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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 63-5

RED LAKE - LANSDOWNE HOUSE AREA, NORTHWESTERN ONTARIO

Bedrock Geology, Geophysical and Geochemical Investigations

(Parts of 42, 43, 52, 53)

(Report, Map 2-1963, Map 3-1963)

S. Duffell, A. S. MacLaren
and R. H. C. Holman

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RED LAKE - LANSDOWNE HOUSE AREA, NORTHWESTERN ONTARIO

INTRODUCTION

by S. Duffell

This area, which covers approximately 50,000 square miles, was investigated over a 3-year period in a cooperative project between the Ontario Government and the Federal Government. The project was a result of the Federal Government's policy to aid the provinces in building roads to northern areas for developing the country's resources. Both the Federal Government and the Government of Ontario realized that adequate geological and geophysical information is a prerequisite to a proper assessment of the need for, and location of, any roads that may be considered.

In this instance, aeromagnetic, geological, and related investigations were required to assess the mineral potential of the area before consideration could be given to the location and construction of any roads. In the spring of 1959 the Ontario Department of Mines and the Federal Department of Mines and Technical Surveys agreed to make the necessary surveys. The agreement called for the geological survey of an area that included the map-areas of Trout Lake (52N), North Spirit Lake (53C), Lake St. Joseph (52 O), North Caribou Lake (53B), Miminiska (52P), Wunnummin Lake (53A), Fort Hope (42M), and Lansdowne House (43D). In addition to the geological mapping, the first phase was to be an aeromagnetic survey covering more than 60,000 square miles. This would include, in addition to the map-areas mentioned, the northern halves of Lac Seul (52K), Sioux Lookout (52J), Armstrong (52I), and Nakina (42L).

The agreement further provided that Ontario would bear 75 per cent of the cost of the aeromagnetic survey, including preparation of the maps, and that the Federal Government would pay the remainder. The Geological Survey of Canada was to be responsible for the cost and execution of all ground surveys.

For a number of years the Geological Survey had been striving to provide its field officers with aeromagnetic coverage of map-areas prior to ground geological investigation. However, the newer and more efficient techniques used in field operations had increased the pace of geological mapping to such an extent that this was possible in only a very few instances. For this project it was not only desirable but quite possible to do so. To have the aeromagnetic information available for the major concentration on ground surveys in 1960 and 1961, the aeromagnetic survey was started early in the spring of 1959.

Preliminary bedrock-geology surveys also started in 1959. J.A. Donaldson mapped the Trout Lake area (52N) for publication on a scale of 1 inch to 4 miles. This work, of course, had to proceed without the aid of aeromagnetic data, but the results from it, together with information obtained by Y.O. Fortier from a general aerial reconnaissance of the whole project area, were used to assess methods of work, types of investigation, and logistic and operational data for major field operations in 1960 and 1961.

Y.O. Fortier, after his aerial reconnaissance of the project area in 1959, recommended that the Geological Survey's investigations be comprehensive and include, in addition to the bedrock geology, surficial geology studies, geochemical surveys, and ground investigation of specific aeromagnetic anomalies outlined on the aeromagnetic maps. Accordingly the 1960 program was planned as a coordinated project in four map-areas, namely North Spirit Lake (53C), North Caribou Lake (53B), Lake St. Joseph (52O), and Miminiska (52P).

Altogether 48 persons were directly associated with the project in the field: 8 staff members, 37 summer student assistants from Canadian universities, 2 pilots, and a cook. Staff personnel were from the Regional Geology, Economic Geology, and Geophysics Divisions.

The operation was supported by Beaver and Super Cub aircraft and for two weeks at the end of the season by a Bell G 1 helicopter. The Beaver was used for supply and movement of personnel, the Super Cub for actual traversing and landing on small lakes for rock observations, and the helicopter to fill in areas difficult of access by other means. The combination of ground, Super Cub, and helicopter traverses gave excellent coverage over the area.

The four map-areas were completed in 1960 and the other three—Wunnummin Lake (53A), Lansdowne House (43D), and Fort Hope (42M)—were completed in 1961. Preliminary geological maps of all areas on a scale of 1 inch to 4 miles were published by March 31, 1962.

This publication is a preliminary compilation of all the information presently at hand, comprising: (a) aeromagnetic investigations, (b) bedrock geology, and (c) geochemical data. A complementary report is being published on the surficial geology.[1]

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[1] Prest, V.K.: Red Lake - Landsdowne House Area, Northwestern Ontario: Surficial Geology; Geol. Surv., Canada, Paper 63-6 (1963).

