# Late Permian and Triassic palynomorphs from the Allan Hills, central Transantarctic Mountains, South Victoria Land, Antarctica

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**Palynology is an established tool for age determination and correlation of sedimentary sequences. The palynomorphs retrieved from the Weller and Lashly formations of Allan Hills, central Transantarctic Mountains, South Victoria Land, Antarctica have been studied for precise age determination. Forty-five different groups of palynomorphs have been recovered from the Weller and Lashly formations. The palynoflora of Weller Formation shows dominance of striate bisaccate pollen taxa, mainly *Striatopodocarpites*, *Faunipollenites* (*Protohaploxypinus*), *Crescentipollenites*, *Striatites* and *Verticipollenites* in association with *Horriditriletes*, *Cuneatisporites*, *Alisporites*, *Plicatipollenites*, *Gnetaecaepollenites*, *Sahnites*, *Tiwariasporis*, *Rhizomaspora*, *Pretricolpipollenites*, *Chordasporites* and sporadic occurrence of *Lundbladispora*, *Klausipollenites* and *Densoisporites*. In the present study, a Late Permian age based on palynological evidences has been suggested for the Weller Formation, which was earlier assigned an Early Permian age. The Late Permian age of the Weller Formation is corroborated by similarity of its palynoassemblage with that of the Upper Stage-5 (Late Permian) of Australia. Additionally, the palynoflora of Weller Formation is comparable with the Late Permian palynoassemblages of India and South Africa. The younger palynoassemblage of the Lashly Formation contains *Klausipollenites*, *Falcisporites* and *Alisporites* in prominence and shows rare occurrence of *Minutosaccus*, *Goubinispora*, *Lundbladispora*, *Densoisporites*, *Aulisporites* and *Chordasporites*, indicating Early to Middle Triassic age and showing affiliation with *Aratrisporites parvispinosus* zone of Australia, *Alisporites* zone (A&B) of Feather Conglomerate and Fremouw Formation of Antarctica.**

**Keywords:** Allan Hills, Antarctica, Late Permian, palynology, Triassic.

PALYNOLOGICAL studies on Antarctic sediments have been extensively utilized in the biostratigraphic delimitation of P/T boundary in the past. The microfossil studies have been carried out from the Early Permian sediments of Milorgfjella, Dronning Maud Land[1], Mackellar Formation (Early Permian) of Beardmore glacier region, central Transantarctic Mountains[2], Weller Coal Measures of Mount Crean and Allan Hills, South Victoria Land[3], Middle Permian rocks of Basen Nunatak in northern Vestfjella mountain range of western Dronning Maud Land, Antarctica[4], Amery Formation (Late Permian) of Prince Charles Mountain[5], Early–Late Permian sediments of Fossilryggen and the NW Nunatak section in the Vestfjella mountain range, Dronning Maud Land[6,7], middle and upper members of Weller Formation, South Victoria Land, Queen Maud Formation in the Nilsen Plateau, upper part of the Mount Glossopteris Formation in the Ohio Range (Permian), uppermost Feather Conglomerate and Lashly Formation (Triassic) of South Victoria Land[8,9], Buckley Formation (Late Permian) of Mount Achernar, Fremouw Formation (Early–Middle Triassic) of Fremouw Peak and Falla Formation (Late Triassic) of Mount Falla region, central Transantarctic Mountains[10,11], Bainmedart Coal Measures (Late Permian) and Flagstone Bench Formation (Triassic) of Amery Group, northern Prince Charles Mountains, East Antarctica[12]. The present study deals with the palynostratigraphy of the sediments collected from the Weller and Lashly formations of Allan Hills, South Victoria Land, Antarctica. The study provides an additional and detailed knowledge of microfossils from the area earlier studied by Kyle[8], and Kyle and Schopf[9] around three decades ago and is applied for precise age determination of the sediments.

## Geological setting

The stratigraphy of Allan Hills (76°43′S; 159°40′E), South Victoria Land, Antarctica has been widely discussed in the literature[8,13–17] and Permian to Jurassic age has been assigned to the rocks of Gondwana system exposed there. The Permian and Triassic sediments of Allan Hills are known as Metschel tillites, Weller Formation, Feather Conglomerate and Lashly Formation (Figure 1). The Lashly Formation is overlain by the Maswon (Early

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Jurassic) and the Ferrar fomations (Late Jurassic). Palynomorphs are recovered from the Weller (Permian) and Lashly (Triassic) formations. The Weller Formation is exposed in a narrow belt that extends along the edge of the Polar Plateau in southern Victoria Land. This Formation was deposited on an alluvial plain by a braided river system with repetitive coal layers[16]. It disconformably overlies the glacial Metschel Tillite in most localities, indicating a rapid change from glacial to post-glacial conditions and consists of conglomerate, arkosic sandstone, shale and coal in fining-upwards cycle. The Formation is about 250 m thick and is easily recognizable from its coal-bearing horizons. It consists of three members: A, B and C. Exposure of Weller Formation at Allan Hills is restricted largely to Member C. This member contains plant mega- and microfossils and consists of 70 m-thick sediments of interstratified sandstone, siltstone, alternating with coal beds up to 4 m thick (Figure 2). There are seven coal seams encountered in the Allan Hills separated by sheet-like clastic units, predominantly sandstone and subordinate siltstone and conglomerates. The Lashly Formation containing *Dicroidium* flora gradationally overlies the Feather Conglomerate. The Formation is composed of four members: A, B, C and D. Base member A is a cyclic sequence of fine-grained sandstone and green siltstone. Member B is predominantly medium-grained sandstone. Member C – interbedded sandstone and carbonaceous siltstone, contains *Dicroidium*-bearing carbonaceous shale[18]. Member D, however, principally consists of medium-grained sandstone. Microfossils of the present study have been recovered from the carbonaceous shale of member C of Weller and Lashly formations (Figure 2).

