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Lower Cretaceous bivalve biostratigraphy of Antarctica

By

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With 7 text figures and 1 table

ABSTRACT

A preliminary sequence of inoceramid and buchiid bivalves can now be established for the Lower Cretaceous of Antarctica. Although taxonomic studies have yet to be completed, it is evident that there are representatives of several widespread species groups. On Alexander Island the Berriasian *I. ovatus* group is succeeded by the *neocomiensis*, *concentricus* and *anglicus* groups, which collectively have a Barremian–Albian age-range. The *neocomiensis* and *concentricus* groups are also present on James Ross Island and the latter may occur in Patagonia too. Valanginian–Barremian *Inoceramus* species are poorly represented, but there are records of both the *I. heteropterus* group (Hauterivian–Albian?) and *I.* cf. *anomiaeformis* (Hauterivian–Barremian) from Annenkov Island.

The lack of any Lower Cretaceous *Buchia* species in Antarctica may be further evidence of a stratigraphic hiatus during part of the Neocomian. There are, however, many Barremian–Albian buchiids referrable to the genus *Aucellina*. The *A. andina-radiatostriata* group is of particular importance as it occurs in all the major basins of deposition and can be used for local correlations.

A further characteristic element of Antarctic Lower Cretaceous faunas is the genus *Anopaea*. Its apparent confinement within the Southern Hemisphere to the Antarctic region indicates that at least some inoceramids had a much more restricted distribution.

KURZFASSUNG

In der Unterkreide der Antarktis kann eine vorläufige Abfolge mit Inoceramen und Buchiiden aufgestellt werden. Obwohl taxonomische Untersuchungen noch vervollständigt werden müssen, zeigt es sich, daß einige überregional weitverbreitete Artgruppen vorkommen. Auf der Alexander-Insel folgen über der im Berrias auftretenden *I. ovatus* Gruppe die *I. neocomensis*, *I. concentricus* und die *I. anglicus* Gruppen, die zusammen ein Barreme bis Alb Alter anzeigen. Die *I. neocomiensis* und die *I. concentricus* Gruppen finden sich auch auf der James Ross Insel, letztere kommt ebenfalls in Patagonien vor. *Inoceramus*-Arten aus dem Valangin-Barreme sind schwach vertreten, jedoch gibt es Funde sowohl der *I. heteropterus* Gruppe (Hauterive-Alb) als auch von *I.* cf. *anomiaeformis* (Hauterive-Barreme) auf der Annenkov-Insel.

Das Fehlen von Unter-Kreide *Buchia*-Arten in der Antarktis mag ein weiterer Hinweis sein für stratigraphische Lücken im Neokom. Es gibt jedoch Vertreter der Buchiiden, typisch für das Barreme-Alb, die der Gattung *Aucellina* angehören.

Die *A. andina-radiatostriata*-Gruppe ist von besonderer Bedeutung, da sie in allen großen Ablagerungsbecken auftritt und für lokale Korrelationen benutzt werden kann. Ein weiteres charakteristisches Element der unterkretazischen Fauna in der Antarktis ist die Gattung *Anopaea*. Die offensichtliche Beschränkung dieser Gattung auf die Antarktis innerhalb der südlichen Hemisphäre zeigt, daß zumindest einige Inoceramen eine regional sehr eingeengte Verbreitung besaßen.

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I. INTRODUCTION

Lower Cretaceous marine sediments can be traced along the Antarctic Peninsula, through the Scotia arc, and into southern South America (Fig. 1). Study of their biostratigraphy is of particular importance for they document both the early stages of break-up of the central regions of Gondwana, and the establishment of new marine biogeographic patterns that this entailed. To complement existing ammonite studies (THOMSON, this volume), a preliminary bivalve zonation of these Lower Cretaceous strata has now been established. This is necessarily incomplete, for taxonomic studies of a number of key groups are still in progress. The scheme is at present based on the two commonest groups, the inoceramids and buchiids, but it is hoped that it will eventually be extended to include other common types, such as the parallelodontids, pectinids and trigoniids.

