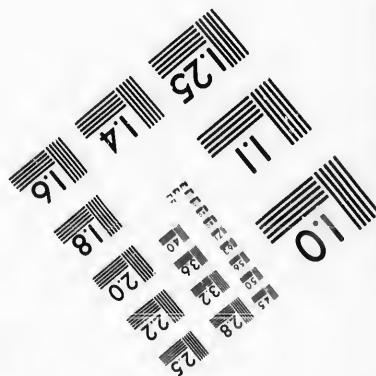
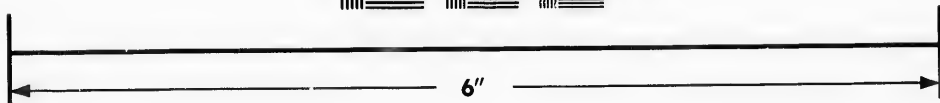
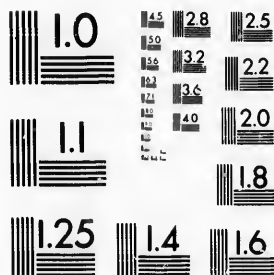


**IMAGE EVALUATION
TEST TARGET (MT-3)**



**Photographic
Sciences
Corporation**

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503



**CIHM/ICMH
Microfiche
Series.**

**CIHM/ICMH
Collection de
microfiches.**



Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques



© 1987

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- Coloured covers/
Couverture de couleur
- Covers damaged/
Couverture endommagée
- Covers restored and/or laminated/
Couverture restaurée et/ou pelliculée
- Cover title missing/
Le titre de couverture manque
- Coloured maps/
Cartes géographiques en couleur
- Coloured ink (i.e. other than blue or black)/
Encre de couleur (i.e. autre que bleue ou noire)
- Coloured plates and/or illustrations/
Planches et/ou illustrations en couleur
- Bound with other material/
Relié avec d'autres documents
- Tight binding may cause shadows or distortion along interior margin/
La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/
Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- Additional comments:/
Commentaires supplémentaires:

Pagination is as follows : [224] - 232 p.

- Coloured pages/
Pages de couleur
- Pages damaged/
Pages endommagées
- Pages restored and/or laminated/
Pages restaurées et/ou pelliculées
- Pages discoloured, stained or foxed/
Pages décolorées, tachetées ou piquées
- Pages detached/
Pages détachées
- Showthrough/
Transparence
- Quality of print varies/
Qualité inégale de l'impression
- Includes supplementary material/
Comprend du matériel supplémentaire
- Only edition available/
Seule édition disponible
- Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/
Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	14X	18X	22X	26X	30X
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12X	16X	20X	24X	28X	32X

The copy filmed here has been reproduced thanks to the generosity of:

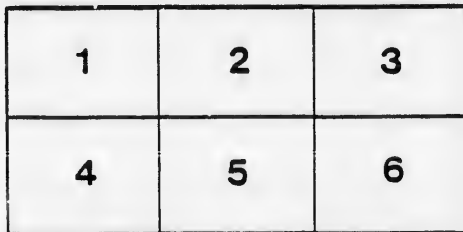
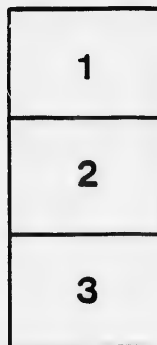
Library,
Geological Survey of Canada

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol \rightarrow (meaning "CONTINUED"), or the symbol ∇ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:



L'exemplaire filmé fut reproduit grâce à la générosité de:

Bibliothèque,
Commission Géologique du Canada

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont le couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole \rightarrow signifie "A SUIVRE", le symbole ∇ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.

Mc826

P98

A 1892

[FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. XLIII, MARCH, 1892.]

OBSERVATIONS UPON THE STRUCTURAL RELATIONS
OF THE UPPER HURONIAN, LOWER HURONIAN
AND BASEMENT COMPLEX ON THE NORTH
SHORE OF LAKE HURON.

