

Australian Geochemical Mineral Exploration: It all began at Moonta through V.P. Sokoloff

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Tradition has it that the Moonta – Wallaroo field began when Cornish men spotted ‘green stuff’ in soil dug from a wombat’s hole, and noticed that burning local bushes produced a green flame, all indicative of copper.¹ Some people were sceptical of this explanation of the origins but despite the field’s illustrious history, V.P. Sokoloff, on behalf of the Zinc Corporation, conducted the first systematic geochemical mineral exploration in Australia, at Moonta, in the late 1940s,² (Figure 1). The idea was that traces of copper could be held at varying levels in the soil profile above a mineralised zone in the bedrock. At Moonta the soil mantle varied from 2 metres to more than 6 m (Figure 2).³ Sampling was carried out over a total length of 13 km, 326 soil profiles were examined and about 2,000 samples were chemically tested. Three geochemical anomalies were located (Fig. 3). The subsequent drilling revealed mineralisation in the bedrock, but not of economic grade. Thus the method proved technically sound, but uncommercial. The method was later taken up elsewhere in Australia, with varying success. Today the contribution of Sokoloff to mineral exploration in Australia is virtually forgotten, as are details of his background. So, who was Sokoloff, where was he from, and where did he go?

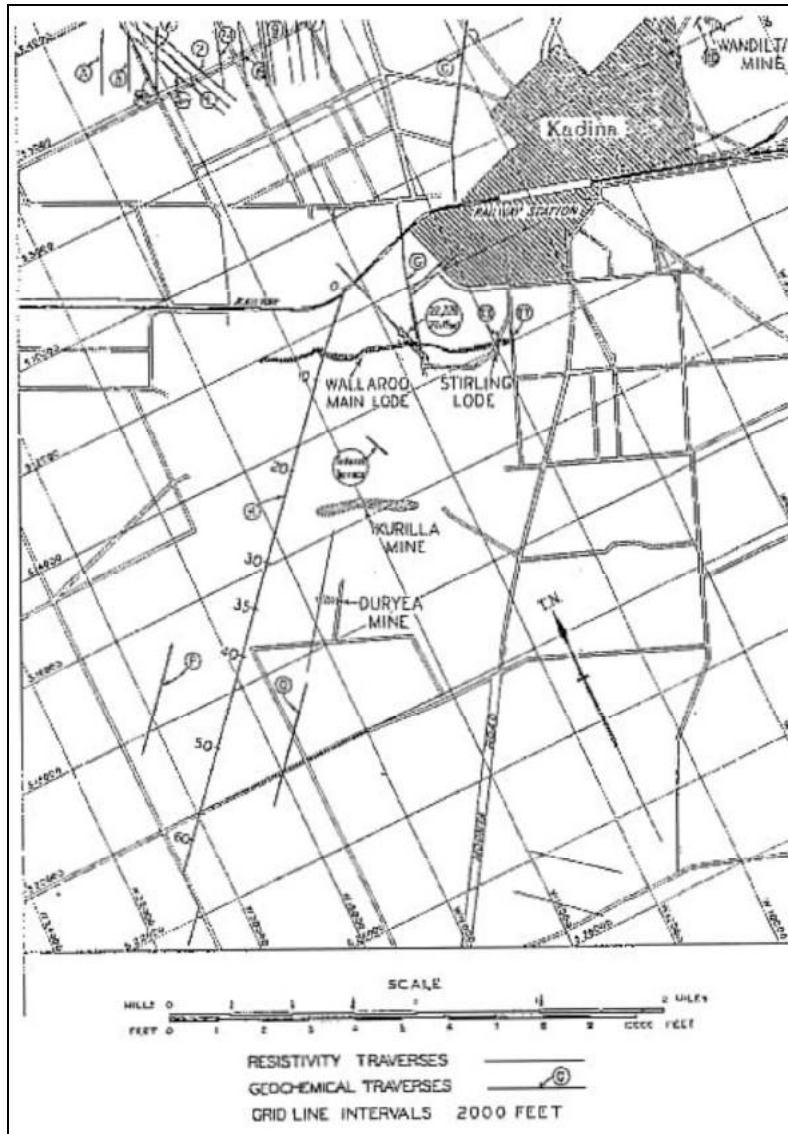
The Early Years, 1904 - 1943

Vladimir Petrovich Sokoloff proves to have been an interesting person, and scientist. He was born at Tomsk, Siberia on 8 November 1904. He died at Largo, Florida, on October 29, 1995. His was a full 91 years of activity over a wide range of endeavours.⁴

One source tells us he was ‘over the years a labourer, a lumberman, a laboratory foreman, an assistant professor of microbiology (probably at UCLA), a military geologist with the US Geological Survey, a Lt Colonel in the Army Engineering Corps [this may have been an assimilated rather than a commissioned rank in the Army Corps of Engineers], an oil exploration consultant, a mineral commodity analyst, a physical scientist

and a translator of Russian technical articles - and, of course, a geochemist'.⁵ Some of these occupations can be fitted into his life story, but the period of others is not at all clear.

