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Stratigraphy and depositional setting of the Lagrelius Point Formation from the Lower Cretaceous of James Ross Island, Antarctica

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Abstract: The Lagrelius Point Formation (?Barremian–Aptian) is the basal unit of the Gustav Group and crops out on the north-west coast of James Ross Island. It consists of about 250 m of coarse-grained siliciclastic rocks. The type section of the Lagrelius Point Formation is defined here from just south of Lagrelius Point. The measured section comprises the uppermost 80 m of the unit and mainly consists of clast-supported, boulder, cobble to pebble conglomerates; very coarse to medium-grained sandstones occur rarely. Four sedimentary facies are recognized. A disorganized conglomerate facies (1) is interpreted as having been deposited from non-cohesive debris flows and high density gravelly turbidity currents. Inversely graded conglomerate facies (2) and normally graded to graded stratified conglomerate and pebbly sandstone facies (3) reflect sedimentation from high density gravelly turbidity currents. Massive and parallel stratified sandstone facies (4) is thought to record deposition from high density sandy turbidity currents. Two types of facies assemblages have been recognized. A *major channel assemblage*, represented by the lower part of the measured section and the *minor channel assemblage* forming the upper part of the section. The total succession is thought to represent the aggradation of a major submarine braided channel followed by the establishment and subsequent infill of a series of minor channels in a marginal terrace.

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Key words: sedimentary environment, stratigraphy, turbidite systems, Cretaceous, James Ross Island

Introduction

The Lagrelius Point Formation is the least known unit of the Cretaceous succession on James Ross Island, Antarctica. It crops out at a single locality, near Lagrelius Point, where it forms high and steep cliffs which make detailed observations difficult. Nordenskjöld (in Andersson 1906) first recorded the existence of coarse-grained sandstones and conglomerates in the area, and Andersson (1906) included these rocks in the "Snow Hill Beds". The unit was originally defined by Bibby (1966) as the Lagrelius Point Conglomerate and was subsequently raised to the status of formation by Medina *et al.* (1981). Ineson *et al.* (1986) defined the lithostratigraphy of the Gustav Group, confirming the formation status of the Lagrelius Point Formation. Recently, the lithostratigraphy of the Lagrelius Point Formation was briefly reviewed by Medina *et al.* (1992).

Although Ineson (1989) tentatively suggested a deep-water origin for the Lagrelius Point Formation and Buatois & López Angriman (1992a) interpreted this unit as representing deposition in submarine braided channels, its facies remain undocumented and no in-depth study has been done. Work undertaken in the area during the 1990 austral summer field session provides new data on the stratigraphy and sedimentology of this unit. The aim of this paper is twofold: (1) to define a stratigraphical type section for the Lagrelius Point Formation, and (2) to characterize the sedimentary facies and discuss the depositional setting.

Regional and stratigraphical setting

James Ross Island is situated to the east of the Antarctic Peninsula, in the northern Weddell Sea area (Fig. 1). The Antarctic Peninsula is thought to represent the eroded roots of a Mesozoic–Tertiary volcanic arc, formed as a result of the subduction of proto-Pacific ocean crust beneath the southern continental margin of Gondwana. A back-arc basin, James Ross basin (del Valle *et al.* 1992), developed to the east during these times. The basement of the basin is represented by the deformed metasedimentary rocks of the Trinity Peninsula Group. The origin of the James Ross basin was probably related to oblique extension that took place at the beginning of the break-up of Gondwana during the Early Cretaceous (Macdonald *et al.* 1988, Ineson 1989). The Mesozoic–Tertiary strata exposed on the Antarctic Peninsula, James Ross, Vega, Snow Hill and Seymour islands represent the basin-fill. Outcrops also occur farther south at Kenyon Peninsula (Whitham *et al.* 1987, Macdonald *et al.* 1988). Detailed summaries of the basin stratigraphy and evolution can be found in Macdonald *et al.* (1988), Ineson (1989), Medina *et al.* (1989), Pirrie *et al.* (1991) and Buatois & López Angriman (1992a).

The sedimentary succession exposed on James Ross Island comprises a thick sequence (*c.* 4000 m) of Barremian–Maastrichtian age which is divided into two major lithostratigraphic units: the Gustav Group (Ineson *et al.* 1986) and Marambio Group

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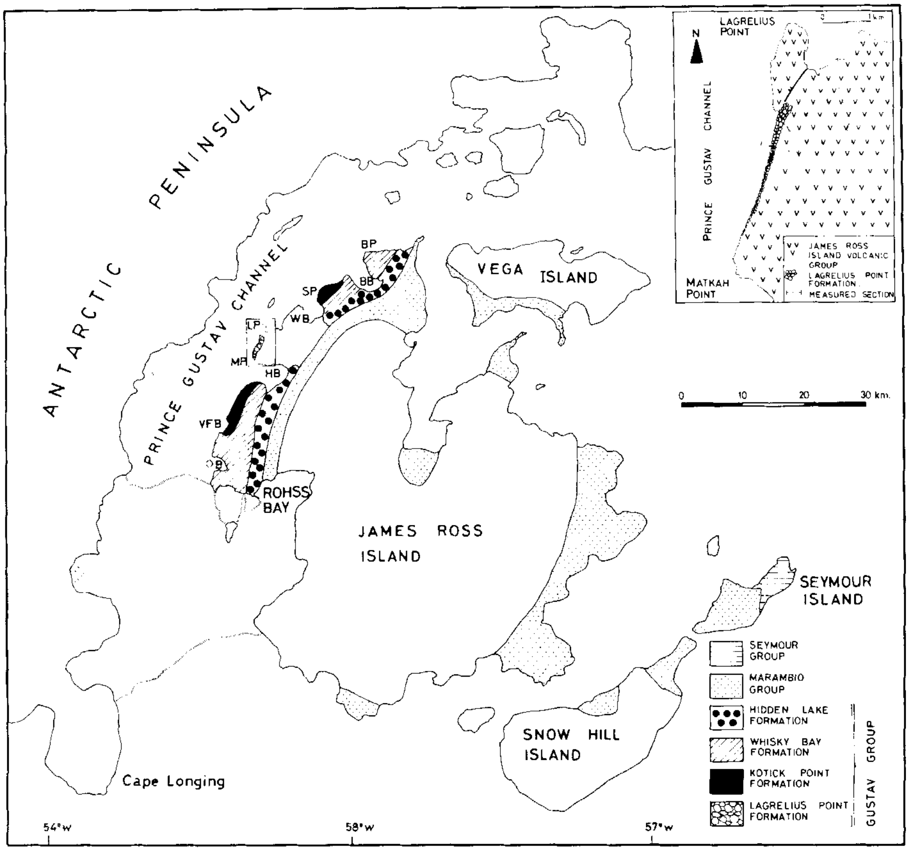

