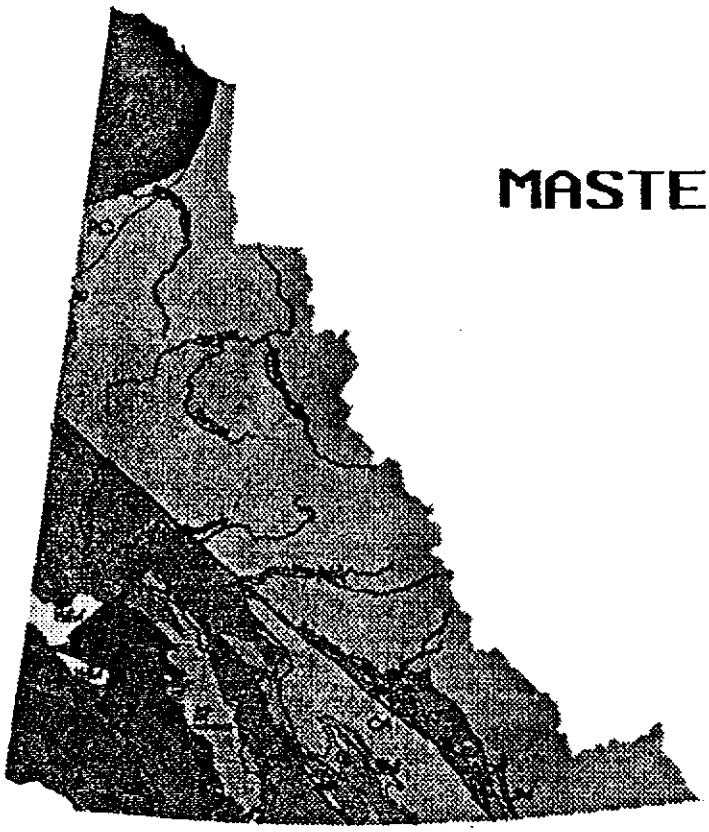
YUKON GEOSCIENCE - a blueprint for the future



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Transactions of the first Yukon Geoscience Planning Workshop

Lakeview Marina, 25-26 April, 1995

Second draft, 1 June, 1995

YUKON GEOSCIENCE - A BLUEPRINT FOR THE FUTURE

Transactions of the first Yukon Geoscience Planning Workshop

LAKEVIEW MARINA, YUKON, 25-26 APRIL, 1995

Co-chairs T.J. Bremner (DIAND)
and R.P. Hill (Government of Yukon)

7 June, 1995

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EXECUTIVE SUMMARY

Mining is expected to remain as Yukon's most important industry during the next 5-10 years. The future prosperity of the mining industry in Yukon depends on the discovery of new mineral deposits. These new discoveries will depend on up to date geoscientific research: geological mapping, geochemical and geophysical surveys, and mineral deposit studies. Government and First Nations also need the results of this research to evaluate mineral potential and assist with land use planning and environmental impact assessments. With this in mind, the Geological Survey of Canada, Northern Affairs Program (DIAND), Government of Yukon and the Yukon Chamber of Mines collaborated on a 2 day workshop in April, 1995, to identify and prioritize Yukon's Geoscience requirements for the next 5 to 10 years. This document summarizes the results of the workshop. It represents a consensus between the four sponsoring agencies, based on input from 34 geoscientists currently working in Yukon, and will be used in planning geoscientific research to ensure that priorities are met and that maximum value is obtained from available funding.

The delivery of geoscience programs in Yukon is presently split among three agencies: the Geological Survey of Canada, DIAND and Government of Yukon, and additional work is carried out by various universities. This splintering of geoscience programs is opposed by the Chamber of Mines and presents a strong argument in favour of devolution of mineral resource administration to Government of Yukon. A step in this direction was taken in 1990 with the creation of the Canada-Yukon Geoscience Office, using funding from the Canada-Yukon Mineral Development Agreement (MDA).