Figure 1: *Moonta map*



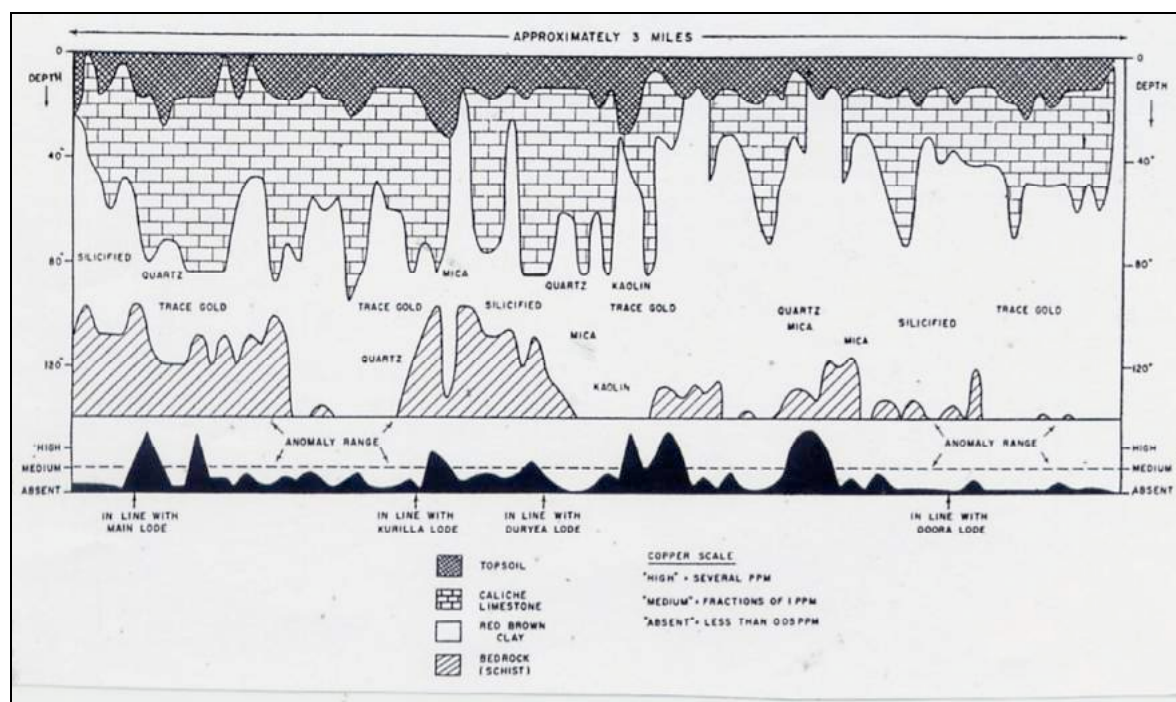
Source: V.P. Sokoloff, 'Exploration for copper in Wallaroo mining district, South Australia', *South Australian Mining Review* 88, 1949.

When he went to the USA is uncertain, but it was probably about the time of the Russian Revolution, and probably with his Jewish family. There is little information about his early years, but at some stage he became a naturalised US citizen. There is a comment that he had a bachelor's degree in chemistry from the University of Arizona but no date has

yet been obtained for this.⁶ However, he followed this up with a PhD in soil science at the University of California (Berkeley). This wasn't until May 1937, when he was 33 years of age, and some four years after he married, but to whom is not known. He also pursued post-doctorate studies in microbiology at Berkeley, and probably studied Spanish at this time.⁷

Although his written English was very good, there are occasional slight infelicities consistent with him learning a second language, possibly as a teenager. For instance in the Wallaroo report he says that the narrow lodes 'constitute an exploration problem of a peculiar difficulty' and refers to 'metals in the enumerated materials'.⁸

