COMBINED LM AND SEM STUDIES OF CRETACEOUS (APT-ALBIAN) SPORES AND POLLEN FROM CENTRAL MONGOLIA

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ABSTRACT

The coal-bearing strata from Mongolia (Tevshiingovi Formation) of Albian to middle Aptian age contain next to dominating spores of Bryophytes and ferns, Pinaceae, Cupressaceae and Ginkgoaceae pollen only few taxa that can be affiliated with angiosperms and angiosperm-like pollen.

The coal-bearing strata of the Khovil-Tugrug coal mine is located in central Mongolia southeast of Ulaanbaatar in the Choir-Nyalga basin (Figure.1) and its stratigraphic range is confined by the presence of various spores *Pilosisporites notensis, Osmundacidites wellmanii, Aequitriradites spinulosus, Taurocusporites reduncus, Todisporites minor, Densoisporites sp, Cicatricosisporites australiensis, Cicatricosisporites dorogensis, Cyathidites australis, Leptolepidites verrucatus, Lycopodiumsporites sp., Lycopodiumsporites marginatus and pollen as a Podocarpites multisimus, Podocarpidites décorus, Piceapollenites sp., Pinuspollenites oralicus, Pinuspollenites sp., Alisporites sp., Cycadopites sp., Ginkgocycadophytes sp., Araucariacites australis, Araucariacites sp., Inaperturapollenites sp., Taxodiaceaepollenites sp., Classopollis classoides* and angiosperm *Clavatipollenites, Retimonocolpites, Liliacidites-like, Platanus-like* (Bratseva, G.M. Novodvorskaya, I.M.1975; Masamichi Takahashi., 1997; Punt, W., Hoen, P.P., Blackmore,S.,Nilsson, S.& Le Thomas,A. 2007; Hesse.M, Halbritter.H, Zetter, R, 2009) *(*Plate. I-VII).

Key words: Cretaceous, spore, pollen, SEM, LM

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1. Introduction

The Lower Cretaceous Khovil mine is located in the Tugrug Nuur coal deposits of the Choyr-Nyalga coal bearing basin situated 170 km southeast of Ulaanbaatar capital in Mongolia.

Tugrug Nuur coal deposits are located in a shallow depression filled with Lower Cretaceous rocks. The depression divided into two equal parts by a fault: The Takhilt subbasin in the northeast and the and Khovil subbasin in the southwest. Outline of the geological setting, geochemistry of rocks, and petrology of coals have been reported in previous studies, however detailed palynological studies in the Khovil subbasin have never been undertaken before. The present paper reports the first detailed palynological study on spores, by aplying of the combination routinely the combination of LM and SEM on various spores from the sedimentary rocks of the Lower Cretaceous coal bearing sediments

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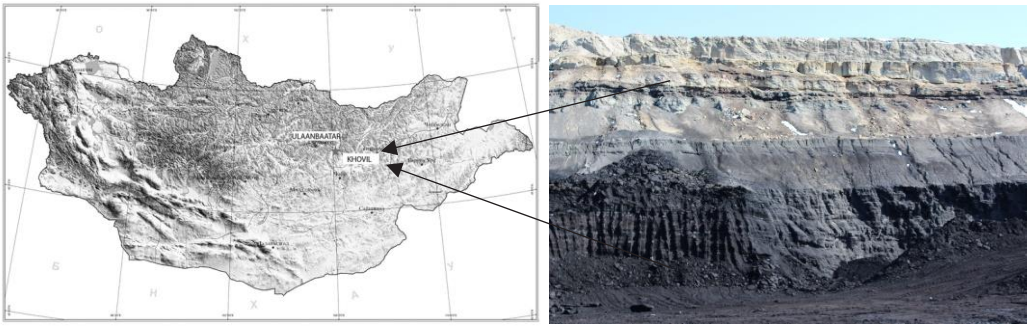

Fig.1. Location map of study area

2. Geology

The sediments belong to the Tevshiin Govi Formation, a sequence of conglomerates, sandstones, and siltstones, with thick lignite seams (metre thickness), which have been deposited in terrestrial, fluvial to lacustrine environments (Leslie et al ., 2013; Shi et al. 2014; Herrera et al., 2015; Shi et al., 2016). The Tevshiin Govi Formation is of Aptian–Albian age (125–99.6 Mya; Gradstein et al., 2012), based on palynomorphs recovered from the Tevshiin Govi plant bearing localities (Ichinnorov, 2003; Nichols et al.,2002, 2006; Ichinnorov et al., 2012) and stratigraphic correlations with other Lower Cretaceous rocks from Mongolia (Graham et al., 2001; Erdenetsogt et al., 2009).

3. Material and methods

During a field survey in 2016 in the Khovil mine 30 samples were collected (lat.46^0 52´ 31.68´´ N, long. 108^0 10´ 51.58´´E, fig2). The sample material included mudstones, coaly mudstones and clayey coals.

The sample material was then crushed by hand with a mortar and pestle, the sedimentary rock powder was treated with HCl and HF using standard palynological procedures (Zetter.R., 1989), washed several times using a centrifuge. The resulting organic extract was not sieved to retain palynomorphs smaller than 10µ, and acetolyzed to reduce additional organic matter such as wood fragments, cuticles etc., and finally mixed with glycerine and kept in small glass tubes. For LM investigation a drop of well-mixed organic extract is evenly smeared on a glass slide. Spore taxa of particular interest are then transferred with a hair on a preparation needle into a clean drop of glycerine onto a new slide. LM photography was done with a Samsung digital camera. After being photographed for further examination under the SEM (FEI Inspect 500), the spores were transferred to a SEM stub (with a hair on a needle), carefully washed with 100% alcohol to remove the glycerine and than sputtered with gold. Stubs are stored under the inventory numbers IPUW 7840-1-1 to IPUW 7840-50-10 in the Department of Palaeontology, University of Vienna.

