

THE RANDOM FORMATION OF SOUTHEASTERN NEWFOUNDLAND: A DISCUSSION AIMED AT ESTABLISHING ITS AGE AND RELATIONSHIP TO BOUNDING FORMATIONS

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ABSTRACT. The Random Formation of southeastern Newfoundland is a sequence of orthoquartzites, sandstones, and siltstones that crops out on the Bonavista and Avalon Peninsulas (southeasternmost Newfoundland) and also in parts of the region west of the two peninsulas: islands in Placentia Bay, east side and southern end of the Burin Peninsula, Fortune Bay area. Until recently the sequence of sediments present westward from Placentia Bay was called the Blue Pinion Formation. Prior to its relationship with the Random being established, both sequences were studied separately.

In southeasternmost Newfoundland the Random Formation is overlain by early Cambrian sediments at all but two localities and underlain by late Precambrian rocks. The age of the formation and the conformable/disconformable nature of its boundaries in that region have been subjects of controversy since it was named and assigned to the Precambrian in 1900; its age there has subsequently been regarded as Precambrian, latest Precambrian to earliest Cambrian, and Cambrian.

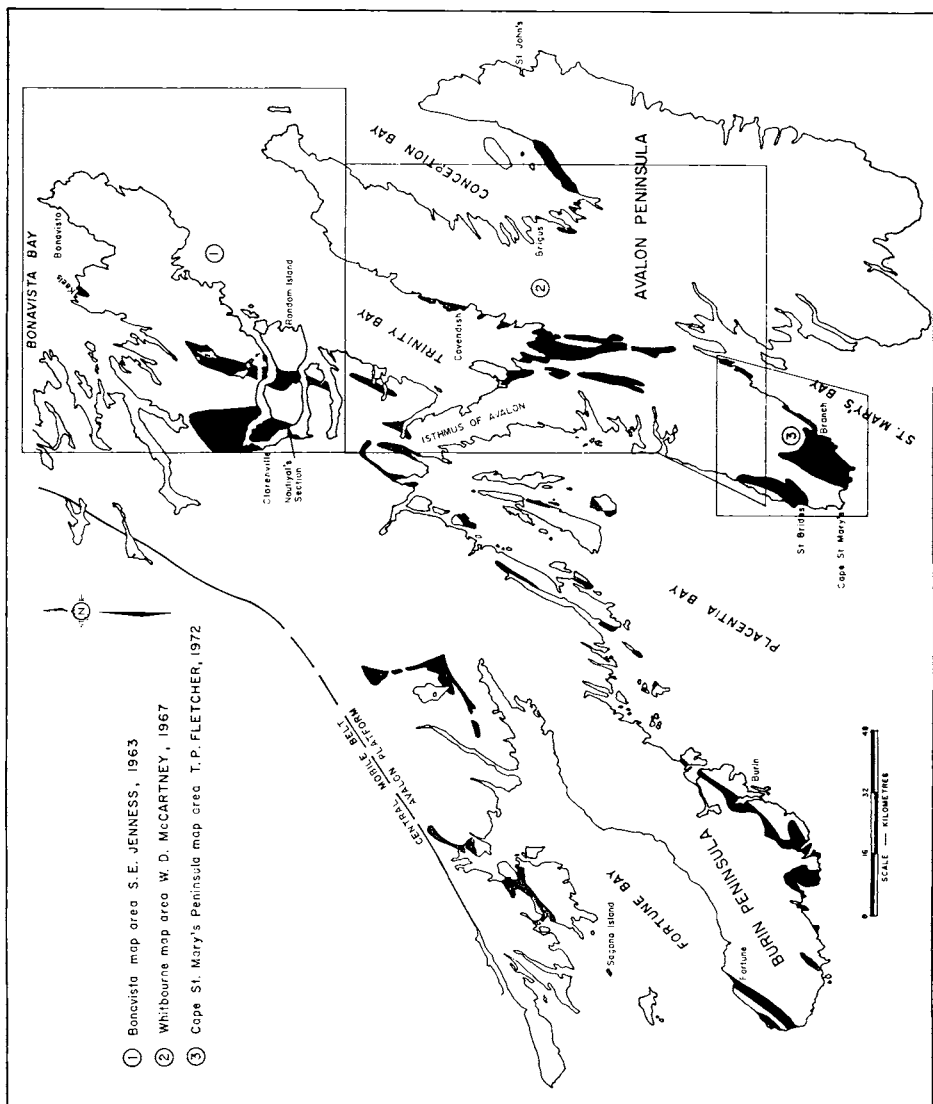
Westward from Placentia Bay the Random Formation is underlain conformably by fossiliferous sediments of earliest Cambrian age (Chapel Island Formation) and overlain from east to west by strata of early Lower Cambrian to Middle Cambrian age. Opinions differ as to both the overall age of the Random and the existence of a disconformity at its top in that region; its age has recently been given as early Lower Cambrian in the east (east side Burin Peninsula) and as early Lower Cambrian to early Middle Cambrian in the west (Fortune Bay area).

The most widely held view regarding the age of the Random Formation as a whole in southeastern Newfoundland is that eastward and westward respectively from about the center of Placentia Bay it ranges from late Precambrian to early Lower Cambrian and from late Precambrian to early Middle Cambrian.

The following conclusions have been reached as a result of the discussion of stratigraphic and palaeontological evidence pertinent to its aims. The Random Formation is of early Cambrian (Tommotian) age throughout southeastern Newfoundland, and it probably correlates with all but the uppermost part of the middle or *Dokidocyathus regularis* Zone of the Tommotian Stage, the basal stage of the Cambrian succession of the Siberian platform in the USSR, although it is possible that the lowermost part of the formation, limited to the region westward from Placentia Bay, is equivalent to the uppermost part of the underlying basal zone of the Tommotian Stage. The base of the Random is diachronous but not markedly so, because the diachronism falls well within the time-span of the Tommotian.

A disconformity exists at the top of the Random throughout southeastern Newfoundland; a disconformity is also present at its base except westward from Placentia Bay where the Random is conformable below with the Chapel Island Formation. Association of the Random with the Chapel Island Formation and its separation from other bounding formations by disconformities is accounted for by the following sequence of events: transgression from the west (sequential deposition of sediments of Chapel Island and Random Formations with the latter overstepping the former to rest disconformably on late Precambrian rocks in southeasternmost Newfoundland) — regression (loss of sediments of upper part of Random by erosion) — renewed transgression from the northeast (deposition of Cambrian sediments concomitant with advance of the sea over a land surface underlain by Random sediments; hence latter overlain progressively and disconformably by the former). The transgression referred to is the Cambrian transgression which began in southeastern Newfoundland slightly before the close of the Precambrian (lower part of Chapel Island Formation of latest Precambrian age).

The Lower Cambrian succession of southeastern Newfoundland comprises five rock-units (oldest to youngest): upper part of the Chapel Island Formation and the Random, Bonavista, Smith Point, and Brigus Formations.



INTRODUCTION

On the Bonavista and Avalon Peninsulas of southeastern Newfoundland (fig. 1) the Random Formation is a sequence of orthoquartzites, sandstones, and siltstones that overlies a variety of late-Precambrian rocks and underlies all presently exposed isolated remnants of fossiliferous Cambrian beds with two exceptions, both on the Avalon Peninsula.

The nature of the boundaries of the Random Formation on the two peninsulas and its age have been controversial subjects since 1900 when Walcott and Howley named the formation, and the former assigned it to the Precambrian (Walcott, 1900).

In western parts of the Avalon Peninsula, the presence of a major disconformity (shallow angular unconformity) beneath the Random Formation has been well documented by Hutchinson (1953), McCartney (1967), and Fletcher (ms). The Precambrian rocks of the Musgravetown Group in the Cape St. Mary's Peninsula area and of the Hodgewater Group (equivalent in part to the Musgravetown Group) in southeast Trinity Bay were very gently folded and strongly eroded during a prolonged interval of erosion that preceded deposition of Random sediments. Brückner, Choubert, and Faure-Muret (1977) consider that this interval may represent a period of some 300 Ma. Although confirmation is needed of an erosional period of that magnitude, it nevertheless appears to have been a very long one judging from the considerable thickness of Precambrian sediments known to have been removed from the areas affected during the period: 1800 m on the southeast shore of Trinity Bay (McCartney, 1967) and over 450 m in the southeastern part of Cape St. Mary's Peninsula (Fletcher, ms).