Figure 2: *Generalised cross section of soil mantle in Wallaroo mining district*

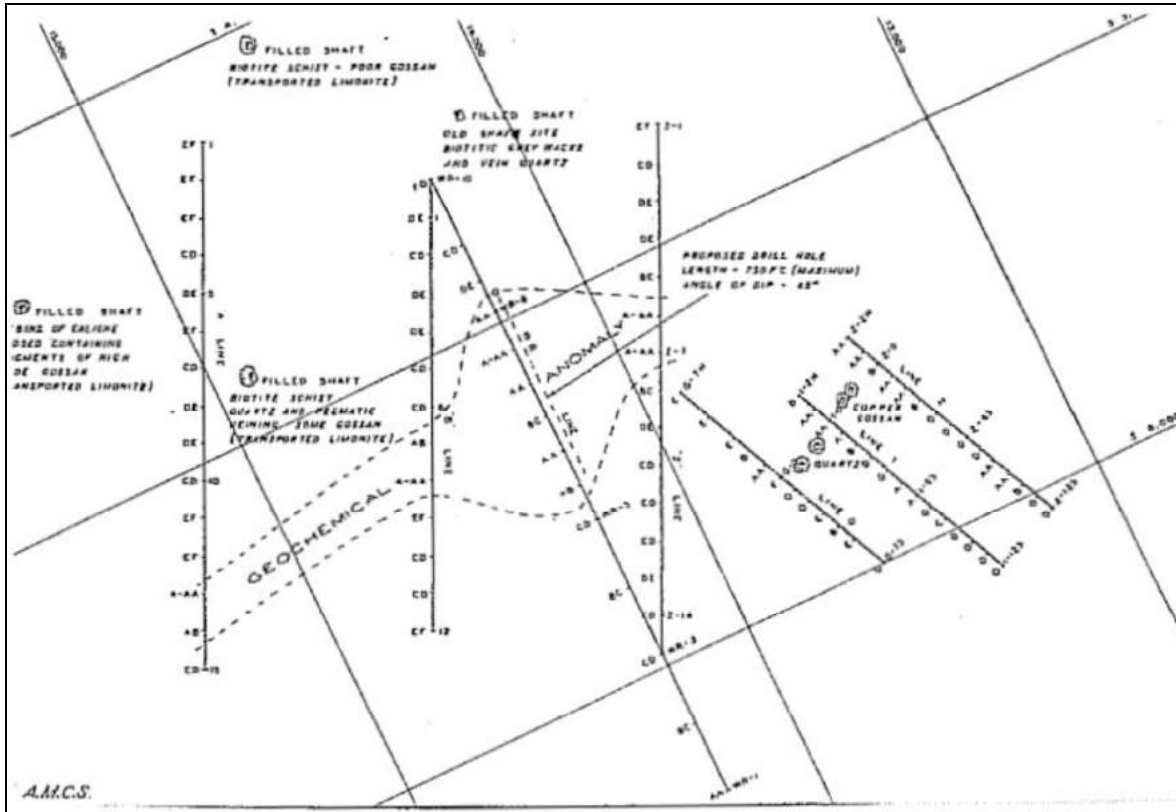


Source: V.P. Sokoloff, 'Exploration for copper in Wallaroo mining district, South Australia', *South Australian Mining Review* 88, 1949.

What do we know of Sokoloff that adds to the basic information? From some published papers he was certainly doing geochemical work as early as 1933, when he wrote on the 'Determination of Water of Crystallisation in the Total Solids of Water Analyses'. Two years later he was at the R.F. Reitemeier Laboratory of the US Department of Agriculture at Riverside, California where he published two papers alone on saline soil solutions, and jointly with F.M. Eaton on 'Absorbed Sodium in soils affected by the soil-

water ratio'.⁹ In 1938 he wrote on the 'Effects of neutral salts of Na, Ca on C and N in Soils', published in the *Journal of Agricultural Research*. This came essentially from his previously mentioned thesis for PhD.¹⁰

Figure 3: Moonta geochemical anomalies.



Source: V.P. Sokoloff, 'Exploration for copper in Wallaroo mining district, South Australia', *South Australian Mining Review*, 88, 1949.

In 1943, Sokoloff was joint author with F.M. Turrell and L.J. Klotz on the 'Structure and composition of citrus leaves affected with mesophyll collapse' in *Plant Physiology*.¹¹ Only one address is given in conjunction with the paper, so it is surmised that all three authors were then at the University of California Citrus Experimental Station, Riverside, California, which had been set up in 1906.¹² No doubt the paper was written in the previous year or so, prior to him joining the USGS.

There is a time gap in the period from 1938 to 1943, which might have seen Sokoloff involved in the Army Corps of Engineers, although his biographical summary does not refer specifically to war service.¹³

The US Geological Survey period, 1943 - 1950

Sokoloff did not become involved in mineral exploration work until after 1943, when he apparently joined the US Geological Survey as a soil scientist, remaining there until 1950.¹⁴ However, there aren't many papers from the period, always excepting those on Moonta. A paper on hydrologic studies in California possibly owes its origin to work done before Sokoloff joined the Geological Survey, but this is not necessarily so.¹⁵ The Geological Survey was probably also still involved in some security work, which probably explains Sokoloff's involvement in terrain intelligence studies.¹⁶ With the renowned T.S. Lovering (senior author) and Hal T. Morris, a paper concerning mineral geochemistry appeared in *Economic Geology* in August 1948.¹⁷ By this time Sokoloff was in Australia.

