SWEDISH GEOLOGICAL SURVEY

Geochemical Division

Project: Biogeochemical Exploration for Uranium

Jan Byman

GEOKEMIRAPPORT 80/10

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BIOGEOCHEMISTRY WITH EMPHASIS ON URANIUM EXPLORATION

NEA/IAEA WORKSHOP, LULEÅ, SWEDEN 3-5 SEPTEMBER 1979

Sverige har med hjälp av Sveriges geologiska undersökning (SGU) åtagit sig värdskapet för ett IAEA/NEA (International Atomic Energy Agency/Nuclear Energy Agency) expertmöte i biogeokemi med inriktning på uranprospektering den 3-12 september. Ett trettiotal experter från tio länder skall samlas i Luleå för att diskutera pågående biogeokemisk forskning och utveckling samt utarbeta riktlinjer för F o U (Forskning och Utveckling) insatser i gemensamma pilotprojekt över kända uranmineraliseringar och fastställa de tekniska kraven för projektens praktiska genomföranden. Föreslagna projekt kommer därefter att granskas av en till OECD hörande expertgrupp.

Att Sverige tillfrågats att arrangera detta möte beror på att SGU internationellt anses vara ledande inom biogeokemisk prospekteringsteknik och Sverige av tradition ett föregångsland. Kemisk analys av växtdelar som en prospekteringsmetod (biogeokemisk prospektering) utvecklades av en i mötet deltagande SGU-expert, N H Brundin, redan under 1930-talet.

Mötet avslutas med en demonstration av i Sverige tillämpade geokemiska metoder för uppsökandet av ekonomiskt utvinnbara metaller samt besök till svenska uranförekomster och till urananrikningsverket i Ranstad.

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Biogeochemistry with Emphasis on Uranium Exploration

NEA/IAEA Workshop, working session, Luleå, Sweden 3-5 September 1979

PROPOSED AGENDA

Monday, 3 September

09.00 - 09.15	Introduction by Carl Allan Nilsson, Head of Prospecting Branch of the Geochemical Division
	Talk by Dr. Derek Taylor, Representative of NEA (OECD)
	Talk by Dr. Mike Wilson on Uranium occurrences and uranium prospecting in Sweden
	Talk by Dr. Nils Herman Brundin on Development of biogeochemical prospecting methods for heavy metals with special reference to uranium
	Talk by Dr. John Ek on Practical application to biogeochemical uranium prospecting in Sweden
10.45 - 11.15	Break for coffee
	Presentation of brief papers (15-30 minutes) by participants on Biogeochemical prospecting methods for Uranium (techniques, current research etc.) forming the basis for later discussions
12.30 - 14.00	Lunch
	Continuation of the presentation of participants' papers
16.00 - 16.15	Break for coffee
	Discussions on Alternative geochemical prospecting techniques and requirements under different climatic and environmental conditions
20.00	Dinner at SAS Globetrotter Hotel, Storgatan 17, Luleå

Tuesday, 4 September

09.00	Tour of SGU laboratory and uranium exhibition by Allan Danielsson, Head of Geochemical Division and Dr. John Ek.
	Discussions on Sample preparation, Analytical methods and Computer treatment of biogeochemical data
10.45 - 11.00	Break for coffee
	Continuation on discussion on sample preparation etc.

12.00 - 13.00	Lunch
	Identification of Research and development proposals and evaluation of research projects
15.00 - 20.00	Excursion to Kvarnån uranium mineralisation. Demonstratio of bog peat sampling. Tour to Storforsen waterfall. Sandwiches and beers will be provided.

Wednesday, 5 September

09.00	Continuation on Identification of R & D proposals. Financing on Research and Development projects.
	Breaks for coffee and lunch
19.30	Dinner at Margaretas Inn (värdshus), Gammelstad (costs about 100 crowns). Individual transport by taxi.

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

Working Document

RESTRICTED

Paris, 3rd October, 1979

STEERING COMMITTEE FOR NUCLEAR ENERGY

COMMITTEE FOR TECHNICAL AND ECONOMIC STUDIES
ON NUCLEAR ENERGY DEVELOPMENT AND THE FUEL CYCLE (FCC)

NEA/IAEA Joint Group of Experts on R & D in Uranium Exploration Techniques

Summary Report on Workshop on Biogeochemical Prospecting for Uranium Luleå, Sweden, 3rd-5th September 1979

A workshop was held in Luleå (Sweden) to discuss biogeochemical prospecting for uranium with a view to formulating proposals for a co-ordinated programme of R & D.

