Discussion of the progress report of the Federal–Provincial Committee on Huronian Stratigraphy

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It is argued that the term "Huronian", which has been, and still is, widely used as a time-stratigraphic term, serves a useful purpose in correlating the early Proterozoic rocks of Ontario with those of the Lake Superior region. It should not be used, therefore, as a rock-stratigraphic name of only local significance, as has been suggested in the progress report of the Federal–Provincial Committee on Huronian Stratigraphy, but be retained as an informal 'systemic' name pending clarification of conflicting results of age relationships of early Proterozoic rocks of the Great Lakes region.

A scheme of stratigraphic nomenclature is tentatively outlined for the early Proterozoic rocks of the Great Lakes region.

In a summary of the interim report of the Federal–Provincial Committee on Huronian stratigraphy (Robertson *et al.* 1969) it has been suggested that stratigraphic terminology and correlation are confused by conflicting details, unsubstantiated correlations, and use of different nomenclatural schemes. There is now almost complete agreement among interested parties regarding correlation of the Huronian rocks of the north shore of Lake Huron. We agree with the revised scheme of rock-stratigraphic nomenclature suggested by the Committee with the qualification that perhaps the Bar River (see Table I) Formation might be subdivided into two or three formations and raised to group status. We also agree with Robertson *et al.* (1969) that there is need for a major rock-stratigraphic subdivision (supergroup) for the early Proterozoic rocks of the north shore of Lake Huron. However, we feel that use of the term "Huronian" as a supergroup designation of only local significance is a disservice to a word of great antiquity which has been used for rocks occurring over a far greater area than simply the north shore of Lake Huron, and which consequently is known to Precambrian stratigraphers throughout the world.

In the spirit of Article 28f of the Code of Stratigraphic Nomenclature, viz. "New Precambrian time stratigraphic units should be introduced only when they can be useful for interregional time-stratigraphy and for geochronology," we would point out that elimination of time-stratigraphic units, should also be carried out only after a careful examination of their usefulness in interregional time-stratigraphy and correlation. It is the purpose of this discussion to show that the early Proterozoic rocks of the Great Lakes region constitute a single stratigraphic succession, as was contended by most of the early writers on the geology of this region, and that the concept of a "Huronian system" is valid and useful in interregional time-stratigraphic correlation.

Application of the term "Huronian" to rocks of the Lake Superior region has a long history. On Logan's first map of Canada, published along with the description in which the term "Huronian" was used for the first time (Logan and Sterry Hunt 1855), the Huronian includes not only the early Proterozoic of Ontario but also that of Thunder Bay and Michigan, some of the Keweenawan, and some rocks on the north shore of Lake Superior now considered to be Archaean. Reference to the meta-sedimentary rocks of the Marquette area in Michigan as Huronian was also made by Hunt (1891), and Weidman (1904, p. 10) in his description of the Baraboo quartzite of Wisconsin reported that Hall (1862) "was the first to correctly place the quartzite in the Huronian system." In the Report of the Special Committee for the Lake Superior region by Van Hise (1905), the early Proterozoic of the Lake Superior region is also included in the Huronian system. However, in more recent times there has been considerable controversy concerning the affinities of the Proterozoic rocks of Michigan, Minnesota, and Wisconsin with those of Ontario (Alcock 1934). Moorhouse (1957, p. 75) stated that, "The questionable lithological similarity

TABLE I

Lithostratigraphic correlation and proposed supergroup nomenclature of Huronian rocks of the Lake Huron and Lake Superior regions