The Geoscience Office is a joint venture funded 70% by DIAND and 30% by Government of Yukon, and is currently administered by Government of Yukon. The Geological Survey of Canada has assisted by seconding a geologist to the project, and by conducting regional geochemical and geophysical surveys using MDA funds. By March, 1996, the current 5 year program will have delivered 22 bedrock geology maps at a scale of 1:50 000, plus three airborne geophysical surveys and a number of special studies. It has also resulted in the near completion of regional stream sediment geochemistry south of 65°30' N. These geochemical maps were instrumental in the discovery of Loki Gold Corp.'s 21 million tonne Brewery Creek gold deposit in 1987 and Cominco's 13 million tonne Kudz Ze Kayah massive sulphide deposit in 1994. The present MDA program is scheduled to end in March, 1996, but the results to date make it imperative to continue the program in some form.

The workshop was divided into three sessions: (1) Bedrock geology and mineral deposits; (2) Surficial, environmental and placer geology; (3) Regional geochemical and geophysical surveys. The main conclusions and recommendations are summarized below, and in Table 1.

1. Continued bedrock and surficial geological mapping is vital to the search for new mineral resources, and to allow sound decision making about environmental and land use issues. Multi-disciplinary studies should be organized where possible because they allow sharing of logistics and better interpretation of the data. Multi-disciplinary studies were recommended as a high priority in the following areas:

- Snag/Stewart River (bedrock and surficial geology, airborne geophysics)
- Finlayson Lake (bedrock mapping, regional geophysical surveys, mineral deposit studies)
- Nadaleen River (bedrock mapping of Proterozoic rocks, airborne magnetic surveys)

- Blow River (bedrock mapping, evaluation of petroleum and mineral potential)
- Eagle Plains (surficial mapping, evaluation of oil and gas potential)
- Carmacks and Aishihik areas (bedrock mapping, surficial and placer potential mapping, localized radiometric studies at Apex Mountain, Minto and Williams Creek, and mineral deposit studies of Dawson Range porphyry deposits)
- Tombstone Plutonic Suite (geophysical and mineral deposit studies, in conjunction with surficial mapping in Dublin Gulch area)

2. In order to solve particular structural, stratigraphic or tectonic problems, a total of 61 sheets were recommended as a high priority for 1:50 000 scale mapping (see Table 1).

3. Mapping of placer potential is urgently needed to develop new placer gold reserves. A larger proportion of research funding should be allocated for placer-related research.

4. With the large amount of detailed information now available, regional-scale compilations are required. The production of a Yukon geological atlas, consisting of a series of 1:500 000 scale maps, was proposed for 1998.

5. Assessment reports are an important source of data, but are currently under-utilized due a long standing policy that they can remain confidential indefinitely, as long as a single claim remains in good standing. Participants agreed that changes to the current policy should be investigated. A finite confidentiality period for assessment reports would bring Yukon into line with the rest of Canada. Opinions on a desirable length for the confidential period ranged from 3 to 10 years, with a consensus at around 5 years' duration. There was also general agreement that industry would benefit if 100% of work was filed, as in Quebec.

6. Mineral district studies, broad metallogenic studies and comparative studies are required in certain areas. The highest priorities are the Dawson Range porphyry deposits, the gold deposits in the Tombstone Plutonic Suite, massive sulphide deposits in Yukon-Tanana Terrane and high grade silver-lead veins in the Keno Hill district.

7. Till geochemistry is a useful indicator of buried mineral deposits in glaciated areas and is also important for background environmental studies. Till sampling programs should be carried out in conjunction with all surficial mapping in glaciated areas.

8. Studies of oil and gas potential in the Beaufort Sea-Mackenzie Delta Region and the Eagle Fold Belt were assigned a high priority, based on exploration which is expected within the next 5 to 10 years.

9. Gaps in regional geochemical and airborne magnetic surveys should be filled to assist with interpretation of regional metal background and structure and to allow completion of the Canada-wide database.

10. Airborne multi-sensor gamma ray-EM-magnetic surveys, although expensive, are required to elucidate geology and structure and indicate mineral potential in poorly exposed areas such as Snag-Stewart River, Tintina Trench, Finlayson Lake and southern Nash Creek.

TABLE 1. SUMMARY OF RECOMMENDED WORK.

