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南极维多利亚地南部Carapace Nunatak中侏罗世孢粉植物群

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摘 要 南极维多利亚地的费拉群孢粉植物群时代一直被认为是早侏罗世,从维多利亚地南部Carapace Nunatak费拉群火山岩夹层中发现的数量丰富、类型多样的孢粉化石(计35属54种),可与澳大利亚西部、阿根廷、印度及巴基斯坦孢粉植物群比较,推断费拉群时代应为中侏罗世,并很可能为中侏罗世早期。这一结论得到从相同地点获得的叶肢介化石的佐证。根据孢子花粉化石的可能植物亲缘关系,推断中侏罗世早期维多利亚地南部以掌鳞杉科植物较繁盛,并伴有桫椤科、里白科、紫萁科、网叶蕨科、马通蕨科、海金沙科、石松科、南美杉科、松科等植物,属温带-亚热带气候。

关键词 中侏罗世 孢子花粉 维多利亚地 南极

1 序言

南极维多利亚地的费拉群(Ferrar Group)主要为火山沉积岩系。1965年,Norris研究了列尼克冰川地区(Rennick Glacier region) Section Peak的费拉群孢粉,将其时代归为早侏罗世。1978年,Tasch和Lammons对横跨南极山脉(Transantarctic Mountains Antarctic)的某些河湖相夹层中的孢粉化石进行了研究,并单独出示了Carapace Nunatak 10种孢子花粉照片,认为其时代仍为早侏罗世。Carapace Nunatak位于维多利亚地南部,费拉群中的河湖相夹层发育,盛产动植物化石,近来从这一地区含有叶肢介化石的这套岩层里已分析出属种繁多、保存甚佳的孢粉化石,从而为深入研究费拉群孢粉植物群的性质、特点及时代归属打下了基础,本文即是这一孢粉研究的成果。笔者研究的孢粉样品由沈炎彬提供,钱泽书分析处理样品,标本摄影与图件清绘得到宋之耀、任玉皋的帮助,于此向他们一并致谢。

2 地层简述

Carapace Nunatak的中生代火山沉积岩系统称费拉群(Ballance and Waters,1971),其由两部分组成:下部称喀尔巴司砂岩(Carapace Sandstone),为一套大约120m厚的河流冲积的火山质砂岩,上部称柯克巴特里克玄武岩组(Kirkpatrik Basalt Formation),为一套厚300m以上的火山角砾岩,两组之间为整合关系。含孢粉化石的样品F1和F3采自Carapace Nunatak南端(插图1),F2采自北端。3块样品均从柯克巴特里克玄武岩组下部的河湖相夹层获得(亦皆为叶肢介化石点),其中F1采自喀尔巴司砂岩顶部以上8cm处透镜体,岩性为粉砂质泥岩,F3在F1之上6.3cm处,岩性为粉砂岩,F2采自柯克巴特里克玄武岩组底部

的玄武岩之上 2cm 厚的河湖相夹层，岩性为粉砂质泥岩。

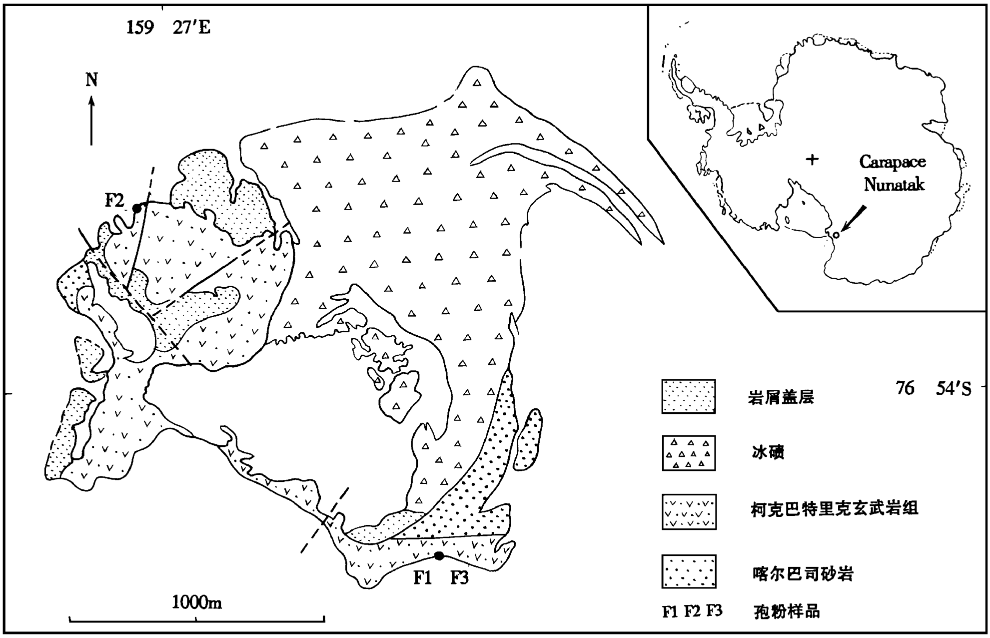

插图 1　Carapace Nunatak 含孢粉样品位置图(据沈炎彬，1994)

Geological map of Carapace Nunatak showing the sporepollen-bearing localities (after Shen Yanbin，1994)

3　孢粉组合特征及时代讨论

Carapace Nunatak 费拉群孢粉组合以裸子植物花粉明显多于蕨类植物孢子为特征(表 I)，前者在组合中约占 73.32%，后者约占 26.51%。裸子植物花粉以 *Classopollis* 属占绝对优势，在组合中约占 49.51%，其它主要分子有 *Ginkgocycadophytus nitidus*，*Cerebropollenites carlylensis*，*Callialasporites dampieri*， *C. segmentatus*，*C. turbatus*，*Perinopollenites elatoides*，*Araucariacites australis*，*Chasmatosporites apertus*，*Pteruchipollenites thomasii*，*Pinuspollenites enodatus*，*Pseudopicea variabiliformis* 等；蕨类植物孢子以 *Todisporites* 较多，在组合中约占 5.13%；*Cyathidited* 次之，约占 4.76%，其它主要分子有 *Calamospora tener*，*Dictyophyllidites mortoni*，*D. harrisii*，*Concavisporites toralis*，*Gleicheniidites senonicus*，*Converrucosisporites cameroni*，*Klukisporites variegatus*，*Lycopodiumsporites austroclavatidites*，*Contignisporites cooksoni*，*Polycingulatisporites* sp. 等。