The basal Random sediments of the Random Island and Cape St. Mary's Peninsula areas commonly overlie rocks regarded by Fletcher (ms), on lithological and stratigraphic grounds, as belonging to the same formation (bearing different names locally) at the top of the Musgravetown Group. The presence of the same formation beneath the Random in both areas is inconceivable if it is accepted, as most authors have done, that after the Musgravetown sediments had been laid down, deposition continued uninterrupted in the Random Island area, while to the east and southeast (in western parts of the Avalon Peninsula), erosion of Musgravetown or stratigraphically equivalent sediments was taking place. Obviously if over a long period sedimentation had continued as envisaged, then a sedimentary sequence of considerable thickness should be present west and southwest of Trinity Bay separating the rocks of the Musgravetown Group from those of the Random Formation. Such a sequence does not exist. Clearly, in the Random Island

← Fig. 1. Distribution of the Random Formation together with overlying Cambrian deposits in southeastern Newfoundland; the Random Formation is not present beneath the Cambrian outcrops bordering Conception Bay (see footnote 7). Sediments underlying Lockers Flat Island (not shown), some 44 km northwest of Keels, are believed to represent the northernmost occurrence of the Random Formation. The areas mapped by (1) Jenness (1963), (2) McCartney (1967), and (3) Fletcher (ms) are outlined (distribution from Butler and Greene, 1976).

area, marine sediments at the base of the Random Formation must overlie continental Musgravetown sediments disconformably, even though they appear conformable or even gradational in the field. The lithological similarity of the basal Random sediments to those below is probably due, as Fletcher has suggested (ms, p. 88), to Random deposition having begun with a reworking of poorly consolidated Musgravetown sediment which gave rise to the apparent continuity of sequence.

The upper boundary of the Random Formation is also marked by a disconformity. The latter, which separates the Random from the overlying Lower Cambrian Bonavista Formation, is considered later in this introduction and in footnote 4.

The quartzites of the Random Formation are massive to thin-bedded, and they are characteristically white, although pink to red and purplish varieties are also widespread. Quartz granule and pebble conglomerate are associated with the quartzite in some areas. The sandstones are light to dark gray, gray-green, and, more rarely, red; true shales are rare. The proportion of quartzites to other rock types in the sequence is variable, from over 90 percent in some areas to less than 20 percent in others.

The preserved thickness of the Random Formation on the Bonavista and Avalon Peninsulas ranges from 2 to more than 165 m, but in most cases it is less, and commonly much less, than 90 m.

In the Fortune Bay area and on the Burin Peninsula (fig. 1) a quartzite-sandstone-siltstone unit, the Blue Pinion Formation (Widmer, ms), is regarded by Hutchinson (1962), Greene and Williams (1974), and Butler and Greene (1974, 1976) as part of the Random Formation, because in addition to resembling closely the Random lithologically it is also overlain disconformably by fossiliferous Cambrian sediments. A separate name for the "unit" is therefore unnecessary. On the east side of the Burin Peninsula the Random Formation is overlain disconformably by sediments of the upper part of the Bonavista Formation. Farther west the Bonavista Formation is unrepresented, and the Cambrian sediments above the Random range in age from late Lower Cambrian on the west side of the Burin Peninsula to early Middle Cambrian on the north side of Fortune Bay (Hutchinson, 1962).

The Random Formation west of Placentia Bay is underlain conformably by a thick sequence of sediments that rests unconformably, where the basal contact is exposed, on late Precambrian volcanic rocks. On the west side of the Burin Peninsula fossils are present in the upper part of the pre-Random sequence at several localities, and they have also been found near the top of the Random Formation on Sagona Island, Fortune Bay (fig. 1); the former are small shelly fossils resembling representatives of the non-trilobite fauna of the Lower Cambrian succession (as recognized by Hutchinson, 1962) on the Bonavista, Avalon, and Burin Peninsulas, and the latter are inarticulate brachiopods, tentatively identified as *Acrothele* and *Linnarsonia*, that are probably of latest Lower Cambrian or early Middle Cambrian age (Greene and

Williams, 1974). The fossil evidence thus indicates that on the west side of the Burin Peninsula the Random Formation is of early Cambrian age and that northward from there it may be time transgressive.

Greene and Williams (1974) conclude from their study of the Random Formation (fossil evidence for diachroneity, nature of upper contact at all known exposures, regional thickness, and facies variations) and from information obtained from Hutchinson's (1962) isopach map for the Bonavista Formation (fig. 2) that (1) its upper contact is gradational and conformable in Placentia Bay but becomes disconformable to east and west away from that central region, (2) the oldest sediments of the formation, of late-Precambrian age, lie close to the axis of a depositional trough which trends northeast from Placentia Bay through the western side of the Bonavista Peninsula, (3) Random sediments become younger to east and west of the axial region: Lower Cambrian on the east and west sides of Placentia Bay and on the east side of Trinity Bay. However, apart from the fact that an isopach map for the Bonavista Formation cannot be used to establish where the oldest sediments of the Random Formation were laid down, the boundary between the Random and Bonavista Formations in the Random Island area (close to the

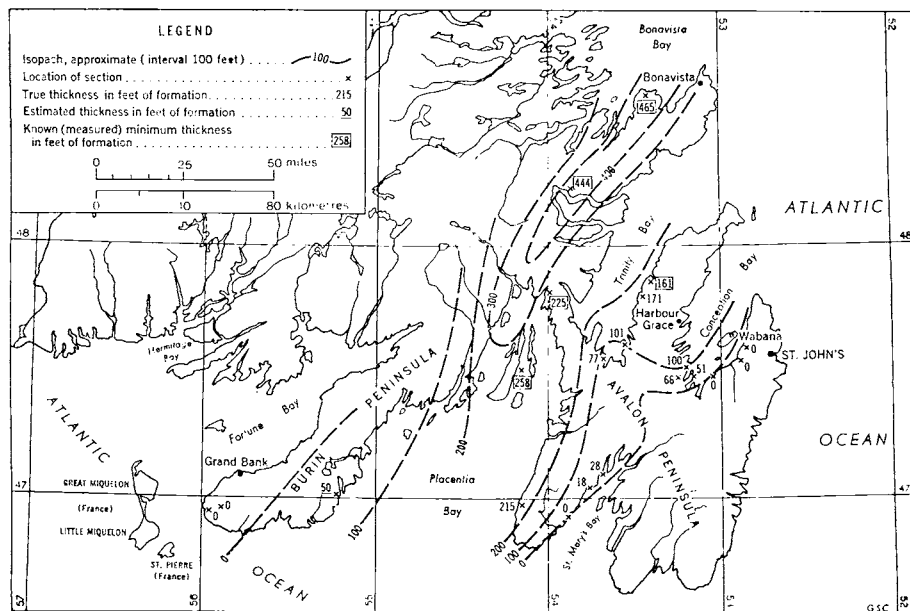


Fig. 2. Isopach map of the Bonavista Formation (after Hutchinson, 1962). The course of the marine transgression during which sediments of the Bonavista Formation were laid down over much of southeastern Newfoundland and the relative rate of advance of the sea across different parts of the region can be judged from the distribution of the isopachs and other thickness data shown on the map. Note however that the thickness of Bonavista sediments deposited in the "axial" part of Placentia Bay was greater than is apparent from the map because their thickness on the west side of Cape St. Mary's Peninsula is now known to exceed 92 m (Fletcher, ms).

northern end of the axis of the depositional trough of the Bonavista Formation) is not gradational and conformable but disconformable¹, and there is no evidence for the formation being as diachronous east of the west side of the Burin Peninsula as fossil evidence suggests it may be to the west of that peninsula. Furthermore, the stratigraphic sections of the Random Formation and adjacent units in figure 2 of Greene and Williams (1974, p. 322) do not portray accurately the age of the Random Formation at different localities between Fortune and Trinity Bays as intended, because thickness of sediments has erroneously been equated with time. The sections in figure 2 also make no allowance in terms of time for the disconformity thus making the age of the Random Formation at each of the localities shown even more inaccurate. It is evident from the preceding comments that Greene and Williams (1974) have not provided evidence establishing that the Random Formation is of late-Precambrian age on the Bonavista Peninsula and of Lower Cambrian age on the Avalon Peninsula.