		Iron and Dickinson counties, after James (1958)	Marquette and Sands quadrangles, after Gair and Thaden (1968)	North shore of Lake Huron after Robertson *et al.* (1969)			North shore of Lake Superior after Tanton (1931)	
MARQUETTE RANGE = "ANIMIKIE SERIES" SUPERGROUP	*Paint River Gp.*	Fortune Lakes slate Stambaugh Fm. Hiawatha Gwke. Riverton iron-fm. Dunn Creek slate						
	Baraga Gp.	Badwater greenstone Michigamme slate Fence River Fm. Hemlock Fm. Goodrich qtzite.		volcanic unit* quartzite unit* argillite, qtzte and iron-fm. unit†			Rove slate Gunflint iron-fm.	*Animikie Group*
	Menominee Gp.	Vulcan iron-fm. Felch Fm.	Negaunee iron-fm. Siamo slate Ajibik qtzite.	Bar River Fm.			Kakabeka Cg.	
			Wewe slate	Gordon Lake Fm.			profound	unconformity
	Chocolay Gp.	Randville dolomite Sturgeon qtzite. Fern Creek Fm.	Kona dolomite Mesnard qtzite. Enchantment Lake Fm.	Lorrain Fm. Gowganda Fm.	*Cobalt Gp.*		*ARCHAEAN*	
		profound	unconformity					
		ARCHAEAN		Serpent Fm. Espanola Fm. Bruce Fm.	*Quirke Lake Gp.*	*? BRUCE MINES ? SUPERGROUP*		
				Mississagi Fm. Pecors Fm. Ramsay Lake Fm.	*Hough Lake Gp.*			
				McKim Fm. Matinenda Fm.	*Elliot Lake Gp.*			
				profound	unconformity			
				ARCHAEAN				

*Personal communication, Card 1969.
†Unnamed formations, McGregor Bay area of Lake Huron.

of the Lower Huronian of Michigan and the Bruce series of Ontario is not supported by any direct field evidence known to the writer." Likewise, James (1958, p. 34) expressed the view that, "continued designation of the Michigan strata as Huronian is not justified." He recommended use of the term "Animikie series" for theMichigan rocks because he considered them to include rocks both older and younger than the type Animikie and because in Michigan the Animikie included several groups. Such a rationale is contrary to the recommendations set out in the Stratigraphic Code (1961, Article 9f), published later than James' use of the term "Animikie Series," according to which it would now be more appropriate to use "Animikie" as a supergroup designation.

The doubt expressed by Moorhouse (1957) and James (1958) with regard to all the proposed lithological correlations between the Huronian of Lake Huron and the early Proterozoic rocks of the Lake Superior region was justifiable ten years ago. However, new developments have provided evidence in support of one of the possible correlations discussed by James (1958, p. 34)—the correlation of the Chocolay Group of Michigan with part of the Cobalt Group of Ontario (Table I).

The discovery of tillite in the Fern Creek area of Michigan (Pettijohn, 1943) and more recently in the Dead River Storage Basin area (Reany Creek Formation) west of Marquette (Engel 1954; Puffett 1969), in both cases at the base of the early Proterozoic succession, greatly strengthens the case for the correlation suggested by Young (1966) of the Cobalt Group of Ontario with the Chocolay and Menominee Groups of Michigan. Gair and Thaden (1968) also reported the presence in the Marquette district, at the base of the early Proterozoic succession, of texturally immature conglomerates and muddy sandstones (Enchantment Lake Formation) which they correlated with the Fern Creek Formation farther south. Puffett (1969) and Young (1969) have pointed out the remarkable lithological and chemical similarities between the Gowganda Formation of Ontario and the Reany Creek Formation of Michigan, and both suggested a possible lithological correlation. Because the Reany Creek Formation is separated by faults from the other Animikie formations, its stratigraphic relations are uncertain. However, the Fern Creek Formation, which was considered by Engel (1954) to be correlative with the Reany Creek Formation, is overlain by a succession of unusual rock types such as vitreous quartzites and ferruginous strata which is almost identical to the sequence above the Gowganda Formation of Ontario. The case for a lithological correlation between Ontario and Michigan is much strengthened when it is considered that iron-bearing strata (some units contain more than 15% iron and might therefore be called iron-formation) occur above white quartzites of the Bar River Formation in the McGregor Bay area of Ontario (Collins 1925; Young 1966). Correlation of the Huronian Lorrain Formation of Ontario with the Sturgeon Quartzite of Michigan is also confirmed by the presence in both units of "exotic" aluminosilicate-bearing quartzites (James *et al.* 1961, p. 153; Church 1967; Chandler *et al.* 1969) a rock-type unique to the Lorrain and those quartzites above and below the lower iron-formation of the Michigan Animikie (Tyler *et al.* 1940). Card[1] has also reported the presence in the McGregor Bay region of metabasalt apparently overlying white quartzite. The metabasalt unit would be equivalent to the Hemlock Formation of the Animikie succession. These lithological similarities are of particular interest in view of the statement of James (1958, p. 34) that, "The strata assigned to the Animikie group (of Minnesota) by Grout and his associates can be correlated with the Michigan strata with reasonable assurance, chiefly because of the presence of major units of iron-formation." The correlation is based therefore on the presence of a single "exotic" lithologic unit, and can only be made with "reasonable assurance." Because of the *several* stratigraphic similarities between the Huronian rocks of Lake Huron and the early Proterozoic rocks of the south shore of Lake Superior, we see little reason for continued acceptance of James' (1958, p. 35) opinion, at least with regard to the correlation of the Animikie between Minnesota and eastern Michigan, that "the extension of the Animikie to the Michigan strata rests on *far firmer* grounds than the extension of the term Huronian." (our italics).