	HIGH PRIORITY	MEDIUM PRIORITY	LOW PRIORITY
BEDROCK MAPPING-1:250 000 SCALE	Blow River - 117A-D; Lansing - 105N, W/2; Nadaleen - 106C; Frances Lake - 105H; Wolf Lake - 105B; Stewart River - 115 N&O; McQuesten - 115P; Snag - 115 J&K; Dezadeash - 115A	Old Crow - 116O&N; Bell River - 116P Nash Creek - 106D; Larsen Creek - 116A; Watson Lake - 105A	Coal River - 95D; Aishihik Lake - 115H; Carmacks - 115I; Glenlyon - 105L; Lake Laberge - 105E; Whitehorse - 105D
BEDROCK MAPPING-1:50 000 SCALE	Blow River - 117A/1,8,13,14; Herschel - 117D4,8 Wernecke - 106E/1,2,7,8; 106F/4; 106E/4; 116H/1 Nadaleen - 106C/1,2,3,4 Larsen/Nash - 106D/5,6; 116A/3,4,5,6,7,8,12 Finlayson/Frances - 105H/4,5; 105G/7,8,9,10 Lapie River - 105F/15 Whitehorse - 105D/1 Division Mountain - 105E/5; 115H/8 Carmacks - 105E/13,14; 105L/3,4; 115I/1,2,7,10,11 Beaver Creek - 115F/16; 115G/13,14; 115K/1,2,7,8; 115J/5,12 Kluane - 115F/7,8,9,10,15; 115G/5,12	Nadaleen - 105C/5,6,11,12 Larsen - 116A/9 Whitehorse - 105D/8,9 Mendenhall - 115H/1 Apex Mountain - 115J/8 Dezadeash - 115A/2,3,6,11,13; 115B/16	Nadaleen - 106C/7,8,9,10,15,16 Ketza River - 105F/9 Whitehorse - 105D/7,10
MINERAL DEPOSIT STUDIES	Precious metals associated with Tombstone Suite Porphyry Cu/Au systems in Dawson Range VMS deposits in Yukon-Tanana Terrane Data compilation in Keno Hill camp	Mesothermal shear-zone hosted gold deposits Wheaton River gold district Mantos (e.g. Ketza-Seagull type) Industrial Minerals	Wernecke Breccias; Magmatic Cu/Ni/PGM; Tungsten skarns; Coal; Epithermal gold along Tintina Fault; Cu/Au skarns; Mississippi Valley & Blende type Zn/Pb deposits; Sedex Ni; Dimension Stone; Jade; Asbestos; Tin; Sedimentary iron formation; Uranium; Rare Earths
REGIONAL SURVEYS-1:250 000 SCALE	Complete NGR coverage south of 65°30'N - La Biche River - 95C; Coal River - 95D; Flat River - 95E; Watson Lake - 105A (east half); Bonnet Plume - 106B; Nadaleen - 106C (east half); Snake River - 106F (south half)	Reanalysis of NGR samples for additional elements. New aeromagnetic surveys in Nadaleen - 106C (west half); Nash - 106D (north half); Wind River - 105E (south half); Snake River - 106F (southwest quarter); Infill survey in Mayo - 106M; Reprocessing of existing data in Larsen - 116A (north half); Dawson - 116B (north half); Ogilvie 116F&g (south half); Hart River - 116H (south half)	
REGIONAL SURVEYS-1:50 000 SCALE	Fine fraction sampling and gold analyses: Tombstone-McQuesten area; Dawson Range; Marsh Lake-Skukum-Wheaton area; Rancheria; Wellgreen. Airborne multisensor gamma ray-EM-mag surveys - Tintina Trench; Snag-Stewart - 115J&K, 115N&O; Finlayson area; Marg deposit	Airborne gamma ray-mag-VLF surveys: Minto-Williams Creek; Tombstone-McQuesten; Apex Mountain; Mactung-Cantung; Wernecke Breccias. Soil/drift geochemical sampling and mapping. Purchase and compilation of existing private sector geophysical data.	Fine fraction sampling and platinum analyses. Lithogeochemical sampling and analysis.
REGIONAL SURVEYS-OTHER	Filing of 100% of private sector work for assessment.	Heavy mineral concentrate studies. Geochron studies of Tombstone Suite, Aishihik Suite, Nansen/Carmacks suite, in conjunction with 1:50 000 mapping.	Remote sensing studies. Sulphate testing studies. Biogeochemistry. Yukon atlas. GIS development.
SURFICIAL MAPPING-1:250 000 SCALE	Eagle River - 116I Bell River - 116P Snag/Stewart River. 116O+N	N/A	La Biche R. - 95C; Coal R. - 95D; Flat R. - 95E; Watson L. - 105A; Wolf L. - 105B; Lansing - 105N; Niddery L. - 105O; Bonnet Plume - 106B; Nadaleen - 106C; Nash Ck - 106D; Wind R. - 106E; Snake R. - 106F; Trail R. - 106K&L; Ogilvie R. - 116F&G; Porcupine River - 116 J&K
PLACER POTENTIAL STUDIES-1:50 000 SCALE	Snag/Stewart - 115J,K,N,O * Dawson Range - 115H (north half) and 115I (south half) Dublin Gulch - 105M/13; 106D/4; 115P/16; 116A/1	N/A	N/A

