ART. XLVI.—*Geology of the Rainy Lake Region, with remarks on the classification of the Crystalline Rocks west of Lake Superior. Preliminary note;* by ANDREW C. LAWSON.

IN the Rainy Lake Region there can be distinguished five groups of rock formations which are geologically distinct from one another. The petrographical characters of each group are peculiar to itself to a great degree; so that a scheme of classification which takes into account only those conditions of mutual relationship, as observed in the field, that serve to distinguish the different groups with respect to their stratigraphical position, age and genesis is at the same time probably the best that could be adopted for considering systematically the purely petrographical characters of the rocks of this field by laboratory methods. The rocks comprised in the first of these groups may be arranged in the following scheme in which Rosenbusch's nomenclature is employed for the non-foliated varieties. With regard to the foliated varieties it will be observed that the word "gneiss" is used simply with reference to the structure of the rock independently of its mineral composition.

Type.	Non-Foliated.	Foliated.	Texture.
Granite, (quartzose).	True granite. Granitite. Amphibole Granite.	Granite-gneiss. Amphibole-granite-gneiss.	Medium grained, or fine grained.
Syenite. (quartz absent or only sparingly present).	Hornblende syenite.	Hornblende-syenite-gneiss.	Usually very coarse grained and in micaceous varieties of porphyritic aspect.
	Mica syenite.	Mica-syenite-gneiss.	
	Augite syenite.	Augite-syenite-gneiss.	

The rocks classified thus under two main types, the granitic and the syenitic, cannot as yet be separated in the field in such a way as to afford a definite suggestion as to their mutual geological relations. Geographically it is frequently possible to map off the quartzose, usually finer grained: rocks included in the two parallel series of the granitic type from the very slightly quartzose, coarse-grained members of the syenitic

type. But what this geographical separation means, whether the one is earlier or later than, above or below, the other, or what other geognostical relation exists between them, either in space or in time, the meagre amount of field work that has yet been done, relatively to the magnitude of the units with which we have to deal, leaves still an unsettled question. Such feeble suggestions of possible relations as have been received will be set forth in another place.

The granites and the foliated rocks of similar composition and habit, which are classed with them in parallel series, are genetically the same, the latter owing their distinctive characters to a differentiation in structure due to the influence of certain conditions affecting portions of a more or less homogeneous magmatic mass at the time of its solidification. The field evidence establishing the common genesis of the granite and gneiss is so strong that there is no room for doubt in the matter to one who has carefully studied their occurrence in nature. It is of course possible for geologists who are wedded to extreme metamorphic views to regard these rocks, even granting their sometime magmatic condition, as fused sedimentary strata; and they are at perfect liberty to do so, but so far as evidence goes the supposition is purely gratuitous and cannot in the absence of facts to support it be entertainted as a very probable hypothesis. The evidence in favor of such a supposition is, so far as can be gathered from a study of the region under consideration, very speculative. What is said of the granites and granite gneisses is also true of the syenites and their foliated varieties. The identity and igneous origin of the foliated and non-foliated series is shown by (1) the direct traceable passage from the granitic to the gneissic phase in a rock mass which must be regarded as a geological unit; (2) by the identical nature of their contact relations to other series of rocks to be mentioned, viz: the igneous, brecciated nature of the contact, the gneiss or granite holding angular fragments of the rock through which it breaks, and sending apophyses into it, which, where the rock is gneissic are often distinctly foliated; (3) the identity, as revealed by the microscope, of the mineral composition and structure of two varieties of the same mass.

This group of crystalline rocks, granites and syenites, foliated and non-foliated, forms the floor of the region upon which rest all other formations that are not in the condition of dykes or intrusive bosses. Regarded as a geological system of rocks it occupies an apparently paradoxical and anomalous place in any scheme of classification. As the floor or basis upon which the geological column of stratiform rocks rests it must be regarded as the first or fundamental system of rocks of which

we have any cognizance. If, however, we inquire as to the age of these rocks we are forced by the direct application of the simplest principles of geological science to look upon them as of later age than certain of the series which overlie them. We do not yet know their original condition prior to the fusion from which they solidified into granites, syenites and gneisses. They may have been sedimentary; they may have been the original crust of the earth. The abstract speculations that are so often indulged in on this and similar questions have not decided the facts of the matter. There is as yet no sufficient ground for a just opinion upon it. But whatever may have been that original condition the evidence is clear on this point, viz: that the fusion and solidification, whereby they were brought into their present condition as firm crystalline rocks, took place at a period subsequent to the existence, in a hard, brittle condition, of the stratiform and often very distinctly clastic rocks which occupy a higher place in the column. Therefore, as rocks, the members of this fundamental system are of younger age than that of the nearest overlying formations. An analogous case with which every geologist is familiar is that of dykes. These are of younger age than the strata they cut, although the main mass, of which they are merely the apophyses, is far inferior to those strata and may form the base upon which they rest. These apparently paradoxical but naturally quite consistent attributes of absolute inferiority of position with reference to all observable stratiform systems or series, and an age younger than part of the latter, places a classification of these Archæan formations based on age at variance with that which has reference to stratigraphical position. This is not usual in geology, except in the case of intrusive sheets of trap, and raises the question of which method should be adopted. The classification according to age is the usual one, but although this is facilitated in the post-Archæan formations by a knowledge of the laws governing the distribution in time of organic forms, it is primarily based upon the relative position of strata. The most prominent idea associated with these granites and syenites and their gneissic modifications is their basal or fundamental relation to all stratiform rocks. The formations of the region are, therefore, considered in their natural ascending order, in so far as they are stratiform, while dykes and intrusive bosses are taken in order of their age.