A revealing brief note by H.E. Hawkes indicates that real geochemical work at the US Geological Survey did not begin until July 1946, and there was considerable scepticism among Survey members, and particularly among the top brass, about its value in mineral exploration. Hawkes, together with Helen Canon and Lyman Huff, from three different backgrounds (ore-deposits, palaeobotany and hydrology), felt that trace elements might be useful in the search for ore-bodies and obtained a surprisingly large grant to test their ideas. Sokoloff and Bert Lakin were quick to 'sign up' for the new unit.¹⁸

The next couple of years must have been busy, as Sokoloff is credited with three other joint papers in 1948, so they must have been completed before the middle of the year when he came to Australia, or more likely in 1947. While there are only two or three fully published papers, there are also Geological Survey File reports involving Sokoloff, such as his solo 'Geochemical Reconnaissance in Kokomo Mining District, Colorado,' and two others in the same year: one with Hawkes and Lakin, the other with T.S. Lovering and Morris, both of whom must have become interested in the geochemical methods.¹⁹

Perhaps Sokoloff was feeling the need to spread the gospel as we also find him writing for the more popular scientific and mining press. 'Geochemical Prospecting for Ore' appeared in *Mines Magazine* in April 1948, a short effort, but accompanied by a map and other illustrations.²⁰

Apparently a sociable person, Sokoloff was elected to membership of the Geological Society of Washington's, Cosmos Club of Washington, on 12 March 1947. He presented three papers to the club's meetings. The first was just a little more than a month

(23 April 1947) after his election. He spoke on a rather different topic than what might have been expected: ‘Engineering map units in Fairfax County Virginia’ (although see his previous involvement in terrain analysis), which was discussed by member Paige and Club President Woodring.²¹ An abstract of this talk was later published.²² Almost three years later, at the 689th Club meeting, 12 April 1950, he spoke on his last two years of work that involved ‘Geochemical exploration in Australia in 1948–49’. It invoked discussion by colleagues Lakin, Almond, Stevens and Stadmichenko. He was back again at the Cosmos Club on 30 November 1960 when 100 members heard him talk about the ‘separation of tantalum from niobium in bacterial cultures’, which drew comments from members Sisler and Pecora.²³

V.P. Sokoloff in Australia, 1948

Sokoloff is first heard of in Australia in a brief report to the Commonwealth Bureau of Mineral Resources, written at Broken Hill on 18 June 1948. Here he outlined his tentative proposals for the operation of the Wallaroo - Moonta project. He pointed out that the exact plan of operation would, of course, only be determined at the site. He noted that the ‘interest of a colleague assistant would be appreciated heartily’, both in the sampling and in the testing operations. He felt that the time involved would likely exceed ten days in the field, with a subsequent period of no more than five days laboratory work - 15 days in all.²⁴ Although not confirmed, the author believes the then young Alan Hargraves, a recent mining engineering graduate, acted as the enthusiastic assistant, for more about the operation of the project is revealed in Hargraves’ paper.²⁵

Sokoloff’s final report on the Wallaroo-Moonta project, first published in 1949, a year after its completion, makes it clear that the main sponsor of the work was the Zinc Corporation.²⁶ The available papers of the Zinc Corporation and of its then Director of Exploration and Research, Maurice (Maurie) Mawby (later Sir Maurice, 1904–1977) and of Chief Geologist at Broken Hill, Haddon King (1905-1990) in the Melbourne University Archives, do not clarify just when, and through whom Sokoloff was contacted to undertake his work in Australia.²⁷ At the time King first came to Australia to work for Western Mining in 1934, the object of his employment was ‘to apply the latest ideas in geology, geophysics, geochemistry and aerial photography to the scientific search for new

minerals'.²⁸ However of this list, geochemical work was the last to be implemented, geophysics and aerial photography being in full swing soon after the end of WW2, with pioneer work being carried out in the 1930s and even before.²⁹

It was possibly that moves were made as early as 1945 to get into geochemical mineral exploration, when Mawby was in the USA between 7 August and 3 September making contact with mining companies and looking for new ideas in exploration. However, at this time the US Geological Survey was not yet interested in such matters (see below).

While the Mawby papers (mainly letters) only give direct information about Sokoloff and the Moonta project from 8 July 1948 to 9 March 1949, these letters are revealing.³⁰ They show, in particular the friendship that developed between Sokoloff, Mawby, King and others from the Zinc Corporation. Sokoloff signed himself 'Pete', and is thus referred to in letters between Mawby and King, and by H.E. Hawkes (1996).³¹ Mawby wrote to King on 8 July 1948, sending Progress Report No. 1 'on Sokoloff's Geochemical Studies on the Wallaroo Moonta District'.³² Mawby commented:

I presume you will shortly be paying a visit to this district with Mr. Weiss, and it is interesting to note the general agreement on the Bacon's Find traverse line between the electrical resistivity and geochemical profiles. I suggest that you show this report to Mr. Weiss.³³

Oscar Weiss was the South African geophysicist contracted to the Zinc Corporation and engaged in numerous projects. There is evidence in the letters that Weiss and L.R. (Lew) Richardson, Geophysicist of the Commonwealth Bureau of Mineral Resources, were somewhat at loggerheads.

