5. THE FEDERAL-PROVINCIAL URANIUM RECONNAISSANCE PROGRAM

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Abstract

The overall objectives of the Federal-Provincial Uranium Reconnaissance Program are to provide industry with high quality reconnaissance exploration data to indicate those areas of the country where there is the greatest probability of finding new uranium deposits, and to provide government with nationally systematic data to serve as a base for uranium resource appraisal.

The program will involve high sensitivity airborne gamma-ray spectrometry over areas of low relief and some outcrop, required geochemistry in mountainous terrain and in areas with extensive overburden, and special emphasis on hydrogeochemistry in flat-lying sedimentary basins.

The administrative arrangements for the program are being modelled as closely as possible upon the Federal-Provincial Aeromagnetic Program which commenced in 1961. The Federal Government, through the Geological Survey of Canada and in consultation with the relevant provincial agencies, will be responsible for designing and administering contracts for the execution of this work which will be undertaken by Canadian contractors. The Geological Survey of Canada will be responsible for conducting limited airborne and ground pilot studies ahead of the contracted operation in order to verify the suitability of particular areas for the available methods, and in order to provide control data.

Results from the program will be published as rapidly as they can be compiled. They will be released simultaneously by the Federal and Provincial authorities as has been the practice in the Aeromagnetic Program.

Introduction

In December 1974, there was a meeting of the Federal and Provincial Ministers of Mines in Ottawa to discuss various aspects of Canadian mineral policy. At the conclusion of that meeting a communique was issued which announced that "The Ministers agreed in principle with the establishment of a Uranium Reconnaissance Program as proposed by the Federal Government, provided agreements are negotiated with each province on an individual basis and without prejudicing financing of any other project". The communique concluded with the statement that "The requirement of searching for other minerals as a complementary activity to the Uranium Program should be considered within the framework of the program if such is a provincial priority". This was reported in the Northern Miner for December 26, 1974. As a matter of record, preliminary discussions between Federal and Provincial officials commenced about twelve months ago, culminating in a presentation to Technical Committee Number 1 at the annual conference of the Provincial Ministers of Mines in Moncton last October, but the research and development program which permitted this to be launched goes back at least ten years (see bibliographies).

In summary, the overall objectives of the Uranium Reconnaissance Program are to provide industry with high quality reconnaissance exploration data to indicate those areas of the country where there is the greatest probability of finding new uranium deposits, and to provide governments with nationally consistent systematic data to serve as a basis for uranium resource appraisal. The Federal-Provincial Uranium Reconnaissance Program will be administered and executed in a manner similar to the Federal-Provincial Aeromagnetic Program which commenced some fourteen years ago. The operation, however, is considerably more complex involving both geophysics and geochemistry. The program will involve the following technical activities:

(1) Airborne gamma-ray spectrometry will be undertaken over all areas of relatively flat topography where there is some outcrop and generally thin overburden. High sensitivity equipment will be employed with a specification similar to that developed by the Geological Survey and proved in use over the last six years. Line spacing for reconnaissance purposes will normally be 5 km. In areas which are rather remote and may not be reached by the main program for a number of years, some advance reconnaissance work will be done at very wide spacing, for example 25 km, in order to assign priorities for later work. Airborne gamma-ray spectrometry will be used principally over the Shield although coverage may be extended over some adjoining areas, and over other parts of the country where the topography is not so rugged as to prevent effective coverage by fixed wing survey aircraft.

(2) Regional geochemistry will be used primarily in mountainous areas, in areas with extensive overburden, in selected areas which are considered particularly favourable for uranium occurrence, and in some areas where the potential for other metals is equal to or greater than the potential for uranium. Regional geochemistry will be based upon stream sediment, lake sediment, or bedrock analysis. Sample spacing will normally be in the range of one per 12.5 km^2 to one per 25 km^2.

(3) Hydrogeochemistry will be carried out wherever possible as part of the regional sampling program. In addition, this technique has a unique application for the analysis of subsurface waters from aquifers to detect possible uraniferous horizons in flat-lying sediments, or below thick overburden.

Results from this program will be published as rapidly as they can be compiled. They will be made available simultaneously by the Federal and Provincial authorities, following the established practice of pre-announced time releases.

The Basis for the Program

The design of the Uranium Reconnaissance Program owes much to the now long-established aeromagnetic program. However, it differs in one important respect and for this reason the philosophy underlying the Uranium Reconnaissance Program needs to be closely examined. The feature by which the Uranium Reconnaissance Program will differ from the aeromagnetic surveys is in density of coverage. The standard specification for the aeromagnetic program with half-mile line spacing and a flight elevation of 1000 feet above terrain has resulted in what is effectively saturation coverage for near surface magnetic bodies with dimensions of the order of 1000 feet. In other words all bodies of that size will be found. Unfortunately there is neither time nor funds to make it possible to obtain such coverage with the Uranium Reconnaissance Program. The planned line spacings and sample densities only permit the equivalent of 5 to 10 per cent coverage of any particular area. It is for this reason the logic underlying the program is important.

The program rests upon the concept that most uranium deposits occur within or marginal to regions of the crust containing higher than average amounts of uranium. Reference should be made again to Figure 3.1 of this publication. As mentioned in paper 3 uranium may be found to be weakly concentrated in granitic rocks especially those late in an orogenic cycle. It may be found concentrated in high temperature pegmatites or in lower temperature vein deposits. These are all components of a primary source area which through erosion and redistribution can provide the material to form secondary deposits in any suitable adjacent geochemical trap. The reconnaissance program is designed primarily to identify all zones of primary enrichment within the country, and secondly to indicate, if possible, the limits of areas where secondary processes have operated. The primary source areas are undoubtedly the easier targets to find, but it is important and logical that we should begin at the beginning and find these before going on to find the more difficult secondary targets, since our present knowledge of even the gross distribution of uranium in the country is far from complete. It is important not to dismiss anomalous areas as simply being low-grade igneous rocks of no economic importance. Such areas may have considerable potential as source areas, and geological knowledge must be brought into play to determine where the eroded material from these source areas has been deposited. It is the

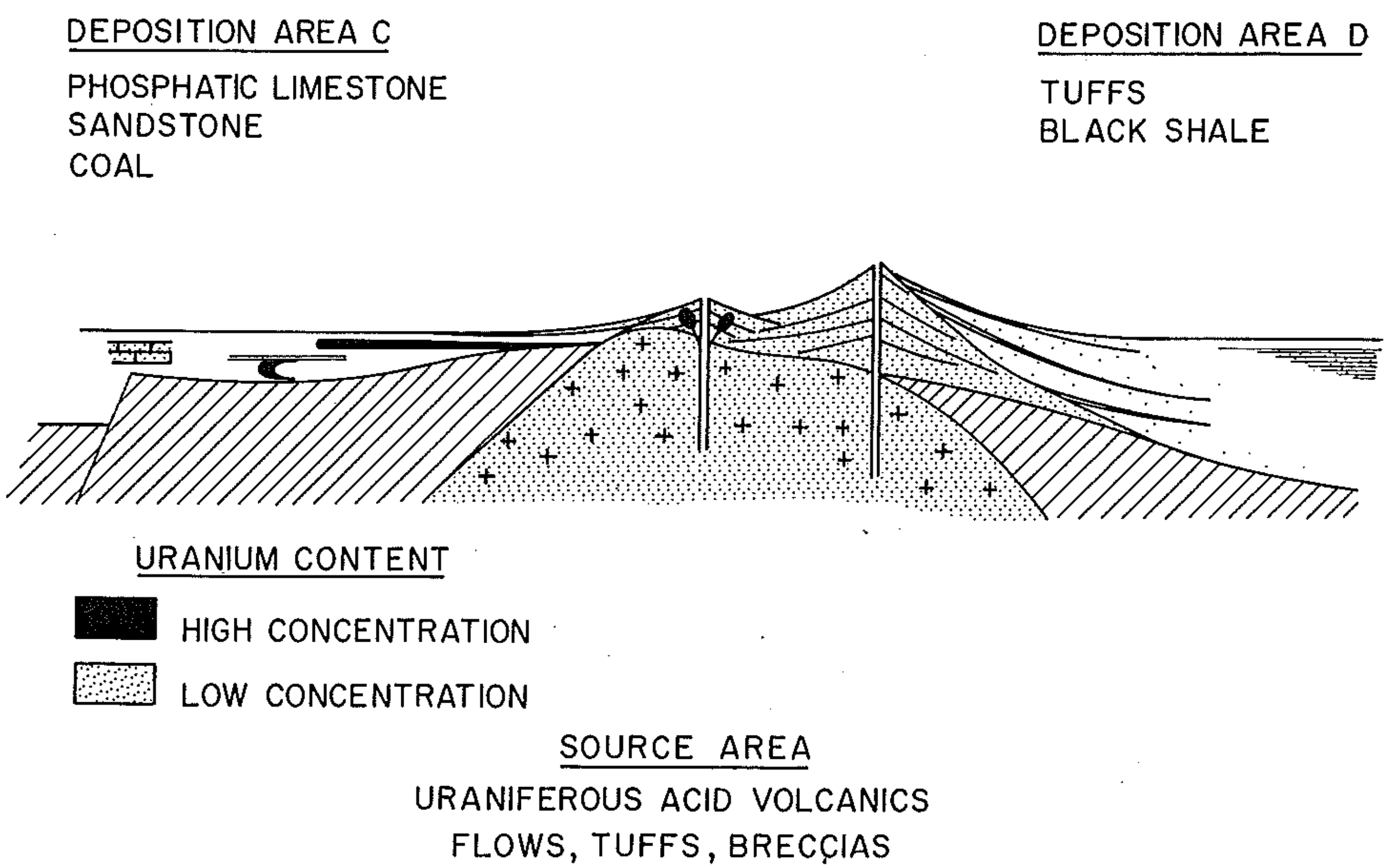

Figure 5.1. Schematic diagram: uranium source and depositional areas.

