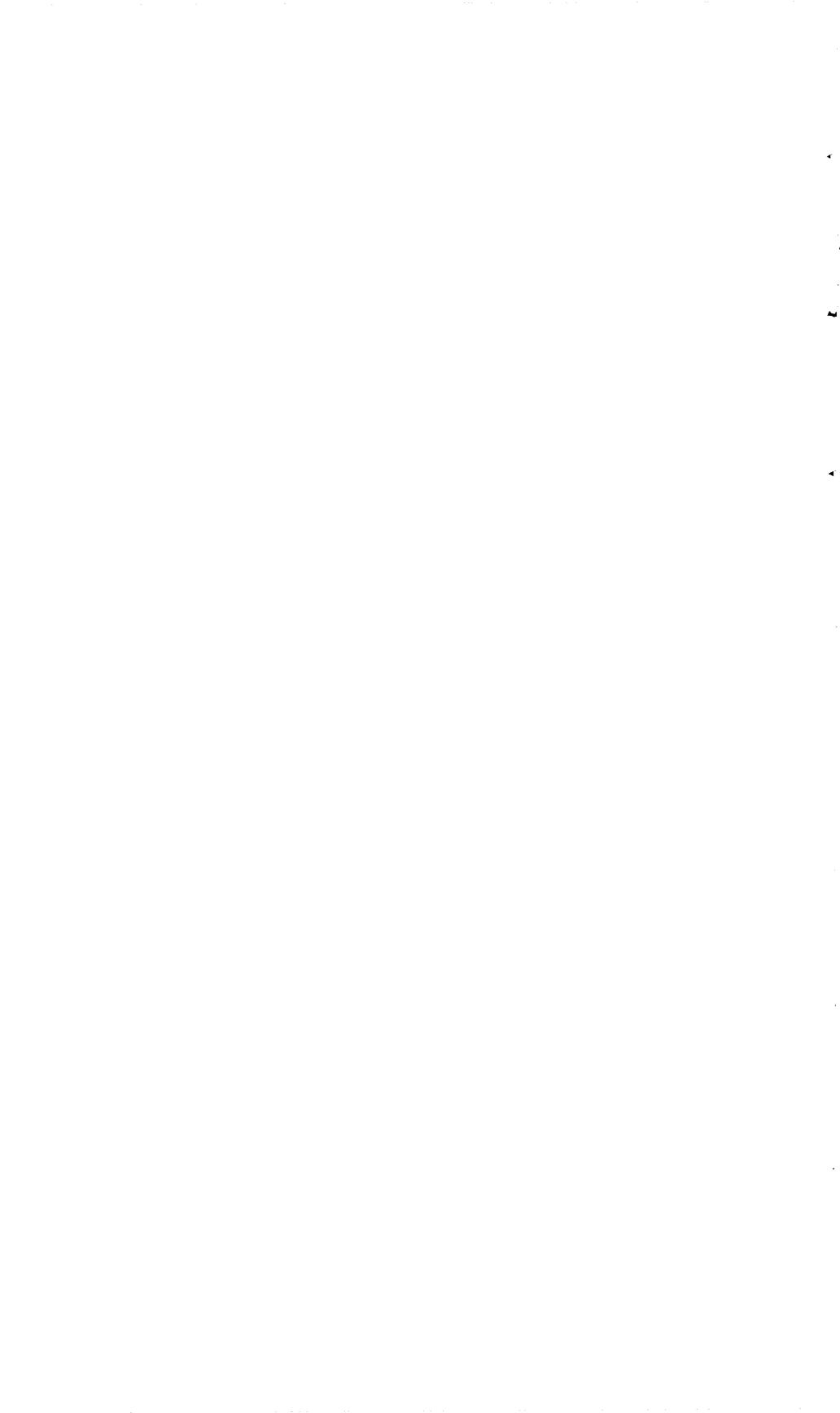


Geochemical Prospecting Abstracts July 1952–December 1954

GEOLOGICAL SURVEY BULLETIN 1000-G





CONTRIBUTIONS TO GEOCHEMICAL PROSPECTING FOR MINERALS

GEOCHEMICAL PROSPECTING ABSTRACTS, JULY 1952-DECEMBER 1954

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INTRODUCTION

This bulletin is the second in a series of Geochemical Prospecting Abstracts. The first, Bulletin 1000-A, by John W. Harbaugh includes abstracts of most of the literature through June 1952. The present bulletin carries the abstracts forward through December 1954 and includes a few abstracts for earlier years not included in Bulletin 1000-A. References to geochemical prospecting for petroleum are not included in the report.

Wherever possible, the abstracts of the authors were used. Other abstracts, particularly abstracts of foreign publications, were taken from Annotated Bibliography of Economic Geology, Bibliography and Index Exclusive of North America, Chemical Abstracts, and Geophysical Abstracts. Where it was impossible to prepare an abstract, only the reference to the report is given.

Most of the foreign titles of reports have been translated. The language in which the article is written is the same as that indicated in the title of the reference unless otherwise indicated.

ABSTRACTS

1. Adams, J. A. S., 1954, Uranium content of Wisconsin rivers and their use in geochemical prospecting [abs. of paper presented at the meeting in Los Angeles, Nov. 1-3]: Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1225.

More than 100 samples from 18 stations on Wisconsin rivers, including the Mississippi, have been analyzed fluorimetrically for uranium. Uranium content from 0.01 to 1.1 parts per billion were found, with an over all average of 0.45 parts per billion. Experiments indicate an average error of ± 6.4 percent of the amount present.

At different seasons of the year one station on the Mississippi showed unsystematic variations from 0.08 to 0.82 parts per billion, and other stations on large rivers showed similar variations. Small northern Wisconsin rivers systematically had their maximum uranium concentrations in winter; it is believed that ground water is responsible for most of the uranium in these streams. Southern Wisconsin rivers systematically had their maximum ura-

niium concentrations in the spring; it is believed that uranium from phosphate fertilizer is responsible for this springtime peak. Analyses of representative samples of phosphate fertilizer used last spring in Wisconsin showed uranium contents from 22 to 56 parts per million, which would give uranium concentrations of about 8 pounds per square mile of fertilized land. These data and material balances based upon them are very useful in suggesting a pattern of geochemical prospecting based upon sampling ground and surface waters.—*Author's abstract.*

2. Agnew, A. F., 1953, Application of geology to the discovery of zinc-lead ore in the Wisconsin-Illinois-Iowa district [abs. of paper presented at the joint meeting of the Soc. of Econ. Geologists and the Am. Inst. Min. Metall. Eng., Los Angeles, Feb. 16-19, 1953]: *Econ. Geology*, v. 48, no. 4, p. 322.

Geochemical prospecting has shown that MgO/CaO ratio, heavy metal content, and locally, percentage of insoluble material increase near ore; these increases may be used as guides to ore.—*Author's abstract.*

3. Almond, Hy, 1953, Determination of traces of cobalt in soils: *Anal. Chemistry*, v. 25, p. 166-167.

The growing use of geochemical prospecting methods in the search for ore deposits has led to the development of a field method for the determination of cobalt in soils. The determination is based on the fact that cobalt reacts with 2-nitroso-1-naphthol to yield a pink compound that is soluble in carbon tetrachloride. The carbon tetrachloride extract is shaken with dilute cyanide to complex interfering elements and to remove excess reagent. The cobalt content is estimated by comparing the pink color in the carbon tetrachloride with a standard series prepared from standard solutions. The cobalt 2-nitroso-1-naphtholate system in carbon tetrachloride follows Beer's law. As little as 1 ppm can be determined in a 0.1-gram sample. The method is simple and fast and requires only simple equipment. More than 40 samples can be analyzed per man-day with an accuracy within 30 percent or better.—*Authors' abstract.*

4. Almond, Hy, 1953, Field method for determination of traces of arsenic in soils—confined spot procedure using a modified Gutzeit apparatus: *Anal. Chemistry*, v. 25, p. 1766-1777. [Originally released as a U. S. Geol. Survey open-file report. See abs. 93]

Traces of arsenic are usually determined by either the Gutzeit method or the molybdenum blue method, but the latter is not suitable under field conditions because of the interference of SiO_2 and $\text{PO}_4^{=}$. In the Gutzeit method the sample is dissolved by fusing a wetted sample with KOH. Zinc is then added to an acidified aliquot in the apparatus, and the gases are passed through lead acetate to a confined spot on HgCl_2 paper. The reaction of HgCl_2 with H_2S is prevented by filling the glass pipe of the apparatus with glass wool which has been saturated with lead acetate.

At least eight samples can be analyzed for arsenic in 90 minutes with suitable sensitivity. Amounts as low as 5 ppm can be determined in a 0.1-gram soil sample, and a range from 50 to 2,000 ppm is covered by using the 2-ml aliquot. Several variable factors, such as the rate of evolution of hydrogen, the amount of arsenic remaining behind, and the absorption of arsine in the lead acetate, may affect the accuracy of a determination by the Gutzeit apparatus. Detailed descriptions of the preparation of standards and the procedure used in the test are given.

5. Almond, Hy, Stevens, R. E., and Lakin, H. W., 1953, A confined-spot method for the determination of traces of silver in soils and rocks: U. S. Geol. Survey Bull. 992, pt. 7, p. 71-81.

A procedure for estimating traces of silver in soils and rocks was developed to provide a method suitable for geochemical prospecting. Silver can be determined in a 0.5-g sample in concentrations between 0.2 and 20 ppm. A specially designed extractor prevents bumping during the acid digestion of a soil and upon cooling automatically filters the acid digest. The final estimation is made with a chromograph, a device which automatically controls the rate of flow to test solution through a confined spot on filter paper. A preliminary ignition of the sample to eliminate organic matter and mercury is followed by a nitric acid digestion. Silver is separated from the colored ions in the nitric acid solution by collecting the silver salt of *p*-dimethylaminobenzalrhodanine at the interface between amyl alcohol and the aqueous solution and then discarding the aqueous extract. This silver precipitate is dispersed by adding ethyl alcohol and is then collected on a confined spot by means of the chromograph. The intensity of the red color on the filter paper, compared with spots prepared from standard solutions, is a measure of the silver content of the original sample. About 20 samples can be analyzed per man-day.—*Author's abstract.*

6. Anderson, R. Y., and Kurtz, E. B., 1954, Factors influencing uranium accumulation in plants [abs. of paper presented at the meeting in Los Angeles, Nov. 1-3]: Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1226.

In an attempt to account for the great variability in the accumulation of mineral salts by plants growing in the field, detailed laboratory studies have been made of the factors that influence accumulation with respect to uranium. Plants were grown in the greenhouse by nutrient-culture methods and analyzed by the alpha-scintillation method. Results indicate that different species vary markedly in their ability to accumulate uranium. By determining the relative ability of each species to accumulate uranium under standard conditions it should be possible to correlate among species in the field. Uranium accumulation seems to be a linear function of uranium concentration in the soil medium. Some plants increase their uranium content with age, while others decrease their content with age. In two plants the older organs contained the most uranium, but in a third plant the younger organs contained the most. Low levels of soil phosphate greatly increased the accumulation of uranium, probably by increasing the availability of uranium in the soil. High levels of phosphate delayed flowering in oats; however, high levels of uranium, which would be expected to tie up the phosphate, also delayed flowering. Other factors being studied include soil acidity (pH), transpiration, variation within the species in the ability to accumulate uranium, and mineral nutrition. Refinement of the present field methods of biogeochemical prospecting should be possible by determining the importance of each factor for each species used.—*Authors' abstract.*

7. Arndt, R. H., and Kuroda, P. K., 1953, Radioactivity of rivers and lakes in parts of Garland and Hot Spring Counties, Ark.: Econ. Geology, v. 48, no. 7, p. 551-567.

A wide range of radon content in surface waters was noted incidental to studies of radon in spring and well waters of Hot Spring and Potash Sulphur

Springs, Garland County, Arkansas. Subsequently a reconnaissance survey of radioactivity of nearby streams and lakes showed the radon contents of streams range from 0.0084 to 1.07 millimicrocuries per liter of water, and those of lakes range from less than 0.001 to 0.123 millimicrocuries. Streams flowing over Ordovician black shales contained an average of 0.275 millimicrocurie radon per liter of water. Those flowing over black Stanley shale of Mississippian age contained an average of 0.064 millimicrocurie radon per liter of water.

The radon content in Potash Sulphur Creek where it flows over the uranium-bearing rocks of the Potash Sulphur Springs syenite complex ranged from 0.09 to 3.16 millimicrocuries per liter of water. Ground water in a drill hole in uranium-bearing rock contained an average of 58.75 millimicrocuries per liter of water. Waters from small springs were shown to lose as much as 41.3 percent of total radon content in the first 4 feet of surface flow below the point of emergence. The methods of radon determination in the field are believed applicable to prospecting for low-grade uraniferous deposits, especially in black shale areas, in areas of heavy overburden, and in areas of saturation by ground water where ordinary detection devices may be somewhat limited.—*Authors' abstract.*

8. Biringuccio, Vannoccio, 1540, *Pirotechnia*, Venice, translated by C. S. Smith and M. T. Ginudi, *Am. Inst. Min. Eng.*, v. 1942, p. 15.

A discussion of how water samples are evaporated to obtain certain residues, and how these residues are then analyzed for constituents.

9. Bischoff, C. T., 1954, Testing for copper and zinc in Canadian glacial soils: *Min. Eng.*, v. 6, no. 1, p. 57-61.

This paper describes the results of testing with colorimetric methods, using "dithizone," soil samples taken over various known copper and zinc deposits covered by glacial till. Variation in results is shown for different depths and types of overburden as well as grade and type of deposit. Limiting factors for the practical application of this work are discussed. The method has proved successful for copper and zinc deposits under clay and fine sand with depths up to at least 30 ft. but fails in coarse sand and gravel unless depths are very shallow. Swamps require penetration to the underlying subsoil for sample material.—*Author's abstract.*

10. Bloom, Harold, 1953, Methods used in geochemical prospecting analytical laboratory [abs. of paper presented at the joint meeting of the Soc. Econ. Geologists and the Am. Inst. Min. Metall. Eng., Los Angeles, Feb. 16-19, 1953]: *Econ. Geology*, v. 48, no. 4, p. 322-323.

