

A NONMARINE LATE CRETACEOUS DEPOSITIONAL UNIT ON KING GEORGE ISLAND, WEST ANTARCTICA

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Abstract A new lithostratigraphic unit—Half Three Point Formation is determined on an inlet (62°13'40"S, 58°59'01"W) near Half Three Point of Fildes Peninsula of King George Island, South Shetland Islands. This formation consists of volcanic breccia, sediment—tuff, tuffaceous siltstones and mudstones about 5.5m thick. The Palynomorph assemblage is of Late Cretaceous age (Campanian—Maastrichtian). Isotopic age of the tuffites by Rb—Sr whole rock method is 71.30 ± 0.3 Ma.

The calcite of sand—sized tuffites formed by calcitization during early diagenesis has very light $\delta^{18}\text{C}$ value of -26.24% , PDB, and $\delta^{13}\text{C}$ value of -5.130 to 5.631% , PDB. It suggests that the calcitization is related to thermal freshwater originally. The tuffaceous mudstone contains lower B content of 48.4 ppm, corresponding to that of lacustrine mudstones. Low $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.703189—0.703320) indicates the tuffites of continental origin. Therefore, the formation may represent a lacustrine deposit under low energy and reducing environment. This is only known to define the late Late Cretaceous lacustrine sediments in Antarctica

Key words Late Cretaceous, Lacustrine sediment, West Antarctica

Introduction

On an inlet (62°13'40"S, 58°59'01"W) near Half Three Point of Fildes Peninsula of King George Islands, South Shetland Islands (Fig. 1), the sedimentary rocks cropped out are referred to the "Jurassic Volcanic Group" by Barton (1965) and to the Tertiary Fossil Hill Formation by Li and Liu (1987), Liu and Zheng (1988). According to palynoflora components obtained from the rocks (Cao, 1989, 1990), the writer (1989, 1990, 1991) considered them to be Late Cretaceous in age.

This study is concentrated on the lithology, Palaeontology, geological age and depositional environment of Half Three Point Formation (HTPF). The diverse and abundant palynomorphs as well as the excellent exposures of these rocks provide a basis for

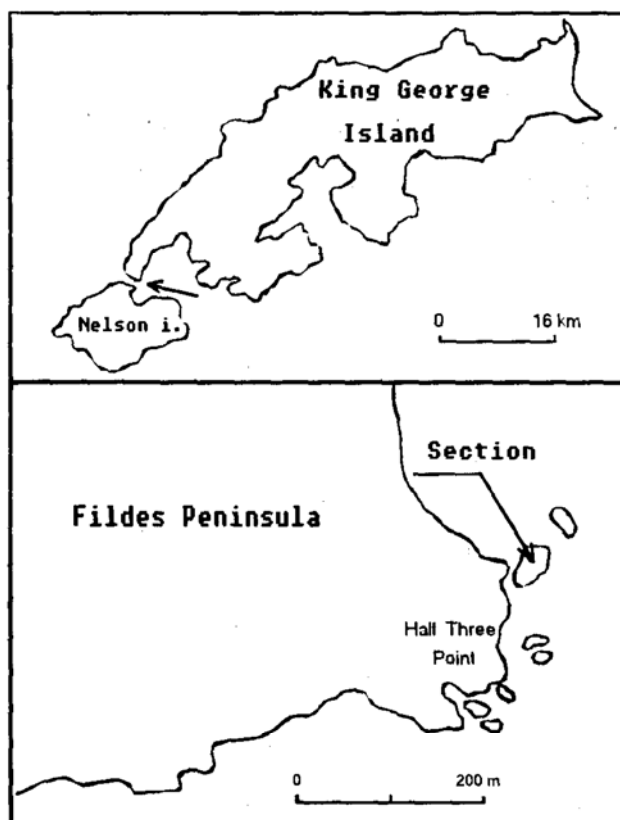


Fig. 1 Sketch showing the location of type section of Half Three Point Formation

definition of a new stratigraphical unit (Shen, 1991). This work is essentially based on the data collected by the 4th Chinese Antarctic Expedition (1987—1988).

Geological Background

The Fildes Peninsula contains subalkaline volcanic rocks and rich flora — bearing pyroclastic—sedimentary sequence. Barton (1965) divided the volcanic rocks of the Fildes Peninsula into two groups, the "Jurassic Volcanic Group" located in the southern part and the Fildes Peninsula Group (FPG) distributed in the central and northern parts. There was, however, no palaeontological evidence to indicate that the "Jurassic Volcanic Group" is Mesozoic in age. Li and Liu (1987) subdivided the volcanic rocks into five formations, which all belong to FPG, and considered the sedimentary rocks near Half Three Point to be equivalent to Eocene Fossil Hill Formation.