By RAPHAEL PUMPELLE and C. R. VAN HISE.

LIBRARY
UNIVERSITY OF MICHIGAN

ART. XXVII.—*Observations upon the Structural Relations of the Upper Huronian, Lower Huronian and Basement Complex on the north shore of Lake Huron*; by RAPHAEL PUMPELLY and C. R. VAN HISE.

DURING the past summer we visited the north shore of Lake Huron in order to find evidence, first, as to whether the Original Huronian of Logan and Murray is divisible into two series as recently advocated by the late Professor Alexander Winchell; and, second, to ascertain more definitely the relations which obtain between the Lower Huronian and the Basement Complex of the region, usually called Laurentian. The term Basement Complex is here preferred in order to avoid a discussion as to any correlation with the original Laurentian rocks.

Relations of the Upper and Lower Huronian.

Prof. Winchell found, as he thought, evidence of two series in the Original Huronian near Echo Lake. At this place, according to him, there is in descending order, a slate-conglomerate and quartzite with a dip of about 20° . There is then an interval of a third of a mile, after which appears a quartzose slate-conglomerate, followed by quartzite, and this by alternations of quartzite, quartz-schist, and various slates, schists and argillites, the series having a dip of 35° to 80° southwesterly, and being as a whole more crystalline than the first slate-conglomerate and quartzite. A break is consequently placed between the two, the upper series including all of the limestones and intervening formations of Logan and Murray's Huronian.*

About two miles east of Garden River is a ridge of banded blue and cream colored limestone fully 200 feet high, which may be easily found as a quarry is here located. Its strike is about N. 30° W., and its dip 45° south of west. On its steep northern slope, and underlying the limestone, is found the typical lower slate-conglomerate. The actual contact between the two was not found, although they are separated by only about 50 feet at one place. The lowest layer of limestone is very siliceous, probably indicating that the passage from the conglomerate to the limestone is a gradation such as ordinarily occurs when a change takes place from mechanical to chemical or organic sedimentation. The exposure of lower slate-con-

* A Last Word with the Huronian; Alex. Winchell: Bull. Geol. Soc. America, vol. ii, pp. 114-124.

Y. 1881
 V. 1881 P. 123-124

glomerate was not sufficiently large to enable one to determine strike or dip.

Passing now a few paces south of the main limestone ledge, i. e., geologically upward, the actual contact between it and the upper slate-conglomerate is seen, although for no great distance. This contact is perfectly sharp. Upon one side of the line is the typical limestone; upon the other is the coarse conglomerate. The bedding of the latter is not sufficiently distinct to determine whether between the two formations there is a discordance. Above the contact occurs a good sized exposure of upper slate-conglomerate. This contains innumerable characteristic fragments of this formation, including besides various granitic fragments those of basic eruptives, of quartzite and of jasper. The distinctive feature of the exposure is, however, the presence of very numerous fragments of limestone, which sometimes reach a foot or more in diameter. These fragments have precisely the appearance of the strongly laminated underlying limestone. The bandings of the fragments lie in various directions, showing that this structure existed in the original rock at the time of the deposition of the conglomerate.

About 40 rods east, while the typical upper slate-conglomerate was not found, at the extreme southernmost part of the limestone bluff is a limestone-conglomerate or recomposed limestone, which is regarded at this point as the base of the upper slate-conglomerate.

A large exposure of lower slate-conglomerate some distance to the west of the locality above described shows the bedding to be vertical. It also has a cleavage in several directions so that large fragments under slight blows break into polygonal blocks. As compared with the upper slate-conglomerate it is much more crystalline. Its finer grained phases pass into a siliceous schist. The outcrop of lower slate-conglomerate adjacent to and north of the limestone has the same lithological character as the large bluff to the west.