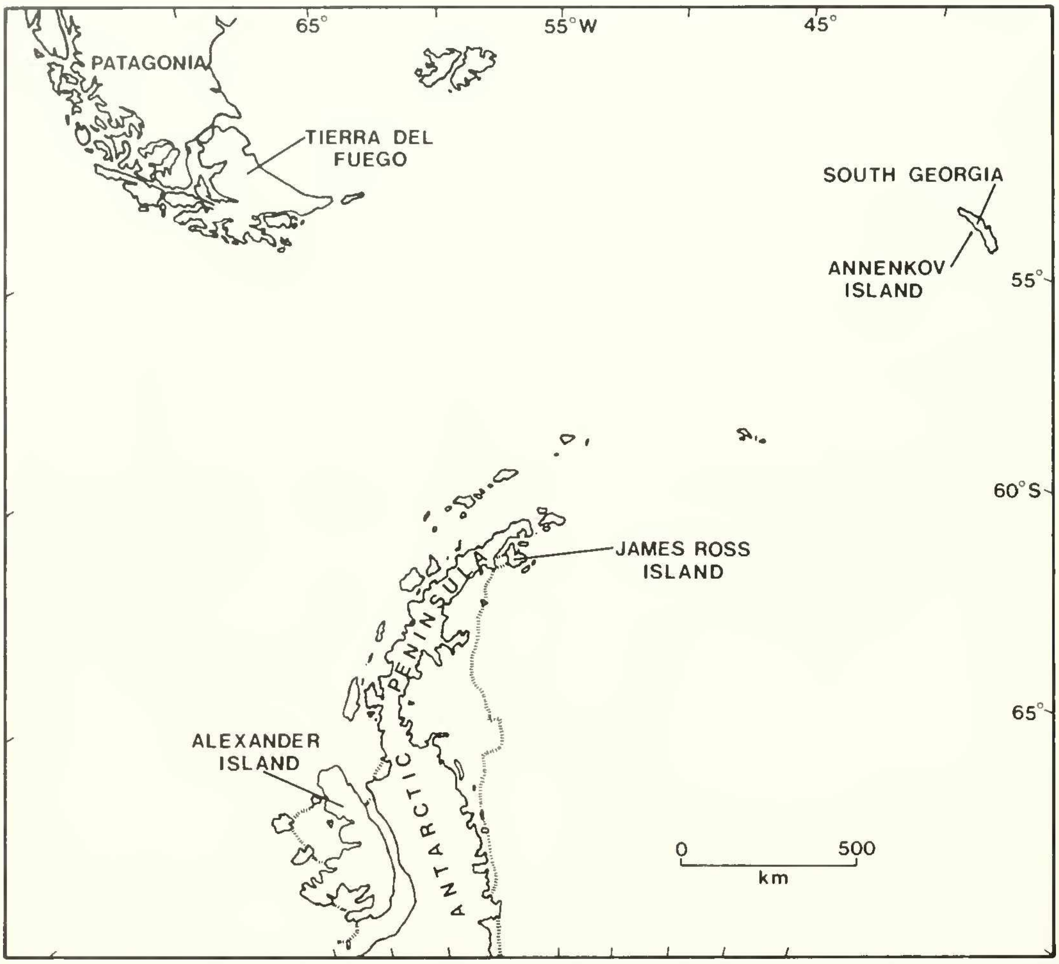

Fig. 1. Locality map for the Antarctic Peninsula–Scotia arc–Patagonia region.

II. ALEXANDER ISLAND

The Fossil Bluff Formation forms a narrow but continuous strip along the eastern margin of Alexander Island (Figs. 1 & 2). Composed of a variety of fine- to coarse-grained clastic and volcaniclastic sediments, it has a probable thickness of at least 5000 m and an approximate age-range of Kimmeridgian–Albian. Current interpretations suggest that the sediments accumulated in a fore-arc basin marginal to an extensive volcanic arc trending along the axis of the Antarctic Peninsula (TAYLOR, THOMSON & WILLEY 1979).

Antarctic Jurassic inoceramid faunas are dominated by members of the genus *Retroceramus*. The latest species, *R. everesti* (OPPEL), occurs in the highest Tithonian strata of the Fossil Bluff Formation at Callisto Cliffs (Figs. 2 & 3), and at both this locality and Tombaugh Cliffs (Figs. 2 & 3) can be traced up into strata of probable early Berriasian age (CRAME 1982) (Fig. 3). At an approximately equivalent level in the Ablation Valley section (Fig. 3), the first inoceramids referable to the genus *Inoceramus* occur in close association with