FPG is essentially a monoclinical sequence dipping to northeast at 10° — 15° , but HTPF dipping to ENE 26° is affected by small faults and several thin basalt dykes near the Half Three Point. The HTPF is about 5.5m thick and is traced laterally for approximately 30m and submerged in sea water at both sides (Fig. 2).

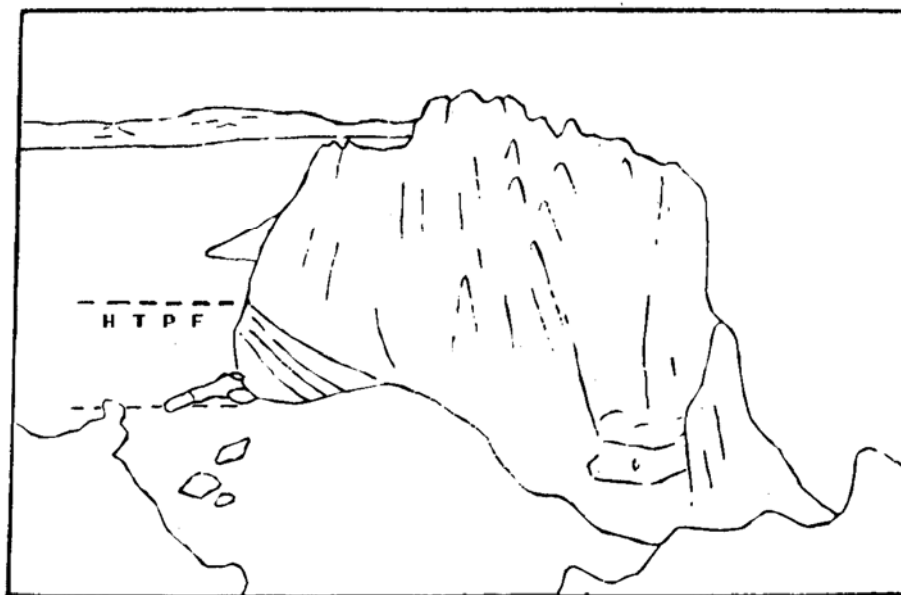


Fig. 2. Sketch showing outcrop of Half Three Point Formation (HTPF)

Lithology

The HTPE cropping out consists mainly of volcanic braccia, well consolidated and finely laminated dark greyish sediment — tuff, tuffaceous siltstone and mudstone with manganese bands, containing pyrite and siderite. Its contact with underlying Paleocene agglomerates is faulted and is covered unconformably with possibly Paleogene andesitic lavas.

The stratigraphical sequence of the type section at Half Three Point is described in descending order as in Fig. 3.

The formation is uncomplete base, because of disturbance by the fault.

Fossils

Only micro — and megafloora have been found in the formation. Palynomorph preservation is generally poor. The sporopollen grains are dark brown, indicating thermal metamorphism in this area. The following palynomorphs have been identified; a species of acritarch cyst, 38 species of fungal spores (including one new genus and 16 new species), two species of bryophyte spores, 21 genera and 40 species of fern spores (including 7 new species), 6 genera and 7 species of gymnosperm pollen, and 5 genera and 10 species of angiosperm pollen. Altogether, there are 98 species (Cao, 1990, unpub. , Song and Cao, unpub.). The palynomorph assemblage is characterized by:

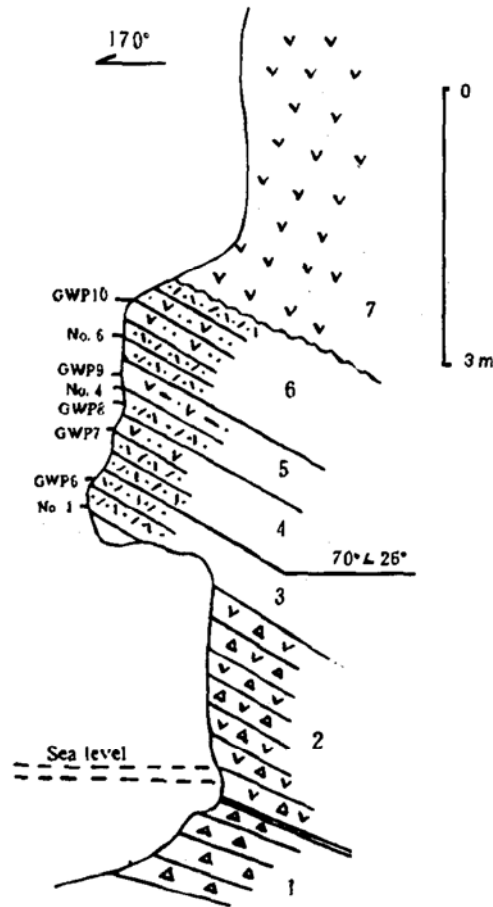


Fig. 3. The stratigraphical profile of Half Three Point Formation

Paleocene Agate Beach Formation

7. Grey thick bedded andesitic lavas, with vertical joints forming erosion cliff topographically, unconformably resting on the underlying beds. >25m

Half Three Point Formation

6. Grey calcified crystalloclastic and lithoclastic tuffites and blue — greyish finely laminated mudstone containing siderite and sporopollen (Gwp 5, 10) 1.5m
5. Grey and blue — greyish chloritized and calcified sediment — tuff, tuffaceous sandstone and mudstone, with finely laminated structure, containing pyrite, sporopollen and megafloora (Gwp 8, 9), *Podocarpus fidesensis* Zhou (sp. nov.), *Nothofagus* sp., *Dictylophyllum* sp., *Sphenopteris* sp. 0.6m
4. Dark — grey and blue — greyish thin — bedded calcified sediment — tuff and tuffaceous mudstone with finely laminated structure, containing sporopollen (Gwp 7) and megafloora *Podocarpus* sp. 0.9m
3. Green — greyish thin — medium bedded sediment — tuff, containing sporopollen (Gwp 6) 0.5m
2. Grey volcanic breccia with manganese bands, with fault contact underlying beds. 2.0m

Paleogene

1. Green — greyish agglomerates

1. Fern spores account for 81.5% of total number of the assemblage. Among them Gleicheniaceae, Cyatheaceae and Adiantaceae account for 28%, 20.5% and 10.5% of the total respectively. Thus, the three families are obviously the dominant group of the assemblage.

2. Fungal spores amount for 12% of the total or even to 20% in individual samples.

3. Gymnosperm pollen is poor in content, reaching 2% of the total.
4. Angiosperm pollen is low in content, only amounting to 3%.
5. Bryophyte spores are scarce in content, accounting for 1%.
6. Acritarch cyst is present individually, only amounting to 0.5%.

In the HTPF the fern spores, including *Foraminisporis dailyi*, *Cyathidites*, *Deltoidospora*, *Klukisporites*, *Appendicisporites* and *Aequitriradites spinulosus*, are widespread elements in the Late Mesozoic and often found in the Cretaceous strata in Antarctic Peninsula. *Gleicheniidites* and *Clavifera* are developed mainly in the Cretaceous, though visible in Paleogene. *Asterisporites* is known to occur in the Jurassic and Cretaceous, and has not yet been found in Paleogene. In the gymnosperm pollen Araucariaceae and Podocarpaceae are main elements, which are also distributed in the late Mesozoic to Paleogene strata in the southern hemisphere. Included in the present palynoflora are such angiosperm pollen as *Nothofagidites* cf. *N. senectus*, *Cranwellia*, *Gothanipollis*, *Tirporopollenites* and *Tricolporopollenites*.

Numerous leaf impressions and some fragments of stems are arranged parallel to the sedimentary layers. The leaves are locally crowd, but it is more difficult to collect. They include *Podocarpus fildesensis* Zhou (sp. nov.), *Nothofagus* sp., *Dictylophyllum* sp., and *Sphenopteris* sp. (Zhou and Li, unpub.).

Geochronology

1. Palynology

Although a lot of leaves were collected from the formation, but they are not age—diagnostic elements. Considerable sporopollen grains can hardly be identified, because of poor preservation. However there are some forms in the palynomorph assemblage being available for identification, they include some genera and species which are of significance to determination of stratigraphic age. According to Cao's study (1989, 1990), the palynoflora is mainly characterized by a large number of Gleicheniaceae spores, which account for more than 50% of the total spore content, forming a predominant population.

