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Title: Notes on Resource Geophysics and Geochemistry (RGG) Division's Rise and Fall: a personal perspective

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Related Documents: GSCHIS-B006
GSCHIS-B006 contains is a listing of staff in the Resource Geophysics and Geochemistry Division and three photographs of staff with names.

Author Biography:
Dr. Arthur Darnley joined the Geological Survey of Canada in 1966 from the British Geological Survey as Head, Remote Sensing Section, Geophysics Division. In February 1971 he was appointed Division Chief, Exploration Geophysics and in 1972, this expanded to become the Resource Geophysics and Geochemistry Division. He remained as Director until March 1986 when the Earth Physics Branch and the Geological Survey of Canada were amalgamated and the Division was dissolved. He retired in 1995, and died in Ottawa on September 7, 2006.

Notes on Resource Geophysics and Geochemistry (RGG) Division's Rise and Fall : a personal view

A. G. Darnley

[Principal source GSC Internal Annual Reports + A.G.Darnley files]

Extract from 1985/86 GSC Internal Annual Report: summary of RGG activities

"RGG Division was established on January 1, 1972.
The objectives of RGG division, and the method of achieving them were set out in 1972 and remained substantially unchanged throughout its 14 year history. The results have been sufficiently successful to suggest that the methods should continue to be applied in the future. The purpose of the RGG Division has been "to set standards for and conduct systematic geophysical and geochemical surveys in Canada as an aid to both direct resource appraisal and understanding the geology of Canada; to develop and test new geophysical and geochemical methods relevant to regional mapping, resource identification and assessment; to appraise existing methods; and to devise new methods of interpreting and integrating data. The work comprises three stages: research into new methods and development of the most promising; experimental use and appraisal of the latter under carefully controlled conditions; formulation of specifications for routine application of the best new methods by industrial contractors, and monitoring of contractors' performance. The results of both the second and third stages are continuously fed back into the first so that ideas on new and old methods can be continuously revised."

"Fourteen years can be considered a reasonable length of time over which to judge whether objectives have been met, and methods have been suitable. It is appropriate, and may be instructive, to review some of the achievements during this period, against the background of external events which have had a major influence, both positively and negatively. The period has been marked by a slow decline, which began prior to 1972, in the level of support for ongoing (A-Budget) activities, and hence in the ability to launch new lines of long-term research. Scientific knowledge is inherently a growth phenomenon and thrives best at times of economic expansion. The division's major achievements in airborne geophysics, which came to full fruition in the period under review, had been initiated by major expenditures in the late 60s. Reconnaissance geochemistry, which required much smaller capital expenditures, began in 1972 as Operation Bear-Slave. Techniques developed in that large scale test survey were modified, and then became routine from 1974 onwards. Potential new developments that were deferred, or in some degree frustrated, by declining resources included the evaluation of TAGA (Trace Atmospheric Gas Analyser) for airborne geochemistry, the optimization of radar for subsurface exploration, and the introduction of airborne resistivity mapping. In 1972 it might reasonably have been expected that by 1986 the primary aeromagnetic survey of all of Canada's land areas would have been completed. Unfortunately that is not the case. Nevertheless there has been substantial progress."

"Inevitably there is an element of subjectivity in making a short-list of achievements. The ensuing list gives priority to those achievements which required a substantial team effort, which were by no means certain winners at the time the activity began, and which have since received international commendation.

- *the successful development, introduction and general acceptance of reconnaissance geochemical and airborne radiometric surveys as essential components of a national resource data-base.*
- *the successful development, introduction and general acceptance of the airborne magnetic vertical gradiometer as a detailed geophysical mapping tool.*
- *the establishment of quantitative standards and standardized procedures as the basis for systematic geoscientific surveys; international adoption of many of these standards and procedures.*
- *pioneering the introduction of computer-controlled colour plotting for geophysical and geochemical maps, combined with extensive experimentation as to methods of presentation.*
- *portrayal of the crustal structure of Canada by means of coloured magnetic anomaly maps.*

- *the development of high-resolution shallow reflection seismic techniques.*
- *completion of the Athabasca Project, a comprehensive multi-disciplinary investigation and documentation of exploration data pertaining to a major ore district.*
- *discovery of the Cosmos 954 satellite debris by in-flight recognition of its distinctive gamma-ray signature."*

"In addition to the above readily documented products there have been

- *substantial contributions to Canadian industry through the transfer of RGG-developed instrumentation and methodology in airborne, ground, borehole and marine geophysics and laboratory mensuration.*
- *essential support to the development and evaluation of new instrumentation devised by the geophysical and geochemical equipment industry.*
- *design and supervision of geoscientific aid projects in 12 countries [Brazil, Cameroon, Guyana, Ivory Coast, Kenya, Mali, Niger, Pakistan, Rwanda, Thailand, Upper Volta, Zimbabwe].*
- *extensive participation in international co-operative R&D projects, most notably those relating to geophysics and geochemistry applied to uranium exploration, but also magnetism, engineering seismic methods and analytical instrumentation.*
- *international recognition of GSC's expertise in a wide range of mineral exploration technology, especially airborne and borehole geophysics, and geochemical sampling and quality control."*

"RGG had focused its main efforts on satisfying the need of the mineral exploration industry. Undoubtedly its main impact has been through its map production. Aeromagnetic maps had been the top priority (and most used) product of the original Geophysics division for many years, although in terms of numbers produced these had been steadily declining from the peak year of 1964 (530,000 km² covered). In RGG the production trend continued downwards, from 230,000 km² surveyed in 1972 to 60,000 km² in 1984, due to steadily increasing costs, a budget which did not keep pace with inflation, and a 50% cut in the aeromagnetic budget in 1978. There has been an abrupt (temporary?) reversal in 1985, to 270,000 km², made possible by supplementary funding from three special programs."

"The opportunity to launch reconnaissance geochemical and radiometric surveys on a national basis was provided, fortuitously, by the 1973 Energy Crisis, which resulted in a proposal through the Provincial Mines Ministers Conference for a shared-cost Federal-Provincial Uranium Reconnaissance Program (URP), modeled on the earlier Federal-Provincial Aeromagnetic Program. The required techniques had already been developed and were ready and waiting for an opportunity to be applied. Through URP, the four years 1975-78 permitted a great leap-forward in national geoscientific data production. In 1974 URP received Ministerial approval as a 10 year program, but this did not prevent its termination for economic reasons at the end of FY 78-79. At the time of its cancellation, costs and production were on schedule, and a favourable review by a committee of the Canadian Geoscience Council had just been published. URP funding supported the first extensive aeromagnetic gradiometer demonstration survey, the acquisition of the first Applicon computer-controlled colour-plotter in Canada (the second in North America), and the first radiometric borehole probe calibration facilities in Canada. Termination of URP was a major blow because URP was providing a much expanded geoscientific data base more directly targeted towards mineral resource assessment than pre-existing survey methods. In retrospect the name of the program should have been changed (to National Resource Reconnaissance) after the second year to reflect its multi-facetted application. Following its cancellation systematic surveys could only be continued at a substantially reduced level until the inauguration of a new series of Mineral Development agreements in 1983. Although these have permitted a significant increase in systematic survey production, (including extensive application of the gradiometer technique by contractors) they have been accompanied by a much increased administrative workload (relative to URP) due to a more complex management hierarchy. The practice whereby the Federal-Provincial Aeromagnetic and Uranium Reconnaissance Programs were planned and budgeted by direct discussion between the Division Chief and Provincial Chief Geologists made for relatively simple, flexible and fast execution of operations, although sometimes with the formal legal agreements, Treasury Board Approval and Ministers' signatures following some distance behind."

"Total map production during RGG's existence (1972 – 1986) has been as follows:

<u>Canada</u>	*Aeromagnetic*	*3,319*
	Radiometric	*2,038*
	Geochemical	*1,799*
	TOTAL	*7,156*
<u>Overseas</u> (for CIDA)	*Aeromagnetic*	*1,501*
	Radiometric	*665*
	TOTAL	*2,166*
	<u>COMBINED TOTAL</u>	*9,322*

This total includes maps at all scales from 1:20,000 to 1:5M, magnetic total field, vertical gradient, and magnetic anomaly maps, 7 gamma-ray spectrometer parameters and up to 15 geochemical elements. (A small number of AEM maps have been included under the aeromagnetic total)."

"Quantitative maps, prepared according to pre-determined specifications and standards, provide a data base of long-term if not permanent value, available for wide variety of purposes, some of which may only become apparent in the light of subsequent discoveries or events."

