STRUCTURAL FEATURES IN THE NORTHWEST TERRITORIES.

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ABSTRACT. A study of air photographs covering a large belt of the Northwest Territories interpreted in the light of information collected from field studies in certain areas of this belt has furnished considerable data regarding the structural features of the region. The major lineaments have been platted, and many of them can be recognized as faults, others as dykes, and still others as giant quartz veins.

LINEAMENTS OF THE CENTRAL NORTHWEST TERRITORIES.

AERIAL photographs are widely used as the basis of topographical mapping of areas in northern Canada. Since 1923 when systematic photography for this purpose began hundreds of thousands of square miles have been mapped from the air. The maps have made travel much easier and quicker, but the photographs themselves, when they can be carried, are an even greater aid to the prospector and geologist. Their larger scale and finer detail show many features such as river conditions, vegetation and land shapes which cannot be so fully shown on a map. How much they show depends upon the character of the country, and one can distinguish three main types for which the photographs show different kinds of information.

First, in regions of limited rock exposure the areas of outcrop can be readily distinguished from those of drift.

Second, in regions of extensive drift many features of glacial origin can be recognized and mapped.

Third, where bedrock is sufficiently exposed, photographs may indicate its nature and features of its structure.

Since covered areas are more numerous than areas of exposed rock, most progress has been made in the first two of the above, but there are many places scattered over Canada where photographs have helped geologists and prospectors to distinguish types of rocks, trace bedding or gneissosity, interpret structures, follow faults or dykes and even find such limited features as large quartz veins and pegmatite dykes. One such district, with an immense extent of exposed outcrop, lies in the central part of the Northwest Territories. East from a line joining Slave and Coppermine Rivers tens of thousands of square miles have very sparse soil covering, of which the barest parts lie between and skirt the eastern ends of Great Bear, Great Slave, and Athabaska lakes.

More than 100,000 square miles of this region have been aerially photographed since 1930. The photographed area is a continuous block from Athabaska to Great Bear lakes, and extends to the western edge of the Precambrian shield but frays

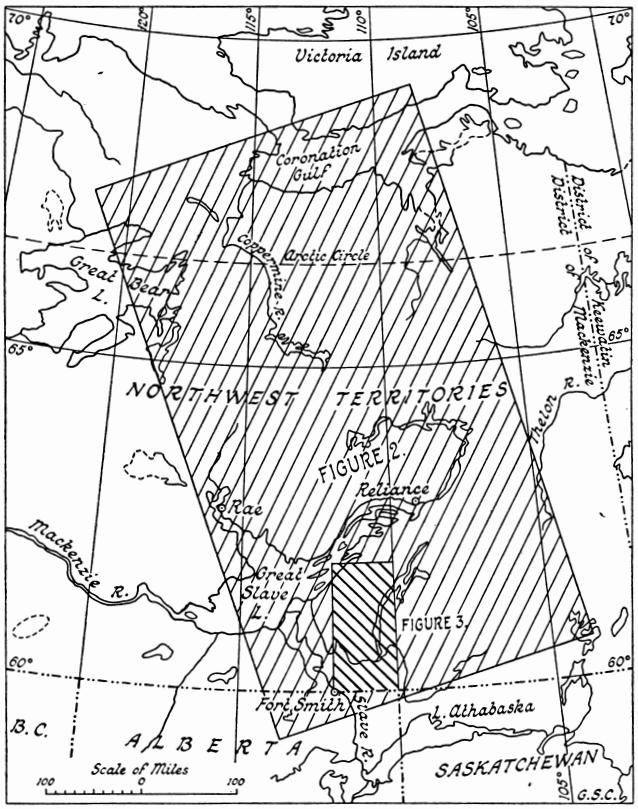

Fig. 1. Key map showing locations of the areas mapped in Figs. 2 and 3.

out on the east into strips along the main travel routes. It includes much of the region of bare outcrops and also some drift-covered areas farthest east. Some of the geological features seen from the air have already been described by Nichols[1] and Henderson and Jolliffe.[2] A year ago, the writer examined

[1] Nichols, D. A.: Solifluction Features from the Air. Royal Society of Canada, Transactions Sec. IV, Vol. 26, pp. 267-275, 1932.