The group of rocks comprised in the table given above is designated geologically as the Laurentian System in accordance with the practice in vogue among geologists of so naming the lowest well-defined system of crystalline rocks which is clearly separable from overlying strata. It is not intended by

the use of this term to imply that the rocks are necessarily of the same age as those described as the typical Laurentian by Logan, or as those named Laurentian in any other part of the world. For it is manifestly at variance with scientific methods to definitely correlate, with reference to age, rocks in which there are no criteria for comparison other than their petrographical characters. That the rocks considered have passed through a period of fusion and solidification is a palpable fact in the Rainy Lake Region, and will probably be also established beyond question in other regions when they come to be carefully studied.*

But to assume that the period of solidification, which defines the age of the rock, was the same the world over, is as yet unwarranted. If prior to fusion the material was in form of stratiform sediments, these may have been of many different ages, and may have been fused in different parts of the earth at very diverse periods anterior to the deposition of fossiliferous strata. If it constituted, prior to fusion, the first formed crust of the globe, the period of fusion might, as before, be very different in different regions before the advent of life upon the surface of the earth. The loose way in which the term Laurentian is used is convenient in the present state of science, but let it be clearly understood—as it is not generally—that the usage is different from that familiar in the fossiliferous formations. It is in this loose sense—the strictest permissible in the present state of science—that these rocks are referred to the Laurentian.

Superimposed upon the rocks thus referred to the Laurentian system, the splendid exposures of the shores of Rainy Lake reveal as the next geological group a thick series of very distinctly stratiform mica schists and fine grained, gray, evenly bedded, often garnetiferous, very quartzose granulitic-gneisses. The use of the same term "gneiss" both for the foliated modifications of granites and syenites which are clearly of igneous origin, and for bedded rocks of similar composition to the granites, but whose natural history has evidently been very different, is very confusing. The lack of distinction in terms has been fruitful of much error. The term gneiss is coming more and more to be used by geologists to describe a certain phase of structure independent of composition. The fine-grained bedded gneisses often have the character of granulites when exam-

* Wadsworth has already called attention to the fact that the foliated granite of the Marquette district, described by Brooks and other geologists as Laurentian, is of more recent age than the rocks there referred to the Huronian and the intrusive nature of the contact is described. Vide Notes on the Geology of the Iron and Copper Districts of Lake Superior, Bull. Mus. Comp. Zöol., Harvard, 1880, p. 52 et seq., p. 70 et seq. The work was not known to me when I described the Contact of the Laurentian and Keewatin of the Lake of the Woods, Annual Report, Geol. Survey of Canada, 1885.

ined under the microscope, and the term "granulite-gneiss" might be useful as a distinguishing term if the granulitic character can by more extensive study be shown to be a common one. For the present it will be used provisionally as one that suggests the contrast that exists between them and the granite-gneisses.

This thick series of mica schists and granulitic gneisses attains its greatest development so far as has yet been observed in the southern part of Rainy Lake, where its thickness in continuous exposure, with the strata at low angles which preclude the idea of reversed dips, can be measured for a thickness of over two miles in a low anticlinal. The series is for convenience designated the Coutchiching series, from the Coutchiching Rapids at the head of Rainy River where the rocks are first met with on entering Rainy Lake from the west. They are very sharply and distinctly marked off from the lower granites and gneisses of the Laurentian. The geological contact between the Coutchiching series and the Laurentian system is one of neither conformity nor unconformity. The break is of an entirely different order, and the contact is eminently that of an igneous injection or intrusion of the lower through the upper rocks. This series appears to thin out rapidly toward the north, and on the north shores of the southern part of Rainy Lake, in the neighborhood of Seine, Swell, Red-gut and Rocky Islet Bays, and on the islands of the lake, it is seen to form a trough in which lies folded another higher series of entirely different characters. The rocks comprising it are for the most part of volcanic origin. They are chiefly black-green, compact, hornblende schists; softer, less compact, and more fissile green schists in which hornblende is the prevailing constituent, but with chlorite, calcite, epidote and other decomposition minerals well represented in them; and, in intimate association with these schists and interbedded with them, great sheets of 'trap' comprising uralitic diabases and gabbros (often called diorites) and other massive altered basic volcanic rocks of less determinate characters. These altered traps are sometimes quite massive and sometimes schistose to a varying extent, in which case the crushed or stretched condition of the rock is so clearly displayed in microscopic sections as to leave no doubt that the schistosity is due to pressure and to stretching or pulling forces upon the rock after the assumption of a firm crystalline condition. When the crushing has been excessive the original character is often almost or completely obliterated, particularly as the comminution of the rock under such forces is accompanied by the development of secondary minerals like quartz, calcite, epidote, zoisite, chlorite and albite. Included also in this series are dark green, very fissile glossy schists

holding water-worn pebbles; green volcanic breccias; finer textured clastic rocks or 'graywackes'; sericitic schistose quartz-porphyries and regular porphyroids; and soft, fissile, nearly always much decomposed hydromicaceous schists with which are associated yellowish dolomitic segregations.