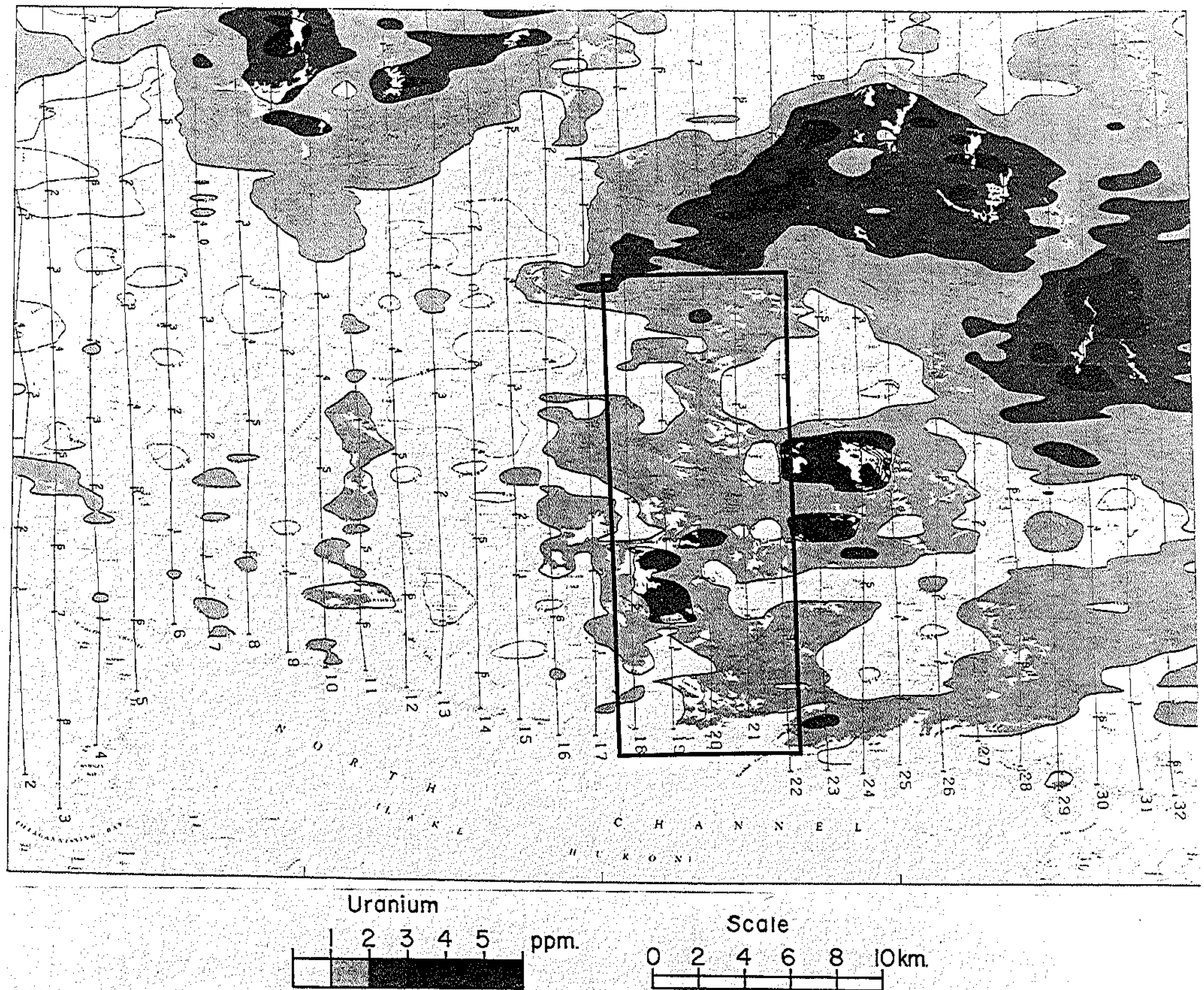

Figure 5. 2. Uranium distribution, Blind River sheet, Ontario.

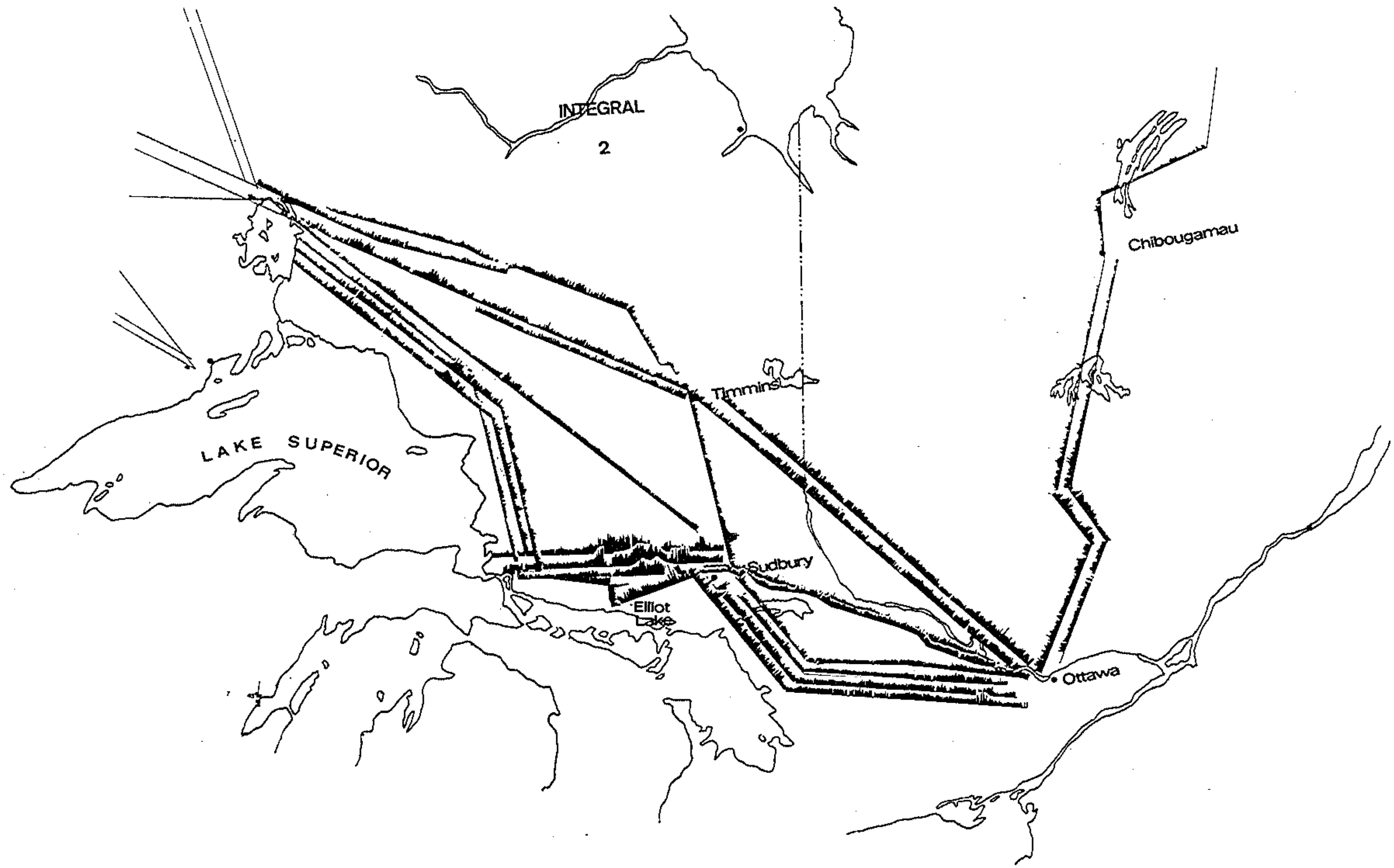

Figure 5. 3. Regional variation in total radioactivity shown by profiles along flight lines crossing N. E. Ontario and W. Quebec.