Fig. 1. Geological map of James Ross Island and the Lagrelius Point – Matkah Point area (inset), showing the outcrops of the Lagrelius Point Formation and the position of the measured section in Figs 3 & 7. BP = Bibby Point, BB = Brandy Bay, SP = Stoneley Point, WB = Whisky Bay, LP = Lagrelius Point, MP = Matkah Point, HB = Holluschikie Bay, VFB = Villar Fabre Bay, OB = Obelisk Bay.

(Olivero *et al.* 1986). The Gustav Group crops out on the north-west coast of James Ross Island, adjacent to Prince Gustav Channel (Fig. 1). The lower three units of this group (Lagrelius Point, Kotick Point and Whisky Bay formations) are thought to record sedimentation in different subenvironments of a submarine fan-slope complex (cf. Ineson 1985a, 1986, 1989, López Angriman 1988, Macdonald *et al.* 1988, Buatois & López Angriman 1992a,b, Buatois 1992). Sedimentation along a tectonically-controlled margin has been suggested by different authors (e.g. Ineson 1985b, 1989, López Angriman 1988). The Kotick Point Formation mainly records sedimentation on a slope apron, whereas the overlying Whisky Bay Formation is currently interpreted as representing part of a turbidite depositional system, specifically a braided submarine channel complex (Ineson 1985a, 1986, 1989, López Angriman 1988, Buatois & López Angriman 1992a, Buatois 1992). The uppermost unit of the Gustav Group is represented by the Hidden Lake Formation which records deposition in fan delta and shelf environments (Pirrie *et al.* 1991, Buatois & López Angriman 1992a).

Fig. 2. General view looking south showing the Lagrelius Point Formation outcrop in high steep cliffs near Matkah Point.

Stratigraphy

The Lagrelius Point Formation crops out from 1.5 km south of Lagrelius Point to Matkah Point (Fig. 1) in high and generally inaccessible cliffs plunging into the sea (Fig. 2). Bedding is vertical to sub-vertical. The Lagrelius Point Formation strikes roughly N-S and dips steeply (vertical to 80°E). On the basis of measurements from air photographs, Ineson *et al.* (1986) estimated a thickness of at least 500 m for the Lagrelius Point Formation. In the northern part of the outcrop, at the top of the cliff, a stratigraphical section of about 80 m thick was measured, comprising the uppermost part of the formation. However, projection of the roughly N-S strike along the cliff line indicates that the total thickness of the unit cannot be more than 250 m (Medina *et al.* 1992). Although the steep cliffs preclude a detailed analysis of the whole sequence, the stratigraphical

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section measured in the northern area is considered here as the type section of the Lagrelius Point Formation (Fig. 3). Some of the beds can be traced southward for a few hundred metres to the point where they form inaccessible cliffs. The base of the unit is not exposed. The Lagrelius Point Formation is overlain unconformably by the Cenozoic James Ross Island Volcanic Group. Consequently, the stratigraphical relationship with the other Cretaceous formations cannot be established directly. Bibby (1966) assigned these beds to the base of the James Ross Island succession on the basis of structural considerations. J.E.A. Marshall (Ineson *et al.* 1986, p. 147) mentioned the existence of probable Barremian–Aptian palynofloras. With the exception of fragmentary plant remains, no fossils were found in the unit during our field work. The succeding unit of the Gustav Group, the Kotick Point Formation, is currently considered late Aptian to Albian in age (Medina *et al.* 1982, Ineson *et al* 1986, Medina *et al.* 1992) based on ammonoid and bivalve data. However, recent work on dinoflagellate cysts suggests that this unit may not extend down into the Aptian (Riding *et al.* 1992), leaving a bigger time gap between the Lagrelius Point and the Kotick Point formations.

As a consequence of the isolated nature of the exposures and the absence of biostratigraphical data, doubts persist concerning the stratigraphical position of the Lagrelius Point Formation. Since the work of Bibby (1966), all previous authors have considered the Lagrelius Point Formation as the basal unit of the Gustav Group (Medina *et al.* 1981, 1992, Ineson *et al.* 1986).

Discrete conglomerate bodies are also present in the Kotick Point and Whisky Bay formations; in particular, a conglomerate packet is present in the middle part of the Kotick Point Formation at Whisky Bay and Stoneley Point (Ineson 1989, Buatois 1992). This coarse-grained body is 170 m thick in Whisky Bay and apparently thickens southwards (Ineson, 1989). The overall aspect of the conglomerates of the Kotick Point and Lagrelius Point formations is closely comparable, although the latter is vertical to subvertical. However, clasts of the Lagrelius Point Formation are composed mainly of metasedimentary rocks and, locally, arc-derived volcanic rocks, whereas the clast composition of the Kotick Point conglomerate also includes a considerable volume of Jurassic volcaniclastic sandstone and tuff fragments. Accordingly, petrographical data do not suggest a correlation between both conglomerate units. A basal position for the Lagrelius Point Formation is still considered to be its most likely stratigraphical position.