At the end of July 1948 Sokoloff spent several days at Cobar with King and P.C. Benedict. Lew Richardson was expected, but did not turn up. King told Mawby on 2 August 1948, that 'Ben will I hope write you his impressions and Pete will report separately on the geochemical tests carried out during our brief stay'.³⁴

In a footnote to his Moonta report Sokoloff mentioned tests done at Mount Isa and at Wollogorang, Northern Territory. He gave no details of what must have been a rushed trip or trips but there is photographic evidence of him at the Redbank Prospect, Wollogorang, in the Northern Territory in July. These several photographs are the only ones known by the author in which Sokoloff is identified, along with P.C. Benedict, King

and D.R. Bunney, who was probably the geologist on site. One photo shows that Sokoloff carried out some trenching, and probably did some field tests with the assistance of several unnamed Aborigines, but no notes on this venture have been located.

While the Wallaroo-Moonta project proved economically disappointing the anomalies measured and the relatively quick and cheap method of exploration apparently pleased the various authorities. In July 1948, Mawby told King:

I have written to Sokoloff stating that we are anxious to have a member of our staff learn something of his technique and we should have Trezise on the job before long. Garretty has also asked whether we would permit Lee Parkin or some other member of his staff spend two or three days with Sokoloff. This, of course, we would be only too happy to do.³⁵

M. Duan Garretty was Chief Geologist for North Broken Hill Mine. There is good evidence in this note of co-operation at this time between potentially rival companies involved in exploration in Australia.³⁶

Thus Sokoloff was asked to train a 'Commonwealth Team' testing for copper, lead and zinc by undertaking examination of a number of sites in western New South Wales, where there was considerable geophysical information based on work by the Zinc Corporation's consultant Weiss, and by the Commonwealth Bureau of Mineral Resources. While members of the Bureau of Mineral Resources, probably including Walter [Wally] Dallwitz, the Bureau's mineralogist/petrologist were certainly involved. The team also included personnel from the NSW Geological Survey (not presently identified), and 'representatives of Zinc Corporation (presumably Trezise) and North Broken Hill' (probably Lee Parkin). Sokoloff calls it the 'first study of its kind' by the team:

a demonstration of the dithizone tests for traces of some heavy metals in the field environment, of operational procedures, and ... [requiring only] a relatively small amount of reconnaissance.³⁷

Seven sites were examined. There were three in the Cobar region at the 'Peaks' and the 'Western Anticline', where rock samples were taken, and the 'Spotted Leopard' for soil only. At Nymagee there were two traverses at the 'Shuttleton' site, collecting both rock and soil samples, and the same process was undertaken at the nearby 'Wirlong', together with what Sokoloff labels the 'granitization series'. The party then moved to Broken Hill where

rock and soil were collected from the 'Laurel anticline'. They must have been quite busy, as the whole project took only 17 days, between 5 and 22 October 1948. Sokoloff provided a report on this project to the Commonwealth Bureau of Mineral Resources.³⁸ There is also a brief note in the October 1948 monthly summary of Bureau activities that a manuscript by Sokoloff in association with Dallwitz and other Bureau members, had been written, which might refer to the Sokoloff report mentioned above.³⁹

Despite the lack of any commercial success following drilling at Moonta, the theoretical success of indicating significant anomalies there, and in the following experimental program, encouraged later work in Australia using the dithizone method. Mawby reported to Sokoloff in December 1949 that '[C.J.] Sullivan speaks of the Commonwealth ... [doing] geochemical work in the Brocks Creek area [NT] next year after the wet, about April 1950'.⁴⁰ The author has seen no report on this proposed project. However, John Ivanac, at that time at the Bureau of Mineral Resources, was impressed with the technique, and when he joined National Lead of New York as Manager of Exploration in Australia he introduced the method in programs in the Cloncurry, Queensland, and James Range, Northern Territory during 1953. D.F. Branagan after a short stint in the James Range was in charge of the Cloncurry work with chemist Ken Broome carrying out the laboratory testing. Anomalies were located and later tested by drilling, but the results were not economically viable.⁴¹

V.P. Sokoloff in Australia, 1949

Sokoloff returned to Australia in 1949, this time carrying out work in Western Australia on gold prospects, mainly for Western Mining. The following year he published some of the results of this work in the *Australian Chemical Engineering and Mining Review*.⁴² However, he did not mention some of the interesting work he began there on 'gold bugs', an attempt to precipitate gold and beneficiate gold ore by bacterial means. This work seems to have been supported by Lindsay Clark.⁴³ This experimentation was being undertaken some years before N.H. Fisher, A.A. Öpik and others of the Commonwealth Bureau of Mineral Resources began looking at the possibilities of biological processes causing ore deposition. Laurens Baas-Becking, from the Commonwealth Scientific and Industrial Research Organisation [CSIRO] began experimenting for the Bureau in Canberra in 1958,

and the Baas-Becking Laboratory was set up through the support of the Commonwealth Bureau of Mineral Resources, the CSIRO, and the Australian Mineral Industry Research Association [AMIRA], at the time chaired by Haddon King.⁴⁴