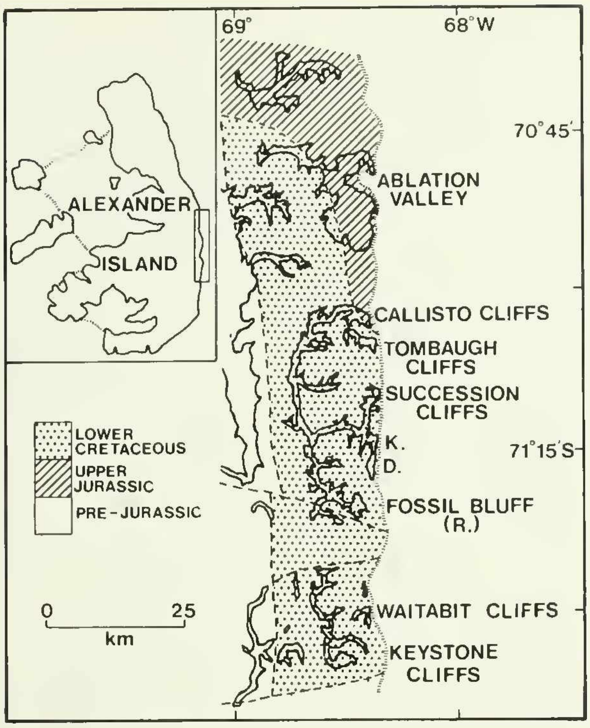

Fig. 2. Geological map of the central east coast of Alexander Island. – The Upper Jurassic and Lower Cretaceous strata constitute the Fossil Bluff Formation.

a Berriasian *(Haplophylloceras – Bochianites)* ammonite assemblage. The best-preserved of these specimens, which is small, slightly inequivalve and has a distinctive elongate-pyriform outline, can be referred to a group of species centred around *I. ovatus* STANTON. This species has a Neocomian (Berriasian–Valanginian) age in California and Siberia (ANDERSON 1938; ZAKHAROV 1968).

Although the uppermost beds of the Ablation Valley and Tombaugh Cliffs sections are not well exposed, it is likely that they correlate with a level just below the base of the section at locality K (Fig. 3). Diagnostic fossils are scarce at the latter locality, apart from specimens of an inoceramid that has been referred to the genus *Anopaea*. Rounded wedge-shaped in outline and with a distinctive anterior sulcus and lunule, this genus is interpreted as having been functionally endobyssate (CRAME, 1981). It characterizes the Upper Jurassic – Lower Cretaceous Boreal Realm of the Northern Hemisphere and may well have a mirror-image distribution in high latitude regions of the Southern Hemisphere. The two Jurassic species occurring in the lower levels of the Fossil Bluff Formation are distinct from *A. trapezoidalis* (THOMSON & WILLEY), the species present at localities K and D (Figs. 2 & 3) (CRAME 1981). Originally thought to be Berriasian, *A. trapezoidalis* may now be better assigned to an undifferentiated Neocomian age.