[2] Henderson, J. F., and Jolliffe, A. W.: Relation of Gold Deposits to Structure, Yellowknife and Gordon Lake Areas, N.W.T., C.I.M.M. Bulletin No. 326, pp. 314-336, 1939.

a great many of the photographs. Some of them he used to map certain glacial features in an area of about 18,000 square miles to the northeast of Great Slave Lake.[3] Others of the district east of Slave River and near Wray Lake he used throughout two summers of field work.

The writer had hoped to examine all photographs of the central Northwest Territories, correlate the information thus obtained with what was known from reports and field work, and see what conclusions, and especially what suggestions to aid field work, could be reached. The completion of this project has had to be postponed until after the war, but enough has been done to justify this short interim report on certain bedrock features. The writer gratefully acknowledges the assistance of the Draughting Division of the Geological Survey of Canada in preparing the maps.

In the photographed region, broad subdivisions between different types of bedrock can generally be made if many photographs are examined. Usually the larger areas of Precambrian sedimentary and volcanic rocks may be distinguished from those of granites and gneisses. Further subdivision is possible in some areas, but differences are subtle and no subdivision can be safely attempted without a good knowledge of the ground and a very careful study of the photographs. It is very easy to err in interpreting color differences. Thus, photographs of part of Slave River region display areas of two different shades, which were first thought to indicate different kinds of bedrock. It was found eventually that the difference in shade had nothing to do with geology but was due to forest fires of different dates. The darker area was that of the earlier fire, where the second growth of vegetation was of course better developed.

On the other hand features perhaps not at first noticed in the photographs may become, in the light of field work, of great use. In Wray Lake district, for example, it was found that such minor features could be used with confidence in distinguishing Early Precambrian volcanic rocks from sedimentary rocks. However, experience has shown that only the main subdivisions can be distinguished safely without a good deal of field work and that suggestions of this kind gained from photographs must chiefly be used as a guide to ground observations.

[3] Wilson, J. T.: Eskers Northeast of Great Slave Lake, Royal Society of Canada, Trans. Sec. 4, Vol. 33, pp. 119-129, 1939.

Large structural features of the bedrock, on the other hand, can be better seen in photographs than on the ground. They are not easily confused with anything else, and they show through a moderate cover of drift. Some of these are the great scarps and troughs which cross all the Precambian rocks in straight and gently curving lines and are termed lineaments or "breaks." Many of them were proved in the field to be large faults. Others are definitely only large joints and tension cracks, but their association with the others in definite patterns strongly suggest that they are members of connected systems of faulting. Such a conclusion is not at all improbable, for wherever detailed geological mapping has been done on these rocks, great numbers of faults have been found.

The scarps can be seen and studied in the field, but on the ground the view is limited, and their full significance is not appreciated. During the past two years, many of them have been examined on the ground and many more have been plotted from photographs. That they form a pattern and that the pattern is associated with, and controlled by, major faults has become increasingly apparent, because along many of the largest and most continuous scarps the formations are offset and some of the offsets are measured in miles. Along other large scarps zones of mylonite and augen gneiss, up to several miles wide, have been traced for scores of miles. It has been found in the field that the Late Precambrian diabase and gabbro dykes are practically always parallel with, and habitually follow, these scarps. Moreover, large quartz veins of a type marked by size, by stockwork, and by replacement, are habitually found to occur along these lineaments. These quartz veins are common east of Slave River and are there younger than the diabase dykes. They also include the "giant quartz veins" which occur near Great Bear Lake and Beaverlodge Lake and which carry pitchblende. At Wray Lake and perhaps elsewhere, there are definite suggestions that these lineaments influence the distribution of ore.

The faults may be of more than one age, and movements may have been continued along some of them over a great period of time. Most of them, however, seem to be fairly Late Precambrian in age. Some of them cut all of the Precambrian rocks except the late diabase and gabbro dykes which follow the faulting, while others cut these dykes. The present scarps