It is concluded from the above observations that bearing in favor of a considerable break between the Upper and Lower Huronian are the following points:—There is (1) a difference in degree of metamorphism. The Lower Huronian has been so much altered as to have become semi-crystalline and to take on various cleavages, while the upper slate-conglomerate has no such characters. (2) Blocks of limestone in the upper slate-conglomerate are in exactly the same condition as in the original ledge. (3) Also the jasper fragments here contained were probably derived from the hematitic jaspery formation which is known to occur in the Lower Huronian. This sedimentary formation, like the limestone, belongs to one series, while the

series which contains them as detritus is of later age. The existence of jasper fragments in the Red Jasper Conglomerate was interpreted by Logan as "showing their derivation from a more ancient stratified rock."

Thus, so far as evidence was found by us, it bears in the same direction as the facts cited by Dr. Winchell, except that we would place the unconformity in the Huronian above the lower limestone member, whereas he places it below this formation. The Lower Huronian series would then comprise, in ascending order, Logan and Murray's Nos. 1 to 4 inclusive, the whole being according to these authorities about 5000 feet thick; while the upper series would comprise Nos. 5 to 13 inclusive, the whole being about 13,000 feet thick.*

Relations of Lower Huronian to the Basal Complex.

Contact near Garden River.—On the left side of the road leading from the Canadian Sault Ste. Marie, to Garden River, is a huge bluff of lower slate-conglomerate which has a north and south extent of at least an eighth of a mile. This conglomerate has all of the features heretofore described, that is, a vertical bedding, cleavages in various directions, and a semi-crystalline character. In passing from south to north the contained fragments as a whole increase in magnitude, although even after the exposure becomes strongly conglomeratic other layers lower down may be found which are nearly or wholly free from coarse detritus. When the north end of the exposure is reached the rock has become a magnificent basal conglomerate, consisting almost wholly of granite fragments set closely together and forming a stucco. The sparse fine-grained matrix is here composed of materials largely identical with the coarse fragments. Mingled with the numerous great bowlders some of which are several feet in diameter are other bowlders of intermediate sizes. In the passage from south to north along the bluff there is also noticed a tendency for the bowlders to become angular. Turning now around the northwest corner of the ledge, and following along its foot to the east, there appears just north of a sharp ravine not more than 100 steps from the conglomerate a great bluff of massive red granite (the syenite of the early Canadian geologists). On the talus slope of this bluff were found numerous angular blocks which are a genuine recomposed granite. These on their freshly broken surfaces so closely resembled the solid ledge that they can not be discriminated from it, but on the weathered surface their complex character is readily recognized since the discrete fragments of which they are composed stand out

* Geology of Canada, 1863, pp. 55-57.

sharply. The granite of the ledge, the fragments of the recomposed granite, and the great majority of those of the conglomerate are of identical character. Although the actual contact between the granite and conglomerate was not seen, there can be no doubt that here was an old shore line and that the granitic debris of this lower slate-conglomerate was derived from the granite, this being a pre-existent ledge. A second visit to this place was made by us in the company of Dr. Charles Barrois, Dr. Hans Reusch, Dr. Carl Schmidt and Dr. Th. Tschernyschew. After having carefully examined this and another adjacent locality in which the relations were somewhat obscure, these gentlemen all agreed that the above is a correct interpretation of the facts.

This contact is not between the lowest formation of the Original Huronian of Logan and Murray and their Laurentian, but is at the base of their lower slate-conglomerate, that is, is below a member of the Lower Huronian series. When it is considered that granitic rocks do not originate at the surface, but must have been deeply denuded before they can yield blocks to a basal conglomerate it may be considered a certainty that at Garden River, there is a physical break of great magnitude between the Lower Huronian series and the basement rocks of the region.