"It was recognized early in the history of the original Geophysics Division that it was quite impossible to satisfy industry's appetite fro new maps and at the same time attempt to provide a comprehensive interpretation of the possible geological and economic significance of each map produced. Consequently only a tiny fraction of the maps produced have been interpreted in any detail. Life has been too short! The normal practice has been to provide selected examples of how data can be used, and to describe the principles and processes, and instrumentation involved, so that users will be encouraged to do their own interpretation. Thus, in 14 years the staff of RGG have completed approximately 1200 papers, ranging in size from R.W. Boyle's 584 page Bulletin on Geochemistry of Gold, to numerous short (but sometimes highly significant) items in Current Research. The international impact of the work is underlined by the number of RGG publications that have been translated into Chinese."

"In retrospect it has been an exciting 14 years, and the work of RGG Division has contributed in a substantial way to changing the types of output that are expected from forward-looking Geological Survey organizations. RGG has been more innovative and entrepreneurial than most government organizations are supposed to be, and I would like to place on record my appreciation of the part played by many present and past members of the Division for making this possible."

<u>Pre – RGG Highlights</u>

1955 - GSC established a Geophysics Division.
1962 - Federal-Provincial Aeromag Program began (the trigger was a motion from the floor at the 1960 Mines Minister's meeting, instigated by Morley)
1963 - High-sensitivity off-shore aeromag successfully demonstrated (in co-op with National Aeronautics Establishment) (Bower)
- Experiment to determine attenuation in air of gamma-rays from mineral sources, (Gregory)
- Construction of first field-usable portable gamma-ray spectrometer (Doig)
- Gregory in Nigeria for aeromag. aid project.
- Athabasca basin refraction seismic survey undertaken (MacAulay/Hobson)
1964 - Peak-year for Fed-Prov Aeromag production.
1965 - Rb vapour mag experiments with NAE - digital data compilation began (Bower?).
- Hood presents paper on advantage of magnetic gradient measurements
1966 - Hood given charge of Magnetic Methods Section;

- paper on aeromag reconnaissance of Labrador Sea attracted petroleum industry attention;
- first airborne mag gradiometer experiments with NAE aircraft;
- Remote Sensing Methods section established under Gregory;
- Doig's field portable spectrometer used by Killeen at Elliot Lake.
- Long magnetic lineaments (hitherto unknown) traced by aeromag compilations;
- compilation of an Aeromagnetic Map of Canada commenced (digital compilation was attempted by Bhattarcharyya).
- Morley on 6 country tour of Africa for External.

1967 - Off shore aeromag, using NAE aircraft, provided data "of great interest to modern theories on ocean floor spreading."(Morley's words) (Hood, Bower et al. responsible).
- Development of a high sensitivity AGRS system commenced in cooperation with AECL (Darnley); interest in uranium beginning to revive.
- Morley on 10 country tour of Africa for External;.
– Name change: Exploration Geophysics Division;
- design of a light-weight digitally recording high-sens airborne magnetometer commenced (Sawatzky);
- ground and helicopter experiments to establish specs for airborne system (Darnley);
- Morley responsible for organizing the Centennial Conference on Mining and Groundwater Geophysics in Niagara Falls (reps. from 51 countries)

1968 - Queen Air and Skyvan aircraft delivered, installation of equipment commenced (Hood and Darnley respectively);
- seismic depth-to-basement map of Athabasca basin completed (Hobson/Overton).
- Electrical rock properties lab initiated (Collett/Katsube);
- Calibration facilities established for field and airborne gamma-ray measurements.

1969 - Morley appointed D-G Canada Centre for Remote Sensing - Hobson Actg Div. Chief;
- Skyvan completed a trial survey at Bancroft, and a return low-level cross-country profile to Yellowknife;
- CIDA requested tech. assistance for aeromag surveys in Niger and Cameroun (Larochelle). - -
- Preparation of Aeromag map of Canada reverted to manual compilation from attempted digital (MacLaren)

1970. - Annual Report refers to three methods in first stage of development: ARES, variable frequency airborne resistivity mapping system (Becker); Overhauser Mag (Waskurak); ATGAS airborne trace gas analyzer system(French, UofT); the first two were unsuccessful, the third eventually became the Sciex I-C plasma mass-spectrometer
- Queen Air undertook first experimental survey with high-sens. Rb vap. mag (St. Mary's River Nova Scotia).
- Skyvan flew first large-area survey at 5 km spacing in Fort Smith area.
- Hood and Hobson visited Guyana for CIDA. Led to aeromag survey of country.

1971 - Darnley became Div. Chief of Exploration Geophysics (Feb 1).
- Detailed AGRS survey at Mont Laurier (GSC-Quebec shared cost).
- First request from Brazil for technical assistance in uranium exploration.
- Problems with computer-compiled aeromag maps (Timmins maps withdrawn before release) -
- Searched for (non-existent) fall-out from Amchitka nuclear test (using NAE Northstar - Richardson).
- Arrangements made for first shared-cost AGRS survey in Sakatchewan.

Selected RGG Highlights

[There are many more "achievements" listed in the Annual Reports, which contain the names of the scientists responsible for each project, than are listed here.. In most instances the work was the result of a team effort, so it seems somewhat invidious to single-out individuals for credit. Emphasis has been placed on activities which resulted in major advances and/or products, with a bias towards airborne methods, since it was these which made RGG Division, and its predecessor, almost unique amongst research institutions anywhere in the world. Canada, with much of its surface virtually inaccessible except by air, has benefited greatly from being in the forefront of airborne exploration methods].

1972 - Resource Geophysics and Geochemistry Division formed, with incorporation of Geochemistry Section (from Economic Geology and Geochemistry Division).

- First large-area low-density regional geochemical mapping project in Bear-Slave; Funds available because many GSC field activities reduced to enable staff to attend International Geological Congress in Montreal. Completion of the project within 10 months (including map publication) proved that "rapid results are not the prerogative of industry."
- Digital data-processing workshop organised for air survey industry:
- Fed-Prov. shared cost high-sensitivity aeromag surveys were carried out by the Queen Air in Ontario and New Brunswick.
- Skyvan AGRS system described, and maps presented, at IAEA meeting in Vienna. The methodology was established as the international standard through IAEA publications.
- Skyvan engaged in the first snow-water depth-measuring profiles.
- Negotiations commence for major technical assistance (Goias) project in Brazil, financed by InterAmerican Development Bank and CIDA, a major commitment with ongoing responsibilities (specifications, monitoring, dispute resolution, training) for next 7 years
- B-budget proposal submitted for a National Geochemical Survey, and digitization of all existing aeromag data (but no action ensued).
- First call for exploration geoscience data to be expressed wherever possible in suitable absolute units.

1973 - Aeromagnetic maps delivered to Upper Volta, Niger, Cameroun and Guyana ("The volume of overseas work is comparable to that relating to Canada")

- Following negotiations in Washington and Rio de Janeiro, the Goias project was designed to cover 375 K km² of Amazon Basin, with $11.5M budget
- Improved methods of permafrost mapping were a major concern, involving experiments with both seismic and electrical methods, and trials of ground-penetrating radar.
- Queen Air used for experimental aeromag survey in Kamloops area of BC to test resolution in mountainous terrain.
- Construction began of the vertical gradiometer system for this aircraft.
- Dr. Ogawa from Japan (subsequently Director General of the Japanese Geological Survey, spent year with Mag. Methods section)
- Skyvan engaged in a shared-cost survey in N. Sask
- OPEC oil embargo in October created opportunity to submit a draft Uranium Resource Program proposal as a B-budget item. Outlined plan for national radiometric and geochemical survey coverage, following specifications already developed in division.

1974 - A 50K km² lake sediment survey was undertaken in Saskatchewan (jointly funded with Province and DREE), a precursor of URP geochem surveys

- AGRS surveys were flown by the Skyvan in Sask., Ont., Quebec, PEI, and Newfoundland;
- Skyvan equipment upgraded to provide full spectral recording;_
- Queen Air gradiometer test flown for first time.
- Radar device developed (in cooperation with CRC) for soil-moisture measurement
- Meetings with provinces and industry to seek their support for URP. Original proposal assumed that all of Quebec would be included. By August Quebec was insisting the province must administer the program, otherwise it would not participate.
- Motion from the floor at Annual Mines Ministers' meeting in Sept. led to acceptance of URP at Fed-Prov. Meeting in December. "For better or for worse the world energy situation has now opened an opportunity that all the scientific papers, persuasive evidence and budgetary submissions of the past few years have failed to provide."
- A cooperative program with industry commenced, to assess commercially available borehole exploration equipment.
- Other items: Goias survey began; more requests from CIDA to participate in foreign aid projects than could be accepted;
- recurrent wish expressed "Interested in any developments permitting aircraft …to record

their position within +/-50 m."[GPS eventually provided this, and better];
- beginning of a continuing debate within GSC; RGG position: "Resource assessment cannot be separated from exploration as far as methodology and philosophy are concerned."
- a form of matrix management was introduced within the division to better coordinate closely related activities.

