

GEOCHEMISTRY

PROJECT: Isotope Studies of Sulphur from Canadian Petroleum Deposits

PERSONNEL: H. R. Belyea, J. A. Maxwell, R. K. Wanless

The first phase of this study was the comparison of the isotopic ratios in sulphides selected from various wells in Alberta. This preliminary work indicated that the ratios within a given formation were relatively constant with depth, and that rather large variations in isotopic composition existed in the transition zones between formations. It was also found that the sulphides in adjacent formations, while internally consistent, commonly varied markedly from one another.

It was not known however, whether the isotopic ratios were constant for a particular formation in various parts of the province. Plans were therefore made to select additional samples from a particular formation from various wells in the region. The results of the second phase are not yet available, although the sulphide samples have been converted to SO₂ and now await mass spectrometric analysis.

(R. K. W.)

PROJECT: Lead- and Sulphur-Isotope Geology of Keno and Galena Hills, Yukon

PERSONNEL: R. W. Boyle, R. K. Wanless

This project parallels the studies outlined for the Sullivan Mine and East Kootenay district deposits and for the gold-quartz deposits of the Yellowknife district. In this investigation, however, both lead- and sulphur-isotope measurements are to be carried out.

The lead-isotope determinations are now complete and preliminary compilation is underway. All sulphide minerals have been converted to SO₂ and are awaiting mass spectrometric analysis.

(R. K. W.)

PROJECT: Isotope Chemistry of Sulphur in Rocks and Minerals

PERSONNEL: R. W. Boyle, R. K. Wanless, J. A. Lowdon,
R. D. Stevens

Two major projects and four minor projects involving the study of sulphur-isotope variations in nature have been undertaken.

The study of the sulphur-isotope distribution in the Yellowknife region is now complete. Interesting trends in the isotopic composition of sulphides found in the granodiorite, in the greenstones, and in the main ore zones were found. The results, which have been published (Economic Geology, vol. 55, pp. 1591-1621, 1960), indicate a direct correlation between the S^{34} content and the thermal history of the particular rock type. The sulphides in the granodiorite, the porphyries, and in the greenstone belts have all been enriched in the heavier S^{34} , to varying degrees, during the early phases of development of the region. The ore zones also contain sulphides enriched in S^{34} and the average values for the ore reflect a kinship to the sulphides in the enclosing country rock.

A second major study has been started in the Keno Hill region. A large number of sulphides have been selected and converted to SO_2 in preparation for isotopic analysis. In this study the lead-isotope abundances will also be determined in an attempt to shed light on the processes responsible for ore concentration.

Four minor projects, essentially of a reconnaissance nature, have been completed. These include studies of the sulphides at the Sullivan Mine, Kimberley, B.C. (G. B. Leech); sulphides from the Blind River region of Ontario (S. M. Roscoe); sulphides in radioactive deposits in the Bancroft area, Ontario (S. C. Robinson); and a preliminary survey of the sulphides from various iron deposits in Canada (G. A. Gross).

(R. K. W.)

PROJECT: Radiocarbon Dating

PERSONNEL: W. Dyck, R. K. Wanless, and others

In order to provide dates in the relatively recent past (0 - 35,000 years), the Geological Survey in 1959 commenced construction of a radiocarbon (C^{14}) dating laboratory. This unit comprises (1) a low-level counting laboratory in the sub-basement of the Survey building, where it takes advantage of the excellent shielding provided by the concrete floors of the building, and (2) a sample-preparation laboratory. Sample materials are converted to CO_2 and the concentration of radiocarbon is determined in proportional counters. In January 1961 the dating laboratory became operative, and during the ensuing months a total of 62 age measurements were completed, using a single, 2-litre proportional counter. Many of the age measurements are reported in Radiocarbon, vol. 4, 1962. Work was also conducted on the design and fabrication of a 5-litre counter; by the end of 1961 this counter was completed and was undergoing tests.