Because of lack of continuity of outcrop it is impossible to demonstrate that a lithological correlation, such as that here proposed for the early Proterozoic rocks of the Great Lakes

[1]Personal communication to Church, 1969.

region, is correct. We can only say that it is highly probable, which is also all that can be said of some correlations that have been made within the outcrop area of the Huronian of the north shore of Lake Huron. Thomson (1957) placed a moratorium on lithological correlation because physical continuity was not demonstrable between the Huronian of the Bruce Mines – Blind River area and identical sequences south of the Murray fault. According to Robertson (1969, p. 4) there still appears to be some uncertainty in regard to correlation of the rocks south of the Murray fault. However, the members of the committee have condoned correlations made across this fault (Card 1967, p. 46; Frarey 1967, p. 135; Robertson 1967, p. 44), thus indicating their willingness to accept correlations made on the basis of probability rather than demonstrability. In the same vein, while we realize that we cannot demonstrate unequivocally the proposed correlation of the early Proterozoic rocks of Lakes Superior and Huron, the evidence of strong lithological similarity and succession of the "exotic" rock types of the Cobalt and, Chocolay and Menominee groups, taken in conjunction with the evidence from radiometric age determinations, suggests that the correlation is probably correct. Card[1] agrees that this correlation is "probable".

The correlation proposed above suggests that the early Proterozoic rocks of both areas together constitute a single stratigraphic succession. Available radiometric age determinations (Van Schmus 1965; Aldrich *et al.* 1965) indicate that the early Proterozoic rocks of both areas were deposited later than the Kenoran orogeny (ca. 2.5 b.y. ago) and before the Penokean orogeny (ca. 2.1–2.0 b.y. ago). The age of the Penokean orogeny is based on the age of the Nipissing diabase of Ontario (Van Schmus 1965) and the age of metamorphic mica in the Sturgeon quartzite of Michigan (Aldrich *et al.* 1965; Church 1968; Card[1]).

While we are well aware that there are breaks in sedimentation both in the "type" Huronian and in the early Proterozoic of the south shore of Lake Superior, none of these appears to involve penetrative deformation or plutonic igneous activity. Also, it is not known what percentage of the available 400 m.y. was involved in deposition of the early Proterozoic sediments of any one area. However, it is not unreasonable, by analogy with the situation in the late Precambrian and early Phanerozoic of Spitsbergen and Wales (Harland *et al.* 1966) and of the Amadeus Basin of Australia (Sprigg 1967) that deposition of such a thickness of sediment (tens of thousands of feet) could involve a period of several hundred millions of years without occurrence of a significant regional hiatus.

If it is argued that the two successions of early Proterozoic rocks of Lake Huron and Lake Superior are separated by a major orogenic event, then the onus is surely on the proponents of such an event, to demonstrate its existence. Such an argument was put forward by James (1958, p. 34) who suggested, among other ideas, that the early Proterozoic rocks of Michigan might be much older (pre-Huronian) on the basis of radiometric age determinations and geological arguments. These age data have now been superceded by more recent determinations (Aldrich *et al.* 1965; Krogh and Davis 1969) and the geological arguments are now considered to be invalid (Van Schmus 1965; Young and Church 1966; Robertson 1969, p. 15). Similarly, Roscoe's (1969, p. 113) suggestion that the Dickinson Group of Michigan is correlative with the Huronian of Ontario is also based on outmoded radiometric data, and is clearly wrong (Aldrich *et al.* 1965).