Classopollis 属花粉对确定地质时代有较重要意义，该属花粉自晚三叠世即有出现，但在早、中侏罗世各地含量不尽相同，尤其在北半球变化较大。如在英国(Couper，1958)，早、中侏罗世地层中 *Classopollis* 含量均较多，尤以中侏罗统更多，可达 60%以上；在哈萨克斯坦(Ponomarenko *et al.*，1973) Hettangian 期地层中 *Classopollis* 含量高达 50%；在法国北部(Muir and van Konijnenburg-van Cittert，1970)、德国(Mädler，1964b；Reinhardt，1962，1964；

Schulz,1962,1967)、匈牙利(Kedves and Simoncsics,1964)、波兰(Rogalska,1954;Orlowska-Zwolinska,1966,1967)的下侏罗统都含有较多的 *Classopollis* 属花粉。在中国南部(张振来,1978;尚玉珂,1981;钱丽君等,1983;白云洪等,1983;尚玉珂、黎文本,1992),早侏罗世即为 *Classopollis* 含量的高峰期,一直延续到早白垩世;而在中国北部,*Classopollis* 属花粉在早侏罗世很少,至中侏罗世约为2%—15%,晚侏罗世含量才突然增至统治地位(张璐瑾,1965;徐钰林、张望平,1980;刘兆生等,1982;尚玉珂,1995)。在南半球早侏罗世即多为 *Classopollis* 含量高峰期,如在印度西部拉贾斯坦(Rajasthan)的下、中侏罗统拉锡组(Lathi Formation)孢粉组合(Srivastava,1966),*Classopollis* 含量占80%;在巴基斯坦中侏罗统(Sah,1955)发现的大量表皮里,最多的是推测产生 *Classopollis* 花粉的母体植物 *Brachyphyllum* 和 *Pagiophyllum* 的分子;在澳大利亚西部的珀斯盆地(Perth Basin)(Filatoff,1975)和澳大利亚西部边缘地区(Balme,1957),*Classopollis* 属花粉含量均达最高值;在澳大利亚东部的罗斯沃德煤田(Rosewood Coalfield)(de Jersey,1963),该属花粉含量从底部往上减少,下部为7.5%,上部为1.2%;在澳大利亚偏南部的利克里克煤层(Leigh Crek Coal Measures)(Playford and Dettmann,1965),*Classopollis* 属花粉含量在早侏罗世可达74.5%;在阿根廷的内乌肯省(Neuquen Province)的中侏罗统(Horacio H. Camacho,1968;Menendez,C. A.,1968),*Classopollis* 与 *Gliscopollis* 花粉是组合中的最主要成分。

从上述分析可以看出,在绝大多数地区 *Classopollis* 属花粉的较高含量可以作为判断早、中侏罗世孢粉组合的显著特征,但在确定早或中侏罗世方面,还要结合其它因素综合考虑,所得时代结论才准确可靠。本组合中,*Classopollis* 属花粉含量占49.50%,与此类花粉在南半球早、中侏罗世孢粉组合中的情形相近。

费拉群孢粉组合中的 *Calamospora tener* 最早发现于瑞士 Keuper 阶,以后在英国下、中侏罗统(Couper,1958)和澳大利亚三叠系(de Jersey,1962)均有见及,该种孢子在中侏罗统以上地层尚未见及。*Converrucosisporites cameroni* 最早发现于澳大利亚伊普斯威奇(Ipswich)中—晚三叠世地层中(de Jersey,1962),后来主要见于南半球三叠系—中侏罗统,如澳大利亚利克里克煤层的 Rhaetian—Lias 阶和南极维多利亚地的 Rhaetian 期地层。*Klukisporites variegatus* 最早发现于英国中侏罗统(Couper,1958),以后广泛见于南北半球 Lias 期至中侏罗世地层。*Callialasporites*,*Perinopollenites*,*Cerebropollenites* 均见于侏罗系以上地层,迄今未见于侏罗系以下地层,其中 *Callialasporites turbatus* 在西部澳大利亚(Balme,1957;Filatoff,1975)见于下、中侏罗统,*C. dampieri* 主要见于中侏罗统;这两种花粉的分布在欧洲也有完全相似的情形,后一种花粉还被视为中侏罗世的特征种(Guy,1971,1978,1982,1985)。尽管 *Contignisporites* 属孢子分布于晚三叠世—早白垩世,重要的是 *C. cooksonii* 始见于中侏罗世,在西部澳大利亚即见于中侏罗世(Filatoff,1975)。组合中还见有少数 *Gleicheniidites senonicus*,该种孢子主要见于中侏罗统以上地层,在英国(Couper,1958)始见于中侏罗统 Bajocian 期 Sycarham 层,在西部澳大利亚始见于中侏罗世 Aalenian—Bajocian 期 *Exesipollenites tumulus* 组合带的 *Dictyophyllidites harristi* 亚组合带(Filatoff,1975)。

值得注意的是本组合中未见任何晚三叠世的孑遗分子,而这是早侏罗世孢粉组合经常出现的特征,如在加拿大西部近海地带(Bujak and Williams,1977)的下侏罗统 Hettangian—