The information in this report was presented by April 1962 to the government agencies concerned, and plans for a start on road construction were announced at Red Lake in May 1962.

AEROMAGNETIC INVESTIGATIONS

by A.S. MacLaren

The aeromagnetic survey was started in the summer of 1959 and the area was flown with a nuclear precession magnetometer by Spartan Air Services during 1959 and early 1960. Mean terrain clearance was 500 feet and flight lines were spaced 1/2 mile apart. The total area, approximately 50,000 square miles, is now covered by 128 aeromagnetic maps on a scale of 1 inch to 1 mile. Composite positive maps on a scale of 1 inch to 4 miles, are to be published shortly by the Geological Survey of Canada.

Owing to the abundance of iron-formation, the relief of magnetic intensity is greater than for any other area so far surveyed with an airborne magnetometer in Canada. The absolute total magnetic field measurements range from less than 51,000 gammas to more than 75,000 gammas. South of North Spirit Lake the highly ferromagnetic area was so strong that the automatic recording equipment went off scale and was not able to record a magnetic intensity above 73,000 gammas. This is illustrated on the 1-mile map, Hewitt Lake (GSC Map 877G), as a blank area in the core of an intense magnetic anomaly.

Four-mile aeromagnetic maps and examination of rocks in the field were used as basis for the aeromagnetic-geological interpretation map accompanying this report.

The steps taken in interpreting the magnetic data were as follows: 1-mile aeromagnetic data were reduced to 1 inch to 2 miles; then, using existing geological maps, an office interpretation was made, which was given to the field geologist as a guide in the field. In Trout Lake, North Spirit, and Miminiska map-areas, however, only part of the magnetic data was available while geologists were in the field. Surface geology was checked against the aeromagnetic data and samples of all rock types were collected. When all the geological data had been plotted on base maps it was checked against the aeromagnetic data and, where possible, contacts were extrapolated.

Approximately ten thousand rock samples were collected for geochemical investigation. The magnetic susceptibility of these samples was measured in a magnetic-susceptibility bridge. As all samples were gound, the magnetic susceptibility was measured on particles of various sizes and allowance made for voids in the final volume susceptibility measurement. All these measurements were tabulated on IBM cards for data processing.

Specific-gravity measurements were also made on each sample to facilitate the interpretation of future gravity surveys in the Precambrian areas of northern Ontario.

The table on page 5 illustrates the mean volume susceptibility of the various rocks in the area.

This interpretive study indicates that the more ferromagnetic rocks—iron-formation, gabbro, diorite, and ultrabasic varieties—can be correlated with areas of higher magnetic intensity and higher magnetic susceptibility. The low magnetic susceptibility of the 2,600 samples of volcanic rocks indicates either a lower than average magnetic susceptibility or post-emplacement alteration causing a reduced magnetic content. The latter is the more probable cause.

The aeromagnetic maps, together with the correlation of rock types and magnetic anomalies, have been of considerable use to the geologists in laying out traverses, extrapolating contacts, and in the final office compilations.

In the interpretation of the aeromagnetic results three major features are well illustrated on the aeromagnetic map and are shown on the geologic-aeromagnetic interpretive map (in pocket). First, the low to medium magnetic areas, commonly circular in form and surrounded by linear belts of higher magnetic intensity, correspond to granite and granodioritic rocks surrounded by relatively narrow belts of metasedimentary and volcanic rocks. Where any members of the metavolcanic or sedimentary rocks contain iron-formation these linear belts attain a magnetic intensity above 62,000 gammas. The largest circular structure of this type has a diameter of approximately 50 miles. It occupies a central position in North Caribou Lake map-area and is displaced on its southeastern extremity by a northwest-trending fault with an apparent horizontal displacement of 12 miles. This fault corresponds to a linear anomaly of low intensity, which coincides with a gabbro dyke. Other illustrations of this structure may be found just south of Pickle Lake in Lake St. Joseph map-area and 4 miles west of Opikeigen Lake in Miminiska map-area.