Nautiyal (1976) described four species of filamentous blue-green algae from shales of the Random Formation exposed in a coastal section on Random Island in Trinity Bay (fig. 1). He also reported the presence of fungal remains in the same shales (p. 611, rock unit 33 of table 1 reproduced with omission of fossil names as table 1 of this paper) which he considers, on the basis of their algal content, as "undoubtedly of late-Precambrian age." In addition to the fossil microorganisms already mentioned, Nautiyal discovered acritarchs (named but not described or illustrated) in all the rock units of the section including those (32 and 31) he assigned to the Cambrian Chamberlain's Brook Formation of the Adeyton Group of Jenness (1963). The Adeyton Group includes four formations, in ascending order, the Bonavista, Smith Point, and Brigus of early Cambrian age and the Chamberlain's Brook Formation of early Middle Cambrian age (Jenness, 1963); the reference in table 1 to the last named being of "Early Cambrian age" appears to be a typographical error due to the omission of the word "Middle" from the statement.

The rocks of the succession described by Nautiyal crop out in low cliffs bordering the western half of a small bay between Fosters Point and Cock and Hen Point (a short distance to the northwest) on the south side of the western end of Random Island; both points owe their existence to resistant dikes of basalt. Steeply dipping siltstones and quartzites of the Random Formation are separated by faults from red shales with nodules of pink limestone of the Chamberlain's Brook For-

¹ Although Walcott (1900), Hutchinson (1962), Jenness (1963), and Fletcher (ms, p. 85) all recognized and discussed the nature of the disconformity in the Random Island area, Greene and Williams (1974) and Butler and Greene (1976) consider that the evidence for a disconformity is only significant in the western part of the Avalon Peninsula (Trinity Bay area: Hutchinson, 1953, McCartney, 1967; Cape St. Mary's Peninsula: Fletcher, ms). However, the disconformity is just as significant on the Bonavista Peninsula as it is in the western parts of the Avalon Peninsula, that is, it indicates that an erosional episode preceded the deposition of the Bonavista Formation in both regions (see, also, footnote 4).

mation to the west and black siliceous argillites (resembling chert) of the late-Precambrian Connecting Point Group to the east (presumably rock unit 35). The beds of the Random Formation are exposed only adjacent to the faults, that is, there are two outcrops, and the intervening part of the section is concealed beneath a grass- and tree-covered bank. The rocks of Nautiyal's rock units 32 and 31 are unlike those of the Chamberlain's Brook Formation at Cock and Hen Point, and the sediments of his rock units 34 and 33, which apparently resemble one another lithologically, cannot be matched with those of the outcrops of either the Random Formation or the Connecting Point Group west of Fosters Point. The color of all rock units (excluding 35) listed in table 1 is typical of the Random, but only rock unit 32 includes beds having lithologies characteristic of the formation. The possibility that the section described by Nautiyal (1976) is at another locality has been considered and rejected, because rocks of the Random Formation are not exposed elsewhere in the western part of Random Island. It is therefore assumed here that the lithology of three of the rock units has been incorrectly described and that all four belong to the Random Formation.

The filamentous blue-green algae found in rock unit 33 have been identified by Nautiyal (1976) as species of the ancient genera *Gunflintia*, *Heliconema*, and *Siphonophycus*. Apart from the stratigraphic range of

TABLE 1
Succession of rock units distinguished by Nautiyal in the section of the Random Formation that he studied on Random Island; data from his table 1 (1976, p. 3).

ADEYTON GROUP	
Chamberlain's Brook Formation:	
Unit 31: Shale, greenish-gray, non-calcareous, compact, and hard	20 ft (6.1m)
Unit 32: Shale and quartzite; shale, medium gray non-calcareous, partly papery, quartzitic, with thin bands of medium grained and greenish-gray quartzite	5 ft (1.5m)
Units 31 and 32, Early Cambrian age (after Jenness and also by Nautiyal method of this paper).	
Random Formation:	
Unit 33: Shale, medium gray, non-calcareous, compact, and hard, occasionally with some black carbonaceous inclusions Late Precambrian age (after Nautiyal method of this paper)	5 ft (1.5m)
Unit 34: Shale, medium gray, non-calcareous, compact, and hard, a fault (?) contact seems to be present between units 33 and 34	12 ft (3.6m)
Unit 35: Chert, light olive gray, non-calcareous, with sporadic distribution of fine grains of pyrite	3 ft (.9m)
Units 34 and 35, Late Precambrian age.	
Lower part of Precambrian sequence not incorporated.	

Formational nomenclature after Jenness (1963); color names given to rocks taken from Rock-Color Chart of the Geological Society of America, 1963.

the species described being unknown, similar filamentous forms occur in younger rocks and also exist at the present time so that they are of no value stratigraphically. Consequently their presence in rock unit 33 cannot be used as Nautiyal suggests (1976, p. 611) for assigning a Precambrian age to the Random Formation.

The age of the Random Formation on the Bonavista and Avalon Peninsulas has, as noted earlier, been a subject of controversy for many years. It has been recognized by different workers as (1) Precambrian (Walcott, 1900; Christie, 1950; Hutchinson, 1953, 1962; Jenness, 1963; Fletcher, ms; Nautiyal, 1976), (2) Precambrian or Cambrian (Hayes, 1948; alternatives 1 and 2 of McCartney, 1967, 1969), (3) Cambrian (Rose, 1948; North, 1971; Strong, 1974), (4) being diachronous and ranging from latest Precambrian to Lower Cambrian (alternative 3 of McCartney, 1967, 1969²) or from latest Precambrian to early Middle Cambrian (Greene and Williams, 1974; Butler and Greene, 1976). The discussion that follows is therefore concerned with establishing, from a study of the available paleontological and stratigraphic evidence, an age for the Random Formation (firstly on the two peninsulas and secondly throughout the region) as well as the relationship of the Random to bounding formations in different parts of southeastern Newfoundland. The Bonavista and Avalon Peninsulas are together referred to hereafter as southeasternmost Newfoundland.

At present the lower boundary of the Cambrian System is undefined in the sense that there is not an internationally accepted lower limit to the unit (Robison and others, 1977). For the purposes of this discussion the beginning of the Cambrian is taken as the base of the Tommotian, the lowest stage of the Lower Cambrian succession of the Siberian platform, currently the standard for correlation purposes. The time-span of the Tommotian Stage is approx 30 Ma (Cowie and Cribb, 1978). Trilobites make their first appearance in the geologic record as body fossils at the base of the succeeding Atdabanian Stage (Matthews and Missarzhevsky, 1975).

DISCUSSION

In southeasternmost Newfoundland the local stratigraphy sets imprecise upper and lower limits on a possible age for the Random Formation, because it is bounded above and below by disconformities representing unknown intervals of time that separate it from overlying and underlying sediments of, respectively, the early Cambrian Bonavista Formation and the late-Precambrian Musgravetown and Hodgewater Groups.

Early Cambrian as far as the Bonavista Formation is concerned means some time before the first appearance of a Lower Cambrian

² Although McCartney gave three alternative possible ages for the Random Formation, he clearly favored a Cambrian age, believing it to be "related to the initiation of the Cambrian depositional sequence rather than to a final stage of Precambrian sedimentation."

trilobite fauna (including the olenellid *Callavia broeggeri*) in the uppermost part of the overlying Smith Point Formation (Hutchinson, 1962; Fletcher, ms). Hutchinson (1962) included the beds without trilobites of the Bonavista and Smith Point Formations in a pre-trilobite faunal zone, *Coleoloides* Zone, that contains a variety of small shelly fossils mostly of small size (hyolithids, inarticulate brachiopods, gastropods, and other as yet undetermined forms). Although trilobites have not been found in this zone, they were undoubtedly living elsewhere well before the time the sediments of the uppermost part of the Smith Point Formation were deposited, as older trilobite faunas than that of the succeeding *Callavia* Zone (Hutchinson, 1962) are known from the Lower Cambrian of Western Canada, California, Siberia, Australia, China, and other places. Thus the sudden appearance of *Callavia* and other trilobites in abundance at virtually the same stratigraphic level throughout southeastern Newfoundland indicates that prior to that event, older forms had been unable to gain access to the sea occupying the region (see, also, p. 828), and that once a way was open migration of trilobites to all parts of the basin was relatively rapid. The upper part, at least, of the sedimentary sequence included in the pre-trilobite faunal zone of southeastern Newfoundland is evidently stratigraphically equivalent to strata containing trilobites in other parts of the world.