表 I 南极 Carapace Nunatak 费拉群孢粉属种百分含量

Percentages of miospore taxa in the Ferrar Group of Carapace Nunatak, Antarctica

孢粉属种	样品号		
	F1	F2	F3
Pteridophyta			
Sphenopsida			
Calamospora tener (Leschik) de Jersey, 1962	1.09	0.99	
Filicinae			
Lycopodiaceae			
Lycopodiumsporites austroclavatidites (Cookson) Potonie, 1956	1.45	0.99	
Foveosporites sp.	0.36	0.99	
Osmundaceae			
Todisporites minor Couper, 1958	3.62	2.96	1.26
T. major Couper, 1958	2.90	2.96	1.72
Cyatheaeae or Dicksoniaceae			
Cyathidites minor Couper, 1958	1.45	5.42	3.00
C. australis Couper, 1958	0.72	1.97	1.72
Dipteridaceae of Matoniaceae			
Dictyophyllidites mortoni (de Jersey) Playford et Dettmann, 1965		1.48	1.26
D. harrisii Couper, 1958	1.09	0.99	0.43
D. sp.	0.72	1.97	
Concavisporites toralis (Leschik) Nilsson, 1958	1.45	1.97	
Gleicheniaceae			
Gleicheniidites senonicus Ross, 1949	0.72	0.99	
Lygodiaceae			
Klukisporites variegatus couper, 1958	0.72	2.46	1.72
Pteridophyta Incertae Sedis			
Deltoidospora directa (Balme et Hennely) Norris, 1965	0.72	2.46	
D. sp		3.45	
Toroisporis sp.	0.72		
Undulatisporites sp.	0.72	0.99	
Granulatisporites minor de Jersey, 1959	1.09		
G. sp.			1.26
Cyclogranisporites sp			2.54
Converrucosisporites comerini (de Jersey) Playford et Dettmann, 1965	1.45	1.97	
C. venitus Batten, 1973		0.99	
C. spp.	1.45	1.48	
Verrucosisporites sp.	0.36	0.99	
Contignisporites cooksonii (Balme) Dettmann, 1963	1.45		0.43
Duplexisporites problematicus (Couper) Playford et Dettmann, 1965			2.15
Polycingulatisporites sp.			0.43
Gymnospermae			
Cycadaceae or Ginkoaceae			
Cycadopites spp.	1.45	1.48	
Ginkgocycadophytus nitidus (Balme) de Jersey, 1962	1.45		2.58
G. subgranulosus (Couper) Norris, 1965		1.48	
Cheirolepidiaceae			
Classopollis classoides Pflug, 1953	42.75	22.66	36.91

续表 1

孢 粉 属 种	样 品 号		
	F1	F2	F3
C. parvus (Brenner) Xu et Zhang, 1980	5.07	2.46	10.30
C. annulatus (Verbitzkaja) Li, 1974	13.41	2.96	12.02
Araucariaceae			
Araucariacites australis Cookson, 1947	1.81	3.94	5.15
A. sp.		1.97	
Taxodiaceae			
Perinopollenites elatoides Couper, 1958	0.92	1.48	2.15
Pinaceae			
Pinuspollenites enodatus (Bolkhovitina) Li, 1984	0.72	1.48	2.15
P. sp.			0.86
Abietineaepollenites sp.	1.97		1.26
Laricoidites sp.		2.96	3.00
Podocarpaceae			
Platysaccus queenslandi de Jersey, 1962	0.72	1.97	
Gymnospermae Incertae Sedis			
Pteruchipollenites thomasii Couper, 1958	1.09	3.45	1.72
Pseudopicea variabiliformis (Maljavkina) Bolkhovitina			0.86
Cerebropollenites carlylensis Pocock, 1970		0.99	2.58
Callilasporites dampieri (Balme) Sukh Dey, 1961	1.81		0.86
C. segmentatus (Balme) Srivastava, 1963	0.72	0.99	
C. turbatus (Balme) Schulz, 1967	0.36	1.48	0.86
Chasmatosporites apertus Nilsson, 1958		1.48	
C. parvus (Brenner) Xu et Zhang, 1980		2.46	10.30
Exesipollenites sp.		1.48	
Psophosphaera spp.	2.17	2.96	1.26
蕨类植物孢子 (spores of Pteridophyta)	23.57	38.47	17.49
裸子植物花粉 (pollen of Gymnospermae)	76.42	61.61	81.94
统计粒数 (counted specimens)	228	254	252

Sinemurian 阶的孢粉组合带和 Sinemurian—下 Pliensbachian 阶的组合带中均有数量占优势的 *Classopollis* 花粉,还出现了晚三叠世常见的 *Kraeuselisporites* 孢子。伊朗中部 Lias (Arjang, 1975)孢粉组合中也含有晚三叠世孑遗分子 *Zebrasporites* cf. *intercriptus*,俄罗斯、哈萨克斯坦(Romanovskaya, 1962) Lias 期地层中也出现过二叠、三叠纪的残余分子 *Taeniaesporites*。在中国的湖南西南部(Shang, 1981),下侏罗统观音滩组也存在 *Chordasporites*, *Anaplanisporites stipulatus*, *A. telephorus*, *Lunzisporites* 等三叠纪十分发育的分子,呈现出三叠纪-侏罗纪过渡性特点。当前组合与此有别,并更充分显示出侏罗纪中期特征。

Norris(1965)曾研究过维多利亚地的 Section Peak 侏罗纪孢粉组合(约 22 属 24 种),根据 *Classopollis* 的优势以及一些孢粉类型的时代分布,将费拉群孢粉组合的时代归为早侏罗世。当前孢粉组合的产地与 Section Peak 孢粉组合的产地相距几百公里,两者均以 *Classopollis* 占优势,共同的有 7 属 7 种:*Cyathidites minor*, *Deltoidospora* sp., *Lycopodiumsporites austroclavatidites*, *Ginkgocycadophytus nitidus* , *Pteruchipollenites thomasii*, *Perinopollenites elatoides*, *Classopollis torosus* (*C. classoides*),这些属种皆为侏罗纪最常见类型。不同的是本组合中增加了不少侏罗纪的特征类型,如 *Klukisporites variegatus*, *Gle-*