1975 - URP surveys commenced this year. [USAEC started a similar, parallel, NURE program; a common philosophy was followed; AGD and USAEC Chief Geophysicist had worked together for some years on the same IAEA committee]
- Mineral economists predicting 15% growth rate for U demand.
- Wide-spaced (25km) AGRS reconnaissance of NWT by contractor
- Skyvan AGRS flown in Sask., Man., and Ont.
- Lake-sediment surveys (100 K km ^{2}) by contractors in Manitoba and NWT.
- Calibration test range established for aeromagnetic surveys, at Bourget, Ontario.
- Queen Air gradiometer used for trial surveys near Ottawa – this aircraft then suffered an undercarriage collapse on landing in Winnipeg, en route to BC (no injuries).
- Cooperative high-Arctic flying program with NAE continued, with new discoveries.
- Seismic and electrical experiments to detect and measure permafrost thickness continued.
- Satellite weather receivers were installed at Tuktoyaktuk and Resolute to assist PCSP operations.
- Electrical Rock Properties lab. automated and operational.
- Start of Brazil-Goias airborne survey delayed, awaiting Brazilian President's approval
- Division also providing support for CIDA projects in Ivory Coast, Pakistan, Cameroun, and Liptako-Gourma area of W. Africa.
- Sundry Chinese delegations visiting
- Note that the last significant addition of new staff to the Division took place during 1975/76.
- AGD on scientific exchange mission to Moscow, with DJMcL and GG –a very frustrating exercise (there was a return match early in 1976).

1976 - Seventy percent of RGG operations budget now devoted to contracts with the air survey industry, industrial laboratories and consultants.
- Less effort available for long range research "to the certain detriment of future technological developments."
- 202 K km² of geochem surveys carried out as part of URP.
- 541 K km² of AGRS flown by contractors, 50 K km² by Skyvan for URP.
- Skyvan flying included detailed surveys over Port Hope and Uranium City to map radioactive contamination within town limits.
- Queen Air was used to fly a gradiometer survey across the SE corner of the Athabasca sandstone to determine depth to basement.
- Standard aeromagnetic survey production continuing in four areas, two in NWT, New Quebec and BC.
- GSC's specifications for AGRS given to Iran as basis for $50 M airborne survey of country (completed after overthrow of Shah, by German-led consortium with Canadian participation). [Probably marked the start of Iran's nuclear ambitions!]
- This was the last year that the NAE North Star was used for Arctic reconnaissance (declared obsolete), equipment was then transferred to NAE's Convair 580.
-. PJ Hood on ITC Trade Mission to China.

1977 - 251 K km² were geochemically sampled as part of URP in four provinces and two territories. This work had a human cost; a helicopter crashed in BC when landing to collect a sample, and the pilot and a student sampler (a contractor's employee) were killed. Fortunately this was the only fatal (or serious) accident during URP.
- URP AGRS surveys were flown by contractors in Ont., Man., Sask., and NWT.
- Negotiations to extend URP to Quebec (begun in 1974), continued for the third year, without reaching agreement.
- Skyvan flew in four provinces – a wide-spaced reconnaissance in south-central Alberta

generated a protest from the Provincial Exploration Licensing Agency; work had been done without applying for a license (we didn't know one was necessary –we assumed Alberta was part of Canada!). Incident eventually de-fused..

- A new computer-based AGRS system was developed and test flown in the autumn (fortuitously ready for Cosmos 954 arrival in Jan. 1978).
- Gamma-ray calibration facilities were constructed in Ottawa, Fredericton and Calgary.
- Standard aeromag surveys continuing in 3 provinces and NWT
- Survey by Queen Air of proposed Chats Falls site for nuclear power station (Ontario Hydro paid).
- Third edition of Magnetic Anomaly Map of Canada published.
- Terrain Geophysics group increasingly involved in R&D relating to radioactive waste disposal
- Close supervision of CIDA projects in Brazil (geochemistry, AEM and ground geophysics), Pakistan and Ivory Coast, also involvement with projects in Kenya and Botswana
- Exploration '77, a major shop window for the division's activities, was held in October (attended by 770 from 36 countries). A large Chinese delegation attended.
- At a meeting of the NEA in Paris it was reported that the USA was proposing to fund an International Uranium Resource Evaluation Program in 27 countries, based on the URP/NURE model.

1978 - Year opened with advice that long-discussed plans for a new combined CCRS-GSC Hangar Complex at Uplands were to go ahead (expected occupation 81/82). One of many schemes which were cancelled by gov't budget cuts later in year.

- Re-entry and break-up of Cosmos 954 over NWT resulted in division staff making international headlines.. Despite absence of prior warning, Skyvan AGRS system (minus aircraft) was on-site and flying (out of Edmonton) within 24 hours. GSC made first positive identification of radioactive debris after several false alarms generated by US team's unsuitable equipment Interesting example of how Washington expects to (and does) call the shots in an emergency. "Operation Morning Light" was major preoccupation during Feb. March and April. 18,000 line km of search data collected – distribution of radioactive fall-out "dust" was mapped.
- An Applicon colour plotter was introduced into routine use during the year, the first in Canada and second in North America (it had been acquired over objections from senior management, misuse of URP funds etc); "The availability of automated rapid colour plotting makes multi-parameter displays feasible in a graphical form which is readily understandable." As a result the first 1:1M colour aeromagnetic maps were produced.
- The budget for F-P aeromagnetic surveys was cut by 50%.
- Government economy measures, announced unexpectedly at the end of August, meant this was the last year of URP data collection, which, over 4 years, resulted in radiometric and/or geochemical maps for 25% of Canada. [27 years later I am astonished by what we accomplished].
- Agreement with Quebec was reached during the early part of the year for URP activities to commence in the province in the 1979 season –but they had missed the boat. Because of the cancellation of URP there was no program in 1979.
- Fed-Prov. aeromag flying in New Quebec was completed.
- Queen air gradiometer was used for survey over proposed rad.waste test site at Pinawa, and for new Darlington nuclear site.
- Rad. waste site studies were major activity of Seismic and Electrical Sections.
- RGG Launch "Ross Mackay" was in use for permafrost studies off Tuktoyaktuk.
- CIDA endeavoured to assert more independent control of new earth science projects by appointing a Consulting Geologist, with Tech. manager and Admin manager to assist, but did not materially change GSC involvement.
- Goias project moved into drilling phase.
- Aeromag maps delivered to Pakistan (reported never to have been released – withheld by military authorities) .
- Minor commitments in Kenya, Swaziland and Lesotho completed.

- Application of unbalanced nested sampling designs in URP geochem field work reduced cost of measuring sampling and analytical variability.
- Thirty outside organizations used the radiometric calibration facilities established in Ottawa.
- RGG-designed nuclear borehole logging system field-tested at Bancroft, Elliot Lake and Chalk River.
- A GSC Task Force on Reorganization revealed some internal antipathy towards RGG Division's activities (and successes?) .This might have had a bearing on future events. Quote: "In our discussions there was widespread concern that growth of geochemistry and geophysics would lead to a situation where they would overshadow geological mapping and related programs and that too strong a geochemistry-geophysics presence in Ottawa would be detrimental to the Geological Survey."[!]
- AGD in France for four months to compare gamma-ray signatures of French granites and uranium districts (and study French, without conspicuous success).
- matrix management for the division's activities was discontinued; whilst theoretically attractive, there were insufficient benefits.

1979 - Year of reorientation and transition.
- 'No growth' environment led to voluntary departure of 7 employees (incl. Scott, Lobach, Davis) This terminated radar probe development.
- Funds for URP ceased as of Mar.31. Data delivery was incomplete, so there were many problems finding money for late payments, but 99% of the outstanding URP data had been released on Open File by October.
- Many protests from industry and provinces about the premature cancellation of URP (Previous Ministerial statements had said the program would continue until 1985).
- Work began on making national compilations of all the extant URP data –eventually finished in 2003!
- Field work began in Athabasca Test Area – one of a series of IAEA/NEA studies in different countries to assess methods of uranium exploration; work involved Sask., EPB and nine outside organizations.
- Four model boreholes were constructed in Saskatoon for SRC.
- Phenomenon of "seismic tube wave" discovered in course of rad. waste R&D –major advance in recognizing permeable zones
- Drilling program completed in Brazil and "official" end of project (before all the airborne survey maps had been delivered!). Project bankrupted prime airborne survey contractor.
- Boyle's magnum opus on "Geochemistry of gold and its deposits" published, also Proceedings of Exploration '77. Big demand for both. Latter volume was translated into Chinese.