In at least one paper Sokoloff claims to have been first invited to Australia in 1947, but had been unable to travel there that year. He claims also that when he came in 1948 he came as a private consultant. However, he seems to have been happy to have had US Geological Survey after his name in two of the three papers that emanated from his Wallaroo-Moonta work. In fact, professionally, Sokoloff seems to have made as much as he could out of the Wallaroo-Moonta project. Of the three papers, two at least are identical. However, its first publication, in the South Australian Government's *Mining Review*, seems to have occurred without Sokoloff's knowledge,⁴⁵ and the second in the *Australian Chemical Engineering and Mining Review*⁴⁶ was probably also done through the South Australian Department of Mines.⁴⁷

An 'unsuccessful' project

Mawby must have been impressed with Sokoloff and his ideas, informing L.B. Robinson who was in London, that 'his wider practical experience, his imaginative, well-trained mind, and his keenness would be an asset'.⁴⁸ He made these comments during a year-long battle to interest Robinson and the Zinc Corporation company directors, and controllers of the purse strings, about a project that had interested him from the early 1940s – the possibility of using bacterial processes to obtain, in commercial quantities, sulphur from gypsum, a method which had been attempted a few years earlier in India.

In 1948 Mawby sent Haddon King a translation, almost certainly by Sokoloff, of a paper 'The manufacture of sulphuric acid from gypsum' written in 1941 by Engineer, E. Zorninger,⁴⁹ commenting that it had 'proved most interesting', but there were distractions for Mawby, so nothing happened on that front during the next year or so.

In late November 1949, Mawby apprised Robinson of Sokoloff's work in Australia, detailing his Wallaroo-Moonta work in 1948 and for Western Mining gold enrichment in 1949. Mawby also wrote that Sokoloff 'has had many years of practical experience in chemical and biological work, particularly with the effect of bacteria on soils and

agriculture'.⁵⁰ At this stage Sokoloff was expressing some interest in the possibility of returning to Australia and working at CSIRO.⁵¹

Sokoloff told Mawby that the sulphur-forming bacteria were rare and little known. He outlined the methods and possible results of the work, which would be 'difficult, full of disappointments and probably time-consuming'.⁵² He was prepared to return to Australia and work with a very small staff to experiment on breaking down gypsum to obtain sulphur. Mawby admitted that an Australian chemist could possibly undertake such a project but he felt that Sokoloff's qualities placed him in a higher category of research. However, while Mawby was happy to see an experimental project tackled by Zinc Corporation alone, Robinson wanted to bring other companies in and preferred to have research done on purely metallurgical methods rather than biochemical. He told Mawby, correctly at the time, that Sokoloff's research plan was nebulous and that it would be impossible to pay Sokoloff in dollars.⁵³ Mawby countered that only a token payment would be necessary and could be made in sterling.

At this time, late in 1949, Sokoloff was apparently having some trouble with his employment in the US Geological Survey, or with the closely related US Bureau of Mines, and Mawby hoped 'they will soon realize the necessity of carrying out an intensive investigation of the application of Geochemistry to Mining Geology'.⁵⁴ However, things didn't work out on that front and Mawby was able to tell Robinson that Sokoloff 'will probably leave the USGS in mid 1950 and accept a position at John [sic] Hopkins University, Baltimore', where he would have 'complete freedom of research and facilities' with 'superb equipment' in exchange for talking once a week to students about geochemistry.⁵⁵

In February, Mawby passed on to Sokoloff information about sulphur being produced, largely naturally, in a lake in Cyrenaica in North Africa.⁵⁶ Mawby kept pushing Robinson for support, but Robinson still felt it was not clear what Sokoloff would do, and suggested he be left to 'do his own thing' in America, while 'we get C.S.I.R. or someone from Teddington' [the English National Chemical Laboratory] for Australian research.⁵⁷ Mawby replied, pointing out that if Sokoloff undertook research in the US without the company's involvement and token payment, someone else might end up with a US patent, and 'we could suffer'.⁵⁸ By this time Robinson was getting a bit touchy about the whole

matter and left things for a few months, finally telling Mawby that he would discuss the proposal ‘when in Australia.’⁵⁹ Without the Zinc Corporation’s support Sokoloff got on with other projects at Johns Hopkins. After an enquiry by Mawby as to whether anyone in the US was working on the bacterial reduction of gypsum to sulphur, Sokoloff replied:

nothing is being done here, ... when I attempted to interest the McCallum-Pratt Institute ... with Carter’s support we were shrugged away ... the great men thought the project impossible and foolish ... [they were] not interested in anything unproven.⁶⁰

And that was the end of the matter. No direct evidence has been discovered of further contact between Mawby and Sokoloff and it appears they went their separate ways.