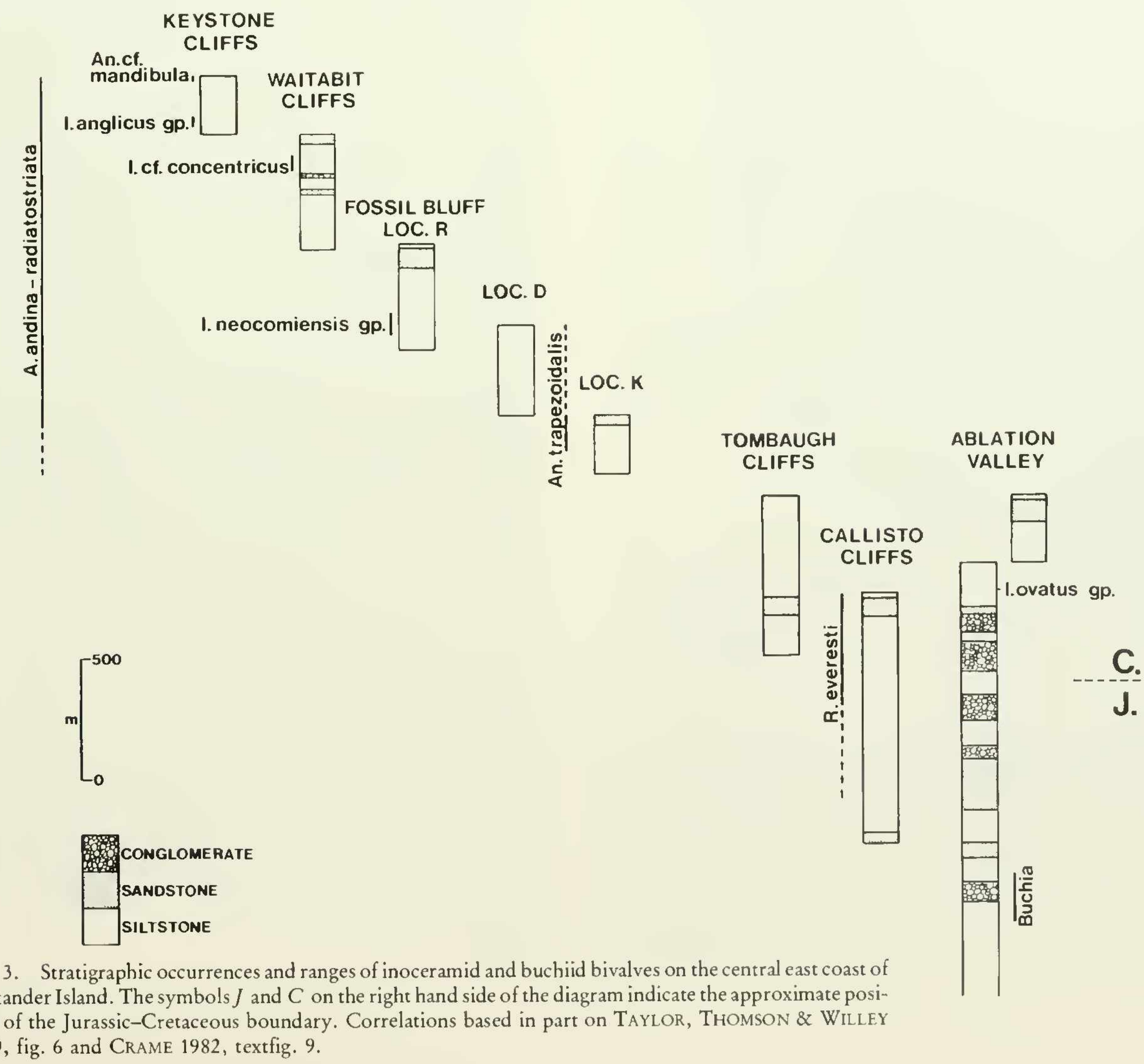

Fig. 3. Stratigraphic occurrences and ranges of inoceramid and buchiid bivalves on the central east coast of Alexander Island. The symbols *J* and *C* on the right hand side of the diagram indicate the approximate position of the Jurassic–Cretaceous boundary. Correlations based in part on TAYLOR, THOMSON & WILLEY 1979, fig. 6 and CRAME 1982, textfig. 9.

Numerous specimens of an *Inoceramus* belonging to the *I. neocomiensis* D'ORBIGNY group have been collected from the lower levels of the Fossil Bluff (locality R) section (Fig. 3). Weakly inflated and very slightly inequivalve, these specimens show the rounded-triangular outline and fine, regular ornament that are so typical of this group. Perhaps the greatest resemblances are to species such as *I. subneocomiensis* GLAZUNOVA and *I. obtusus* GLAZUNOVA from the Aptian of the Volga Basin (USSR) (GLAZUNOVA 1973). Although *I. neocomiensis* is generally regarded as an Aptian species (WOODS 1911), it has to be remembered that both it and other closely related forms have been recorded from the Neocomian and Barremian. There are several records of Hauterivian – Aptian age-ranges for the *I. neocomiensis* group in Europe (SORNAY 1965; GLAZUNOVA 1973) and these may well be extended down to the Valanginian around the northern Pacific margins (POKHIALAINEN 1974).

Representatives of two further cosmopolitan *Inoceramus* groups occur at a slightly higher stratigraphic level in the Fossil Bluff Formation. Specimens of the first of these, the *I. concentricus* PARKINSON group, were obtained from the upper levels of Waitabit Cliffs (Fig. 3). THOMSON and WILLEY (1972) assigned them to *I.* aff. *concentricus*, noting that, although they showed the pronounced gryphaeoid form of this species, they were somewhat larger than typical European specimens. Nevertheless, in his description of English material, WOODS (1911) emphasized the variable nature of *I. concentricus*, and it is apparent that in New Zealand many large forms have been found (WOODS 1917). The European age of the species is usually given as Middle – Upper Albian (e. g. WOODS 1911; SORNAY 1965; TRÖGER 1981), but certain members of the group also range into the Cenomanian in the Far East of the USSR, Japan and New Zealand (NAGAO & MATSUMOTO 1939; PERGAMENT 1966; RAINE, SPEDEN & STRONG 1981). The second group, which is based on *I. anglicus* WOODS, is represented by a series of specimens from Keystone Cliffs (Fig. 3). The *anglicus* group as a whole shows a number of marked similarities to the *neocomiensis* group, but can usually be distinguished by the steeper curvature of the concentric ribs, which are often symmetrically arranged, and the more convex outline of the anterior margin. The Alexander Island specimens closely resemble small forms of *I. anglicus* from both North America and the USSR (IMLAY 1961; SAVELIEV 1962; PERGAMENT 1965; GLAZUNOVA 1973); perhaps the greatest similarity is with PERGAMENT'S (1965) subspecies *I. anglicus elongatus*. A consistent Albian age has been assigned to the *anglicus* group, with most authors indicating a Middle – Upper Albian range (e. g. WOODS 1911; IMLAY 1961; PERGAMENT 1981). Finally, the stratigraphically highest inoceramid so far recorded from the Fossil Bluff Formation is a small *Anopaea* close to *A. mandibula* (MORDVILKO) from the Albian of Mangishlak (USSR) (SAVELIEV 1962) (Fig. 3).