TABLE 2. DELEGATE LIST

Abbott, Grant	DIAND/ Canada-Yukon Geoscience Office
Bremner, Trevor	Northern Affairs Program
Carne, Rob	Archer, Cathro and Associates (1981) Ltd
Colvine, Sandy	Geological Survey of Canada, Vancouver
Copland, Hugh	Northern Affairs Program
Duk-Rodkin, Alejandra	Terrain Sciences Division, GSC, Calgary
Fuller, Ted	Canada-Yukon Geoscience Office
Garrett, Bob	Geological Survey of Canada, Ottawa
Gordey, Steve	Geological Survey of Canada, Vancouver
Hart, Craig	Canada-Yukon Geoscience Office
Hein, Fran	University of Calgary
Hill, Rod	Government of Yukon, Energy and Mines Branch
Hulstein, Roger	Kennecott Canada Inc.
Jackson, Lionel	Geological Survey of Canada, Vancouver
Johnston, Steve	Canada-Yukon Geoscience Office
Kowalchuk, John	Canada-Yukon Geoscience Office
LeBarge, Bill	Northern Affairs Program
MacKay, Gord	MacKay, Falkiner and Associates
Morison, Steve	Northern Affairs Program
Mortensen, Jim	University of British Columbia
Murphy, Don	Canada-Yukon Geoscience Office
Paradis, Susan	Geological Survey of Canada, Vancouver
Pigage, Lee	LCP Consultants/Wheaton River Minerals
Power, Mike	Amerok Geophysics
Roots, Charlie	GSC/Canada-Yukon Geoscience Office
Schmidt, Stuart	Klondike Placer Miners' Association
Schultz, Carl	Hemlo Gold Corp.
Shives, Rob	Geological Survey of Canada, Ottawa
Stroshein, Robert	YGC Resources Ltd
Tempelman-Kluit, Dirk	Formerly Geological Survey of Canada, Vancouver
Teskey, Dennis	Geological Survey of Canada, Ottawa
Thorkelson, Derek	Canada-Yukon Geoscience Office

Major contributions were later received from:

Larry Lane	Geological Survey of Canada (Calgary)
Alain Plouffe	Geological Survey of Canada (Ottawa)

INTRODUCTION

Since the discovery of gold in the Klondike on August 17, 1896, mining has been Yukon's most important industry, and will continue to be a major source of revenue and a major employer of Yukoners into the 21st century. Geoscientific research is critically important to the discovery of new mineral deposits and is becoming increasingly important as a basis for land claim negotiations, land use decisions and the assessment of environmental impacts. Many pressing environmental, mineral resource, geologic hazard and urban planning issues can only be resolved adequately with a good geological database. To be useful in resolving these problems, geological maps must represent modern geologic thought and be of adequate scale. As concepts and information change, geological mapping must be continually updated so that accurate information is available when specific decisions need to be made. A good geological database takes time to develop and can not be ordered up overnight.

The U.S. clearly recognizes the importance of a national geoscience database. The National Geologic Mapping Act of 1991 calls for systematic geological mapping of the entire United States, at a scale of 1:24 000 in most areas. The Federal Geographic Data Committee was recently established to coordinate the collection and sharing of geologic and other geographically referenced data Several states including Alaska have recently solicited public input on the role of their geological surveys and the best way to meet the geoscience needs of their citizens.