In addition to the reduction in status of the term "Huronian" from a name referring to rocks of a wide area to that of a local supergroup, the recommendations of the Federal–Provincial Committee also involve a change in usage of the term from time stratigraphic to rock stratigraphic.

The name "Huronian" has been used for more than 100 years (Hall 1862; Young and Church 1966) with a connotation of time. Van Hise (1905) proposed a future subdivision of the "Algonkian" on a systemic basis, and suggested that the Huronian be one such system. Likewise Alcock *et al.* (1934) in the Report of the National Committee on Stratigraphical Nomenclature proposed use of Huronian as a systemic name. Thomson (1957, p. 36; 1962, p. 79) referred to the Huronian as a time-stratigraphic unit as also did Pettijohn (1943, 1957) and Young and Church (1966). So deeply entrenched in the literature is the time connotation of the name "Huronian" that even members of the Federal–Provincial Committee use it in this way (Card 1967, p. 46; Robertson 1969, p. 628). The latter author persisted in this usage even subsequent to the pub-

lication of the recommendations by the Federal–Provincial Committee. It is therefore evident that the restriction proposed by the Committee on the use of "Huronian" is not only invalid but also impractical (cf. James 1958, p. 29). Because we feel that the Huronian succession might be correlatable over large distances with other successions within and beyond the Canadian Shield (e.g. Hurwitz Group of the N.W.T., Medicine Bow Mountains of Wyoming, Ketilidian of Greenland, Loch Maree Series of Scotland, etc.) we suggest that the term "Huronian" be used, for the present in an informal manner, for the early Proterozoic rocks of the Great Lakes region, and that it be preserved for possible future international use as a time-stratigraphic term comparable to the Phanerozoic terms "Cambrian", "Ordovician" etc. It might be argued that the term "Aphebian", recently proposed by Stockwell (1965) already fills this need: however, this term has not received unanimous International recognition, and its use is thus rendered impractical for purposes of correlation and communication in the Great Lakes region. The same objection pertains to "Paleoaphebian", in addition to the fact that it is difficult to see what advantage is to be accrued in terms of economy of writing or aesthetics in the use of "Paleoaphebian" rather than "Huronian". Objections to "early Aphebian" are the same as those raised by Stockwell (1965, p. 7) against "early Proterozoic". If a rock stratigraphic term is needed for formal application to the early Proterozoic rocks of the north shore of Lake Huron, as has been suggested by the Committee, then we propose a new supergroup term such as "Bruce Mines Supergroup".

A closely analogous revision of stratigraphic nomenclature was recently carried out by Harland *et al.* (1966) for the Upper Proterozoic Hecla Hoek succession of the Spitsbergen area. The Upper Proterozoic of this region was originally divided into groups, comprised of three or more "series". The "series" were renamed as groups, and the groups replaced by supergroups with new names (e.g. Lower Hecla Hoek Group became Stubendorffbreen Supergroup). In this way the well-known name "Hecla Hoek" is now available for use as a general and informal term for all the geographically separate areas of late Proterozoic rocks of Spitsbergen which are considered to form part of the same general succession. Because the term "Hecla Hoek" is well known in geological circles throughout the world it is fitting that it be retained and applied as an informal designation for all of these rocks in Spitsbergen. In contrast, supergroup names such as "Stubendorffbreen" are of local significance only.

Recommendations concerning the stratigraphical nomenclature of early Proterozoic rocks of Great Lakes region should include consideration of the problems involved in use of the term "Animikie Series." The name "Animikie" was originally proposed by Hunt (1873) for a group of rocks in the Thunder Bay area of Ontario but has subsequently been widely accepted as a name for all the early Proterozoic rocks of the south shore region. This correlation was based on lithostratigraphic comparisons between the rocks of the type area at Thunder Bay and those in northern Michigan and Minnesota. Correlation between the type Huronian and "Animikie" of Michigan has been refuted on the basis of apparent differences in radiometric age determinations on the rocks of these two areas (Frarey 1966). Likewise long accepted lithologic correlations, between the type Animikie at Thunder Bay and the "Animikie" of the south shore of Lake Superior, have been questioned on the basis of differences in radiometric ages.