Sedimentary facies

Sedimentary facies have been defined according to lithology, sedimentary structures, bed geometry and bed boundaries. Four facies have been recognized: (1) disorganized conglomerates, (2) inversely graded conglomerates, (3) normally graded to graded stratified conglomerates and pebbly sandstones and (4) massive and parallel stratified sandstones (Table I).

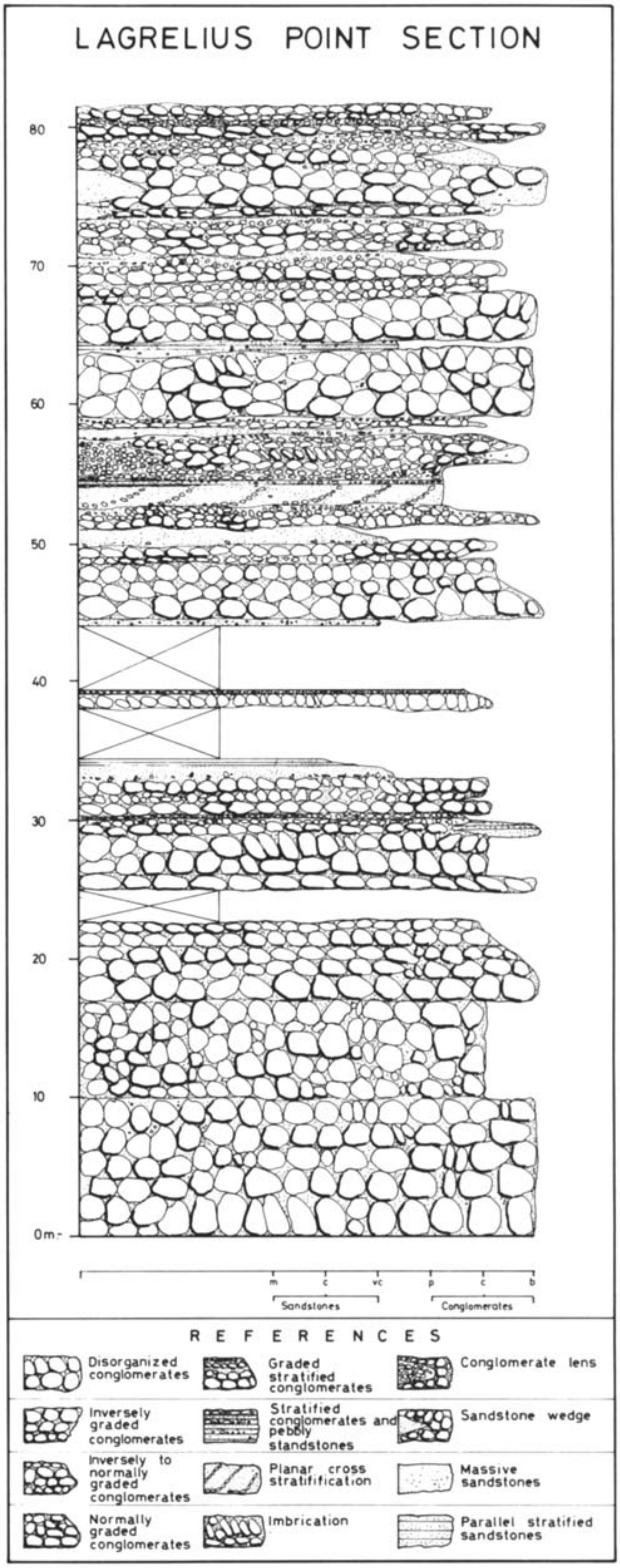

Fig. 3. Stratigraphical log of the type section of the Lagrelius Point Formation.

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Table I. Summary of Lagrelius Point Formation facies and their interpretations.

Facies	Lithology	Structures/Fabric/Texture	Depositional processes
1. Disorganized conglomerates	Boulder, cobble or rarely pebble conglomerates.	Disorganized. Clast-supported. Imbrication rare.	Non-cohesive debris flows and high density gravelly turbidity currents. Frictional freezing.
2. Inversely graded conglomerates.	Pebble, cobble to boulder conglomerates	Inversely graded throughout the whole bed or at a basal interval which pass up to a normally graded zone. Clast-supported.	High density gravelly turbidity currents. Freezing of a traction carpet followed by suspension sedimentation.
3. Normally graded to graded-stratified conglomerates and pebbly sandstones	Boulder, cobble to pebble conglomerates and pebbly sandstones.	Normally graded and normally graded-stratified. Planar cross-bedding rare. Clast to matrix-supported. a(p) a(i) imbrication.	High density gravelly turbidity currents. Traction, velocity fluctuations and direct suspension sedimentation.
4. Massive and parallel stratified sandstones	Very coarse to medium-grained sandstones.	Massive or parallel-stratified. Thin basal pebble and granule layers.	High density sandy turbidity currents.