The field tests that have been developed for geochemical prospecting and tried during the past four years, have undergone some changes leading to the improvement of some and the de-emphasis of others.

The [table on p. 361] shows the elements, methods, productivity, and sensitivity in parts per million, of some of the methods in use by the laboratory.

Equipment for running any of these tests costs under \$100. Over 24,000 determinations have been made for these metals on 11,000 samples during the past year in this laboratory.—*Author's abstract.*

Elements	Method	No. determinations per man-day	Sensitivity ppm
Zinc.....	Dithizone.....	100	20
Lead.....	Dithizone.....	60	10
Copper.....	Dithizone.....	60	10
Heavy Metal.....	Dithizone.....	100	50
Nickel.....	Chromograph.....	100	15
Copper.....	Chromograph.....	100	10
Silver.....	Chromograph.....	30	0.2
Tungsten.....	Thiocyanate-stannous chloride.....	40	10
Molybdenum.....	Thiocyanate-stannous chloride.....	40	1
Antimony.....	Rhodamine B.....	40	1
Arsenic.....	Modified Gutzeit.....	60	10
Manganese.....	Permanganate.....	60	50

11. Brundin, Nils, Romford, England, 1939, Method of locating metals and minerals in the ground: U. S. Patent 2,158,980, May 16, 1939.

This invention relates to a method of detecting the presence and location of metals and ores in the ground, which comprises the steps of taking samples of vegetable material of the same species at substantially regular intervals along lines distributed over the area to be investigated; ashing the samples; subjecting the ash to spectrographic analysis; and plotting the results obtained in the form of a graph or map of the area investigated so as to exhibit areas of greatest concentration of the metal. Claim allowed, 1. Geophysical Abstracts 100, U. S. Geol. Survey Bull. 925, p. 44.

12. Butler, J. R., 1954, Spectrographic estimation of lead in twig samples: Analyst, v. 79, no. 935, p. 103-104.

This method was devised for the semiquantitative estimation of Pb in twigs from several types of trees growing over mineralized ground. Eleven twig samples of known concentration were supplied by Dr. J. Webb and were analyzed using a Hilger medium spectrograph. Pb was detected only when present to the extent of several hundredths of a percent in oven-dry material. In the arc, the excitation of lead was found to be more intense, and the simple procedure used is described.

The limit of detection was about 0.5 ppm in oven-dry material or half the value taken by Webb and Millman as background count for twigs from trees in barren areas. The reproducibility for line intensities corresponding to Pb contents of as much as 50 ppm was found to be ± 50 percent; the error increased at higher concentrations. The results obtained using this method were in close agreement with the known values, and the method is adequate for geochemical prospecting. The time required for running the 11 samples was 50 minutes.

13. California Division of Mines, 1953, Geochemical prospecting: Calif. Div. Mines Mineral Inf. Service, v. 6, no. 3, p. 1-5.

A brief summary of geochemical prospecting including sections on chemical, biogeochemical, and geobotanical methods is presented.

14. Canney, F. C., Hawkes, H. E., and Richmond, G. M., and Vhay, J. S., 1953, A preliminary report of geochemical investigations in the Blackbird district: U. S. Geol. Survey open-file rept., 20 p., 4 pls.

(See abs. 36.)

15. Cannon, Helen L., 1952, The effect of uranium-vanadium deposits on the vegetation of the Colorado Plateau: *Am. Jour. Sci.*, v. 250, p. 735-770.

A study has recently been made by the U. S. Geological Survey of the relation of plants to uranium-vanadium deposits in several districts of the Colorado Plateau. The deposits occur mainly in the Salt Wash sandstone member of the Jurassic Morrison formation. The ore contains unusual concentrations of uranium, vanadium, and selenium, and plants growing near shallow ore deposits accumulate small amounts of these metals. To investigate the extent of this relationship, basic biogeochemical studies were made in the Thompsons district, Grand County, Utah. The information gained from these studies is being used in the development of biogeochemical methods of prospecting for uranium ores in sandstones of the Colorado Plateau.

Three lines of investigation have been pursued. The effects of these concentrations of metals on plant growth have been observed, the absorption of uranium and vanadium by plants has been investigated, and the ecology of the plants in several uranium districts has been studied. Because of the association of selenium-indicator plants with the uranium deposits of the Thompsons district, the distribution of various species of indicator plants was mapped in detail.

Four conclusions have been drawn from this work. First, the plants growing on dumps and areas of mine seepage where the metals are oxidized show chlorotic symptoms and dwarfing, but those rooted in unoxidized ore are not noticeably affected. Second, it has been demonstrated that plants absorb small amounts of uranium and vanadium that can be detected by analyzing a given part of the plant. The amount of uranium is consistently greater where the plants are rooted in ore than where rooted in barren sandstone. Third, a uranium-tolerant flora has been recognized and a list of the plants compiled from a study of thirteen areas. The flora is characterized by selenium-indicator plants and by sulfur-accumulating members of the mustard and lily families. Fourth, where selenium-bearing ores lie at shallow depth and where the geography and rainfall are favorable for plant growth, the distribution of selenium-indicator plants is shown to accord with that of the carnotite ores. Certain species of selenium-indicator plants, depending on the quantity of selenium in the ore, can be mapped in a particular area as a guide to exploration.—*Author's abstract.*

16. Cannon, Helen L., 1953, Geobotanical reconnaissance near Grants, N. Mex.: U. S. Geol. Survey Circ. 264, 8. p.

The application of geobotanical methods of prospecting in uranium-bearing areas in McKinley County, near Grants, N. Mex., has been investigated briefly. The uranium deposits occur in the Todilto limestone member of the Wanakah formation and in the overlying Morrison formation, both of Jurassic age. Carbonaceous uranium ore in the Morrison formation contains a high percentage of selenium, and selenium-indicator plants are commonly associated with these deposits. Such plants have not been observed on the Todilto deposits.

The average uranium content in the ash of trees rooted in ore deposits of the Todilto limestone member is more than 20 parts per million, and trees

rooted in barren limestone average about 10 ppm. The uranium content of the plant ash is detectable by fluorimetric methods. Uranium analysis of trees growing on the Todilto bench and mapping of selenium-indicator plants of the sandstones of the Morrison formation are recommended as a method of prospecting.—*Author's abstract.*

17. Cannon, Helen L., 1954, Botanical methods of prospecting for uranium: Am. Inst. Min. Metall. Eng. Trans., v. 199, p. 217-220; Tech. Paper 3724-L, p. 217-220; Min. Eng., v. 6, no. 2, p. 217-220.

Botanical methods of prospecting for metalliferous ores are based on the premise that deposits at depth may be reflected chemically in surface vegetation. Plant physiologists have shown that uranium is a necessary nutrient for plant growth and therefore is present in all plants. The amount present is small but measurable. Selenium and sulfur, two elements associated with uranium and vanadium in ores of many districts, are necessary in large quantities only to certain groups of plants. These indicator plants are present only in soils and rocks containing large amounts of Se and S. *Sisymbrium altissimum*, *Toxicoscordion gramineum*, *Eriogonum inflatum*, *Lepidium montanum*, *Stanleya pinnata*, and *Allium acuminatum* are sulfur-indicator plants common in uranium districts. *Astragalus confertiflorus*, *A. preussi* var. *arctus*, *A. thompsonae*, *A. pattersonii*, *Oryzopsis hymenoides*, and *Aster venusta* are Se-indicator plants common in uranium districts. The *Astragalus* species are the most effective indicators in carnotite districts. The accuracy of predicting mineralized ground is of a high order. More than 2 ppm U in trees is indicative of geologically favorable ground. Prospecting by plants was tested in the Thompson district, Utah, where plants were mapped over an area of 6 sq. mi. and where 1,000 holes were subsequently drilled. Of 194 holes drilled in areas supporting the growth of indicator plants, 90 were in mineralized ground. Four ore bodies of 10 discovered in the Yellow Cat (Utah) area would not have been found by means of the grid pattern of exploration drilling had it not been for the additional information furnished by the shrubs. Uranium is absorbed through the roots of plants, and much of the U is precipitated within the cells of the roots and held there; a lesser amount is transported to the branches and leaves and suffices for reconnaissance prospecting. The U content varies with the species, time of year, and availability of the metal in the soil. It is rare for the U in the ash of any species growing in nonmineralized sandstone to be greater than 1 ppm. A uranium content of several parts per million is common in the ash of plants rooted in ore. Any species of plant can be used in a systematic sampling program if that plant is widely distributed and the roots penetrate the ore zone.—*C. W. Schuck*, in Chem. Abs., v. 48, no. 10, col. 5748.

18. Carpenter, R. H., 1954, Exploration geology in mining: Min. Cong. Jour., v. 40, no. 2, p. 62-64.

A brief summary of geochemical prospecting activities during 1953 and of discoveries of ore bodies using geochemical prospecting techniques is presented.

19. Clark, O. M., Jr., 1953, Geochemical prospecting for copper at Ray, Arizona: Econ. Geology, v. 48, no. 1, p. 39-45.

Copper assays of oak and mesquite leaves and the soil derived from them were made from trees growing over the Ray ore body and vicinity. Results show a marked increase of copper in plants and soil over the ore body as compared with

samples taken from areas beyond the limits of mineralization. The copper content of trees growing in the stream bed below the ore body was lower than expected. Soil assays are affected by type of rock, drainage, and extent of leaching. High erroneous assays are found in regions contaminated by smelter smoke.—*Author's abstract.*

20. Craven, C. A. U., 1954, Statistical estimation of the accuracy of assaying: *Inst. Min. Metallurgy* [London], *Trans.* v. 63, 1953-54, pt. 12, p. 551-563.

The method described here is a simple application of the techniques of mathematical statistics. It is set out so that it can be successfully applied without any knowledge of analysis used in geochemical prospecting and by a second example in which it was applied to check the reliability of a custom assayer. The potential field of application of this statistical technique covers all methods of analysis, whether by chemical or physical means.—*Author's abstract.*

21. Davidson, Patrick, 1953, Geochemistry—a new weapon in Australian prospecting: *South African Min. Eng. Jour.*, v. 64, pt. 1, no. 3157, p. 987.

A discussion of Debham's work on Mt. Isa is presented.—(See abs. 23.)

22. Davidson, Patrick, 1953, The use of geochemistry in prospecting at Mount Isa, Australia: *Min. Jour.* [London], v. 240, no. 6164, p. 669-670.

A discussion of Debham's work on Mt. Isa is given.—(See abs. 23.)

23. Debham, A. H., 1954, Geochemical prospecting at Mt. Isa, Queensland: *Inst. Min. Metallurgy Bull.* 568, p. 269-283.

Geochemical anomalies in soils over zones of lead mineralization were studied, both in known mineralized areas and in areas of suspected mineralization. The anomalies were readily detected and outlined by using a dithizone technique on acid extracts of soil samples collected from grid systems.

By assuming the principles of mechanical mixing of the mineralized rock with other material during soil formation, and of downhill migration of soils, the anomalies were correlated with the zones of their origin: the asymmetric anomalies discovered are typical of such conditions.

Applied to areas of suspected mineralization the geochemical prospecting was responsible for the discovery of two bands of lead mineralization and several large lead and copper anomalies. The method proved to be extremely useful for indicating the most favorable areas for more detailed prospecting such as diamond or churn drilling and geophysical methods.—*Author's abstract.*

24. *Engineering and Mining Journal*, 1953, Diphenylthiocarbazon—Australians are using it to find ore: v. 154, no. 10, p. 134.

(See abs. 23.)

25. Fricke, Karl, 1953, Heavy metal content of mineral springs: *Zeitschr. Erzbau Metallhüttenw.* [Stuttgart], Band 6, p. 257-265.

A general discussion as to whether the mineral content of springs has its origin in thermal action upon old ore deposits or whether it originates in new sources. In addition to chloride, CO₂, and Li, traces of Cs, Ru, Ni, and Co are reported.

Thirty references.—*H. Stoertz*, in *Chem. Abs.*, v. 47, no. 20, col. 10774d.

26. Fujiwara, Takshira, 1951, On geochemical prospecting for metallic ore deposits [abs. of paper read before the Geol. Soc. of Japan, 58th Annual meeting]: Geol. Soc. Japan Jour., v. 57, no. 670, p. 331. [Japanese.]

A very general discussion of geochemical prospecting is presented.

27. Furon, Raymond, 1949, La biogéochimie appliquée à la prospection minière [Biogeochemistry applied to prospecting for minerals]: Année Biol. [Paris], v. 25, no. 5-6, p. 111-113. [French.]

The locating of mineral deposits by means of analyzing plant ash is discussed.—*W. C. Tobie*, Chem. Abs., v. 46, no. 21, col. 10057.

28. Gaskin, A. J., 1950, Geochemistry: Australasian Inst. Min. Metallurgy Proc., no. 156-157, p. 20-25.

Geochemical methods are of great value in the search for economic minerals. Spectrographic analysis of samples for trace elements carried out over an area can be used for localizing concentrations of elements. Unfamiliar rare elements may have obscure modes of occurrences in minerals. In such a search, economic quantities of indium are found by spectrographic examination of cassiterites, which are likely to be host for minute amounts of indium. Establishment of minor-element association may make the making of inferences on origin of deposits easier. Geobotanical estimation of trace elements in plants may indicate the presence of underlying ore deposits.—*S. Mowry*, in Chem. Abs., v. 48, no. 9, col. 5082.

