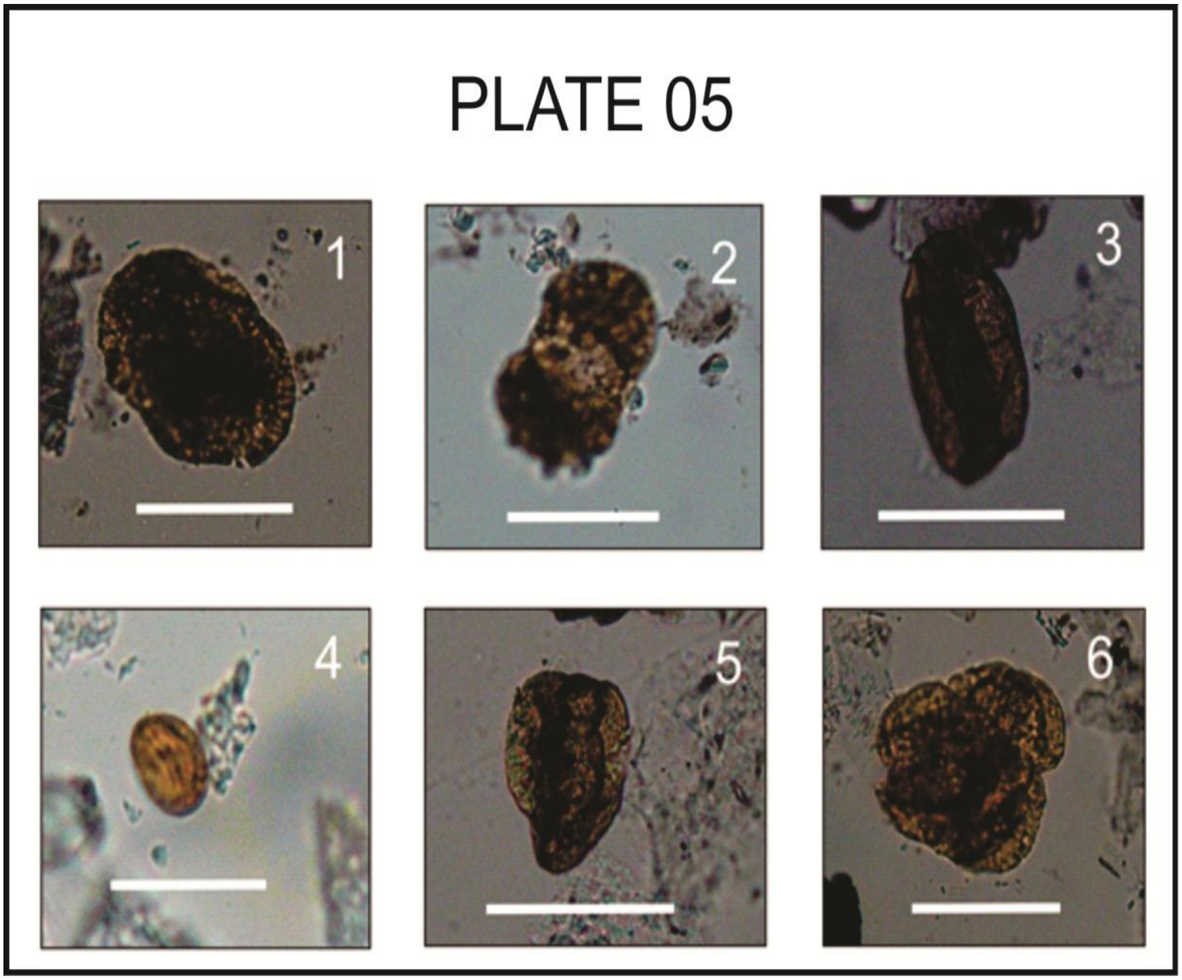
1. Cyclogranisporites arenosus, Zaluch section, Sample ZK2,
2. Cythidites australis, Zaluch section, Sample ZT8,
3. Concavissimisporites sp., Zaluch section, Sample ZT8,
4. Cycadopites sp., Zaluch section, Sample ZT8,
5. Cyclogranisporites arenosus, Zaluch section, Sample ZT8,
6. Vitreisporites pallidus, Zaluch section, Sample ZT8,
7. Cythidites australis, Zaluch section, Sample ZT8,
8. Vitreisporites pallidus, Zaluch section, Sample ZT8,
9. Osmundacidites, Zaluch section, Sample ZT8,
10. Vitreisporites pallidus, Zaluch section, Sample ZT8,
11. Kalusipollenites schaubergeri, Zaluch section, Sample ZT8,
12. Alisporites radialis, Zaluch section, Sample ZT8



Note: Scale bar represent 50µm for all figures.