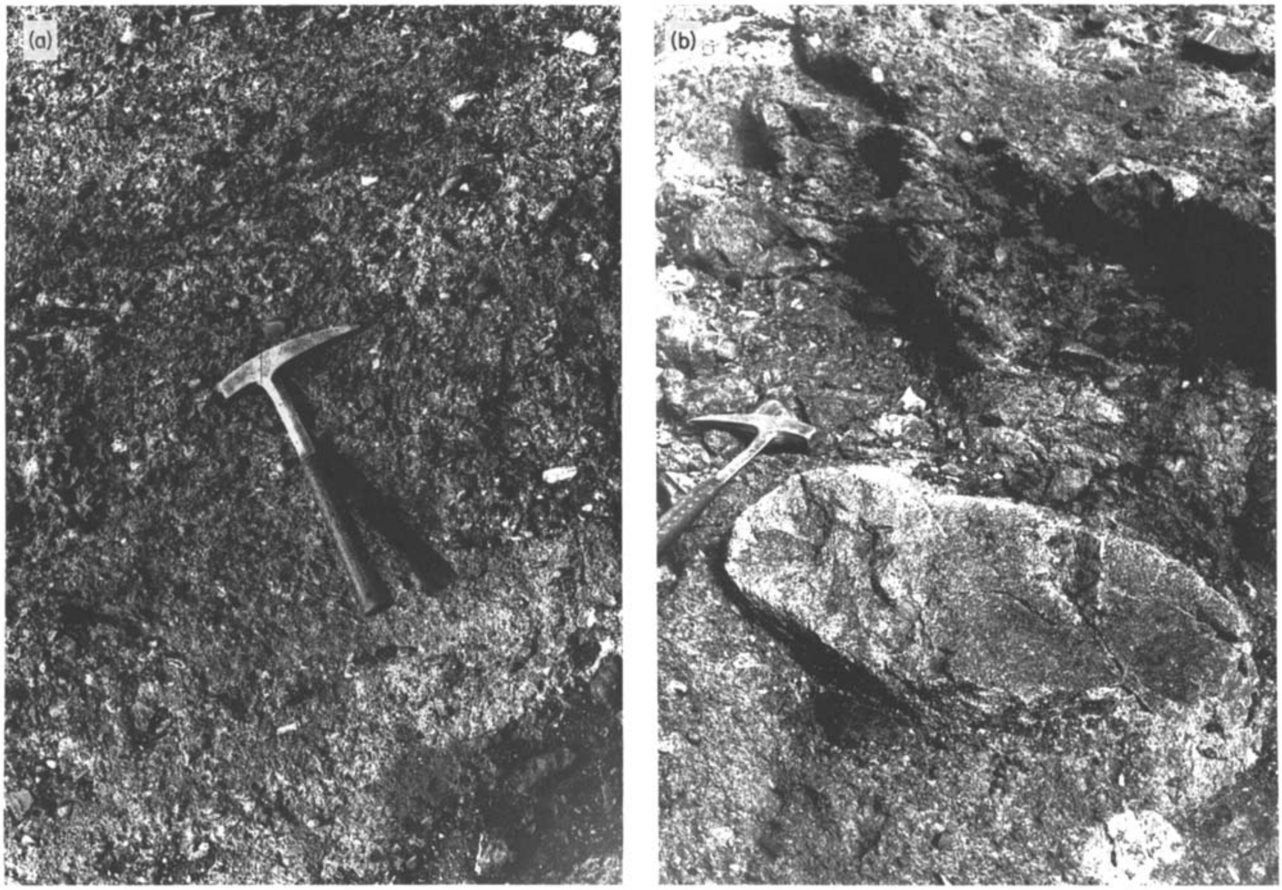

Fig. 4. Detail of facies 1. **a.** disorganized medium-grained conglomerate bed. **b.** large volcanic clast within a chaotic coarse/medium-grained conglomerate; the hammer is 33 cm in length.

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Facies 1: disorganized conglomerates

This facies consists of greenish to yellowish grey, clast-supported, boulder, cobble or rarely pebble conglomerates lacking internal organization (Fig. 4a,b). The conglomerates are moderately sorted, clast shape ranges between rounded to subangular, clast size is up to 57 cm, and the grain size of the matrix varies from medium sand to granules. Individual beds are laterally persistent for tens of metres or lenticular at a scale of 5–20 m. They range from 0.3–10 m in thickness. Bases are erosive, but commonly flat. Imbrication is rare. Sand lenses up to 0.3 m thick are present locally but rare overall.

This facies resembles facies A1 (disorganized conglomerates) of Walker & Mutti (1973), subfacies A_2 (disorganized conglomerates) of Mutti & Ricci Lucchi (1975), disorganized-bed type of Walker (1978, 1984), facies A1.1 (disorganized gravels) of Pickering *et al.* (1986, 1989), and subfacies mG (massive gravels) of Ghibaudo (1992). The disorganized conglomerate facies is interpreted as having been deposited from non-cohesive debris flows and high density gravelly turbidity currents with predominant grain-size population 1 of Lowe (1982). The absence of a mud matrix indicates a non-cohesive mechanism. Final rapid deposition of the grains by frictional freezing is envisaged (cf. Pickering *et al.* 1986). Similar conglomerates have been recognized from the Whisky Bay Formation: see facies 1 of López Angriman (1987, 1988), subfacies 7a of Ineson (1989) and lithofacies 1 of Buatois and López Angriman (1992b).

Facies 2: inversely graded conglomerates

Facies 2 consists of yellowish grey, clast-supported, inversely graded, pebble and cobble to boulder conglomerates (Fig. 5a). In some cases the entire bed is inversely graded but beds with an inversely graded basal zone that pass up to a normally graded interval are also common. Conglomerates are moderately sorted. The shape of the clasts varies from rounded to subangular and clast size ranges up to 30 cm. Matrix grain size ranges from medium sand to granule. Beds are lenticular and lateral wedging may be common at the scale of a few metres. Thickness varies from 0.35 to 2.4 m. Beds are erosively-based. Imbrication is absent.