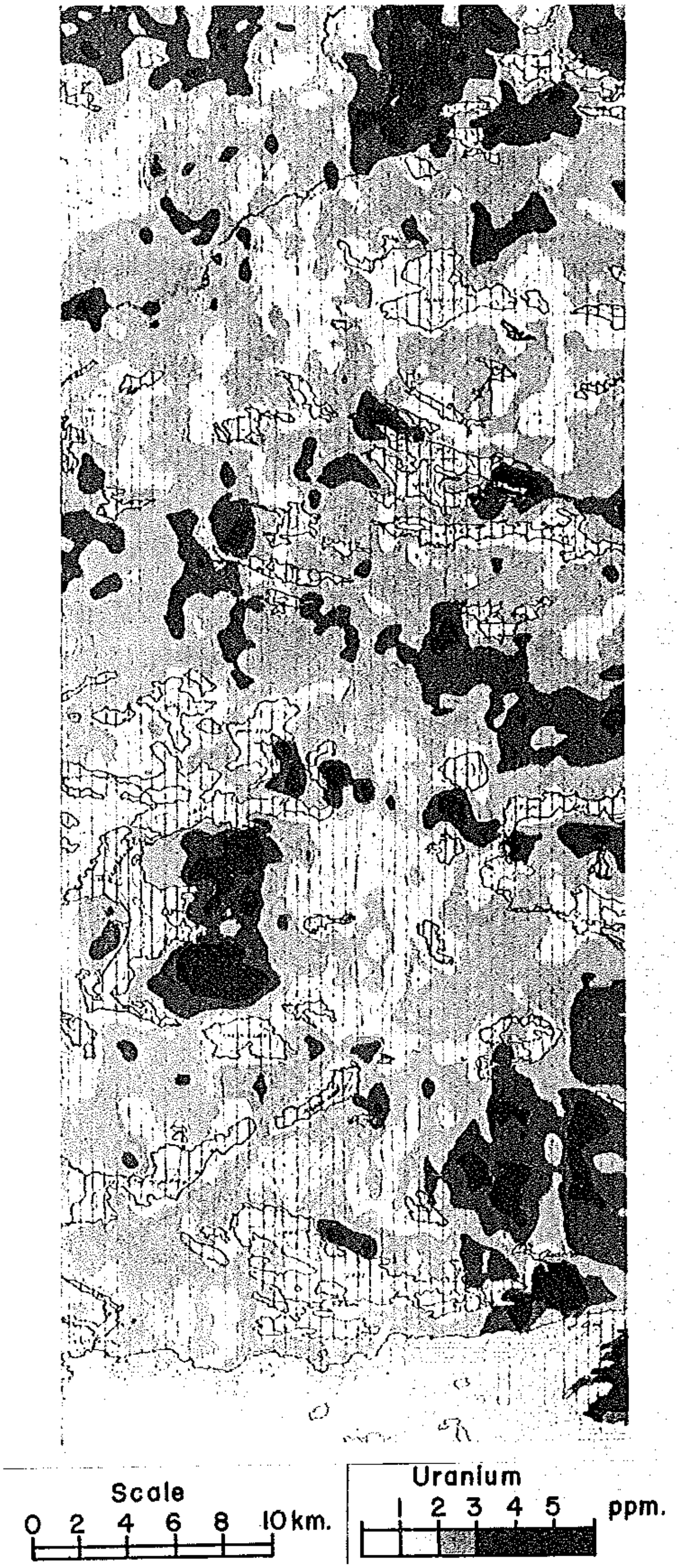

Figure 5. 4. Uranium distribution, area immediately west of Elliot Lake outlined in Fig. 2, from 0. 5 km flight line spacing.

first objective of the Uranium Reconnaissance Program to delineate as rapidly as possible the major areas of uranium enrichment in Canada. There is reason to believe that there are more of these than are generally known at the present time.

Figure 3. 1 illustrates one idealized composition type of source area which might be found in the Canadian Shield environment. Figure 5. 1 illustrates another combination of source area and depositional environments which is perhaps more akin to situations known in the United States. This represents a source area of acid volcanics with weakly uraniferous flows, tuffs and breccias, between two sedimentary basins. Typically these are restricted and nonmarine. On one side there is a uraniferous coal, uranium in sandstone and uraniferous phosphatic limestone, on the other, tuffs and uraniferous black shale. Wherever potential source areas or potential widespread source materials such as uraniferous tuffs are found, efforts should be concentrated to search for possible mineralization. The South March uranium occurrence outside Ottawa referred to elsewhere appears to provide a text-book example of the conjunction of a potential source area (the Gatineau Park vicinity) on the margin of the Shield and a depositional area in nearby overlapping dolomitic sandstone of Paleozoic age. The uranium content of the Gatineau Park area is weakly but distinctly anomalous on a regional basis. Dyck (this publication, paper 4) has shown some of the various types of anomaly associated with this area.

Results from Recent Airborne Radioactivity Surveys

A series of figures now follows to illustrate and substantiate two points: first, the concept of regional uranium enrichment and source areas; and second, that airborne surveys with a 5 km flight line spacing are adequate to locate and delineate the various types of area that show uranium enrichment.

It must be stressed that the contoured maps which follow indicate the mean surface equivalent uranium concentration (eU) expressed in parts per million. This value is normally less than the bedrock uranium concentration. Local highs and lows caused for example by variations in the amount of outcrop and swamp are smoothed out in the compilation process. For detailed examination reference should always be made to the flight line profiles.

The first example is the Elliot Lake area. Figure 5. 2 shows the uranium distribution over the Blind River map-sheet (1: 250 000). The contours are in parts per million equivalent uranium and this is compiled from a survey at 5 km line spacing, flown by the Geological Survey Skyvan aircraft in the summer of 1974. Disregard the area of high concentration immediately north and east of Elliot Lake, caused by the combination of rock dumps, tailings and natural exposure. These can be separated only by very detailed work. Note that there is an extensive area of above average uranium content covering hundreds of square miles lying to the north and northwest of Elliot Lake and extending beyond the limits of this map sheet. On the basis of extensive cross-country reconnaissance flights flown by the Geological Survey across Ontario in recent years, this can be shown to be a regionally anomalous feature (Fig. 5. 3). This conjunction does not prove, but makes it plausible to believe, that the source of the Elliot Lake uranium mineralization was in the extensive area of pre-Huronian basement to the north. This has been proposed previously by Roscoe and Steacy (1958) with evidence based on the analysis of individual rock samples, but questioned by Bottrill (1971). It is now possible to confirm the existence and show the magnitude of this source area.

The rectangular block west of Elliot Lake outlined within Figure 5. 2 was flown by the Geological Survey in 1970 with a line spacing of 0. 5 km. Both surveys were flown with north-south flight lines. Results compiled from the detailed survey are shown in Figure 5. 4. The two maps show considerable similarity with the highest concentrations occurring southeast of Matinenda Lake on both maps. The detailed map shows more extensive areas of low concentration and higher peak concentrations, features that are modified by the smoothing of data necessary to produce contour maps from the reconnaissance survey.

Figure 5. 5 shows uranium distribution over the Havre St. Pierre map-sheet (1: 250 000) in Quebec,