A list of those attending the workshop is attached (Annex 1) together with a copy of the proposed agenda (Annex 2).

1. The participants were welcomed to the Swedish Geological Survey (SGU) by Dr. J. Bergstrom who chaired the meeting.

2. Dr. C. Nilsson described the organisation of SGU and the work being undertaken by the Prospecting Branch of the Geochemical Division.

3. Dr. D.M. Taylor (NEA) welcomed the participants on behalf of the two agencies, described the nature of the ongoing NEA/IAEA R & D projects and outlined the tasks before the workshop.

4. Dr. M. Wilson, head of SGU's uranium prospecting project described the reasons for uranium prospecting in Sweden, the methods of financing the exploration, and the discovery and nature of several of the uranium occurrences.

5. Dr. N.H. Brundin (Sweden) reviewed the development of biogeochemical prospecting methods for heavy metals and the role played by mosses, stream peat and roots in concentrating uranium. Recent work in Iran had indicated that plant roots from dry streams were more suitable indicators of uranium than stream sediments collected at the same locality. Dr. Brundin emphasized the need for much additional study of biogeochemical techniques.

6. Dr. J. Ek (Sweden) described the development of geochemical prospecting which started in the late 1960's using the conventional sampling methods of stream waters and sediments. Experience had soon shown that there were serious disadvantages to these methods and from studying alternative sampling media it became apparent that organic stream samples, which were available everywhere and easy to sample, gave good anomaly patterns for mobile elements such as uranium with a relatively low sample density (15-20 samples per 100 km^2). Dr. Ek gave examples where organic stream sampling had been used on a reconnaissance and regional scale to discover uranium mineralization. Studies were being undertaken on follow-up techniques for detailed surveys.

There was a general discussion following Dr. Ek's presentation to decide if organic stream sampling, as described by Dr. Ek, should be regarded as a biogeochemical method with the majority opinion being that it should.

7. Participants at the meeting were then invited to present information on biogeochemical prospecting methods for uranium presently being used in their countries.

Dr. P. Noras described the geochemical mapping programme in Finland which had started in 1971 and was based on lake and stream sediments and ground-waters. To date approximately 10% of Finland had been covered by lake sediment sampling. Several anomalies had been located but no mineralization had been found.

Mr. Grimbert described the wide experience of the French CEA in biogeochemical prospecting for uranium in France, Niger and Gabon. He concluded that to date there had been very little success with the different methods attempted and that the cost of sampling and analysis was greater than more conventional methods which were at least as successful in detecting buried mineralization.

Dr. Plant (United Kingdom) reviewed the geochemical surveys being undertaken by the IGS and made many interesting observations on errors that can occur during sample collection and data analysis. There are several areas in the U.K. in which stream peat sampling could be undertaken.

Dr. Dunn briefly described the biogeochemical studies being undertaken in Canada and gave some very interesting data from a recent study carried out over a uranium deposit in Saskatchewan. This study appeared to indicate that the woody parts of certain plants, in particular the Labrador tea bush, concentrated uranium and a deposit located at a depth of 150 m had been outlined. Further studies were planned in this area.

Dr. J. Erdman (U.S.G.S.) gave details of a biogeochemical study conducted at a uranium prospect in the Tertiary volcanics of South West Texas. A widespread desert shrub, catclaw mimosa, was found to be more responsive to uranium mineralization than the associated soils, though its capacity to penetrate the basalt caprock that concealed most of the mineralization was disappointing. Further studies were planned.

Dr. V. Price (U.S. DOE) indicated that work by the Savannah River Laboratory (SRL) had shown that water sampling could be affected by recent weather conditions and that sampling biogeochemical media, which tend to integrate values over a period of time, could be advantageous. It had been found that regression analysis assisted in the interpretation of the data. SRL was conducting biogeochemical sampling of trees in seven test areas and peat sampling would be conducted in Maine, Florida and other states.

8. The major part of the second day of the meeting involved a tour of the sample preparation and analysis laboratories and a visit to Kvarnån to study the local uranium mineralization and where biogeochemical sampling techniques were demonstrated.