A second feature illustrated by the magnetic data is the position of faults. Faults may be indicated by large apparent horizontal displacement (as described above in the first example of circular structures) or by dissimilar-trending magnetic patterns on either side of the fault-line trace. One example of the latter phenomenon is the contrast in magnetic lineation in the southern part of Fort Hope map-area. There a fault is assumed to lie between the northwest lineation south of Washi Lake and the eastern lineation north of the lake. This fault joins the thrust fault mapped by Prest (1944)[1] in the central part of Miminiska map-area.

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[1]Names and/or dates in parentheses refer to publications listed in the Selected Bibliography.

Rock Type	No. of Samples	Mean Magnetic Susceptibility in C.G.S. Units	Range in Magnetic Susceptibility ($x10^{-6}$ C.G.S. Units)
Gabbro-diabase ultrabasic dykes	47	548.9×10^{-6}	100 - 6,500
Undivided granitic rocks	41	400×10^{-6}	100 - 10,100
Leucocratic granite	483	551×10^{-6}	100 - 12,000
Massive granite and quartz monzonite....	2,439	525×10^{-6}	100 - 15,100
Porphyritic granite	589	972×10^{-6}	100 - 8,900
Foliated coarse-grained quartz diorite and granodiorite	1,565	535×10^{-6}	100 - 8,700
Banded gneiss, paragneiss	527	138×10^{-6}	100 - 16,500
Gabbro, diorite, and ultrabasic rocks	497	$1,197 \times 10^{-6}$	100 - 15,800
Anorthosite	4	100×10^{-6}	100 - 100
Iron-formation	46	$37,810 \times 10^{-6}$	30,000 - 187,000
Sedimentary rocks and paragneiss	463	403×10^{-6}	100 - 24,100
Conglomerate	28	335×10^{-6}	100 - 5,500
Volcanic rocks, undifferentiated mafic rocks.....	2,621	509×10^{-6}	50 - 31,400
Volcanic breccia	22	168×10^{-6}	100 - 300
Acidic volcanic rocks...	53	220×10^{-6}	100 - 1,100

Thirdly, long linear magnetic anomalies, ranging in intensity from 62,000 gammas to higher than 76,000 gammas, indicate the presence of iron-formation. An example of this is the iron-formation along the south shore of Lake St. Joseph, shown on the interpretive map (Map 3-1963, in pocket) as heavy black lines (unit 3).

Another prominent magnetic feature is the large, highly magnetic area (outlined by dots on Map 3-1963) in the northern part of Lake St. Joseph map-area. This higher magnetic intensity is caused by the presence of large amounts of ferromagnetic porphyritic granite.

Several types of mafic (unit 5 on Map 3-1963) to ultramafic (unit 4 on Map 3-1963) rocks conform to oval or circular magnetic anomalies of low to high intensity. The oval-shaped anomaly across the Otoskwin River is caused by gabbro and anorthositic gabbro. Anomalies of higher magnetic intensity correspond to strongly ferromagnetic gabbro. West of Eyapamikama Lake, seven small anomalous areas about 600 gammas above background intensity correspond to areas of serpentinized dunite and peridotite (unit 4 on Map 3-1963). One, designated as "A" on Map 3-1963, contains a small amount of asbestos. Two circular areas of high magnetic intensity in the northwestern corner of Wunnummin Lake map-area are interpreted as coinciding with ultramafic plugs.

The mafic volcanic rocks correspond chiefly to areas of linear anomalies made up of positive and negative members of medium to low magnetic intensity. In some places mafic volcanic rocks, owing to alteration, coincide with areas of very low magnetic intensity, but most volcanic belts can be readily traced using magnetic maps. In this area the volcanic belts trend east, southeast, and northeast.

The acidic to intermediate rocks are more difficult to interpret from the magnetic data than the mafic rocks. Generally the gneisses, if they contain some magnetite, coincide with linear anomalies of low magnetic intensity. Granites, on the other hand, correspond to a large anomalous area of low positive or negative intensity without preferred orientation.

Certain areas (numbered "6" on Map 3-1963 and outlined by dash marks) show magnetic continuity with volcanic belts and/or higher magnetic intensity than adjacent granitic rocks. These areas are interpreted as granitized volcanic rocks.

Work in this area has proved beyond question that aeromagnetic data is of great assistance to the bedrock geologist, particularly if aeromagnetic maps are made available well in advance of field mapping.