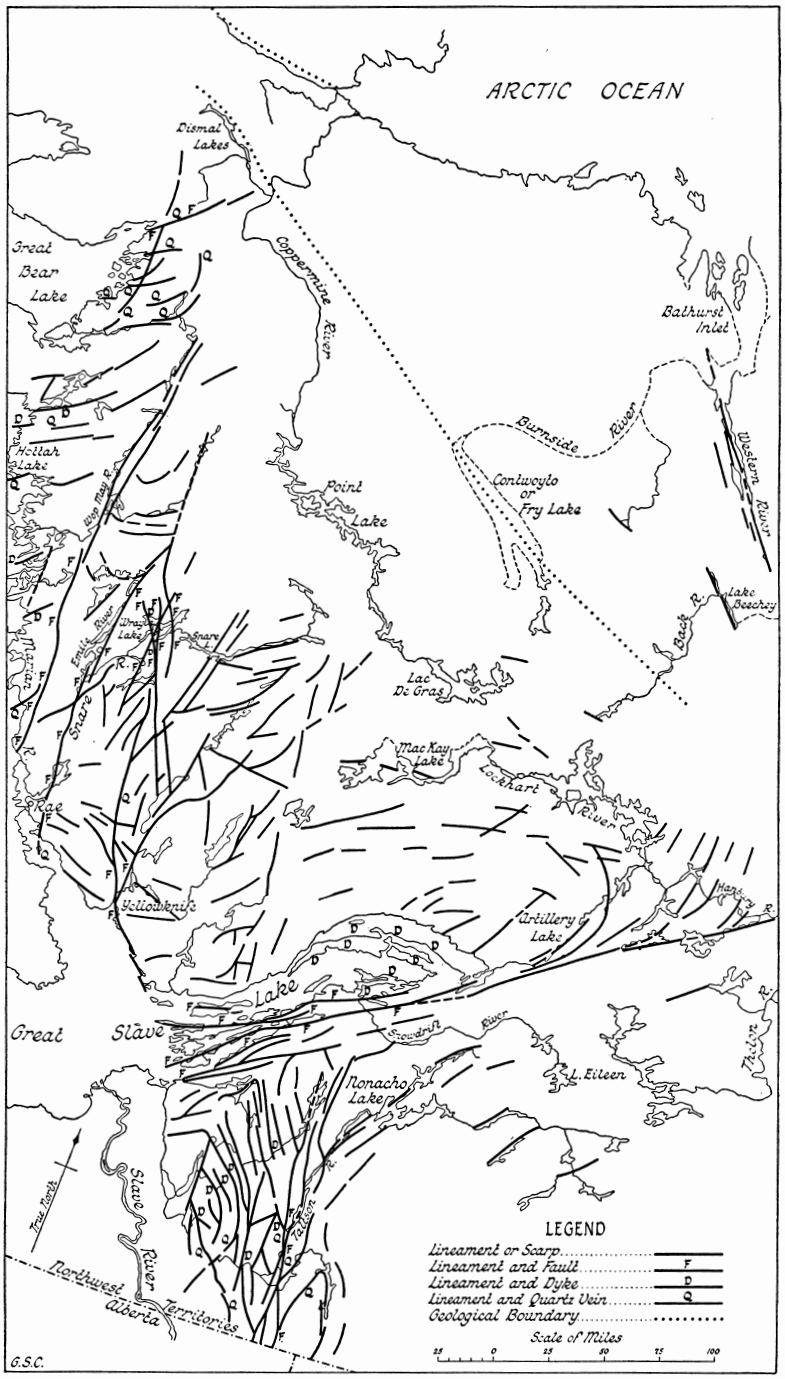

Fig. 2. Map of part of Northwest Territories showing major lineaments, faults, dykes and giant quartz veins.

and trenches are not, of course, due to the faulting but to later erosion along lines of weakness. An outline of some of the lineaments is shown on the map (Fig. 2). The most prominent is that great system which extends along the south shore of Great Slave Lake from Slave River to Reliance and thence south of Artillery Lake to the junction of Thelon and Hanbury Rivers. The existence and some of the features of this series of nearly parallel scarps has already been described by the writer,[4] while Stockwell[5] shows that the scarps in the East arm of Great Slave Lake are huge faults, of which the downthrow side is on the north. There is a suggestion from the offsets of contacts in the islands of the East arm that these are right-hand faults of several miles displacement. At the Hanbury River, however, the north side seems to be upthrown, so that the faults are perhaps huge hinge-faults.

Connected with this fault system are a number of curved lineaments along its north side between Artillery Lake and Hanbury River. They control the drainage pattern and may be the expression of horsetail joints.