At the present time, the mandate for geoscience in Yukon is shared among three major organizations: Geological Survey of Canada, Indian and Northern Affairs Canada (DIAND) and Government of Yukon. Various Canadian universities also play a significant role. With the settlement of Land Claims, Yukon First Nations are important new stakeholders in the Yukon mining industry and will also become increasingly involved in geoscientific research as they explore and develop mineral resources on their lands.

The organizations responsible for creating and maintaining Yukon's geoscience database are currently being buffeted by winds of change which have reached gale force. The Geological Survey of Canada is facing major cutbacks in staff and financial resources. The sun is setting on the Canada-Yukon Mineral Development Agreement, due to expire in March, 1996. Increasingly, DIAND's and Government of Yukon's energies are being absorbed by the demands of new clients including park planners, environmental review committees, policy analysts, land use planners and First Nations. New legislation including changes to the Quartz and Placer Mining Acts and the implementation of land use regulations on mineral claims will accelerate these demands. At the same time, Geoscience is tasked with maintaining Yukon's economic base at a time when mineral exploration is becoming increasingly sophisticated, requiring large inputs of data, new technology, and the development of new scientific concepts to find deposits which may have no surface expression.

In this context, a workshop was proposed by the Geological Survey of Canada and the Yukon Chamber of Mines to coordinate the efforts of the agencies currently engaged in geoscientific data gathering and research, to establish concrete goals for future research and to involve industry in the planning process. The workshop was modelled on a seminar pioneered by the B.C. Geological Survey and the Geological Survey of Canada in 1993. On April 25 and 26, 1995, thirty two government and industry geoscientists currently working in Yukon met at Marsh Lake, Yukon to prepare a blueprint of Yukon's geoscience needs for the next five to ten years. Five out of seven divisions of the Geological Survey of Canada were represented, as well as DIAND, Government of Yukon, Canada-Yukon MDA Program, Yukon Chamber of Mines, Yukon Prospectors' Association, Klondike Placer Miners' Association, University of British Columbia and University of Calgary.

Mining companies active in Yukon were represented by Archer, Cathro and Associates (1981) Ltd, Hemlo Gold Corp., Kennecott Canada Inc. and YGC Resources Ltd.

Participants were divided into three working groups covering (1) Bedrock Geology and Mineral Deposit Studies (2) Surficial, Environmental and Placer Geology and (3) Regional Geophysical and Geochemical Surveys. The recommendations of the three working groups were discussed at a plenary session and a draft report was prepared and circulated to all of the delegates for comment. This second draft is being circulated widely to other researchers and explorationists, and following further revisions the resulting document is intended to represent a consensus between industry and government, and will be used by all participating agencies in planning their work over the next 5 to 10 years.

We believe that this joint planning and harmonization of goals among different government agencies will prevent duplication of services, encourage sharing of resources and ideas and improve product design and program delivery. The successful completion of this process also represents an important first step in the devolution of mining administration from DIAND to Government of Yukon. We are confident that the recommendations made are in the best interests of Yukon.

COMMENTS BY SPONSORING ORGANIZATIONS

The workshop opened with four speakers who were asked to explain their organizations' geoscience priorities and how they see the future of geoscience in Yukon. The views presented in this session provided a framework for the discussions which followed, and are included even though in some cases they conflict with the consensus reached during the subsequent sessions. The speakers were Steve Morison, Director of Mineral Resources (DIAND), Bill Oppen, Deputy Minister of Economic Development (Government of Yukon), Sandy Colvine, Director (Geological Survey of Canada - West Coast), and Gregg Jilson, President, Yukon Chamber of Mines.

The present Canada-Yukon Mineral Development Agreement is a cooperative venture between DIAND and Government of Yukon, with assistance from the Geological Survey of Canada. By March, 1996 the current 5 year program will have produced 22 bedrock geology maps at a scale of 1:50 000 and three airborne geophysical surveys as well as a number of special studies. It has also enabled almost complete stream sediment geochemical coverage of the Yukon Territory south of 64.5 degrees. The regional stream sediment geochemistry was instrumental in Noranda's 1987 discovery of the 21 million tonne Brewery Creek gold deposit and Cominco's 1994 discovery of the 13 million tonne Kudz Ze Kayah massive sulphide deposit. Continuation of this work is a major concern for all three government organizations and for the mining industry.