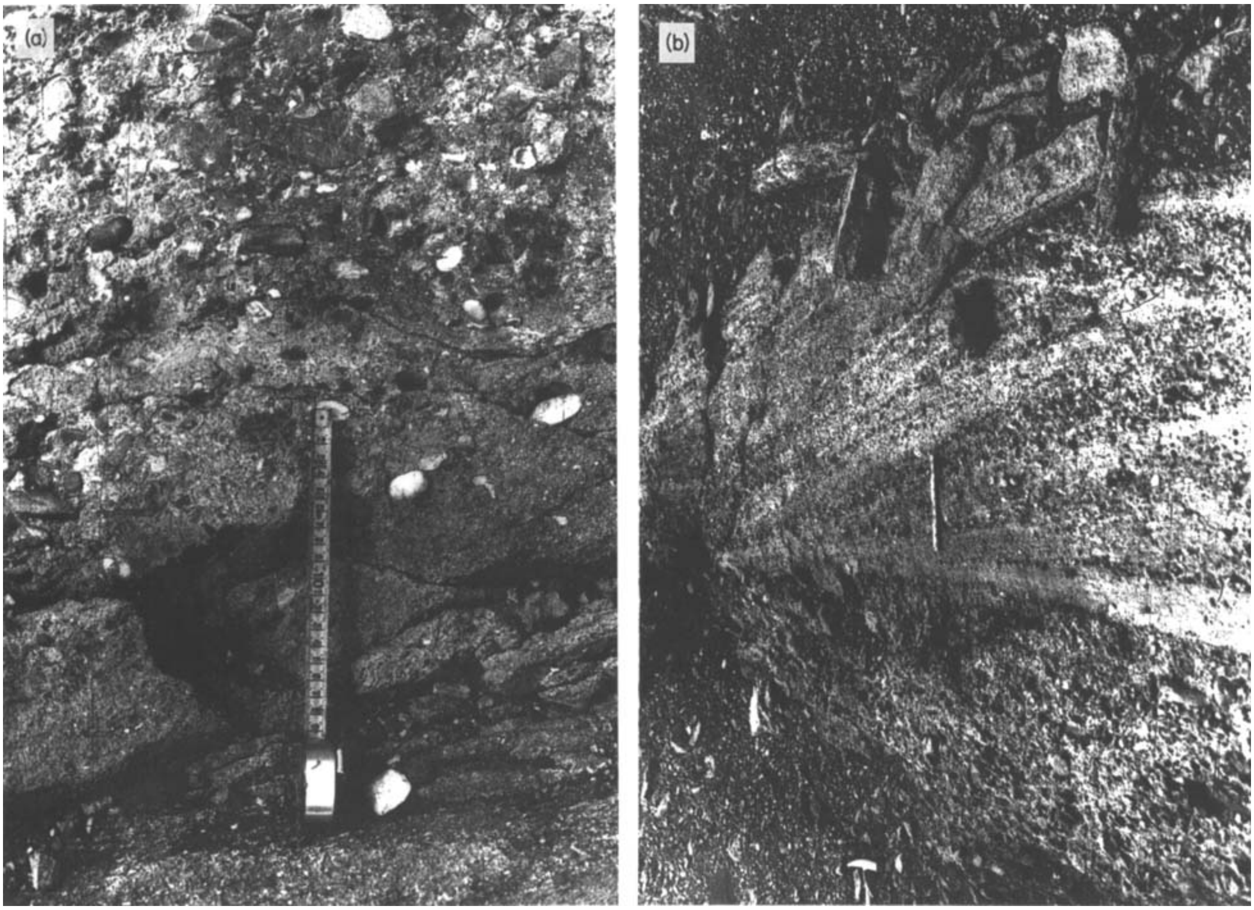

Fig. 5. Sedimentary facies. **a.** Facies 2, inversely graded conglomerate; scale in cm. **b.** Facies 3, normally graded coarse to fine-grained conglomerate (left) that passes upwards into a low-angle planar cross-stratified zone (right); hammer towards the base of the photo is 33 cm in length.

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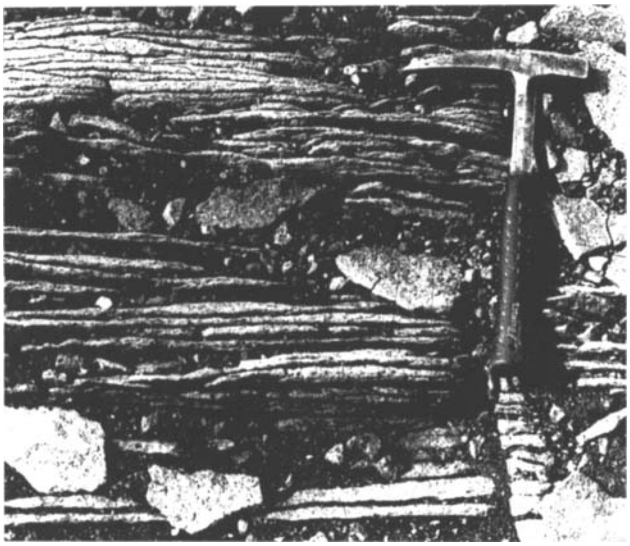

Fig. 6. Parallel stratified sandstones of facies 4; hammer is 33 cm in length.

Facies 2 invites comparison with the inverse to normally-graded bed type of Walker (1978, 1984), facies A2.2 (inversely graded gravels) of Pickering *et al.* (1986, 1989), and subfacies gG (graded gravels) of Ghibaudo (1992). This facies is thought to represent deposition from high density gravelly turbidity currents with predominant grain-size population 1 of Lowe (1982). According to him, sedimentation of the gravel involves freezing of a traction carpet resulting in an inversely-graded basal zone, followed by direct suspension sedimentation from a highly concentrated flow producing the normally-graded interval. Dispersive pressure played a significant role in this process (see also Nemec & Steel, 1984). Similar deposits have been described from the Whisky Bay Formation by Ineson (1989; subfacies 7b).

Facies 3: Normally graded to graded-stratified conglomerates and pebbly sandstones

This facies consists of greenish to yellowish grey, boulder, cobble and pebble conglomerates to pebbly sandstones, displaying normal grading and stratification (Fig. 5b). Commonly, a bed shows a normally graded, clast-supported, gravelly basal zone passing up into a normally graded-stratified, matrix-supported, sandier interval. Although individual beds display normal grading, strata of coarser grain size are repeated upwards throughout the bed. Stratification varies from diffuse through horizontal to rarely planar cross-bedding (Fig. 5b). Sand wedges up to 0.4 m thick may be present. Conglomerates are moderately sorted. Clast shape varies from well-rounded to subrounded, with a maximum size of 60 cm. The grain size of the matrix varies from medium sand to granule. Beds are commonly lenticular at a scale of 3–15 m, but locally may be laterally persistent up to 60 m, displaying lateral thickness changes. Lateral wedging over a few metres is also remarkably common. Individual beds are erosive to sharp-based and 0.4–5.3 m thick. Imbrication of a(p) a(i) type (Harms *et al.* 1975) is relatively common.