4. Results and discussion

Systematic palaeontology

Division: Pteridophyta

Family: Incertae Sedis

Genus: *Pilosisporites* Delcourt and Sprumont, 1955

Pilosisporites notensis (distal view) (Figure.1A-C)

Description. Spore, trilete, outline triangular in distal view, equatorial diameter 76.6-80.0 µm in SEM, exospore 3.6 µm thick, amb triangular slightly concave, apices rounded; sculpturing of exospore echinate (LM), echinate to baculate (SEM), on apices

echini/ bacula 4.3-5.0 µm long (SEM), basal diameter of echini/bacula 1-2 µm wide (SEM), echini/bacula are loosely spaced (SEM), echini/bacula slightly shorter in the center of the proximal polar area (SEM).

Pilosisporites notensis (proximal view) (Figure. 1D-F)

Description. Spore, trilete, outline triangular in distal view, triangular to lobate in proximal view equatorial diameter 70.9-72.7 µm in LM, 63.7-65.0 µm in SEM, laesurae ½ of the spore radius, exospore 5.4 µm thick in LM, amb triangular concave, apices rounded,, distinct labrum present 3.3 µm wide in SEM, labrum consist by fused echini in SEM; sculpturing of exospore baculate (LM), on apices bacula 1.8 µm long (LM), echini/bacula are 2.1 µm long (SEM), basal diameter of echini/bacula 1-2 µm wide (SEM), loosely spaced (SEM), echini/bacula are more short center of proximal polar area between laesurae (SEM).

Pilosisporites sp.*1.* (Figure. 1G-I)

Description. Spore, trilete, outline t, equatorial diameter 54.0-52.7 µm in LM, 48-50 µm in SEM; laesurae ½ of the spore radius, exospore 4.0-4.3 µm thick (LM), amb concave, apices rounded; sculpturing of exospore echinate (LM), echinate to baculate (SEM), on apices echini/ bacula up to 2-3 µm long, in the proximal polar area 1.3-0.6 µm long (SEM), basal diameter of echini/bacula 1-2 µm wide (SEM), echini/bacula are longer on the apices (SEM).

Remarks. **S**imilar species have been first reported from the Wealden of the Hannover district in Germany by Thiergart (1949), and described from the Wealden of Belgium by Delcourt and Sprumont (1955), and from the Purbeck and Wealden of England by Couper (1958).

Pilosisporites sp. 2 (Figure J-L)

Description. Spore, trilete, outline oblique in equatorial view, equatorial diameter 76.0-78.0 µm in LM, 61.4-64.2 µm in SEM, laesurae ½ of the spore radius, exospore 6.0-8.0 µm thick in LM, amb convex, apices well rounded, distinct labrum present 5.0 µm wide in SEM; sculpturing of exospore echinate to baculate (LM), echini/bacula are 2.2 µm long (LM), 3.3-4.1 µm long (SEM), whole spore surface is covered by densely arranged echini/bacula (SEM).

Pilosisporites sp. 3 (Figure. 2A-C)

Description. Spore, trilete, outline triangular slightly circular in polar view, equatorial diameter 56-61 µm in LM, 56-61 µm in SEM, laesurae ½ of the spore radius, exospore 4.0-4.3 µm thick in LM, amb straight to slightly convex, apices rounded, distinct labrum present (LM), labrum 5µm wide (SEM); sculpturing of exospore echinate (LM), echinate to baculate (SEM) on apices echini/bacula 2-3 µm long (SEM), in proximal polar area 1.3-0.6 µm long (SEM), basal diameter of echini 1-2 µm wide in (SEM), whole spore surface is covered by densely arranged echini/bacula (SEM).

Pilosisporites sp. 4 (Figure. 2D-F)

Description. Spore, trilete, outline triangular in polar view, equatorial diameter 67.2–61.8 µm in LM, 57.1-65.7 µm in SEM, laesurae ½ of the spore radius, exospore 3.6 µm thick in LM, amb triangular weakly concave, apices rounded, distinct labrum present (LM), labrum 5.7 µm wide (SEM), sculpturing echinate (LM), echinate to baculate (SEM), echini/bacula 2.5-3.4 µm long (SEM), basal diameter of echini/bacula 0.6 µm wide (SEM), echini/bacula are densely spaced over the whole spore surface, length of echini/bacula are shorter in the center of proximal polar area between the laesurae (SEM).

Pilosisporites sp. 5 (Figure .2G-I)

Description. Spore, trilete, outline triangular to slightly circular in polar view, equatorial diameter 66-68 µm in LM, 64.2-67 µm in SEM, laesurae ½ of the spore radius,

exospore 3.2-4.3 µm thick in LM, amb slightly concave, apices well rounded, distinct labrum present (LM), sculpturing echinate (LM), echinate to baculate (SEM), on apices echini/bacula 1.6 µm long, in proximal polar area 1.0 µm long (SEM), echini/bacula basal diameter sometimes very wide 3.6-4.4 µm (SEM), usually 1.0-1.7 µm wide (SEM); echini/bacula loosely spaced (SEM), echini/ bacula ornamentation is less dense and slightly shorter in center of the proximal pole between the laesurae (SEM).