1980 - Loss of key employees continued (Holroyd and Conaway).
- More maps (595) were released on behalf of CIDA (for Brazil, Kenya, Ivory Coast), than for Canada.
- Arctic aeromag flights by GSC/NAE confirmed that Lomonosov ridge contained igneous rocks.
- Queen Air flew gradiometer surveys in 4 provinces.
- Steps taken in conjunction with Ontario and DREE to transfer gradiometer technology to industry (two companies accepted).
- Increasing evidence from Skyvan and ground follow-up surveys that gamma ray spectrometry useful in finding alteration (e.g. K addition or depletion) associated with a variety of non-radioactive mineral deposits.
- Field work continued in Athabasca Test Area.
- Geochem survey data from URP (and post-URP data by BC and Ontario) compiled into 1:2M scale coloured compilation maps (20 booklets covering about 10% of Canada issued on Open file)
-. On behalf of CIDA planned and monitored helicopter aeromag/radiometric survey of Rwanda.
- Trainees from Turkey, Bangladesh, Philippines, Yugoslavia, and China working in the division. [It was easier to accept people from outside the country –they had funding!]
- Drafted proposal for a National Exploration Technology Development Program (recurrent

theme for next several years, which never came to fruition).
- National Geological Surveys Committee emerging and stirring.
-. Unanimous motion from the Provincial Mines Ministers Conference: “The Ministers of Mines urge the Federal Government to allocate increased funds to conduct regional geological, geochemical and geophysical surveys across Canada.”

1981 - Division annual report produced for the first time using a word processor
-. In-house development of shallow seismic technique demonstrated as capable of mapping shallow overburden thickness.
- Importance of calibrating borehole geophysical measurements demonstrated in an international intercalibration exercise – a 10 % discrepancy in US uranium measurements and therefore overestimation of reserves.
- Production of 1:1M colour maps became a standard item (set generated from Goias project data was given to Brazil as token compensation for contractor being 18 months late in delivering contracted items).
- Queen air team much preoccupied with experiments with Loran-C to test precision of overwater navigation
-. Standard aeromag survey of N. Labrador completed.
- CIDA projects - Rwanda flying in progress, discussions began re Zimbabwe survey.

1982 - Release of Queen Air gradiometer maps of Val d’Or area caused immediate exploration staking - excellent definition of intrusive plugs and contacts.
- 100 K km² geochemical sampling to NGR standards in Labrador and Ontario (Mineral Agreement funding).
- Skyvan flew maps sheets along N. shore of L. Superior to fill gap in URP coverage and provide regional context for Hemlo area gold discoveries.
- Skyvan being increasingly used for detailed surveys in direct support of Provincial Min. Dev. Agreement requests (a diversion from completing national wide-spaced coverage)
-. Queen Air gradiometer surveys in Flin-Flon and Lynn Lake areas, similar funding.
- NAE/GSC excursions to Kane Basin and Nares Strait.
- Contract management of aeromag survey of Georges Bank area (off NS)- to provide evidence for boundary dispute settlement
-. Results of Athabasca Test Area project presented in Paris at NEA/IAEA Symposium.
- Meetings with provinces and industry to promote a National Exploration Technology Development Program

1983 - Skyvan engaged on detailed surveys, financed by F-P Agreements, in Labrador and NS.
- Geochem surveys to NGR standards undertaken in BC, Man., and Labrador, financed by Mineral Development Agreements.
- Know-how concerning shallow seismic profiling in international demand – IDRC funded trip to Malaysia and India.
- Negotiations began for major new technical assistance project in Thailand, with ADB and CIDA funding. As in Brazil eleven years previously, the Thais attached great importance to GSC “know-how” and tried very hard to obtain a large permanent attachment of GSC professional staff for the intended duration (5 years) of the project. That was impossible, we had far too few specialists.

1984 - An expansion of activities, similar to previous year. Additional activities made possible by funding from add-on programs; Min. Dev. Agreements, Frontier Geoscience, Boundary Dispute, etc, collectively providing 63 % of the Division’s operating budget, totalling $8.8M, enabling all the established methods to be used.
- A helicopter-borne magnetic gradiometer system was developed by a contractor.
- There were several in-house developments to expand bore-hole exploration capabilities.
- Because of its financial dependency on the above programs, the Division was losing control of its ability to complete the geophysical and geochemical reconnaissance of Canada, committees were now deciding the priorities. Liaison with CIDA, which (since requests

mostly focused on geophysics and geochemistry) had always been managed from within the Division, was transferred (nominally) to the D-G's office. This did not affect the one major independent activity over which the Division had control (for project design and monitoring), the Thailand survey. This project (for coverage of the whole country by aeromag and radiometrics) commenced during the year. It was the largest single contract of its kind ever awarded ($25M), and GSC's participation was written into the loan agreement between the ADB and the Government of Thailand. Amongst many responsibilities GSC monitored th construction of radiometric calibration pads outside Bangkok. Unfortunately major problems developed as a result of numerous disagreements between the Canadian prime contractor (Kentings) and the Thai bureaucracy, which necessitated almost non-stop mediation by GSC staff over the ensuing 5 years (and contributed to Kenting's subsequent demise).

- Other items: the fourth edition of the Magnetic Anomaly Map of Canada was published.
- Contemporary comments: "Unfortunately the resources to ensure that a new generation of methods will be available for routine use around the turn-of-the-century are not at hand." "One lesson of past innovations in geophysics and geochemistry is that innovations are rarely conceived or stimulated by a committee approach; at best committees provide encouragement after ideas have been proved successful."

1985 - Shadows on the horizon.

- Uncertainty as to the future developed during the year, arising from the Program Review initiated by the Mulroney government, designed to reduce the size of government. Two reports of the many Neilson Task Forces impinged on the work of GSC. The work of the division appeared to match very well the recommendations of one of the reports (R&D support for industry, etc), but clearly changes were in the wind. However, at no time was there any indication or discussion between GSC Branch and RGG Division management of what these changes might be.
- The major item of technology development accomplished during the year was the completion and sucessful test-flying of a trigonal magnetic gradiometer array on the Queen Air aircraft. Unfortunately because of the organizational changes which took place the following year this was never exploited. Subsequently the aircraft was used in the single-sensor mode for Great Lakes surveys.
- The dollar value (but not distance flown) of contracted aeromagnetic surveys reached an all-time high. The largest contract was for the Orphan Knoll survey off Newfoundland, supported by five Calgary-based oil companies. It was the first aeromag survey in the world to use GPS as the prime navigation aid.
- Another aeromagnetic survey over the Laurentian Channel was marred by the deaths of the crew of three Kenting employees in a crash in fog on the SW tip of Newfoundland. This was caused by a navigational error. This was only the second fatal accident since GSC sponsored aeromagnetic surveys commenced in the 1950s
-. It was noted during the year that the quality of survey products delivered by contractors was deteriorating. Presumed due to cost-cutting and downsizing
- In addition to regional geochemical mapping supported by Mineral Development Agreements in six provinces and the Yukon, the geochemistry subdivision became involved in the Seafloor Hydrothermal Program for the first time, with four scientists participating
-. An inductively coupled plasma mass spectrometer for laboratory use was acquired during the year – this was a derivative of the ATGAS airborne trace analyzer first sponsored by the Division 15 years previously, which evolved into the TAGA system used by Ontario for environmental monitoring.
- A Workshop on Airborne Resistivity Mapping, with participants from 15 countries, was held to encourage greater standardization of AEM measurements. Regrettably this initiative was not pursued following the 1986 reorganization.
- In an effort to satisfy the Thai demand for a continuing on-site GSC representative, a scientist was recruited on a CIDA contract for the duration of the project.
- The first (predigital) compilation of a Radioactivity Map of Canada was completed.

1986 - On the afternoon of Jan 10, 1986, I was informed by the ADM (W.W.Hutchison) and the Director General (R.A.Price) (two hours prior to my departure for a conference in Berlin) that RGG Division would cease to exist, effective April 1. My future position was to be determined. The division's components would be distributed amongst four other divisions. No alternatives were suggested or invited, and there was no discussion. There had been no previous discussion. It was the end of an era. The sole justification given was that the Nielson Program Review called for the amalgamation of GSC and EPB, and as a result a reorganization of divisions was necessary.

- Two Neilson Reports, on "Natural Resources" and "Major Surveys" respectively, had reviewed the work of the Geological Survey. The latter report also examined the Earth Physics Branch. Both reports had almost identical, and complimentary, statements about the work of GSC. The work of individual Divisions was not discussed. There was no indication that the committees disapproved in any way of the work performed by RGG. Subsequently Doug Mackay, previously President of Kenting, the senior private sector member of the Major Surveys committee, told me that the statement in his committee's report: "The industrial/private sector is highly supportive of the ongoing work and objectives of the survey", particularly reflected his views on the value of our work. By contrast, the Committee's stated opinion on the programs of the Earth Physics Branch was not as positive: "a reduced effort would not have serious consequences for the national requirements."
- In retrospect it was clear that the decision to dismember RGG Division had been taken some time previously. By not informing me until it was a *fait accompli,* the possibility of my telling provincial agencies and industry of what was about to happen, and seeking their support to oppose the decision, was prevented. (There were protests after the event, but they were unorganized and too late to have any effect). Telling me immediately before I was leaving the country for 9 days was the *coup de grace*. It was not a happy departure!
- Contemporary understatement (from 85/86 RGG Annual Report): "The demise of the division was somewhat unexpected, given the role it had played in introducing innovative, rapid, geoscientific survey methods on to the Canadian and world scene."