icheniidites senonicus，*Contignisporites cooksonii*，*Callialasporites turbatus*，*C*. *segmentatus*，*C*. *trilobatus*，*Cerebropollenites carlylensis*；其中 *Gleicheniidites senonicus*，*Contignisporites cooksonii*，*C*. *trilobatus* 还是中侏罗世以后的重要种。另外，随着孢粉地层工作的不断深入，Section Peak 组合中一些被 Norris(1965)认为限于早侏罗世以前的大部分属种，如 *Cyathidites minor*，*Deltoidospora* sp.，*Lycopodiumsporites austroclavatidites*，*Punctatosporites scabratus*，*Pteruchipollenites thomasii*，*Classopollis torosus* 等均已在南、北半球中、晚侏罗世甚至早白垩世地层中见及。Norris 指出的靠近晚三叠世和早侏罗世界线的 *Ginkgocycadophytus* 和 *Protopinus* 的种也已越过早侏罗世，甚至中侏罗世，这正如 Norris(1965)所预言的：“更加详细的研究将可能显示 Section Peak 微古植物群的时代为中侏罗世”。

Tasch(1978)在研究横跨南极山脉孢粉组合时，也曾研究过 Carapace Nunatak 组合(文中 A-B-C 组合)，出示了 10 种孢粉照片，在所列名单中，与本组合相同的有 8 属 10 种：*Araucariacites australis*，*Callialasporites dampieri*，*C*. *segmentatus*，*C*. *trilobatus*，*Inaperturopollenites turbatus* (*Callialasporites turbatus*)，*Classopollis calssoides*，*Contignisporites cooksonii*，*Duplexisporites problematicus*，*Lycopodiumsporites austroclavatidites*，*Todisporites minor*。本组合新增加的属种中，*Calamospora tener*，*Cyathidites australis*，*C*. *minor*，*Converrucosisporites cameroni*，*Klukisporites variegatus*，*Classopollis annulatus*，*C*. *parvus*，*Cerebropollenites carlylensis*，*Pteruchipollenites thomasii*，*Perinopollenites elatoides* 均为中侏罗世的重要类型，其中 *Cyathidites australis*，*C*. *minor*，*Classopollis annulatus*，*C*. *parvus* 在早、中侏罗世，尤其是中侏罗世孢粉组合中十分常见，而在 Tasch(1978)研究的组合里却未发现。罕见的是在 Tasch(1978)研究的组合里发现了不止一粒 *Clavatipollenites* cf. *hughesii*，而该属花粉确为具单沟的早期被子植物花粉。迄今为止，这一类花粉仅见于上侏罗统以上地层。当前组合与 Tasch(1978)研究的组合相比，虽均以 *Classopollis* 占优势为特征，且以侏罗纪的成分为主，但当前组合类型要丰富得多，所显示的中侏罗世的色彩更明显。

Tasch(1978)在讨论费拉群孢粉组合时代时，将其与西澳大利亚珀斯盆地 Evergreen 组的组合作对比，认为共同的种有 62%，并指出“*Inaperturopollenites turbates*，*Ginkgocycadophytus* sp.，*Protopinus* sp.，*Patinasporites* sp. 在横跨南极山脉组合中的出现，表明其时代为早侏罗世，而不是中侏罗世，这类似于 Norris(1965)在 Section Peak 费拉群发现的情形”。如前所述，Tasch 在这里所指属种显然不能成为推断早侏罗世的证据。

对于与西澳大利亚的对比，笔者重新作了研究，在 Filatoff(1975)划分为唯一的早侏罗世 *Exesipollenites tumulus* 组合带的 *Classopollis chateaunovi* 里，我们未见到 *Contignisporites cooksonii*，*Callialasporites dampieri* 等重要分子，而这些在 Tasch(1978)研究的组合带和当前组合里均有出现。事实上，费拉群组合与珀斯盆地中侏罗世早期 *Exesipollenites tumulus* 组合带 *Dictyophyllidites harrisii* 组合带更为相似。珀斯盆地的这一组合里，*Classopollis* 属花粉仍占最高含量，与本组合共同的重要分子有 *Calamospora mesozoica*(*C*. *tener*)，*Lycopodiumsporites austrocalvatidites*，*Duplesisporites problematicus*，*Todisporites minor*，*Dictyophyllidites harrisii*，*Klukisporites variegatus*，Cyatheaceae/Dicksoniaceae-type spores，Osmundaceae-type spores，*Gleicheniidites senonicus*，*Callialasporites dampieri*，*C*. *turbatus*，*C*. *segmentatus*，*Araucariacites australis*，*Exesipollenites* sp.，Cycadopisda-type pollen， Pinaceae/Podocarpaceae-type pollen 以及 Cheirolepidaceae-type pollen (*Classopollis* spp.)。其中十分重要的是已出现中侏罗世以后的种 *Callialasporites dampieri*，虽然 *Contignisporites cooksonii* 在珀斯盆地晚侏罗世的 *Callialasporites dampieri* 组合带的 *Contignisporites cooksonii* 亚带里才出现，但此种孢子自中侏罗世早期即有分布。另一差别是珀斯盆地的孢粉组合里 *Exesipollenites* 较多，且有一些本地区特有分子，但两组合基本面貌相似。

阿根廷的 Neuquen Province 中侏罗世孢粉组合(Volkheimer, 1968)主要由 *Classopollis* 和 *Araucariacites* 组成，*Todisporites major* 和单沟花粉也有一定含量，重要分子还有 *Cyathidites minor*, *C. australis*, *Lycopodiumsporites austroclavatidites*, *Ischosporites morburgensis* de Jersey, *Callialasporites dampieri*, *C. segmentatus*, *Vitreisporites pallidus* (Reissinger) Nilsson, *Alisporites robustus* Nilsson, *Podocarpidites* cf. *ellipticus* Cookson，组合中同样含有 *Callialasporites dampieri* 等中侏罗世重要分子。Menendez(1968)接着也发表了同一地区中侏罗统该层孢粉组合的论文，其基本面貌相似，另外还见到 *Concavisporites* 与 *Foveosporites* 属的孢子。这两属在本组合均有，不同的是阿根廷组合中还有一些形体较大的光面型孢子 *Hemenophyllumsporites*，这一类形态的孢子自中侏罗世晚期才出现，是早白垩世的特征分子。据 Menendez(1968)报道，该层已发现中侏罗世 Callovian 期菊石，因此本组合时代归为中侏罗世早期较合适。