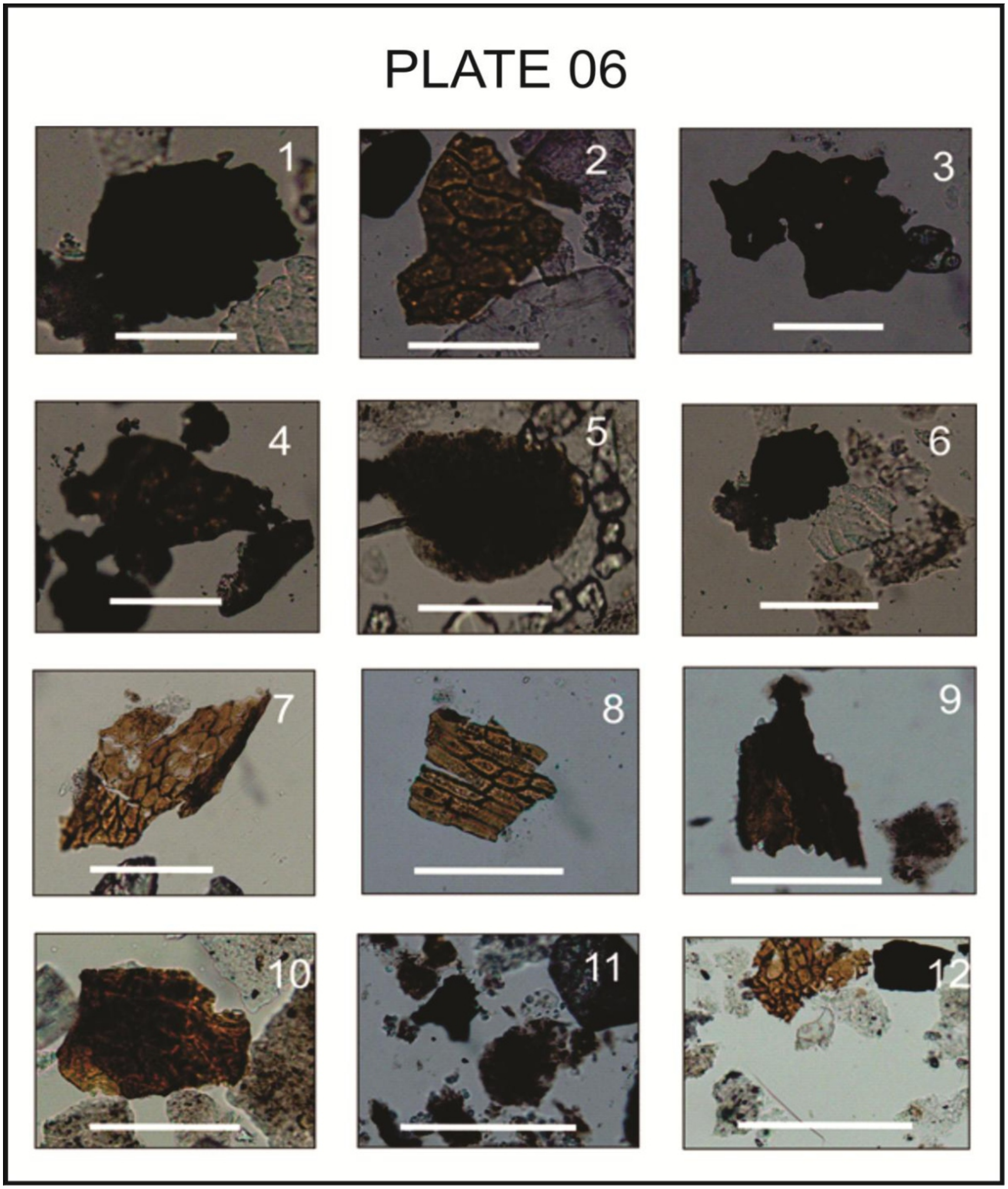
PLATE 4

1. Falcisporites sp., Zaluch section, Sample ZK2,
2. Klausipollenites sp., Zaluch section, Sample ZT8,
3. Monossacite, Zaluch section, Sample ZK2,
4. Alisporites landianus, Nammal section, Sample NT2,
5. Sulcatisporites sp., Zaluch section, Sample ZT8,
6. Striatopodocarpites auriculatus, Zaluch section, Sample ZT8,
7. Convolutispora sp., Zaluch section, Sample ZK2,
8. Grebespora rimulata sp, Zaluch section, Sample ZK2,
9. Taeniaesporites sp., Zaluch section, Sample ZK2



Note: Scale bar represent 50µm for all figures.

PLATE 5
1. Monossacite, Zaluch section, Sample ZK2,
2. Alisporites landianus, Nammal section, Sample NT2,
3. Decussatisporites sp., Nammal section, Sample NT1,
4. Lundbaldispora willmotti, Zaluch section, Sample ZT8,
5. Praecolpatites sinuosus, Zaluch section, Sample ZK2,
6. Tetrad of Monossacite pollen, Zaluch section, Sample ZK2



Note: Scale bar represent 50µm for all figures.

PLATE 6

1. Opaque organic matter of terrestrial origin, Zaluch section, Sample ZK2,
2. Gymnosperm woody matrix, Nammal section, Sample NT1,
3. Leaf epidermal tissue, Nammal section, Sample NT1,
4. Leaf epidermal tissue, Zaluch section, Sample ZK2,
5. Marine amorphous organic matter, Zaluch section, Sample ZK2,
6. Decomposed terrestrial phytoclast, Zaluch section, Sample ZK2,
7. Leaf epidermal tissue, Zaluch section, Sample ZK2,
8. Woody matrix, Nammal section, Sample NT2,
9. Woody matrix, Nammal section, Sample NT2,
10. Sporangial mass, Zaluch section, Sample ZT8
11. Abundant amorphous marine organic matter, Nammal section, Sample NT2
12. Abundant terrestrial woody matrix and decomposed phytoclast, Zaluch section, Sample ZK2

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