From the North arm of Great Slave Lake another group of large lineaments trends north. From the mouth of the Marian River to Wop May River, one has been traced and shown to be a fault by Lord.[6] From the photographs, it can be seen to continue far to the north, perhaps even as far as the big bend in the Coppermine River.

Another lineament nearly parallel to it crosses an island in Great Slave Lake near Rae and has been traced as a major fault up the Snare and Emile Rivers for about 150 miles. Parallel to it through Wray Lake there is a shorter lineament which is significant as it is the locus along which all known gold-bearing veins in the Wray Lake area have so far been found. There is good evidence in places to suggest that this lineament follows a strike fault in the Early Precambrian sedimentary rocks.

Through Wray Lake, there is also a group of large faults with an approximate southeast-northwest direction. They were found in the field to be all left-hand faults, with displacements

[4] Wilson, J. T.: loc. cit.

[5] Stockwell, C. H.: East and West sheets East arm of Great Slave Lake 4 mile—1 inch maps 377A, 378A, Geological Survey of Canada.

[6] Lord, C. S.: Snare River Area, Geological Survey, Canada, Paper No. 39-5, 1939.

from a quarter of a mile to three miles each. In the photographs, and even on the Wecho River topographical map sheet,[7] they can be traced as prominent lineaments as far as Yellowknife, where one of them forms the West Bay fault mapped by Jolliffe[8] and shown to have a five-mile throw in the same direction. Extending north from Yellowknife there are a number of other prominent faults which show up plainly as lineaments. It is perhaps not a coincidence that Yellowknife and Wray Lakes, which are both limited areas of sedimentary rocks surrounded by much granite, should each be the focus of converging systems of faults.

These north to northwest trending faults north of Great Slave Lake are characterized by shearing and by known horizontal displacements. Along them there are few large quartz veins and only small diabase dykes in a few places. At an angle to these is a northeast trending series of shorter and more sharply curved lineaments which are followed by several very large gabbro dykes[9] and by many giant-quartz veins.[10] Only the most northern at Hunter Bay, and the most southern across the Marian River, are known to be faults with large displacements. Their nature suggests that most of them originated as tension cracks.

East of Yellowknife, the Beaulieu River area exhibits a change from the northwest faults at Yellowknife to lineaments parallel to the north shore of the East arm of Great Slave Lake. The latter are still the dominant features in the Lockhart River basin, but there is also a pattern of other lineaments across them. Very little field work has been done there.

Of the region farther north there are no photographs, except along narrow strips. Some of these show very striking northwest lineaments along the Western River. It is not known whether these are faults and, if so, whether it is along them that the Late Precambrian sedimentary rocks of Bathurst inlet have been downfaulted. Prospectors have suggested to the writer that there are extensive areas of these sedimentary rocks

[7] Wecho River sheet—Topographical Survey of Canada, 4 miles to 1 inch. Preliminary sheets on 2 miles to one inch.

[8] Jolliffe, A. W.: Yellowknife Bay-Prosperous Lake area. Geological Survey, Canada, Paper 38-21, 1938.

[9] Kidd, D. F.: Rae to Great Bear Lake, Mackenzie District, N.W.T., Geological Survey, Canada, Memoir 187, 1936.

[10] Kidd, D. F.: Great Bear Lake area, Northwest Territories, Geological Survey, Canada, Summ. Rept. 1932, Pt. C, pp. 1-36, 1933.