9. After a discussion on the types of biogeochemical prospecting most likely to benefit from further study, the participants identified five specific topics which should form the basis of R & D proposals. The participants then divided into groups to draft these proposals and reconvened later to discuss and modify them. Copies of the proposals thus generated are attached (Annex 3).

In addition the workshop strongly recommended that a "State of the Art" report should be prepared on the methods and techniques used in biogeochemical prospecting. This should include either a comprehensive bibliography on biogeochemical prospecting or details of the availability of such a bibliography. The participants unanimously recommended that every effort should be made to obtain details of as much previously unpublished information as possible including details of unsuccessful case histories.

10. The workshop was followed by a field visit to several areas of uranium mineralization in Sweden. Details of this visit are given in a separate document (Uranium in Sweden : An Excursion Guide prepared by SGU).

Secretariat Note : A consolidated proposal on Uranium Biogeochemistry was later prepared by the Secretariat with the assistance of several participants in the workshop. A copy of the consolidated proposal, which is the eighth in the series of R & D proposals produced from the various workshops held so far, is attached as Annex 4.

ANNEX 1

LIST OF PARTICIPANTS

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* Meeting only

** Excursion only

*** Meeting and excursion

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UNITED KINGDOM	*	Jane Plant Institute of Geological Sciences 154 Clerkenwell Road London EC1R 5DU
UNITED STATES	***	James Erdman United States Department of the Interior Geological Survey Box 25046 Denver Federal Center Denver, Colorado 80225
	***	V. Price El Dupont Co. Savannah River Plant Aiken, S. Carolina
COMMISSION OF THE EUROPEAN COMMUNITIES (CEC)	*	L. van Wambeke Commission of the European Communities 200, rue de la Loi B-1049 Bruxelles
NUCLEAR ENERGY AGENCY (AEN)	***	Derek M. Taylor OECD/NEA 38, Boulevard Suchet 75016 Paris

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* Meeting only

** Excursion only

*** Meeting and excursion

ANNEX 2

Biogeochemistry in Uranium Exploration

NEA/IAEA Workshop - Luleå, Sweden, 3rd-5th September 1979

PROPOSED AGENDA

Monday, 3rd September

Introduction by Carl Allan Nilsson, Head of Prospecting Branch of the Geochemical Division.

Talk by Dr. Derek Taylor, Representative of NEA (OECD).

Talk by Dr. Mike Wilson on Uranium occurrences and uranium prospecting in Sweden.

Talk by Dr. Nils Herman Brundin on Development of biogeochemical prospecting methods for heavy metals with special reference to uranium.

Talk by Dr. John Ek on Practical application to biogeochemical uranium prospecting in Sweden.

Presentation of brief papers (15-30 minutes) by participants on Biogeochemical prospecting methods for uranium (techniques, current research, etc.) forming the basis for later discussions.

Discussions on Alternative geochemical prospecting techniques and requirements under different climatic and environmental conditions.

Tuesday, 4th September

Tour of SGU laboratory and uranium exhibition by Allan Danielsson, Head of Geochemical Division and Dr. John Ek.

Discussions on Sample preparation, Analytical methods and Computer treatment of biogeochemical data.

Identification of Research and Development proposals and evaluation of research projects.

Excursion to Kvarnån uranium mineralisation. Demonstration of bog peat sampling. Tour to Storforsen waterfall.

Wednesday, 5th September

Continuation on Identification of R & D proposals. Financing of Research and Development projects.

ANNEX 3

PROPOSAL 1

TERRESTRIAL VEGETATION SURVEYS FOR U : R & D ON METHODS

OBJECTIVES

To establish the species and parts of plants most indicative of uranium mineralization, and ascertain the conditions under which they can help in locating buried ore deposits.

To establish pathfinder elements in vegetation which are indicative of U mineralization.

Evaluate the effectiveness of biogeochemical methods in comparison with other techniques.

Investigate factors unrelated to mineralization that can give false anomalies, or inhibit the formation of biogeochemical anomalies.

METHODS

Collect plants growing over buried ore deposits and separate plant parts prior to analysis for a range of trace metals.

Consider test areas of differing geological, hydrological and climatic conditions, and record physico-chemical parameters.

Examine the relationships between elements within plants, and between plants and soils.

Exchange composite samples between laboratories in order to measure errors in sample preparation and analysis.

Analyse uraniferous soil in order to determine the location of the U, and compare availability of such U with concentrations in plants growing within such soil.