Pilosisporites sp. 6 (Figure 2J-L)

Description. Spore, trilete, outline triangular to circular in equatorial view, equatorial diameter 54.5-56.6 µm in LM, 45 µm in SEM, diameter from pole to pole 50.9 µm in LM, 45 µm in SEM, exospore 5 µm thick in LM, sculpturing of exospore baculate (LM), baculate to echinate (SEM), on apices echini/bacula are 3.3 µm long (LM), 3.0-4.0 µm long, most of the circinate echini mostly adpressed to spore surface (SEM), in between long echini few of are shorter than

These findings shown figure 1-7 by LM and SEM imaging.

5. Conclusion. A detailed palynological analysis (LM and SEM) made first time in this area.Palynological assamblages relatively abundant spores of Bryophytes and ferns, Pinaceae, Cupressaceae and Ginkgoaceae. Almost all those spores and pollen described before by Ichinnorov (2003, 2009, 2016) from coal deposits from Central Mongolia. (Shivee Ovoo, Tevshiin govi, Khuren Dukh, Tugrug Nuur)

In this assemblage not observed spores *Appendicisporites,* pollen *Cedripites* but contain chloranthaceous angiosperms *Clavatipollenites* and unknown angiosperm pollen *Retimonocolpites* and coarse reticulate pollen, monocotyledonous angiosperms *Liliacidites-like* and tricolpates *Platanus*-like occur in this assemblage.

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PLATE I

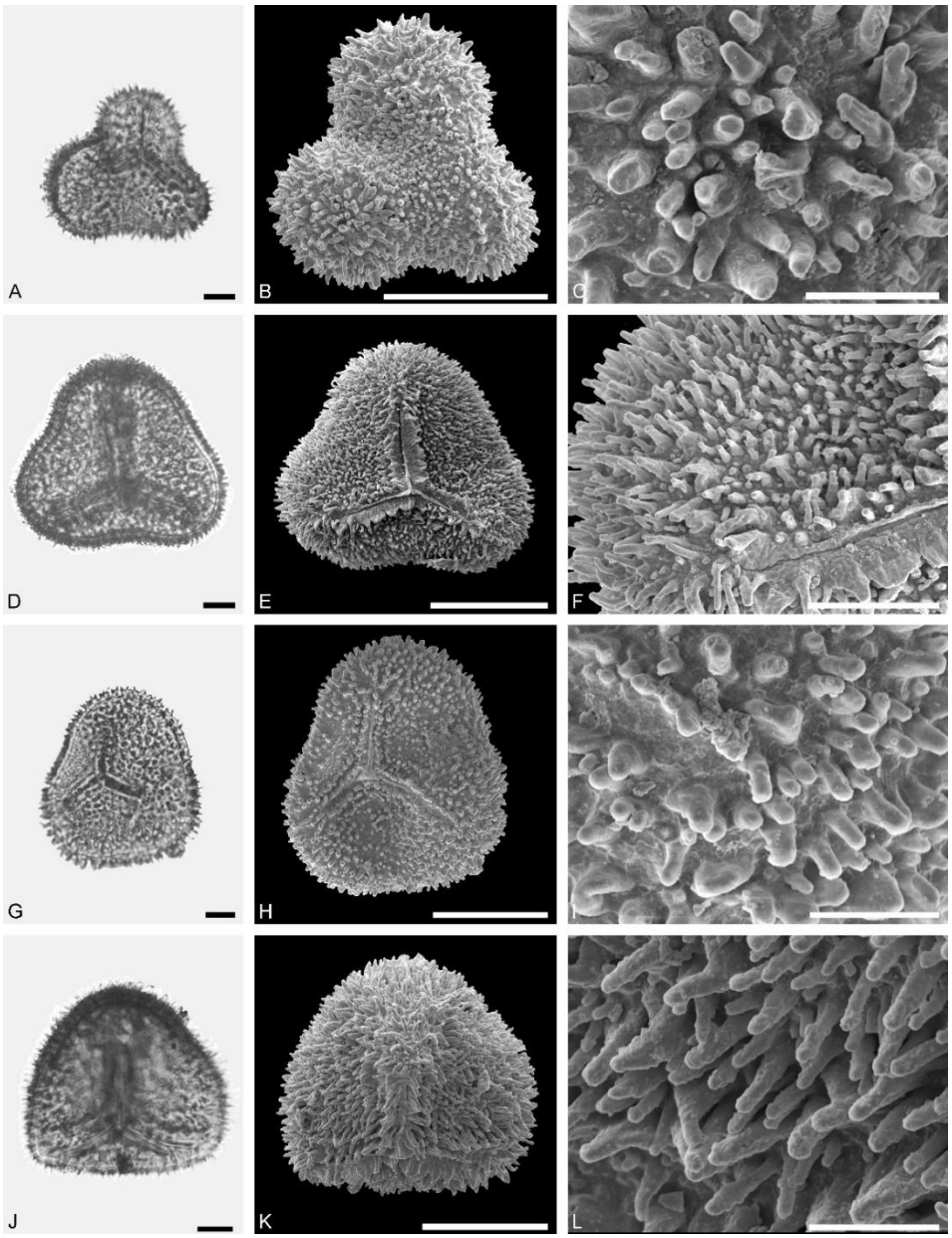

Fig. 1A-1L. ***Pilosisporites notensis; A,D,G,J, LM photo, B,E, H,K SEM photo, C,F,I,L SEM detail photo***