Sokoloff in the 1950s

Sokoloff was still with the US Geological Survey in 1950 when, together with another pioneer of Geochemical work, H.E. Hawkes, a number of Russian papers on geochemical prospecting for ores were published.⁶¹ Perhaps most significant of the papers was E.A. Sergeev’s 52 page work, ‘Geochemical Methods of Prospecting for Ore Deposits’, published originally in 1941. Sergeev was Senior Scientific Associate for Materials of the Soviet Union Geological Institute. Sokoloff provided a ‘Translator’s Foreword’ saying that he had in places provided an idiomatic translation, and was often searching for the correct meaning to express what he calls ‘inadequately defined new concepts.’⁶² Other translated papers date from as early as 1939. It is almost certain that the translations were made in the mid-1940s, rather than later, and were only put together as Sokoloff was severing his links with the US Geological Survey. The major paper by Sergeev in 1941 was referred to in the first published version of Sokoloff’s 1949 Wallaroo paper.⁶³ Other Russian papers are also quoted in the Wallaroo – Moonta paper. Perhaps Sokoloff realized the general value of this Sergeev paper after his Australian work, for it describes the dithizone technique in considerable detail.

Johns Hopkins and beyond

Sokoloff’s move from the Geological Survey seems to have been prompted by the Survey’s apparent lack of interest in large-scale geochemistry. Perhaps, from pressure from the top

the preference was to look only at individual sites of interest.⁶⁴ It is possible his period in Australia gave him a feeling for larger projects, and for the freedom to pursue them, and in 1950 the opportunity arose to move into such a position at Johns Hopkins University, Baltimore, in the Isaiah Bowman School of Geography. While settling in to new work, he was happy to accept the advice of new colleague, George F. Carter, Chairman of the School, to tidy his Wallaroo-Moonta paper and present it to a wider audience. The work was published in the newly established journal, *Geochimica et Cosmochimica*.⁶⁵ In addition to acknowledging the help of Mawby and Carter he noted advice from Dr J.T. Singewald Jr (1884–1963) then Chairman of the Department of Geology at Johns Hopkins, Ernst Cloos of the same Department, and Dr Earl Ingerson, Chief of the Geochemistry and Petrology Branch of the US Geological Survey. Also mentioned were references to Zinc Corporation file reports by P.C. Benedict and W.R. Bacon.⁶⁶

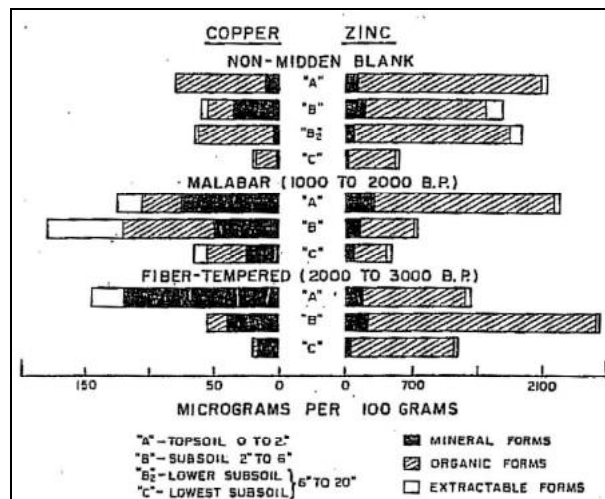
Singewald was apparently impressed by the Wallaroo-Moonta research and talked Sokoloff into giving a talk on his work at the 63rd Annual Meeting of the Geological Society of America. This occurred before the paper was published in the new journal. However, it did not go well at the convention as his presentation was placed last on the last day and whoever was chairing the session had not made earlier speakers stick to time. Sokoloff gave up on reading the paper and just showed the slides, as most of the members melted into the distance.⁶⁷

The period at the Isaiah Bowman School saw Sokoloff begin with rather general local soil, landform and irrigation studies,⁶⁸ before being drawn into a new field, archaeology, where geochemistry was only just being established.⁶⁹ His earlier study of Spanish while in California would have proved useful in his examination of archaeological sites in Mexico, and broader studies on the cultivation of citrus in mediaeval Spain and mineral reserves there.⁷⁰

The 1952 joint paper with Carter on ‘Time and Trace Metals in Archaeological sites’ published in *Science* is particularly interesting. It dealt with the study of an Aboriginal midden - what the authors call ‘a geochemical anomaly undergoing dissipation’. The work examined the anomalies in the midden created by human refuse, looking at possible enriched contents of copper, zinc, tin, lead, gold, manganese and phosphorus, nitrogen, and considering the reduction, indeed disappearance, of the anomalies given time,

through continued weathering. The methods were designed to examine archaeological sites that were too old to give reliable ages based on the C¹⁴ technique (Figure 4). The researchers, however, were not attempting to make exact quantitative measurements, but were concerned to see if their methods could broadly differentiate middens which were possibly 1,000, 10,000 and 100,000 years old. That is, they were seeking a qualitative, rather than a quantitative assessment of age. Following on from this work, Sokoloff examined the archaeological site in Mexico, mentioned above.

Figure 4: *Archaeological dating using geochemistry: Distribution of copper and zinc in two midden soil profiles of different age and in a nonmidden blank.*



Source: G.F. Carter and V.P. Sokoloff, 'Time and Trace Elements in Archaeological Sites', *Science*, vol. 116, no. 3001, 4 July 1952.