## Materials and methods

An extensive collection of the *Glossopteris* and *Dicroidium* flora was made by one of the authors (S.C.) during the field season of 1982–83 from the Weller and Lashly formations of the South Victoria Group, Allan Hills, Antarctica, which is presently being studied. Two samples (TTU-ATP-66 and TTU-ATP-289) from member C of both the formations were processed for the recovery of spores and pollen grains. The samples were crushed into small pieces (2–3 mm in size) and treated with hydrofluoric acid (40% concentration) to dissolve the siliceous component, followed by nitric acid to digest the organic matter and finally 5–10% alkali to remove the humus. The samples were thoroughly washed with distilled

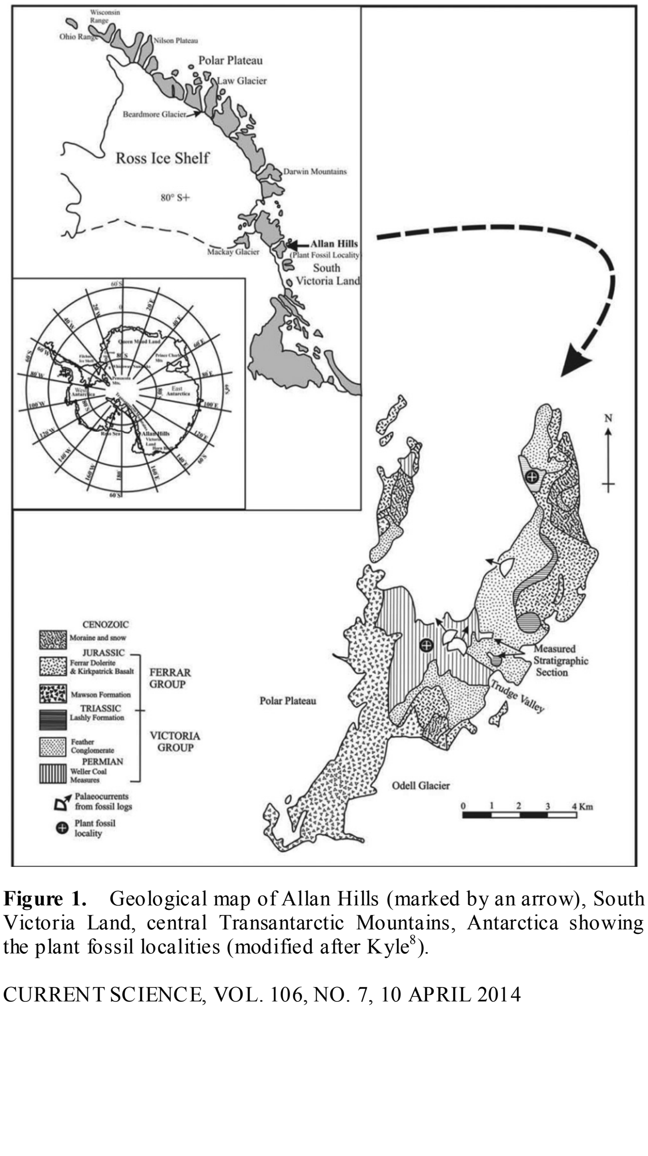


**Figure 1.** Geological map of Allan Hills (marked by an arrow), South Victoria Land, central Transantarctic Mountains, Antarctica showing the plant fossil localities (modified after Kyle[8]).

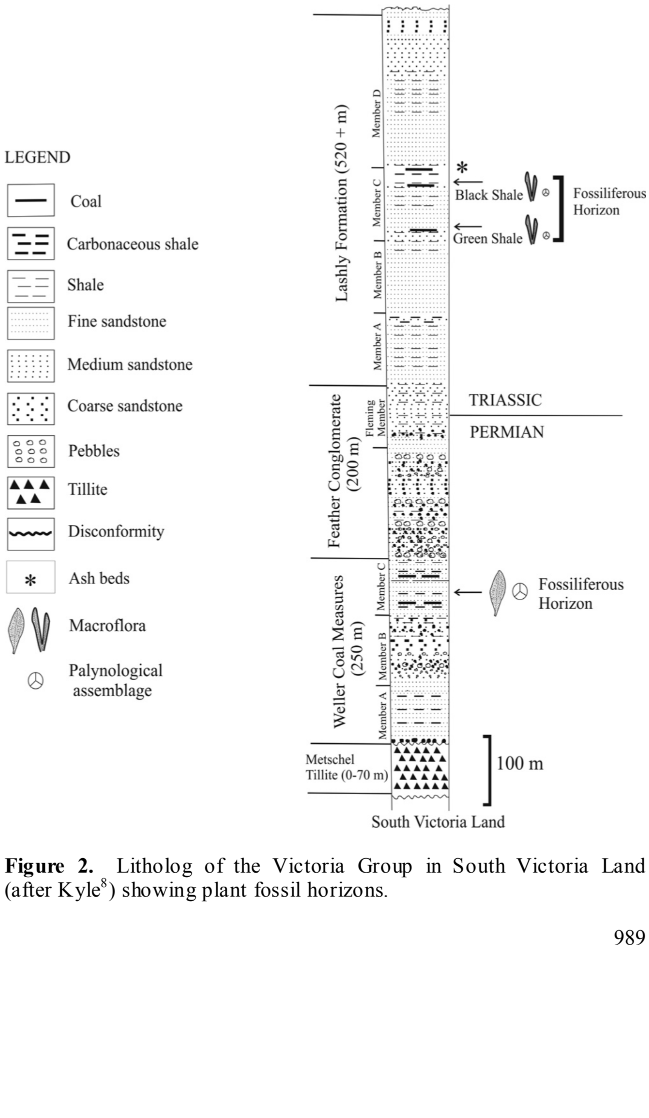


**Figure 2.** Litholog of the Victoria Group in South Victoria Land (after Kyle[8]) showing plant fossil horizons.

water, the residue mixed with polyvinyl alcohol, smeared over cover glass and dried at room temperature. The slides are deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