29. Gawel, Antoni, 1947, O pewnej chemicznej metodzie poszukiwania kurszców [A probable chemical method of analyzing soils]: Waidomości Muz. Ziemi [Polish Geol. Mag.], v. 3, p. 71-77.

The methods and principles of geochemical prospecting for ore deposits are discussed. Bibliography and Index of Geology Exclusive of North America, v. 16, p. 108, 1951.

30. Geneslay, Raymond, 1948, Géophysique appliquée; méthodes sismiques et méthodes diverses [Applied geophysics; seismic methods and diverse methods]: Géologie appl. et prospection min. [Nancy], no. 3-4, p. 237-248.

The principles and applications of geochemical and geobotanical prospecting are described. Bibliography and Index of Geology Exclusive of North America, v. 16, p. 109.

31. Gilbert, Ray E., 1953, Testing geophysical exploration methods: Min. Eng., v. 51, p. 50-52.

A discussion of geochemical, electrical, and magnetic methods as applied to the search for new ore bodies in the Park City mining district, Utah, is presented. The author concludes that only geochemical techniques used on residual soils collected for lead and zinc are applicable to the direct search for ore.

A more detailed abstract of the geochemical work in the area can be found in Bulletin 1000-A, by J. W. Harbaugh, abstract 27.

32. Gross, W. H., 1950, A study of the spatial relation of gold ore to intrusive bodies in northwestern Ontario: Geol. Assoc. Canada Proc., v. 3, p. 123-139.

Radioactivity determinations by alpha-counts were made around four intrusive rock masses. For three of these, variation in SiO_2 content paralleled variation in

radioactivity, and in one of the three also paralleled variation in ZrO_2 content. This indicates that Zr, Si, U, and Th were all concentrated in late-cooling parts of the rock masses and that the direction of flow of the solutions can thus be deduced.—*Michael Fleischer*, in *Chem. Abs.*, v. 46, no. 1, col. 9754g.

33. Gross, W. H., 1952, Radioactivity as a guide to ore: *Econ. Geology*, v. 47, no. 7, p. 722-742.

One of the principles of prospecting is to confine detailed exploration to relatively small areas considered most favorable for the occurrence of ore. Ore is often found in and around the boundaries of igneous intrusives and a method is given for localizing ore-search around intrusives ranging in size from small stocks to batholiths. The method is based on the occurrence of broad areas of higher-than-normal radioactivity in the igneous rock in the vicinity of ore structures. Nine intrusives were examined and high radioactive anomalies occurred in the neighborhood of associated ore bodies, whereas no such concentration was found in two intrusives barren of ore.

The distinctive association of radioactivity with ore is believed to be independent of whether the so-called igneous body was formed from a cooling magma or from heated and recrystallized sediments; or whether the ore solutions were genetically related to the present erosion surface or were derived from unknown sources at some greater depth.—*Author's abstract*.

34. Groves, A. W., 1951, Geochemical prospecting: *Colonial Geology and Min. Res.* [London], v. 2, no. 4, p. 333-337.

Developments in the various fields of geochemical prospecting are discussed.

35. Haberlandt, Herbert, 1953, Die systematische Grundlage und die Fortschritte in der Erforschung der Spurenelemente als geochemische Leitelemente in Mineralien und Erzen [Systematic basis and advances in the study of trace elements as geochemical indicator elements in minerals and ores]: *Fortschr. Mineralogie*, Band 31, 1952, p. 76-89.

A review of the literature regarding the distribution of trace elements in minerals and ores, with special reference to Austrian investigations, a summary of the probable types of binding of such elements, and suggestions for reaching correct conclusions as to their significance relative to the origin of the minerals and ores.—*A. N. Winchell*, in *Bibliography and Index of Geology Exclusive of North America*, v. 18.

36. Hawkes, H. E., 1952, Geochemical prospecting in the Blackbird cobalt district, Idaho [abs. of paper presented at the joint meeting of Soc. Econ. Geologists and the Geol. Soc. America, Boston, Mass., Nov. 13-15, 1952]: *Econ. Geology*, v. 47, no. 7, p. 771-772; *Geol. Soc. America Bull.*, v. 63, no. 12, pt. 2, p. 1260.

During the 1951 field season, the U. S. Geological Survey conducted an experimental geochemical prospecting study in the Blackbird cobalt district, Lemhi County, Idaho. The purpose was to determine whether the distribution of minor amounts of cobalt and copper in soil could be correlated with the distribution of cobaltite ore. More than 1,800 samples of soil and stream sediment were collected and analyzed for cobalt and copper by rapid chemical methods, developed by Hy Almond of the Geological Survey. The data of this investigation show that: (1) the mean cobalt content of soil outside the mineralized district is 20 ppm (parts per million); and (2) within an area of about 2 square miles

enclosing almost all the known cobaltite occurrences of the district, the mean cobalt content of the soil is 100 ppm. The amount of cobalt within the anomalous area, in excess of that over unmineralized ground, is in the order of 1,000 times the amount of cobalt in all the known deposits, when both amounts are expressed as tons per foot of depth. The cobalt content of soils over known cobalt ore ranges from 200 ppm to 1,000 ppm. Trenching on the basis of geochemical data uncovered a zone strongly mineralized with cobaltite in a previously unexplored and unknown area. In some parts of the area studied the variation in copper content parallels the variation in cobalt content; elsewhere the cobalt and copper patterns appear to be independent. The content of cobalt and copper in stream sediment closely reflects the content of those metals in the soils in the drainage basin upstream.—*Author's abstract.*

37. Hawkes, H. E., 1953, Instructions for sampling in geochemical prospecting: U. S. Geol. Survey open-file rept., 8 p.

Before sampling an area the author states that two factors must be considered: (1) what to sample, and (2) where to sample. No universal rules can be followed in sampling because not enough geochemical prospecting has been done to predict the problems that arise. A test area to determine the nature of these problems should be tried in the vicinity of known deposits to evaluate reliability of results, and once the distribution of traces of metals around known deposits is established and the reliability of results ascertained, reconnaissance sampling can proceed with some assurance. Background (the average composition of normal material—rock, soil, and vegetation—in the absence of mineralization) must be established in an area before an intelligent interpretation of geochemical anomalies can be made.

Sampling procedures for rock (primary halos), residual soil, stream sediment, vegetation, and water are discussed. Other factors such as size of sample, spacing of sample points, spacing of traverse, depth, size fraction, contamination, and field procedure are considered.

38. Hawkes, H. E., 1953, Some recent American developments in geochemical prospecting for minerals [abs. of paper presented at the joint meeting of the Soc. of Econ. Geologists and the Am. Inst. Min. Metall. Eng., Los Angeles, Feb. 16-19, 1953]: *Econ. Geology*, v. 48, no. 4, p. 327.

Developmental research and practical application of geochemical methods of prospecting for minerals have been progressing rapidly since the last general progress report at the San Francisco A. I. M. E. meeting four years ago. New or improved chemical procedures developed by the Geological Survey will be discussed in the paper by Harold Bloom. Experimental field projects have been conducted by the Survey in ten major mining districts in the United States; six other Survey field projects in progress. At least 25 privately sponsored geochemical prospecting crews are active in the United States at the present time. Geochemical soil surveying has been most generally effective, and has assisted materially in several major discoveries. Botanical methods have been successfully applied in one major district. Studies of traces of epigenetic metals in rocks adjoining or overlying ore deposits show promise in a wide variety of geological environments. The distribution of traces of metals resulting from upward migration of metal from bedrock sulfides also shows promise where the bedrock is buried beneath a blanket of glacial or alluvial material.—*Author's abstract.*

39. Hayashi, Shoichiro, Sekine, Setsuro, and Kishi, Haruo, 1951, Chemical prospecting by natural water in the Kidogawawa mine, Totigi Prefecture [abs. of paper read before the Geol. Soc. of Japan at its 58th meeting]: Geol. Soc. Japan Jour., v. 57, no. 670, p. 331. [Japanese.]

In October 1950, about 250 water samples were collected from geologically significant points, and the pH and Zn, Cu, and SO₄ content were determined. The region is composed of Miocene green tuff, prophyllite with flow structure, and quartz-trachyte, and the ore consists chiefly of chalcopyrite, zincblende, and pyrite.

Results of analyses are shown on the accompanying table. The eastern part of Minamizawa seems to be promising and should warrant further exploration. Abstracted from translation by P. K. Kuroda, U. S. Geological Survey.

Results of analyses expressed in mg/l

Locality	pH	SO ₄	Cu (dithi- zone method)	Zn (dithi- zone method)
Kidogawawa adit	7. 4-7. 6			
Surface water near dump	4. 5-6. 6	20-25		
Other areas	5. 7-7. 1	1-10		
River Kinugowa	7. 0-7. 1	10		
Minamizawa dump		5-25	0. 2 -0. 6	0. 4-1. 4
Sabizawa River (lower course).			0. 001-0. 02	
Chalcopyrite outcrop at Sabiwara.			0. 005-0. 02	0. 18-0. 38
Abandoned quarry at Totai- zawa.				0.9 (decreasing to 0 down- stream).
Maënozawa				0. 5-1. 2
Ookunozawa				0. 3-0. 6
Tamanosawa (upper course)				0. 2-0. 4

40. Huff, L. C., 1952, Abnormal copper, lead, and zinc content of soil near metal-
liferous veins: Econ. Geology, v. 47, no. 5, p. 517-542.

Samples of normal soils and soils near metalliferous veins were tested to investigate the behavior of copper, lead, and zinc during the formation of residual soil. The copper, lead, and zinc content of unmineralized bedrock ranges from 20 to 200 parts per million of each metal, and the content of these metals is of the same general magnitude in normal soil. The content of these metals is only slightly higher in soils from hillsides just above most of the fourteen veins studied. The soil directly over or immediately downhill from a vein commonly contains much higher concentrations of metal and may contain as much as 10,000 parts per million (1 percent). The ratios of the highest to the lowest metal value determined near each vein range up to 106 to 1 for copper, 170 to 1 for lead, and 33 to 1 for zinc. The survey is sufficient to detect in the soils is high enough to permit easy detection of most of the geochemical anomalies by quick or "field-type" analytical methods.

The geochemical anomaly in soil near veins is broad and low in contrast to the sharp, high anomaly in the unweathered rock. The anomaly in soil is characteristically asymmetric, with normal or "background" values just uphill from the vein, an abrupt high near the vein, and progressively lower values ex-

tending as much as several hundred feet downhill. In general, the anomalies in soils have characteristics that can be explained by assuming a simple mechanical mixing of the vein and wall rock materials during weathering, and a downhill creep of the weathered product.

At some veins, chemical analysis of soils revealed the presence of significant quantities of ore metals for which no corresponding ore minerals were identified in the vein outcrop. Chemical analysis of soils also revealed the location of other veins even though they were completely hidden by residual soils. Two examples are described where chemical methods were used to locate concealed extensions of known veins. Prospecting by sampling surface soil at 50- to 100-foot intervals, and analyzing by quick tests apparently can locate some veins concealed by residual soil; however, there are many problems that must be solved before the limitations of this prospecting method can be defined adequately.—*Author's abstract.*

41. Huff, L. C., 1953, A "fossil" geochemical anomaly near Jerome, Arizona [abs. of paper presented at the joint meeting of the Soc. of Econ. Geologists and the Am. Inst. Min. Metall. Eng., Los Angeles, Feb. 16-19, 1953]: *Econ. Geology*, v. 48, no. 4, p. 327. [This has since been published as U. S. Geol. Survey Bull. 1000-C, 1955.]

The Precambrian copper deposits at Jerome, Arizona, and their enclosing metamorphic rocks are overlain unconformably by the Tapeats sandstone of Cambrian age. Samples of the Tapeats sandstone were analyzed to determine if copper eroded from these ore deposits was incorporated in the Tapeats sandstone as it was deposited. Trace analyses of these samples reveal anomalous copper concentrations of more than 100 parts per million in the basal Tapeats sandstone throughout an area extending at least two miles from Jerome in contrast to a background elsewhere of about 20 parts per million. Anomalous zinc concentrations of more than 100 parts per million are distributed in roughly the same area as the copper, but abnormal lead concentrations are limited to the immediate vicinity of the mines.

The geochemical anomaly in the Tapeats sandstone is interpreted as a feature formed as the sandstone was deposited. By comparison with geochemical anomalies exhibited in residual soil, in alluvium, or in other sediment of Recent geologic age, the preserved anomaly in the Tapeats might be considered a "fossil" anomaly. The search for such geochemical anomalies may offer a new approach to prospecting areas in which the ore-bearing formation is covered unconformably by younger sediments.—*Author's abstract.*

42. Hunt, E. C., and Wells, R. A., 1954, Inorganic chromatography on cellulose; pt. 15—A rapid chromatographic method for the determination of niobium in low-grade samples: *Analyst*, v. 79, p. 351-359.

A rapid and simple chromatographic method is described for the determination of niobium in a hydrofluoric acid solution of an ore by upward diffusion on a paper strip. The niobium is detected as a yellow band on spraying the strip with aqueous tannic acid. An accurate determination of niobium is made by direct visual comparison of the band with standard strips. The chromatographic separation takes 20 minutes, and a simple technique is described for carrying out ten separations simultaneously. The accuracy is 10 per cent on ores containing more than 0.10 per cent of niobium pentoxide.—*Authors' abstract.*

43. Hunt, E. C., North, A. A., and Wells, R. A., 1954, The application of paper chromatographic methods of analysis to geochemical prospecting: Chem. Research Lab. Unclassified Sci. Rept. CRL/AE 114, 31 p., Teddington, England. [This report has since been published in the *Analyst*, v. 80, p. 172-194, 1955.]