PLATE II

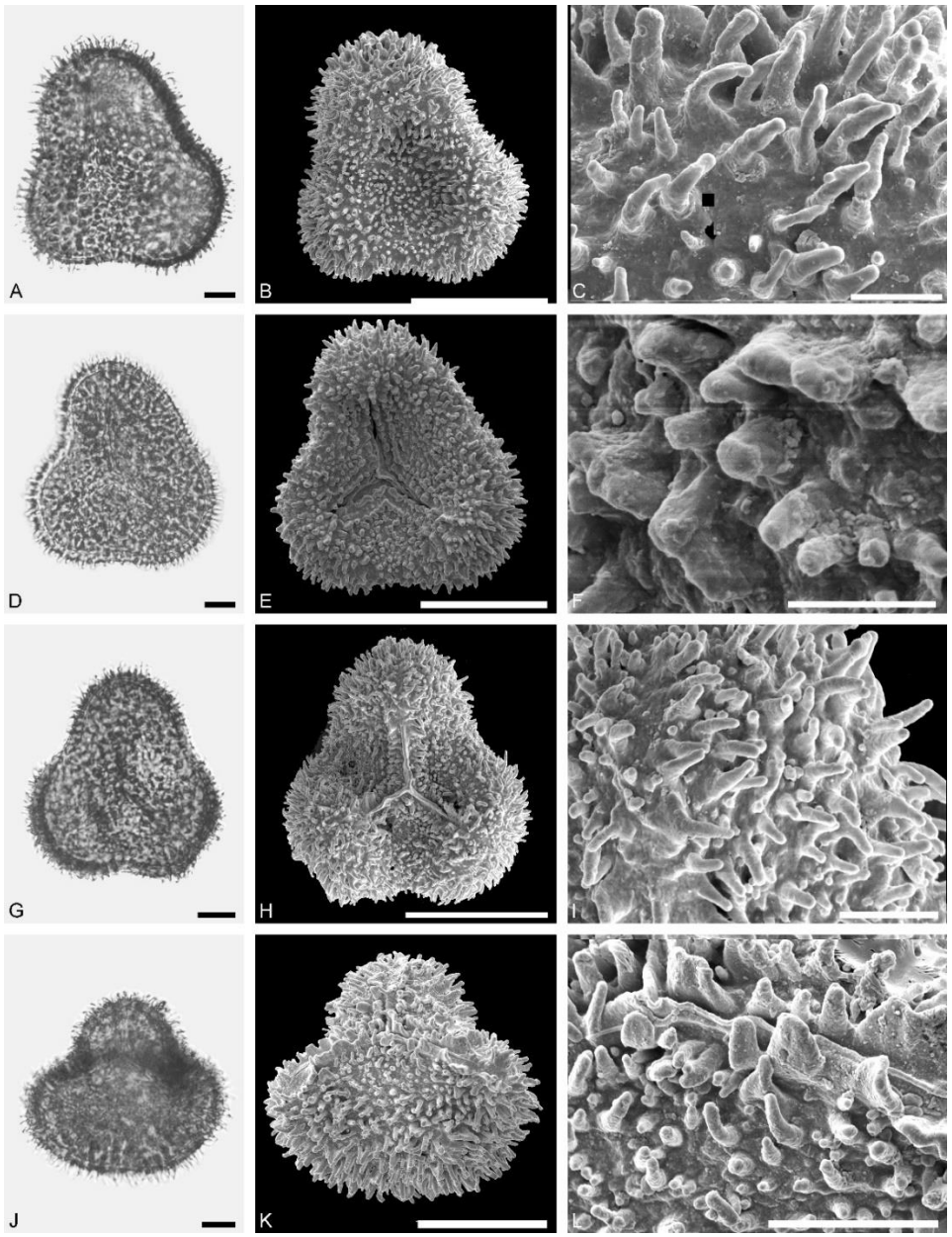

Fig. 2A-2L . ***Pilosisporites sp., A,D,G,J, LM photo, B,E, H,K SEM photo, C,F,I,L SEM detail photo***