## Palynological composition and age

The palynomorphs recovered from the Weller and Lashly formations are grouped into two palynozones. Sample no. TTU-ATP-66 of the Weller Formation qualifies for the *Densipollenites magnicorpus* palynozone[19]. Quantitative analysis revealed that this zone includes *Faunipollenites (Protohaploxypinus*) and *Striatipodocarpites* (50–60%), *Cresentipollenites* (3%), *Striatites* (2%), *Verticipollenites* (1%), *Densipollenites* (1%) in association with *Horriditriletes* (1%), *Brevitriletes* (1%), *Cuneatisporites* (2%), *Lunatisporites* (1%), *Microbaculispora* (0.5%), *Alisporites* (1%), *Didecitriletes* (0.5%), *Plicatipollenites* (0.5%), *Parasaccites* (0.5%), *Osmundacidites* (0.5%), *Gnetaecaepollenites* (1%), *Sahnites* (0.5%), *Tiwariasporis* (0.5%), *Rhizomaspora* (1%), *Scheuringipollenites* (1%), *Pretricolpipollenites* (1.5%) and *Chordasporites* (0.5%), with sporadic occurrences of *Goubinispora*, *Lundbladispora*, *Klausipollenites* and *Densoisporites* and suggests a Late Permian (Lopingian) age of the assemblage (Figure 3).

Sample no. TTU-ATP-289 of the Lashly Formation shows dominance of non-striate bisaccate pollen grains, rare striate bisaccates and cavate spores. Quantitative analysis suggests the presence of *Klausipollenites* (40%), *Falcisporites* (20%) and *Alisporites* (10%). The other palynotaxa encountered in the assemblage are *Minutosaccus* (2%), *Goubinispora* (1%), *Lundbladispora* (2%), *Densoisporites* (1%), *Aulisporites* (1%) and *Chordasporites* (1%) along with sporadic occurrence of *Striatopodocarpites* and *Faunipollenites*, indicating an Early to Middle Triassic (Induan to Ladinian) age (Figure 4). Therefore, palynoflora of the Lashly Formation can be equated with *Klausipollenites schaubergerii* Assemblage zones (Assemblage PI) described by Tiwari and Singh[19] and palynozone X of Tiwari and Tripathi[20].

## Correlation with other Gondwana countries

Several workers[5–8,10,21–29] have tentatively attempted to correlate the main palynozones across different Gondwana countries and have adopted different methods to correlate the palynological data. Mac Rae[30] (South Africa) used the methodology of concurrent range zone, and Tiwari and Tripathi[29] (India) used the dominance and sub-dominance of spore-pollen species in an assemblage zone and generic acme zone to correlate Gondwana sediments. The Australian palynozones are marked by the first occurrence of the index taxa. In the present article, the palynozones are based on the dominance of spore-pollen species and the first appearance datum (FAD) and last appearance datum (LAD) of palynotaxa. The palynological zones recovered from the Weller and Lashly formations of Allan Hills, South Victoria Land, Antarctica and their possible correlation with other Gondwana countries, including different regions in Antarctica are discussed below.

### *Australia*

The assemblage (*Densipollenites magnicorpus* palynozone) identified here closely compares with *Microbaculispora* sp. A and *Guttulapollenites hannonicus* palynozones described from the northern Perth Basin, Western Australia[31]. The *Microbaculispora* sp. A lies just above the *Camptotriletes warchianus* and *Guttulapollenites hannonicus* palynozone below the Sabina Sandstone. Due to the common presence of *Densipollenites*, *Horriditriletes* and *Protohaploxypinus* spp., the palynoflora of both these assemblage zones resembles that of the Weller Formation. However, the taxa *Dulhuntyispora* and *Camptotriletes warchianus* are not recorded in the present assemblage. Foster[32–34] identified ‘Stage 5’ for the assemblage zones of Bowen Basin, Queensland, eastern Australia. This is an interval zone characterized by the first appearance of *Dulhuntyispora parvithola* and last appearance of *Triplexisporites playfordii*. The assemblages assigned to Upper Stage 5 are characterized by the dominance of striate bisaccate pollen grains, *Protohaploxypinus* spp. in association with *Didecitriletes* and *Scheuringipollenites*, which are also reported in the assemblage of Weller Formation. The present palynoassemblage thus shows close similarity with the palynoflora of western Australian Upper Stage 5 palynozones[24,35–38]. However, as mentioned above, *D. parvithola* is not recorded in Antarctica.

The palynoflora recovered from the Lashly Formation exhibits dominance of non-striate bisaccate pollen grains, namely *Klausipollenites*, *Falcisporites* and *Alisporites* in association with trilete cavate forms (*Densoisporites*, *Lundbladispora* and *Osmundacidites*). Besides, rare occurrence of striate bisaccate pollens grains *Faunipollenites*, *Striatopodocarpites* and *Lunatisporites* is also observed. Similar palynoflora has been described from the Upper Rewan Formation[39] and overlying Clematis Sandstone[40] from the Bowen Basin, Australia. *Aratrisporites parvispinosus* zone identified in the Lashly Formation is comparable with the *Tigrisporites playfordii* zone of Locker Shale of Carnarvon Basin, Western Australia recorded by Dolby and Balme[41].

