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Stratigraphy and age of the Lower Cretaceous Pedersen Formation, northern Antarctic Peninsula

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Abstract: The Pedersen Formation includes conglomerate-dominated successions exposed on Pedersen Nunatak (142 m thick) and southern Sobral Peninsula (750–1000 m thick). As re-defined here, it also includes mudstone and sandstone in tectonic contact with Nordenskjöld Formation strata on a nunatak north of the Sobral Peninsula conglomerate outcrops. $^{40}Ar/^{39}Ar$ ages and palynological data indicate an early Aptian age for the lower part of the formation on Sobral Peninsula. The Pedersen Nunatak strata have yielded conflicting age determinations, although an Early Cretaceous age seems likely. The Sobral Peninsula conglomerates are lithologically similar to, and possibly coeval with, basal Gustav Group strata (Lagrelius Point Formation) on James Ross Island. Although further field sampling is required to resolve the age of the Pedersen Nunatak strata, on present evidence the Pedersen Formation appears to form part of the same tectono-stratigraphic unit as the lower part of the Gustav Group, and we therefore propose that it be included in that group.

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Key words: Aptian, Gustav Group, James Ross Basin, palynology, Sobral Peninsula

Introduction

The northern part of the Larsen Basin (commonly termed the James Ross Basin; del Valle *et al.* 1992), on the eastern margin of the Antarctic Peninsula (Fig. 1a), contains one of the thickest and most complete onshore Cretaceous–Palaeogene sedimentary successions in the Southern Hemisphere (e.g. Crame *et al.* 1996, Riding *et al.* 1998). However, the sedimentary record for the period following deposition of the Kimmeridgian–Berriasian Nordenskjöld Formation (Whitham & Doyle 1989) and prior to that of the Aptian–Eocene succession on James Ross Island (Fig. 1b; Riding *et al.* 1998) is fragmentary. The only known strata that may have been deposited during this time interval are conglomerate-dominated successions exposed on Pedersen Nunatak and southern Sobral Peninsula (Fig. 1b). These rocks may be older than, or time-equivalent to, the basal, Aptian part of the Gustav Group on James Ross Island (Fig. 1b; e.g. Elliot 1988, Riding *et al.* 1998). Although they have been grouped together to form the Pedersen Formation (del Valle *et al.* 1983, del Valle & Fourcade 1986), a formal definition has not yet been presented. This paper reviews already published age determinations and stratigraphical data, presents new palynological analyses, and assesses the relationship of these strata to other basin-fill successions. These data form the basis for a formal definition of the Pedersen Formation as part of the Gustav Group.

Lithology, thickness and field relationships

The 142 m thick succession exposed on Pedersen Nunatak consists mainly of clast-supported, pebble–cobble conglomerate (Fig. 2a). The conglomerates form 10 to 20 m thick packets of amalgamated, generally 1 to 2 m thick beds, together with a single 14 m thick normally graded unit. Conglomerate units/packets are separated by 3 to 23 m thick intervals of generally thin-bedded sandstone and siltstone with minor conglomerate (Farquharson 1982, 1983a). Neither the base nor the top of the succession is exposed.

The conglomeratic strata exposed on southern Sobral Peninsula are estimated to be some 750 to 1000 m thick (Farquharson 1982). The small part of the succession that has been investigated in any detail, on Hamer Hill and the north-west spur of Mount Lombard (Fig. 1c), consists largely of red-brown weathering, amalgamated, clast-supported conglomerate (Fig. 2a), with subordinate pebbly sandstone and sandstone (Association A of Hathway & Kelley 2000). Conglomerate beds are up to 13.5 m thick (Farquharson 1983a), but most are less than 4 m thick. These sections, which are close to the base of the succession, also include a number of discrete pale-weathering Association B intervals up to 23 m thick, which consist mainly of clast-supported conglomerates with sandstone caps (beds up to 3 m thick) and graded-stratified pebbly sandstones. The rest of the Sobral Peninsula conglomeratic succession appears to be similar to the Mount Lombard and Hamer Hill sections, although it apparently lacks the pale-weathering Association B intervals.