In addition to trilobites, brachiopods, and archaeocyathids, Lower Cambrian faunas include a variety of small shelly fossils belonging to a number of different groups of organisms (gastropods, hyolithids, hyolithelminthids, poriferids, tommotiids, anabaritids, and others) of known, uncertain, and unknown affinity (Matthews and Missarzhevsky, 1975, and references therein). The earliest representatives of most of these groups of organisms occur in rocks of the Tommotian Stage (in which trilobites have as yet not been found), but fossils of certain of the groups make their first appearance locally in Siberia in Precambrian strata immediately below the base of the Tommotian Stage (Rozanov, 1975). (Whether or not the fossiliferous Precambrian strata should be included in the Cambrian is a subject of controversy). Small shelly fossils are therefore an important element of the fauna of the oldest accepted Cambrian, the Tommotian Stage, which also includes inarticulate brachiopods and archaeocyathids. Archaeocyathids are however less widely distributed than the shelly fossils so that the former are unrepresented in some Lower Cambrian (Tommotian) sequences. Furthermore in some parts of the world in facies contemporaneous with those containing shelly fossils (or shelly fossils and archaeocyathids), such fossils are rare or absent, and trilobite trace fossils including *Rusophycus* (resting excavation) and *Cruziana* (furrow) as well as non-trilobite traces are present.

Trace fossils resulting from the activities of trilobites thus provide evidence for the existence of older and more primitive forms than those

that first appear in the geological record as body fossils³, and they are known from almost the base of the Cambrian system. Consequently in strata below those containing trilobite body fossils, traces showing the existence of trilobites and traces made by other organisms that do not occur stratigraphically below the lowest trilobite traces indicate an early Cambrian age for the sediments with which they are associated (Alpert, 1977). The importance of trace fossil assemblages contemporaneous with shelly forms elsewhere as stratigraphic indicators for distinguishing Lower Cambrian (Tommotian) sediments where shelly fossils are unrepresented has been demonstrated by Daily (1972).

Correlation of the Lower Cambrian succession in southeastern Newfoundland (as recognized by Hutchinson, 1962) with the Lower Cambrian sequences of, respectively, the Comley area of Shropshire, England and the Siberian platform of the USSR (see app.) suggests that the lower part of the Bonavista Formation is equivalent to the upper part of the Siberian Tommotian Stage. This portion of the Tommotian Stage is included in the *Dokidocyathus lenaicus*-*Majatheca tumefacta* Zone, the uppermost of the three zones (based on the occurrence of *Archaeocyatha* and *Hyalithelminthes*) into which the stage has been divided. If the base of the Bonavista Formation is no older, or only slightly older, than the lower limit of the *Dokidocyathus lenaicus*-*Majatheca tumefacta* Zone, there is room in the Lower Cambrian (in relation to the Russian scheme) to accommodate the Random Formation. However, the disconformity separating the Bonavista and Random Formations has to be taken into account. Clearly the shorter the time interval that it represents, the greater the likelihood of the age of the whole of the Random sequence being equivalent to that of part or all of the Siberian Tommotian succession beneath the *Dokidocyathus lenaicus*-*Majatheca tumefacta* Zone.

Little information is available regarding the extent (in terms of thickness) to which the Random sediments were eroded following their uplift⁴. However, isopach maps for the Random Formation (Butler and

³The oldest known trilobites are those in which the carapace first became sufficiently strongly mineralized to be readily fossilizable. Earlier trilobites, since they left traces, must have had appendages rigid enough to excavate burrows and imprint the surface of the sediment over which they walked, but their dorsal integuments were either completely chitinous or so weakly mineralized that they escaped fossilization (Daily, 1972). A similar view regarding the presence of "soft-bodied" trilobites in the early Cambrian has been expressed by Crimes (1975). Furthermore, from his study of the Middle Cambrian Burgess Shale fauna, Conway Morris (1979) concluded that "the pervasive idea that certain groups must have had hard parts to function effectively is negated by the presence of relatives (for example *Naraoia* among trilobites, Whittington, 1977) with fragile cuticles." Thus "soft-bodied" trilobites did exist in the Middle Cambrian, and therefore there is no reason for supposing that such forms were not present in earlier times.

⁴In the southwestern part of the Avalon Peninsula (Cape St. Mary's Peninsula), Fletcher (ms) found that pre-Cambrian (that is, pre-Bonavista) erosion was responsible for the removal of some 90 m of Random sediments in the Redland Cove area. Examination of the Random-Bonavista contact in the Random Island area shows that the latter rests on different Random beds at different localities (Milton: on gray-green siltstones; Petley: on reddish quartzitic sandstone; 1.2 km east of Hickmans Harbour: on white quartzite). The erosion surface beneath the Bonavista Formation is even in some places, uneven in others; it is overlain by a generally thin layer of granule to pebble conglomerate commonly with a calcareous cement or by stromatolitic limestone containing scattered pebbles.

TABLE 2
Lower Cambrian lithostratigraphic and biostratigraphic units (including those of Cobbold), Comley area, Shropshire, and equivalent units of southeastern Newfoundland.

		Comley		Southeastern Newfoundland	
Rock Units	Subdivisions of Cobbold	Zones	Zones	Rock Units	
Lower Cambrian	Lower Comley Limestones	Ad <i>Lapworthella nigra</i> Cobbold	Protolenid-Strenuella	4 zones††	Brigus Formation
		Ac ₅ <i>Protolenus</i>		Proto-lenus	
		Ac ₄ <i>Strenuella</i>		Strenuella	
		Ac ₃ <i>Eodiscus bellimarginatus</i> (Shaler & Foerste)*		Serrodiscus	
	Lower Comley Sandstone	Ac ₂ (Red <i>Callavia</i> Sst.) Callavia	Olenellid	Callavia	Smith Pt. Fm.
		Ac ₁ (Green <i>Callavia</i> Sst.)			
		Ab ₃ <i>Kjerulfia</i> (?) <i>lundgreni</i> (Moberg)**			
	Lower Comley Sandstone	Ab ₂ <i>Hyalithes de geeri</i> (?) Holm	Non-Trilobite	Coleoloites	Bonavista Fm.
		Ab ₁ <i>Obolella</i> (?) <i>groomi</i> (Matley)			Unconformity
		Aa One fragment of a horny brachiopod†			Unrepresented
Wrekin Quartzite	Unconformity			Random Fm.	
	Precambrian				

* This species is now referred to *Serrodiscus* R. and E. Richter.

** Claimed to be *Fallostaspis*? by Hupé (1953, pp. 102, 127).

† Also, according to Raw (1936, p. 238), a single Mesonacid fragment. The fragment has since been lost, and it appears unlikely that it was found in the Wrekin Quartzite; Raw did not collect the fragment himself.

†† Not directly correlatable (Fletcher, ms).

Greene, 1976) and the disconformably overlying Bonavista Formation (Hutchinson, 1962) show a remarkable resemblance to one another (despite the former depicting variations in preserved thickness and the latter depicting variations in original thickness) which suggests that most of the loss of Random sediments took place contemporaneously with the deposition of Bonavista sediments during the time it took the sea to advance gradually across much of southeasternmost Newfoundland. Obviously in any one place erosion preceded deposition. It follows that erosion of Random sediments continued longest in those parts of the region that were the last to be transgressed or were still above sealevel at the end of Bonavista time. Random sediments still above sealevel at that time were inundated shortly afterward as the sea continued its advance.