### *Africa*

Palynostratigraphic zone identified as the microfloral zone-5 from the Permian and Triassic sediments, Karoo

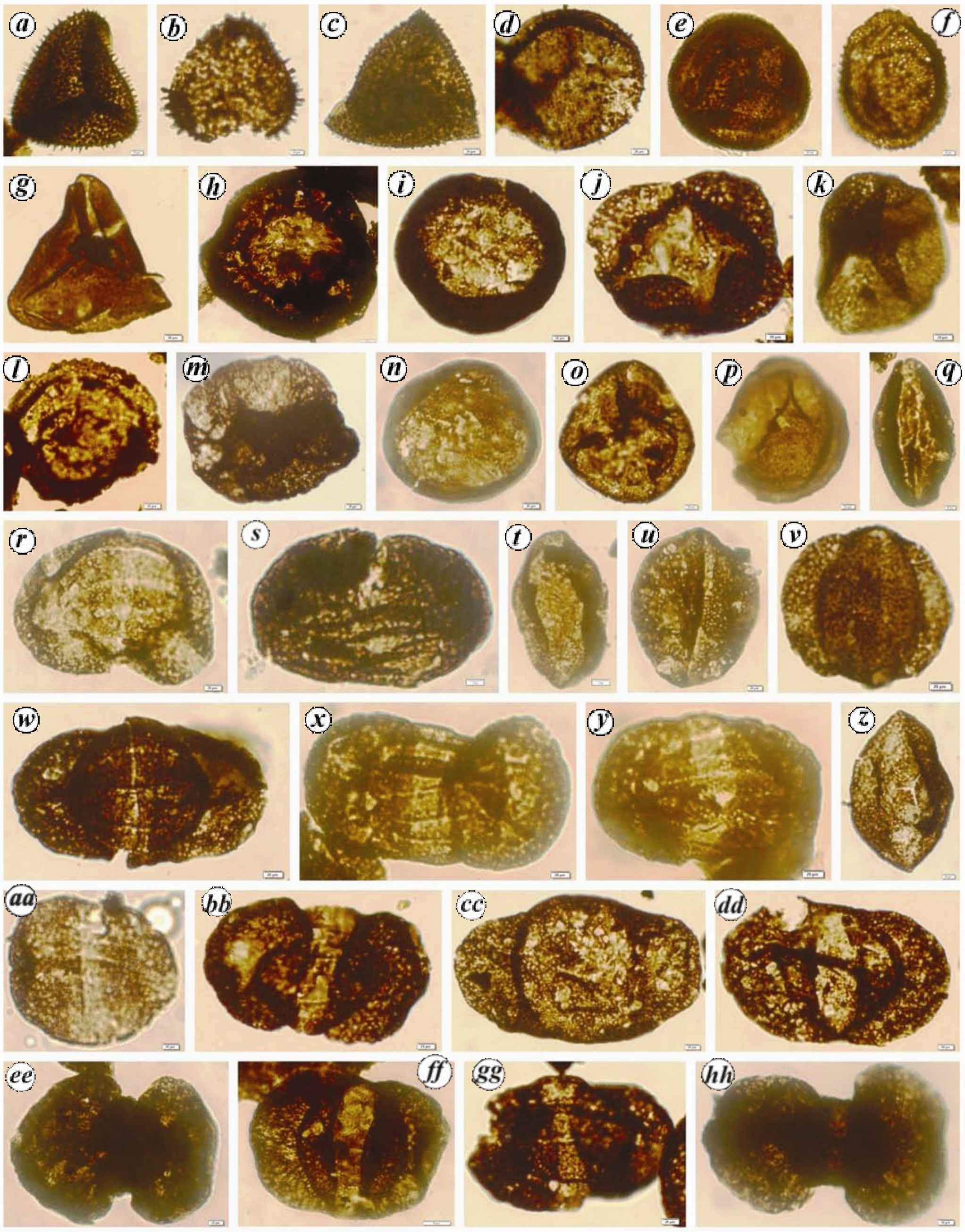


**Figure 3.** ***a***, *Didecitriletes ericianus* BSIP Regd. Sl. no. 14934, coordinates12 × 138. ***b***, *Horriditriletes ramosus* BSIP Regd. Sl. no. 14935, coordinates 08 × 112. ***c***, *Microbaculispora indica* BSIP Regd. Sl. no. 14935, coordinates 15 × 119. ***d***, *Osmundacidites senectus* BSIP Regd. Sl. no. 14934, coordinates 14 × 111. ***e***, *Lundbladispora brevicula* BSIP Regd. Sl. no. 14937, coordinates 15 × 105. ***f***, *Lundbladispora obsoleta* BSIP Regd. Sl. no. 14934, coordinates 20 × 142. ***g***, *Lacinitriletes conatus* BSIP Regd. Sl. no. 14935, coordinates 06 × 120. ***h***, *Plicatipollenites indicus* BSIP Regd. Sl. no. 14935, coordinates 13 × 108. ***i***, *Parasaccites obscurus* BSIP Regd. Sl. no. 14936, coordinates 14 × 110. ***j***, *Goubinispora morondavensis* BSIP Regd. Sl. no. 14936, coordinates 10 × 115. ***k***, *Densipollenites indicus* BSIP Regd. Sl. no. 14934, coordinates 15 × 121. ***l***, *Uvaesporites verrucatus* BSIP Regd. Sl. no. 14938, coordinates 10 × 115. ***m***, *Densipollenites invesus* BSIP Regd. Sl. no. 14938, coordinates 04 × 123. ***n***, *Callamospora* cf. *C. microrugosa* BSIP Regd. Sl. no. 14934, coordinates 12 × 121. ***o***, *Densoisporites complicatus* BSIP Regd. Sl. no. 14934, coordinates 12 × 111. ***p***, *Marcupipollenites triradiatus* BSIP Regd. Sl. no. 14934, coordinates 10 × 115. ***q***, *Praecolpatites sinuosus* BSIP Regd. Sl. no. 14934, coordinates 18 × 114. ***r***, *Faunipollenites perexiguus* BSIP Regd. Sl. no. 14938, coordinates 13 × 110. ***s***, *Faunipollenites varius* BSIP Regd. Sl. no. 14939, coordinates 18 × 110. ***t***, *Cycadopites follicularis* SIP Regd. Sl. no. 14939, coordinates 10 × 123. ***u***, *Scheuringipollenites triassicus* BSIP Regd. Sl. no. 14934, coordinates 07 × 120. ***v***, *Alisporites opii* BSIP Regd. Sl. no. 14934, coordinates 11 × 107. ***w***, *Lunatisporites pellucidus* BSIP Regd. Sl. no. 14936, coordinates 06 × 139. ***x***, *Striatopodocarpites solitus* BSIP Regd. Sl. no. 14937, coordinates 18 × 124. ***y***, *Faunipollenites singraulensis* BSIP Regd. Sl. no. 14934, coordinates 15 × 109. ***z***, *Marsupipollenites triradiatus* Sl. no. 14936, coordinates 17 × 134. ***aa***, *Faunipollenites cogoensis* BSIP Regd. Sl. no. 14938, coordinates 08 × 119. ***bb***, *Striatopodocarpites nidpurensis* BSIP Regd. Sl. no. 14934, coordinates 15 × 134. ***cc***, *Sahnites panchetensis* BSIP Regd. Sl. no. 14935, coordinates 06 × 114. ***dd***, *Chordasporites* sp. BSIP Regd. Sl. no. 14936, coordinates 08 × 130. ***ee***, *Striatites communis* BSIP Regd. Sl. no. 14934, coordinates 08 × 110. ***ff***, *Crescentipollenites fuscus* BSIP Regd. Sl. no. 14934, coordinates 10 × 118. ***gg***, *Taeniaesporites noviaulensis* BSIP Regd. Sl. no. 14938, coordinates 06 × 111. ***hh***, *Verticipollenites gibbosus* BSIP Regd. Sl. no. 14937, coordinates 17 × 108.