Carapace Nunatak 的费拉群大植物化石由 Plumstead(1962)和 Townrow(1969)所研究，前者认为费拉群时代为早侏罗世，后者认为属中侏罗世。鱼化石由 Schaeffer(1972)描述，时代为早侏罗世。该地区丰富的叶肢介化石最早由 Tasch(1987)所描述，沈炎彬(1994)对本文所及同一地点的叶肢介进行了研究，认为以 *Carapacestheria* 为特征的费拉群叶肢介动物群时代很可能为中侏罗世早期。

4 古植被、古气候探讨

根据 Potonié(1954, 1960)和近年来研究原位孢子学者提供的丰富资料，笔者将维多利亚地南部 Carapace Nunatak 的费拉群孢子花粉植物亲缘关系归类情况列于表 I。可以初步推测，中侏罗世早期，Carapace Nunatak 地区有着茂盛的植被，以掌鳞杉科，桫椤科植物为主，其它蕨类植物与裸子植物的种类较多，有紫萁科，石松科，里白科，网叶蕨科，马通蕨科，海金沙科，南美杉科，银杏科，松科，罗汉松科，苏铁科等。

掌鳞杉科植物生长在阳光充足的较干燥地带或排水良好的坡地，桫椤科是现今仍生存在热带潮湿地区及南半球的温带和亚热带植物。石松科喜湿，马通蕨科与海金沙科为热带和亚热带分子，紫萁科现存于温带、亚热带和热带。银杏科的孑遗分子仅存于中国和日本的温带地区。苏铁科分布于南、北半球热带及亚热带，松科植物为全球分布。南美杉科植物主要分布于热带、亚热带，罗汉松科植物生长在热带、亚热带的湿润地区。根据上述绝大多数植物的现今生态环境，推断中侏罗世早期，Carapace Nunatak 地区为较温暖湿润的温带及亚热带气候。

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MIDDLE JURASSIC PALYNOLOGY OF CARAPACE NUNATAK, VICTORIA LAND, ANTARCTICA

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Key words palynology, Middle Jurassic, Antarctica

Summary

The Ferrar Group cropping out on the Victoria Land of Antarctica is the principal volcanic sedimentary rock series. In 1965, Norris studied the spores and pollen grains of this group from the Section Peak of the Rennick Glacier region, and attributed it to Early Jurassic in age. Tasch and Lammons (1978) also reported the spores and pollen grains from some lacustrine interbeds of Transantarctic Mountains in Antarctica. In the paper, they illustrated 10 species from Carapace Nunatak, and still considered these sporopollen to be Early Jurassic. Carapace Nunatak is situated in the southern part of Victoria Land, where the Ferrar Group is well-developed, containing fluviolacustrine intercalations. Recently, abundant spores and pollen grains have been obtained from this suite of strata in which some conchostracans were found at the same locality, thus laying a good foundation for deepgoing studies on the nature, characteristics and age attribution of this palynoflora.

The Ferrar Group in Carapace Nunatak is composed of two parts (Ballance and Water, 1971). The lower part is the Carapace Sandstone, a suite of fluvial volcanic rocks about 120 m in thickness, and the upper part named the Kirkpatrik Basalt Formation, is a suite of volcanic flows-breccia more than 300 m in thickness conformably overlying the lower part. The palyno-

logical samples F1, F2 and F3 were collected from the conchostracan-bearing fossil localities, the fluviolacustrine intercalations in the lower part of the Kirkpatrik Basalt Formation. F1 and F3 were collected at the southern extremity of Carapace Nunatak (Tex-fig. 1). F1 was from lenticles, 8 cm above the top of the Carapace Sandstone; F3 is 6.3 cm apart above F1, while the position of F2 is at the northern extremity of Carapace Nunatak, where the basalt lies above the Carapace Sandstone, with sample F2 collected from the graded unit about 2 cm in thickness above the basalt.

Just as indicated in Table 1, the palynological assemblage in Carapace Nunatak is characterized by the absolute predominance of *Classopollis* and presences of some other principal elements such as *Calamospora tener*, *Todisporites minor*, *T. major*, *Cyathidites minor*, *C. australis*, *Dictyophyllidites mortoni*, *D. harrisii*, *Concavisporites toralis*, *Gleicheniidites senonicus*, *Converrucosisporites cameroni*, *Klukisporites variegatus*, *Lycopodiumsporites austroclavatidites*, *Contignisporites cooksoni*, *Ginkgocycadophytus nitidus*, *Araucariacites australis*, *Cerebropollenites carlylensis*, *Callialasporites dampieri*, *C. segmentatus*, *C. turbatus*, *Chasmatosporites apertus*, *Pteruchipollenites thomasii*, *Pinuspollenites enodatus*, *Abietineaepollenites* sp., *Laricoidites* sp., etc.