Two species groups of the genus *Buchia* can be traced in the Tithonian strata of Ablation Valley (Fig. 3). At higher levels, however, the next specimens referrable to the Buchiidae are not encountered until approximately the lower levels of the locality K section. Here, the first representatives of the genus *Aucellina* are found, and these then become steadily more common through the sequence (Fig. 3). *Aucellina* bears a strong superficial resemblance to *Buchia*, but is distinguished by its more clearly defined radial sculpture and the long anterior ear and deep byssal notch of the right valve. Amongst the several collections of *Aucellina* made from southern South America and South Georgia, WILCKENS (1947) determined that only one species *(A. radiatostriata* BONARELLI) could be recognised. COX (1953), however, after considering this and further material from Alexander Island, thought that a second species *(A. andina* FERUGLIO) could be justified. Although MACELLARI (1979) upheld COX'S conclusions, it has become apparent, from study of further large collections from Alexander Island, that these two species may well intergrade. For this reason, they have been assigned to a single species group in this study. The age of *Aucellina* in the South America – Scotia arc – Antarctic Peninsula region has been consistently given as Aptian, largely on the basis of co-occurrence with certain types of aconeceratid and heteromorph ammonites (WILCKENS 1947; COX 1953). However, it now seems that some at least of these ammonites may range down into the Barremian (THOMSON, this volume), and in Patagonia *A.* cf. *radiatostriata* has been obtained from beds yielding the Hauterivian – Barremian ammonite, *Favrella* (RICCARDI 1971). As the topmost beds of the Fossil Bluff Formation very probably have an Albian age, the true range of the *A. andina-radiatostriata* species group in Alexander Island is best considered as Barremian–Albian.

The lack of any age-diagnostic bivalves between the Berriasian *I. ovatus* group of Ablation Valley and the Barremian – Albian species of Fossil Bluff, Waitabit Cliffs and Keystone Cliffs (Fig. 3) may yet prove to be of some significance. Species of *Buchia* are known to be particularly common in the Berriasian – Valanginian (e. g. IMLAY 1965; JELETZKY 1970; POKHIALAINEN 1974) and their apparent absence may point to a stratigraphic hiatus during part of this time. The same is true of the Hauterivian, for characteristic circum-Pacific Hauterivian *Inoceramus* groups (such as the *I. aucella, I. colonicus* and *I. heteropterus* groups, see e. g. PERGAMENT 1965; POKHIALAINEN 1969, 1974) are also missing.

At first sight, the ages suggested by the bivalves in the upper levels of the sequence correspond fairly well with those determined by ammonites. Barremian – Aptian ages for the *A. andina-radiatostriata* and *I. neocomiensis* groups accord with the occurrence of types such as *Aconeceras, Theganeceras* and *Acrioceras* at locality D and Fossil Bluff, and *Sanmartinoceras* in the lower levels of Waitabit Cliffs (Fig. 3) (TAYLOR et al. 1979). Species of *Eotetragonites* from higher in the latter section have Albian affinities, as do several ammonites from Keystone Cliffs (Fig. 3). However, it is apparent that there are also several forms from the uppermost levels of the Fossil Bluff Formation which show strong similarities to certain European Neocomian and Barremian species. Their presence is anomalous, and cannot at present be satisfactorily explained (THOMSON, this volume). Probable Aptian and Albian strata from the vicinity of Succession Cliffs (Fig. 2) associated with a prominent thrust zone have been excluded from this discussion.