The presence of *Asterisporites* indicates that the palynoflora—bearing beds should be of Mesozoic age. The pollen grains of *Nothofagidites* made their earliest appearance in Campanian stage of the Late Cretaceous in the southern hemisphere, including Antarctic Peninsula. Therefore, based on the component analysis of this palynoflora assemblage, it would be more appropriate to assign the age of the formation to the middle—late stage of Late Cretaceous (Cao, 1989, 1990). Many elements of the sporopollen flora are very similar to those in the Upper Cretaceous Lopez de Bertodano Formation on the Seymour Islands, Antarctic Peninsula and in the Upper Cretaceous of Australia.

2. *Isotopic data*

The isotopic age of 12 samples of the sediment—tuff from the HTPF by Rb—Sr whole—rock method is 71.3 ± 0.3 Ma (Wang *et al.*, 1992). So both palaeontology and isochron data show that the HTPF is of Late Cretaceous, and very possibly from Campanian to Maastrichtian in age.

Depositional Environment

1. *Palaeontological evidence*

In the HTPF no marine fossils have yet been found in the samples. The leaves with distinct venations and partly preserved cuticular organization seem to be deposited in situ, not be transported from another place at a long distance. The stems, one of about 40cm length, distributed on the layers reflect their origin nearby.

The palynomorphs reflect a vegetation characterized mainly by the presence of fern plants *Gleicheniaceae*, *Cyatheaceae*, *Adiantaceae*, *Dicksoniaceae*, *Lygodiaceae*, *Osmundaceae* and *Polypodiaceae* (including fern trees of *Cyatheaceae* and *Dicksoniaceae*) which were growing on the lakeshore or the adjacent hillslope. On the nearby mountainland, there occurred *Araucariaceae*, *Podocarpaceae* and *Nothofagaceae*, which made up rainy forest. Therefore, the present sporopollen assemblage reflects a vegetation scenery like what there were mainly Luxuriant hygrophilous and thermophilous ferns on the lake shore and hillslope under the warmer and humid climatic conditions. The palynomorph flora also contain many species of fungal spores which have a preference for the warmer and humid climatic environment.

2. *Lithological characteristics*

The volcanic breccia cropped out in the formation (bed 2) represents an accumulation of volcanics. Laminated beds (bed 3—6) usually contain flora and successive laminae are taken to represent periodic lacustrine deposition. The flora—bearing rocks chiefly consisting of dark—greyish finely laminated sediment—tuff, tuffaceous siltstones and sandstones containing pyrite and siderite, reflect a low energy and reducing environment.

The calcite of sand—sized sediment—tuff formed by calcitization during early diagenesis exhibits very light $\delta^{18}\text{O}$ values of -26.24% , PDB, and $\delta^{13}\text{C}$ values of -5.631% , PDB, which suggest that the calcitization is related to thermal freshwater originally. The tuffaceous mudstones contain lower B content of 48.4ppm corresponding to that of lacustrine mudstones (Xu, unpub.). Low $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.703189—0.703320) indicates the sediment—tuff being of continental origin (Wang *et al.*, 1992).

To sum up, the HTPF represents a transition from volcanic accumulation at the early

stage to lacustrine sedimentation at the later stage. Oxygen and carbon isotopic analysis and B content and $^{87}\text{Sr}/^{86}\text{Sr}$ ratio determination provide evidence suggesting that the HTPF belongs to fresh-water lacustrine deposits, that fits with palaeontological evidence. Based on both the Palynomorph assemblage and isotopic data, the HTPF defined in this study can be assigned to the Late Cretaceous (possibly Campanian—Maastrichtian) in age.

Upper Cretaceous volcanic rocks so far determined in Antarctica were only reported in Admiralty Bay of King George Island and Greenwich Island of South Shetland Islands, and consist of basaltic and andesitic lavas intercalated with few fossil leaves and woods. The former was subdivided into two groups: Paradise Cove Group and Baranowski Glacier Group. The isotopic data are $67.6 \pm 3.5\text{Ma}$ and $77 \pm 4\text{Ma}$ respectively (Birkenmajer, 1982, 1986, 1988). The latter consists of two volcanic—sedimentary units, which are separated by angular unconformity and contain plant fossils. The isotopic data of K—Ar whole-rock samples are $77.6 \pm 2.3\text{Ma}$ and $70.3 \pm 1.9\text{Ma}$ respectively (Fensterseifer *et al.*, 1991). So Half Three Point is known to be only one locality found with Late Cretaceous lacustrine sediments in Antarctica. The HTPF might be related to those on Admiralty Bay and Greenwich Island.

Therefore, the ascertainment of nonmarine Late Cretaceous deposits is very significant to recognize the geological development and Palaeogeography of the western margin of the magmatic arc in Antarctic Peninsula.

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