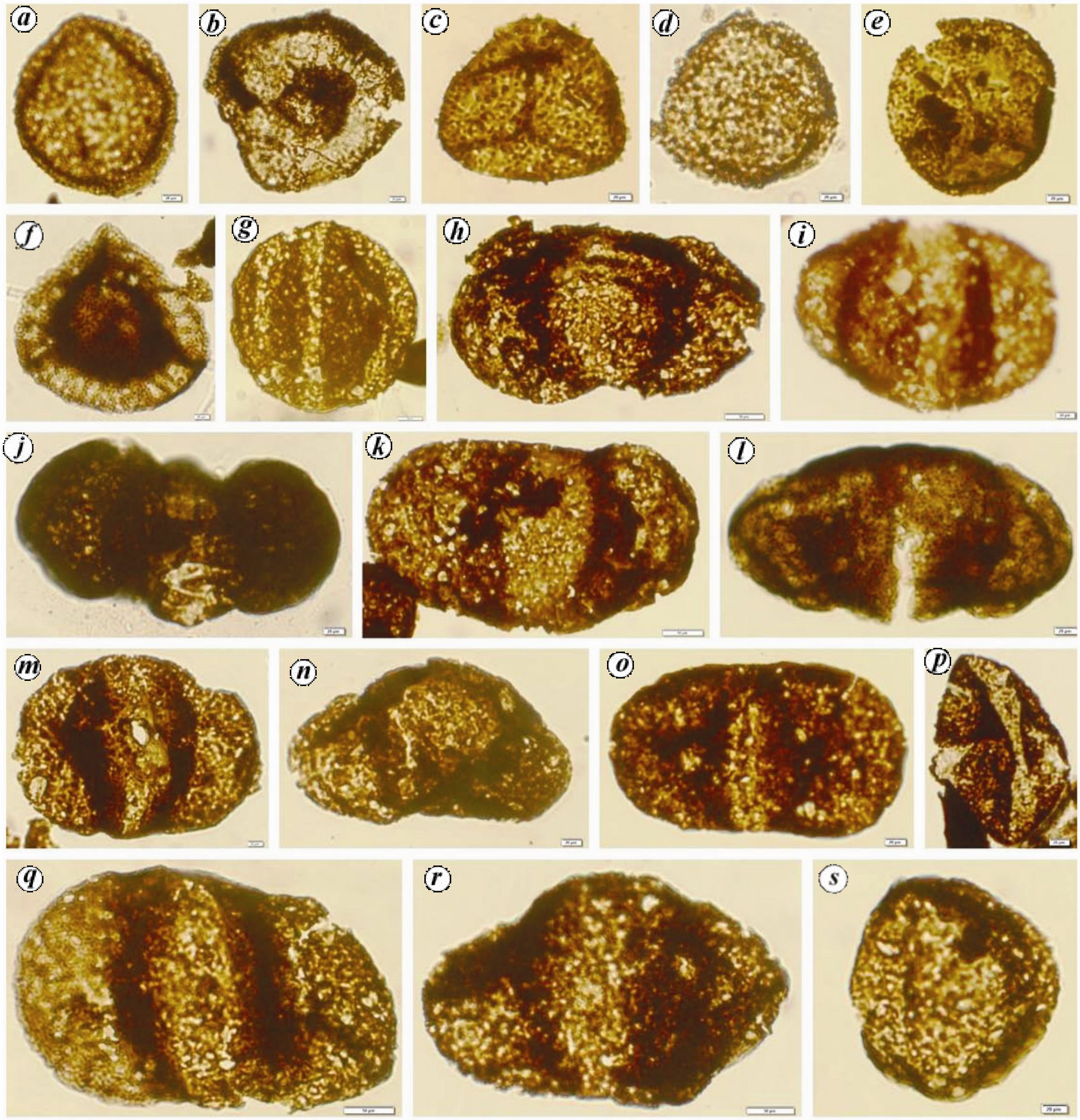


**Figure 4.** ***a***, *Lundbladispora brevicula* BSIP Regd. Sl. no. 14940, coordinates 14 × 129. ***b***, *Playfordiaspora cancellosa* BSIP Regd. Sl. no. 14941, coordinates 09 × 134. ***c***, *Osmundacidites senectes* BSIP Regd. Sl. no. 14940, coordinates 10 × 131. ***d***, *Cyclogranisporites distinctus* BSIP Regd. Sl. no. 14942, coordinates 14 × 142. ***e***, *Convertubisporites variabilis* BSIP Regd. Sl. no. 14942, coordinates. ***f***, *Limatulasporites fossulatus* BSIP Regd. Sl. no. 14943, coordinates 08 × 142. ***g***, *Alisporites opii* BSIP Regd. Sl. no. 14940, coordinates 09 × 136. ***h***, *Striatopodocarpites* sp. BSIP Regd. Sl. no. 14941, coordinates 18 × 114. ***i***, *Alisporites tenuicorpus* BSIP Regd. Sl. No. Sl. no. 14940, coordinates 15 × 107. ***j***, *Verticipollenites secretus* BSIP Regd. Sl. no. 14940, coordinates 15 × 107. ***k***, *Klausipollenites stabilis* BSIP Regd. Sl. no. 14940, coordinates 10 × 128. ***l***, *Klausipollenites minutosaccus* BSIP Regd. Sl. no. 14944, coordinates 11 × 127. ***m***, *Falcisporites nutheliensis* BSIP Regd. Sl. no. 14944, coordinates 05 × 134. ***n***, *Klausipollenites schaubergeri* BSIP Regd. Sl. no. 14944, coordinates 16 × 122. ***o***, *Satsangisaccites nidpurensis* BSIP Regd. Sl. no. 14940, coordinates 21 × 141. ***p***, *Brachysaccua eskensis* BSIP Regd. Sl. no. 14941, coordinates 14 × 128. ***q***, *Falcisporites nutheliensis* BSIP Regd. Sl. no. 14944, coordinates 15 × 134. ***r***, *Minutosaccus acutus* BSIP Regd. Sl. no. 14940, coordinates 20 × 120. ***s***, Cf. *Guttatisporites* sp. BSIP Regd. Sl. no. 14940, coordinates 12 × 129.

Basin, South Africa[42] is comparable with the *Densipollenites magnicorpus* assemblage zone of Allan Hills in the presence of common taxa like *Didecitriletes*, *Osmundacidites*, *Scheuringipollenites*, *Microfoveolatispora*, *Indotriradites*, *Gondisporites*, *Praecolpatites*, *Lophotriletes*, *Protohaploxypinus* spp. and *Lunatisporites* spp.