III. JAMES ROSS ISLAND

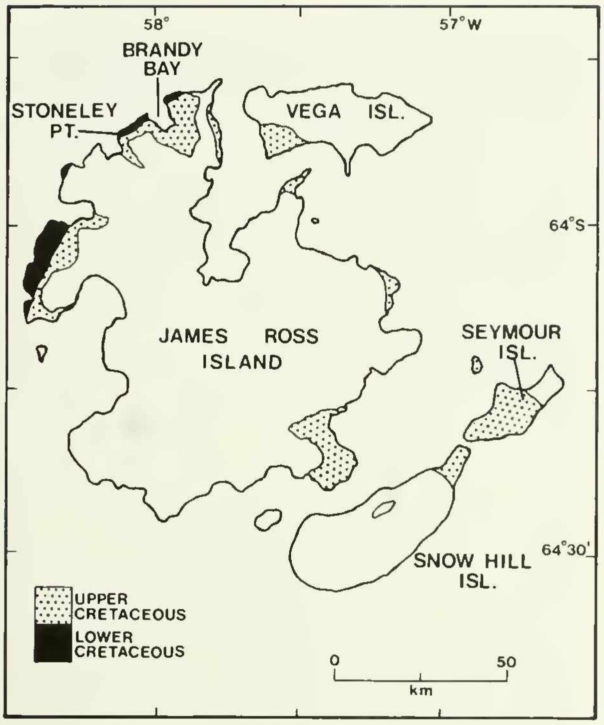

Fig. 4. The distribution of Lower and Upper Cretaceous strata on James Ross and neighbouring islands.

Traditionally regarded as being entirely Upper Cretaceous, the extensive sedimentary sequence exposed in the James Ross Island group (Figs. 1 & 4), is now thought to range down into the Lower Cretaceous. Recent investigations in the Brandy Bay – Stoneley Point region (Fig. 4) have indicated that both the Lower and Upper Kotick Point Beds and at least part of the Stoneley Point Conglomerates (BIBBY 1966) can now be assigned to this age. Collectively, these units comprise over 1500 m of strata which are composed of lithologies ranging from fine, bioturbated siltstones to coarse breccia-conglomerates (Fig. 5). They are interpreted as representing periods of quiet-water deposition (within a back-arc setting), punctuated by pulses of coarse debris flows.

The lowest beds in the sequence are poorly exposed and so far have not yielded any age-diagnostic fossils. However, in the topmost levels of sections D. 8209 & 8210, and in sections D. 8211 & 8212 (Fig. 5), a variety of material has been found. Prominent within this are small aconeceratid and ancyloceratid ammonites, and an *Inoceramus* which is very probably a member of the *I. neocomiensis* group. The latter is considerably smaller than the Alexander Island representative of this group, but has a sub-erect form and fine ornament pattern that link it to small European specimens of this species, such as those illustrated by HARBORT (1905), WOLLEMANN (1906) and GILLET (1924). There is also a strong resemblance to types such as *I. volgensis* GLAZUNOVA and *I. borealis* GLAZUNOVA, which are small Aptian members of the *I. neocomiensis* group from the Volga basin (GLAZUNOVA 1973). *Aucellina* is common at the same levels and it would seem that the range of variation shown by the specimens falls within that defined for the *A. andina-radiatostriata* group. *Anopaea* sp. occurs at locality D. 8212B, and in the upper part of the succession there is a level in which members of the *I. concentricus* group are common (Fig. 5). These specimens are smaller than their Alexander Island counterparts and, on the whole, much better preserved. The left valves have narrower, more elongated umbonal regions and overall the specimens are very close to European representatives of *I. concentricus* (e. g. WOODS 1911; SAVELIEV 1962).

Preliminary assessment of these fossils suggests that the strata between the base of the section and the prominent unconformity (Fig. 5) have an Aptian – Albian age. However, bearing in mind previous comments on the ranges of certain bivalves, it is possible that this sequence both extends down into the Barremian and up into the Lower Cenomanian.

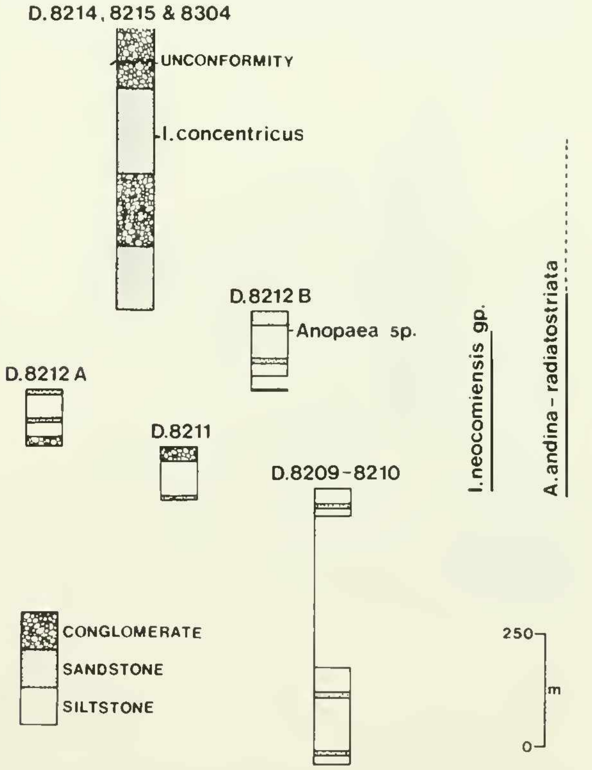

Fig. 5. Stratigraphic occurrences and ranges of inoceramid and buchiid bivalves in the Lower Cretaceous of James Ross Island. Localities D. 8209–8215 and 8304 are situated between Brandy Bay and Stoneley Point (Fig. 4).