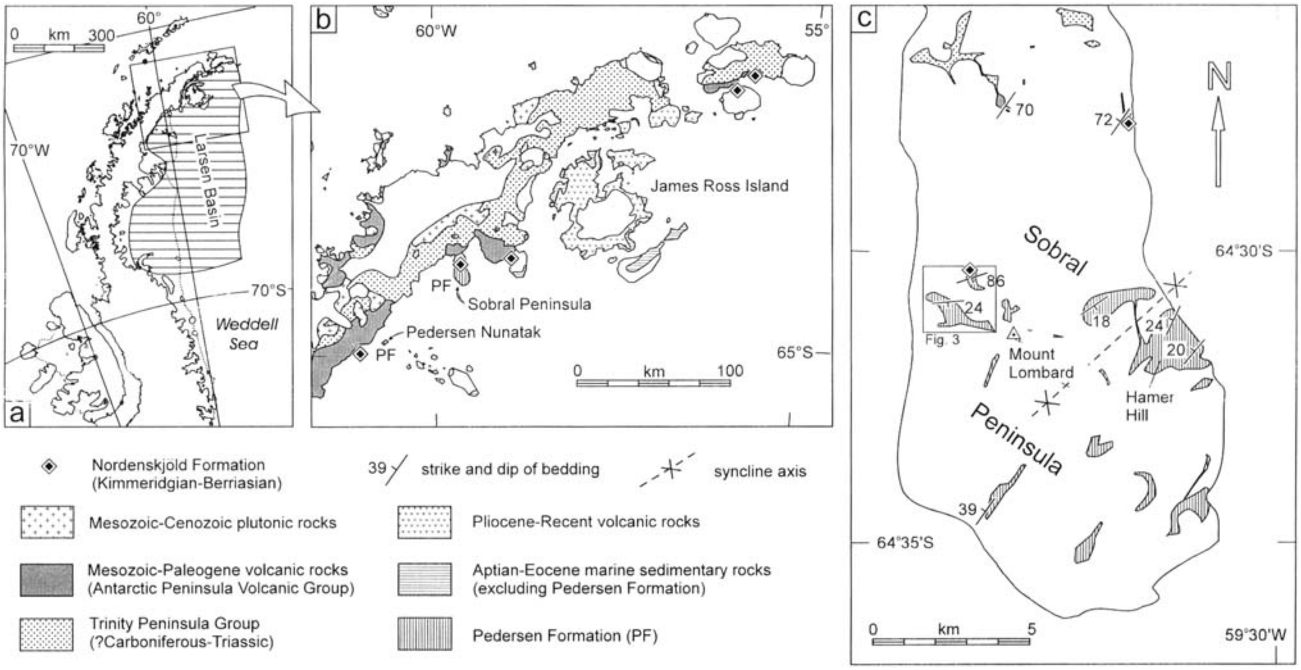

Fig. 1.a. & b. Maps showing location of Sobral Peninsula and Pedersen Nunatak in the Antarctic Peninsula region (geology in b. after British Antarctic Survey 1985). **c.** Geological sketch map of southern Sobral Peninsula, after Elliot (1966) and Farquharson (1983b).

The top of the succession is not exposed. To the north-west of Mount Lombard, the conglomerate overlies some 33 m of dark grey to black mudstone with minor thin beds of fine sandstone (Figs 2b & 3, location DJ.754). The boundary between the two is not exposed but bedding orientation suggests a conformable contact. Lithologically similar mudstone is more extensively exposed on a nunatak 1 km to the north-east (Fig. 3; 'western locality' of Whitham & Doyle 1989, 'El Manco Nunatak' of Scasso & del Valle 1989), where it is in fault contact with Tithonian–Berriasian radiolarian-rich mudstone and tuff of the Nordenskjöld Formation (Whitham & Doyle 1989). Farquharson (1983b) had originally assigned all the strata exposed on the nunatak to the Nordenskjöld Formation, but Whitham & Doyle (1989) recognized the presence of a separate 'mudstone association' (the forementioned mudstone: distinguished from adjacent Nordenskjöld Formation strata by its lack of radiolarians and interbedded tuffs) and 'sandstone association' (consisting mainly of thick-bedded pebbly sandstone), both of uncertain affinity. Both associations are fault-bounded and, like the conglomerate and mudstone farther south, lack macrofossils other than plant material. Because of abundant small-scale folding and faulting, Whitham & Doyle (1989) found it impossible to estimate their thicknesses.

Depositional setting and provenance

The conglomerates and pebbly sandstones that dominate the successions on southern Sobral Peninsula and Pedersen Nunatak, can, for the most part, be interpreted as high-density sediment gravity flow deposits (e.g. Thomson & Farquharson 1984, Hathway & Kelley 2000). In the mudstone-dominated intervals on Sobral Peninsula, minor sandstones are interpreted as turbidites, while the mudstones are likely to represent deposition from low-concentration turbidity currents with a component of hemipelagic settling.