Falcon[23] divided the Permian sequence of Rhodesia into four palynoassemblage zones. The youngest, i.e. palynozone IV is further divided into two sub-zones, namely G and H. Both the subzones show dominance of bisaccate pollen grains (older subzone G shows 40–60% and younger subzone H exhibits 60–80% bisaccate pollen grains). The palynoassemblages include the common elements *Striatopodocarpites*, *Faunipollenites* and non-striate, bisaccate pollen grains comprising *Sulcatisporites* (*Scheuringipollenites*), *Densipollenites indicus*, *Gullatipollenites hannonicus* and *Lunatisporites*. The sub-zone G is dominated by *Protohaploxypinus* (*Faunipollenites*) and *Striatopodocarpites*, while sub-zone H contains *Lunatisporites*, *Guttulapollenites* and *Lueckisporites*. Besides, other palynoflora recorded in both the assemblages consists of *Microfoveolatispora*, *Indotriradites*, *Gondisporites*, *Densipollenites* and *Weylandites.* Hence, the palynoflora recorded from Allan Hills locality shows a close similarity with Madumabisa Mudstone of Rhodesia, South Africa. The palynoflora described by Utting[43] from the upper part of Madumabisa Mudstone of Rhodesia, South Africa contains *Protohaploxypinus* (*Faunipollenites*), *Striatopodocarpites*, *Scheuringipollenites*, *Horriditriletes*, *Weylandites*, *Guttulapollenites* and *Lueckisporites*. The present study suggests that the Allan Hills palynoflora exhibits a fair resemblance with the Rhodesian palynoflora. The palynoassemblage recorded from the Normandien Formation, KwaZulu-Natal, South Africa by Prevec *et al.*[44] containing high percentage of bisaccate pollen grains (*Protohaploxypinus* and *Striatopodocarpites*) followed by non-striated bisaccate pollen grains *Alisporites*, *Falcisporites* and *Klausipollenites* in association with *Horriditriletes*, *Apiculatisporites*, *Lophotriletes*, *Weylandites*, *Chordasporites* and *Lunatisporites* also shows similarity with the Allan Hills palynoflora.

Additionally, the Late Permian palynoflora (Zone 1st C)[45–47] from the Lower Sakamena Group of Malagasy compares with the Late Permian palynoflora recorded from Allan Hills in view of common occurrence of *Horriditriletes*, *Protohaploxypinus* (*Faunipollenites*), *Striatopodocarpites*, *Weylandites*, *Chordasporites*, *Guttulapollenites*, *Densipollenites* and *Lunatisporites* (*Taeniaesporites*).