The breccias, graywackes and hydromica schists are more commonly met with in the northern part of the Rainy Lake Region than on Rainy Lake itself. This group of rocks is the same as a large portion of the series described in my report on the Lake of the Woods Region as the Keewatin series, and in the northern part of the Rainy Lake Region can be traced in direct continuity with that series. They will therefore be referred to as the Keewatin series of rocks. Concerning the geological relations of the Coutchiching and Keewatin series it is not possible to make any sweeping statement as to their conformity or unconformity. The Coutchiching rocks do not appear to have been at all disturbed prior to the deposition of the Keewatin, and the parallelism of the strike and dip of the strata or beds of the two series is often seen to be perfect. But as Geikie points out the geological conformity or unconformity of two sets of strata implies a broader question than the mere relations in space of their contiguous portions. Strata which are in close contact and show at certain places perfect parallelism may sometimes be separated by ages. The appearance of parallelism is often simulated by pressure and folding so that it is not always a criterion of continuity of geological history. The very diverse character of the two series, the Coutchiching and the Keewatin, is proof of a profound alteration in the conditions of rock formation, which implies a geological break, though it does not indicate its duration. The Coutchiching series is seen occasionally to be cut by intrusions of a certain character which have not been detected traversing the Keewatin rocks. These may possibly be instances of vents from which the traps of the Keewatin series were extravasated. In the northern part of the Rainy Lake Region the Keewatin series comes into direct contact with the Laurentian without the intervention of the Coutchiching series, and the conditions of contact are those which have been described as obtaining in the Lake of the Woods Region. The contact of the hornblende schists and altered traps with the Laurentian rocks is of the same igneous or brecciated character as that observed on the Rainy Lake between the Coutchiching and the Laurentian, the direct inference being, of course, that the Laurentian rocks are of more recent age as such than either the Coutchiching or Keewatin, although stratigraphically they are inferior to both.

Of later age than Laurentian, Keewatin or Coutchiching is a system of dykes and bosses of red granite, in which there has

never been detected the slightest tendency to gneissic foliation. This granite is found cutting the Laurentian gneiss in sharply defined but irregular dykes in certain parts of the region, particularly in the Northwest Bay of Rainy Lake. These dykes are very frequently associated with "veins" of pegmatite. Where exposures are few and isolated there is danger of confusing these granites with the older granites of the Laurentian; where the country is well uncovered, however, the different relationships of the two are quite apparent.

Of still later age is a system of strong, well-defined dykes of diabase cutting the Laurentian, Coutchiching and Keewatin rocks and the post-Laurentian granites. These, wherever observed in various parts of the region have a strike of N.W. to N.N.W. Their width is generally from 60 to 150 ft., and they are sometimes traceable for miles. These dykes have been studied microscopically, as have all the chief types of rocks occurring throughout the region, and some interesting features have been brought to light concerning them which will be found described elsewhere. Besides these dykes there occurs between Seine River and Turtle Lake, east of Rainy Lake, a somewhat extensive mass or boss of very coarse grained saussurite gabbro, concerning the age of which it is only known that it cuts the Keewatin rocks, and is therefore younger than them. It is not improbable that it is of synchronous origin with the diabase dykes, possibly the plutonic facies of the same rock. These later diabases and gabbro have an interesting possible or problematic relationship to the trap flows which form so large a part of the Animikie and Keweenawan series.

The rocks of the region or their equivalents appear in their eastward geographical distribution in the neighborhood of Lake Superior to pass in a folded state under the flat lying beds of the Animikie series, the contact being one of marked unconformity. The Animikie is, according to the prolonged and valuable researches of Prof. R. D. Irving, of the United States Geological Survey, the geological equivalent of the typical Huronian of Logan.* The Animikie or Huronian is, according to the same eminent authority,† distinct from and underlies the Keweenawan (Nipigon). Hence the classification of the various geological systems or series of rocks in the country west of Lake Superior, so far as our present knowledge goes, is with reference to their place in the ideal geological column, as follows:

Keweenawan (Nipigon).
Huronian (Animikie).
Keewatin.

* Monograph V, United States Geol. Survey, pp. 367–386, p. 390.
† Op. cit., pp. ibid.

Coutchiching.
Laurentian.

With reference to their age, as follows:

Keweenawan (Nipigon).
Huronian (Animikie).
Diabase dykes and gabbro.
Granite, post-Laurentian.
Laurentian.
Keewatin.
Coutchiching.

Petrographical Laboratory, Johns Hopkins University, March, 1887.