BEDROCK GEOLOGY

by S. Duffell

The bedrock geology map accompanying this report is a compilation on a scale of 1 inch to 8 miles of the eight preliminary geological maps of the project area that have been published by the Geological Survey of Canada on a scale of 1 inch to 4 miles. No Pleistocene features are shown on this map, as they are dealt with in the surficial geology report of the area.[1] A considerable amount of interpretation and extrapolation was required to extend the bedrock geology under the drift cover, and this was guided by the outcrops available, aeromagnetic information, and some photo interpretation. In that part of the area where Palaeozoic rocks overlap onto the Precambrian basement, an attempt has been made to portray some of the Precambrian formations under the Palaeozoic cover.

The aeromagnetic interpretation map accompanying this report makes some structural implications not shown on the geological map because evidence for these implications was not observed by the geologist during the course of ground traverses. This does not mean, however, that the implications are without merit. Rather, the structures indicated should be considered together with the bedrock geology to give a more complete picture.

The bedrock geology may best be described as a granitic terrain in which belts and small isolated areas of metamorphosed volcanic and sedimentary rocks are preserved. As a rule the areas of volcanic and sedimentary rocks (so-called 'greenstone belts') are outlined by the aeromagnetic data. In some places, however, areas of volcanic rocks not indicated aeromagnetically were mapped by the ground surveys.

Much was known previously of the greenstone belts, particularly in the western and central parts of the project area, where they had been well prospected prior to 1940. In addition the Ontario Department of Mines had previously mapped many of the belts in more detail than was possible on the scale of mapping used on this project. Much of this earlier work was therefore accepted with a minimum of checking. The present work in the western part of the area extended some of the belts and indicated the presence of small areas of volcanic and sedimentary rocks not previously shown. It is in the eastern part of the project area, however, that the present surveys have indicated the presence of significant amounts of volcanic and sedimentary rocks not previously shown on published maps.

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[1] Prest, V.K.: Red Lake - Landsdowne House Area, Northwestern Ontario: Surficial Geology; Geol. Surv., Canada, Paper 63-6 (1963).

The most persistent belt of such rocks extends from Woman Lake eastward through Lake St. Joseph, Pickle Lake, Miminiska and Eabamet Lakes, and eastward to the eastern boundary of the area. Except for minor breaks where it has been cut by granite the belt can be traced continuously for the whole distance. East of Miminiska Lake and particularly near Fort Hope the belt increases in size and sedimentary rocks are prominent. The number of diabase or gabbro dykes increases greatly in the Fort Hope area, and there also appears to be an increase of visible sulphide minerals in the rocks in this area. The variety of rocks in the Fort Hope area, along with the structural elements and increase in metallic-mineral occurrence compared to the remainder of the area, points to possibilities for mineral occurrences in significant amounts.

Other major belts of volcanic and sedimentary rocks are in North Caribou Lake map-area and along the northern part of the project area from Wunnummin to Mameigwess Lakes. The present surveys extended the boundaries of these belts considerably.

The volcanic and sedimentary rocks in North Caribou Lake map-area form a crude 'girdle' around a circular mass of granite and granitized material some 50 miles in diameter. In the southern part of the structure the greenstone belt running from Windigo Lake to Horseshoe Lake is broken at Sasiginaga Lake because the rocks have become granitized and are now a foliated granitic rock rich in hornblende. The aeromagnetic trend indicates that the belt originally continued for the whole distance. Elsewhere within the core of the circular structure are areas of hybrid granitic rocks with abundant amphibolitic inclusions, probably granitized volcanic rocks.

The volcanic belt from Wunnummin to Mameigwess Lakes is similar to the others except that in its eastern end the metabasalts become coarse grained and resemble meta-diorites. The association of the coarser-grained varieties with the other rocks, along with their general relationships, suggests they are metamorphosed lava flows.

Volcanic and sedimentary rocks also occur at Red Lake, North Spirit Lake, and Favourable Lake, in the western part of the project area.

The volcanic and sedimentary or 'greenstone' belts described above are composed mainly of units 1, 2, 3, and minor amounts of unit 5 (as shown on the bedrock map accompanying this report).

Unit 1 comprises mainly meta-basalts and meta-andesites, which are greyish green to dark green, fine- to coarse-grained amphibole plagioclase rocks commonly containing as accessory minerals, epidote, sphene, quartz, magnetite, and pyrite. Minor acidic flows are present in some places, as are bands of tuff, breccia, and agglomerate. Many of the flows exhibit well-defined pillow structure. Unit 1 also contains minor amounts of sedimentary material.