The sea entered the region from the north at the beginning of Bonavista time, initially advancing southwestward across the Bonavista Peninsula (Hutchinson, 1962); its subsequent progress can be gauged from figure 2, Hutchinson's (1962) isopach map for the Bonavista Formation. The preserved thickness of the Random Formation is in general greatest close to the axial region of the basin in which Bonavista sediments were deposited, that is, where the oldest sediments of that formation are to be found. It can therefore reasonably be assumed that, prior to the initiation of Bonavista sedimentation, the interval of Cambrian time during which Random sediments were exposed to erosion was relatively short. Consequently there is room in the Lower Cambrian to accommodate the Random Formation. However, before that can be done it has to be established that the formation is partly or entirely of early Cambrian (Tommotian) age.

The following is a listing of the acritarchs found by Nautiyal (1976) in rock units 34 to 31 of the coastal section of the Random Formation he studied on Random Island:

Unit 31: *Leiosphaeridia* sp. 1, types 1 and 2, *L. cf. granulata*, *Leiofusua filifera*.

Unit 32: *Archaeohystrichosphaeridium* sp. 2, *Baltisphaeridium* sp. 1, *Leiosphaeridia* sp. 1, types 1 and 2, *Leiofusua filifera*, *Multiplicisphaeridium lancarae*, *M. martae*, *Nucellosphaeridium* sp. 2, and *Orycmatosphaeridium* sp. 1.

Unit 33: *Leiosphaeridia* sp. 1, types 1 and 2, and *Leiovalia ovalis*.

Unit 34: *Nucellosphaeridium* sp. 1.

(Note: *Archaeohystrichosphaeridium* = *Baltisphaeridium*: Downie and Sarjeant, 1963).

This assemblage of acritarchs is not characteristic of either the latest Precambrian or the early Cambrian, and some of the forms stated to be present have, judging from their known ranges, undoubtedly been misidentified. Consequently no reliance can be placed on the identification of the most significant of the acritarchs listed, that is, *Baltisphaeri-*

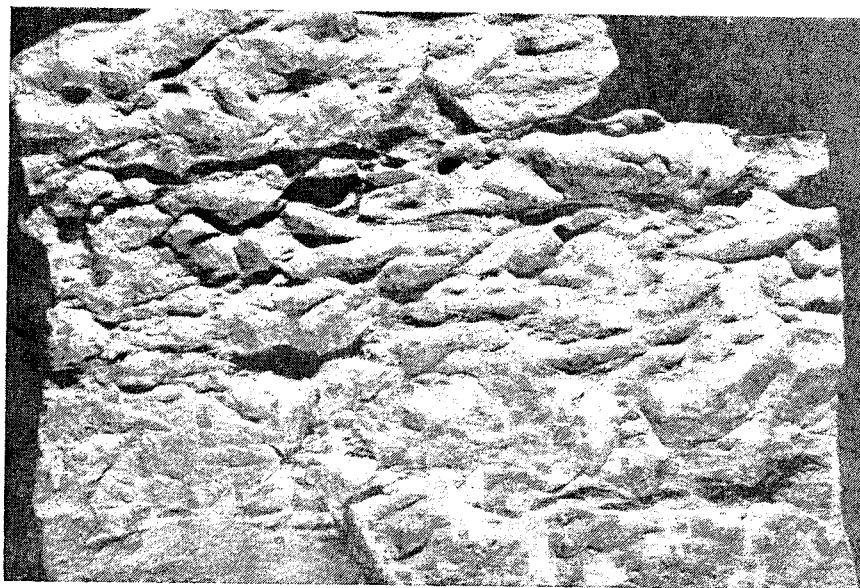
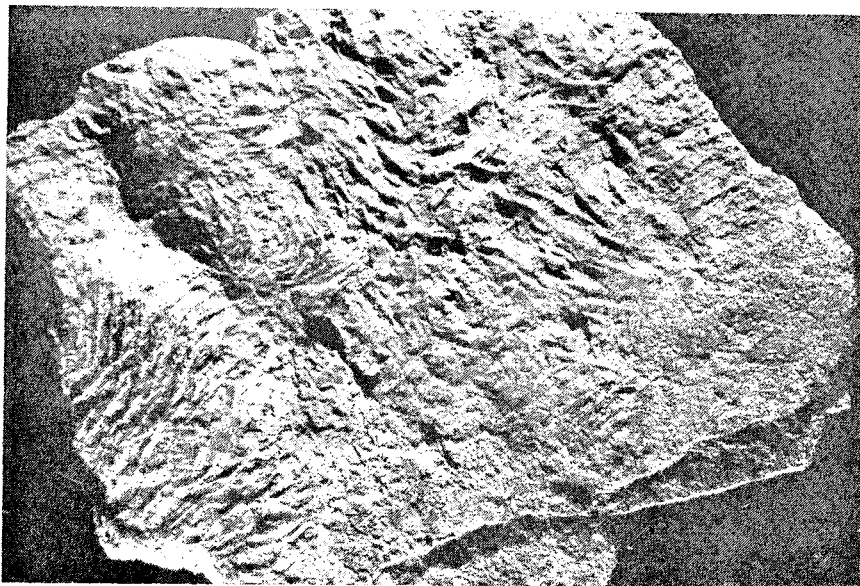
dium, the presence of which would otherwise provide evidence for a Cambrian age for the Random section (Potter, 1974). Nevertheless, Nautiyal's assignment of several of the acritarchs in rock units 33 to 31 to genera characterized by spines or other processes suggests that the assemblage is Cambrian or, more precisely (since the Random is of pre-Atdabanian age), Tommotian rather than late-Precambrian because spiny or acanthomorph acritarchs are rare in the latter⁵.

In addition to acritarchs, the Random Formation contains trace fossils, some of which provide evidence for a Tommotian age for much of the formation. Thus recent finds by Professor B. Daily (Univ. Adelaide) and the writer of simple to more complex types of trace fossil (to be described elsewhere), including traces of trilobite and non-trilobite origin indicative in the present context of a Tommotian age, on bedding surfaces of the middle and upper parts of the Random Formation show that the greater part of the formation is of that age. Only one diagnostic trace of each category (Alpert, 1977, p. 6) need be mentioned here: *Monomorphichnus* of trilobite origin and *Phycodes*, closely resembling *P. pedum*, of non-trilobite origin. The former (pl. 1-A) consists of a series of paired ridges 2 cm or slightly more in length made by the clawed limbs of trilobites during their swimming-grazing manner of locomotion (Crimes, 1970), and the latter (pl. 1-B) is a featherstitch pattern of tunnels made by a sediment feeding probably wormlike burrowing animal. Some authorities consider that trilobite traces are not present in strata of pre-Atdabanian age (despite the fact that the earliest trilobites known as body fossils did not arise *de novo*), but it is immaterial here whether the traces shown in plate 1-A were made by trilobites or by some other large arthropod with clawed limbs, because such traces have not been found associated with sediments of Precambrian age.

Paleontological evidence of another kind confirms that much of the Random Formation is of Tommotian age, namely the successive appearance in time of trace fossils, shelly fossils, and trilobite body fossils (faunal sequence) which is evident in the Lower Cambrian succession of all the remnants of the eastern margin of Iapetus other than Cape Breton Island (relevant information lacking) even where one element of the faunal sequence is unrepresented as in eastern Massachusetts (trace fossils apparently missing in basal quartzites, Theokritoff, 1968) and in Scania (trace fossil assemblage followed by trilobites + shelly fossils, Martinsson, 1974; Daily, 1972). In southeasternmost Newfoundland the trace fossil assemblage is present in the Random Formation. Consequently, if the Random Formation is excluded from the Cambrian, it creates an anomalous situation in that region which does not exist elsewhere, that is, trace fossils of complex types, some made by trilobites (or other arthropods), making their first appearance

⁵The presence of ornamented and unornamented acritarchs (as yet unidentified) in siltstones of the Random section west of Fosters Point has recently been confirmed by Grace Parsons (personal commun.). The former are less abundant than the latter but by no means rare.