Facies 3 resembles facies A2 (organized conglomerates) of Walker & Mutti (1973), subfacies A_1 (organized conglomerates) of Mutti & Ricci Lucchi (1975), graded bed and graded-stratified bed type of Walker (1978, 1984), facies A1 of Mutti (1979), facies A2.3 (normally graded gravels) and A2.4 (graded stratified gravels) of Pickering *et al.* (1986, 1989) and subfacies gsG (graded to plane-stratified gravels) and gxG (graded to cross-stratified gravels) of Ghibaudo (1992). This facies is interpreted as having been deposited from high density gravelly turbidity currents with grain-size populations 1 and 2 of Lowe (1982). The presence of the described stratification types suggests traction deposition and velocity fluctuations (cf. Pickering *et al.* 1986). The normally-graded interval results from direct suspension sedimentation of the gravel. Similar conglomerate facies were described from the Whisky Bay Formation by López Angriman (1987, 1988; facies 2, 3 and 4); Ineson (1989; subfacies 7c and 7d) and Buatois & López Angriman (1992b; lithofacies 3, 4 and 6).

Facies 4: massive and parallel stratified sandstones

Facies 4 consists of yellowish grey, massive or parallel and weakly stratified very coarse to medium-grained sandstones. Pebbles and granules may be present, concentrated in a thin basal layer. The sandstones are well- to moderately sorted and grading is absent or poorly developed. Where present, stratification is defined by bands of sandstones up to 1.5 cm thick (Fig. 6). Beds are commonly tabular up to 70 m in extent or, more rarely, lenticular on a scale of a few metres. Individual beds are erosive to sharp-based and vary from 0.50–0.85 m thick. Pebbles and granules may be imbricated. Out-size clasts up to 12 cm across are locally present. Poorly preserved trace fossils (*Palaeophycus* isp., ?*Thalassinoides* isp.) occur rarely in this facies.

Facies 4 resembles facies B2 (massive sandstones without dish structure) of Walker & Mutti (1973), massive sandstones of Walker (1978, 1984), facies B1.1 (thick/medium-bedded disorganized sands) and facies B2.1 (parallel-stratified sands) of Pickering *et al.* (1986, 1989) and subfacies mS (massive sands) and sS (plane-stratified sands) of Ghibaudo (1992). This facies is thought to record sedimentation from high density sandy turbidity currents with predominant grain-size population 2 of Lowe (1982). The presence of stratification suggests freeezing of a series of thin traction carpets at the base of a high concentration flow with grain interaction producing imbrication. Massive sands indicate insufficient time for the formation of a bed-load layer or a traction carpet, recording deposition from grain-by-grain suspension fall-out or freezing of a dense cohesionless suspension (cf. Lowe 1982, Pickering *et al.* 1986). Similar facies were recorded from the Whisky Bay Formation by López Angriman (1987, 1988; facies 6), Ineson (1989; facies 3 and 4) and Buatois & López Angriman (1992b; lithofacies 7).

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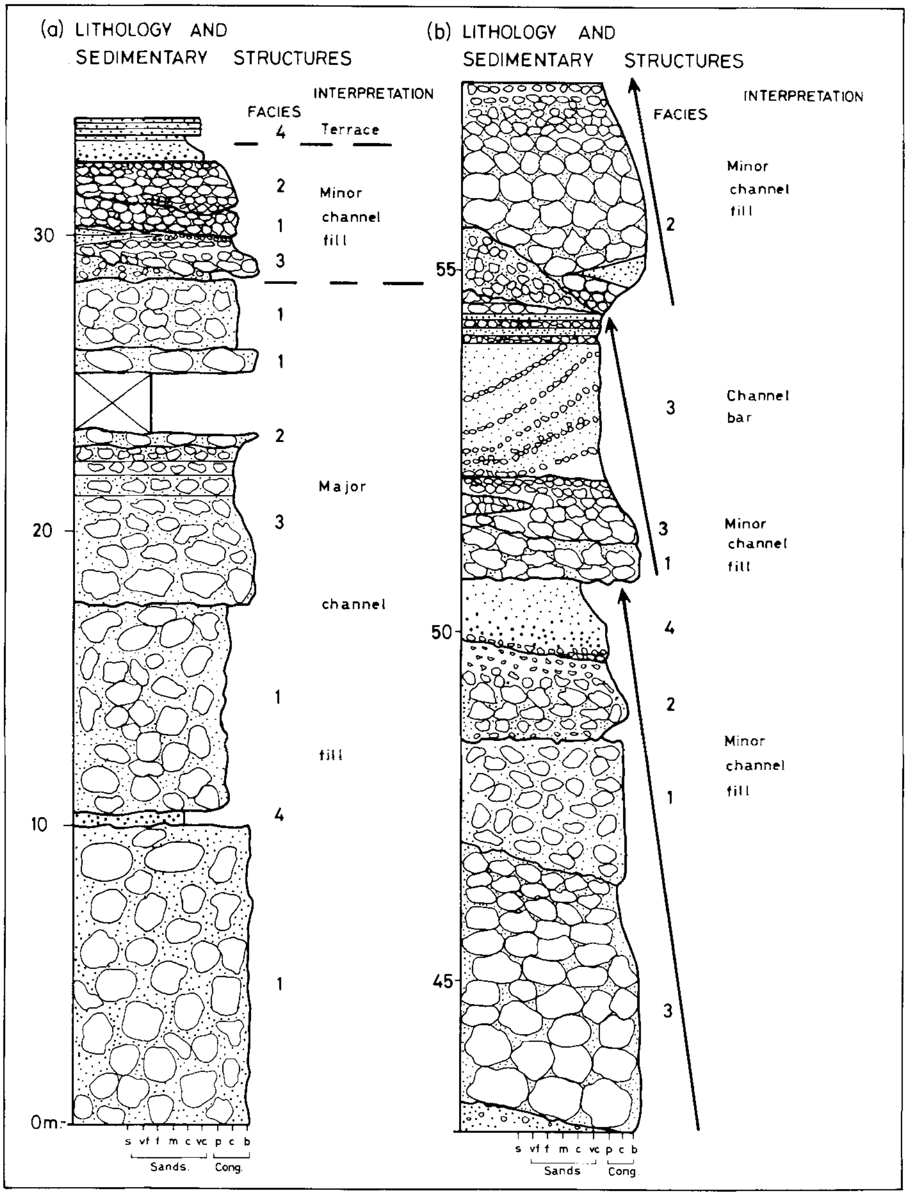