Palaeocurrent data from the Sobral Peninsula and Pedersen Nunatak conglomerates indicate derivation from the Antarctic Peninsula arc massif to the north-west (Farquharson 1982, Hathway & Kelley 2000). Most clasts appear to be derived either from the ?Carboniferous–Triassic (Smellie & Millar 1995) (meta)sedimentary Trinity Peninsula Group (TPG), which forms the basement of the arc, or from the overlying Mesozoic volcanic succession (Antarctic Peninsula Volcanic Group). Clasts of both types are typically fine grained and dark (except for some pale silicic volcanic clasts), and can be hard to distinguish in the field. No clast-count data are available for the conglomerates. Elliot (1966) thought they had a largely volcanic provenance, with a subordinate amount of TPG-derived material, though he judged the latter to be more important at Pedersen Nunatak than Sobral Peninsula. However, Farquharson (1983a, Farquharson *et al.* 1984) thought that clasts at both locations were derived predominantly from the TPG, with only 5–20% volcanic-sourced material. Volcanic grains of largely basaltic–intermediate-composition, and combined metamorphic and sedimentary fragments, both thought to be largely TPG-derived, form approximately equal proportions of the lithic fraction in Association A sandstones from Mount Lombard (mean composition $Qt_{13}F_{22}L_{65}$; Hathway & Kelley 2000). In the Association B intervals, the gravel

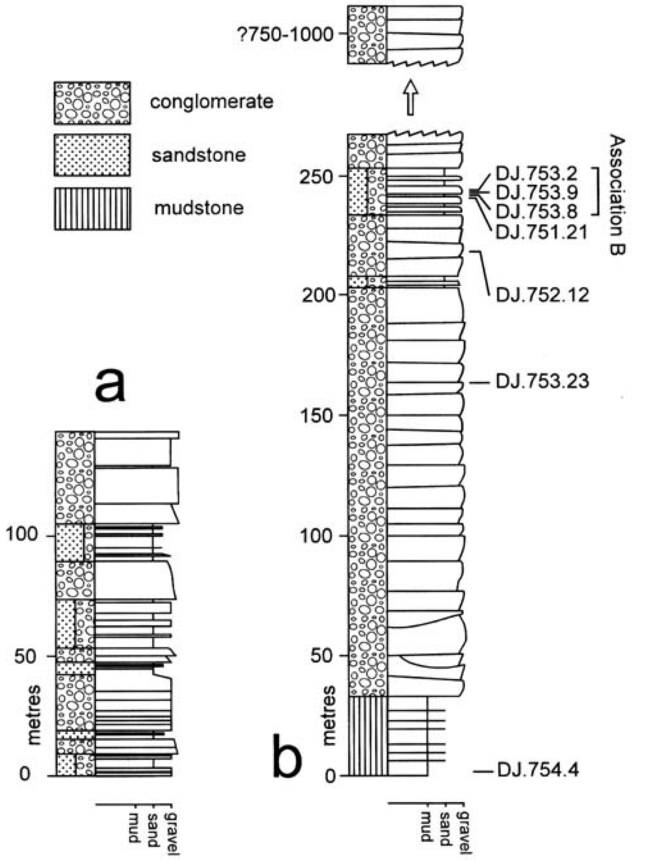

Fig. 2. Schematic graphic sedimentary logs for Pedersen Formation on **a.** Pedersen Nunatak (modified from Farquharson 1983a) and **b.** Sobral Peninsula (excluding 'El Manco Nunatak' sections), with positions of palynological and $^{40}Ar/^{39}Ar$ samples.

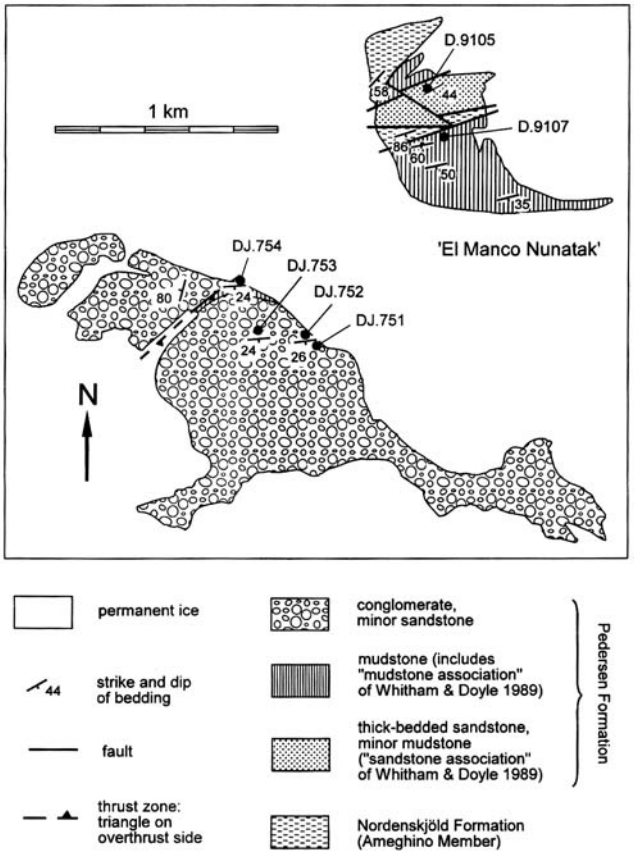

Fig. 3. Sketch geological map of area north-west of Mount Lombard, Sobral Peninsula, with sample locations. See Fig. 1c for map location. Geology of 'El Manco Nunatak' after Whitham & Doyle (1989).

fraction is compositionally similar to that in the enclosing strata, but crystals and vitric grains considered to have been redeposited in the immediate aftermath of explosive silicic volcanism in the arc dominate the sand-grade content (Hathway & Kelley 2000).