Israel, 1953 -1956 and after

Following his Australian travels, perhaps the wanderlust continued to call him, as from 1953 Sokoloff spent almost three years in Israel. Here he worked on a 'Point Four assignment' as consulting geochemist at Makhtsavei, acting as 'Geochemist in the Negev', during which time he apparently re-evaluated Timna, King Solomon's reputed copper-mining centre.⁷¹ Research indicates the Timna mines were not worked at the time of Solomon.⁷² Sokoloff's interest in languages ensured that he studied Hebrew, possibly to gain an insight into ancient records relating to some of the historic sites he was examining. During this period he apparently spent part of 1954 undertaking work on humisol (organic, perennially saturated soils) at the Geographical Institute of the University of Istanbul.⁷³

Through 1956 and 1957, after he returned to the USA from Israel, Sokoloff did some consulting work for his former employer, the US Geological Survey, and Shell Oil Company. The cold war period seems to have brought an awareness of Sokoloff's value as an interpreter and translator of Russian scientific activities and publications, so between 1958 and 1966 he was 'Eastern Europe Specialist & Physical Scientist' in the Division of International Activities of the US Bureau of Mines, DC.⁷⁴ In 1960 Sokoloff's translation from the Russian of I.I. Ginsburg's *Principles of Geochemical Prospecting*, which dealt with the 'techniques of prospecting for non-ferrous ore and rare metals' was published.⁷⁵ In 1964 the Bureau published the summary paper by Sokoloff, 'The Mineral Industry of the USSR'.⁷⁶ In 1966, all this work was recognised when he was awarded the Commendable Service Medal of the US Department of the Interior.⁷⁷

An intriguing note in *American Men and Women of Science* says that Sokoloff was a consultant to Conzinc-Riotinto in 1965.⁷⁸ This has not been confirmed but it seems likely that Mawby and Sokoloff re-established contact. By this time Mawby had become a Director of Conzinc-Riotinto.⁷⁹ But what was it about? It might have concerned bauxite at Weipa, or iron in the Pilbara.

Sokoloff seems to have spent his last working years, 1966-1974, at the American Geological Institute, where he was involved mainly as a translation review editor, and in reviewing international geological literature in general. One particular translation caused the prestigious journal *Geophysics* to break from its policy of not publishing material that had previously published elsewhere. This was Sokoloff's 1966 'What Soviet Scientists saw in the United States'.⁸⁰ After retirement he moved to Miami, where he maintained some interest in technical matters as a member of the Florida Society of Metallurgical Engineers.⁸¹

Among research and activities hardly touched on in this paper are those Sokoloff listed in 1994 under the general heading of 'Applied geochemistry: the physiology and parasitism of nitrate-reducing micro-organisms; bacterial leaching of ores and soil physics in terrain intelligence'.⁸² Fiedman tells us that Sokoloff had 'travelled in most parts of the world on technical assignments or on loan to foreign countries', possibly including South Africa, Italy and Spain,⁸³ but did he ever revisit the land of his birth? These are questions which might be broached in a separate paper.

Conclusion

Sokoloff's pioneering work in a number of fields is not completely forgotten today. It is interesting to see his 1938 work taken from his PhD research, being quoted by CSIRO researchers in 2001.⁸⁴ While the name Sokoloff is not well remembered in Australian mining circles, there is no doubt that his work marked the beginning of the use of geochemistry in mineral exploration in Australia. While it cannot perhaps be convincingly argued that the method has, alone, resulted in the discovery of a major, or even minor, economic orebody, nevertheless the method has surely reduced the cost of exploration by indicating areas for detailed prospecting and by eliminating wide tracts which might otherwise have been the focus of attention. The fact that, as one reviewer has said, 'the paper sets the scene for the intense geochemical exploration that has taken place over the last few decades', surely speaks for the success of the method, in economic terms.

Acknowledgements

I am very much indebted to Dr. Cliff Nelson US Geological Survey, Reston, Virginia, who gave me leads into Sokoloff's wide ranging work through the biographical information in the *American Men and Women of Science*, and the Fiedman article. Melbourne University Archives (through Dr. Michael Piggott and Helen McLaughlin) gave me access to the Mawby papers, and permission to reproduce illustrations from these papers. Dr Tony Miller at Melbourne University Archives kindly assisted me in working with the Mawby Papers. Bev Allen, Geoscience Australia Librarian, assisted in locating Sokoloff material at the Library, Canberra. My thanks also to the staffs of Fisher Library, the University of Sydney and of the State Library of New South Wales for assistance in locating sources. The positive criticisms by two referees, and by the Editor, have helped to make the paper more accessible.

Endnotes

¹ R. Lockhart Jack, 'The Geology of the Moonta and the Wallaroo Mining District', *Bulletin 6*, Geological Survey of South Australia, 1917, 135pp. For the most recent geological/geochemical information on the Moonta field see J.L. Keeling and K.L. Hartley, 'Poona and Wheal Hughes Cu Deposits, Moonta, South Australia,' CRC LEME, Primary Industries and Resources, South Australia, 2005.

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