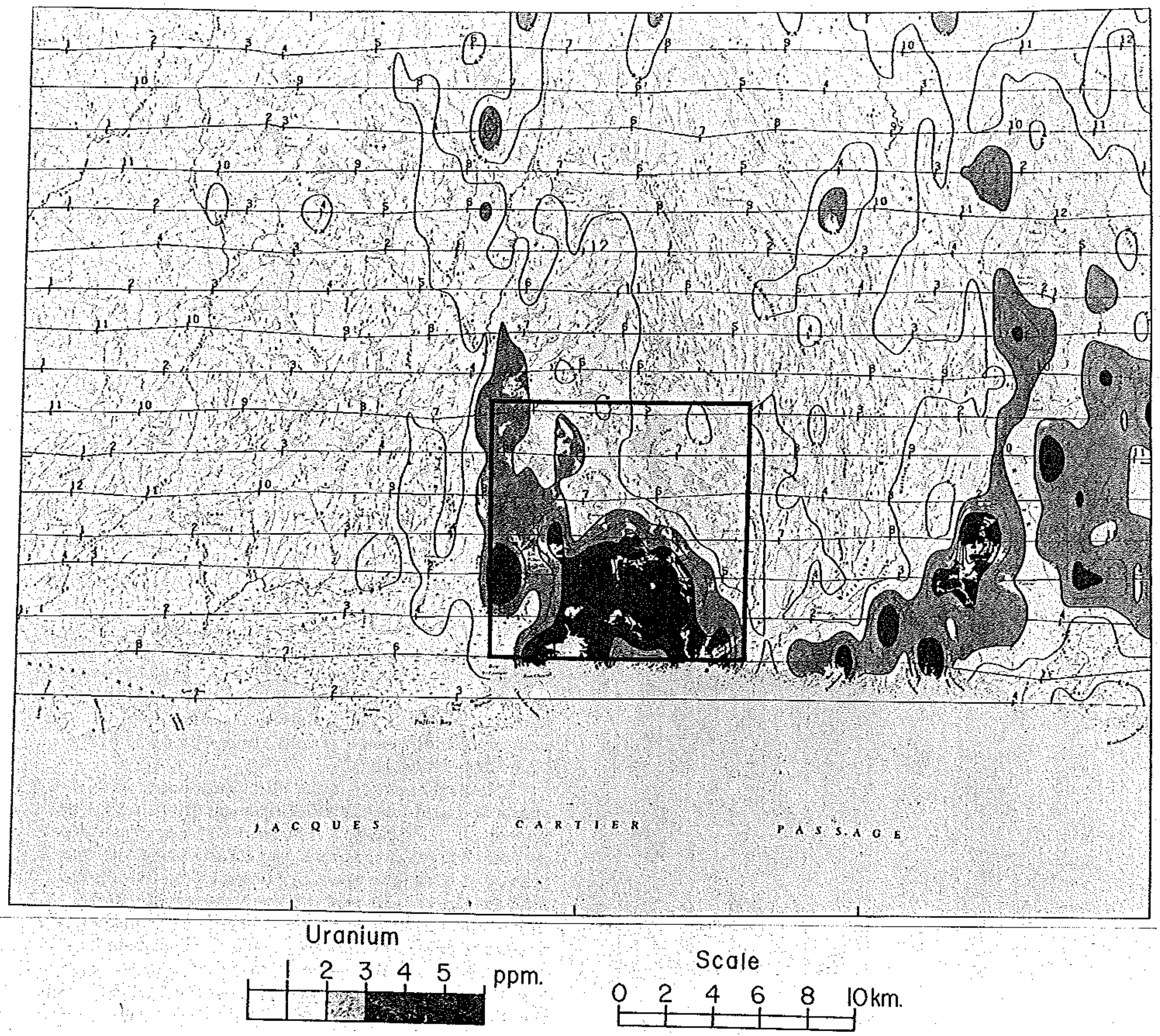

Figure 5. 5. Uranium distribution, Havre St. Pierre sheet, Quebec, from 5 km flight line spacing.

again for a survey flown with 5 km line spacing. Figure 5.6 shows that part of the area around Johan Beetz flown with 1 km line spacing. Unusually uraniferous pegmatitic granite is known to occur there. Flight lines were east-west in both cases. The reconnaissance survey is clearly adequate to outline this anomalous region.

Figure 5.7 shows the Tazin Lake map-sheet (1: 250 000) in Saskatchewan. This was flown at 5 km spacing with east-west flight lines. Figure 5.8 shows a portion of this area around Beaver-lodge with north-south flight lines at 2 km spacing. There is no way in which the anomalous nature of the Uranium City area could be missed, even if there were no mine dumps scattered around the surface. It can be seen that the wide flight line spacing results in some distortion of the shape of the enriched region, but all anomalous areas such as this, supposing they were virgin, should

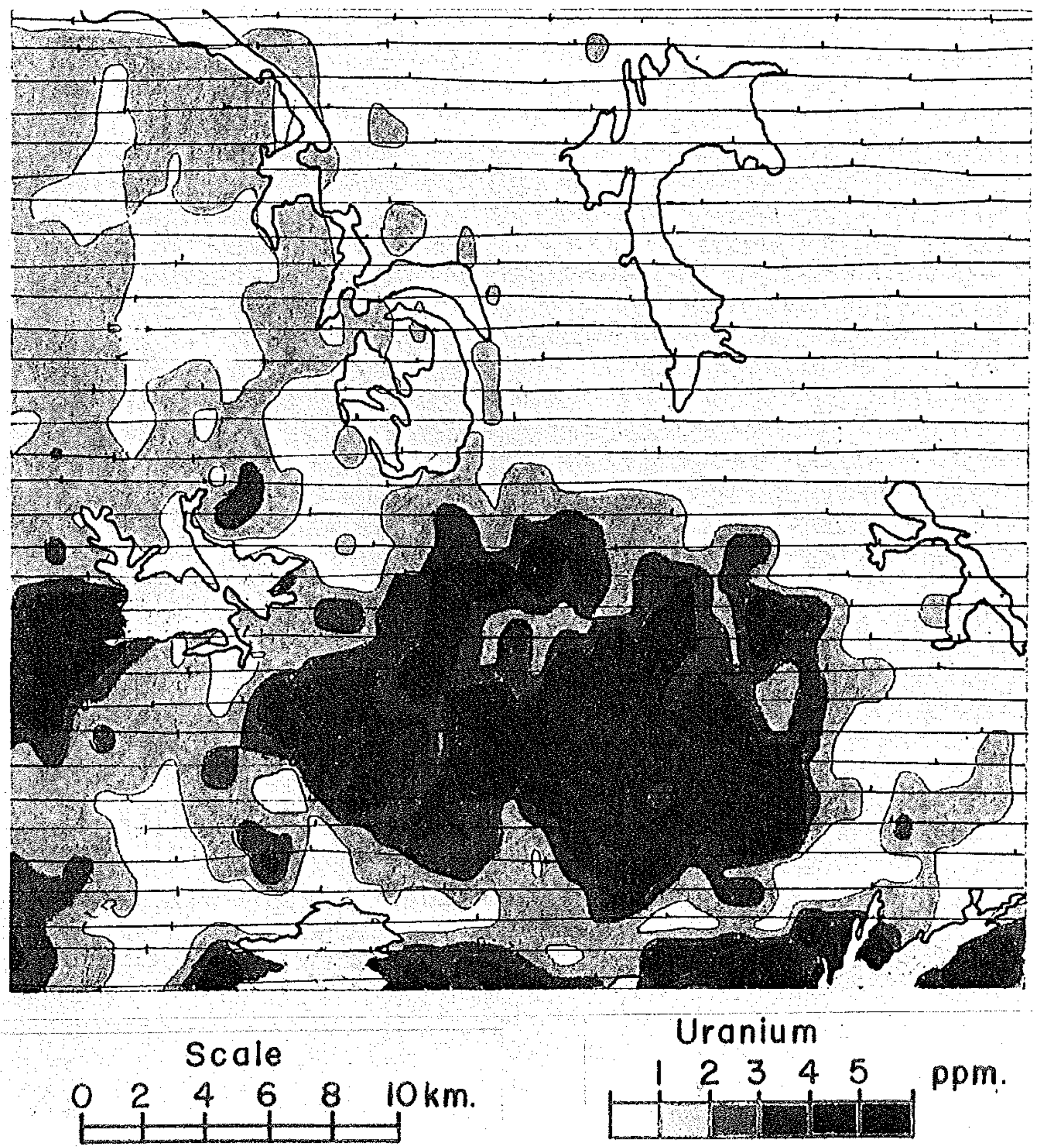

Figure 5.6. Uranium distribution in Johan Beetz area, outlined in Fig. 5, from 1 km flight line spacing.

be followed up with closer line spacing in order to obtain better definition of their features, and identify target zones.

To emphasize the fact that Canada's known major uranium districts are associated with large areas of uranium enrichment, further examples can be provided.

Figure 5.9 is a map of the Bancroft area in Ontario showing a 3 to 4 mile wide zone of above-average uranium content stretching from the southwest side to the northeast corner.

Figure 5.10 from the Mont Laurier map-area in Quebec, once again shows a broad zone of high uranium content extending across the map-area, which in this case is of the order of thirty miles across.

Figure 5.11 is an east-west profile, about 75 miles long, running through Wollaston Lake in Saskatchewan. The Gulf Minerals Rabbit Lake orebody is about 1.5 miles north of the flight line on the west side of the lake. It can be seen that this is on the edge of a large belt of high uranium content which occupies the ground between Wollaston and Reindeer lakes. This particular zone or belt appears to be more or less continuous over a distance of several hundred miles trending northeasterly and extending into the Territories.