Rapid and simple methods are described for the determination of copper, cobalt, nickel, niobium, tantalum, lead and uranium in soils. Following the breakdown of the samples and dissolution of the trace metals by methods applicable in the field, the trace metal or metals are separated chromatographically by upward diffusion on slotted sheets of paper, enabling ten separations to be performed simultaneously. The trace metals are detected by spraying the strips with sensitive reagents and the amount present determined by visual comparison with standards. Copper, cobalt, and nickel are determined after a single separation. The same soil extract is used for the determination of both niobium and tantalum.—*Authors' summary.*

44. Imai, Hideki, editor, 1949, Geology and mineral deposits, and geophysical prospecting: Tokyo Special Comm. Explor. and Research, v. 1, 206 p.; v. 2, 222 p., 1951. [Japanese.]

The methods and results of geochemical prospecting in certain mineralized areas are discussed.

54. Ishida, Y., Kishi, H., and Kata, K., 1953, Geochemical prospecting at Kuroiwa section of Yonaihata mine, Fukushima Prefecture: Japan Geol. Survey Bull. 4, p. 447-460. [Japanese.]

Zinc and sulfate in the natural water, and Zn, Cu, Ca, and sulfate in soils of this area were analyzed, and the authors found that Ca and sulfate are useful for indicators of gypsum ore, and Zn, Cu, and sulfate for kuromono (black ore). The presence of a gypsum ore deposit, 300 m long and 30-60 m wide, was indicated by this prospecting. In some part, the presence of kuromono ore deposit was also presumed.—*K. Yagi*, in Chem. Abs., v. 48, no. 10, col. 5746.

46. Jedwab, J., 1953, La signification des traces d'étain dans certains minéraux communs des pegmatites [Traces of tin in certain minerals common to the pegmatites]: Annales Soc. Géol. Belgique, Bull. et Mém., v. 76, no. 4-7, p. B101-B105.

Spectrochemical analysis shows that the muscovite of nonstanniferous pegmatites contain quantities of tin comparable to that contained in the stanniferous pegmatites, while the feldspars of different pegmatites contain amounts of Sn depending upon their mineralization. A semi-quantitative method of analysis is employed in which results are reported to $\pm 20-25$ percent.—*G. E. Klein*, in Chem. Abs., v. 47, no. 20, col. 10415f.

47. Kennedy, V. C., 1952, Geochemical studies in the Coeur d'Alene mining district, Idaho: U. S. Geol. Survey Circ. 168, 15 p.

A study of the lead, zinc, and copper content of soils near veins in the Coeur d'Alene mining district of northern Idaho was begun during the summer and fall of 1950. All samples were analyzed by a quick field test which consisted of a nitric acid digestion followed by an estimation of the lead, zinc, and/or copper using the organic reagent dithizone (diphenylthiocarbazone). Relatively large quantities of these metals were found to be dispersed in the soil for

several hundred feet downslope from the projected extension of many of the veins. It was possible to trace the Little Pittsburg vein by detailed sampling even where the amount of lead or zinc added to the soil from the vein caused an increase in the concentration of these metals of less than 0.01 percent. From these data the writer concludes that analysis of soils probably would offer an effective method of prospecting in the Coeur d'Alene mining district.—*Author's abstract.*

48. Kimura, Kenjiro, and Shima, Makoto, 1954, Geochemical prospecting for ore deposits: Japan, Sci. Research Inst. Jour., v. 48, p. 49-58. [English.]

A semiquantitative or qualitative analytical method, using dithizone or other analytical methods, to detect traces of elements—the indicator elements—in natural water and soil were described. Although the reagents of extreme purity are required, only a simple equipment is needed, and the test can be carried out in a short time in the field. The anomalies of distribution of indicator elements can be explained by assuring two factors, physical and chemical, during weathering. The distribution of indicator elements in soil and in natural water reveals the location of ore deposits, even if they are completely hidden.—*Authors' abstract.*

49. Kimura, Kenjiro, and Shima, Makoto, 1954, On geochemical prospecting: Min. Geology [Tokyo], v. 4, no. 11, p. 34-35. [Japanese.]

(Not reviewed.)

50. Kimura, Kenjiro, Fujiwara, Shizuo, and Nagashima, Kozo, 1951, Chemical prospecting in the Takara mine district: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 72, p. 434-438. [Japanese.]

Copper and zinc contents of 275 samples of surface and pit waters of the Takara mine, Yamanashi Prefecture, were determined by the dithizone method. A close relation exists between the Zn content in the river water and the location of the ore bodies composed of pyrites and "black ores." It is probably due to the special character of Zn which is easily soluble in water and is not reprecipitated from the solution, while Cu is easily reprecipitated and removed from river water. Thus, if a trace amount of Cu is detected in river waters, it is a good indication of ore bodies in the vicinity.—*K. Yamasaki*, in Chem. Abs., v. 46, no. 4, col. 1399.

51. Koehler, G. F., Hostetler, P. B., and Holland, H. D., 1954, Geochemical prospecting at Cobalt, Ontario: Econ. Geology, v. 49, no. 4, p. 378-388.

A program of geochemical prospecting was carried out in the summer of 1952 near Cobalt, Ontario. The area in which this work was done lies in the Precambrian shield of Canada, about 320 miles north of Toronto. Much of the area is covered by glacial deposits. The known ore bodies are predominantly thin veins of silver, and nickel and cobalt arsenides found as mesothermal fissure fillings in vertical faults and joints of the area. The cobalt concentration in samples of glacial material, collected on a horizontal and vertical grid over an area of proven mineralization at depth, was determined in order to test the applicability of geochemical prospecting techniques in locating ore bodies in similar situations. A cobalt anomaly in the overburden was located; subsequent drilling proved up mineralization in non-commercial quantities in the bedrock. It is concluded that the present technique is applicable in locating ore bodies where mineralization

extends to the bedrock surface in geologic setting similar to those in the Cobalt area, Ontario.—*Authors' abstract.*

52. Leutwein, Friedrich, and Pfeiffer, Ludwig, 1954, Ergebnisse und Anwendungsmöglichkeiten geochemischer Prospektionsmethoden auf hydrosilikatische Nickelerze [Results and possible uses of geochemical prospecting methods on hydrosilicate nickel ores]: *Geologie*, Band 3 [Berlin], Nr. 6-7, p. 950-1008.

Quantitative spectrochemical analyses of Ni and qualitative spectrochemical determinations of Co, Cr, Mn, V, Sn, Ge, Pb, Cu, Zn, Ag, As, Sb, Bi, and Ba were made on 677 samples, taken from six profiles that cut weathered serpentinites, high in Ni. The samples, ashed at 800° before analysis, included 231 soils, 136 samples of humus, and 290 plants. The latter included 22 varieties, most of the analyses being made on birch (*Betula verrucosa*), spruce (*Picea abies*), and pine (*Pinus silvestris*). The metal content of a given plant may vary greatly at different seasons and may be very different for needles, twigs, and bark. The results indicate that the method can be used, with proper precautions, as a means of prospecting. Ni contents (in g/ton) of more than 300 in soils, more than 500 in the ash of pine bark, more than 600 in the ash of birch leaves, and more than 1,000 in spruce bark were observed only above rocks enriched in Ni. Qualitative data indicate that Co and Cr could be used as indicators of Ni.—*Michael Fleischer*, in *Chem. Abs.*, v. 49, no. 5, col. 2960.

53. Ljunggren, Pontus, 1951, The biogeochemistry of manganese: *Geol. fören. Stockholm Förh.*, v. 73, p. 639-652. [English.]

Thick layers (up to 5 mm) of inorganically or organically precipitated MnO₂ occur as coatings on stones and boulders in most water courses in northern Vermland in Sweden. They originate from weathering solutions from manganese-rich areas. To locate their source, spruce (*Picea excelsa*) needles were ashed, at least 300 needles of an age of 3 years being taken from each test tree, and the Mn content of the ashes was determined by the bismuthate method. The locations of the test trees are described. The bed rock of the area consisted of granite. The manganese content of the ashes varied from 1.3 to 7.6 percent with the following average, in percent, old river beds 7.6, moraine 2.9, river gravels 2.7, bogs and swamps 2.7, gravel ridge 2.4, fluvial sand deposits 1.9. Differences in water supply seem to affect the manganese content. Moraine sites were found to be suitable for sampling. The determination of the manganese content in spruce needles in a profile over a distance of approximately 32 km and covering gneisses, hyperite, granites, dolerites, sandstones, and porphyries revealed the presence of too great variations (0.9-7.8 percent) to be of practical value. The expected differences in the manganese content of the spruce-needle ashes have been largely compensated for by certain conditions, including those regulating the manganese fixation in the plant. It is possible that Mn²⁺ will become built up in the chlorophyll instead of Mg²⁺, and the fixation of manganese may partly be responsible for the slight variations in the manganese content of spruce needles, as compared with those expected from the content of manganese in various rock types. With an abundant supply of magnesium from basic rocks, the magnesium excess may somewhat prevent the uptake of manganese. Chemical analysis of water from the Likå River gave Fe 0.98 mg/liter, Mn 0.05, Ca 7.0; pH 5.6-6.3.—*Kalervo Rankama*, in *Chem. Abs.*, v. 46, no. 11, col. 4972.

54. Macfall, R. P., 1954, Desert plants—a new key to uranium: *Sci. and Mech.*, v. 25, no. 2, p. 79-81.

Geobotanical reconnaissance work for uranium in the Colorado Plateau has been undertaken by the U. S. Geological Survey under the direction of Helen Cannon. Two varieties of milkvetch, *Astragalus preussi* and *Astragalus pattersoni* have been found to tolerate relatively large amounts of metals, especially selenium, which was found around 13 of the 26 prospect holes in the Yellow Cat uranium district. The narrow leafed saltbush (*Atriplex canescens*) does not grow around carnotite deposits, but the shadscale saltbush (*Atriplex confertifolia*) replaced it there. The sagebrush and hopsafe (*Grayia*) are very intolerant of uranium and selenium.

In the Thompsons district, Grand County, Utah, the vegetation was mapped in an area of 6 square miles, and 1,000 holes were drilled. Of these, 194 were drilled on the evidence of indicator plants and nearly half discovered mineralized ground. In ground where the geology was favorable to ore, 180 indicator plants were found.

Portions of plant and tree parts have been analyzed in geobotanical work, and the ash from plants in a carnotite region contained 40 ppm of vanadium oxide and 1.5 ppm of uranium oxide, whereas plants rooted in the carnotite contained as much as 300 ppm and 100 ppm, respectively. Plants growing in unmineralized ground averaged rarely greater than 1 ppm, but ground where the plants contained 2 ppm was regarded as favorable for prospecting. Two carnotite deposits were found in the Thompsons district alone, and several new carnotite bodies were discovered in the Grants area, New Mexico. Most of the uranium is concentrated in the roots of the plants; the method of analysis is useful for finding ore under as much as 50 feet of cover, but this method should be used by someone who has geologic knowledge and experience.

55. Maliuga, D. P., 1950, Concerning biogeochemical provinces in the southern Urals: *Akad. Nauk SSSR Doklady* [Moscow], tom 70, p. 257-259. [Russian.]

During the earlier investigations of the author, a high content of Fe, Mn, Ni, Co, Cu, and other metals was identified in soils of the Urals. A very significant gradation of Ni, Co, and Cu content takes places in soils, plants, and waters in the area of the beds. See table.

Content, in percent

	Co	Ni	Cu	Co:Ni:Cu
Average soil.....	1. 0·10 ⁻³	4. 0·10 ⁻³	2. 0·10 ⁻³	1:4:2
Average water.....	2. 0·10 ⁻⁷	4. 0·10 ⁻⁷	2. 0·10 ⁻⁶	1:2:10
Plant ash.....	2. 4·10 ⁻⁴	7. 0·10 ⁻⁴	1. 4·10 ⁻³	1:3:6
Water in the area of serpentinite in the S. Urals, average of 6 analyses.....	7. 0·10 ⁻⁷	4. 1·10 ⁻⁶	1. 4·10 ⁻⁶	1:6:2
Soil of a nickel occurrence, S. Urals, average of 20 analyses..	1. 7·10 ⁻²	2. 5·10 ⁻¹	1. 0·10 ⁻²	1:15:0. 6
Ash of <i>Linosyris villosa</i> Benth. et Hook, Ni occurrence, average 20 analyses.....	1. 8·10 ⁻³	1. 8·10 ⁻¹	1. 0·10 ⁻²	1:10:5. 5
Ash of <i>Stipa Johannes</i> Czelak, Ni occurrence.....	2. 5·10 ⁻⁴	3. 8·10 ⁻³	5. 0·10 ⁻³	1:15:20
Ash of <i>Anemone patens</i> L., normal form.....	2. 6·10 ⁻⁴	7. 8·10 ⁻⁴	1. 3·10 ⁻³	1:3:5
The adequate anomalous blank form of a Ni occurrence.....	1. 4·10 ⁻³	3. 7·10 ⁻²	1. 3·10 ⁻²	1:26:9

The appearances of anomalous forms in the area of the beds can be noticed by prospecting. (V. I. Vernadskiy, Inst. Geochem. Anal. Chemistry, Acad. Sci. U. S. S. R.). Translated from abstract by A. Mirtshing, Zentrabl. für Mineralogie, Jahrg. 1951, Teil 2, Heft 2-3, p. 168, 1952.

56. Maliuga, D. P., and Makarova, A. I., 1954, Cobalt content of soils and plant ashes of Tuva: Akad. Nauk SSSR Doklady, tom 98, p. 811-813. [Russian.]