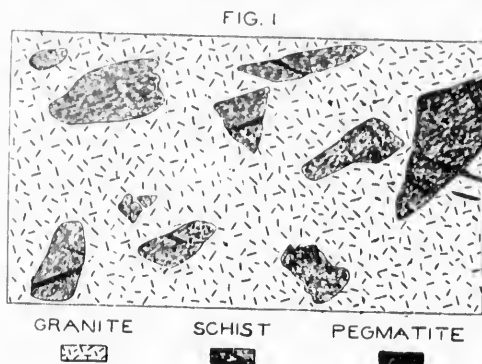
Contact east of Thessalon.—A locality four or five miles east of Thessalon visited by the late Prof. Irving and the junior writer in 1883, and described by Prof. Irving in 1887,* was again visited by the writers last summer. Prof. Irving states that this place shows a true unconformity between the Huronian and the Archean. He describes and figures a granitic and gneissic basement complex upon which rests, with actual contact exposed, a great conglomerate, the debris of which is derived from the immediately subjacent rocks. While in 1883 the basal conglomerate was seen on a magnificent scale, the contact was found only for a few feet at the end of one island.

At our recent visit to this locality the water of Lake Huron was very low, at least three feet lower than in 1883. The contact instead of being exposed only for a few feet at one place was seen all the way across two low, dome-shaped glaciated islands, the length of contact in each case being 40 or more feet. The facts observed are as follows:

The lowest rocks of this vicinity were found not to be simply a granite or granitoid gneiss as might be inferred from the general descriptions of Logan, but are an intricate mixture of granites, granitoid gneisses or foliated granites, and various

*Is there a Huronian Group? R. D. Irving: This Journal, III, 1887, vol. xxxiv, pp. 207-216.

crystalline schists. A gray granite-gneiss and a red granite occurs in considerable masses, as do also dark colored schistose rocks. Here the fine-grained gneisses and crystalline schists have been most intricately intruded by the granite, and later still both have been cut through and through by pegmatitic granite. In passing from a granitoid exposure to a schist exposure the first evidence of the schists is the appearance of angular and partly rounded inclusions of these rocks. In passing onward there appear very numerous blocks of the schist which have been free to move, and the laminations of



which strike in various directions, although there is often a rough parallelism in their structures. (See figure 1, drawn from a photograph.) The schistose blocks have been more or less absorbed and the whole has a pseudo-conglomeratic appearance which is identical with pseudo-conglomerates of

a similar origin described by Lawson about Rainy Lake.* In passing onward towards the schistose area the intrusive granite has cut across the lamination of the schists and parallel to them so as to make a network of intrusive dikes; but the schistose material has not greatly moved from its original position, consequent upon which there is a parallelism of structure. In passing still onward the schists are cut by veins or dikes of granite, but in subordinate quantity, and finally the continuous schists are found (lower part of fig. 3.) No observing geologist would take these intrusive relations and pseudo-conglomerates to indicate that the schists are later than the granite-gneiss. Such doubtless are the relations described by Barlow,† as a consequence of which he drew the conclusion that nowhere on the north shore of Lake Huron are any detritals which are later than and rest unconformably upon the basement complex. If we understand his descriptions, he regards the dark-colored crystalline schists as Huronian, whereas they are really pre-Huronian. Seeing facts of one kind and

* Report on the Geology of the Rainy Lake Region, Andrew C. Lawson, Geol. and Nat. Hist. Survey of Canada, vol. iii, 1887, pp. 130F-139F.

† On the Contact of the Huronian and Laurentian Rocks North of Lake Huron, Alfred E. Barlow: Am. Geol., 1890, vol. vi, pp. 19-32.

failing to find those of another, Barlow erroneously concluded that the latter do not exist.