PLATE I



(A) *Monomorphichmus* sp. $\times 1$. (B) *Phycodes* cf. *Phycodes pedum* Seilacher $\times 1$. Both specimens from coastal outcrop at Milton, immediately north of Clarendville fig. 1).

in the latest Precambrian instead of early in the Cambrian. On the other hand, if the Random Formation is included in the Cambrian, the trace fossils are then in their correct stratigraphic position in relation to Cambrian sequences elsewhere, and the local faunal sequence is complete.

Only simple types of trace fossil have so far been found in the lower part of the Random Formation in southeasternmost Newfoundland, and since they are not useful for establishing its age, it is necessary to look at previously unconsidered stratigraphic evidence, both local and from outside Newfoundland, that may help to establish whether or not the entire thickness of the formation in that region is of Tommotian age.

The presence of a major stratigraphic break beneath the Random Formation in southeasternmost Newfoundland, referred to in the Introduction, clearly rules out any possibility of the Random being part of the underlying late Precambrian Musgravetown and Hodgewater Groups. There is, therefore, no longer a compelling reason for considering the lower part of the Random Formation in the region to be Precambrian. Nevertheless the transgression that initiated Random sedimentation could have begun before the close of the Precambrian. However, as far as the writer is aware, a transgressive sequence resulting from a transgression commencing in the latest Precambrian and clearly distinguishable as preceding the beginning of the Cambrian has not been reported in the literature dealing with the late-Precambrian geology of other areas outside southeastern Newfoundland that also formed part of the eastern margin of Iapetus at that time. In fact, during the latest Precambrian the existing remnants of the margin from Scandinavia in the north to eastern Massachusetts in the south were exposed to erosion (glacial over much of Scandinavia). During the erosional episode reduction of their relief facilitated their inundation at about the beginning of Cambrian time, when, as in many other parts of the world, marine transgression resulted in extensive areas marginal to oceans being flooded (Matthews and Cowie, 1979).

In southeasternmost Newfoundland, since much of the Random Formation is of Tommotian age and the advance of the sea during which Random sediments were deposited was preceded by a long period of erosion in the latest Precambrian, it is evident that that advance occurred during the Cambrian transgression. The presence westward from Placentia Bay of a sequence of marine sediments (with shelly fossils in its upper part) underlying the Random conformably and transitional below with late Precambrian continental deposits indicates that the sea advanced from that region into southeasternmost Newfoundland and not *vice versa*, as otherwise the pre-Random and Random sequences would be separated from one another by a disconformity. The upper part of the pre-Random sequence has already been shown by Greene and Williams (1974) to be of early Cambrian age, and therefore the whole of the Random succession throughout southeasternmost Newfoundland

is of early Cambrian (Tommotian) age, and the Random Formation forms part of the Lower Cambrian succession of the region.

The Cambrian transgression, as far as southeastern Newfoundland is concerned, began with an advance of the sea into the Fortune Bay area from the west, and its subsequent encroachment on the southern end of the Bonavista Peninsula and the west side of the Avalon Peninsula (marginal to Placentia Bay) took place after the initiation of Random sedimentation. Hence the sediments of the pre-Random sequence are overstepped by those of the Random Formation well to the northeast and east of the southern end of the Burin Peninsula (within the confines of Placentia Bay).

It follows from the recognition of the Random Formation as forming part of the Lower Cambrian succession of southeastern Newfoundland that the disconformity between the Random and overlying Cambrian formations is intra-Cambrian. The post-Random Cambrian succession was deposited during a transgression that began, as noted earlier, in the northeastern part of the region. The extent of the sea at the end of Bonavista time is shown in figure 2. Later in the Cambrian, the sea occupied practically the same area in southeastern Newfoundland as that over which Random sediments were deposited earlier which accounts for the constant association of Random sediments with overlying Cambrian beds throughout the region (with two exceptions⁶) mentioned in the Introduction. It also accounts for the fact that Cambrian sediments overlying the Random Formation are not of the same age everywhere, especially westward from the east side of the Burin Peninsula. The latter region was above sealevel until well on in Bonavista time, but thereafter the sea advanced westward across it so that Random sediments there are overlain disconformably from east to west by younger and younger Cambrian sediments of, respectively, the Bonavista, Smith Point, Brigus, and Young's Cove Formations⁷. The Young's Cove Formation (Hutchinson, 1962, p. 30) includes sediments of Middle Cambrian and presumed Middle Cambrian age (upper part apparently unfossiliferous) on Sagona Island and north and west of Fortune Bay.

⁶The exceptions are (1) locally near the southern end of Cape St. Mary's Peninsula where, as a result of the removal of the entire thickness of the Random from one area, early Cambrian sediments rest directly on late-Precambrian rocks of the Musgravetown Group (Fletcher, ms), and (2) the remnants of the Cambrian bordering Conception Bay on the north side of the Avalon Peninsula (fig. 1) that overlie Precambrian volcanic and sedimentary rocks unconformably and late-Precambrian granite nonconformably. On the southwest side of the bay Random sediments may have been removed by pre-Bonavista erosion, or they were never deposited there. Non-deposition undoubtedly accounts for the absence of the Random on the southeast side of the bay, as on that side only, the Bonavista and Smith Point Formations are also missing, and this indicates that the sea did not advance into the area until well on in the Lower Cambrian, that is, it was part of a resistant land area of some relief lying east and south of Conception Bay that had been in existence since the late Precambrian.

⁷Only the lower and upper parts respectively of the Brigus and Chamberlain's Brook Formations are represented in the Cambrian succession above the Random Formation on the west side of the Burin Peninsula which suggests that there was either virtually no deposition of sediments during much of the time the sea was advancing westward or that transgression was interrupted by regression.

The fossiliferous sediments of the lower part of the formation are considered by Fletcher (ms) to be equivalent to those of only the uppermost member (his Deep Cove Mudstones Member) of the six that he distinguished in the Chamberlain's Brook Formation in southeasternmost Newfoundland. It is evident from the preceding comments that west of Placentia Bay the time interval represented by the disconformity between the Random Formation and overlying younger Cambrian formations is very much greater in the west (on Sagona Island and north and west of Fortune Bay) than it is in the east (on the Burin Peninsula). Consequently the inarticulate brachiopods probably of early Middle Cambrian age (Rowell *in* Greene and Williams, 1974) said to be present in the uppermost part of the Random Formation on Sagona Island (Greene and Williams, 1974) are either of that age, in which case the enclosing sediments belong to the lower part of the Young's Cove Formation (= uppermost part of the Chamberlain's Brook Formation), or they are in reality much older forms. The possibility that sediments like those of the Random Formation continued to accumulate in an arm of the Cambrian sea west of the Burin Peninsula for tens of millions of years after deposition of Random sediments had ceased elsewhere, that is, from early in Lower Cambrian time to well on in Middle Cambrian time, is not entertained here. The reason for not doing so is that the thickness of the Random Formation on Sagona Island and north of Fortune Bay is not significantly greater than its preserved thickness in some other parts of southeastern Newfoundland which it assuredly would be if deposition of sediment had continued to take place west of the Burin Peninsula for some 40 Ma longer in that area than in other parts of the region (30 Ma = time-span for the Lower Cambrian excluding the Tommotian, Cowie and Cribb, 1978; the additional 10 Ma is a conservative estimate for the time during which deposition of the greater part of the Chamberlain's Brook Formation took place).

It is no longer necessary from here on to separate the Random Formation into an eastern and a western part as has been done for the purposes of the discussion up to this point. The Random sediments on the Bonavista and Avalon Peninsulas are laterally continuous with, and an eastern extension of, those present westward from Placentia Bay. Although the Random Formation lies at the base of the Lower Cambrian succession on the Bonavista and Avalon Peninsulas, westward from Placentia Bay it is underlain conformably by a sedimentary sequence that has been divided into two formations which have received various names in the past, the most widely adopted being the Chapel Island above (as in Hutchinson, 1962) (Greene and Williams, 1974; O'Brien, Strong, and Evans, 1977a, 1977b) and Rencontre below (O'Brien, Strong, and Evans, 1977a, 1977b). North of Fortune Bay in the Belloram map-area, Williams (1971) has included sediments distinguished here as the Chapel Island and Random Formations within the undivided Young's Cove Group (White, ms), the upper part of which, referable to the Cambrian, is the Young's Cove Formation mentioned

earlier in the discussion. The Chapel Island Formation consists of green (predominant color), red, and brown siltstones, argillites, and sandstones with minor limestones, and it contains trace and shelly fossils; the trace fossils are present throughout the greater part of the formation whereas the shelly fossils are restricted to its upper part (about 275 m). The latter has, as noted in the introduction and elsewhere, already been shown by Greene and Williams (1974) to be of early Cambrian age and therefore it also forms part of the Lower Cambrian (Tommotian) succession in southeastern Newfoundland.