FORM IN WHICH RESULTS WILL APPEAR

(a) Annual progress reports on workshop meetings

(b) Final publication either collected in a single volume or as separate papers in scientific journals.

Submitted by : Colin Dunn (Canada)
M. Gonfalini (Italy)
Franco Vitrani (Italy)
Sven Jonasson (Sweden)
Carl-Allan Nilsson (Sweden)

PROPOSAL 2

THE USE OF AQUATIC MOSSES AND FILAMENTOUS ALGAE, AND PLANKTON IN PROSPECTING FOR URANIUM

JUSTIFICATIONS

Mosses, in particular, are recognized as metal accumulators, and in some instances are direct indicators of mineralization (see for example the papers by Shacklette, USGS, copper mosses and mosses as mineral indicators). Aquatic mosses are ubiquitous over large regions, and because of their large surface-to-volume ratios can serve as a very effective medium in mineral exploration.

OBJECTIVES

(1) To determine whether aquatic vegetation as a sampling medium is preferable to more conventional methods of prospecting, such as stream sediment, surface water or peat sampling.

(2) To assess the merits of the three different media under consideration.

(3) To study the importance of the species effect on the U concentration in the tissue.

(4) To consider the importance of accessory elements such as Mo, Se, As as pathfinders.

METHODS

Initial studies are proposed in several test areas of known U mineralization both in the USA (uraniferous arkose in Tertiary volcanics) and in Sweden (Arjeplog) in a cooperative effort by SGU and USGS (Branch of Regional Geochemistry). Sampling procedures as well as sample preparation and analysis need to be standardized. We propose, therefore, that the samples be processed and submitted to SGU's laboratories in order to minimize procedural and analytical error. When appropriate, we suggest that water, sediment and/or stream bank peat samples be collected simultaneously. Comparisons of U levels in these various types of materials will therefore, allow us to judge which medium is most suitable.

Upon completion of the initial studies of the test areas we propose extending such an investigation to new areas of known or suspected U potential, such as the bog country of the Great Lakes, U.S.A.

Submitted by : N.H. Brundin (Sweden)
J. Erdman (U.S.A.)

PROPOSAL 3

APPLICATION AND EVALUATION OF HUMID MATERIAL AND ROOTS FROM STREAMS IN REGIONAL URANIUM PROSPECTING

OBJECTIVES

Based on many years experience, SGU has shown that biogeochemical methods are useful and efficient in prospecting for uranium in the humid temperate climatic zone. Hence it is important for uranium prospecting internationally to evaluate, in pilot projects, the Swedish biogeochemical prospecting technique in other countries in the same climatic zone and in other climatic zones such as the semi-arid, the arid and the tropical zones.

METHODS

It is recommended that a geological organization in one country coordinates and leads the projects with the cooperation of organizations in participating countries in which known uranium occurrences are situated. Test areas should :

(1) include mineralised and non mineralised situations

(2) should not have been mined or "worked" and it is preferred that such areas :

  (a) should have available a range of other sample types e.g. stream sediments, waters, rocks etc.

  (b) should contain other metalliferous mineralisations associated with the uranium.

Sampling types and procedures should be based on those of the Swedish Geological Survey with modifications necessary for different test areas. Details of methods are available in publications and will be sent to participating countries. Analyses, sample preparation and data processing will be coordinated by the SGU and based on their standard procedures. Interpretation and evaluation of results will be carried out by SGU in collaboration with participating organizations.

Before the next meeting participating countries should be prepared to specify test areas consistent with the criteria described above. These should include areas from arid, semi-arid and tropical climatic zones in addition to the temperate humid zones.

COSTS

The principal costs will be those of sample collection and analysis and these would be covered by in kind contributions by participating countries.

METHOD OF REPORTING

Reports will be on a test area by test area basis with a final report on completion of the project.

TIME

The total time estimated is 3 years (assuming a total number of samples of 6000 or 2000 samples per year).

Submitted by : J.P. Valois (France)
J. Bergstrom (Sweden)
J. Byman (Sweden)
J. Plant (United Kingdom)
V. Price (United States)

PROPOSAL 4

METHODOLOGICAL STUDY OF FOREST LITTER FOR URANIUM PROSPECTING

OBJECTIVES

To investigate whether forest litter is useful or not as a sampling media for biogeochemical uranium exploration. The forest litter consists of dead, not yet decomposed organic matter, deriving from trees, shrubs and herbs. This material is available in large parts of the world and has the advantage of representing the average composition of the vegetation within a certain area. Sampling may often be carried out in a rapid and easy way compared to other sampling media.