PROJECT: Chemical and Spectrographic Analyses of Rocks and Minerals

PERSONNEL: J.A. Maxwell, S. Abbey, W.H. Champ, S. Courville, and others

This project is an active part of the Survey's laboratory research. Many of the results are published in areal geological reports published by the Survey; others are in outside publications. During 1961 almost 9,000 chemical determinations were made. Work is continuing to develop new chemical and spectrographic methods of analysis and to improve the accuracy, range, sensitivity, and speed of existing methods.

PROJECT: Investigation of Recent Methods for Determining Ferrous Iron in Rocks and Minerals

PERSONNEL: J.A. Maxwell, J.M. Moore, Jr. (Carleton University)

Investigation of the applicability of a rapid colorimetric method (developed by L. Shapiro of the U.S. Geological Survey) revealed that it did not give complete recovery of the iron but that further work might produce a useful method.

PROJECT: Origin of Sulphides in Radioactive Conglomerate

PERSONNEL: S.M. Roscoe

The systematic difference in isotopic composition in a few sulphide samples from Elliot Lake, Ontario, has led to further isotopic studies of sulphides in various rocks at Elliot Lake and the adjacent region. These studies have revealed that sulphides associated with radioactive minerals in conglomerates have a limited range of S^{32}/S^{34} ratios, which differs significantly from those of other groups of sulphides in the area including: pre-Huronian and post Huronian hydrothermal sulphides (both lower), sulphides in Huronian black argillites (much lower), and epigenetic, probably sedimentogenic, sulphides in Huronian strata (higher). A slight but significant difference is found between sulphur-isotope constitution of pyrite in ore-grade conglomerates and that in sub-ore-grade conglomerates.

Neither local metamorphism nor local intense hydrothermal alteration of ores has significantly affected the isotopic composition of their sulphur. Extreme sulphur-isotope differentiation has occurred in certain late sulphides.

The data support deductions and mineralographic and chemical evidence that a mixture of pyrites of different origins is present in the conglomerates.

(S. M. R.)

PROJECT: Isotopic Study of Canadian Ore Leads

PERSONNEL: R.K. Wanless, G.B. Leech, R.W. Boyle,
R.D. Stevens

A study of the lead-isotope distribution of the Sullivan Mine, Kimberley, B.C. and of smaller lead deposits in the East Kootenay District has been completed. The results are to be published in the Buddington Volume of the Geological Society of America.

The isotopic distribution within the large Sullivan deposit was found to be extremely constant. The average of this deposit has been compared with the isotopic values found in the other deposits of the district, many of which contain lead with a much higher radiogenic lead-isotope composition. Detailed calculations based on a model for lead evolution since the formation of the earth have been carried out. From this, one may postulate the type of source responsible for the production of a lead body with the isotopic distribution now found in the Sullivan Mine.

The lead-lead age of the Sullivan deposit has been compared with K-Ar age measurements on a lamprophyre dyke within the mine and on mica from a granitic intrusion nearby. This work indicates that the Sullivan deposit is between 765 and 1,250 m.y. old.

(R.K.W.)

PROJECT: Magnesium-Isotope Studies

PERSONNEL: R.K. Wanless, J.A. Maxwell, C.H. Smith,
W.D. Loveridge

A reconnaissance survey of magnesium-bearing minerals was undertaken to establish the possible existence and range of natural magnesium-isotope variations. This study involved the development of special techniques required to produce and detect satisfactory ion currents in a solid-source mass spectrometer. Several methods of sample preparation were studied and a series of samples were analyzed.

This initial survey has shown that small magnesium-isotope variations do exist in natural materials and that the lighter magnesium-isotope, Mg^{24} , is slightly enriched in low-temperature hydrous-mineral phases.

A preliminary report was made to the American Geophysical Union's Annual Meeting in Washington, D.C., April 1961.

(R.K.W.)