PLATE III

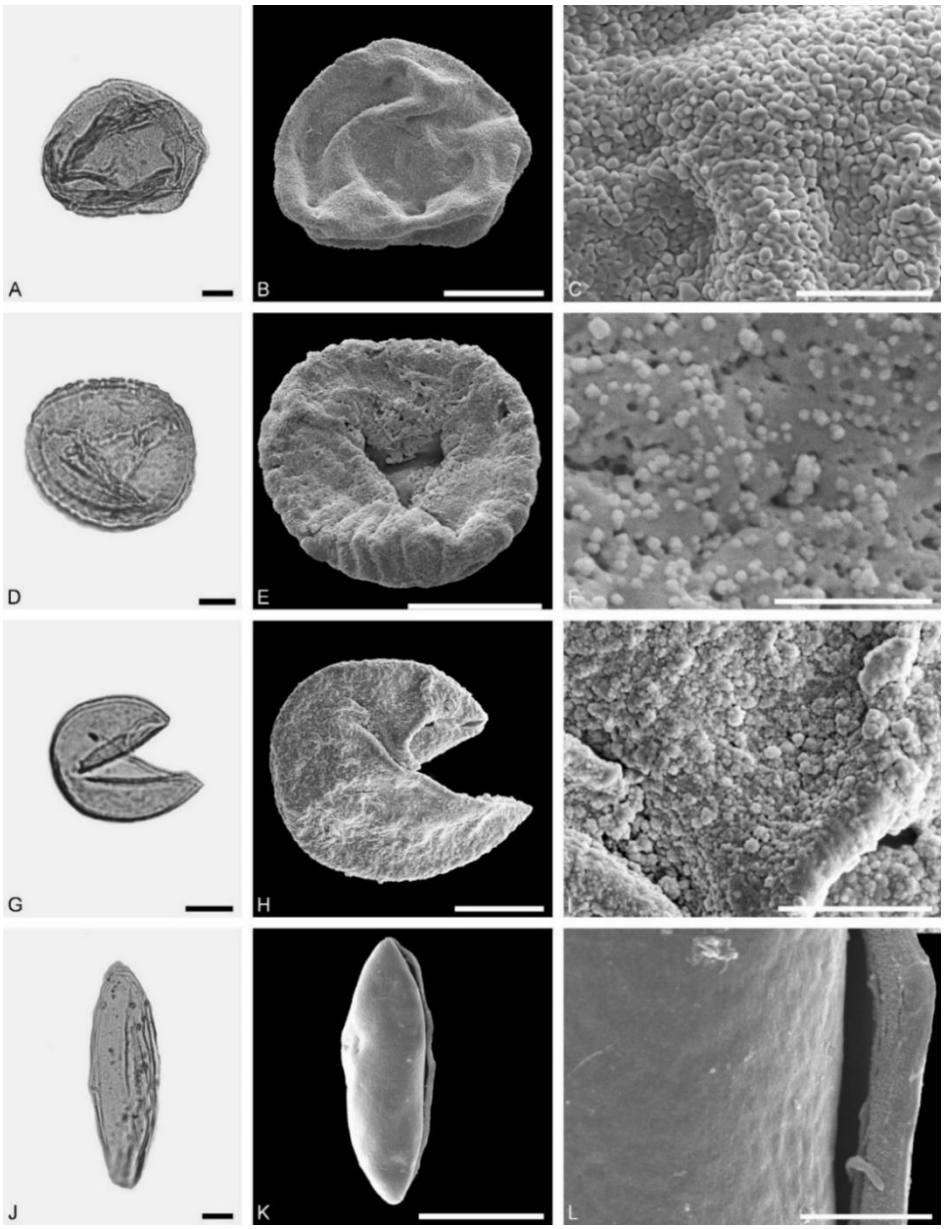

Fig. 3A-3L. 1.*Araucariacites australiensis* (Cookson, 1947) A-C, A. LM photo, 400x, 10µm, B.SEM photo, 5 502x, 20 µm , C.SEM detail photo,20 000x, 5 µm. 2. *Classopollis classoides* D-F, D.LM photo, 400x, 10µm, E.SEM photo, 6 683x, 20 µm F.SEM detail photo, 50 120x, 2 µm. 3.*Taxodiaceaepollenites sp.,* G-I, G. LM photo, 400x, 10µm, H.SEM photo, 8 803x, 10 µm I.SEM detail photo, 36 000x, 4 µm. 4.*Cycadopites sp*., J-L, J. LM photo, 400x, 10µm, K.SEM photo, 2 751x, 40 µm L.SEM detail photo., 20 000x, 5 µm.