Fig. 7. Detailed sedimentological logs of selected intervals of the Lagrelius Point Formation section: **a.** Main channel sequence. **b.** Stacked cycles of minor channels in marginal terraces. (Modified from Buatois & López Angriman 1992a).

Depositional environment

We have distinguished two types of facies assemblages according to sedimentary body geometry and facies types. The *major channel assemblage* is dominated by facies 1 (disorganized conglomerates), but the other facies are locally present. The most striking features of these deposits are their considerable thickness and lateral persistence. The lower part of the section (*c.* 30 m thick) probably represents a main channel-fill (Fig. 7a). The base of the packet is not exposed, so reliable estimation of the actual thickness of the deposit is not possible. Individual beds can be traced in most cases for tens of metres, but grain size variations are frequent. The basal packet is remarkably continuous and can be traced for more than 100 m to where it forms inaccessible cliffs. Lateral wedging and lensing are less common than in the upper part of the studied sequence. Disorganized conglomerate beds are very thick (up to 10 m). Sandstone caps are rare and reflect periods of low discharge. Sedimentation in a deep, aggrading, major braided submarine channel is envisaged. Palaeocurrents from these deposits and directed towards the ESE (Fig. 8b). These deposits resemble the Coarse Channelled Association of Hein & Walker (1982), the Conglomerate Association, Assemblage A of Ineson (1989), the major channel deposits of Buatois & López Angriman (1992a) and Major braided channel Association of Buatois & López Angriman (1992b).

The *minor channel assemblage* consists of small-scale thinning and fining upward cycles (Fig. 7b). From base to top, a typical cycle is composed of facies 1 (disorganized conglomerates), 2 (inversely graded conglomerates), 3 (normally graded to graded-stratified conglomerates and pebbly sandstones) and 4 (massive and parallel stratified sandstones). However, variations to this general pattern can be detected. Sedimentation in the minor

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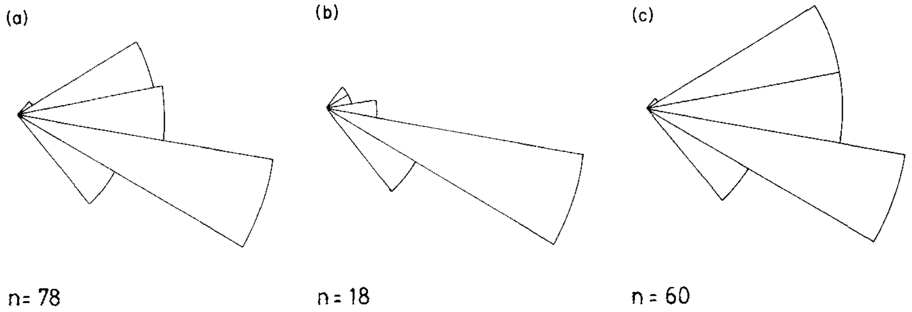

Fig. 8. Lagrelius Point Formation palaeocurrents. **a.** General. **b.** Major channel deposits. **c.** Minor channel deposits.

channels is recorded by the upper part of the section (about 50 m thick). Individual cycles range in thickness from 1.90–5.45 m. Beds tend to be laterally inpersistent and show a series of multiple scour fills. Wedging and lensing are remarkably abundant, commonly at a scale of a few metres. These deposits represent sedimentation in a marginal terrace adjacent to the major channel. Palaeocurrents from this assemblage are also directed predominantly towards the ESE, but with more dispersion (Fig. 8c). This fact may reflect more variability in the orientation of the minor channels than in that of the main channel. Facies 1, 2 and 3 record minor braided channel scouring and filling from non-cohesive debris flows and high density gravelly turbidity currents spilling out of the major channel. Facies 4, commonly more laterally continuous, is interpreted as representing deposition from high density sandy turbidity currents in a less channelled and finer-grained area of the marginal terrace. In one case, a pebble conglomerate and coarse-grained sandstone bed with planar cross-stratification was identified (Fig. 5b). The bed is 1.6 m thick and more than 10 m across, being replaced laterally by channelized deposits. This bed is interpreted as a small braid bar associated with the minor channels. Planar cross-bedding dips eastwards, suggesting formation by frontal accretion. These deposits favour comparison with the Multiple-Scoured Coarse Sandstones of Hein & Walker (1982), the Conglomerate Association, Assemblage C of Ineson (1989), the minor channel and marginal terrace deposits of Buatois & López Angriman (1992a) and the Terrace and minor braided channel Association of Buatois & López Angriman (1992b).