The abundance of *Classopollis* is of some importance in dating. Although several species appeared as early as in Late Triassic, the genus gradually reached its climax only after entering into the Jurassic. However, during Early—Middle Jurassic, the content of this genus varies rather greatly in different places in Northern Hemisphere. For instance, in Britain (Couper, 1958), this genus has a relatively high content in Early—Middle Jurassic, especially in Middle Jurassic, attaining 60% or more. In Kazakstan of Russia (Ponomarenko *et al.*, 1973), *Classopollis* reaches as high as 50% in the Hettangian stage. Relatively abundant pollen grains of the genus occur in the Lower Jurassic of North France (Muir and van Konijnenburg-van Cittert, 1970), Germany (Mädler, 1964; Reinhardt, 1962; Schulz, 1962, 1967), Hungary (Kedves and Simoncsics, 1964) and Poland (Rogalska 1954; Orlowska-Zwolinska, 1966, 1967). In South China (Shang, 1981; Qian *et al.*, 1983; Shang and Li, 1992), *Classopollis* reaches its climax in the Lower Jurassic; however, its high abundance may extend up to the Lower Cretaceous. Whereas in North China, the pollen grains of this genus were scarce in the Lower Jurassic and still low in content in Middle Jurassic (usually less than 3%), but became dominant up to the Upper Jurassic (L. Zhang, 1965; Xu and W. Zhang, 1980; Liu *et al.*, 1981; Shang, 1995). In the Southern Hemisphere, this genus mostly reached its climax in content while entering into Early Jurassic. In Rajasthan of western India, *Classopollis* occupies 80% in content in the palynological assemblage of the Lower-Middle Jurassic Lathi Formation (Srivastava, 1966). In Pakistan, the abundant cuticles discovered from the Middle Jurassic (Sah, 1955) mostly belong to *Brachyphyllum* and *Pagiophyllum* which have been inferred as the parent plants of *Classopollis*. In western Australia, this genus reaches its highest value in the Lower Jurassic both in Perth Basin (Filatoff, 1975) and in the marginal area (Balme, 1957), whereas in eastern Australia, this genus is low in content and decreased from bottom upward in the Lower Jurassic in the Rosewood Coal Field(de Jersey, 1963), from 7.55% in the lower part to 1.2% in the upper part. In the Neuquen Province of Argentina, *Classopollis* and *Gliscopollis* are the most important components of the assemblages during Middle Jurassic (Menendez, 1968). From what has been cited above, it is obvious that the high abundance of *Classopollis* may be regarded as an important referential index of Early-Middle Jurassic in most areas, but can not be taken as a unique marker for distinguishing Early and Middle Jurassic. Besides the condition of production and preservation, the abundance of *Classopollis* pollen depends not only on difference in phytoprovinciality but also on climate, substratum and distance to shore where the parent plants of *Classopollis* lived. However, *Classopollis* which amounts to 49.50% in content in the present assemblage is comparable to those in the Early—Middle Jurassic palynological assemblages of the Southern Hemisphere.

Among the miospores of this assemblage, *Calamospora tener* was first discovered from the Keuper stage of Switzerland (Leschik, 1955), and later found from the Triassic of Ipswich in Australia(de Jersey, 1962), but it has not yet been found from the strata above Middle Jurassic. *Converrucosisporites cameroni* was discovered from the Middle—Late Triassic strata in Ipswich of Australia by de Jersey (1962), and later mainly found from the Triassic—Middle Jurassic of Southern Hemisphere, such as the Rhaetian-Lias stage of Leigh Creek Coal Measures in Australia(Playford and Dettmann, 1965) and the Phaetian strata of Victoria Land in Antarctica (Norris, 1965). *Klukisporites variegatus* was discovered by Couper (1958) from the Middle Jurassic of Britain, and later extensivly found from the Lias—Middle Jurassic of the Southern Hemisphere and Northern Hemisphere. *Callialasporites*, *Perinopollenites* and *Cerebropollenites* are all elements found from the Jurassic upward; among them, *Callialasporites turbatus* was found in the Lower—Middle Jurassic in western Australia (Balme, 1957; Filatoff, 1975), while *C. dampieri* was mainly found in Middle Jurassic. Similar status in the distribution of these two species also may be found in Europe; and the latter has even been taken as the key species of the Middle Jurassic (Guy, 1971; Guy-Ohlson, 1978, 1982, 1985). Despite the genus *Contignisporites* ranging from Late Triassic to Early Cretaceous, the species *C. cooksonii* is mainly found in Middle Jurassic in the Southern Hemisphere, such as western Australia (Filatoff, 1975). In our assemblage, a small amount of *Gleicheniidites senonicus* also has been found; this species is mainly reported from the Middle Jurassic upward, such as the Bajocian Sycarham Beds in Britain(Couper,, 1958), and the Aalenian—Bajocian *Dictyophyllidites harristi* Assemblage Subzone of the *Exesipollenites tumulus* Assemblage Zone in western Australia (Filatoff, 1975).

It is noteworthy that no any relic elements of the Late Triassic have been procured in this assemblage, whereas such relic elements usually represent one of the important characteristics of the Early Jurassic palynological assemblages. For instance, *Kraeuselisporites* which is usually characteristic of Triassic has been found in association with abundant *Classopollis* in the Hettangian—Lower Pliensbachian stage in the offshore area along western Canada (Bujak and Williams, 1977). In central Iran, the Lias palynological assemblage (Arjang, 1975) also contains *Zebrasporites* cf. *intercriptus*, a relic element from Late Triassic. In the Lias in Kazakstan of Russia (Romanovskaya, 1962), there has even appeared *Taeniaesporites*, a relic element from Permian and Triassic. In China, in the Lower Jurassic Guanyintan Formation of suthwestern Hunan (Shang, 1981) there also exist such elements as *Chordasporites*, *Anaplanisporites stipulatus*, *A. telephorus*, *Lunzisporites*, etc., which were well-developed in Triassic, showing some transitional aspect from Triassic to Jurassic. In this regard, the present assemblage is different from all other Early Jurassic assemblages in displaying more prominent features of the Middle Jurassic.