PLATE IV

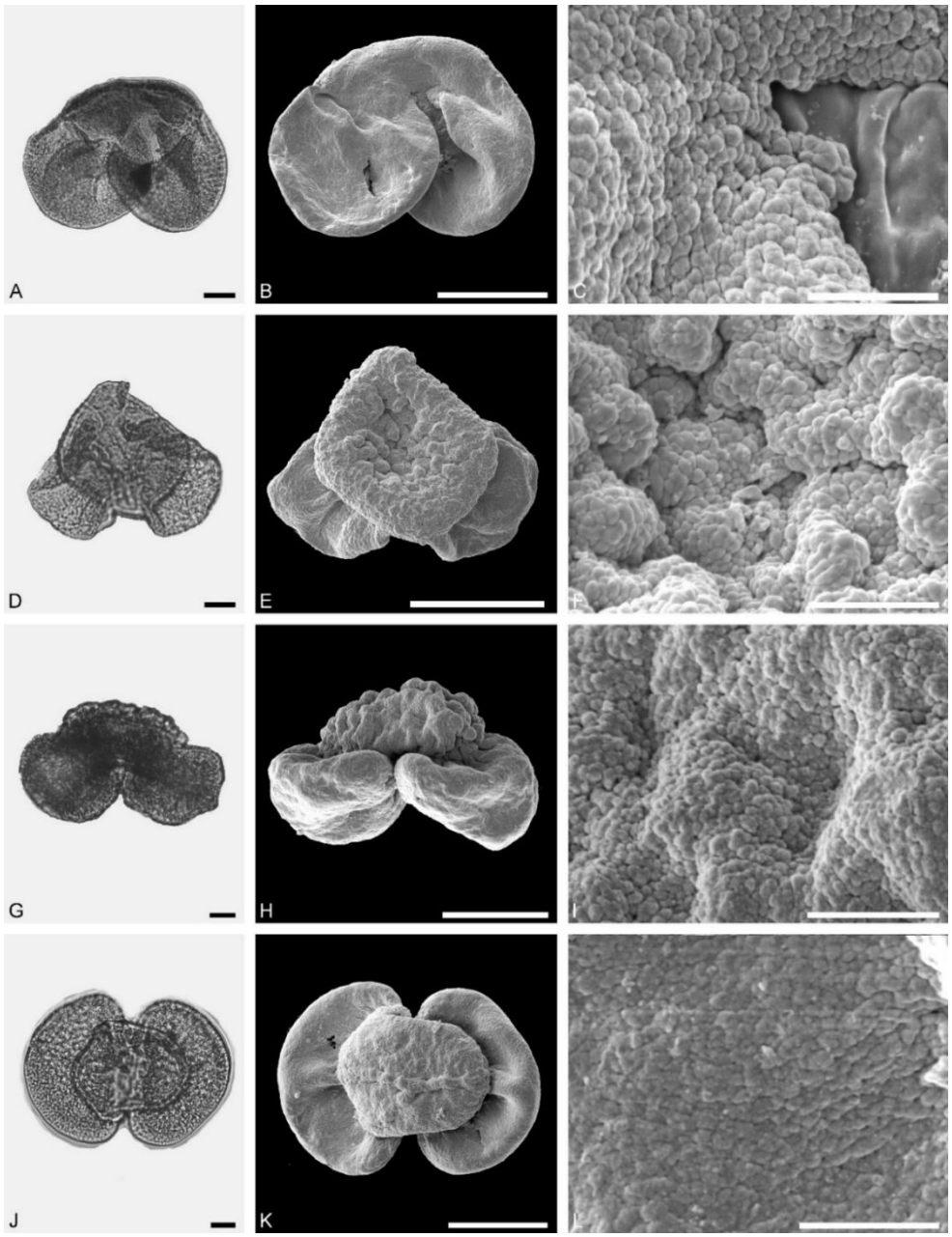

Fig. 4A-4L. 1.*Piceapollenites sp* A-C, A. LM photo, 400x, 10µm, B.SEM photo, 2 313x, 50 µm C.SEM detail photo, 20 000x,5 µm.2.*Pinuspollenites oralicus* D-F, D.LM photo, 400x, 10µm, E.SEM photo, 4 627x, 30 µm F.SEM detail photo, 20 000x, 5 µm.3.*Podocarpites multisinus*, G-I, G. LM photo, 400x, 10µm, H.SEM photo, 3 701x, 30 µm I.SEM detail photo, 20 000x, 5 µm.4.*Podocarpites luteus* J. LM photo, 400x, 10µm, K.SEM photo, 3 566x, 30 µm L.SEM detail photo, 21 213x, 5 µm.