DIAND currently funds Yukon Geoscience through a 70% contribution to the MDA Geoscience program, and is currently responsible for mining administration in Yukon. This role is rapidly becoming more complex as a result of new legislation such as the Canadian Environmental Assessment Act, the Development Assessment Process, the Yukon Placer Authorization, the Surface Rights Act, the Land Claim Settlement Act, and pending changes to the Yukon Quartz and Placer Mining Acts and associated regulations. DIAND currently maintains or is developing databases of mineral deposits, placer occurrences, and active geological processes. These databases are designed both to assist the mineral exploration industry and to assist with in-house environmental reviews. DIAND also conducts placer and mineral deposit studies as resources permit.

Government of Yukon manages and contributes 30% to the cost of the MDA Geoscience program and has a stated commitment to providing a level of government geoscience comparable to other jurisdictions in Canada in order to promote economic development. It also provides financial incentives for prospecting and mineral exploration and provides geological advice to prospectors and junior mining companies. Government of Yukon has also made a commitment to carry out mineral resource assessments prior to the creation of parks and special management areas.

Devolution of mining administration from DIAND to Government of Yukon to form a Yukon Department of Mines is currently a high priority with both organizations and will result in the continuation of geoscientific studies which are the key to a healthy and sustainable mining industry.

The Geological Survey of Canada (GSC) is a major reservoir of geoscientific expertise but is currently undergoing major change, with downsizing and cuts to operating budgets. In response to these changes, GSC is setting up agreements with provincial and territorial governments and is adopting direct client response and cost recovery systems. In the past GSC has provided the framework geological mapping and aeromagnetic surveys for the whole Yukon, multi-element silt geochemical coverage over much of the Territory, regional surficial mapping and a host of special studies. Its continued presence is essential for Yukon's economic development. The West Coast division of the newly restructured organization is committed to serving the

whole of the Cordillera and to providing geoscientific interpretation and synthesis.

The Yukon Chamber of Mines represents a variety of large and small mining companies and prospectors active in Yukon. It sees the value of geoscience as helping its members find mines. The Chamber prefers to see government funds spent on projects where mining companies can not compete, such as 1:50 000 scale bedrock mapping, surficial mapping, regional geochemical and aeromagnetic surveys, and data compilation and regional synthesis. The value of regional syntheses derives from their low cost, large areal coverage and their common legend. The Chamber would like to see an atlas of Yukon geoscience data (seven 1:500 000 maps with a common legend, remote sensing images and geochemistry). Although the Chamber of Mines does not directly represent the Placer Mining Industry, it would like to see spending on placer and surficial geology increased to one sixth of all government funding for geoscience, based on the proportion of total mining dollars contributed by the placer industry.

The Chamber of Mines does not support the involvement of Government geoscience agencies in mineral assessments or property-scale studies and thinks in general mining companies should pay for their own environmental studies. The Chamber believes that the cost of mineral assessments for areas to be withdrawn as parks etc. should be borne by the proponent agency and the work should be conducted by a contractor. The Chamber regards regional geophysical surveys other than aeromagnetic surveys as expensive believes they detract from efforts to understand bedrock geology.

Assessment reports are a valuable resource currently going to waste because of current government policies on confidentiality. Industry has not reached a consensus on how current policies and regulations governing assessment work should be changed but is prepared to continue discussions on this topic. Some suggestions include improving the data by requiring the filing of all work or upgrading the standards for work filed, allowing all government geologists access to the reports, and releasing reports to the public after a fixed time period. Full consultation with industry is requested before implementing any of these changes.

The Chamber perceives that Yukon geoscience is currently splintered among several agencies. This will be improved as a result of devolution, and improved communication such as the present workshop.