Numerous small ultrabasic bodies are associated with the volcanic rocks, many of them too small to be shown separately on the map and therefore included with unit 1 rather than unit 5.

The mainly sedimentary unit (2) includes slate, argillite, quartzite, greywacke, and conglomerate. Thin beds of crystalline limestone are present on Borthwick, Setting Net, and Hewitt Lakes, in North Spirit Lake map-area. Primary sedimentary structures are not common, but locally graded bedding, crossbedding, and ripple-like structures are preserved. The conglomerate bands contain pebbles and cobbles of all types of rocks, as felsite, basalt, gneiss, granite, and other sedimentary rocks. Granodiorite boulders up to 4 1/2 feet long were noted in the conglomerate on the north side of Makokibatan Lake in Fort Hope map-area.

Iron-formation (3) occurs associated with both volcanic and sedimentary rocks. It is composed typically of fine-grained, interbedded, quartz-rich and magnetite-rich bands, which range from paper thickness to as much as 9-12 inches thick. Iron silicates and specularite may be present. Some occurrences of iron-formation hold promise of economic significance, but those in the northern parts of the project area will require extensive exploration and development to determine their size and production potential. The most significant occurrence at the present time is that held by Steep Rock Iron Mines on Lake St. Joseph at the southern boundary of the project area.

Unit 4 consists of hybrid and mixed rocks such as migmatites, lit-par-lit gneiss, amphibolites, and granitic rocks with abundant inclusions. They are present where the volcanic and sedimentary belts have been granitized, or as amphibole-rich inclusions or roof pendants in the foliated granitic rocks (6).

Unit 5 includes a wide variety of basic to ultrabasic rocks. Small ultrabasic bodies occur both concordantly and discordantly within most of the volcanic-sedimentary belts and many of these have been tested by exploration companies since they showed up aeromagnetically. In some places, however, their aeromagnetic indication was masked by the presence of iron-formation. Other basic rock varieties included in this unit are olivine and anorthositic gabbro, pyroxenite, and melanocratic diorite and granodiorite. The diorite and granodiorite occur mainly in the northeastern corner of the project area. Anorthositic gabbro bodies occur east of Nibinamik Lake in Wunnummin Lake map-area and north of Gitche River in Lake St. Joseph map-area.

Two aeromagnetic anomalies in the northwestern part of the Wunnummin Lake area are caused by ultrabasic or alkaline bodies with associated carbonatite. The area containing these anomalies was staked for a prominent industrial corporation for their columbium possibilities. These intrusions were not previously known and were indicated for the first time by the aeromagnetic survey.

An attempt has been made to group the granitic rocks into three broad categories. The largest group (6) consists mainly of foliated granitic rocks, which in many places appear to have been derived from the granitization of volcanic and sedimentary rocks. The second group (7) are porphyritic and distinctive. Phenocrysts of feldspar 1 inch or more in length are common. The largest area underlain by these rocks is in Lake St. Joseph map-area and is indicated by a distinctive pattern on the aeromagnetic maps, aeromagnetically probably because of a higher content of magnetite. Smaller areas of porphyritic granite do not appear to have any special magnetic properties. The third group of granitic rocks (8) are mainly leucocratic, pink and white, massive granites, which appear to be the latest expression of granitic emplacement in the project area. In some places, owing to insufficient outcrop or inaccessibility, the granitic rocks could not be subdivided; such places are indicated on the geological map as unit (9). One small body of syenite with a high content of accessory titanite is shown separately as unit 10.

Diabase and gabbro dykes (11) are prevalent in the southeastern corner of the project area. They are mostly aligned in a northwesterly direction, but a few trend northeasterly. The most westerly member of these dykes is a persistent diabase dyke that extends from the southern boundary of Miminiska map-area northward to Pickle Crow; thence it can be traced by aeromagnetic data north-northwest to North Caribou Lake, where diabase outcrops were noted along a weakly magnetic linear believed to be the extension of the dyke. Some palaeomagnetic investigations are planned to check if these dykes are coeval with the Nipigon diabase to the southwest.

The bedrock and aeromagnetic surveys indicate that the eastern part of the project area near Fort Hope has more unexplored volcanic and sedimentary rocks than elsewhere, and also that evidence of sulphide mineralization is more prevalent in the rocks there. Unfortunately, drift cover is heavier there, so that prospecting and exploration is more difficult. However, this part of the project area probably has the best potential for mineral occurrence.