The conglomerate- and mudstone-dominated strata on southern Sobral Peninsula and Pedersen Nunatak are lithologically similar to the conglomerate and mudstone associations described by Ineson (1989) from the lower Gustav Group on western James Ross Island. It is probable that, like the James Ross Island successions, the Sobral Peninsula–Pedersen Nunatak strata represent gravelly submarine fans or aprons interspersed laterally with mud-dominated slope-apron deposits along the fault-controlled basin margin (Ineson 1989, Hathway & Kelley 2000).

Biostratigraphy and radiometric ages

Pedersen Nunatak

This outcrop has yielded fragmentary moulds of an ammonite identified as *Favrella wilckensi* (Favre), for which a Hauterivian age is thought probable, and, apparently, a late Cretaceous (Turonian–Maastrichtian) calcareous nannofossil assemblage (Farquharson 1983a, Thomson & Farquharson 1984). Thomson & Farquharson (1984) accepted the younger age and suggested that the ammonites were derived. Three mudstone samples processed for palynology as part of the present study were found to have undergone significant thermal alteration. The only palynomorphs recovered were two non-age-diagnostic bisaccate pollen grains from one sample (Table I). In view of the evidence for thermal alteration, and the preservation of ammonites as moulds, preservation of calcareous nannofossils, which were described from a single, unspecified sandstone sample, is surprising. The lithological similarity of the Pedersen Nunatak succession to the Sobral Peninsula conglomerates, and their similar situations relative to the basin margin suggest a similar stratigraphic position. Until the nannofossil determination can be confirmed, we suggest that the Early Cretaceous (?Hauterivian) age is preferred (cf. del Valle & Fourcade 1986).

Table I. Distribution of palynomorphs (listed alphabetically within their constituent groups) in examined Pedersen Formation samples.

Sample number	DJ.754.4	DJ.753.23	DJ.752.12	DJ.751.21	D.9105.6A	D.9105.5	D.9107.2	D.9107.1	R.1382.4	R.1381.2	R.1379.9
Dinoflagellate cysts:											
Batioladinium micropodum	...	...	...	...	...	...	2	?1	...	...	...
Chorate dinoflagellate cysts - indeterminate	1	8	8+?1	...	...	...	...	...	...	...	...
Cribroperidinium perforans	...	?1	1+?1	...	...	...	...	...	...	...	...
Cribroperidinium spp.	?1	3	3	...	...	...	1	1	...	...	...
Diconodinium sp. (*?D. cristatum*)	...	...	...	...	...	...	1	...	...	...	...
Dinoflagellate cysts - indeterminate	?1	10	11	?2	2	...	...	3	...	...	...
Endoceratium sp.	...	?1	...	...	...	...	...	...	...	...	...
Florentinia sp.	...	...	?1	...	...	...	...	...	...	...	...
Hystrichodinium sp.	...	...	...	...	...	...	1	...	...	...	...
Muderongia australis	...	...	...	...	...	...	...	1+?1	...	...	...
Muderongia sp.	...	1	...	...	...	...	?1	1	...	...	...
Odontochitina spp.	...	?2	?1	...	...	...	??1	...	...	...	...
Oligosphaeridium pulcherrimum	...	...	...	...	...	...	5	8	...	...	...
Oligosphaeridium complex	1	4+?1	...	...	...	...	...	...	...	...	...
Oligosphaeridium spp.	?2	3	2	...	...	...	3+?3	3	...	...	...
Spiniferites ramosus	...	...	?1	...	...	...	...	...	...	...	...
Miscellaneous microplankton:											
Cyclopsiella	...	...	...	...	...	1	...	...	...	...	...
Foraminiferal test linings	...	...	...	...	?1	...	...	...	...	...	...
Palynomorphs - indeterminate	...	...	...	...	3	...	...	1	...	...	...
Pollen:											
Bisaccate pollen - undifferentiated	...	28	11	2+?1	2	2	10	5	2	...	...
Callialasporites dampieri	...	...	1	...	...	...	...	...	...	...	...
Callialasporites trilobatus	...	...	...	...	...	1	...	...	...	...	...
Callialasporites turbatus	...	1	...	...	...	...	...	...	...	...	...
Callialasporites spp.	?1	?2	2+?2	...	...	...	...	...	...	...	...
Pollen - indeterminate	...	...	1	...	1+?1	...	...	...	...	...	...
Vitreisporites pallidus	...	2	1	...	...	...	...	1	...	...	...
Spores:											
Ceratosporites equalis	...	...	...	?1	...	...	...	...	...	...	...
Cicatricosisporites spp.	...	1	2	...	...	...	...	...	...	...	...
Contignisporites cooksoni	...	...	1	...	...	...	...	...	...	...	...
Cyathidites australis	...	6	7	...	...	...	...	...	...	...	...
Cyathidites minor	...	...	4	...	...	...	...	...	...	...	...
Cyathidites spp.	...	...	...	...	...	...	?1	6	...	...	...
Gleicheniidites senonicus	...	...	1	...	...	...	1	...	...	...	...
Ischyosporites sp.	...	...	2	...	...	...	...	...	...	...	...
Lycospora spp. (recycled Palaeozoic)	...	5	1+?2	...	...	...	...	...	...	...	...
Spores - indeterminate	2	...	3	?1	...	1	...	...	...	...	...