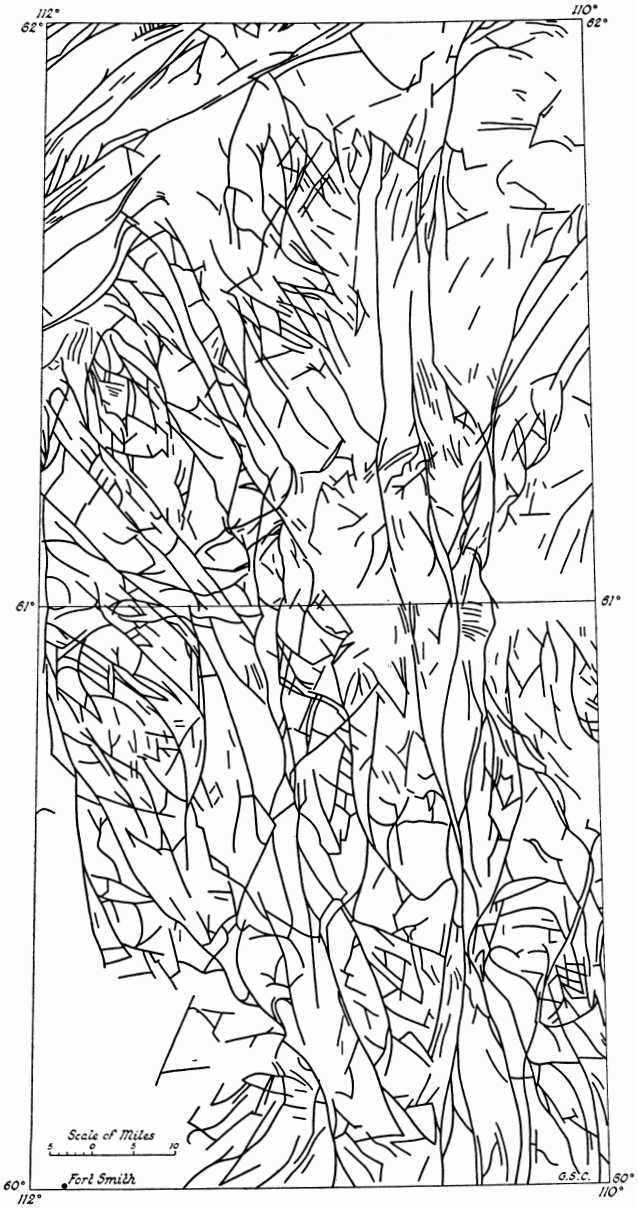

Fig. 3. Detail of all lineaments visible in aerial photographs of an area embraced by latitudes 60° to 62° and longitudes 110° to 112°.

in all the area from the Coppermine River to Lake Beechey on Back River and Bathurst inlet, and that Contwoyto Lake is a large glint-lake on the southern boundary of this area of sedimentary rocks, just as are the Dismal Lakes farther to the west. There is very little known about this country, however, and the suggestions are speculative. Photographs and the maps made from them do suggest, by the topography, that the rocks around Beechey Lake are like those on the lower Coppermine, as Dawson[11] suggested in 1887.

South of Great Slave Lake, the photographs that cover two four-mile to one-inch sheets have been examined and the lineaments mapped (Fig. 3). These areas have been mapped in the field by Henderson [12] and the writer.[13]

The most prominent series of scarps is that extending south from Great Slave Lake along the Taltson River and thence to Lake Athabaska. In the field, it was found that these scarps are followed by a zone of mylonite and augen gneiss more than a mile wide in places. There was some evidence of considerable horizontal displacement. This zone has evidently undergone shearing. There are some replacement-type large quartz veins, but no diabase dykes along these faults.

Between Taltson River, Slave River, and Great Slave Lake, there is an area cut by many parallel scarps trending southeast. Along many of them there are diabase dykes and in some places large quartz veins with much stockwork and replacement. A few of these cut the diabase dykes. It is believed that these lineaments are along tension cracks or faults due to tension.

East of the Taltson River, only strips of the country have been photographed. The country is more heavily drift-covered and less is known about the scarps. Some may be covered by drift and others are parallel to the direction of glaciation and difficult to distinguish.

This brief description of some of the main lineaments of the central Northwest Territories will suffice to show that many

[11] Dawson, G. M.: Notes on the northern part of Canada, Geological Survey, Canada, Annual Report, Vol. II, p. 27R, 1887.

[12] Henderson, J. F.: Nonacho Lake area, N.W.T. Paper 37-2, 1937, Taltson Lake Map No. 525A, 1939. Geological Survey, Canada.

[13] Wilson, J. T.: Fort Smith area. Geological Survey, Canada, Paper 39-11, 1939.

of the lineaments represent faults due either to shearing or to tension. The existence of a complex but coordinated fault pattern has been suggested. Much could be done to outline it by an adequate study of aerial photographs, but in order to find the age of, and to understand the movements causing these faults, a great deal of field work will be necessary. If this paper in any way stimulates that field work by suggesting the presence of large faults that might otherwise be overlooked it will have served its purpose.

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