The magnitude of some of these regional zones of uranium enrichment can be gauged from Figure 5.12 which is another map of uranium distribution compiled at a scale of 1: 1 million from Geological Survey airborne radiometric surveys extending over 600 miles from

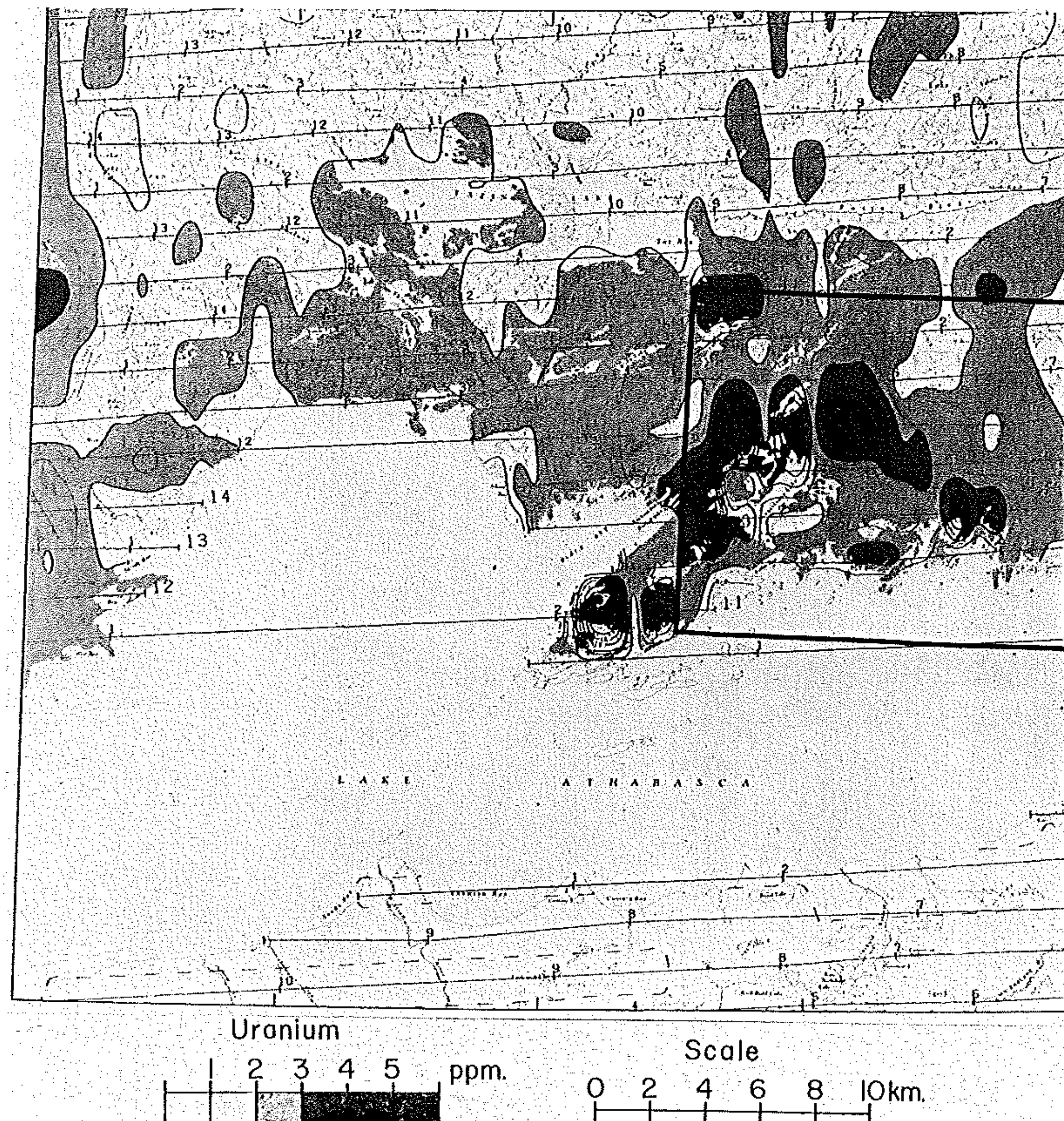

Figure 5.7. Uranium distribution, Tazin Lake sheet, Saskatchewan, from 5 km flight line spacing.

Great Bear Lake in the northwest to south of Fort Smith at the southern margin. The apparent continuity of this feature from the Bear structural province of the Shield, through the Slave and into the Churchill is of particular scientific interest. Groundwork at selected sites along this feature has demonstrated that the zone is definitely characterized by above-average uranium content, and that it is not a spurious effect caused solely by the extensive outcrop and relatively thin overburden along this edge of the Shield. There are large areas of granitic rocks in the Yellowknife vicinity which are well exposed but which do not approach the levels of high uranium content found in the region farther to the northeast of Yellowknife. Erosion of this well endowed portion of the Shield must have removed a very large amount of uranium, and any ideas as to where it might have been deposited would seem to be well worth pursuing.

Regional Geochemical Surveys

The results presented in the previous section were gathered from the air but a similar general pattern of uranium distribution can be demonstrated by geochemical sampling carried out at ground level.

Figure 5.13 shows how the country can be divided according to physiographic characteristics into areas of suitability for different geochemical reconnaissance methods. In the Cordillera, the Appalachians, and other regions with moderate to high relief, the greatest reliance will be placed on stream sediment sampling. This method has been proved in Canada and other

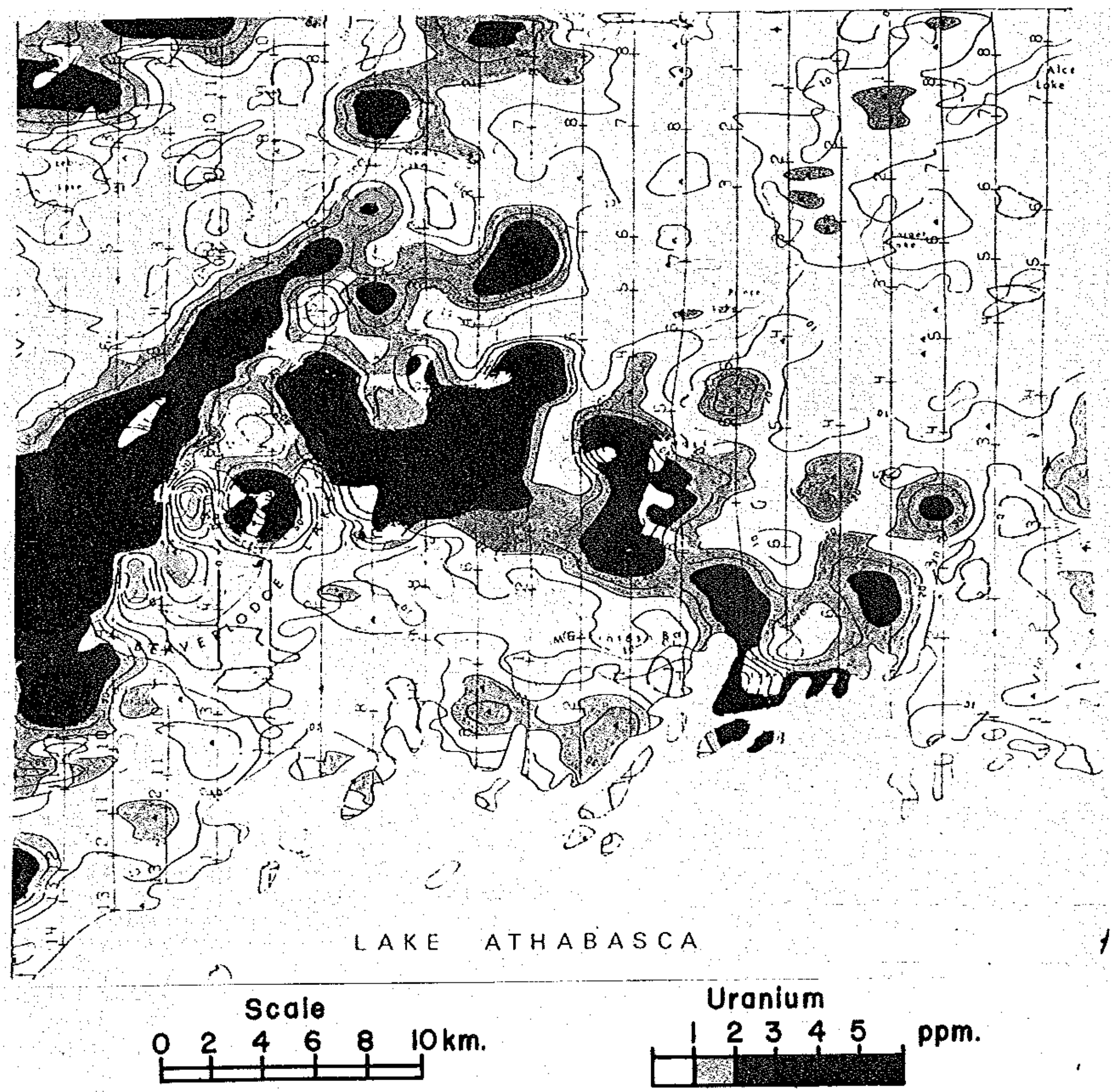

Figure 5.8. Uranium distribution, in Beaverlodge area, outlined in Fig. 7, from 2 km flight line spacing.