## *India*

The palynostratigraphy of Indian Gondwana sequences from Permian to Early Cretaceous was synthesized by Tiwari and Tripathi[29]. On the basis of dominance and FAD and LAD of the selected key-taxa, three assemblage zones were identified in the Late Permian strata, namely *Densipollenites densus* assemblage zone (zone-VII), *Densipollenites raniganjensis* assemblage zone (zone-VIII) and the youngest *Densipollenites magnicorpus* assemblage zone (zone-IX). The *D. magnicorpus* assemblage zone contains dominance of striate bisaccate pollen grains like the *D. raniganjensis* assemblage zone with sporadic appearance of *Lundbladispora brevicula*, *Lunatisporites diffuses* and *Klausipollenites* spp. The palynoflora recorded from the Weller Formation can be correlated with the *D. magnicorpus* zone due to the common occurrence of the palynotaxa *Striatopodocarpites*, *Faunipollenites*, *Chordasporites*, and sporadic occurrence of *Lundbladispora*, *Klausipollenites* and *Densoisporites*. The recovered palnoyflora is also correlated with assemblage R-II, A and B of Tiwari and Singh[19].

The palynoflora described from the Permian sediments of the Amb, Warangal and Chhidru formations, Salt Range (West Pakistan) contains *Faunipollenites* (*Protohaploxypinus*), *Striatopodocarpites*, *Lunatisporites*, *Densipollenites, Scheuringipollenites* and sporadic occurrence of *Alisporites*, *Klausipollenites*, *Falcisporites*, *Plicatipollenites* and *Lunatisporites.* The palynoflora recorded from the Allan Hills shows a fair resemblance with assemblage of the Upper Chhidru Formation. However, *Indospora clara*, *Pinuspollenites thoracatus*, *Iraqispora* and *Cedripitus* are absent in the assemblage of Upper Chhidru Formation. The Lower and Middle Triassic palynofloras described from the Mianwali (Kathwai, Mittiwali, Narmia members) and Tredian (Landa and Khatkiara members) formations of Nammal Gorge contain *Alisporites*, *Klausipollenites*, *Falcisporites*, *Densoisporites*, *Lundbladispora* and *Alisporites* are closely comparable with the palynoflora recovered from the Lashly Formation of Allan Hills.

## *Antarctica*

Lindström[6,7], Kyle[8], and Kyle and Schopf[9] have recognized an informal palynostratigraphic zonation of Permian sediments of the South Victoria Land, Transantarctic Mountains and Dronning Maud Land, Antarctica. The palynozone (*D. magnicorpus*) recovered from the Weller Formation (Member C) contains dominance of bisaccate gymnospermous pollen grains, mainly *Protohaploxypinus* spp. and *Striatopodocarpites* spp. and is fairly well comparable with the *Protohaploxypinus* zone defined by Kyle[8] due to the common occurrence of the taxa – *Horriditriletes*, *Brevitriletes*, *Microbaculispora*, *Pretricolpipollenites*, *Scheuringipollenites* and *Alisporites*. However, many of the taxa, namely *Lunatisporites*, *Densipollenites*, *Osmundacidites*, *Gnetaecaepollenites*, *Goubinispora*, *Lundbladispora* and *Klausipollenites* found in the present study are not recorded by Kyle[8], and Kyle and Schopf[9]. Therefore, the present study infers a younger age for member C of Weller Formation than that suggested by Kyle[8]. The assemblage described by Kyle and Schopf[9] from the Upper Mount Glossopteris Formation in the Ohio Range and from the Queen Maud Formation of the Nilsen Plateau containing high percentage of bisaccate pollen grains, mainly *Protohaploxypinus* spp. shows similarity with the present assemblage, except for the absence of *Bascanisporites undosus*. The palynoassemblage described by Lindström[6,7] from the Dronning Maud Land contain *Protohaploxypinus* (*Faunipollenites*) and the palynoassemblages from Fossilryggen and NW Nunatak comprising *Lunatisporites*, *Alisporites*, *Scheuringipollenites*, *Densipollenites* and *Striatopodocarpites* are tentatively correlated with each other and also show resemblance with the present assemblage. However, *Indospora lavigata* and *Bascanisporites undosus* are not recorded in the Allan Hills palynoassemblage. Late Permian palynoflora recorded[5,26,48,49] from the Amery Group (the Radok Conglomerate, the Bainmedart Coal Measures and the Flagstone Bench Formation) in the Prince Charles Mountains contains *Striatopodocarpites*, *Faunipollenites* (*Protohaploxypynus*), *Cresentipollenites*, *Horriditriletes*, *Microbaculispora*, *Marsupipollenites*, *Cuneatisporites*, *Alisporites*, *Plicatipollenites*, *Pretricolpipollenites* *Bascanisporites*, *Indospora* and *Calamospora*. Except for the absence of the taxa *Bascanisporites*, *Indospora* and *Guttulapollenites*, these assemblages closely compare with the assemblage of Allan Hills. Farabee *et al.*[11] described a Late Permian palynoflora from the Buckley Formation of Mount Archernar in the central Transantarctic Mountains containing *Calamospora* sp., *Camptotriletes*, *Leiotriletes*, *Striatopodocarpites*, *Faunipollenites* (*Protohaploxypinus* spp.), *Marsupipollenites*, *Didecitriletes* and *Praecolpatites*. The genus *Camptotriletes* is absent in the present assemblage. However, the presence of some rare Triassic palynotaxa such as *Goubinispora*, *Lundbladispora* and *Klausipollenites* in the Allan Hills assemblage indicates younger age than the Buckley Formation.

Playford[26] proposed a third informal *Praecolpatites* palynozone which contains high percentage of striate bisaccates, namely *Faunipollenites* (*Protohaploxypinus*), *Striatopodocarpites* and *Guttulapollenites* in association with *Densipollenites*, *Barakarites*, *Horriditriletes* and *Scheuringipollenites*. Accordingly, the *Praecolpatites* zone is considered younger than the *Protohaploxypinus* zone described by Kyle[8] and older than the Triassic *Alisporites* zone described by various researchers[5–7,9,48–50].