Commentary on the dissolution of RGG:

The dissolution of RGG Division marked a distinct change in direction in the priorities of GSC. The Program Review was used as an opportunity to put in place organizational changes which had been contemplated and under discussion for some considerable time (perhaps a year or two). The changes which were made, using the Neilson Program Review as a justification, apart from combining GSC and EPB, and effecting a small reduction in the activities of the latter, did not follow the first priority stated in the review, namely, *mapping in support of mineral exploration and development across Canada*. From being an organization which, historically, had been directed towards providing maps and reports to assist and encourage the mineral industry, GSC's priority was changed to much longer term, more academic research. Rather than produce information and develop methods which would benefit industry in the short to medium-term, GSC's new priority was to gain a better understanding of earth science processes, and the structure of the lithosphere. [A similar change in priorities took place in Australia, at BMR, at about the same time, following the installation of Roye Rutland (a former colleague of mine) as Director. It had similar consequences for the organization]. GSC's change of direction overlooked the fact that, to survive, a Geological Survey must produce information which has the exploration industry, the provinces, and other active users, waiting at the door when the latest maps and Open file reports are released. A geological survey must be seen to be useful. RGG Division, in particular, was very good at this. It may be noted, as an explanation of the unexpected change in priorities instigated by W.W.Hutchison (ADM) and R.A.Price (Director General), that neither of them were much involved with the professional mining exploration community, as represented by the Prospectors and Developers Association, or the Canadian Institution for Mining and Metallurgy. Nor were they familiar with the organizations where much RGG work was published, such as the Society of Exploration Geophysics, Association of Exploration Geochemists and the International Atomic Energy Agency. RGG's reputation was high amongst those communities (as demonstrated by service on professional committees). Conversely, RGG staff had little involvement with the GAC or GSA which were more concerned with "pure science". RGG catered primarily to the applied science community connected with the exploration industry, and with their provincial counterparts.

The intent of the re-organization appeared, to many observers, to be an effort to transform GSC+EPB into a non-teaching Earth Science Research Institute, with scientists grouped in multidisciplinary teams, dedicated to fundamental studies. It seemed, to these observers, that fundamental studies were deemed to rate more highly in the scheme of things than, for example, developing and applying new methods of exploration. The change might have been a desirable objective for a non-governmental institution in an ideal world, but it could be foreseen that it would not have any short-term return. It could only be a very long-term investment. After a short time the difficulty of providing an economic justification for this switch in GSC priorities and output began to be recognized externally, and it resulted in diminishing support for the work of GSC. GSC's new management failed to anticipate the extent to which increasing concern over the national debt, would reduce the government's willingness (and ability) to fund any long-term science. Over the next few years funds and people were cut, morale declined, and the remnants of RGG began to lose, slowly at first, then more rapidly, their international reputation as both innovators and practitioners in the latest exploration technology. But budget cuts, and diminishing capital in the preceding years, had already sown the seeds of this decline.
It is an unpredictable world, and it was somewhat ironic that those responsible for the details of the GSC/EPB reorganization, and the demise of RGG, continued for only a short time in their positions. Bill Hutchison died an unexpected early death in 1987, and Ray Price returned to Queen's University in 1988.

Commentary on the external "climate":

The BNA Act of 1867 did not anticipate the growing importance of mineral and energy resources in the world economy. Awarding the Provinces jurisdiction over these resources has greatly hindered the development of systematic national policies to ascertain and manage those resources. Giving the Provinces control over their resources was not, in the light of 20th Century international demand for these resources, a wise decision. The work of RGG and its predecessors was much concerned with developing methods and gathering data to provide a national overview relating to their distribution. All mineral and energy resources are associated with tell-tale geophysical and geochemical signatures – the challenge is to develop methods which can locate them when they are some distance beneath the surface. Some provinces (Saskatchewan, Manitoba, the Atlantic) were very easy to work with (as were the Territories). Some (Ontario, B.C.), could be temperamental, sometimes cooperative, sometimes not. The remainder (Quebec, Alberta), being particularly conscious of their provincial jurisdiction, could be very awkward. This greatly affected the provision of URP national coverage, and to a lesser extent, other activities also. Obviously most work was done where there was a 'welcome mat,' and where there were the fewest political and administrative obstacles.

During the period covered by this overview (starting in the late 60s) there were gradual changes in public attitudes, public policies, budgeting and program management which affected the work of the division adversely in a variety of ways. Public support for big government spending, and government-managed activities, declined. Following the last of the Apollo moon-landings, public interest in science waned. The Energy Crisis of 1973/74 provided only a short-term boost. Neo-conservatism began to influence political decisions. The consequences slowly filtered down through the bureaucracy.

There were (and still are) recurring political demands for government departments to achieve "greater accountability" in the expenditure of public funds. In practice the consequences were negative as far as productivity was concerned. More paper work was demanded; time went into preparing explanatory memos for bureaucrats with little interest in the work of the organization. A good "paper trail" was deemed more important than good products (I was once told by an auditor, "I have no way of judging the value of the products, I do not understand them." The moral of this encounter seemed to be that well-documented garbage was much preferable to undocumented treasure!) Over the years, a succession of Management Consultants persuaded the senior bureaucracy that by introducing their particular (copyright) management system, government would become more efficient, and everyone, from the Auditor-General downwards, would live happily ever afterwards. The Grid Plan, Management by Objectives, Programming, Planning, Budgeting, were the names of some of these alleged panaceas. Paperwork circulated, time was spent on training courses, some of the ideas were toyed with for a period, and then they faded from memory. After a year or two another management system would go through the same cycle. The only winners were the consultants. As part of the "greater accountability" process, beginning towards the end of the 70s, the work of GSC, and/or the Division, was examined by a number of visiting committees, mostly under the nominal auspices of the Canadian Geoscience Council. Each committee involved the Division in the preparation of much paper-work. One committee dealt specifically with URP activities – and reported favourably, with results published in the Northern Miner. Usually, once the membership of a committee was known, whether they would produce a favourable or unfavourable assessment could be judged in advance, based on the background and interests of the constituent members. The government's pursuit of ever greater "accountability" reduced the time which staff could devote to science, and did nothing to improve their morale, or their enthusiasm for their work.

"Make or buy" started to become a policy issue from about 1970 – and it contributed to the increasing volume of paper work, both to satisfy demands for information, and to convey some "facts of life" to its proponents. As far as RGG and its predecessors were concerned, from the beginning of the F-P Aeromagnetic Program, there was substantial "contracting-out". All the routine or "standard" aeromagnetic surveys were undertaken by contractors, wherever possible on multi-year contracts, because completion dates were weather-dependant and uncertain. A substantial percentage of the Division's operational budget was spent in this way. When URP started, airborne radiometric surveys, and helicopter-mounted geochemical surveys, both executed according to the Division's strict specifications, were also undertaken by contractors. So were a large proportion of the chemical analyses required as part of the geochemical survey program. The Division's two aircraft were flown and maintained by contractors (the geophysical equipment was maintained and operated by RGG personnel). It was therefore easy to provide statistics showing that a significant percentage of RGG's budget was being paid to contractors. This allowed the more interesting, creative, work carried out by Division scientists, to continue in-house. Good scientists resent spending their time as purchasing agents. Bureaucracy was satisfied. However, as technology advanced, methods became more complex (and expensive), staff did not increase, and capital budgets were cut, the ability to keep advancing in all the active areas of the science became more difficult. As funds diminished, by the mid 1980s the Division was approaching the situation where it could neither make nor buy. New ambitious projects could no longer be entertained. It was increasingly difficult to continue with those that existed. RGG could no longer claim to be in the forefront with all its activities. Others were catching-up, or had caught up. For that reason I tried hard for several year to obtain approval for a National Exploration Technology Development Program (NEXTDP). There was outside support (from industry and some provinces) for the idea, but the political climate was against it. NEXTDP never got off the ground.

In the days of the former Geophysics Division, and up to the mid-70s and later in some instances, the Division Chief, once his annual budget had been allotted by the Branch Director and /or Chief Geologist, had a relatively free hand in how it was used within the Division. Similarly with the allocation of staff time.

Procurement, before the days of DSS, was a relatively straight-forward matter, provided funds were available. For example, the project to develop airborne gamma ray spectrometry. It was an ambitious and expensive project at the time. Ten or fifteen years later, before starting such a project, there would have been pressure (or a demand) to consult an external advisory committee on the likelihood of the project's success. In 1966 such a committee, if it had existed, would most likely have voted against it, as being too uncertain and speculative. Members from the air survey industry, realising that if it succeeded it would make their existing equipment obsolete, and therefore their services less saleable, would have argued that it was unnecessary. Physicists from academia would have said (correctly) that there was nothing in the refereed literature to show that useful results would be obtained, so they also would have voted it down. [Critical data to show that it was feasible were in an obscure Mines Branch Report (by Gregory), and in promotional literature from the Texas Instruments Company, describing recently declassified US Navy equipment]. If the advisory committee hurdle could have been surmounted, then DSS procedures would have placed numerous further obstacles in the procurement process. In 1966/67 a few visits, and an exchange of letters, quickly established that AECL was the only organization in Canada with the necessary know-how to work with GSC in developing the instrumentation. We were able to go ahead within a few months of conceiving the project.