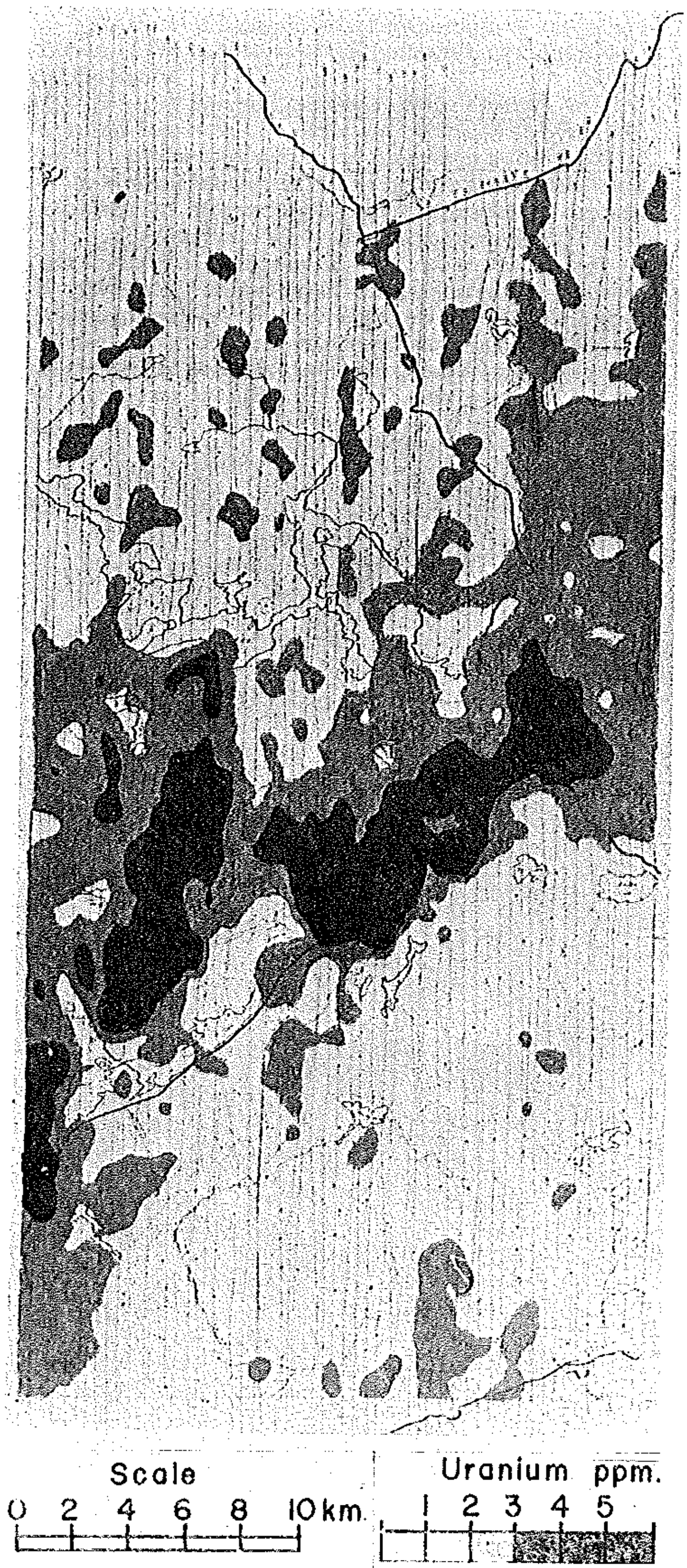

Figure 5. 9. Uranium distribution, in Bancroft area, Ontario. from ¼ mile flight line spacing.

parts of the world as a most effective reconnaissance exploration technique. Since large parts of the regions in question have already been sampled for stream sediments, consideration is being given to the use of existing sample material. Preliminary enquiries, however, suggest that the availabiltiy of reliable sample material collected over large blocks of the country is limited.

The Geological Survey has in recent years concentrated much effort on the development of geochemical methods for the Canadian Shield, based on lake sediment analyses. This is because prior to the development of such methods there was no effective technique for geochemical reconnaissance within this large area of the country. The methods developed, and still being developed, appear to provide a highly efficient method of reconnaissance for many areas of the Shield. Lake sediment reconnaissance has been shown capable of delineating areas containing a variety of mineralization including uranium and massive sulphides. Using fast turbine-powered helicopters, it has been possible to achieve sampling rates of 12 to 15 per hour at reconnaissance spacing. This allows the total cost of geochemical surveys including analysis to be kept below $10 per square mile of sampling at densities of 1 per 5 square miles in areas of the Shield with moderately good accessibility. In this way large areas can be covered very rapidly. For instance, a recent contract survey required little more than a month to sample a 20 000 square mile area of Saskatchewan using one helicopter at the above sample density.

The first full scale test of lake sediment reconnaissance was carried out in 1972 when a 36 000 square mile area of the Bear and Slave provinces was sampled in six weeks. A number of significant anomalies were located for uranium and other metals. In the Bear Province anomalous uranium appeared to be structurally controlled (Figure 5. 14). This is the type of regional correlation that becomes possible if data are collected over a large region. Follow-up studies on this survey have largely concentrated on multi-element anomalies derived from massive sulphide mineralization. This work has demonstrated a fact not previously widely known or appreciated that sulphide mineralization is being actively oxidized even in the permafrost environment. Mobile metals such as zinc and uranium are widely dispersed in solution before being precipitated in lake sediments. The dispersion pattern for zinc demonstrated in Figure 5. 15 indicates why a wide sampling interval can be used for reconnaissance sampling. Figure 5. 15 shows how the zinc concentration in water falls off over a distance of 7 km from its source and how it becomes fixed in centre lake sediments, and to a lesser extent in nearshore sediments.

Areas that may contain roll-type uranium deposits present particular problems. This is because these deposits by their nature occur at depth often with little surface trace of mineralization. For these areas emphasis will be placed on geochemical methods that Dyck (*see* this publication, paper 4), describes involving sub-surface water and spring sampling.

Figure 5. 10. Uranium distribution, in Mont Laurier area, Quebec, from ¼ mile flight line spacing.

The major costs of geochemical reconnaissance in Canada are sampling costs. It, therefore, would be missing a major opportunity to analyze samples for uranium alone, besides the fact that other metals may be associated with uranium and may in some circumstances be dispersed more widely. The samples which are collected under the program will be analyzed for a variety of constituents including zinc, copper, silver, cobalt, nickel, lead, mercury, molybdenum and arsenic. Thus the geochemical component of the program will provide data to assist in the search for and evaluation of a number of mineral commodities.

Implementation

Figure 5. 16 shows the steps involved in the organization of the geochemical component of the program. The principal part of the work will be carried out by Canadian contractors. Sampling and analytical work will be separate contracts. This is done in order that the Geological Survey may introduce blind duplicate samples and control standards for analytical quality control. This approach also reduces the number of persons with access to economically sensitive information on the location of anomalous samples. Orientation