BEDROCK MAPPING AND MINERAL DEPOSITS

INTRODUCTION

This sub-group consisted of co-chairs Grant Abbott (DIAND) and Steve Gordey (Geological Survey of Canada), along with participants Rob Carne (Archer, Cathro and Associates (1981) Ltd), Sandy Colvine (Geological Survey of Canada, Vancouver), Steve Gordey (Geological Survey of Canada, Vancouver), Craig Hart, (Canada-Yukon Geoscience Office), Steve Johnston, (Canada-Yukon Geoscience Office), Jim Mortensen (University of British Columbia), Don Murphy (Canada-Yukon Geoscience Office), Susan Paradis (Geological Survey of Canada, Vancouver), Lee Pigage (LCP Consultants/Wheaton River Minerals), Charlie Roots, (GSC/Canada-Yukon Geoscience Office), Dirk Tempelman-Kluit (Former Director, Geological Survey of Canada, Vancouver) and Derek Thorkelson (Canada-Yukon Geoscience Office). Larry Lane (GSC Calgary) did not attend the session but subsequently provided valuable input regarding bedrock mapping in the North Yukon.

WHY GEOLOGIC MAPS?

Geologic maps are the primary geoscience information source for nearly all land-based investigations. Geoscience information portrayed on such maps is vital in the search for new mineral resources. It is instrumental in rationalizing new mineral exploration programs and in selecting and narrowing potential exploration targets. These maps however, are also playing an increasingly important role as a basis of decision making on other societal values including land evaluation and planning (park siting, land claims), hazard awareness, and locally tourism values. The publication of geologic maps through government agencies serves as an unbiased public infrastructure for all users.

Geologic maps portray not only base-line geologic information, but inherently contain a large component of interpretation that reflects the methodologies, techniques and scientific paradigms prevailing at the time they are made. They are increasingly becoming multidisciplinary products which require input from a wide variety of disciplines. All of the component disciplines (e.g. paleontology, geochronology, structural geology and others), like all scientific endeavours, have experienced rapid advances in technology and development of new techniques and theories. A geologic map is therefore not static. Depending on the integrity of its original preparation and its vintage it will require varying degrees of reinterpretation and collection of new data to maintain its relevance. Because of the interpretive aspect, experience in the geology of the region is necessary to enable the geologist to produce the best possible product.

A geological mapping project must strike a balance between the degree of detail versus the aerial extent of map coverage desired. Mapping of a small area in relative detail (detailed or 1:50 000 scale mapping) serves to resolve more specific geologic problems and to more narrowly and precisely define geologic units. Coverage of larger areas (framework or 1:250 000 scale mapping) in the same time frame allows resolution of broader scale geologic problems and establishes regional continuity of geologic entities. It also serves to outline where further more detailed work may be necessary. To maintain and upgrade the geoscience information base at a timely rate both scales of investigation are critical. A third type of investigation, thematic mapping, at both large and small scales, focuses on a single geologic problem, structure or unit. Although there are many areas in Yukon where the general distribution of rock units and structures is not well enough known pursue thematic studies at the present time, thematic and topical studies are expected to become increasingly important in the future.

PRESENT GEOLOGICAL MAP COVERAGE OF YUKON

Systematic geological mapping coverage in Yukon began in 1929 in the Laberge area of central Yukon. From this time until about 1957, about one quarter of the Yukon was mapped at 1:250 000 scale using teams of packhorses and fixed wing aircraft for logistics. It was arduous work carried out at a slow rate. The application of helicopters to regional mapping in about 1958 revolutionized the pace of mapping. In responding to the need of the day for a first-order assessment of the main geological elements of the territory, huge tracts were covered in short periods of time. This initial reconnaissance of most of the rest of the Yukon was completed by 1972, covering an area about three times that covered by packhorses, and accomplished in about half the time. A slower paced program of revision framework mapping began in 1973 to address the shortfalls of the earlier work and continues to the present. The use of microfossils to determine geologic age, technological advances in isotopic dating and the advent of plate tectonic theory were all applied to this revision mapping and led to a quantum leap in our understanding and interpretation of parts of Yukon geology.

The earliest systematic 1:50 000 scale maps were produced by the GSC in the Keno Hill Camp in the 1950's and 1960's, and in the Tombstone Range near Dawson in response to the need to aid mineral exploration and development. Very little work followed until the 1980's when a variety of areas were mapped by GSC and DIAND personnel in response to the need to assist mineral exploration and development, and in the normal course of framework mapping where sufficient complexity and exposure warranted. In 1984, the first Mineral Development Agreement was initiated in the Yukon and 1:50 000 scale mapping commenced on a regular more systematic basis. The first MDA program used short term contractors to undertake the mapping, but deficiencies with this process led to the establishment of the Canada/Yukon Geoscience Office in 1990, jointly funded by DIAND (70%) and Government of Yukon (30%). Since then mapping under the MDA has been undertaken by permanent employees based in Whitehorse, managed by Government of Yukon.