IV. SOUTH GEORGIA AND ANNENKOV ISLAND

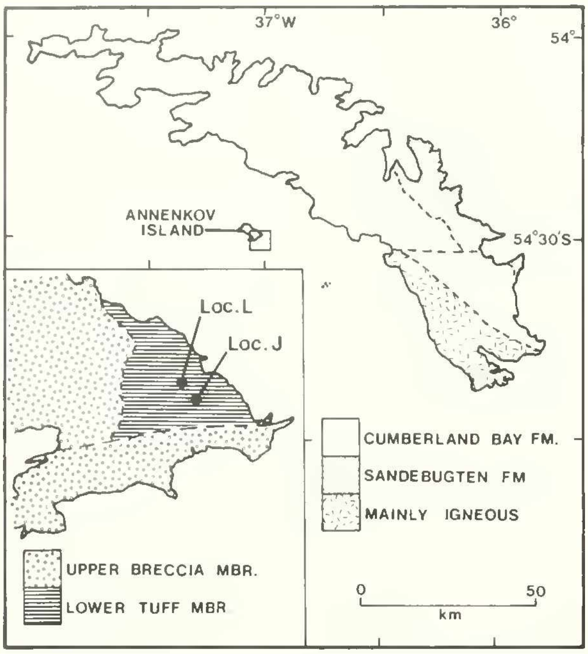

Fig. 6. Simplified geological maps of South-Georgia and the south-eastern corner of Annenkov Island. Based on TANNER 1982, fig. 18.1 and PETTIGREW 1981, fig. 2.

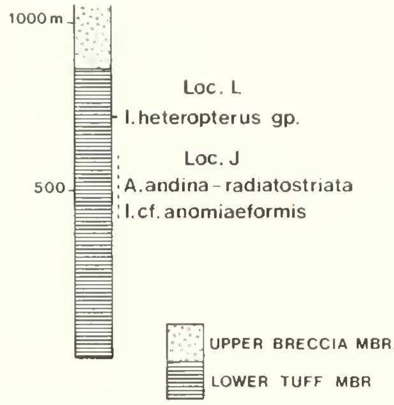

Fig. 7. Stratigraphic occurrences of Lower Cretaceous inoceramid and buchiid bivalves on Annenkov Island. The dotted line indicates the uncertainty as to the exact position of Locality J. Stratigraphic data from PETTIGREW 1981.

Remnants of an island arc – marginal basin system exposed in this region can be directly correlated with a comparable suite of rocks in southern South America (TANNER 1982). The island arc assemblages outcrop on a series of small islands lying off the south-west coast of South Georgia, the largest of which is Annenkov Island (Figs. 1 & 6). Here, a 1860 m sequence of volcaniclastic sediments has been divided by PETTIGREW (1981) into a Lower Tuff Member (860 m) and an Upper Breccia Member (1000 m). Tuffs and mudstones from the former of these units have yielded a variety of ammonites, but, unfortunately, these are all too badly preserved to be positively identified (THOMSON, TANNER & REX 1982). Their general Neocomian – Aptian affinities are confirmed by the presence of the *A. andina-radiatostriata* group, and perhaps also by an *Inoceramus* close to *I. anomiaeformis* FERUGLIO, at locality J (Figs. 6 & 7). The latter species is a small, circular, flattened form with markedly irregular ornament. It has no obvious close relatives and in Patagonia comes from strata of probable Hauterivian – Barremian age (RICCARDI 1977). A second species, from locality L (Figs. 6 & 7), is rounded-elongate in outline, strongly inequivalve and with narrow, pointed umbones on both valves. The ornament is very reduced and overall there are strong resemblances to members of the circum-Pacific *I. heteropterus* group (POKHIALAINEN 1969, 1974). The Hauterivian age of this group may, at first sight, make such a comparison seem unlikely, but studies in progress indicate a close link between *I. heteropterus* and later Cretaceous species such as *I. dunveganensis* MCLEARN (Albian) from Canada and Alaska and *I. procerus* WHITEHOUSE and *I. scutulatus* WHITEHOUSE (both Albian) from Australia. The *I. heteropterus* group may in fact range from Hauterivian – Albian. The only fossil so far collected from the Upper Breccia Member is a belemnite belonging to the Aptian – Albian genus, *Dimitobelus*.

