Afternoon Session
Chairman J.S. Webb

USE OF MERCURY IN GEOCHEMICAL EXPLORATION

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One of the problems of applied geochemistry is the development of methods for discovering deeply buried deposits. Stimulated by the work of Saukov (1946), research work on the behaviour of mercury in the vicinity of a wide variety of known ore deposits, has been carried out in the last six years by a number of research groups in many countries.

Mercury anomalies have proved to be particularly extensive and as a result of its high mobility in the vapour stage, mercury can be used with success as a pathfinder element in mineral exploration. The so-called "mercury-halo method" and its application in mineral exploration has been described in a number of Russian papers (Ozerova, 1959, 1962 and others), and more recently by Williston (1964, 1965), James & Webb (1964), Vaughn & McCarthy (1964), Friedrich & Hawkes (1965, 1966), and Friedrich & Kulms (1969).

During the history of an ore body mercury vapour migrates at two principal stages: (1) At the time of ore deposition, forming primary aureoles, and (2) during weathering and oxidation of the ore, when mercury vapour is released and moved upwards into the overlying rocks and soils. In addition to these two definite stages we may expect a third stage of the migration of mercury, which might occur during the process of metamorphism. At any time during this history, mercury may be removed from the vapour phase by adsorption on the surface of minerals or by the formation of loosely bonded complexes. Clay minerals, for example, are known to adsorb and hold mercury very tightly. Residual soils derived from unmineralized rocks overlying blind deposits might therefore reflect distribution patterns caused by the secondary migration of mercury vapour.

In virtue of its occurrence at extremely low levels of concentration in geological materials (0.03 to 0.08 ppm in igneous rocks, 0.005 to 0.3 in soils) it has been necessary to develop reliable techniques for the determination of the nanogram (1 nanogram = 10^{-9} grams) quantities of mercury present in geological materials. Three types of analytical methods have received attention: colorimetry, spectrometry and ultra-violet absorption. The most sensitive and most practical method for geochemical studies is the procedure to determine the concentration of mercury vapour in air (given up by a heated sample) by measuring the absorption of ultra-violet light at a specific frequency (in the 2537 Angstrom range).

Several instruments have been designed by different research groups operating either on the single beam or on a double beam system. The principal disadvantage of the single beam system and the conventional double beam systems lies in the fact that any interfering substance present in the sample (organic matter, water, sulphides) will give a reading on the instrument. One method to make the instrument specific for mercury is to collect the mercury in air on gold while the interfering gases are exhausted. In a second step the gold is heated to volatilize the mercury which then gives a specific reading on the instrument (Vaughn & McCarthy, 1964; Friedrich & Kulms, 1969). The sensitivity and reliability of this technique have been demonstrated.

The application of mercury as a pathfinder

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element for gold, lead-zinc, copper, barite, and fluorite deposits, and the use of mercury in soil gas and air as a potential tool in mineral exploration will be discussed.

THE APPLICATION OF THE MERCURY–HALO METHOD

1. In the West Shasta copper-zinc district, California, where lenticular and flat-lying massive sulfide ore deposits are known at a depth of 20 to 70 meters, overlain by a series of unmineralized rhyolite or rhyolite tuff, pronounced mercury anomalies were found over the Early Bird, Keystone and Mammoth mines. The mercury content of anomalous soils ranges up to 340 pp over a background of 20 to 60 ppb. The ore consists of massive pyrite and small amounts of chalcopyrite, sphalerite, galena, tetrahedrite, pyrrhotite, and magnetite.

2. In the Pachuca-Real del Monte silver-producing district in Mexico soils, from an area well mineralized but with no known ore coming closer to the surface than 120 m, contain from 150 to 600 ppb Hg with peaks corresponding to the location of the surface projections of the vein structures.

3. Mercury anomalies occur in soils over the buried Lucky Friday vein, Coeur d'Alene lead-silver district in Idaho/USA, known in a depth of 35 m. The soils contain from 20 to several hundred ppb Hg with peaks corresponding to the blind vein.

4. In the Magdalena mining district, New Mexico, where lenticular sheets of copper-lead-zinc ore occur in late Paleozoic sedimentary rocks, F. M i s s a g h i (1966) has carried out a stream sediment survey. The area is typical for a semidesert environment, and there are no permanent streams within the area. The anomalous mercury values range from 150 to 1200 ppb and usually correspond to zinc, lead, copper or molybdenum anomalies.

5. Significant mercury anomalies with peaks up to 4.400 ppb occur over the "Gangzug Hangender Sommer", Bensberg mining district, West Germany, where a sphalerite-galena bearing vein is known at a depth of 50 m.

6. Recent studies on mercury dispersion patterns in the vicinity of known but buried barite veins at Dreislar, West Germany, suggest, that mercury might be used as a pathfinder element for barite deposits.

7. The mercury content in soil gas and in the atmosphere was measured by M c C a r t h y et al. in several mining districts to test the possibility that the mercury content in the atmosphere is higher over ore deposits than over barren ground. At Cortez, Nevada, the distribution of anomalous amounts of mercury in the air collected at ground level (soil gas) correlates well with the distribution of gold-bearing rocks that are covered by as much as 35 meters of gravel. The mercury content in the atmosphere collected at an altitude of 70 m by an aircraft over a mercury deposit was 20 times and over two porphyry copper deposits 10 times the background value. M c C a r t h y et al. are recommending the use of an aircraft to detect mercury which might make it possible to explore rapidly large and inaccessible areas, to delineate or extend metallogenic provinces, or to detect new large regional mineral belts or trends; particularly, if the data on mercury are used in conjunction with regional geophysical data.

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Discussion

L.J.G. Schermerhorn wondered at what maximum depth might blind ore bodies still be detected by mercury surveys.

G.H. Friedrich said that no general figure could be given; the depth at which blind deposits can be detected by Hg measurements depends on local conditions.

S. Dijkstra remarked that the literature mentions primary Hg dispersion in the form of complex compounds such as HgS, Hg_2Cl_2, etc. He wished to know if there were any new developments in the investigation of primary dispersion patterns.

G.H. Friedrich said that little is actually known concerning the mode of primary Hg dispersion; investigations are meeting with technical difficulties. With regard to the extent of primary Hg aureoles, the Russians have reported figures as high as 1000 meters. The aureoles which he had investigated himself did not exceed 20 m.

H. Martin requested some information on the type of bonding of mercury found in soils.

G.H. Friedrich answered that most of the mercury in soils occurs as adsorbed ions on the surfaces of clay particles.

P.D. Jongerius asked if it was feasible to sample horizons other than the B-horizon.

G.H. Friedrich answered that in some instances other horizons may be considered. Sampling of the A-horizon, however, has a drawback in so far as the chemical and biological properties of the material have an adverse effect on the quality of Hg determinations.

Tydink wished to know at what level of concentration the presence of Hg in the soil is to be regarded as dangerous to humans living close to mercury mines.

G.H. Friedrich said that no danger level was known yet; historically people have been living close to mercury mineralisations over extended periods, without their health having been affected. Mercury concentrations in mine air can constitute a danger. It is safer to work in a relatively cool atmosphere than to work under warm to hot conditions owing to the influence of temperature on Hg vapour pressures.

J.J. Cramer thought that arsenic might also be used as a trace element for exploration purposes.

Although the author agreed in principle, he also commented that the results of As surveys are not typically superior to the results of surveys involving other more easily detected trace metals.