Faure and Kovach (1969) have argued that the Animikie of the type area at Thunder Bay is no more than approximately 1.64 b.y. old. These authors also suggested that the Gunflint Iron Formation, together with the iron formations of the Cuyuna and Mesabi ranges, represents a miogeosynclinal facies deposited at the time of folding, metamorphism and uplift of the Thomson Formation to the south.

A major objection to this idea is that iron-formations such as those in Minnesota and Ontario represent an environment almost totally free of externally derived coarse clastic materials. This contrasts strongly with what one might expect on the flanks of a rising orogen. Also the Rove Formation of Ontario was derived from the north rather than the south (Morey 1967).

There are two other problems raised by Faure and Kovach's interpretation:

1. The Trommald Iron Formation and associated formations of the Cuyuna Range are deformed and metamorphosed to at least the biotite grade. Consequently (according to the hypothesis of Faure and Kovach) there must have been two phases of deformation and metamorphism—one before deposition of the Trom-

mald Formation (that affecting the Thomson Formation) and one after.

2. Since the Mahnomen Formation is considered by Faure and Kovach to be 1.85 b.y. old and the overlying Trommald Formation 1.64 b.y. old, it follows that there must have been a period of non-deposition approximately 200 m.y. long separating these formations. There is, to our knowledge, no field evidence in support of such a break.

If the age data are accepted at face value then it follows that the iron-formations of Michigan are not correlative with those of northern Minnesota and northern Ontario. The hypothesis of Faure and Kovach and also the more orthodox interpretation that the iron formations of Michigan and Ontario–Minnesota *are* correlative, may be accommodated by retaining the name "Animikie Group" as a local rock stratigraphic term for the rocks of the Thunder Bay area, and that a new supergroup name (e.g. Marquette Range Supergroup[2]) be coined to include all the early Proterozoic rocks of the Michigan–Wisconsin area. In this way, partisans of both hypotheses will be free to incorporate the Animikie Group within or dissociate it from the "Marquette Range" Supergroup without causing nomenclatural confusion. Thus, the system of nomenclature suggested in Table I is not in disagreement with the proposals of Faure and Kovach. Should it be shown that the Animikie rocks of northern Minnesota and Ontario are in fact older than 1.64 b.y. (and some of the geological arguments above suggest that this may be the case) then these rocks could also be incorporated into the Supergroup. If the arguments of Faure and Kovach prove untenable, an alternative would be to raise the status of the Animikie to that of a supergroup, and invent a new name (e.g. Thunder Bay Group) for the Animikie of Ontario. It is apparent that James (1958) used the name "Animikie Series" in an informal way to represent a rock stratigraphic sequence, and consequently the change from "Animikie Series" to "Animikie Supergroup" would be in conformity with the recommendations of the Stratigraphic Code. The term "Huronian" would be a general informal designation for all the early Proterozoic (lower Aphebian in the terminology of Stockwell 1965) rocks of the Great Lakes region.

In conclusion we would like to reiterate the following points:

1) The term "Huronian" has been used in reference to the early Proterozoic rocks of the south shore of Lake Superior for a very long period of time.

2) The early Proterozoic successions of Ontario and Lake Superior region constitute a single stratigraphic sequence, the upper part of the succession in Ontario being homotaxial with the lower part of the Lake Superior succession. The similarities are more striking than those between the "Animikie" of Michigan and the Thunder Bay area. Consequently, doubts previously expressed about the validity of the correlation of the Ontario and Michigan successions are no greater than those raised by the recent results of Faure and Kovach concerning "Animikie" correlations in the Lake Superior region.

3) "Animikie" has been used as a rock stratigraphic name whereas "Huronian" has been widely, and is still currently used as a time-stratigraphic term.

We therefore recommend on grounds of practicability, and following the precedent of other workers, that a new supergroup name should be coined for the early Proterozoic rocks of Ontario, and the term "Huronian" be left for the present, pending further work and discussion, as an informal time-stratigraphic term denoting the material unit recording the interval of time between the deposition of the Matinenda Formation of Ontario and the Fortune Lake Slate of Michigan sometime between the Kenoran and Penokean orogenies.

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[2]We are grateful to Dr. G. V. Cohee and his colleagues of the United States Geological Survey and the Geological Surveys of Michigan and Wisconsin, for suggesting the term "Marquette Range Supergroup" to replace "Animikie Series" as a name for the early Proterozoic rocks of the south shore of Lake Superior.

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