Norris (1965) studied the Jurassic playnological assemblage from the Section Peak of the Victoria Land, at a locality which is several hundred kilometers apart from the locality of the present assemblage, with the discovery of palynomorphs including about 22 genera and 24 species. Based on the predominance of *Classopollis* and the chronological distribution of some palynomorphs, he attributed the assemblage of the Ferrar Group to Early Jurassic in age. A comparison between the present assemblage from the Carapace Nunatak and Norris' assemblage from Section Peak indicates that both are similar in the predominance of *Classopollis*, with seven genera and seven species in common, namely, *Cyathidites minor*, *Deltoidospora* sp., *Lycopodiumsporites austroclavatidites*, *Ginkgocycadophytus nitidus*, *Pteruchipollenites thomasii*, *Perinopollenites elatoides* and *Classopollis torosus* (*C. classoides*), which are usually found in Jurassic. But there are differences between them. Our assemblage contains some forms characteristic of the Jurassic, including *Klukisporites variegatus*, *Gleicheniidites senonicus*, *Contignisporites cooksonii*, *Callialasporites turbatus*, *C. segmentatus*, *C. trilobatus and Cerebropollenites carlylensis*. Among them *Gleicheniidites senonicus*, *Contignisporites cooksonii* and *Callialasporites turbatus* are important species from the Middle Jurassic strata upward. Moreover, with the deepgoing development in palynostratigraphy over the past two decades, the geological and geographical distribution of some palynomorph genera and species have further been made clear. Most of the genera and species which Norris (1965) pointed out as ranging from pre-Jurassic to Early Jurassic have been found to extend in Middle—Late Jurassic and even Early Cretaceous in the Southern and Northern Hemispheres, such as *Cyathidites minor*, *Deltoidospora* sp., *Lycopodiumsporites austroclavatidites*, *Punctatosporites scabratus*, *Pteruchipollenites thomasii* and *Classopollis torosus*. The species of *Ginkgocycadophytus* and *Protopinus* which Norris remarked to be close to the Late Triassic and Early Jurassic boundary have extended beyond Early Jurassic and even Middle Jurassic. This is probably just like what Norris predicted in 1965: "……more detailed work may subsequently show the Section Peak microfloras to be Middle Jurassic." His prediction has already been demonstrated by facts.

Tasch (1978) reported the assemblage from Carapace Nunatak (assemblage A-B-C), in the Transantarctic Mountains of Antarctica. In his fossil list there are 8 genera and species in common with our assemblage, namely, *Araucariacites australis*, *Callialasporites dampieri*, *C. segmentatus*, *C. trilobatus*, *Inaperturopollenites turbatus* (*Callialasporites turbatus*), *Classopollis classoides*, *Contignisporites cooksonii*, *Duplexisporites problematicus*, *Lycopodiumsporites austroclavatidites* and *Todisporites minor*. However, some important Middle Jurassic palynomorphs are absent in Tasch's assemblage, such as *Calamospora tener*, *Cyathidites australis*, *C. minor*, *Converrucosisporites cameroni*, *Klukisporites variegatus*, *Classopollis annulatus*, *C. parvus*, *Cerebropollenites carlylensis*, *Pteruchipollenites thomasii* and *Perinopollenites elatoides*, among which *Cyathidites australis*, *C. minor*, *Classopollis annulatus* and *C. parvus* are very often found in the Lower-Middle Jurasssic, especially in the Middle Jurassic. It is curious that in Tasch's assemblage there are two or three pollen grains of *Clavatipollenites* cf. *C. hughesii*, which are doubtlessly of an early angiospermous origin and so far have only been found from the Upper Jurassic strata upward. In comparison of the present assemblage with Tasch's (1978) assemblage, both are characterized by the dominance of *Classopollis*, with Jurassic elements as their principal components; however, the present assemblage is more abundant and diverse, indicating a Middle Jurassic age. While discussing the age of the assemblage, Tasch pointed out: "The presences of *Inaperturopollenites turbatus*, *Ginkgocycadophytus* sp., *Protopinus* sp. and *Patinasporites* sp. in the TAM (Tranantarctic Mountains, Antarctica) assemblage suggest an Early, rather than Middle Jurassic age, a situation similar to that found by Norris 1965 in the Ferrar assemblage of Section Peak." As mentioned above, these genera and species obviously can not be taken as the evidence for an Early Jurassic inference.

In addiion, Tasch compared the palynological assemblage from the Ferrar Group with the Evergreen Formation assemblage from the Perth Basin of Australia, and concluded that both assemblages share 62% of the species. On correlation with western Australia, such important elements as *Contignisporites cooksoni* and *Callialasporites dampieri*, etc. have not been recorded in the *Classopollis chateaunovi* Assemblage Subzone of the *Exesipollenites tumulus* Assemblage zone which was defined by Filatoff as the unique Early Jurassic assemblage zone, whereas these elements have all appeared in Tasch's (1978) assemblage and the present assemblage. As a matter of fact, the Ferrar Group assemblage is more similar to the *Dictyophyllidites harrisii* Assemblage Subzone of the *Exesipollenites tumulus* Assemblage Zone from the early stage of Middle Jurassic in the Perth Basin of Australia. In the latter assemblage, the pollen grains of *Classopollis* still occupy a maximum content, and the important elements in common with the present assemblage include *Calamospora mesozica* (*C. tener*), *Lycopodiumsporites austraclavatidites*, *Duplexisporites problematicus*, *Todisporites minor*, *Dictyophyllidites harrisii*, *Klukisporites variegatus*, Cyatheaceae / Dicksoniaceae-type spores, Osmundaceae-type spores, *Gleicheniidites senonicus*, *Callialasporites dampieri*, *C. turbatus*, *C. segmentatus*, *Araucariacites australis*, *Exesipollenites* sp., Cycadopsida-type pollen, Pinaceae / Podocarpaceae-type pollen and Cheirolepidaceae-type pollen (*Classopollis* spp.). Among them, especially important is the appearance of *Callialasporites dampieri* known from the Middle Jurassic upward, while *Contignisporites cooksonii* may extend in the *Contignisporites cooksonii* Oppel Zone of the *Callialasporites dampieri* Assemblage Zone in the Perth Basin as late as in the Late Jurassic; although it first occurs in the early stage of Middle Jurassic. Another difference lies in the relatively abundant *Exesipollenites* in the *Dictyophyllidites harrisii* Subzone of the *Exesipollenites tumulus* Assemblage Zone in the Perth Basin, as well as the presence of some peculiar elements restricted to this region. However, both assemblages are similar in basic features, and may be correlated with each other.