Trace fossils present in the lower part of the Chapel Island Formation (about 450 m) are of non-trilobite (or non-arthropod) origin. They appear in abundance in beds stratigraphically above the lowest part of the formation which consists of rock types lithologically resembling those of the underlying Rencontre Formation alternating with rock types typical of the Chapel Island Formation; the sediments of this transitional sequence and the Rencontre Formation are barren. The sudden appearance of traces in beds overlying a thick succession of barren strata indicates firstly that it resulted from migration into the region of the soft-bodied animals responsible for their formation and secondly that a change from unfavorable to favorable environmental conditions for their existence preceded or accompanied the migration.

The base of the Cambrian has been taken here as the base of the Tommotian Stage, and because shelly fossils define the base of the latter and make their first appearance in the upper part of the Chapel Island Formation, the lower part of the formation is considered to be of latest Precambrian age. Consequently in southeastern Newfoundland Precambrian rocks are followed above by Cambrian rocks without any break in the succession.

The Rencontre Formation consists, at the southern end of the Burin Peninsula, of a sequence of bright red micaceous sandstones and siltstones with subordinate mudstones above a basal conglomerate of variable thickness which rests unconformably on volcanic rocks (Marystown Group, Strong and others, 1976); as it underlies the Chapel Island Formation conformably it is, like the lower part of that formation, of latest Precambrian (Vendian) age. Around the head of Fortune Bay the Rencontre Formation is widely distributed and up to 1500 m thick (Bradley, 1962; Williams, 1971). The nature of the very coarse to fine-grained predominantly purple to red sediments of the succession and the sedimentary structures associated with them, including unidirectional westward-dipping cross-lamination, indicate that they are fluvial deposits derived from an upland area to the east by a westward flowing river (or rivers) Twenhofel, 1947). Thus the change in environmental conditions referred to above (entry of trace-making organisms) was from fluvial to marine.

It is evident from the distribution of the Rencontre Formation that it was the presence in the Fortune Bay and adjacent areas of an extensive alluvial plain close to sealevel that enabled the sea to encroach

on that region first at the beginning of the marine transgression that initiated the deposition of Chapel Island sediments. The transitional sequence at the base of the Chapel Island Formation at the southern end of the Burin Peninsula (alternation fluvial and marine sediments) was thus deposited during the first stage of the transgression described earlier in the discussion as the Cambrian transgression. It is also apparent from the age of the sediments of the lower part of the Chapel Island Formation that southeastern Newfoundland is one part of the world where the first stage of the Cambrian transgression (limited advance of the sea into the region west of Placentia Bay) took place before the beginning of the Cambrian, that is, in latest Precambrian time.

Now that the sediments of the Random Formation and of the upper part of the Chapel Island Formation are known to be of early Cambrian (Tommotian) age, tentative correlation of these sediments with those of the lower part of the Cambrian successions of the Comley area of Shropshire, England, and the Siberian platform of the USSR can be attempted.

The lower part of the Bonavista Formation correlates (approximately — see app.) with subdivisions Ab_1 and Ab_2 of the Lower Comley Sandstone and with the *Dokidocyathus lenaicus-Majatheca tumefacta* Zone of the Siberian Tommotian Stage. The Lower Comley Sandstone is underlain conformably by the initial formation of the Comley Lower Cambrian succession, the Wrekin Quartzite, which Daily in his correlation chart (1972, fig. 6) equates with the two lower zones of the Tommotian Stage. The Random Formation includes sediments similar to those of the Wrekin Quartzite, but whereas the latter, as just noted, underlie the Lower Comley Sandstone conformably, the relationship of the former to the overlying Bonavista Formation is disconformable. Consequently erosion of the Random took place during the time that the clastic sediments of the Wrekin Quartzite were being deposited. The Random Formation is therefore older than the Wrekin Quartzite, and neither it nor the pre-Random sequence of southeastern Newfoundland is represented by sediments in the Comley Lower Cambrian succession of Shropshire. Hence Daily's correlation of the Wrekin Quartzite with the two lower zones of the Tommotian Stage is incorrect. It probably equates with no more than the uppermost part of the middle or *Dokidocyathus regularis* Zone. In that case the uppermost part of that zone is unrepresented by strata in the Lower Cambrian sequence of southeastern Newfoundland (= hiatus indicated by the disconformity between the Random and Bonavista Formations), and the Random Formation, with the possible exception of its lowermost part, correlates with the greater part of the *Dokidocyathus regularis* Zone. The basal sediments of the Random Formation (westward from Placentia Bay where they are oldest) may correlate with either the lowest part of the *Dokidocyathus regularis* Zone or the uppermost part of the underlying *Ajacyathus sunnaginicus-Tiksitheca licis* Zone, the remainder (or

possibly all) of which is represented by the sediments of the upper part of the Chapel Island Formation with a shelly fauna.

It has been established in the preceding discussion that the sediments of the upper part of the Chapel Island Formation are the oldest Cambrian sediments in southeastern Newfoundland and that they are overlain conformably by the clastic deposits of the Random Formation. Both sequences are older than the Bonavista Formation, the lowermost of the three formations widely regarded until recently as constituting the Lower Cambrian succession of the region. The latter is therefore made up of five rock units and not three, namely, the upper part of the Chapel Island Formation and, in ascending order, the Random, Bonavista, Smith Point and Brigus Formations.

SUMMARY OF CONCLUSIONS DRAWN FROM THE DISCUSSION RELATING
TO THE AGE OF THE RANDOM FORMATION AND THE NATURE
OF ITS BOUNDARIES

1. The Random Formation is of early Cambrian (Tommotian) age throughout southeastern Newfoundland, and it probably correlates with all but the uppermost part of the *Dokidocyathus regularis* Zone of the Siberian Tommotian Stage (uppermost part unrepresented due to post-Random erosion), although it is possible that the lowermost part of the formation, limited to the region westward from Placentia Bay, is equivalent to the uppermost part of the underlying basal zone of the Tommotian Stage.

2. The Random Formation, already known in the Fortune Bay-Burin Peninsula region to be conformable below with the Chapel Island Formation (upper part of earliest Cambrian age), oversteps the Chapel Island Formation within the confines of Placentia Bay, that is, north-eastward to eastward of the Burin Peninsula, so that beyond the overstep, both within the Bay and on the Bonavista and Avalon Peninsulas, Random sediments rest disconformably on late Precambrian rocks of the Musgravetown and Hodgewater Groups.

3. Deposition of the sediments of the Chapel Island Formation and of the lower part of the Random Formation took place during an advance of the sea from the west into the Fortune Bay-Burin Peninsula region in latest Precambrian-earliest Cambrian time; this advance marked the beginning of the Cambrian transgression in southeastern Newfoundland. During the progressive flooding of much of southeastern Newfoundland which followed the inundation of the Fortune Bay-Burin Peninsula region, sediments now forming the middle and upper parts of the Random Formation were laid down.

4. Random sedimentation was brought to a close by a withdrawal of the sea from southeastern Newfoundland. The most recently deposited sediments of the Random Formation were thus exposed to erosion (loss of regressive sequence) which continued until a readvance of the sea (well on in Tommotian time) from the northeast (initially across the Bonavista Peninsula) and renewed sedimentation resulted in the eroded upper surface of the Random being overlain disconformably by sedi-

ments ranging in age from early Lower Cambrian on the Bonavista and Avalon Peninsulas to late Middle Cambrian on Sagona Island and north of Fortune Bay.