PLATE V

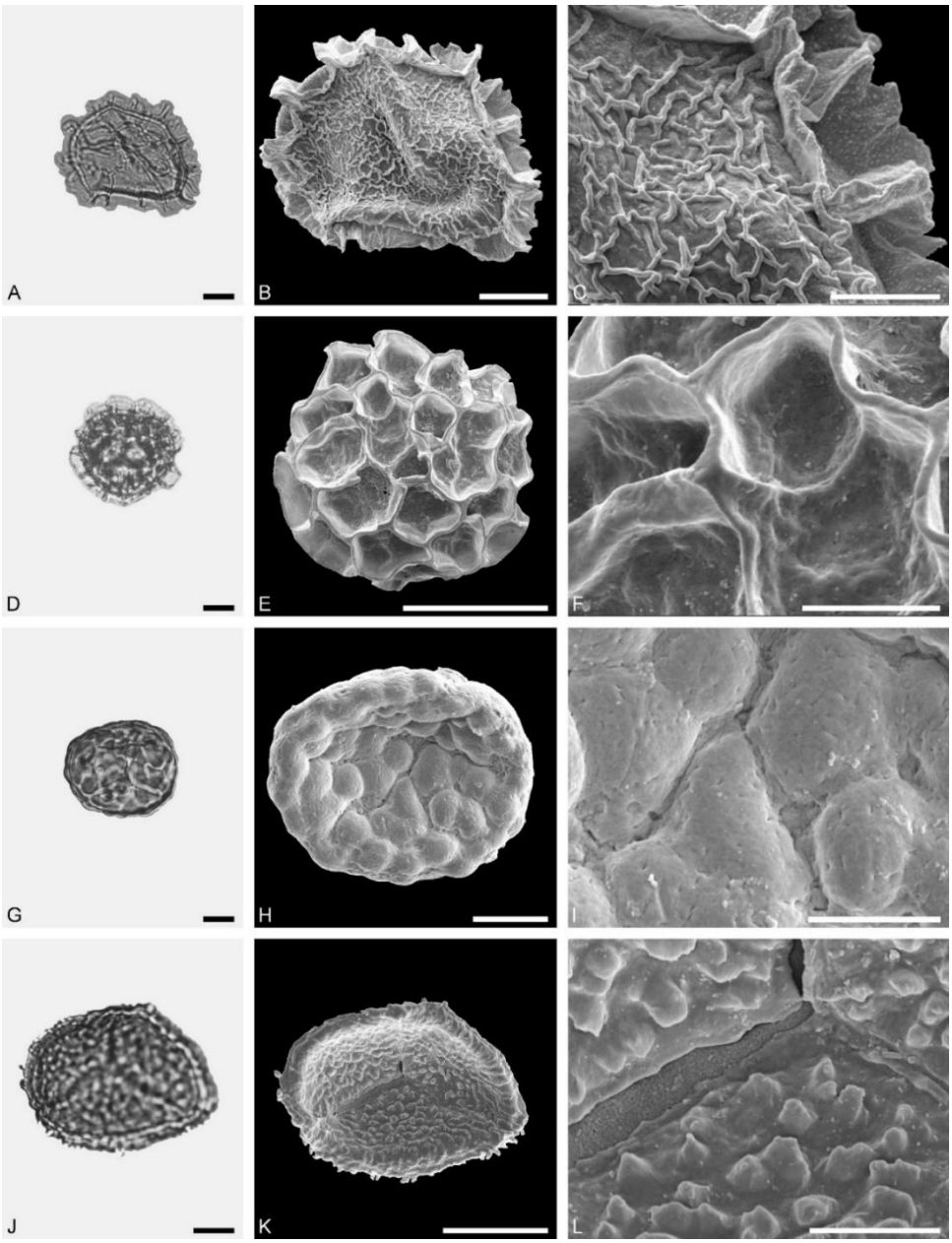

Fig.5A-5L .1.*Lycopodiumsporites sp*., A-C,) A-C, A. LM photo, 400x, 10µm, B.SEM photo, , 10 µm 6 829x C.SEM detail photo, 16 470x, 5 µm. 2.*Lycopodiumsporites marginatus* D-F, D.LM photo, 400x, 10µm, E.SEM photo, 6 683x, 20 µm F.SEM detail photo, 27 043x, 5 µm. 3. *Leptolepidites verrucatus* G-I, G. LM photo, 400x, 10µm, H.SEM photo I.SEM detail photo. 4.*Osmundacidites wellmanii* J-L, J. LM photo, 400x, 10µm, K.SEM photo, 5 746x, 20 µm L.SEM detail photo, 20 000x, 5 µm.

PLATE VI

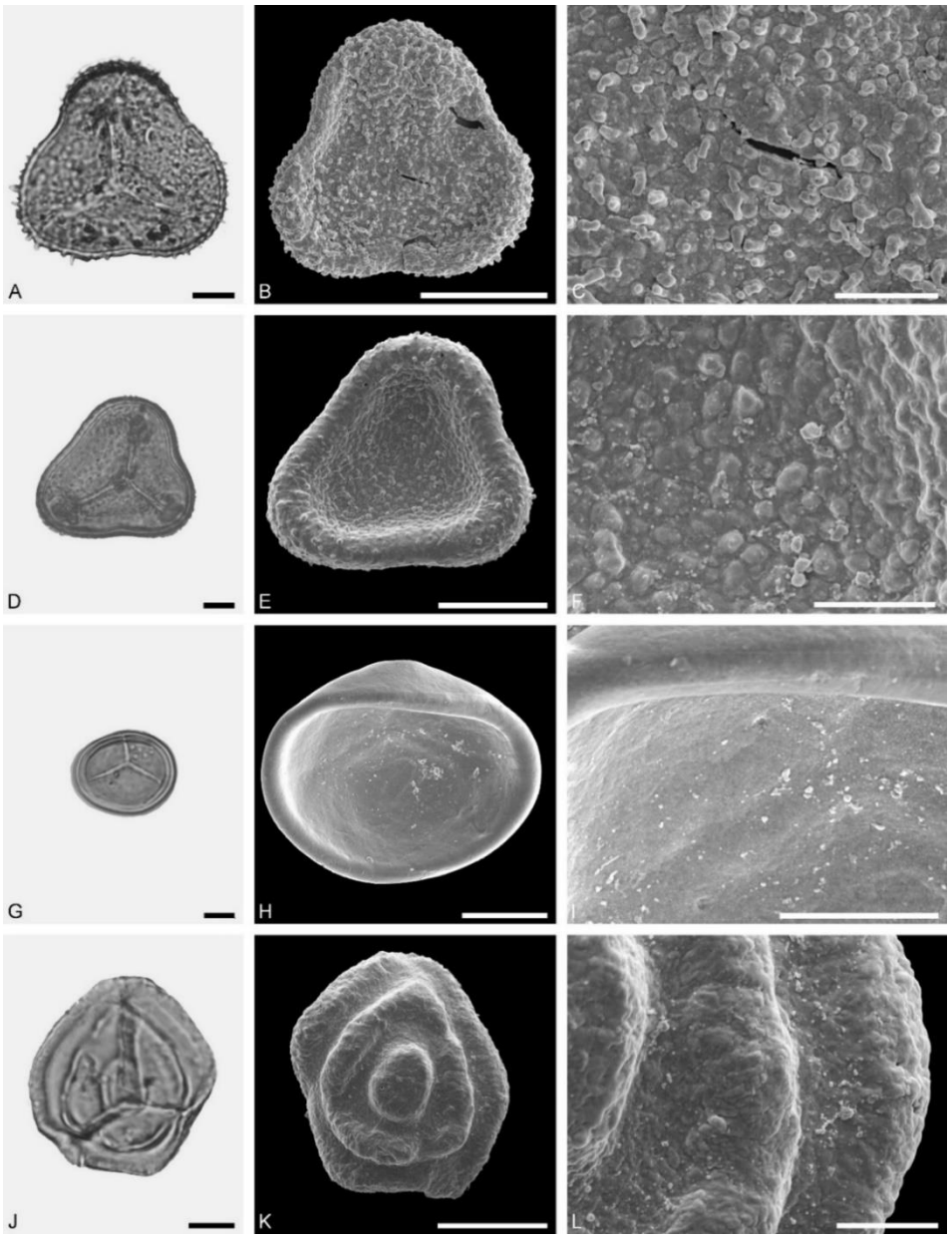

Fig. 6A-6L. 1.*Pilosisporites notensis.,*A-C,) A-C, A. LM, 400, 10µm, B.SEM photo, 6 129x, 20 µm C.SEM detail photo, 18 122x, 5 µm. 2.*Concavisporites punctatus.,* D-F, D.LM photo, 400x, 10µm, E.SEM photo, 6 129x, 20 µm F.SEM detail photo, 18 122x, 5 µm. 3.*Todisporites minor* G-L, G. LM photo, 400x, 10µm, H.SEM photo, 8 724x, 10 µm I.SEM detail photo, 24 241x, 5 µm. 4.*Taurocusporites reduncus* J-L, J. LM photo, 400x, 10µm, K.SEM photo, 453x, 20 µm L.SEM detail photo, 15 952x, 5 µm.