In the Neuquen Province of Argentina, the Middle Jurassic palynological assemblage (Volkheimer, 1968) are mainly composed of *Classopollis* and *Araucaricacites*, with a certain amount of *Todisporites major* and monosulcate pollen; other important elements include *Cyathidites minor*, *C. australis*, *Lycopodiumsporites austroclavatidites*, *Ischosporites morburgensis* de Jersey 1963, *Callialasporites dampieri*, *C. segmentatus*, *Vitreisporites pallidus* (Reissinger) Nilsson 1958, *Alisporites robustus* Nilsson 1958 and *Podocarpidites* cf. *ellipticus* Cookson 1947. This assemblage also contains important elements of Middle Jurassic such as *Callialasporites dampieri*. Subsequently, Menendez (1968) reported a similar assemblage form this horizon of Middle Jurassic in the same region, in which the spores of *Concavisporites* and *Foveosporites* are common to the present assemblage. However, the Argentina assemblage is different in having some relatively large-sized laevigate spores such as *Hymenophyllumsporites*. This form of spores did not appear until the late stage of Middle Jurassic, but they became a characteristic element up to Early Cretaceous. According to Menendez, from this horizon have already been discovered some ammonoids of the Middle Jurassic Callovian stage, and therefore it is relatively appropriate to attribute the present assemblage to the early stage of Middle Jurassic.

Plumstead (1962) and Townrow (1987) studied the megafloras in Carapace Nunatak and considered the Ferrar Group to be Early Jurassic and Middle Jurassic in age respectively. The fish fossils were described by Schaeffer in 1972, who referred the Ferrar Group to the Jurassic. The rich conchostracans in this region were first studied by Tasch (1987); recently, Shen Yanbin (1994) made a study on the conchostracans from the same locality involved in this paper, and concluded that the conchostracan fauna of the Ferrar Group, characterized by *Carapacestheria*, is probably of early Middle Jurassic age.

From the possible affinity of the dispersed fossil spores, it may be deduced that in early stage of Middle Jurassic, Carapace Nunatak was extremely rich in floras, which include Pteridophytes belonging to more than 7 familes, such as Cyatheaceae, Osmundaceae, Dipteridaceae, Matoniaceae, Lycopodiaceae, Lygodiaceae, Gleicheniaceae, etc. Among the Gymnosperms, the comparatively flourishing plants are those of Cheirolepidiaceae, Araucariaceae, Cycadaceae, Ginkgoaceae, Pinaceae, Podocarpaceae and Taxodiaceae. From the ecological environment of the parent plants, it has been inferred that this region was under a warm and humid temperate to subtropic climate at that time.

图 版 说 明

所有图影均放大 600 倍，标本号注明于各属种名下，全部标本保存在中国科学院南京地质古生物研究所。

图 版 I

1. *Undulatisporites* sp.
F1-79。
2. *Gleicheniidites senonicus* Ross
F2-46。
3. *Deltoidospora* sp.
F2-25。

4—6. *Cyathidites minor* Couper
4. F2-31；　5. F2-36；　6. F2-34。

7. Deltoidospora adirecta (Balme et Hennely) Norris
F2-6。

8—10. *Todisporites minor* Couper
8. F1-63；　9. F1-65；　10.　F2-67。

11. *Concavisporites toralis* (Leschik) Nilsson
F2-50。
12. *Dictyophyllidites mortoni* (de Jersey) Playford et Dettmann
F2-35。
13. *Calamosppora tener* (Leschik) de Jersey
F1-69。
14. *Converrucosisporites vernitus* Batten
F2-12。
15. *Granulatisporites* sp.
F3-75。
16. *Granulatisporites minor* de Jersey
F1-59。
17. *Converrucosisporites cameroni* (de Jersey) Playford et Dettmann
F2-51。
18. *Cyclogranisporites* sp.
F3-84。
19. *Klukisporites variegatus* Couper
F2-2。
20. *Converrucosisporites* sp. 1
F2-52。
21. *Converrucosisporites* sp. 2
F2-3。

22a, b. *Contignisporites cooksonii* (Balme) Dettmann
F1-60；　a. distal face；　b. proximal face.

23. *Toroispora* sp.
F2-42。
24. *Polycingulatisporites* sp.
F3-87。

图 版 Ⅱ

1,2. *Chasmatosporites apertus* Nilsson
1.F2-26; 2.F2-43。

3. *Classopollis parvus* (Brenner) Xu et Zhang
F3-91。

4—9. *Classopollis annulatus* (Verbitzkaja) Li
4.F1-54; 5.F3-29; 6.F3-92; 7.f2-1; 8.F1-80; 9.F3-95。

10—12. *Classopollis classoides* Pflug
10.F2-48; 11.F1-55; 12.f1-85。

13. *Ginkgocycadophytus nitidus* (Balme) de Jersey
F2-32。

14,15. *Laricoidites* sp.
14.F2-17; 15.F3-96。

16. *Cerebropollenites carlylensis* Pocock
F3-93。

17. *Araucariacites* sp.
F2-28。

18,19. *Araucariacites australis* Cookson
18.F3-97; 19.F3-84。

20a,b. *Perinopollenites elatoides* Couper
F2-33; a.proximal face; b.distal face.

21. *Cycadopites* sp.1
F2-19。

22. *Cycadopites* sp.2
F1-74。

23. *Callialasporites dampieri* (Balme) Sukh Dev
F1-58。

24. *Callialasporites turbatus* (Balme) Sukh Dev
F2-24。

图 版 Ⅲ

1—3. *Pteruchipollenites thomathii* Couper
1.F2-23; 2.F1-71; F2-30。

4—6. *Pinuspollenites enodatus* (Bolkhovitina) Li
4.F2-21; 5.F3-86; 6.F2-47。

7. *Pseudopicea variabiliformis* (Maljavikina) Bolkhovitina
F3-109。

8. *Abietineaepollenites* sp.
F3-113。

9. *Platysaccus queenslandi* de Jersey
F2-44。

10,11. *Pinuspollenites* sp.
10.F3-103; 11.F2-59。

12,13. *Psophosphaera* sp.1
12.F3-90; 13.F3-98。

14,15. *Psophosphaera* sp.2
14.F3-82; 15.F2-66。