5. The base of the Random Formation is diachronous, being oldest in the Fortune Bay-Burin Peninsula region and becoming progressively younger northeastward and eastward from that region, but not as markedly as formerly believed, because the diachronism falls well within the time-span of the Tommotian Stage.

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APPENDIX

Correlation of the pre-Callavia Lower Cambrian sequence of southeastern Newfoundland with the corresponding portion of the Lower Cambrian successions of the Comley area of Shropshire, England, and the Siberian Platform of the USSR, respectively.

On the basis of similar stratigraphic position and faunal content, Hutchinson (1962, p. 12) correlated the Bonavista Formation with the *Obolella groomi* grit (now known as the *Obolella groomi* Beds) and the lower part of the Lower Comley Sandstone of the Comley area, Shropshire, England. The *Obolella groomi* Beds are currently recognized as a member of the Lower Comley Sandstone (Cowie, Rushton, and Stubblefield, 1972), and the part of this sandstone that Hutchinson refers to is assumed here to be up to the level, some 60 m above its base, at which the first olenellid appears in the sandstone (table 2). The Lower Cambrian rocks of the Comley area constitute the Comley Series which includes the Wrekin Quartzite (7-40 m), the Lower Comley Sandstone (about 150 m; basal 8 m = the *Obolella groomi* Beds), and the Lower Comley Limestones (about 1.8 m) (Cowie, Rushton, and Stubblefield, 1972; Rushton, 1974). These rock units are less useful for correlation purposes than the ten subdivisions of the sequence that Cobbold (1921, 1927) distinguished by their fossils; he allocated index letters to each subdivision, for example limestones containing *Strenuella* = Ac₁. The relationship of these subdivisions to the rock units of the Comley Series and to British Lower Cambrian zones is shown in table 2.

The topmost bed (14 cm thick) of the Smith Point Formation, which lies at the base of the *Callavia* Zone in southeastern Newfoundland, contains *Callavia* and *Acanthomimemacca* (Fletcher, ms). The presence of these trilobites indicates a correlation of this bed with a low part of the *Callavia*-bearing sequence (Ac₁-Ac₂) in the Comley area (Fletcher, ms). The underlying (non-trilobite) beds of the Smith Point Formation are equivalent, at least in part, to lowermost *Callavia*-bearing beds elsewhere (inferred from the sudden appearance of trilobites named above in the topmost bed). The beds of subdivision Ab₁ of the Comley sequence beneath the Green Callavia Sandstone (Ac₁) contain a meager fauna consisting almost exclusively of rare ostracodes (bradoriids) (Cobbold, 1921), and therefore the first appearance of *Callavia* and associated trilobites in the uppermost part of the Lower Comley Sand-

stone (Ac₁) is just as sudden as it is in the corresponding portion of the Smith Point Formation. Thus, in both areas, their appearance resulted from migration, and it also seems to have been more or less simultaneous. Consequently there is little doubt that the Smith Point Formation (less the topmost bed) correlates with the upper part of Cobbold's subdivision Ab₁ of the Lower Comley Sandstone.

Trilobites older than those of the Callavia fauna are not represented in southeastern Newfoundland, because, earlier in the Cambrian, they were unable to enter the region (physical or biological barrier), or, alternatively, environmental conditions there were unfavorable for their existence. The latter is considered less likely, because a variety of marine organisms apparently thrived equally well in the basin before and after that event. In the Comley area subdivision Ab₂ has yielded a single olenellid (claimed to be *Fallotaspis?* by Hupé, 1953, p. 102, 127) and small shelly fossils. This fossiliferous horizon, some 60 m above the top of subdivision Aa, is taken to be close to the base of the British "Olenellid" Zone (table 2) (Cowie, Rushton, and Stubblefield, 1972). The sandstones above this level and below the base of subdivision Ac₁ with its numerous fossils (*Callavia* fauna), that is, those of the upper part of subdivision Ab₂ and of subdivision Ab₁, contain a sparse fauna predominantly of small ostracodes (Conchostraca of Cobbold and Pocock, 1934) which suggests that during the time of their deposition environmental conditions in the Comley area were inimical to the occurrence of normal marine fauna.

Since the absence of trilobites below the uppermost part of the Smith Point Formation in the *Coleoloides* Zone of southeastern Newfoundland has been accounted for, there is no longer any reason for limiting the correlation of the Bonavista Formation to the lower 60 m of the Lower Comley Sandstone (Ab₁ + Ab₂), especially as doing so makes the Smith Point Formation less the topmost bed stratigraphically equivalent to subdivisions Ab₂ and Ab₁ which together represent a major part, some 90 m, of the about 150 m thick Comley Lower Cambrian sequence above subdivision Aa. The Smith Point and Bonavista Formations have maximum thicknesses, respectively, of 14 and 145 m (Hutchinson, 1962), and as the former is merely a thicker development of limestone than is present at other levels in the Lower Cambrian succession of southeastern Newfoundland, it is most unlikely that it correlates (less the topmost bed) with more than the upper part of subdivision Ab₁ as indicated earlier. The thickness of the mudstones with intercalations of limestone of the Bonavista Formation (145 m) is greater than that of the fine to medium-grained sandstones of the Lower Comley Sandstone below the upper part of subdivision Ab₁ (about 120 m). Since there is little likelihood of the muds and carbonates of the former (which must have constituted a still thicker sequence before compaction) having accumulated more rapidly than the sands of the latter, it can reasonably be assumed that the sediments of the Bonavista Formation were deposited during a time interval at least equal to that during which those of the Lower Comley Sandstone (as restricted above) were laid down. Consequently the writer considers that the Bonavista Formation is equivalent to the Lower Comley Sandstone sequence below the upper part of subdivision Ab₁ and that its lower part (actual thickness presently unknown) correlates with the subdivisions of that sequence, Ab₁ and Ab₂, included in the British "Non-Trilobite" Zone (table 2).

The Comley Lower Cambrian sequence now included in the British "Non-Trilobite" Zone (Cowie, Rushton, and Stubblefield, 1972) has been correlated by Rozanov (1967, p. 426 and table 1) with the basal Cambrian Stage of the Siberian platform, the Tommotian; in his correlation scheme he equated subdivisions Aa, Ab₁, and Ab₂ of the Comley sequence with, respectively, the Siberian Zones of *Ajaciclyathus sunnaginicus-Tiksitheca liscis*, *Dokidocyathus regularis*, and *Dokidocyathus lenaicus-Majatheca tumefacta*, the three assemblage zones into which the stage has been divided. Daily (1972, p. 16), referring to Rozanov's (1967) correlation of subdivision Ab₁ with the *Dokidocyathus regularis* Zone, stated that "it seems more likely that the *Obolella? groomi* Beds (Ab₁). . . . will not be older than the *Mobergella holsti* Zone of the Scandinavian region and the *Dokidocyathus lenaicus* Zone of the Siberian Platform." Consequently in his correlation chart (1972, fig. 6) the Wrekin Quartzite (Aa) is shown as correlating with the two lower zones of the Tommotian Stage. Daily's view regarding the age of subdivision Ab₁ has since been confirmed by the discovery within that subdivision of the problematic phosphatic fossil *Mobergella* (Cowie, Rushton, and Stubblefield, 1972) which is characteristic of the uppermost part of the Tommotian Stage (Matthews and Missarzhevsky, 1975). It follows from the correlation above of the lower part of the Bonavista Formation with subdivisions Ab₁ and Ab₂ of the Lower Comley Sandstone that it correlates also with the Siberian *Dokidocyathus lenaicus-Majatheca tumefacta* Zone. Cambrian strata representing the two lower zones of the Tommotian Stage are therefore unrepresented in southeastern

Newfoundland, unless the quartzites and silstones of the Random Formation are Cambrian. The possibility of the Random being Cambrian is not considered further here as it is dealt with fully in the Discussion section of this paper.

The lower boundary of the Bonavista Formation is unlikely to be at exactly the same stratigraphic level as that of the Lower Comley Sandstone, and neither of these boundaries is likely to coincide precisely with the boundary between the upper and middle zones of the Siberian Tommotian Stage. Consequently, although the correlations made above are probably close to being accurate, they are nevertheless approximations.

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