The acquisition of the Skyvan aircraft in 1968 is another example of the administrative simplicity existing at that time. It was a novel and major expenditure for any geological survey, but two or three memoranda were sufficient to justify the purchase, and show that various alternatives had been carefully considered. These accompanied the purchase order and gathered signatures up to DM level. A short submission to Treasury Board was prepared. To someone accustomed to the interminable processes of the UK Civil Service (e.g. 4 years to buy a mass-spectrometer) it was surprisingly quick and easy! To the extent that there was any discussion, it was restricted to a few senior people within the department, who were all sufficiently familiar with the department's business to understand why the purchase was being made. It could not have happened that way ten or more years later! Even if money had been available (which by then it wasn't) there would have been so many people involved in reviewing the decision that no agreement could have been reached, and nothing would have happened.

Decisions as to forthcoming aeromagnetic survey work in a province would often be made on the basis of a few brief phone conversations and an exchange of letters between a Provincial Chief Geologist and the Division Chief. General intentions were usually known several years in advance, because the aim was to move systematically across the country. Each would know his budget and plans, and agreements could usually be reached very quickly. The formal Ministerial approval would follow many months later – usually long after work had started! Paperwork often shuttled between Federal lawyers and Provincial lawyers for several months. Of course the decisions would be communicated up and down the line, but rarely was anyone other than the Division's technical staff involved in the decision making. The same situation applied in the early years of URP, until DREE money was involved and Management Committees of increasing size appeared on the scene. Of course the Branch Director would be advised of what had been decided, but not until 1985 was there any discussion to change a priority determined at Division level. Prior to that Branch involvement only arose in the case of Quebec, which wanted to assert its prerogative (as it saw the situation) to insist that only Quebec contractors could be employed on any activity involving Provincial money. In the case of aeromag surveys a formula was eventually devised to allow Quebec to do this without increasing the cost to the Federal budget. In the case of URP surveys the situation was more difficult, because there was no company in Quebec equipped to do the work. After four years of sporadic negotiations a compromise agreement was reached, but shortly afterwards URP was cancelled (That is why Quebec is a big blank area on the Radiometric Map of Canada!).

CIDA projects were another activity, consuming significant division resources, where it was left to the Division Chief's discretion whether it seemed prudent or otherwise to become involved. Involvement in major aid projects allowed the Division's senior scientists scope to exercise their professional judgments more freely than in Canada. The recipient countries were eager to have assistance from GSC, and were not inclined to debate our recommendations - although CIDA Consultants sometimes did. Division scientists were presented with a blank slate to work upon, large areas where little or no previous work had been done. The Division refused a few projects (mostly because of staff overload), but the majority were accepted, because they provided an opportunity to demonstrate the applicability of Canadian methods to other very different environments. They broadened the experience of RGG staff, they advertised Canadian expertise, and generally brought credit to Canada. They brought trainees to Canada who subsequently bought Canadian equipment. A number of these later occupied senior positions in their countries. Equally important, CIDA projects employed Canadian contractors. We had a vested interest in keeping Canadian contractors in business and financially solvent so that they would be available to do work in Canada – the air survey business has never been noted for its profitability. In fact two contractors (Northway and Kenting) did go bankrupt because they seriously underestimated the time and cost of completing their contracts (Brazil and Thailand respectively). In part this was because their bids were too low (in their eagerness to win the contracts), in part because they failed to anticipate some of the bureaucratic obstacles that would be erected by their clients. The Thailand survey was particularly difficult in this respect.

From the mid-70s onwards there was increasing pressure for Section Heads (and the Division Chief) to undergo French training. Some refused, many found excuses to delay, some went reluctantly, whilst one or two, with francophone family connections, went willingly. For those who went to Language School, it effectively removed them from their duties for 6 to 9 months. Unfortunately, and despite much effort, the standard achieved was too low to serve any useful purpose. It was very expensive "tokenism," which detracted from the productivity of the Division. Some individuals returned to their duties emotionally drained by the experience.

The Public Service employee classification system was not designed to simplify the management (or reward) of multidisciplinary teams, where the success of the team might hinge on the work of physical scientists, electronics technicians or computer scientists as much as on a research scientist who was nominally in charge, and received most of the credit when results were published. Much of the work of a team engaged in method development was unseen for several years, and until results could be delivered could provide very little material suitable for publication. Then, after a short interval, the output would be regarded as routine production, unworthy of any special recognition, because much of it was in Open File reports, not prestigious publications. The innumerable choices to be made, the trials and tribulations of the development stage, before masses of "routine" data could be generated, tended to be discounted by the organization at large. The Research Scientist classification was not designed with technology development and team leadership in mind. As applied, it rewarded productive individual scientists, engaged in established lines of work, whose output appeared in well known publications. Inevitably, for a Research Scientist involved in rapidly evolving technology, much time was taken up with managing the team. There was less time for preparing publications, and when they appeared they were often in Symposia volumes or unfamiliar journals. So, with an ill-matched promotion system, disproportionate time and effort had to be invested by Division management to try to obtain rewards for what, at least in the eyes of those outsiders qualified to judge, were unique achievements. Not surprisingly, rather than wait for their rewards, some of the best young researchers and technicians walked out of the door.

As an aside, it is interesting to compare the promotion system for scientists in the British and Canadian Geological Surveys. My memory of the British system dates back to the 1950s-60s, and the situation has probably changed drastically since then. Soon after I arrived in Canada I became aware that promotion was much more "publication dependant" than it had been in the UK. In the UK a scientist's primary responsibility was directed towards providing the institution with information for government policy making. How much of that information might subsequently be released to the public was at the government's (i.e. Director's) discretion. There was no expectation that in the normal course of events everything would or should be published – "publish or perish" was regarded as a very North American concept, resulting in an excess of mediocre publications. Accordingly, in BGS productivity could be largely internal reports; promotion was based on the quality of these, and level of responsibility. Management of technical staff was regarded as part of a scientist's duties, and credit was given for this. Managing a successful team could be the basis for promotion. External publications provided bonus points, but they were not the main yard-stick. Maps and memoirs were published, but often they would take years to emerge – that was not where the priority lay, perhaps because the country had long-ago been mapped (geologically) at one inch to one mile, and the current effort was at much more detailed scales, and at answering specific government-related enquiries. I remember being told by an about-to-retire Assistant Director of BGS (a rather fearsome First World War hero) that people who wanted to publish outside papers were just publicity seekers, who wanted to become university professors. He had a low opinion of most of those! He preferred people who were prepared to do what they were asked to do within the organization, and not waste time writing papers for academics, which if they were lucky, might be read by half-a-dozen people! He was particularly suspicious of new entrants (like me) with Ph.Ds – such recruitment was a post-war development in BGS. I was Chairman of the Scientific Staff Association in 1964/65, at the time of the amalgamation of the "Home" and Overseas Geological Surveys, so had many opportunities to see how management decisions were made (or avoided)! On the whole I think the more flexible BGS criteria for promotion of scientists produced more equitable results (with less internal backbiting) than the more constrained Research Scientist classification system of the Canadian Public

Service. Mention of the BGS Staff Association reminds me that, although it did not have much leverage, it had some influence. There was no equivalent organization within GSC. The Staff Association had an official status (as elsewhere in the UK Civil Service), and provided token workplace democracy. Major changes could not be initiated by management without prior warning and consultation. Staff objections could be overruled, eventually, but they could cause a delay, and bring about at least minor amendments to changes proposed by management. I was involved in several such episodes. The manner in which the GSC /EPB amalgamation was announced and implemented would have been unthinkable and unacceptable in the UK, at all levels.

The Division could always have used many more people than it had. Shortage of staff was a perpetual complaint. The argument that Canada is a very big country, and we had a responsibility to examine all of it, never carried much weight! A number of promising projects never came to completion, either because the originators departed and could not be replaced, or there was insufficient technical assistance to follow through on ideas. The Division became capable of producing advanced data at a prodigious rate, far faster than the staff could possibly hope to digest it. Larry Morley always said that if you produce good data someone will find a use for it, and "You cannot hope to provide interpretations that will help every potential user. Provide a few examples of what can be done with the data, and hope that potential users will catch on." I followed the same approach. Unfortunately, many people who you think should be able to "catch on" never find the time to do so, so acceptance and utilization of new types of data is often slower than the originators expect, which can be very frustrating. That is why extended and varied demonstration projects, over a period of several years, are a necessary part of any technology development program.