METHODS

1. Sampling

The material sampled should represent the average composition within a restricted area around each sampling point, for example 4 m^2. About 200 grammes (dry matter basis) should be collected. During sampling, care should be taken to avoid contamination from the mineral soil. At each sampling station soil samples from the B and C horizon should be collected. Also radioactivity by measurement of the soil should be made at each sampling point. Sampling should be carried out over different types of uranium deposits and different geological as well as climatic conditions. Sampling lines should include mineralized areas as well as background areas. Sampling density should be closer across the mineralized zones compared to background areas. Field observations, such as vegetation type, topography, soil type and drainage conditions should be made at each sampling point.

2. Sample preparation

The samples should be dried at about 100°C and homogenized by crushing. Ashing should be done at about 450°C and loss on ignition should be calculated.

3. Analysis

Multi-element determination should be carried out, for example utilizing the XRF.

4. Interpretation of data

The data should be interpreted in relation to factors such as bedrock and surface geology, geophysics, ecology, and of course the uranium content of other sampling media studied as well as ground radiometrics.

FORM IN WHICH RESULTS WILL APPEAR

As a preliminary report for publication.

TIME REQUIRED TO DELIVER RESULTS

Two to three years from the beginning.

ESTIMATED COSTS TO COMPLETION

From U.S. $ 100,000 to U.S. $ 200,000 depending upon the number of samples collected and accessibility to test areas.

Submitted by : J. Ek (Sweden)
A. Grimbert (France)
A. Herbosch (Belgium)
J.O. Larsson (Sweden)
L. Nielsen (Denmark)
A. Préat (Belgium)

PROPOSAL 5

IMPROVEMENT OF LAKE SEDIMENT METHODS OF EXPLORATION FOR URANIUM

OBJECTIVES AND METHODS

1. Determine influence of lake size on applicability to uranium exploration by examining existing data in Canada and Finland. Establish procedures for large lakes and lakes consisting of multiple basins.

2. Determine the influence of suspended organic matter on lake water geochemistry by analysing filtrates etc.

3. Development of follow-up techniques of lake sediment results.

   (a) Evaluate multiple sampling of lakes by studying dispersion of mobile (U, Mo) and immobile (Pb, Ra) elements within anomalous lake basins.

   (b) Follow-up of lake anomalies with organic stream sampling. This work to be done mostly by Finland.

   (c) Evaluate forest litter as sampling medium for lake sediment follow-up. To be carried out by Finland.

4. Improvement in methods of interpretation.

   (a) Use of radiogenic Pb as a pathfinder with or without Pb isotope studies. To be done by Finland and Canada on existing and additional detailed samples.

   (b) Identification of significant metal associations. By examining existing data in Canada and Finland.

   (c) Develop other screening techniques of geochemical lake sediment anomalies i.e. examine influence of hydrous oxides, organic matter and clay minerals.

5. Examine usefulness and applicability of multivariate statistical analyses in interpreting regional and detailed lake sediment data (viz. discriminant analyses, factor analyses etc.). To be done by studying existing data in Canada and Finland.

6. Evaluate usefulness of partial leaching techniques in the identification of significant patterns. To be done on existing samples.

Submitted by : Y. Maurice (Canada)
P. Noras (Finland)

ANNEX 4

PROPOSAL 8*

BIOGEOCHEMICAL EXPLORATION FOR URANIUM

OBJECTIVES

Many of the world's future resources are contained in undiscovered deposits that will have very little, if any, surface exposure. There is unfortunately no direct method of detecting uranium contained in deposits covered by a metre of soil or water. Subsurface waters in contact with the ore can, however, bring extremely small quantities of uranium into the surface or near surface environment where it may give rise to subtle changes in the composition of local organic and/or inorganic matter. Recognition of these changes will be necessary if the deposits are to be located.

Biogeochemical prospecting, by collecting and analysing a wide range of organic material, has proved successful in locating blind ore bodies in certain areas. However, before the techniques can be applied in many of the world's potential uranium areas they will need to be further evaluated and, in some instances, modified.