Samples prefixed DJ from north-west spur of Mount Lombard; with prefix D from 'El Manco Nunatak' (D.9107, 'mudstone association'; D.9105, 'sandstone association'). (see Fig. 2 for locations). Samples prefixed R from Pedersen Nunatak. Numbers given are numbers of specimens counted in each slide/sample. ? indicates equivocal identification. Three dots (...) indicate absence.

Sobral Peninsula

Samples from the Mount Lombard succession were assigned a late Hauterivian to Barremian age by Farquharson (1982, 1983a) based on dinoflagellate cyst assemblages. A further four samples were analysed palynologically as part of this study (Table I). All proved rich in wood and other plant debris, and all are moderately thermally altered. Poorly preserved palynomorphs are rare in two samples, but relatively common in the other two, which are both mudstones from within the conglomeratic succession. One of the latter (DJ.752.12) yielded the dinoflagellate cysts ?*Cribroperidinium edwardsii* (Cookson & Eisenack 1958) Davey 1969, *Oligosphaeridium complex* (White 1842) Davey & Williams 1966 and ?*Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854, all of which have range bases within the late Neocomian of Australia according to Morgan (1980, fig. 8). The presence of the pollen genus *Callialasporites*, which has a Jurassic to Lower Cretaceous range in Australia (Morgan 1980, fig. 10, Helby *et al.* 1987), indicates that the sample is no younger than Albian. *Odontochitina* (dinoflagellate cyst), questionably present in DJ.752.12, has a consistent range base at the

Barremian–Aptian boundary in Australia (Morgan 1977, 1980, Wilson 1984, Helby *et al.* 1987, fig. 26), suggesting an age no older than Aptian. The second of the two samples (DJ.753.23) yielded a similar palynoflora, including *Oligosphaeridium complex* and ?*Odontochitina,* but also containing *Callialasporites turbatus*, which has an Australian range top within the Aptian stage (Morgan 1980, fig. 10, Helby *et al.* 1987, fig. 13). Considered together, these assemblages suggest an early Aptian age for the Mount Lombard conglomerates. *Oligosphaeridium complex* was the one palymorph taxon identified with certainty in a sample from the 33 m thick mudstone succession underlying the conglomerates (DJ.754.4), indicating an age no older than late Neocomian.

DJ.752.12 and DJ.753.23 yielded the reworked Late Palaeozoic spore *Lycospora* spp. (Fig. 4). This genus, which has not previously been reported from the Antarctic Peninsula, is most characteristic of the Carboniferous, although it may range into the Permian (Kaiser 1976, Brugman *et al.* 1988). Although recycled Permian spores and pollen have previously been recovered from Upper Cretaceous and Lower Tertiary strata (e.g. Askin & Elliot 1982, Askin *et al.* 1991, Dolding 1992), this is the first record of possibly older palynomorphs in the James Ross Basin. Grikurov & Dibner (1968) reported Carboniferous spores from the TPG, but their findings have been disputed (cf. Askin & Elliot 1982). Askin & Elliot (1982) considered that the TPG had undergone pre-Late Jurassic metamorphism to a grade too high for good palynomorph preservation, and therefore rejected it as a possible source for Late Palaeozoic spores and pollen in James Ross Basin strata. However, it is possible that palynomorphs could have been derived from TPG rocks of lower metamorphic grade that have since been removed by erosion or covered by ice (cf. Dolding 1992).

Samples from the 'mudstone association' and 'sandstone association' of Whitham & Doyle (1989) yielded abundant organic residues and relatively sparse, low diversity, poorly preserved palynofloras (Table I). Kerogen macerals and palynomorphs are brown/dark brown in colour, indicating a relatively high degree of thermal alteration. Two samples from the 'sandstone association' yielded miospore-dominated palynofloras with few recognisable species. A single specimen of *Callialasporites trilobatus* was noted in D.9105.5. This gymnospermous taxon ranges from Early/Middle Jurassic to earliest Albian in Australia (Morgan 1980, Helby *et al.* 1987, Backhouse 1988). Its occurrence, together with that of *Cyclopsiella*, indicates that the sample is Lower Cretaceous, and no younger than earliest Albian.