However, resting upon the crystalline complex east of Thesalon as a basement is the great conglomerate described by Irving. This conglomerate contains numerous bowlders of the red and gray granite, of the pegmatitic granite, and of the various crystalline schists derived from the immediately sub-

adjacent basement complex, as well as other materials not noted as occurring in this vicinity. The character of this conglomerate is shown by figure 2, drawn from a photograph. How different this true conglomerate is from the pseudo-conglomerate may be seen by comparing figures 1 and 2. In

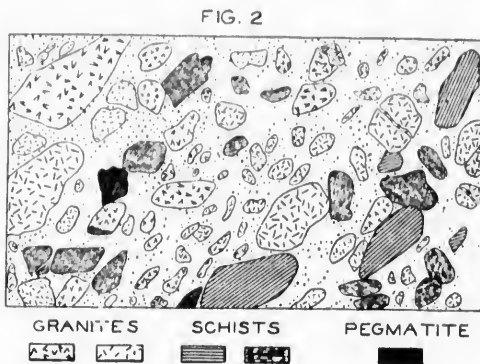
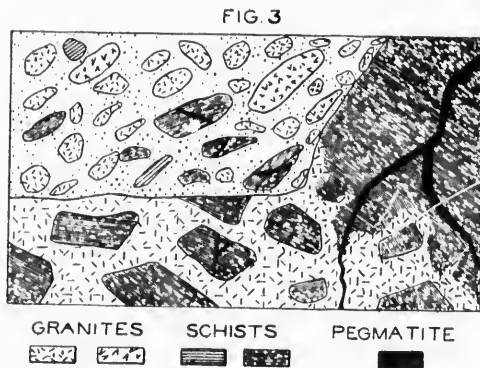


figure 1 the fragments are all alike and the same as the adjacent schist, while those of figure 2 have great variety and are more rounded. Also, although not possible to represent it in figure 2, the matrix is fragmental while in the other case it is crystalline granite.

The line of contact between the true conglomerate and the basement complex across one island is so distinct as to be located to the fraction of an inch. This line is irregular and in one place varies in strike within a foot or two as much as 45° or 50° (see fig. 3).

At places upon the lower side of this line is the gray granite, at other places are the schists, the two having the relations before described, and both are cut by the pegmatite granite. At one place the foliation of the crystalline schist or gneiss abuts perpendicularly against the line of contact. Along the



granite
schis-
talline
granite,
gh by
ure to
ppear-
rocks.
of the
ons of
a vari-
s, al-
often
delism
ntres.
rawn
raph.)
locks
re or
d the
p-sen-
ic ap-
ch is
p-sen-
es of
* In
ranite
them
istose
con-
In
es of
atinu-
rving
endo-
the
ed by
nsion
letri-
the
re re-
reas
and
Geol.
Huron,

line of contact between the basal complex and the true conglomerate, the pseudo-conglomerate also occurs, the fragments being all of one kind, that is derived from the schists intruded.

Above the line of erosion-contact, within an area of a square yard, in the true conglomerate may be seen fragments of the various rocks which occur in the basal complex; gneisses, gneisses and schists of various sorts, all of them showing the characteristic appearance of water rounding.

Upon the second island the relations are somewhat different from those just described. Here, in passing from the undoubted conglomerate on one side to the granite on the other, is an apparent transition. As the line of contact is neared, the bowlders of the conglomerate which are at first of many varieties gradually become more and more predominantly of the kind of granite which is immediately subjacent. Upon getting closer to the contact these bowlders are found to be angular and finally to have moved but little from their original positions. Finally a transition zone between the conglomerate and the granite-gneiss differs only from the solid mass of the latter in being cut by cracks into which detritus has sifted, and then these gradually die out and we are upon the solid granite. The change from unmistakable conglomerate to the solid granite takes place in about six feet. The facts here are in perfect accordance with those heretofore described, only there is the difference that the forces of erosion were not powerful enough to sweep all the coarse debris sharp and clean away from the shore line at this point, but at the beginning of the deposition of the conglomerate, left the blocks of granite and the perhaps somewhat altered granite practically undisturbed. As the sedimentary deposit increased in thickness, more and more material came in from the outside until the conglomerate took on the ordinary phase.