Palaeozoic rocks (12, 13) outcrop along the rivers and streams near the eastern border of the project area, but outcrop is generally scarce. The contact, as shown on the geological map accompanying this report, is only slightly modified from that shown on previous maps by the Ontario Department of Mines.

GEOCHEMICAL INVESTIGATIONS

by R. H. C. Holman

The application of geochemical techniques to a survey of the Red Lake - Lansdowne House area was considered at too late a stage for geochemical orientation studies to be made along with the pilot geological and geophysical surveys initiated in Trout Lake map-area in 1959. Decisions on the kind of geochemical investigation that would best complement the geological and geophysical work were made, therefore, without this advantage. In view of the large area to be covered, it was necessary also to reduce costs to a minimum and to restrict geochemical sampling on the reconnaissance scale to what could be accomplished by the traversing geological parties without seriously impeding the progress of mapping.

Regional geochemical surveys are often made by sampling detritus undergoing active transport in the surface drainage system, thereby exploiting fully the tendency of mechanical and chemical dispersion to enlarge the primary target. In this region of low relief, however, the sampling of stream sediments was open to objection because of the weak erosive power of the streams on bedrock, and transported debris was known to be mainly suspended organic muck, or sediment derived from reworked glacial deposits. The use of waters and swamp material would introduce many problems of sampling, analysis, and interpretation that would be difficult to solve.

Objections to using surficial media for geochemical sampling in this project prompted the consideration of sampling bedrock directly. Little attention has been given to the possibilities of this technique, probably because of the difficulties of sampling and preparing rocks for chemical analysis, together with the fact that secondary dispersion effects are not detected. Certain advantages of working with rocks were apparent: (1) the results would be free from the interpretive difficulties peculiar to studies based on surficial materials; (2) a bedrock study would provide a sound basis for further work on waters, stream and lake sediments, and all other media; and (3) data on the distribution of elements on a regional scale in rocks underlying part of the Canadian Shield were of prime interest.

It was decided, therefore, to undertake an experimental lithogeochemical study throughout the Red Lake - Lansdowne House area for the purpose of revealing any primary geochemical dispersion patterns of sufficient areal extent to be detected by wide-spaced sampling.

For the reconnaissance study, samples of rock weighing between 2 and 3 pounds were collected from outcrops at intervals of about a mile along traverses required for geological mapping. At each station a single specimen of the most common rock type was taken. In areas of visibly heterogeneous rocks, such as

gneisses and migmatites, whatever material was available for sampling at the outcrop was collected, but descriptions of all samples were recorded. The overall sampling density was about one specimen for every 3 to 4 square miles, but in areas of sparse outcrop the coverage was less dense. In certain selected areas more thorough sampling was undertaken for specific purposes.

The samples were split, and a chip retained. The remainder was passed through a jaw crusher (set to 1/4-inch size) and then through a rotating disc pulverizer fitted with ceramic plates (set to 60 mesh/inch size). The resulting powder was mixed by rolling on paper sheets, and a 15- to 20-gram grab sample was taken and ground to finer than 100 mesh/inch size in a ceramic ball mill. The foregoing procedure introduces the minimum contamination and permits the processing of 80 samples daily using a two-man crew. Approximately 10,000 samples were treated in this way.

Chemical analysis of most of the samples has been confined to copper and zinc, because these metals could be determined together rapidly, and are of economic interest. Other elements have been determined in only a few samples. This chemical data and a petrological classification for each specimen have been entered on mechanical data processing cards for automated sorting operations and the electronic computation of appropriate statistical parameters.

Statistical studies are presently being directed to the problems of displaying the copper and zinc results on maps in such a way that significant variations in concentrations are apparent. These provisional maps will be published at an early date. The statistical work will also greatly facilitate the efficient selection of groups of samples for more comprehensive study.

A number of special investigations, already under way on different suites of samples, are listed below.

1. A study of the alkali content of several leucocratic granite bodies by flame photometry and modal analysis, and the distribution of trace elements in the granite-forming minerals.
2. A study of the major elements present in the leucocratic granites using the automatic recording spectrograph.
3. Detailed studies on the distribution of major, minor, and trace elements in selected belts of volcanic rocks.
4. The quantitative determination, using the spectrograph, of several trace elements in specially prepared composite samples, and examination of the results by analysis of variance, and the calculation of the average composition for the rocks of the whole area.
5. Statistical studies on problems of sampling rocks and interpreting geochemical data.

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