Two samples from the 'mudstone association' yielded more numerous palynomorphs and a significantly more diverse palynoflora. As in the 'sandstone association', the miospore floras are dominated by bisaccate pollen grains. The dinoflagellate cyst assemblage, which includes *Batioladinium micropodum* (Eisenack & Cookson 1960) Brideaux 1975, *Cribroperidinium* spp., *Diconodinium* sp., *Hystrichodinium* sp., *Muderongia australis* Helby 1987 and *Oligosphaeridium pulcherrimum* (Deflandre & Cookson 1955) Davey & Williams 1966, is of Early Cretaceous aspect. The ranges of *Batioladinium micropodum* and *Oligosphaeridium pulcherrimum* comprise the majority of the Early Cretaceous (Morgan 1980), but other taxa permit a more refined age assessment. *Muderongia australis*, which is present in D.9107.1, ranges from the late Valanginian to the earliest Aptian in Australia (Backhouse 1987, fig. 3, Helby *et al.* 1987). Specimens of *Diconodinium,* which has an intra-Aptian range base in Australia (Morgan 1980, Helby *et al.* 1987), and the already discussed ?*Odontochitina* were identified in D.9107.2. Together, these key taxa indicate a probable early Aptian age for the 'mudstone association'.

Batches of plagioclase grains from three Association B sandstones from Mount Lombard (Figs 2 & 3, DJ.753) were analysed using the $^{40}Ar/^{39}Ar$ laser step heating method (Hathway & Kelley 2000). $^{36}Ar/^{40}Ar$–$^{39}Ar/^{40}Ar$ inverse isochron plots gave ages of 123 ± 3, 119 ± 3 and 120 ± 4 Ma for the three samples (errors at 2σ level). All plagioclase grains in the selected size fraction (250–500 mm) are considered to be of pyroclastic origin, and to have undergone redeposition shortly

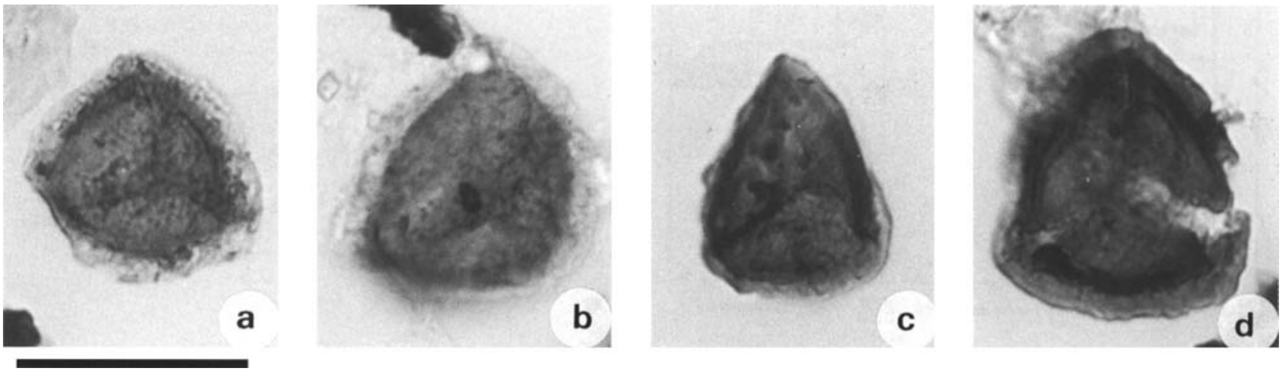

Fig. 4. *Lycospora* spp., reworked Upper Palaeozoic spores from Pedersen Formation strata on Sobral Peninsula. Specimens are housed in the collections of the British Antarctic Survey, Cambridge. Scale bar = 25 mm. All specimens from sample DJ.753.23, except **b.**, which is from sample DJ.752.12.

after eruption. An additional series of single grain fusion analyses were run on plagioclase from sample DJ.753.2, giving an age of 123.5 ± 1.4 (2σ) Ma, with no significant variations from the mean. This age is essentially identical to that obtained by bulk grain analysis, ruling out the possibility of contamination of separates with older plagioclase. $^{40}Ar/^{39}Ar$ ages for the three samples are concordant at *c.* 121 Ma, indicating eruption and redeposition (thought to have been geologically instantaneous) close to the Barremian–Aptian boundary (121.0 ± 1.4 Ma; Gradstein *et al.* 1994) (Fig. 5). They are consistent with the early Aptian age indicated for the succession by the palynoflora.