Commentary on post-RGG events

Amongst the consequences of the 1986 dissolution of RGG were the following:

1) Matters specifically relating to exploration geophysics and exploration geochemistry were no longer automatically on Branch Management's agenda (the Div. Director's position having been abolished); there was no one for whom it was their first responsibility. The absence at Senior Management level of someone familiar with the Canadian mineral exploration service industry (and problems such as the tendency to market new methods prematurely, without adequate development; the reluctance of companies to use calibration procedures and standardize data; etc) meant that actions to try to provide national quality control standards were no longer pursued. In the long term this had international as well as national implications, because RGG's involvement in promoting in such activities provided, in the minds of external organizations, a recognized 'seal-of-approval' for those companies that adopted what were identified as GSC recommendations and methods, and gave them an edge in international marketing. [see company advertisements in the Northern Miner, and elsewhere, in the late 70s].

2) The components of RGG were distributed amongst four divisions, at a subdivision (or lower) level. Their projects, from being priority considerations within a Division, became subordinate issues, competing for support with the existing interests and responsibilities of the units to which they were assigned. By the standards of most GSC activities, RGG's projects had seemed generously funded. Technology development, field trials of experimental equipment, and aircraft operations are expensive! The units to which the various RGG components were allocated, not unnaturally, regarded the funds which arrived with them as a welcome windfall which could be drawn upon to bolster their pre-existing activities. Thus, former RGG projects received diminishing support, and staff morale declined in parallel.

3) Efforts to complete a National Geochemical Survey of all of Canada's land surface ceased. For a short time after the dissolution of RGG, the new management considered abolishing RGG's former Geochemistry subdivision which carried out the work! Astonishing!
The Geophysics Division, and its successor RGG, had been responsible for designing and managing the aeromagnetic survey of Canada. RGG's prime achievement was to initiate the reconnaissance radiometric and geochemical surveys of Canada, to complement the existing geological and geophysical coverage.

Most progress was made during the four years of URP funding. Nevertheless, for several years afterwards, as long as RGG existed, efforts were made to extend national reconnaissance coverage, albeit at a slow rate. When RGG was dissolved, these efforts ceased. In retrospect it was unfortunate that a multi-purpose National Geochemical Survey Program had not been identified by that name. In the eyes of Treasury Board, and others inside and outside GSC, URP was identified solely with uranium, so it was cancelled when uranium and nuclear power lost public and political support. The usefulness of the data for a wide variety of environmental and exploration purposes was overlooked or ignored. (The data still provide the most extensive source of environmental background values for Canada).

4) Airborne geophysics and geochemistry ceased to be regarded as a unique and necessary speciality for GSC and Canada. The new Branch Management had little or no interest in building upon or promoting any facet of airborne geophysics or geochemistry, although the experience acquired and publicized had caused many foreign agencies to buy Canadian services over the previous 20 years. Although China never purchased Canadian services, the Chinese bought two examples of almost every type of earth science equipment manufactured in Canada. One example was for experimentation, the other was for disassembly. The Chinese Central Government modeled the activities of its Institute of Geophysical and Geochemical Exploration in Langfang on RGG's activities at the time of Exploration '77. Their Uranium Exploration Institute in Beijing also adopted RGG methods. It is interesting to note that as of 2003 China had completed a systematic geochemical survey over the whole country, in conjunction with most types of airborne geophysical survey. In contrast, Canada has made very little progress since the mid-80s.

5) As part of the intention to extend the national radiometric surveys, public funds (but very little GSC money) had been spent on a design study to significantly extend the range of GSC's Skyvan aircraft. (It was recognized by 1983 that the possibility of buying a new longer-range replacement aircraft was remote). After modification, the aircraft would have been available to fly reconnaissance coverage in the more distant parts of Canada, and, over a period of time, complete national coverage. These plans were abruptly abandoned following the demise of RGG. The Skyvan continued to be used until 1995, (when it was sold), but almost entirely for detailed radiometric surveys on small, scattered, irregular, "postage-stamp" areas selected by the provinces, or the mining industry, for special attention. The concept of first obtaining a regional overview through systematic national coverage, by adding map sheet to map sheet, had been abandoned. The Queen Air had an earlier demise (in 1988), when it, and its expensive, unique equipment, was sold through Crown Assets for little more than scrap value. In neither case was there any consultation with the individuals who had developed these unique airborne instruments.

6) Various trends in government policies, which were beginning to appear during RGG years, became much more obvious afterwards. Public Service Management seemed to be increasingly preoccupied with 'social-engineering' (to the detriment of useful products and services), to try to accelerate changes in public attitudes concerning bilingualism, multiculturalism, equality of opportunity, etc. The Senior Management of government departments, such as EMR/NRCan, seemed to be increasingly entrusted to individuals with no experience or prior knowledge of the work of the departments. They depended upon external committees for advice, and had no way of knowing whether they were receiving good or bad advice. By changing the Senior Management at short intervals, continuing lack of knowledge was guaranteed, and bad decisions (or absence of decisions) could be swept under the bureaucratic carpet without embarrassment.

7) RGG Division, through its various activities, had established a strong *esprit de corps.* This was reflected in the willingness and efforts of its staff to overcome difficulties and meet deadlines. Their performance during the URP and the Cosmos satellite search was outstanding. Every section contributed. They were rightly proud of their achievements. [Why were they never formally recognized?]. Dissolution of the Division was seen as a slap-in-the-face, by a remote management unwilling, or unable, to recognize the importance and value of what was being lost. A mock funeral procession on the front steps of GSC a few days before disbandment, symbolized the reaction of the staff. It was not a good omen for the future.

8) The value of the work undertaken by RGG Division may have been discounted by GSC's management, but fortunately others elsewhere recognized the significance of what had been achieved. For example, the importance of establishing geochemical background values over large areas for both mineral resource and environmental purposes; the need to place measurements within a global context by means of international

standards. Thus, the concept and methods underlying the URP (and the aid projects in Brazil and Thailand), provided the principal model for the development, over a 10 year period, of an IGCP project known initially as *International Geochemical Mapping*, subsequently as *Global Geochemical Baselines*. Several former members of RGG contributed. RGG's leadership in IAEA uranium exploration activities had resulted in many contacts with scientists and institutions around the world, who recognized the problems arising from existing, inconsistent, databases. Their support gave impetus to the project. In 1996 *Global Geochemical Baselines* became an IUGS Working Group, and was formally recognized by a UN Committee. The recommendations generated by this project have since been acted upon most energetically in China and Europe (where 26 countries have cooperated to publish a two-volume Geochemical Atlas). Chinese institutions, as a consequence of their inquisitive visiting delegations in the late 70s, built upon RGG Division's experience, and as a result are now in the forefront of research. Brazil, India and Russia have also undertaken significant work. Unfortunately, within Canada, progress towards implementing the Global Geochemical Baselines concept has been limited, so far, to the efforts of one or two individuals, with seemingly little official recognition of its importance.

Glossary

ADB Asian Development Bank, affiliated to the World Bank, headquarters in Washington
AEM **a**irborne electromagnetic survey
AGRS airborne gamma ray spectrometry
BGS British Geological Survey – up to 1965, the official title was Geological Survey and Museum, when, on amalgamation with the Overseas (former Colonial) Geological Surveys, it became the Institute of Geological Sciences. The name was changed to British Geological Survey in 1980.
BMR Bureau of Mineral Resources, Canberra, Australia, equivalent of GSC
CCRS Canada Centre for Remote Sensing, a branch of Energy Mines and Resources (now Natural Resources Canada).
DREE Federal Department of Regional Economic Expansion.
DSS Federal Department of Supply and Services
EPB Earth Physics Branch, a branch of Energy Mines and Resources
GPS Global Positioning System; satellite based navigational system introduced c. 1991 which totally revolutionized all types of position finding and tracking
IAEA International Atomic Energy Agency, a branch of the United Nations, with headquarters in Vienna.
IGCP International Geological Correlation Pro**g**ram, supported by IUGS and UNESCO
IRDC International Research and Development Centre, an extension of CIDA activities.
IADB Inter American Development Bank; affiliated to the World Bank, headquarters in Washington
ITC Federal Department of Industry Trade and Commerce
IUGS International Union of Geological Sciences
NAE **N**ational Aeronautics Establishment, a Division of the National Research Council, located at Uplands Airport.
NEA Nuclear Energy Agency, a component of the OECD, headquarters in Paris; worked closely with the IAEA.
NGR National Geochemical Reconnaissance; name used initially to refer to the geochemical survey component of URP; after the demise of URP, used to cover continuation of all former URP activities.
NURE National Uranium Resource Evaluation Program, US equivalent of URP
Queen Air Beechcraft B.80, twin piston-engined aircraft used exclusively for aeromagnetic sensor development and surveys. Very expensively modified to ensure it had near-zero magnetic signature.
RGG Resource Geophysics and Geochemistry Division, successor to the Exploration Geophysics Division. At its peak it had 104 employees.
Skyvan manufactured by Shorts of Belfast. Twin turboprop, selected because large square section fuselage with rear loading ramp, permitted large pieces of equipment to be easily installed without

disassembly. Unlike the Twin Otter it had no under-floor fuel tanks, which act as radiation shields and interfere with gamma radiation measurement.