This contact east of Thessalon is of unusual importance because of two things: First, it is the only locality known to the writers where may be seen together the intrusive relations so well described by Lawson between granite-gneisses and dark colored schists producing pseudo-conglomerates and immediately adjacent to this complex a phenomenon of a wholly different order, a true basal conglomerate which marks the beginning of a new series. Second, this locality is important because the contact is between the lowest member of the original Huronian as described by Logan and Murray and their Laurentian of the North Shore of Lake Huron. Before reaching Thessalon, in going from west to east along the coast, we pass Logan and Murray's lower slate-conglomerate and below this their white quartzite. After passing Thessalon

there
of the
slate
volcanic
zite w

This
unconformity
Huronian
written
by gradation
denecessitates
the basal
occurrence
Finally
completely
quartzite
manifests
between
magnitudes
Gene.

at two
Huronian
ical breccia
Huronian
designated
of these
have been
ranted the
and Murray
there was
this breccia
the Huronian
known member
mentary
are plainly
Huronian
their fragments
always evident
thin section
detritals are

If the fragments
pre-Keweenaw
separable from
Complex, a

* Is there a
p. 210.

there appears below these, division 2, from the base upward, of the Original Huronian, the greenish chloritic and epidotic slate group, which has been shown by Irving to be a surface volcanic.* Below this is found formation 1, the gray quartzite which grades down into the conglomerate just described.

This locality then gives decisive evidence of an erosive unconformity between the lowest member of the Original Huronian and the Basement Complex. The intricate history written in the contorted gneisses and schists, in their intrusions by granites, in the subsequent pegmatization of both, is evidence that a great length of time was taken for the genesis of the basement complex. Then a deep truncation must have occurred before these granites could be found as surface rocks. Finally an orographic movement depressed the crystalline complex below the sea and the basal conglomerate and gray quartzite are the opening chapter of the Huronian. It is then manifest that the time gap represented by the unconformity between the Basement Complex and Huronian is of the first magnitude.

General.—As a result of our observations it is evident that at two distant points, one near the west end of the Original Huronian area and the other near the east end, are great physical breaks between members of the lower division of the Huronian and a more ancient crystalline complex which was designated by Logan and Murray as Laurentian. The nature of these breaks is such as to make it impossible that they can have been local, and the conclusion therefore appears warranted that in the typical district mapped in detail by Logan and Murray, between the Huronian and the Basement Complex there was an immense period of time. As further evidence of this break is the very different lithological characters which the Huronian and basal complex have. In the latter are known no rocks which have been demonstrated to be of sedimentary origin or even surface volcanics, while many of them are plainly deep-seated igneous rocks. The major part of the Huronian rocks, on the other hand, are so little altered that their fragmental character is generally seen in the field, and is always evident at a glance when the rocks are examined in thin section. Finally, the igneous rocks associated with these detritals are in large part surface volcanics.

If the foregoing conclusions are correct, it follows that the pre Keweenaw rocks of the north shore of Lake Huron are separable by unconformities into three series; a Basement Complex, a Lower Huronian and an Upper Huronian. These

* Is there a Huronian Group? R. D. Irving. This Journal, III, 1887, vol. xxxiv, p. 210.

divisions in their order, essential characters, and manner of separation, are exactly analogous to those on the south shore of Lake Superior,* and northwest of Lake Superior at Steep Rock Lake† as shown by Smyth. Is it not then highly probable that the unconformities at these different districts are the same and that the respective series are or once were continuous for the great triangular area between them, including much of the Lake Superior-Lake Huron region.

U. S. Geological Survey,
Madison, Wis., January, 1892.

* This Journal, III, vol. xli, pp. 117 to 137, An Attempt to Harmonize some Apparently Conflicting Views of Lake Superior Stratigraphy, C. R. Van Hise.

† This Journal, vol. xlii, pp. 317 to 331, Structural Geology of Steep Rock Lake, Ontario, Henry Lloyd Smyth.