Relationship to the lower Gustav Group on James Ross Island

The conglomerate-dominated Lagrelius Point Formation is the oldest part of the Gustav Group on James Ross Island (Fig. 5, Ineson *et al.* 1986). Palynological studies indicate that, like the Pedersen Formation strata on Sobral Peninsula, this unit is of early Aptian age (Riding *et al.* 1998). Key to that age assignment are the overlapping occurrences of *Muderongia australis* and consistent *Odontochitina* spp., both also present or tentatively identified on Sobral Peninsula. The Lagrelius Point Formation is lithologically and compositionally similar to the Pedersen Formation conglomerates, with clasts consisting mainly of TPG-derived metasedimentary rocks and arc-derived volcanic rocks (Buatois & Medina 1993, Riding *et al.* 1998). Browne & Pirrie (1995) showed that Lagrelius Point Formation sandstones have a markedly greater metasedimentary lithic content (mean LvLmLs% 41–53–6) than those from the overlying Kotick Point and Whisky Bay formations (mean LvLmLs% 66–17–17 and 71–21–8 respectively). In Association A sandstones from Mount Lombard (mean LvLmLs% 51–18–31), the lithic content thought to be derived from the TPG (Lm+Ls), is similarly high, although it is dominated by sedimentary rather than metasedimentary grains (Hathway & Kelley 2000). The Lagrelius Point Formation lacks the pyroclast-rich Association B horizons seen on Mount Lombard and Hamer Hill, but these are also absent from much of the Pedersen Formation.

There are notable differences between the Pedersen and Lagrelius Point formations. Mean vitrinite reflectance values (R_o) for Pedersen Formation samples from Sobral Peninsula fall in the range 0.69 to 0.73% (Fig. 6), indicating thermal maturity. The Lagrelius Point Formation is significantly less

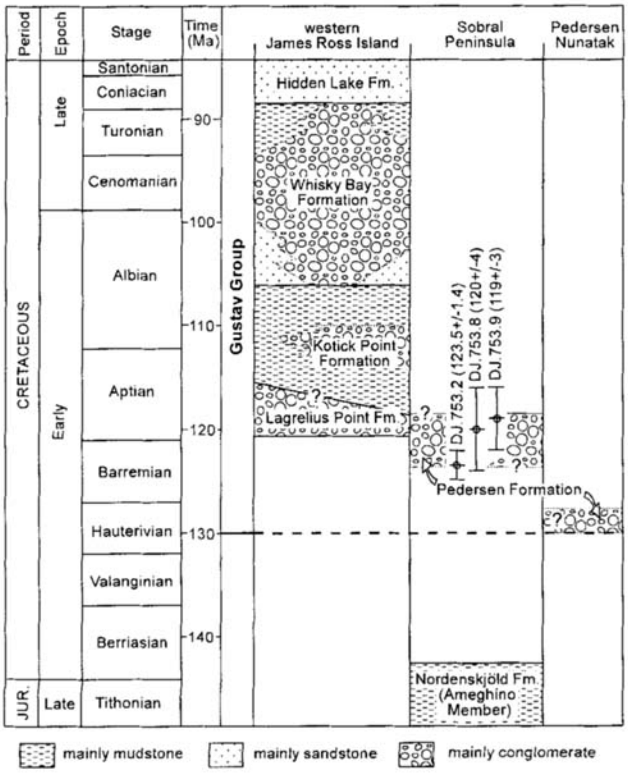

Fig. 5. Summary stratigraphical chart for the James Ross Basin (northern Larsen Basin), adapted from Ineson *et al.* (1986), Ineson (1989) and Riding *et al.* (1998). $^{40}Ar/^{39}Ar$ ages from Sobral Peninsula are shown with 2σ errors. Stage boundary ages from Gradstein *et al.* (1994).