The objectives of this study would be to establish the biogeochemical media most appropriate for uranium exploration under many different climatic conditions and to compare the results with those obtained by other methods. The study has been subdivided into five tasks, each investigating the effectiveness, as a uranium prospecting tool, of a different medium. The media to be studied are :

(a) terrestrial plants
(b) aquatic mosses, filamentous algae and plankton
(c) humus and roots
(d) forest litter
(e) lake sediments

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* As approved by the NEA/IAEA Joint Group of Experts on R & D in Uranium Exploration Techniques at its meeting on 11th October 1979.

In addition , it is strongly recommended that a "State of the Art" report should be compiled for biogeochemical prospecting. This should include a résumé of the methods and techniques presently used, a comprehensive bibliography or details of the availability of such a bibliography and details of previously unpublished case histories of biogeochemical prospecting. All participating countries are urged to provide as much information as possible on previous studies and in this connection, emphasis is placed on the value of data from unsuccessful surveys, many of which may not have been reported.

METHODS

The majority of the tasks to be undertaken will involve the collection of new samples from a variety of test sites. The study of lake sediment samples will, however, utilise many samples already collected and the method of study is described separately.

(a) Test sites

In general it is recommended that participating countries should identify test sites representing a wide range of climatic conditions. These test sites should include both mineralized and non-mineralized areas. It is important that these areas should not have been extensively developed and it is preferable if a wide range of other sample types could be collected and, in some instances, if the mineralization was polymetallic.

(b) Sampling

Sampling procedures would vary depending on the medium, as follows :

(i) Terrestrial plants

Collection of a variety of different plant species which should be separated into the various plant components prior to analysis. Samples of the soils in which the plants are growing should also be collected.

(ii) Aquatic mosses, algae and plankton

Collection of a variety of species from within the three different media under consideration. Methods to be agreed by participants; in the case of plankton, a biomass sample (phyto- and zooplankton).

(iii) Humus and roots

Sampling types and procedures should be based on those used and described by the Geological Survey of Sweden (SGU) with modifications, where necessary, for different climatic conditions.

(iv) Forest litter

Forest litter, consisting of dead but not decomposed organic matter from trees, shrubs and herbs, should be collected from a restricted area (e.g. 4 m^2) around sample points. At each sample station soil samples from the B and C horizons should be collected.

(c) Sample preparation

There would again be some variation from medium to medium. In general the samples would be dried (at 95°C), ashed (at 450°C) and then homogenized.

(d) Samples analyses

All samples would be analyzed for uranium. It is also recommended that as many other elements be analyzed as far as possible, in particular with a view to distinguishing pathfinder elements.

(e) Data interpretation

The data should be interpreted in relation to bedrock and surface geology, geophysics (including radiometrics) and hydrological and climatic conditions. The results obtained should also be compared with those from other media.

It is most important that the methods of sample collection, preparation and analysis be standard for each sample type. This would be best achieved by one organisation co-ordinating the work and analyzing control samples submitted by all other participants.

(f) Lake sediments

(i) Samples would be studied to determine the influence of such factors as lake size and configuration, organic content of waters and sediments, Eh and pH on the metal content of lake sediments and waters.

(ii) Methods of interpretation of lake sediment data would be improved by studying metal associations, isotope composition, particularly the use of radiogenic lead as a pathfinder for U, relative dispersion of mobile (U, Mo) and immobile (Pb, Ra) elements within anomalous basins, and partial leaching techniques.

(iii) New methods of follow-up would be examined and tested : multiple sampling of anomalous lakes, the use of organic stream sediment and forest litter sampling.

TIME REQUIRED TO DELIVER RESULTS AND FORM IN WHICH RESULTS WILL APPEAR

(a) A "State of the Art" report on biogeochemical prospecting (12 months)

(b) Series of reports on specific sample types for each test area. First reports to be available within 12 months.

(c) A final report reviewing the effectiveness of the various techniques in the several test areas (3 years).

IMPLEMENTATION

The Geological Survey of Sweden has been suggested as "lead country" for the project. This would involve the co-ordination of the work undertaken at all the test sites and the analysis of control, and possibly a number of other samples submitted by participating countries.

ESTIMATED COST TO COMPLETION

It is envisaged that no direct funding will be required for this project. A large part of the work is being undertaken by on-going national research programme. The major costs, that of sampling, collection and analysis, would be covered by the "in kind" contributions of the participating countries.