Cobalt is a typical dispersed element and never appears concentrated in specific mineral deposits. It is characterized in its geochemical average amount of 1.1×10^{-7} percent; only in ultrabasic rocks cobalt-containing sulfide ores are observed which enrich cobalt in the oxidation zones. In siliceous rocks its concentration is 4×10^{-4} percent (in peat podzols) and 0.1 percent (in soils above ore deposits). Such a cobalt-enriched soil occurs in Tuva (Central Asia) between the Altai, NW Mongolia, the Sayan Mts., and the Tannu-Ola Range, with Cambrian effusive rocks covered by Silurian and Devonian sediments.. Plant ashes show specific enrichments in cobalt in the same local conditions as the soil on which they have grown. The corresponding enrichments in Co varying from 4×10^{-8} percent Co to 1×10^{-1} percent Co indicate underlying sulfide ore deposits with primary cobalt contents and are very important for ore prospecting purposes.—*W. Eitel*, in Chem. Abs., v. 49, no. 7, col. 4917.

57. Marmo, Vladi, 1950, Kasveista alustan kallioperän indikaatoreina [Concerning plants as indicators of bedrock]: Terra [Helsinki], ärg. 62, no. 2, p. 49-61. [Finnish, German summary.]

With reference to research done in Finland, the role of plants as indicators of the petrologic composition of bedrock in general and the role of certain species as indicators of the presence of lithium, zinc, and other elements in particular are discussed. Bibliography and Index of Geology Exclusive of North America, v. 17, p. 282, 1952.

58. Marmo, Vladi, 1953, Biogeochemical investigations in Finland: Econ. Geology, v. 48, no. 3, p. 211-224.

In the present paper a discussion is given of the relationship of the Cu, Zn, Ni, and Mo contents of the rock, of the ground water, and of the ash of certain plants, based on observations made by the present author within limited regions, characterized by sulfide schists containing pyrrhotite, pyrite, chalcopyrite, and sphalerite, or by granite containing small amounts of molybdenite and chalcopyrite. The results of these investigations are given in part as concentration curves, and the question of the sensitivity of biogeochemical methods in the conditions obtained in Finland is discussed.—*Author's abstract*.

59. Marmo, Vladi, 1953, Geochemical and biogeochemical prospecting: Geologi [Helsinki], v. 5, p. 2-3.

A pyrrhotite-bearing phyllite at Nokia in Finland, locally containing 0.05 percent Cu and 0.5 percent Zn, was followed by analyzing ground H₂O. Lowest pH values in H₂O corresponded to highest magnetic anomalies. Ground H₂O varied in pH from 3.8 (minutes observed) through <5 (sulfide-rich areas) and <6 (sulfide-poor areas) to 6-7 (sulfide-free phyllite). The Cu and Zn contents in the ashes of mountain cranberry (*Vaccinium vitis-idaea*) leaves

corresponded to the results of geomagnetic and geochemical investigations. At Toivakka in Finland very small fluctuations in the Cu and Zn contents of bedrock were reflected in the corresponding contents in ground H₂O. At Rautio in Finland the Mo content of the ashes of Labrador tea (*Ledum palustre*) corresponded to the Mo content in rocks underlying the substratum.—*Kalervo Rannama*, in Chem. Abs., v. 47, no. 10, col. 4802.

60. Miholić, Stanko, 1949, Tin in some samples of plutonic rocks:
Soc. chim. Belgrade Bull., v. 14, p. 121-127. [English summary.]

The following rocks were analyzed: coarse-grained and fine-grained pink gneiss-granite and gray gneiss-granite from Forshem, Västergötland (Sweden), augite schist from the western and eastern part of Mount Medvednica (Croatia), granite (Carboniferous age) (I) and two granulites from Mount Bukulja (Serbia); the percentage of tin is: 0.0010, 0.0041, 0.0028, 0.0041, 0.0016, 0.0069, 0.0069, and 0.0056, respectively. Since tin is the predominant element in the thermal waters in the vicinity of Mount Bukulja and since the tin content of I approaches the values found in granites connected with tin deposits elsewhere, there is a possibility of finding tin ore deposits in the vicinity of this mountain.—*S. E. B.*, in Chem. Abs., v. 46, no. 10, col. 4442e.

61. Minguzzi, Carlo, and Vergnano, O., 1948, Contributo alla conoscenza della distribuzione del nichel nella biosfera: il contenuto di nichel nelle ceneri di *Alyssum bertolonii* Desv. [Contribution to the knowledge of the distribution of nickel in the biosphere: the content of nickel in the ash of *Alyssum bertolonii*]: Rend. soc. mineralogie italiana, année 4, p. 37-38; Soc. toscana sci. nat. Atti, Mem. 55, ser. A., p. 49-74, Pisa.

The particularly high nickel content of the ash is discussed from the geochemical and botanical standpoint. The nickel was determined separately in different parts of the plant: the leaves contain 10 percent NiO in the ash, the seeds 9.24 percent, the roots 5.76 percent, while the soil on which the plants grew is an ophiolite of Impruneta, Toscana, which contained only 0.42 percent NiO. This concentration is still highly toxic: no other plant observed on the same soil was able to concentrate the Ni in such a high degree as *Alyssum*. The alcohol chlorophyll extract contained in the ash residue: 11.72 percent NiO; 9.77 percent MgO; 4.99 percent CaO; 1.04 percent SiO₂; the benzene extract (with some oil and carotenoids) 4.22 percent NiO in the ash. Numerous additional analytical data are given. Evidently, there is a strong specific adsorption ruled by the physiological conditions of the plant tissue: this assumption is confirmed by the observation that the ratio between Ca and Ni in the ashes is rather constant: 4.2-4.7, which is in equilibrium with another rather constant ratio (Mg + Ni): Ni = 1.3-1.7. The Mg concentration in the serpentine-containing soil is exceedingly high. From the geochemical standpoint it is important that *Alyssum* concentrates Ni in such a specific manner. There is a distinct systemic increase from the low Ni content of the primary rock (magmatic gabbro), to that of the weathered soil minerals, and the plant ash which illustrates the transition of the Ni from the lithosphere to the biosphere with an enrichment factor which is unusually high (1:1000). Another more practical viewpoint is the importance of such observations for "geobotanic prospecting" for nickel ore deposits.—*W. E.*, in Chem. Abs., v. 44, no. 19, col. 9003-9004.

62. Mining World, 1953, Northfield explores Idaho cobalt, v. 15, no. 9, p. 55.

Reference is made to the geochemical exploration work done in this area by the U. S. Geological Survey. A summary of the work already completed and plans for the 1953 program are presented.

63. Mitcham, T. W., 1952, Indicator minerals, Coeur d'Alene silver belt: Econ. Geology, v. 47, no. 4, p. 414-450.

Deeply buried, high-grade oreshoots in carbonate-quartz veins are found in the Silver Belt of the Coeur d'Alene district by the application of various geologic criteria. Exploration is costly, and additional indications of the proximity of ore are highly desirable. The purpose of this study is to examine significant mineralogical features of the district in an attempt to develop additional helpful criteria.

A search is made for indicator minerals; i. e., minerals, the spatial distribution of which may be indicative of the position of ore. In this respect, the spatial distribution patterns of most of the vein and country-rock minerals are discussed, and the genesis and time relationships of the minerals are interpreted as an aid in the evaluation of these patterns.

Arsenopyrite is believed to be an indicator, apparently forming envelopes around oreshoots. Similarly, late hydrothermal chlorite is considered to be an indicator. Sericite and carbonates of prehydrothermal-vein origin have a negative significance as indicators; i. e., little ore has been found in areas where these minerals are concentrated. Since beds rich in detrital quartz are the best ore horizons, such quartz is considered to be an indicator of limited practicability.

An attempt is made to clarify the genetic classification of the various minerals, and within genetic types a few minerals not previously described in the district are listed. Six genetic types of chlorite are defined.

The hydrothermal-vein history of the district is divided into three stages. In chronological order these are: (1) the bleaching alteration stage, (2) the carbonate-quartz stage, and (3) the sulfide stage. The hydrothermal bleaching alteration of large areas of the country-rock is largely the destruction of the rock pigments, and no strong sericitization is involved as previously thought.—*Author's abstract.*

64. Mitchell, Blanche B., 1954, "Indicator-flora" plants which aid prospectors: Uranium Mag., v. 1, no. 4, p. 16-17.

A discussion of the work of the U. S. Geological Survey on the Colorado Plateau flora which serve as indicator plants and their relation to uranium deposits is presented.

65. Montgomery, Arthur, 1950, Geochemistry of tantalum in Harding pegmatite, Taos County, N. Mex.: Am. Mineralogist, v. 35, p. 853-866.

The notable tantalum enrichment in the Harding pegmatite, in northern New Mexico, is believed due to (1) a parental tantalum-rich granite, (2) a uniquely favorable environment, (3) specific absence of tantalum-bearing sphene from all adjacent granite, (4) long-continued deformation acting upon crystallizing granite and pegmatite.

A more indirect factor, affecting the type of tantalum mineralogy peculiar to this pegmatite and perhaps responsible for a vertical mineralogical zoning, is

believed to have been a chemical control exerted by pegmatite assimilation of country rock.

A complex series of geochemical events, all affecting each other, seems necessary for any such rare-element concentration.—*Author's abstract.*

66. Morris, H. T., and Lovering, T. S., 1952, Supergene and hydrothermal dispersion of heavy metals in wall rocks near ore bodies, Tintic district, Utah: *Econ. Geology*, v. 47, no. 7, p. 685-716.

Part I, T. S. Lovering

Preliminary work in the Tintic district, Utah, determined the relative distance of migration of ore metals in moist carbonate and silicic wall rocks near ore, and in ground water having a very sluggish circulation through mineralized ground. The analyses of efflorescences in the Tintic Standard mine openings at suitable localities indicated that under the conditions existing during the past 25 years lead has not moved perceptibly; gold has migrated only a few inches; copper has moved a few score feet at most and only in acid solutions; and zinc has traveled hundreds of feet, but not as far as some silver. Silver may travel far in the oxidized zone, but if it comes in contact with sulfides its migration is quickly halted.

The chief chemical factors that influence the migration of metals in supergene solutions are the hydrogen ion concentration (pH) of hydrolysis of the metal ion, the solubility of sulfates of the metals, and the position of the metals in Schuermann's series if the solutions are in contact with sulfides for a considerable time.

Part II, H. T. Morris

Primary dispersion gradients of lead, copper, and zinc, slightly modified by supergene solutions locally, have been recognized in the Tintic district, Utah, in hydrothermally altered wall rocks of gold- and silver-bearing lead-copper veins in monzonite and in dolomite near lead-zinc replacement ore bodies.

The metal content of the rocks near ore seems to decrease logarithmically, and the plotted curves strongly suggest diffusion; the precipitation in the wall rocks at a short distance from the ore must have entailed a concomitant drop in concentration of the metal ions in the mineralizing solution, which in turn would tend to maintain the initial concentration gradient. The curves indicate a short-lived source.

Evidence was found of supergene leaching and precipitation of zinc in the wall rocks near ore bodies in the oxidized zone above the water table, but lead is apparently static under surface conditions and reflects primary dispersion patterns. Copper appears to be relatively stable in a carbonate environment, but moves locally in hydrothermally altered monzonite.

The dispersion patterns of lead in the oxidized zone—and locally the patterns of zinc and copper as well—are similar to those adjacent to primary sulfide ore bodies 700 feet below the water table and 2,600 feet below the surface.—*Authors' abstracts.*

67. Murray, A. N., 1953, Identification of geological formations by growing vegetation: *Tulsa Geol. Soc. Digest*, v. 21, p. 48-51; *Shale Shaker*, v. 4, no. 4, p. 5-6, 8.

A brief review of factors affecting the occurrence of vegetation and some results of botanical prospecting are presented.

68. Nackowski, M. P., 1952, Geochemical prospecting applied to the Illinois-Kentucky fluor spar area: Unpublished Ph. D. thesis, University of Missouri 144 p.

The applicability of geochemical methods of prospecting for fluor spar in the Illinois-Kentucky fluor spar area was investigated. Because a thick soil cover over the bedrock limits direct geological methods of prospecting to date, churn drilling and diamond drilling principally have been used to explore favorable areas. A possible method is geochemical prospecting which utilizes the varying concentrations of elements known as "indicators," which to be of optimum value must occur in media near the surface that can be sampled systematically, be spatially related to fluor spar deposits, and be subject to rapid analysis.

Soil near bedrock was chosen as the best medium for sample analysis. Samples were analyzed for selected indicator elements, fluorine, vanadium, barium, strontium, and the heavy metals copper, lead, and zinc which were determined together as zinc equivalent. Barium, strontium, and vanadium were analyzed spectrographically; fluorine, volumetrically; and the heavy metals as zinc equivalent by a non-specific dithizone procedure.

Three areas were sampled in the search for geochemical dispersion halos. Areas Nos. 1 and 2 in Hardin County, Illinois, are underlain by bedding replacement deposits which are from 150 feet to 450 feet below the surface. Dispersion halos in these two areas are buried by loessal soil, are secondary, and were expected to be diffused, interrupted, and difficult to distinguish from the normal elemental content of the soil. Area No. 3 is along the Babb fault system in Crittenden County, Kentucky, and the nearly vertical fractures containing the vein deposits reach the bedrock surface. The dispersion halos in this area are also buried, are secondary, and were expected to be more intensely developed than the halos over the bedding replacement deposits.

In Areas Nos. 1 and 2, the fluorine content of the soil fraction less than .75 millimeters in diameter ranged from 0.017 percent to 0.051 percent. The mean was about 0.034 percent fluorine, and the positive anomalies were only about 21 percent higher than the mean. In Area No. 3 the fluorine content ranged from 0.034 percent to 0.140 percent. The mean was about 0.065 percent and the positively anomalous concentrations were about 54 percent higher than the mean.

The vanadium concentrations and anomalies were similar in the three sample areas. The vanadium content ranged from 0.003 to 0.02 percent, and the mean was about 0.005 percent. It is suggested that the anomalies represent vanadium which was immobilized as a fluo-vanadate and was not a constituent derived from the mineral zones.