The Lagrelius Point Formation is interpreted as recording deposition from different types of sediment gravity flow. Palaeocurrents measured from clast imbrication throughout the section show a predominant direction towards the ESE (Fig. 8a). These results are consistent with those obtained by Ineson (1989, Fig. 8) from beds exposed farther south at Matkah Point. Walker (1978) pointed out that, in certain situations, a confusion between resedimented and fluvial conglomerates is possible. The Lagrelius Point sequence is devoid of marine body fossils and has only yielded trace fossils (*Palaeophycus* isp., ?*Thalassinoides* isp.), which are not reliable indicators of marine or non-marine conditions. *Palaeophycus* has been recorded from virtually every sedimentary environment and *Thalassinoides*, although more common in marine settings, is also known from non-marine deposits (Bradshaw 1981). Furthermore, the outcrops show no clear field relationship with other marine Cretaceous units. However, the presence of a(p) a(i) imbrication, as opposed to the fluvial a(t) b(i) imbrication, indicates resedimentation processes typical of deep marine settings (see Harms *et al.* 1975, Walker 1978).

In deep-water settings, two different environments are recognized for coarse-grained siliciclastic sediments: submarine fans and slope aprons (Choe & Chough 1988, Ineson 1989, Buatois & López Angriman 1992a). Both types of depositional system have been inferred from the Cretaceous Kotick and Whisky Bay formations (Ineson 1989). The distinction between debris aprons and submarine fans in the stratigraphical record have been discussed by different authors (e.g. Surlyk 1987, Choe & Chough 1988, Pickering *et al.* 1989). Coarse-grained deposits in slope aprons commonly form wedges at the base of slope and are typified by the absence of channels, the random pattern of facies organization and the extremely irregular geometry associated with a line source. Submarine fans are characterized by the lateral continuity of beds formed by channelized flows of point source and the presence of fining and coarsening-upwards cycles (Choe & Chough 1988, p.253). Nevertheless, some of the features that are considered typical of "classical" submarine fans, may be remarkably different in active margin basins. For example, active margin basin turbidite systems are typified by external controls, axial paleocurrent patterns, cyclic vertical growth and proximal-distal variations (Macdonald in press). In the present case, the scarcity of accessible exposures make it difficult to establish if the Lagrelius Point Formation represents deposition on a coarse-grained slope apron or in a submarine fan channel. However, features such as the erosive channelized surfaces, the thinning and fining-upwards cycles, and particularly, the types of facies involved, the lack of slide/slump deposits and the scarcity of debris flow sediments suggest deposition in a turbidite system as the most likely environmental setting. Specifically, a submarine braided channel system is envisaged. In addition, the clast composition points towards sedimentation in a submarine fan system. In the Lagrelius Point Formation, the coarse fraction is dominated by metasedimentary and volcanic rocks, indicating an arc and basement provenance. Ineson (1989) documented the different composition of the conglomerate clasts in the submarine fan and slope apron deposits from the Kotick Point and Whisky Bay formations. The submarine fan coarse-grained sediments consist of well rounded, arc-derived clasts, whereas those from the slope apron are dominated by intrabasinal clasts and angular Jurassic fragments, probably derived from fault scarps (Ineson 1989, p. 816).

As discussed above, the sedimentary facies of the Lagrelius Point Formation are comparable with those reported from the Albian–Coniacian Whisky Bay Formation (cf. Ineson 1985, 1986, 1989, López Angriman 1988, Buatois & López Angriman 1992a,b). The most important differences are the paucity of mudstone intraclasts and the absence of fine-grained deposits of sandy plain and interchannel origin in the Lagrelius Point Formation. The facies described here are also similar to those described from the Cambro-Ordovician of Quebec (Davies & Walker 1974, Hendry 1978, Johnson & Walker 1979, Hein 1982, Hein & Walker 1982), the Ordovician-Silurian of Newfoundland (Watson 1981) and the Cretaceous of Oregon (Walker 1977), California (Nilsen & Abott 1981) and Antarctic Peninsula (Farquharson 1982, Farquharson *et al.* 1984, Scasso & del Valle 1986, Scasso *et al.* 1986, Medina *et al.* 1989).

The Lagrelius Point section is thought to record the aggradation of a main submarine braided channel followed by the establishment and subsequent infill of a series of minor channels in a marginal terrace. The studied sequence may have developed under allocyclic or autocyclic controls. In the first case, it probably reflects a phase of progressive reduction of supply to the basin; alternatively the succession may represent a single cycle of braided channel switching.

Conclusions

The type section of the Lagrelius Point Formation is defined from the northern part of the outcrop, which extends from 1.5 km south of Lagrelius Point to Matkah Point. An 80 m-thick measured section represents the uppermost part of the formation and consists mainly of clast-supported, boulder, cobble to pebble conglomerates; very coarse to medium-grained sandstones occur rarely.

Four sedimentary facies are recognized: (1) disorganized conglomerates, (2) inversely graded conglomerates, (3) normally graded to graded stratified conglomerates and pebbly sandstones and (4) massive and parallel-stratified sandstones. Facies 1 is interpreted as having been deposited from non-cohesive debris flows and high density gravelly turbidity currents, facies 2 and 3 reflect sedimentation from high density gravelly turbidity currents, and facies 4 is thought to record deposition from high density sandy turbidity currents.

Two types of facies assemblages have been recognized according to sedimentary body geometry and facies types. The *main channel assemblage* is laterally persistent and very thick. It is dominated by facies 1 (disorganized conglomerates), but the other facies are locally present. These deposits are represented by the lower part of the measured section (about 30 m thick). The *minor channel assemblage* consists of small scale thinning and fining- upward cycles composed, from base to top, by facies 1, 2, 3 and 4, although variations to this general pattern are present. Sedimentation in these minor channels is recorded by the upper part of the section (about 50 m thick).

Current models envisage two distinct settings for deep-marine, coarse-grained sediments: submarine fans and slope aprons. Although the scarcity of exposures of the Lagrelius Point Formation makes differentiation difficult, features such as the erosive channelized surfaces, the small scale fining and thining-upwards cycles, and particularly, the types of facies involved, the absence of slide/slump deposits, the scarcity of debris flow sediments, and the arc and basement provenance of the detritus favour deposition in a channelized, turbidite submarine system. In particular, the Lagrelius Point section is thought to record the aggradation of a main submarine braided channel followed by the establishment and subsequent infill of a series of minor channels in a marginal terrace.

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