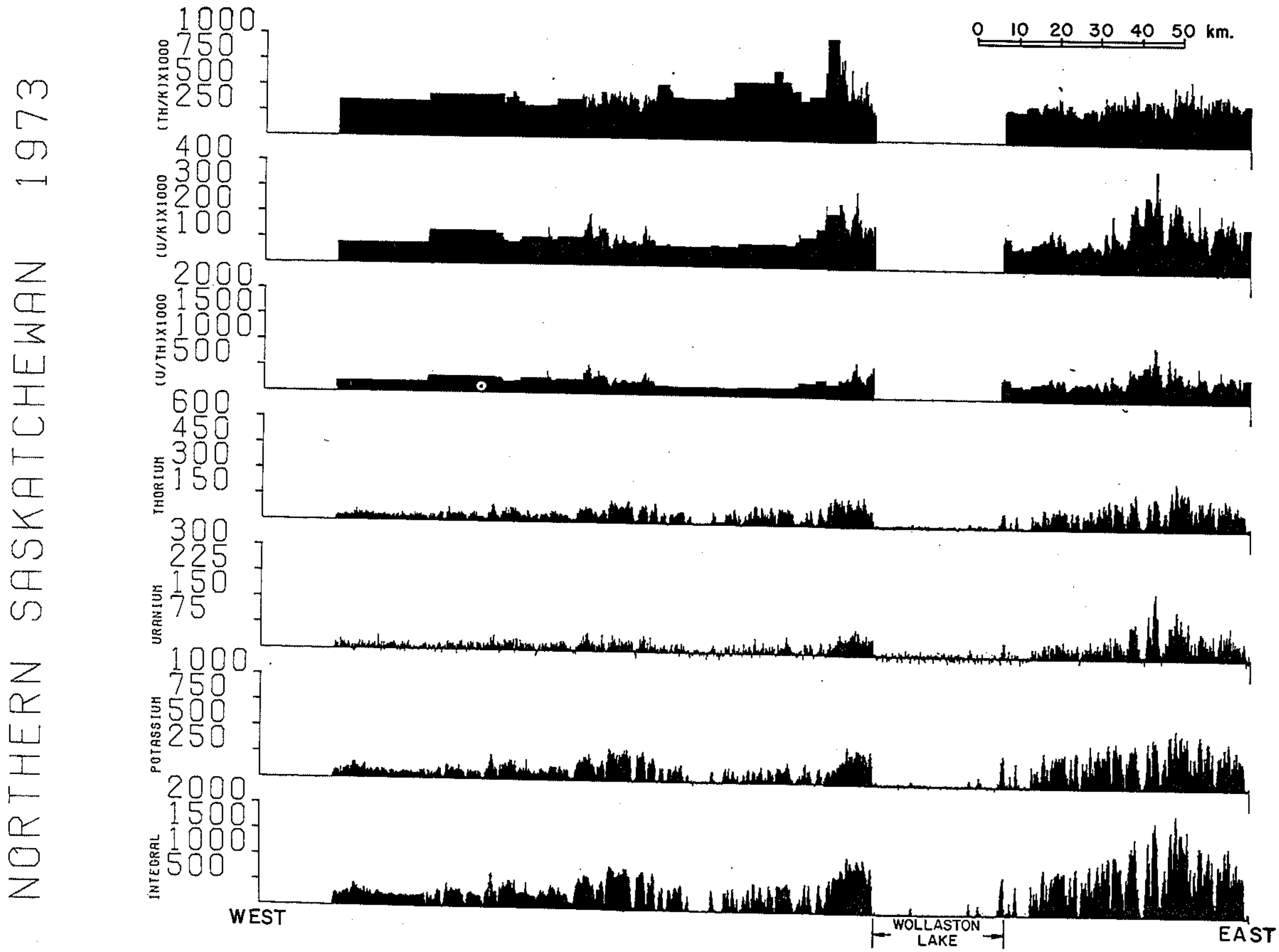

Figure 5.11. Profile across part of N. Saskatchewan, at about 58°10'N.

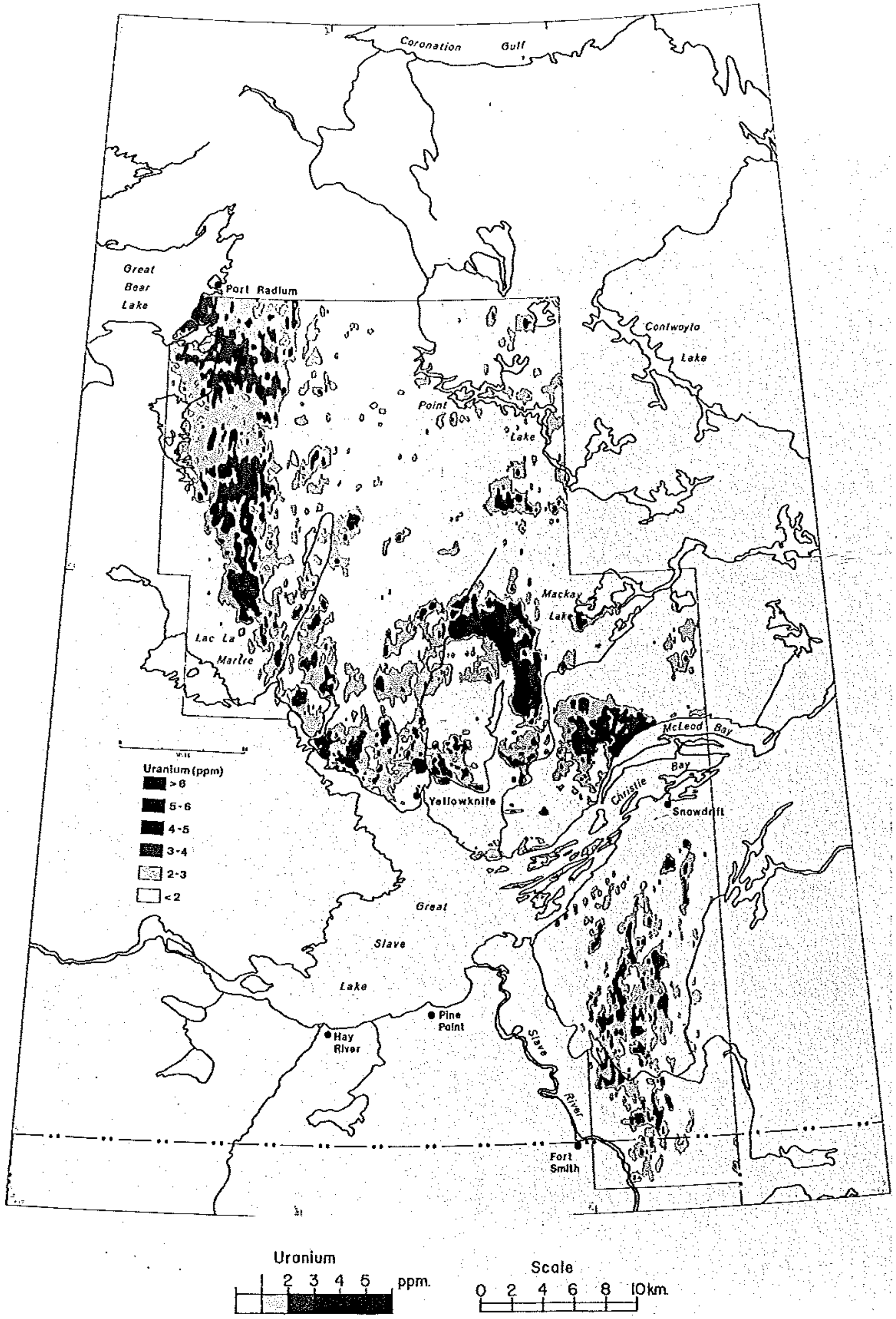

Figure 5.12. Uranium distribution, northwest margin of Canadian Shield.

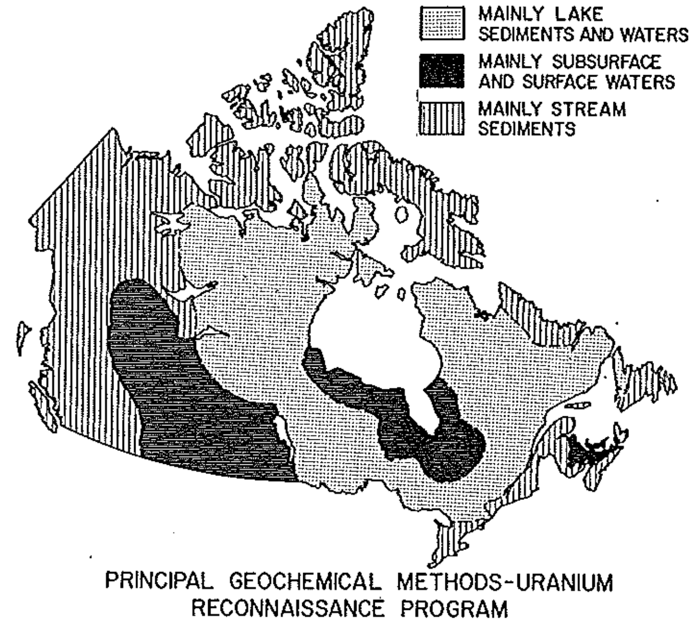

Figure 5.13. Suitability of various geochemical reconnaissance methods to different regions of Canada.

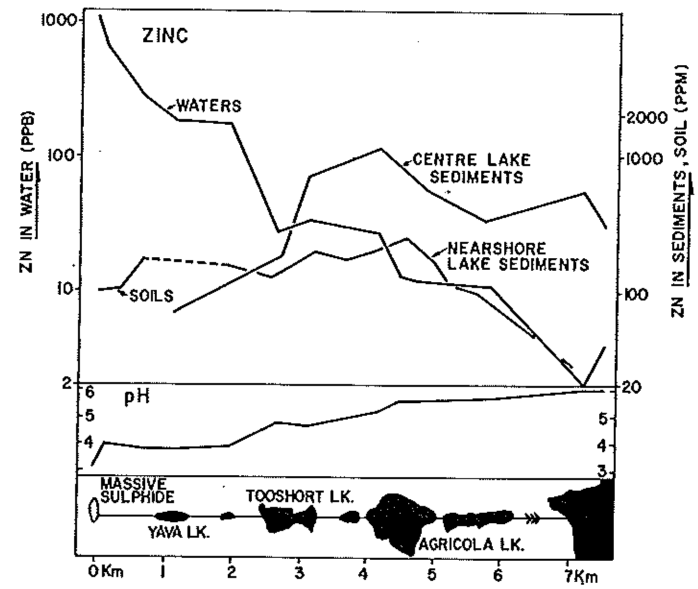

Figure 5.15. Dispersion of mobile metal (zinc) from an orebody in a region of permafrost.