In Area No. 3, barium and strontium showed positive anomalies which were related partly to the traces of vein fractures. No dispersion halos were recognized in Areas Nos. 1 and 2. These elements were derived from the mineralized zones where they occur as components of gangue minerals.

The heavy metal analyses for copper, lead, and zinc, determined as zinc equivalent, ranged from nil to 100 parts per million. The normal content in Areas Nos. 1 and 2 was 12 parts per million; higher values were considered positively anomalous.

Of the elements used as indicators, the heavy metals copper, lead, and zinc, show the most promise as indicators of mineralization. The fluorine is technically unsuited as an indicator element.—*Author's abstract.*

69. The Northern Miner, 1954, Geochemical newest aid—employing old-time panning technique latest method determines amounts of metals dissolved in soils, plants [compiled by Canadian exploration geophysicists]: v. 39, no. 47, p. 18.

A review of the principles and the application of geochemical prospecting by means of chemical analyses of rock, soil, water, and vegetation is presented.

70. Ohashi, Shigeru, 1951, Geochemical studies on the ore deposits in Ishikawa Prefecture, pt. 1—Chemical constituents of the mine waters at Ogoya mine: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 72, p. 793-796. [Japanese.]

The waters of the mine show pH values of about 3 and dissolved salts are mainly sulfates. The amounts are SO₄ 56-2280, Cu 0.2-123, and Zn 1.1-339 mg/liter. The waters collected from the upper parts of a vein contain more total residue, sulfate, and zinc than those of the lower parts, while for copper this relation does not hold.—*K. Yamasaki*, in Chem. Abs., v. 46, no. 13, col. 6046f.

71. Ohashi, Shigeru, 1952, Geochemical studies on the ore deposits of Ishikawa Prefecture, pt. 2: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 73, p. 353-355. [Japanese.]

Sulfate, copper, and zinc contents of about 160 water samples near Ogoya mine, Ishikawa Prefecture, were determined. Close relation exists between zinc content of waters and the location of ore deposits.—*K. Yamasaki*, in Chem. Abs., v. 47, no. 6, col. 2913.

72. Osberger, Rudolf, 1953, Die geobiochemische Prospektionsmethode [The biogeochemical prospecting method]: Berg- u. hüttenm. Monatsh. [Vienna], Band 98, Heft 9, p. 197-202.

(Not reviewed.)

73. Ostle, D., 1954, Geochemical prospecting for uranium: Min. Mag., v. 91, no. 4, p. 201-208.

In recent years, following the development of highly-sensitive analytical methods for the quantitative determination of heavy metals in soils, alluvium, vegetation, and surface waters, it has become possible to explore for metallic mineral deposits by mapping geochemical anomalies. In prospecting for uranium these techniques have been little used, as a consequence of the ease with which small quantities of the radioactive elements can be detected by radiometric monitoring. Systematic sampling and analysis of surface waters, however, can be a rapid and easy means of investigating the distribution of uranium within a drainage system. A study of the distribution of this element in the Fal River, Cornwall, has shown that appreciable anomalies caused by uranium in the waste dumps and old workings of the South Terras mine can be detected in stream water more than six miles downstream.

The analytical technique described utilizes anion exchange resins for the concentration of uranium from water samples. The amount of uranium extracted is then estimated quantitatively by comparing the intensity of fluorescence which it imparts to a fluoride-carbonate flux of standard weight with that of phosphors containing known amounts of uranium.—*Author's abstract*.

74. Petrascheck, W. E., 1953, Zur Anwendung der geochemischen Erzsuche in Österreich [On the application of geochemical search for ore in Austria]: Berg- u. hüttenm. Monatsh. [Vienna], Band 98, Heft 9, p. 194-197.

(Not reviewed.)

75. Pierce, A. P., and Diaz, M. B., 1950, Os metodos geoquimicos na prospecção de jazidas minerais [The geochemical methods in prospecting for mineral deposits]: Bol. Soc. Estudos Colonia Moçambique Lourenço Marquis, Ano. 20, no. 67, p. 99-114.

A review of some methods of geochemical prospecting is given.

Results of a geochemical survey of surficial materials over a blind copper ore body in Jefferson County, Colorado, are described. Heavy-metal anomalies, due to copper, zinc, and lead, were found in weathered rock, stream waters and in partially melted snow above the known position of the ore body. A comparison of the geochemical data with the data of magnetic and spontaneous potential surveys of the same area indicated a more direct correlation between the geochemical anomaly and the position of the ore body than could be observed with the geophysical anomalies.—*A. P. Pierce.*

76. Riddell, J. E., 1950, A technique for the determination of traces of epigenetic base metals in rocks and its application to samples of unaltered rocks surrounding ore bodies of the Amulet mines, Noranda, P. Q.: Quebec Dept. Mines Prelim. Rept. 239, 23 p.

In recent years, the dithizone method has been extensively used for the determination of traces of heavy metals in water, soils, and organic matter. Lovering has applied the method to rocks. Modification of this method renders it useful in the determination of traces of metals in unweathered rocks.

Field tests carried out on samples from the vicinity of ore bodies at the Amulet mine, Noranda, indicate that as an ore body is approached, the determinable heavy metal content increases from less than 1 part per million to over 20 parts per million. This metal content is not the total content of the rock, but probably represents the epigenetic metal introduced by mineralizing solutions.

The method used should prove of value in exploring for hidden base metal concentrations.—*Author's abstract.*

77. Riddell, J. E., 1952, Anomalous copper and zinc values in trees in Holland Township, Gaspé-North County: Québec Dept. Mines Prelim. Rept. 269, 15 p.

During the period September 17th to September 23rd, 1950, a biogeochemical survey was carried out over the Needle Mountain copper deposit of the Gaspé Copper Mines, Ltd., to determine the copper and zinc content in the twigs of balsam fir trees. The results of this survey indicate that higher than average copper values are present in the trees growing in soil immediately over the outcrop of the mineralized zone. This increase in copper is accompanied by an increase in the ratio of copper to zinc. A second zone of high anomalous copper values was indicated close to the known mineralized zone.

A short biogeochemical survey across part of the Holland Gaspé claims revealed a positive anomaly, but at the present time insufficient work has been carried out on these claims to evaluate the biogeochemical results.

The surveyed areas lie on the flanks of Needle Mountain at elevations between 2,000 feet and 2,700 feet above sea level.

The bedrock is overlain by soil only slightly displaced from its original position by mass-wasting and local glaciation. Deposition due to continental glaciation was not noted in the area.—*Author's abstract.*

78. Riddell, J. E., 1952, Preliminary report on hydrochemical analyses of streams and rivers in the Gaspé Peninsula: Quebec Dept. Mines Prelim. Rept. 268, 11 p.

During September, 1950, certain streams and rivers of the Gaspé peninsula were tested for their heavy metal content. The heavy metal content was determined by the dithizone method described by Huff (4), modified so as to make use of the "neutral grey end-point" titration of Warren and Delavault (14). Specially purified and standardized reagents, packaged in ampoules, were supplied by Anachemia Ltd., of Montreal. With minor exceptions these reagents maintained their purity throughout the period of field work.

The heavy metal content of the streams tested ranged from less than 0.001 parts per million to 0.01 parts per million. In the Marsouis river, contamination by drainage from tailings of the Candego mine resulted in an abnormally high metal content of up to 0.25 parts per million.—*Author's abstract.*

79. Riddell, J. E., 1954, Geochemical soil and water surveys in Lemieux Township, Gaspé-North County: Quebec Dept. Mines Prelim. Rept. 302, 23 p.

An area of about 40 square miles in Lemieux Township was explored in 1953 for base metals by means of reconnaissance-type geochemical soil and water surveys. The deposits of economic importance within the area are fissure veins carrying sphalerite and galena in a quartz-carbonate gangue. Chalcopyrite and pyrite veins are present but not of economic interest. Most of the bedrock is concealed by a blanket of residual soil.

"The choice of method was subject to the following considerations:

- (a) The area is well dissected and most of the surface is sloping.
- (b) The residual soils show pronounced downhill movement due to soil creep, solifluction and debris slides.
- (c) The main brooks in the area are more or less parallel to the main vein structures, whereas many of the tributary streams are transverse to structure for part of their length.
- (d) The main veins are long and continuous, and although strong mineralization is confined to shoots, weak mineralization is commonly present throughout the length of the vein.
- (e) Weathering and solution have been active, particularly in the better mineralized parts of the veins, and the products of these processes could be expected to migrate away from the mineralization, downhill towards the nearest drainage channel."

The method used in the Lemieux area would not provide sufficient coverage in an area where the drainage pattern is not well defined.

When the results of the two types of geochemical surveys are compared, soil sampling appears to more accurately indicate the presence of base metal mineralization. The method of analysis used was one developed by Bloom and Crowe. (See abs. 93.)

80. Roberts, R. O., 1953, Geochemical investigations in Nigeria in 1948 and 1949: Colonial Geology and Min. Res. [London], v. 3, p. 347-357.

In geochemical investigations in 1948-49 in the zinc-lead areas of Abakaliki Division, Nigeria, 118 samples, mostly soil, were taken along traverse lines;

Pb-Zn and Pb were determined by the dithizone technique. It was found that Pb values were more reliable, possibly since $ZnSO_4$ is more soluble and leaches out of the surface soil, and that peaks on the Pb curve could be related to known ore bodies. In such Pb-Zn areas this technique could be an aid in prospecting; however, in using the Zn values, topography must be taken into account.—*J. L. Charles*, in *Chem. Abs.*, v. 48, no. 8, col. 4385.

81. Salmi, Martti, 1954, Turvekemiallinen malminetsintämenetelmä [A peat-chemical prospecting method]: *Geologi* [Helsinki], no. 7.

(Not reviewed.)

82. Shapiro, Leonard, and Brannock, W. W., 1953, A field method for the determination of titanium in rocks: *Econ. Geology*, v. 49, no. 4, p. 282-287; *U. S. Geol. Survey open-file rept.*, 1954, 3 p.

About 4 mg of rock powder measured with a scoop is fused with potassium bisulfate in a test tube. Tiron is added to the cool melt and the mixture is dissolved in a buffer solution. Sodium dithionite is added and the approximate concentration of TiO_2 is determined by comparing the resulting yellow solution with permanent standards, which are simple to prepare.

The results obtained by this field method for TiO_2 on 72 rock samples of various types are compared with those obtained by laboratory methods.—*Authors' abstract*.

83. Shima, Makoto, 1953, Geochemical prospecting for gold, silver, copper, lead, and zinc ore deposits; pt. 1—Prospecting for gold and silver ores: *Japan, Sci. Research Inst. Repts.*, v. 29, p. 111-115. [Japanese.]

From the zinc (the indicator element) content of surface H_2O , the prospective deposits were located, and the assays (colorimetric in dithizone- CCl_4 with the sample filtrates of 0.01 *N* HCl extracts) of soil and rocks from the pits of zinc and copper (from which silver in ores could be estimated) were directed towards the gold and silver veins whose ores were assayed for checking.—*J. G. Yoshioka*, in *Chem. Abs.*, v. 47, no. 22, col. 12145.

84. Shima, Makoto, 1953, Geochemical prospecting for gold, silver, copper, lead, and zinc ore deposits; pt. 2—Prospecting for zinc and manganese ore deposits: *Japan, Sci. Research Inst. Repts.*, v. 29, p. 116-120. [Japanese.]

From the assay of surface H_2O for Zn (with dithizone), Mn (colorimetric in NH_2OH), and Fe (colorimetric in NH_4SCN), the Zn and Mn deposits were located. Zn and Mn occurred generally together in ores, but Fe not necessarily.—*J. G. Yoshioka*, in *Chem. Abs.*, v. 47, no. 22, col. 12145.

85. Shima, Makoto, 1953, Geochemical prospecting for gold, silver, copper, lead, and zinc ore deposits; pt. 3—Distribution of copper, lead, and zinc in mine districts: *Japan, Sci. Research Inst. Repts.*, v. 29, p. 207-218. [Japanese.]

From the distribution of Cu, Pb, and Zn in mine districts determined by the assay of surface H_2O and soil, the geologic history from metamorphic rocks to surface heavy-metal minerals was traced and used for prospecting for heavy metals.—*J. G. Yoshioka*, in *Chem. Abs.*, v. 47, no. 22, col. 12145.

86. Shima, Makoto, 1953, Geochemical prospecting for gold, silver, copper, lead, and zinc ore deposits; pt. 4—Gold: Japan, Sci. Research Inst. Repts., v. 29, p. 245-248. [Japanese.]

An abandoned mine was rediscovered by geochemical (not by geologic) prospecting, with Cu and Zn as the indicator elements. The Au ore was separated by sedimentation, dissolved in aqua regia, and titrated for Au with dithizone.—*J. G. Yoshioka*, in Chem. Abs., v. 48, no. 3, col. 1207.

87. Shima, Makoto, 1953, Geochemical prospecting for manganese ore deposits: Japan, Sci. Research Inst. Repts., v. 29, p. 99-110. [Japanese.]

The Mn content (determined by the Ag_2O method) of surface H_2O revealed a prospective site of Mn ores (pH and Fe content not so important), and the assay of soil for MnO_2 and Fe_2O_3 showed the distribution of the ores, and that of H_2O from the pits indicated the quality of the ores. This prospecting method as applied in central Japan was successful.—*J. G. Yoshioka*, in Chem. Abs., v. 47, no. 22, col. 12148.

88. Shima, Makoto, 1953, Geochemical prospecting for sulfur, pyrite, and limonite ore deposits: Japan, Sci. Research Inst. Repts., v. 29, p. 249-258. [Japanese.]

The natural H_2O , soil, and rocks were analyzed for sulfate as indicator for sulfur and pyrite and for iron as indicator for limonite. Combined with the geological and physical prospecting, this method located the deposits accurately.—*J. G. Yoshioka*, in Chem. Abs., v. 48, no. 3, col. 1211.