Much of South Georgia is composed of the Cumberland Bay Formation (Fig. 6) which represents a thick sequence of rear-arc volcaniclastic turbidites (e. g. TANNER 1982). Fossils are scarce in this formation, but a few heteromorph ammonites with general Lower Cretaceous affinities have been found. In addition, *A. andina-radiatostriata* has been collected from several localities and is perhaps the best indicator of an early Cretaceous age (THOMSON et al. 1982).

VI. SOUTH AMERICA

Surprisingly little is known about the Lower Cretaceous inoceramid and buchiid bivalves of southern South America. Members of the *Aucellina andina-radiatostriata* group seem to be the commonest types, and can be traced through Tierra del Fuego (MACELLARI 1979) to several parts of Patagonia (e. g. COX 1953; KATZ 1963). Records of *I. concentricus* from the latter region (BONARELLI & NAGERA 1921; KATZ 1963) must be treated with some caution as they are based on very poorly known material.

VII. DISCUSSION

It is apparent that there are representatives of at least three cosmopolitan *Inoceramus* groups in the Lower Cretaceous of Antarctica. These are the *neocomiensis*, *concentricus* and *anglicus* groups, which can be used to infer maximum age-ranges of Hauterivian – Aptian, Middle Albian – Lower Cenomanian and Middle – Upper Albian, respectively. Besides their links with Northern Hemisphere faunas, these species groups may also prove useful for regional correlations in the Southern Hemisphere. An *Inoceramus* referrable to either the *neocomiensis* or *anglicus* groups occurs in the Motuan (Albian) stage of New Zealand and *I. concentricus* in the Ngaterian (Late Albian – Cenomanian) (RAINE et al. 1981); *I. concentricus* is also known from South Africa (HEINZ 1930). Representatives of two other widespread groups, the *ovatus* and *heteropterus*, are also present, but are less well known palaeontologically and stratigraphically.

The most useful bivalve for local correlations within the Antarctic Peninsula – Scotia arc – South America region is the *Aucellina andina-radiatostriata* group. Its widespread occurrence in all the major basins of deposition enables correlations to be made between the upper Fossil Bluff Formation, lower part of the James Ross Island succession, the Lower Tuff Member of Annenkov Island, Cumberland Bay Formation of South Georgia and Río Mayer and Zapata Formations of South America (Table 1). On a regional scale too, the group is of value, for *A.* cf. *radiatostriata* has been recorded from both the Upper Aptian Roma fauna of Australia (DAY 1969) and the Upper Aptian Korangan stage of New Zealand (RAINE et al. 1981). The *concentricus* and *neocomiensis* groups also offer some potential for local correlations, especially between Alexander Island, James Ross Island and South America (Table 1). However, the range of variation shown by these groups is such that, at present, no precise stratigraphical comparisons can be made.

The presence of several cosmopolitan and widespread bivalve groups could be taken as evidence of open marine connections between Antarctica and many other parts of the world during the Lower Cretaceous. However, there are at least two bivalve genera whose presence tends to counter against this suggestion. *Anopaea* seems to be restricted to high latitude regions in the Southern Hemisphere and, indeed, may even be confined to Antarctica. Similarly, the oxytomid *Maccoyella*, although unknown from Antarctica, is entirely restricted to Patagonia, New Zealand and Australia (WATERHOUSE & RICCARDI 1970).

			ALEXANDER ISLAND	JAMES ROSS ISLAND	ANNENKOV ISLAND	SOUTH GEORGIA	SOUTH AMERICA
Anopaea cf. *mandibula*	-	Albian	X				
Inoceramus anglicus gp.	-	M.- U. Albian	X				
I. concentricus gp.	-	M.- U. Albian	X	X			?
Anopaea sp.	-	Aptian - Albian		X			
Aucellina andina - radiatostriata	-	Barremian - Albian	X	X	X	X	X
I. neocomiensis gp.	-	Barremian - Aptian	X	X			
I. heteropterus gp.	-	Hauterivian - Albian (?)			X		
I. anomiaeformis	-	Hauterivian - Barremian			?		X
Anopaea trapezoidalis	-	Neocomian	X				
I. ovatus gp.	-	Berriasian	X				

Table 1. Ages and geographical occurrences of the principal species mentioned in the text.

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