Kyle[8] studied the *Dicoridium*-bearing Lashly Formation and underlying uppermost Feather Conglomerate bed for recovery of spore and pollen grains and informally identified four sub-palynozones (A–D) within the *Alisporites* zone on the basis of the dominance of non-striated bisaccate pollen grains. This *Alisporites* zone spans from Early to Late Triassic. The *Aratrisporites parvispinosus* palynozone is identified in sample no. TTU-ATP-289 (Lashly Formation) and shows dominance of *Klausipollenites*, *Falcisporites*, *Alisporites* and *Minutosaccus* in association with *Lundbladispora*, *Densoisporites*, *Goubinispora*, *Chordasporites* and sporadic occurrence of *Lunatisporites*, *Striatopodocarpites* and *Aulisporites*. The assemblage recovered from the Lashly Formation is closely comparable with the palynoflora (sub-zones A and B of the *Alisporites* zone) recorded from the basal part of the Falla and upper third part of the Fremouw formations (Middle and Upper members) of Beardmore Glacier[8,9,51].

## Discussion and conclusion

The plant microfossils recovered from the Weller and Lashly formations reflect a succession of two distinct palynofloral assemblages. The older palynoassemblage zone (*D. magnicorpus*) identified from the Weller Formation is dominated by the striate bisaccate pollen grains *Faunipollenites* (*Protohaploxypinus*), *Striatopodocarpites*, *Lunatisporites*, *Densipollenites* and rare non-striate bisaccate pollen taxa *Scheuringipollenites maximus* and *Alisoprites* spp. Simple trilete spores *Brevitriletes*, *Horriditreiletes*, *Leiotriletes* and cavate/cingulate spores like *Lundbladispora*, *Densoisporites*, and *Goubinispora* along with *Chordasporites* and *Pretricolpipollenites* have also been recorded in the assemblage. Within Antarctica, the Late Permian plant microfossils are well documented from the Radok Conglomerate and Bainmedart Coal Measures, Amery Group of the Prince Charles Mountains, Fossilryggen and NW Nunatak areas, Dronning Maud Land[5,7,48]. Previous researches[8,9] suggested that *Glossopteris*-bearing Weller Formation is equivalent to Stage-4 or *Microbaculispora* sp. Zone A of Australia[31,32]. The palynoassemblage of the Weller Formation records FAD of *Lundbladispora*, *Densoisporites*, *Goubinispora* and *Chordasporites* in association with *Alisporites*, *Klausipollenites* and *Falcisporites*, indicating an younger age than the Australian Stage-4, i.e. a Late Permian age. The Weller Formation was earlier described as Early Permian by Kyle[8]. The presently described palynoflora shows a better correlation with the assemblage zone (IX) of Tiwari and Tripathi[20] from India, Stage-5 of Australia[32] and zones 6 and 7 of South Africa[42], which are Late Permian in age.

The younger assemblage of *Dicroidium*-bearing Lashly Formation shows dominance of non-striate bisaccate pollen grains (*Alisporites*, *Klausipollenites* and *Falcisporites*) in association with *Minutosaccus*, *Goubinispora*, *Lundbladispora*, *Densoisporites*, *Aulisporites* and *Chordasporites* and rare striate bisaccate pollen taxa *Striatopodocarpites* and *Faunipollenites*. The presently identified *A. parvispinosus* zone is well compared with *Playfordiaspora cancellosa* palynozone (assemblage zone XI) of Tiwari and Tripathi[20] from India, *Alisporites* zone (A and B) of Allan Hills[8] and palynoassemblage of the upper member of the Fremouw Formation (Early–Middle Triassic)[8]. The palynoflora described from the Falla Formation, central Transantractic Mountains by Farabee *et al.*[10], shows an younger age than Lashly Formation of Allan Hills. The palynoassemblage of the Lashly Formation suggests an Early to Middle Triassic age of the sediments. However, Kyle[8] suggested a Late Triassic age for the Member C of Lashly Formation due to the presence of *Craterisporites rotundus*, which is absent in the present assemblage. According to recent megafossil evidences[18], the age of the Member C of the Lashly Formation extends up to the Late Triassic.

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# Erratum

## Large, secondarily collected data in biological and environmental sciences

**T. N. C. Vidya**

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Page 802, col. 3, para 3:

The following sentence was missing in the printed version. It should be inserted after: …. periods of time. I use 'secondarily collected data' to include both 'secondary data' as referred to traditionally, as well as 'primary data' that are collected secondarily by large numbers of, usually untrained, people, as opposed to solely researchers collecting data. Even graduate students….

Page 803, col. 1, 8th lines onwards till end of para on col. 2 (insertions in quotation mark):

While we may not be unique in this, one important reason why I think we should be wary of large-scale secondarily collected data is that we as a culture do not 'seem to' like to admit that we do not know something, however trivial. We are also not a people who can easily refuse something that is asked of us. Therefore, asking someone 'who is inexperienced' to fill out a datasheet without strict supervision is likely to lead to all columns being filled out, even if with 'meaningless values', rather than an honest account of missing or questionable data. The big picture 'in these cases' is rarely explained to those actually collecting data, and the end-users of the data often have little connect with field conditions.

Page 803, col. 2, lines 12 and 13:

Read as 'large, secondary datasets' instead of 'large secondary datasets'

Page 803, col. 2, line 15

Read as 'secondarily collected data' instead of 'secondary data'

Page 803, col. 3

Reference numbers should begin from '1' instead of '9.

Ref 3: Read as 'Pan Macmillan, London' instead of 'Basic Books'.

We regret the errors.