URP Federal-Provincial Uranium Reconnaissance Program; initially it was called the Uranium Resource Program.

USAEC United States Atomic Energy Commission; subsequently had several name changes

RGG Permanent Staff List

[See Appendix below]

This list contains approximately 165 names. At the peak, RGG had about 100 permanent staff, plus a small number of summer student positions. There was a significant turnover of computer and lab. technician positions, to a lesser extent of scientific positions. Because the Internal Annual Report ceased to be produced after 1987 it is often difficult to confirm when people finally departed the organization, particularly when drastic "downsizing" commenced in the 1990s. Many just faded away!

Post Script: a personal note:

Although in GSC I was identified as a geophysicist, I consider myself a geologist first and foremost. Initially I specialized in mineralogy and petrology. My Ph.D.involved mineral chemistry and petrochemistry. Exploration geochemistry was still very much in the experimental stage in the early 50s, and unheard of in the academic world. My formal geophysics education consisted of three (perhaps four) lectures during a summer course in 1951, but they were on basic earth physics, far removed from mineral exploration . Radioactivity was never even mentioned! All I learned about this subject was during the nine years I worked for the Atomic Energy Division of the British Geological Survey, which provided access to a broad spectrum of expertise. It was whilst I was with the AED that I began to think about the potential of airborne gamma ray spectrometry. I had been interested in aviation from an early age. Between school and university I did National Service in the RAF, and worked in Germany on transport aircraft as an instrument technician during the time of the Berlin Airlift (1948/49). Later, when in N. Rhodesia, I obtained a Pilot's Licence, and whilst working on my Ph.D.at Cambridge I was a pilot in the RAFVR. (I have retained my licence for 52 years). There was no interest in the UK for the development of airborne gamma ray spectrometry, the "experts" of the time did not think it would work, and the British Survey as a whole was not at all progressive, very "boots and hammer" orientated. The AED was being "downsized" (they didn't call it that then) and when I heard (through Ward Neale, who had been Commonwealth Geological Liaison Officer in London) that GSC was looking for someone to take Al Gregory's place, it sounded too good an opportunity to miss. That was in 1966.

How I came to be appointed Chief of the Exploration Geophysics division in 1971, I was never quite sure (perhaps the subsequent union with Geochemistry to form RGG was already anticipated). Possibly it was because I had had involvement with the introduction of various types of instrumentation. Very early in my career I had found it necessary to become what I call a "quantitative geologist". Whilst I was with the British Survey (after completing my Ph.D.) I was responsible for uranium-thorium-lead age determinations, and also for the development of a field-portable XRF measuring device for estimating tin and copper in fine-grained ores. I was also an early user of one of the first X-ray microanalysers, to solve a dispute as to the identity of a fine grained Cu-Co mineral from the Copperbelt.

My interest in quantitative observations resulted from two years of field experience in Central Africa (N. Rhodesia, = Zambia) in 1952-54. Fortunately, in retrospect, my "Chiefs" were two very progressive and energetic exploration geologists, Bill Garlick and Joe Brummer. They had recognized the limitations of conventional geology in Central Africa, and were willing to try any new methods. They introduced me to both exploration geophysics and geochemistry. I was encouraged to use them. I arrived with the training of a traditional geologist, but quickly realized that in flat, forest covered country, with almost no outcrops, 200 or 300 feet of tropical weathering, and, at depth, many dark fine-grained rocks, where even 2 or 3 % mineralization could be almost invisible, the unaided eye-ball is an unreliable tool! Eye-ball identifications and descriptions are frequently inconsistent from person to person, and incorrect. My subsequent thesis work confirmed that lithological descriptions, as recorded in drill-hole logs examined by many individuals, were often misleading or erroneous.

My African experience established my opinion that, for work at every scale, it is necessary to employ quantitative analytical techniques wherever possible. It therefore seemed logical to believe that, particularly in any country where ground access is difficult, systematic airborne geophysics and geochemistry (and air photography) should be applied **before** commencing geological mapping. I had no difficulty in having this viewpoint accepted in Brazil and Thailand, and later in Indonesia and China, but in GSC there was often some opposition to this view! The idea that geological mapping should come first was well entrenched, although some more enlightened individuals were willing to agree that it could be useful to have aeromagnetic maps before going into the field. In more recent years there has been some recognition that radiometric and geochemical maps could be useful too!

To summarize my views on geology, geological interpretation is a very subjective exercise, liable to revision, and it needs all possible assistance from quantitative data. The full range of quantitative analytical techniques (geophysical, geochemical and mineralogical) are needed both in the field and in the lab. Rocks and minerals are not always what they appear to be. Continuous efforts are needed to develop new methods. Concerning earth science mapping in general, before venturing into the third dimension, it is prudent to make a comprehensive map of everything that can be described from the surface. Canada claims sovereignty over eight per cent of the world's land-surface, but has not examined most of its surface to anything approaching the level of detail considered necessary by other developed countries with comparable geology, for example Scandinavia. It has been considered far too costly to even propose this – but surely that is the price of meaningful sovereignty! For this reason I always had difficulty in accepting the diversion of GSC funds into expensive projects such as Lithoprobe, and Canadian participation in the Ocean Drilling Program. If the country cannot afford to invest in and complete its basic science infrastructure, it should not, in my opinion, be using public funds to undertake research which is very unlikely to be economically rewarding in the short or medium term. First things first!

Post script: The present (2005) official policy *not* to fund systematic geoscience mapping of the country is an astonishing development. It illustrates the consequences of a department of government being managed by senior officials lacking any knowledge of the field of science for which they have responsibility. It also raises the question as to whether Canada is morally entitled to assert sovereignty over territory where it is prepared to invest next to nothing!

AGD: 31 Jan. 2006

Addendum

I came across the following remarks in my files and attach them because they provide a vignette of times past. Jacques Parker was an electronics technician for 35 years, spending nineteen in Exploration Geophysics and RGG.

<u>Jacques Parker's retirement, May 2002</u>

I'm sorry that I can't be present in person to give Jacques my very best wishes for a long and happy retirement. Unfortunately some time ago I committed myself to another engagement on this date. If I'd known about this sooner I would have arranged things differently.

Thinking about what I might say about Jacques' retirement, other than that he has always been loyal, diligent, reliable, friendly and good natured, [and never a source of headaches for management, unlike some I could mention], it occurred to me that his departure marks the end of an era. In geological terms an era is a time when life was very different from what it is now. Jacques is the last member of the Remote Sensing Section, in the old Exploration Geophysics Division, to retire.

Jacques joined GSC in the spring of 1967, 35 years ago. I remember him then, very fresh out of school, inexperienced in the ways of bureaucracy and probably somewhat intimidated by the rather eccentric bunch of individuals who constituted the Remote Sensing Section at that time. Roy Slaney, Dick Flint, Harry Gross, Steve Washkurak and myself. Remote sensing was rather new, our objectives very broad, and our ideas very ambitious, so we could (and did) experiment with all sorts of novel devices. Some of our ideas worked out well, some didn't. Very little of our equipment consisted of standard, off-the-shelf items, but Jacques was expected to fix whatever was needed and he rapidly showed his skills.

Perhaps sooner than he expected, a few weeks after joining, he was sent to Bancroft to work with John Carson, to establish a test strip by making a grid of gamma ray spectrometer measurements in the bush. We needed 'ground-truth'. The strip was 3 miles long by half a mile wide, including rocks, swamp, fallen trees, and lots of flies - typical virgin bush. The so-called portable equipment, made by AECL, was technically terrific, but unfortunately so was its weight - it was before the days of microchips. Some called it the muscle builder! Jacque survived that exercise and became, for a time, amongst his other duties, the default operator of the Skyvan airborne spectrometer. He went on the cross-country flight from Ottawa to Yellowknife in 1969, which was flown at 400ft all the way. Head-down, marking fiducial points, threading magnetic tapes whilst bouncing around the sky, between the birds and the rocks, was rarely a pleasant experience, but it was part of the job and had to be done. The data from that trip were part of the evidence which paved the way for the Uranium Reconnaissance Program a few years later.

I hope I have written just enough to remind everyone that Jacques was one of the team that started to put airborne gamma ray data on the map of Canada in the 1960s. It was done by a team of people with a variety of different functions, and Jacques did his essential part. He was one of the pioneers. He has done many other things since, but that achievement sticks most clearly in my memory. Thanks for your help Jacques, Good luck and a long and happy retirement.

Arthur D. 3 May 2002