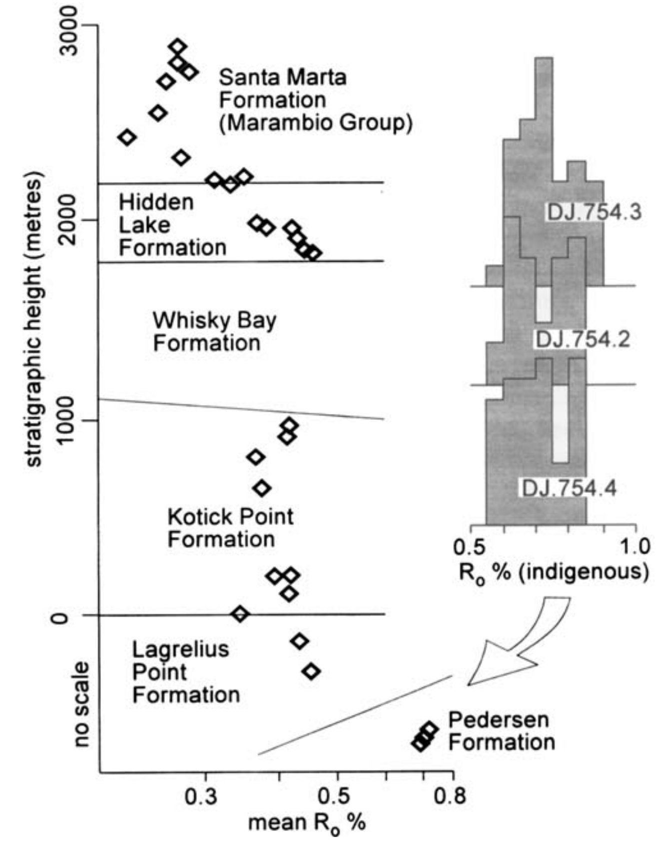

Fig. 6. Graph showing vitrinite reflectance values for Pedersen Formation samples from southern Sobral Peninsula (DJ.754, see Fig. 3 for location; analyses carried out by Robertson Research International Limited), and data obtained by Whitham & Marshall (1988) from western James Ross Island.

thermally altered, with R_o values of 0.4% (Whitham & Marshall 1988), and consequently contains a better preserved palynoflora (Riding *et al.* 1998). The higher degree of thermal alteration seen on Sobral Peninsula may reflect a position closer to the magmatic arc. Lagrelius Point Formation palynofloras include significant amounts of Jurassic taxa thought to be derived from the Nordenskjöld Formation (Riding *et al.* 1998), but these were not observed in the Sobral Peninsula samples. Unlike the Kotick Point and Whisky Bay formations, the Lagrelius Point Formation appears to lack large, easily detectable Nordenskjöld Formation clasts (Buatois & Medina 1993), and the material derived from the latter unit must be finely comminuted (Riding *et al.* 1998). On Sobral Peninsula, Farquharson (1983a pp. 140, 169) identified rare clasts of Nordenskjöld Formation derived mudstone in the Mount Lombard conglomerates, and larger slabs (up to 2.2 x 1.4 m) in the section exposed on Hamer Hill. On examining the Mount Lombard sections in 1995 (Hamer Hill was not accessible), BH found that the mudclasts were lithologically similar to the 33 m thick mudstone section underlying the conglomerates, and therefore likely to be intraformational, which would be consistent with the apparent lack of derived Jurassic palynomorphs. Farquharson (1983a p. 190) also noted locally abundant grey siltstone clasts in the Pedersen Nunatak conglomerates. Significantly, he noted that the lithology closely resembled mudstones then thought to form the topmost part of the Nordenskjöld Formation on Sobral Peninsula, which were subsequently included in the 'mudstone association' of Whitham & Doyle (1989) and are now assigned to the Pedersen Formation (see below).

Definition and status of the Pedersen Formation

As originally proposed by del Valle *et al.* (1983), the Pedersen Formation comprised the conglomerate-dominated successions exposed on Pedersen Nunatak and southern Sobral Peninsula. Based on lithological similarities and palynological data, we also include the 'mudstone association' and 'sandstone association' of Whitham & Doyle (1989) on 'El Manco Nunatak'. A formal definition of the formation follows:

Type area and thickness. Del Valle *et al.* (1983 fig. 4) suggested Pedersen Nunatak as the Pedersen Formation type locality. However, because the age of the 142 m thick succession there is poorly constrained, we prefer to define southern Sobral Peninsula, where the exposed succession is thicker (750–1000 m), as well as better dated, as the type area.

Dominant lithologies. The formation consists largely of clast-supported pebble–cobble conglomerate, with minor mudstone, sandstone and pebbly sandstone.

Boundaries and distribution. The formation is exposed on Pedersen Nunatak and southern Sobral Peninsula. Its only exposed boundaries are the tectonic contacts with the Nordenskjöld Formation to the north-west of Mount Lombard on Sobral Peninsula.

Palaeontology and age. $^{40}Ar/^{39}Ar$ analyses indicate that the beds exposed on Mount Lombard were deposited in late Barremian or early Aptian times. Palynological studies on those strata and on the Pedersen Formation beds exposed on the nunatak farther north suggest an early Aptian age. Only non-age-diagnostic palynomorphs were found in samples from Pedersen Nunatak. The sparse macrofossil content consists of wood fragments and other plant debris, and, on Pedersen Nunatak, fragmentary moulds of the ?Hauterivian ammonite *Favrella wilckensi* (Favre).

The southern Sobral Peninsula strata may be time-equivalent to the lower Aptian Lagrelius Point Formation (Fig. 5), although the exact age relationship is uncertain. It is clear that they form part of the same tectono-stratigraphic unit as the lower part of the Gustav Group on James Ross Island (e.g. Elliot 1988, Hathway 2000). Although further field sampling is needed to resolve the precise age of the Pedersen Nunatak strata, their lithology and position within the basin indicate close affinities with the Sobral Peninsula conglomerates. We therefore propose that the Pedersen Formation be included in the Gustav Group (Fig. 5).

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