PROJECT: Age Determinations of Rocks and Minerals

PERSONNEL: R.K. Wanless, R.J. Traill, S. Abbey, J.C. Paris,
S.C. Robinson, J.A. Lowdon

Age determinations, based on the U-Pb, and Th-Pb ratios, the K^{40} - Ar^{40} ratio and the Rb^{87} - Sr^{87} ratio, are currently being carried out by the Geological Survey. During the early stages of development of the laboratory, age measurements were restricted to the determination of U-Pb and Th-Pb ratios in uraniferous minerals. As the isotopic analyses are carried out on a gaseous sample of $Pb(CH_3)_4$, requiring a relatively large quantity of lead, the application of the method was restricted to regions containing radioactive deposits. The regional restrictions are not as severe in the case of the K-Ar method however, and consequently increased emphasis has been placed on the application of this method. During 1959 a reconnaissance age program based on the K-Ar method was initiated, and a total of 454 determinations have since been published in GSC Papers 60-17, 61-17, and 62-17. This study is continuing. The completion of a new solid-source mass spectrometer provided an opportunity for the application of the Rb-Sr method to age problems, and late in 1961 work was started on the calibration of the isotope-dilution solutions required. Rb/Sr ratios are now being determined on whole rock and separated mineral fractions.

The sample-size restrictions referred to above, in the case of lead analyses, have been removed with the development of solid-source mass-spectrometric techniques. It is now possible to carry out isotopic analyses of lead samples in the 20-to-40-microgram range, on a routine basis. This development has facilitated the extension of age studies to determinations based on the radiogenic lead accumulated in zircons and other minerals. A special lead-free chemical laboratory is now being equipped to handle the extremely small quantities of lead required for this work.

The mass-spectrometer laboratory is at present equipped with two mass spectrometers, one designed to analyze gaseous samples and one equipped for the analysis of solids. Two new instruments, of somewhat smaller design, are now being fabricated. The new gas-source instrument will be employed exclusively for the analysis of argon while the new solid-source unit is designed to handle the expanded Rb/Sr age program. The existing solid-source mass spectrometer will then be available for studies involving trace quantities of lead and for the development of techniques required for other projects dependent on analyses in the solid form.

The results of the K-Ar reconnaissance age study of the Canadian Shield are being used in the development of the tectonic map of Canada. As the general age patterns are established, problems requiring more detailed study are unveiled. Where possible, the various age-measurement techniques will be applied to help elucidate the time relationships of rocks in complex geological settings.

(R. K. W.)

PROJECT: Study of Trace-Element Adsorption by Silicates

PERSONNEL: R. A. Washington

An investigation commenced in 1961 to obtain quantitative data on the amounts of trace elements adsorbed by silicate minerals and rocks, in order to develop a reasonable theory of the mechanisms operative in the formation, metamorphism, and metasomatism of silicate rocks. The effects of pH and temperature on the adsorption of trace elements from solution on finely ground quartz, feldspar, and other minerals are being studied. These studies have revealed that the adsorption of Co^{++} (from dilute solution as chloride) on quartz at room temperature is negligibly small at pH values below ca. 3.5. The amount adsorbed, however, increases markedly as the pH is increased from 3.5 - 4 to 6.5 - 7. Preliminary results also indicate that there is a slight difference in the amount of Co^{++} adsorbed by crystalline quartz from Lyndoch, Ontario, and by massive quartz from Buckingham, Quebec. No firm explanation of this result can be offered at present. Further study will be required to establish whether this small difference is real and to find the reason for it.

Experiments using feldspar (from South March, Ontario, and Buckingham, Quebec) are being carried out, and later experiments will include tests at different temperatures and concentrations, and using other silicate minerals (e.g. mica, olivine, hornblende, pyroxene, etc.) and other trace elements (e.g. Ni, Fe, Tl, Pb, Sr, Zn, etc.). The results of these tests should provide data that can be used to estimate the energy requirements for adsorption, and to explain some of the processes that may be important in regulating the concentration and distribution of trace elements in silicate rocks.

(R. A. W.)