89. Sofronov, N. I., and Solovov, A. P., 1935, The applications of spectrographic analysis to the search for tin deposits: Razvedka Nedr, vyp. 24, p. 24-27.

(Not reviewed.)

90. Sugawara, Ken, Oana, Shinya, and Morita, Yosimi, 1948, The distribution of copper and zinc; pt. 2—The modification of Sandell's dithizone method for the determination of copper and zinc: Chem. Soc. Japan Jour., Pure Chemistry Sec., v. 69, p. 174-176. [Japanese.]

(Not reviewed.)

91. Tkalic, S. M., 1952, Botanical methods in geological exploration: Botanicheskii Zhurnal S. S. S. R. [Moskva], tom 37, vyp. 5, p. 660. [Russian.]

(Not reviewed.)

92. Umemoto, Shunji, 1953, Studies on the chloride and sulfate content of waters and the amounts of chloride and sulfate fixed to the soil in the mineral springs district; pt. 7—possibility of chemical prospecting of mineral springs: Okayama Univ., Repts. Balneological Lab., no. 10, p. 1-2. [Japanese.]

The results of the previous (I-VI) were synthetically discussed and the possibility of the chemical prospecting of mineral springs was concluded. That is by determining the chloride and sulfate content of water. Temperature of well waters and the amounts of chloride and sulfate fixed to the soil, the existence of mineral springs will be prospected.—*Author's English abstract*.

93. U. S. Geological Survey, 1953, Additional field methods used in geochemical prospecting by the U. S. Geological Survey: U. S. Geol. Survey open-file rept., 42 p.

Simple field methods are given for the determination of antimony in soils and rocks by F. N. Ward and H. W. Lakin, arsenic in soils by Hy Almond, cobalt in water by Hy Almond, soluble copper, zinc, and lead in soils and rocks (nitric acid digestion) by Harold Bloom and H. E. Crowe, germanium in coal by Hy Almond, ammonium citrate-soluble heavy metals in soils and sediment by Harold Bloom, manganese in soils by Hy Almond, niobium in rocks by F. N. Ward and A. P. Marranzino, and vanadium in rocks by F. N. Ward and A. P. Marranzino. The methods for the determination of antimony, arsenic, and niobium have also been released as separate reports in journals, and abstracts of these methods can be found in this report under abstracts numbers 96, 4, and 97, respectively.

Traces of cobalt in water react with 2-nitroso-1-naphthol in a slightly alkaline solution to yield a pink cobalt 2-nitroso-1-naphtholate that is soluble in CCl_4 . As little as 4 parts per billion can be detected with this method.

In the procedure for the determination of Cu, Pb, and Zn, a simple attack of the sample with 1+3 nitric acid serves to effect adequate solution of the heavy metals for purposes of geochemical prospecting. Cu, Pb, and Zn can be determined on a single sample solution prepared in this way. About 30 samples per day can be analyzed.

A field method for the determination of germanium was developed with slight modification of the phenylfurone absorptiometric method described by Cluley. The sample decomposition was modified from a fusion of Na_2CO_3 to one with NaOH. The distillation apparatus is an all-glass Erlenmeyer wash bottle to which a pipette is attached. A pink-orange color is developed in an aliquot of the distillate, and gum arabic is added to stabilize the color.

In the method for the determination of ammonium citrate-soluble heavy metals, the sample is shaken with an ammoniacal solution of citrate and a solution of dithizone in xylene, and is then allowed to stand for 30 seconds to permit the phases to separate. Colors from green, to blue, and finally to red in the xylene layer reflect increasing amounts of heavy metals.

The field method for the determination of manganese in soils, adopted from methods described in the literature, consists of a potassium bisulfate fusion followed by acid leachings which dissolves most of the manganese present. The color is developed by boiling the resulting solution, and the purple color is compared with permanganate standards.

Vanadium (III) reacts with thiocyanate in an acid medium in the field test for vanadium, and produces a yellow-colored ion or compound. The complex ion is extracted from the acid phase with ethyl ether. Vanadium (V) does not react with thiocyanate, but the higher valence is readily reduced by stannous chloride to vanadium (III). Molybdenum, rhenium, tungsten, niobium, and uranium are likely to interfere because they react with thiocyanate to form colored compounds extractable with ether. However, molybdenum thiocyanate will usually fade within a half hour; rhenium occurs in such extremely small amounts in the earth's crust that it is unlikely to interfere; tungsten is sufficiently complexed in the presence of citrate; niobium may interfere if it is in large amounts; and uranium is not considered to be a serious interference because the reaction is not sensitive. The vanadium procedure is relatively rapid, and about 66 determinations can be made in $4\frac{1}{2}$ hours.

94. Valyashko, M. G., and Korenenko, O. M., 1950, Hydrochemical prospecting signs of potash deposits: *Gidrokhim. Inst. [Novocherkassk.] Hidrokhim. Material*, tom 18, p. 67-74. [Russian.]

Coefficients of specific elements (ratios of any one element to the total salts in the natural waters or to any one of the elements) obtained from the analytical data on the natural waters are signs of sources of salts and can be used in prospecting for these. With the coefficients of ocean water as the standard, the probable source of certain elements can be judged by comparing the respective coefficients. The natural waters in the areas of potassium deposits give coefficients that show the validity of the approach for determining the migration of potassium.—*J. S. Joffe*, in *Chem. Abs.*, v. 47, no. 11, col. 5321.

95. Vitorov, S. V., 1947, Biological indicators in geology: *Usp. sovrem Biol. [Moskva]*, tom 23, vyp. 2, p. 181-192. [Russian.]

The distribution of certain plants in geologic formations, especially ore deposits, is discussed. Translated abstract by Hans Himmel, *Zentrablatt für Mineralogie*, Jahrg. 1952, Teil 2, Heft 2-3, p. 237, 1953.

96. Ward, F. N., and Lakin, H. W., 1954, Determination of traces of antimony in soils and rocks: *Anal. Chemistry*, v. 26, p. 1168-1173.

A relatively simple, rapid, and moderately accurate method for the determination of traces of antimony in soils and rocks is based on the reaction of pentavalent antimony with rhodamine B in isopropyl ether after extraction of the antimony from 1 to 2 *M* hydrochloric acid. The suggested procedure is applicable to samples containing from 0.5 to 50 ppm of antimony, and with modifications it can be used on samples containing larger amounts. Four determinations on two rocks containing less than 2 ppm of antimony agree within 0.4 ppm, and four determinations on seven soils containing 2 to 10 ppm of antimony agree within 1 ppm of the mean. The conditions for oxidation of the antimony and subsequent extraction of the pentavalent form with isopropyl ether have been established. Experiments show that the antimony-rhodamine B compound is stable in isopropyl ether for more than 3 hours. The suggested procedure permits the determination of 2 γ of antimony in the presence of 30,000 γ of iron, 250 γ of arsenic, and 300 γ of gold and/or thallium. Data are given to show the applicability of the method to routine laboratory and field use. Under field conditions the method has been used to determine traces of antimony in as many as 20 soil samples in an 8-hour day.—*Authors' abstract*.

97. Ward, F. N., and Marranzino, A. P., 1954, A rapid quantitative chemical procedure for analysis of niobium: *Science*, v. 119, p. 655.

A reliable rapid procedure for the determination of small amounts of niobium has been a critical need; such a procedure has recently been developed and is of direct value in the current search for new sources of the metal. The new method is a modification of the thiocyanate colorimetric method to determine niobium in rocks containing 20 to 2,000 parts per million (ppm) of the element. The range may be extended to rocks containing larger amounts after proper dilution of the sample solution. The procedure has found application also in field work when visual methods of color comparison are used.

The thiocyanate reaction is carried out from solutions 4 molar in hydrochloric acid and 0.5 molar in tartaric acid, and the thiocyanate complex is concentrated by extraction with ether. The interference of vanadium is prevented by extraction of the thiocyanate complexes with ether prior to reduction and subsequent removal of the iron by reduction with stannous chloride. The addition of acetone to the ether extract of the niobium thiocyanate inhibits the polymerization of the thiocyanate ion and establishes the niobium thiocyanate color. Absorbancy measurements are made with a Beckman spectrophotometer at a wavelength of 385 millimicrons (385 $m\mu$). Actual quantities are then read from a previously prepared standard transmission curve. The procedure permits the determination of 20 micrograms (20 μg) of niobium in the presence of 1,000 μg of iron, titanium, or uranium of 500 μg of vanadium, or of 100 μg of tungsten and/or molybdenum.

The precision of the method is good. Five determinations each on two rocks containing as much as 100 ppm of niobium agree within 5 ppm of the mean. The coefficients of variation of three rocks containing between 300 and 2000 ppm of niobium do not exceed 15 percent. The results also compare favorably with figures obtained by spectrographic and x-ray fluorescence techniques.—*Authors' abstract.*

98. Warren, H. V., and Delavault, R. E., 1952, Biogeochemistry and hydrogeochemistry: Precambrian, v. 25, no. 5, p. 9–12.

A description of the results of investigations in biogeochemistry and hydrogeochemistry are discussed.

99. Warren, H. V., and Delavault, R. E., 1953, Biogeochemical investigations in eastern Canada [abs.]: Geol. Soc. America Bull., v. 64, p. 1487–1488.

(See abs. 101.)

100. Warren, H. V., and Delavault, R. E., 1953, Geochemical prospecting finds widespread application in British Columbia: Min. Eng., v. 5, no. 10, p. 980–981.

Developments in the fields of hydrogeochemistry, pedogeochemistry, and biogeochemistry in British Columbia are discussed. The emulsion technique developed by Delavault was first used in the Tweedsmuir Park area; anomalous metal content was discovered in two creeks. Additional water testing has been tried and sufficient soil sampling has been done by the authors so that where either copper or zinc minerals occur, anomalous amounts of the appropriate metal may be expected in the soil. No large mine has been located entirely by biogeochemical means. Some species of trees, such as silver birch (*Betula papyrifera*), hemlock (*Tsuga heterophylla*), and balsam (*Abies lasiocarpa*), collect zinc, manganese, and molybdenum, respectively, and may be used as indicators in that particular locality in preference to soil. "Pathfinders" or minerals found in close association with the elements or minerals being sought which can be more readily found or have more anomalous features may prove to be important.

101. Warren, H. V., and Delavault, R. E., 1953, Some biogeochemical investigations in eastern Canada [abs.]: Econ. Geology, v. 48, no. 7, p. 629–630.

During the past five years the authors have investigated the practicability of using biogeochemical methods in prospecting for buried ore bodies in Eastern Canada.

On the basis of more than five thousand analyses "normals" are tentatively suggested for copper and zinc in most of the more common species of trees and lesser plants, including the Jack Pine (*Pinus Banksiana*), Black and White Spruce (*Picea mariana* and *Picea glauca*), Tamarack (*Larix laricina*), Balsam (*Abies balsamea*), Poplar (*Populus tremuloides*), White Birch (*Betula papyrifera*), and Labrador Tea (*Ledum groenlandicum*).

The influence of underlying mineralization has been found to parallel that observed in the Pacific Northwest.

In the light of data presently available, variations above "normal" of more than fifty percent in copper and thirty percent in zinc may be considered possibly anomalous, and more than one-hundred percent in copper and fifty percent in zinc probably anomalous.

The most important conclusions are that:

- (1) With reasonably propitious conditions, practically all trees or lesser plants are capable of reflecting buried mineralization.
- (2) There is no direct relationship between the metal content either of dry plant or ash and the metal content of the underlying mineralization.
- (3) With present techniques biogeochemistry can only, except under unusually favorable circumstances, yield useful results where muskeg or overburden is less than thirty feet thick.
- (4) Just as geologists can point to metallogenetic provinces so the biogeochemists can outline trace element provinces.—*Authors' abstract.*

102. Warren, H. V., and Delavault, R. E., 1953, Water testing for minerals: Western Miner and Oil Rev. [Canada], v. 26, no. 7, p. 38.

The procedures for preparing several reagents used in water testing are described. The remainder of the article contains essentially the same information as it is included in abstracts 105 and 107.

103. Warren, H. V., and Delavault, R. E., 1954, Geochemical prospecting in British Columbia: Western Miner and Oil Rev. [Canada], v. 27, no. 5, p. 48-52.

This article contains essentially the same information as the report by Warren and Delavault entitled "Geochemical prospecting finds widespread application in British Columbia."—(See abs. 102.)

104. Warren, H. V., and Delavault, R. E., 1954, Variations in the nickel content of some Canadian trees: Royal Soc. Canada Trans., Sec. 4, v. 48, p. 71-74.

The following conclusions were drawn by the authors: "On the evidence of more than two hundred determinations, it seems clear that biogeochemical methods in some areas may prove useful in any search for buried nickel mineralization. Geochemical techniques generally may be particularly useful in sorting out geophysical anomalies caused by magnetite and/or pyrrhotite alone from those in which these minerals are accompanied by significant nickel mineralization.

"Except for very young tips and stems more than four years old, the leaves and needles of most trees run from .2 (10) to 2 (100) ppm over the more common geological formations. Over nickel mineralization, the nickel contents may rise from five to twenty times the above figures, with weak nickel occurrences providing intermediate results.

"The ease with which even slightly abnormal amounts of nickel can be detected in some trees suggests that it may be considered a pathfinder element for base

metal deposits such as zinc, much as molybdenum may, on occasion, be used for copper."

The analytical method used was adopted from one by E. B. Sandell (1951) with minor modifications.

105. Warren, H. V., and Delavault, R. E., 1954, Water testing in geochemical prospecting: *Min. Cong. Jour.*, v. 40, no. 4, p. 82-85, 99.