PLATE VII

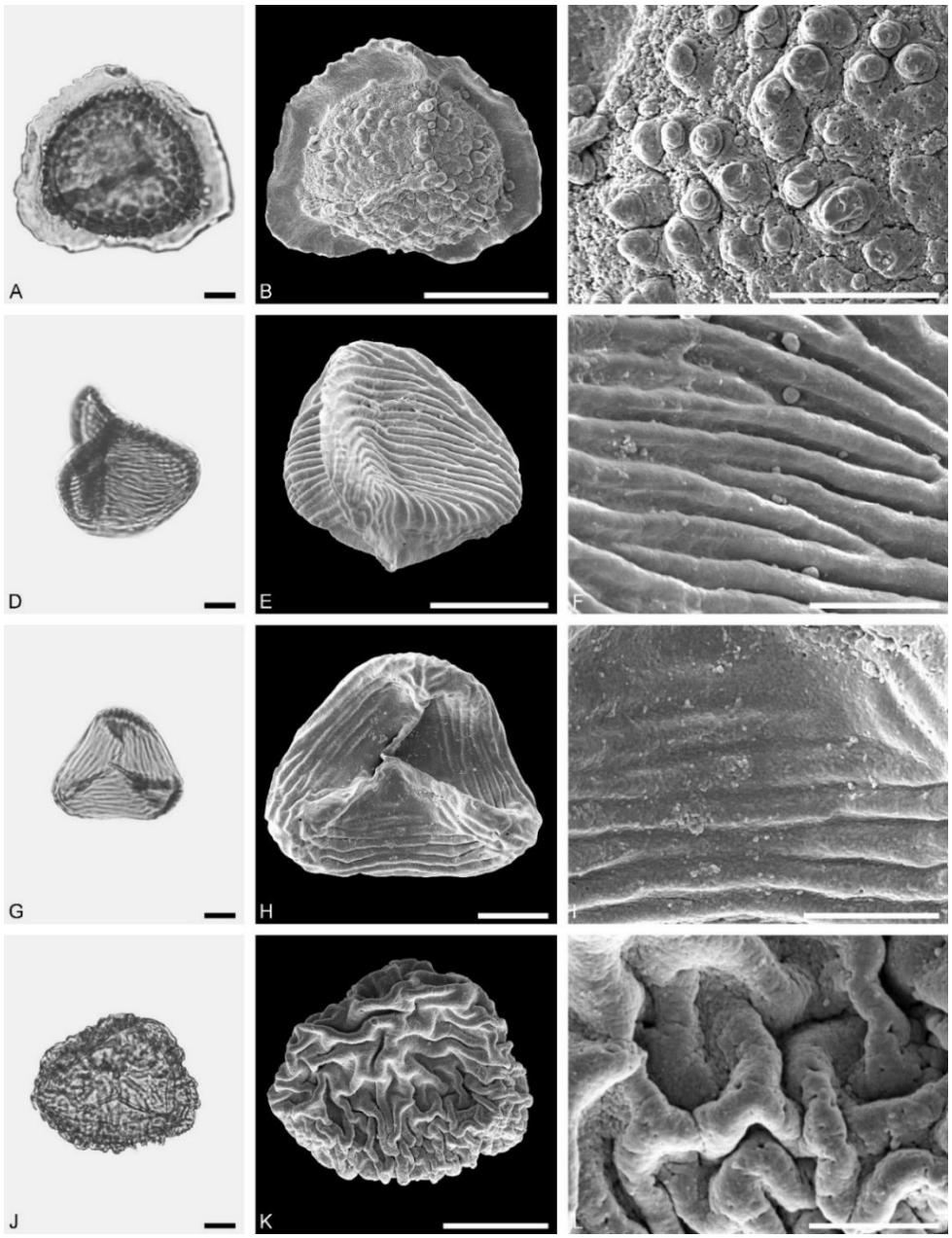

Fig. 7A-7L 1. *Aequitriradites spinulosus* A-C,) A-C, A. LM, 400, 10µm, B.SEM photo, 4 239x, 30 µm C.SEM detail photo 15 753x, 5 µm. 2. *Cicatricosisporites dorogensis* D-C, D.LM photo, 400x, 10µm, E.SEM photo, 5 907x, 20 µm F.SEM detail photo, 20 000x, 5 µm. 3. *Cicatricosisporites australiensis* G-L, G. LM photo, 400x, 10µm, H.SEM photo, 7 451x, 10 µm I.SEM detail photo, 21 117x, 5 µm. 4.*Densoisporites sp,* J-L J. LM photo, 400x, 10µm, K.SEM photo, 5 536x, 20 µm L.SEM detail photo, 20 000x, 5 µm.