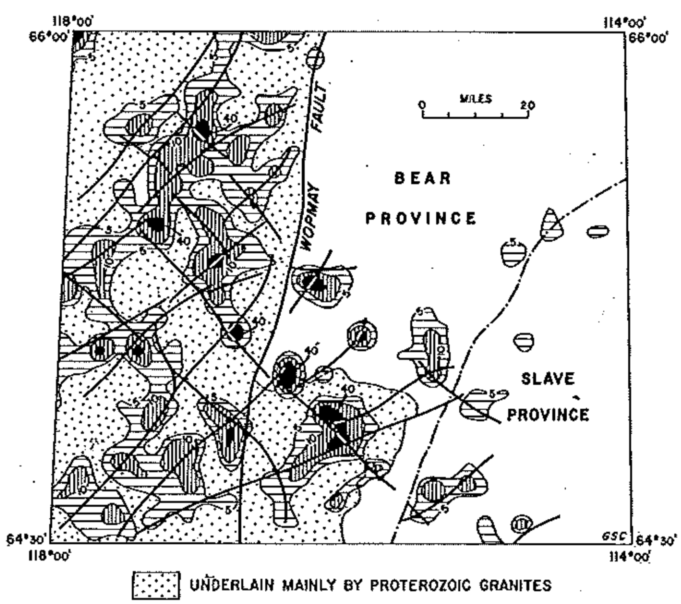

Figure 5.14. Uranium distribution in Bear Province, from lake sediment geochemistry survey.

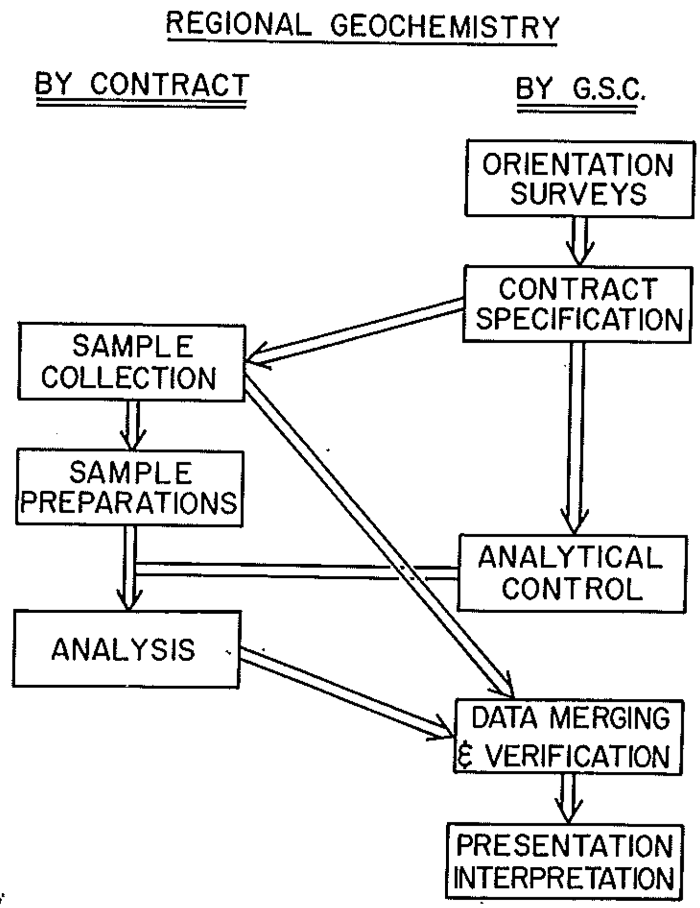

Figure 5.16. Organization of regional geochemical surveys undertaken by the Geological Survey of Canada for the Uranium Reconnaissance Program.

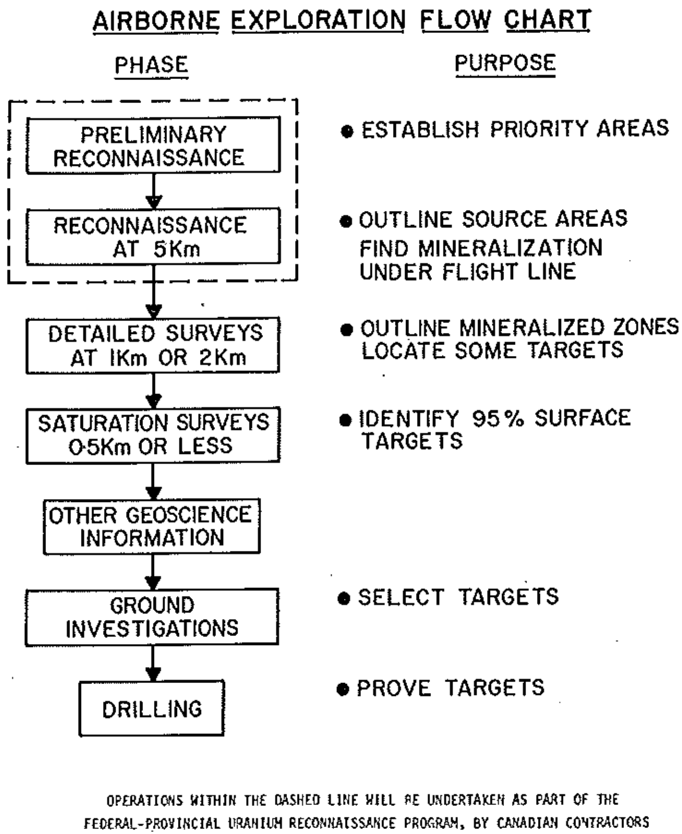

Figure 5.17. The relationship of airborne radioactivity surveys sponsored under the Uranium Reconnaissance Program, to the exploration sequence.

surveys carried out by Survey personnel are an essential part of setting up contract specifications. Although not shown on this sequence chart, it is hoped that Federal and Provincial staff will carry out a limited number of follow-up studies in order to verify the effectiveness of the methods, and to advise on methods of interpretation.

A similar schematic diagram can be shown for the airborne component of the program (Figure 5.17). This shows how the program is intended to fit into a total exploration sequence. The program will provide the first two phases contained within the dashed line. This work will be undertaken by Canadian contractors, as has been the case with the aeromagnetic program. Except for a few limited studies to be carried out by the Geological Survey as part of its on-going scientific investigations of type areas of mineralization, the initiative and responsibility for the remaining phases of the total exploration program must rest with industry. The Geological Survey of Canada is endeavouring to continue its traditional role of providing the best possible basic scientific information as guidelines for industrial initiative.

Present planning calls for the program to cover approximately two thirds of the land area of Canada at the reconnaissance level over the next ten years. The activities will be integrated to the greatest extent possible with related work being undertaken in connection with various Federal-Provincial Mineral Development Agreements sponsored by the Department of Regional and Economic Expansion. Contracted operations will commence in the summer of 1975 but these will not be fully established until 1976. Surveys in 1975 will include geochemical surveys in one province, and two separate areas in the Territories, plus airborne surveys in at least three provinces and the Territories. Geochemical orientation surveys, preparatory to future more extensive surveys will be undertaken by Survey personnel in both the Maritimes and Baffin Island, and probably also in other areas. The stakes are high in the search for uranium, and time, is short.

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APPENDIX 5.1

LIST OF AIRBORNE RADIOACTIVITY SURVEYS FLOWN BY THE GEOLOGICAL SURVEY OF CANADA

OPEN FILE NUMBER	AREA	FLIGHT LINE SPACING
22	1969 Cross-country	double profile across Shield (not shown on index map)
45	Bancroft, Ontario	¼ mile
63	Uranium City, Saskatchewan	2 km
75	Elliot Lake, Ontario	½ km
101	Fort Smith, N.W.T.	5 km
110	Mont Laurier, Quebec	¼ mile
124	Yellowknife, N.W.T.	2.5 km
140	Bear-Slave, N.W.T.	5 km
169	Northern Saskatchewan 53°N-60°N	50 km
188	Marian River, N.W.T.	5 km
242	Wollaston Lake, Saskatchewan	1 mile
254	Tazin Lake, Saskatchewan; Blind River, Ontario; Havre St. Pierre, Quebec; Prince Edward Island; Burin Peninsula, Newfoundland (uranium contour maps only)	5 km
257	Tazin Lake, Fond du Lac, Stony Rapids, Phelps Lake, Saskatchewan	5 km
258	Hatchet Lake, Saskatchewan	½ mile
259	Black Lake, Saskatchewan	½ mile
262	Blind River, Ontario	5 km
264	Ottawa-Arnprior Area, Ontario	½ km
269*	Prince Edward Island	5 km
270*	Burin Peninsula, Newfoundland St. George's Basin, Newfoundland	5 km 2 km
271*	Havre St. Pierre, Quebec Johan Beetz, Quebec	5 km 1 km

All the above Open File releases, except 22 and 169, comprise both flight line profiles and contour maps showing integral, potassium, uranium, thorium corrected count rates, and U/Th, U/K, Th/K ratios. The contour maps are intended to provide an overall view of radioelement distribution, whilst profiles provide detailed information along the flight lines. Open Files 22 and 169 comprise profiles only.

Open Files 101, 124, 140 and 188 provide continuous coverage of the western edge of the Shield from approximately 59°45'N to 66°N.

All are available for reference in the Geological Survey of Canada Library, 601 Booth Street, Ottawa. Copies may be purchased from K.G. Campbell Corporation Ltd., 880 Wellington Street, Ottawa, K1R 6K7.

*To be released in June 1975.

APPENDIX 5.2

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APPENDIX 5.3

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