The earlier tests devised by Huff in the United States and Sergejev in U. S. S. R. were not successful in British Columbia, and a new "emulsion" technique was developed by the authors. A few drops of HCl or acetate buffer were added to 100 cubic centimeters of water to be tested; a few drops of dithizone dissolved in water-soluble acetone were added as well as an emulsion of xylene.

The emulsion breaks up in the acid liquid, and the resulting droplets come to the top of the beaker having collected both the dithizone and dithizone-metal complex. The amount of metal present can be determined by adding a set amount of dithizone and comparing the final color with a scale of colors.

Three suggestions were made for water testing: (1) Water testing should be restricted to relatively shallow streams, (2) A stream should be sampled at least every quarter of a mile, and (3) When testing water, the samplers should be careful that the water table has not fallen below the zone of oxidation.

Plant analysis can be used for closer exploration of an area after water testing is no longer usable.

106. Warren, H. V., Delavault, R. E., and Fortescue, J. A. C., 1954, Sampling in biogeochemistry [abs. of paper submitted for the Seattle, Wash., meetings, Mar. 26-27]: *Geol. Soc. America Bull.*, v. 65, no. 12, pt. 2, p. 1353.

In previous reports the writers have stressed the importance of sampling in biogeochemical work. This paper emphasizes the desirability of accurate sampling and, with the aid of diagrams, demonstrates that it is essential not only to compare organs of the same age, but that to achieve optimum results it is necessary to select that organ which responds best to the element being investigated.

Furthermore, anomalies can best be detected if one remembers that the tops and sides of trees may have significant variations in their content of some metals. The response of tips of one season's growth or less in contrast to that of older growth may vary widely with different metals, notably zinc and molybdenum.

Data suggest that some species reflect more readily geochemical anomalies of a specific metal than do others; this emphasizes the importance of selecting suitable species for biogeochemical studies.—*Authors' abstract.*

107. Warren, H. V., Delavault, R. E., and Irish, R. I., 1953, Acetonic dithizone in geochemistry: *Econ. Geology*, v. 48, no. 4, p. 306-311.

In a previous paper, the authors described a dithizone-emulsion technique by which it was feasible to detect as little as 0.001 ppm (parts per million) of copper and zinc in natural waters.

In practice this method has one major drawback. The dithizone has to be introduced in the form of an ammoniacal aqueous solution which is not stable and normally must be renewed once or twice each day.

An acetonic solution of dithizone is much more stable than an aqueous one. This stability makes it possible in the field to use an acetonic solution of dithizone for weeks, or even months if temperatures remain below 80° to 90° F.

The use of acetonic dithizone affords new possibilities in field and laboratory techniques which are discussed.—*Authors' abstract.*

108. Warren, H. V., Delavault, R. E., and Routley, D. G., 1953, Preliminary studies of the biogeochemistry of molybdenum: Royal Soc. Canada Trans., v. 47, sec. 4, p. 71-75.

Molybdenum anomalies in vegetation appear to be greater than those of copper or tungsten, and thus may be the most valuable of the three in biogeochemical prospecting. There were 140 analyses made of dry needles, tips, or second-year stems of Alpine Fir, Lodgepole Pine, and Creosote Bush. The results showed 0.1 to 0.5 ppm of Mo in areas where there is no recognizable Mo mineralization, 2 to 5 ppm in the presence of modest amounts of Mo, and 40 to 60 ppm where there are potentially economic amounts of Mo. Mere presence of Cu in the vegetation does not appear to increase the Mo intake. Absorption of Mo by plants is determined by the absolute amounts of Mo available, the pH of the soil, and the concentration of other elements in the soil. If other factors are equal, the most Mo will be absorbed in the presence of phosphate salts, and the least in the presence of sulfate salts. The Mo was determined by the following method, developed by the authors: The sample of dried plant material, about 1 g, is ashed at about 600° for 5 hours. The ash is dissolved in warm HCl and is placed in a test tube. One milliliter of 5 percent NH_4CNS and 0.5 ml of 10 percent SnCl_2 in 2 N HCl are added in that order. The volume is made up to 10 ml with 10 percent HCl. Exactly 1 ml of isopropyl ether is added, the tube is stoppered and inverted, and shaken for not more than 30 sec. The same operation is repeated on standards, except that standards with more than 20 γ of Mo, or samples with colors in that range, are not shaken with ether; the latter are compared directly with the appropriate standards. This method makes no allowance for interference by W, since spectroscopic analysis had shown that W was not a measurable factor.—*W. R. Averett*, in Chem. Abs., v. 48, no. 10, col. 5748.

109. Webb, J. S., 1953, A review of American progress in geochemical prospecting: Inst. Min. Metallurgy Trans. [London], v. 62, 1952-53, pt. 7, p. 321-348.

American achievement in geochemical prospecting is reviewed in the light of information gained during a recent visit to America and from published literature. Briefly, experimental work, largely pioneered by the U. S. Geological Survey, has yielded encouraging results. Systematic soil analysis has, under certain conditions, proved particularly successful in locating sub-outcropping mineralization, and this technique is now a standard prospecting practice in some districts. In all, some fifteen mining companies operating in America and Canada are including experimental and applied geochemical studies in their exploration programmes. It is known that the new methods have assisted in the discovery of at least two commercial base-metal deposits, uranium-vanadium ores, a promising cobalt mineralization, and several sub-commercial mineral deposits. In addition, faulted and pinched extensions of known ore bodies have been traced by geochemical techniques on a number of occasions. Further research on the application of the methods and the development of new techniques is being vigorously pursued, but it is already clear that supplementary geochemical aids offer great promise in many areas where the established methods of prospecting yield incomplete information.

Critical investigations of geochemical methods should be carried out in British territory on a scale appropriate to the long-term need for new mineral resources. A coordinated programme of work is proposed, the ultimate aim being to provide the British mining industry with additional methods of exploration particularly

applicable in difficult tropical terrain. The first step in this programme should be to provide selected British personnel, drawn largely from overseas, with a firm background in geochemical prospecting methods.—*Author's abstract.*

110. Webb, J. S., and Millman, A. P., 1953, Heavy metals in natural waters as a guide to ore; a preliminary investigation in West Africa [with discussion]: *Inst. Min. Metallurgy Trans.* [London], v. 59, p. 323-349.

An abstract of the paper is included in U. S. Geol. Survey Bull. 1000-A (see abs. 143). The above reference includes the original report and a discussion of it.

111. Webb, J. S., and Millman, A. P., 1953, Heavy metals in vegetation as a guide to ore—a biogeochemical reconnaissance in West Africa: *Inst. Min. Metallurgy Trans.* [London], v. 62, p. 73-76.

An abstract and the discussion of the paper are included in U. S. Geol. Survey Bull. 1000-A (see abs. 144). The above reference is a reply by the author to the discussion.

112. *Western Miner and Oil Review*, 1954, Water testing for minerals: Canada, v. 27, no. 10, p. 54.

A description of the water kit manufactured by McPhar Geophysics, Ltd., is included, and the test procedure using buffer solution and dithizone in chloroform is described. A color chart is also included with the kit to aid in reading results. Any reading below 0.02 ppm is discounted, but this level will vary from area to area. Anomalous metallic content seems to drop off markedly below waterfalls, but in placid streams the metallic content below a source of metallization may stay constant for several thousands of feet. The use of chemicals of high purity is of extreme importance in this type of work to prevent any accidental contamination.

113. White, W. H., and Allen, T. M., 1954, Copper soil anomalies in the Boundary district of British Columbia: *Am. Inst. Min. Metall. Eng. Trans.*, v. 199, p. 49-52; *Min. Eng.*, v. 6, no. 1, p. 49-52.

The Boundary district was investigated for new ore bodies, and in addition to the basic detailed geologic work, magnetometer and self-potential surveys were made. Potential areas were tested further by a study of copper distribution in tree twigs and (or) in the soil. A deviation from the regular copper method using hydroxylamine hydrochloride to remove all oxidizing influences was utilized. Examples of soil anomalies in the Deadwood, Summit, and Phoenix camps are described and illustrate some of the main characteristics of copper soil anomalies. Most of the area was covered with glacial drift.

The authors drew the following conclusions:

"1. Soil sampling and analysis for copper is a valid technique which properly can be included in a program of exploration for copper ore deposits.

"2. Probably its greatest use will be of secondary testing of geological bets or anomalies obtained by geophysical methods. The cost, although not prohibitive, still is too high to permit wide use of the technique for primary prospecting.

"3. Isolated spot testing is useless. Copper soil anomalies are valid only when they appear as rational contours on the map of an area that has been sampled systematically.

"4. These anomalies must be interpreted with due regard to the geomorphic history of the area. They may correspond closely to the source of the copper, or, alternately, they may have spread and migrated considerable distances. Probably in the latter instance a tail could be detected leading back to the source of the copper.

"5. In the Boundary district of British Columbia the normal copper content of the soil is less than 100 ppm, averaging about 27 ppm. Copper values over 100 ppm can be considered anomalous. Probably in another district having different types of rocks and soils and a different climate other values would represent normal and anomalous relations.

"6. A copper soil anomaly does indicate the presence of unusual amounts of copper in the underlying and contiguous bedrock, but it does not indicate, necessarily, the presence of a commercial ore body. It follows that a strong anomaly is no better indication of an ore body than a weak anomaly."

114. Williams, David, 1954, Geochemical Prospecting Research Centre at the Royal School of Mines, Imperial College of Science and Technology: Inst. Min. Metallurgy [London], v. 64, pt. 2, p. 51-58.

Plans are presented for a Geochemical Prospecting Research Center to further research and development of geochemical techniques of mineral exploration in the British territories.

The threefold aim of the Centre is to make critical investigations of known geochemical prospecting methods under a variety of conditions, to develop new techniques to meet different demands, and to carry out research on the fundamental principles involved in the formation and detection of geochemical dispersions and anomalies. The organization consists essentially of three sections: (1) field investigations, (2) routine analyses, and (3) analytical research.

"The purpose of the Analytical Research Laboratories will be to furnish essential analytical procedures that still remain to be developed, to improve existing techniques and to overcome difficulties that commonly appear when a procedure is applied under novel conditions. The routine Analytical Laboratory will deal with large numbers of samples, including those sent in during the course of field investigations and the series of trial samples that Geological Surveys and Mining companies will be encouraged to collect. The main function of the analytical sections will be to provide essential services to the field section."

"The Field Section will concern itself primarily with the critical investigation of the various geochemical methods in selected field areas, with a view to developing techniques of practical value to mineral exploration."

115. Williams, W. Rees, 1953, Some notes on geochemical correlation with regard to copper in the district of Mpwapwa, Tanganyika [abs. of paper presented at the Fifth East African Inter-Terr. Geol. Conf., 1952]: Colonial Geology and Min. Res. [London] v. 3, no. 3, p. 248.

A brief description is given of work being done by the author in the investigation of copper deposits in Tanganyika. The area in which copper is known to occur now includes 1,500 sq. miles in the districts of Mpwapwa, Kongwa, and Kilosa. The copper occurs in ultra-basic pegmatite, mica-pegmatite and quartz reefs, and has recently been found in mica-pegmatitic rocks of the Basement, basic rocks and felspathic quartzites. Evidence now available indicates that in the south the copper occurs in mica-pegmatites, quartz reefs, and acidic rocks, whilst in the north it occurs only in ultrabasic rocks.

All the known occurrences have been sampled and analyses are being carried out to determine both the copper content and any significant trace metals, such as cobalt and nickel, which might indicate a common centre of origin. The scarps in the area show obvious signs that both iron and copper are very mobile. Soil samples have therefore been taken at intervals down the scarp slopes to the plains below, where there are numerous cupriferous occurrences. The metal content of the soil of the plains may be more closely related to the metal content of the rocks in the scarps above than to that of the underlying rocks. On the other hand, it might also indicate a long process of copper migrations from a secondary ore body below; this is suggested by the minute centres of copper oxidation which are found in the felspathic quartzites occurring at the base of one of the scarps of the Mangalissa mountains.—*Author's abstract.*

116. Wilson, H. D. B., 1953, Geology and geochemistry of base metal deposits: *Econ. Geology*, v. 48, no. 5, p. 370-407.

The geochemical character and principles of distribution of the elements in igneous rocks are summarized. The geology and geochemistry of the base metals are then discussed in turn. Chromium and titanium are small lithophile ions related in size and distribution to ferric iron; thus they are concentrated in early magmatic differentiates associated with ultrabasic and basic rocks, respectively. The thiophile elements nickel, copper, cobalt, zinc, and lead are concentrated in sulphide bodies. Immiscible sulphide deposits can separate only from ultrabasic and basic magmas because of the solubility of sulphur in silicate melts; hence the only thiophile elements that concentrate in the sulphide segregations are copper, nickel, and cobalt which are strongly concentrated in basic rocks and magmas. Nickel sulphide occurs almost entirely in these magmatic sulphide ores because of the small size of the nickel ion, but the somewhat larger cobalt and copper ions may be concentrated in hydrothermal as well as magmatic sulphide deposits. The hydrothermal deposits may be typed according to whether they are copper or copper-cobalt, copper-zinc, zinc-copper-lead or lead-zinc deposits. Each type is associated with specific compositions of igneous rocks or magmas in which the elements are most concentrated because of their geochemical character and association. Many of the principles outlined can be used in assessing deposits and areas for exploration and development.—*Author's abstract.*

117. Yokoyama, Yuji, 1949, Chemical prospecting of manganese deposits: *Chem. Soc. Japan Jour., Pure Chemistry Sec.*, v. 70, p. 402-403. [Japanese]

The manganese contents of mineral waters, underground waters, and river water on the manganese deposit area of Awano town, Tochigi Prefecture, were determined. Some relations were found between the Mn contents of the water and the Mn deposits. It seems possible to prospect the Mn deposits by the chemical method.—*K. Yamasaki*, in *Chem. Abst.*, v. 45, no. 7, col. 3102, 1951.

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