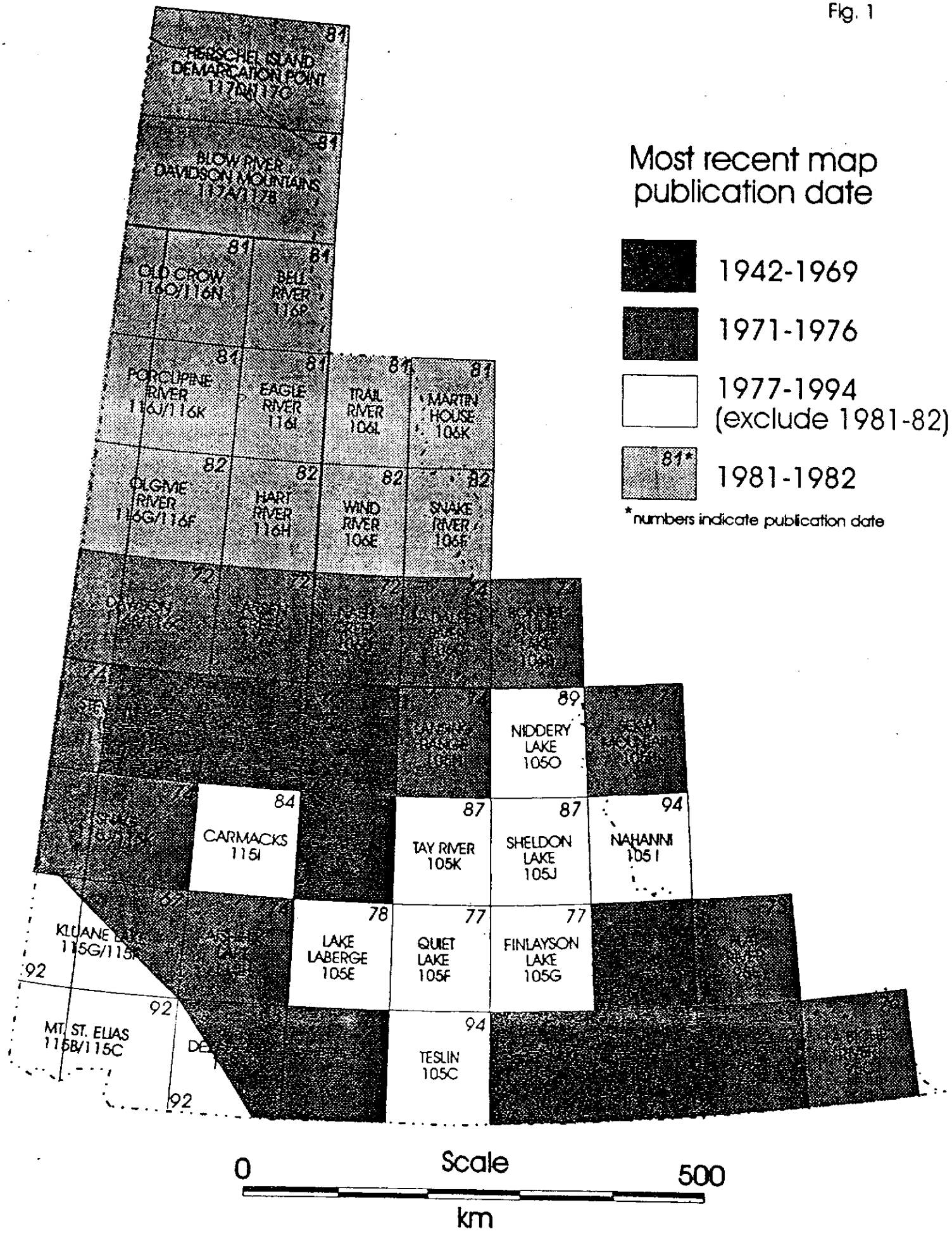
The 1950 and 60's vintage GSC maps were produced in full colour and accompanied by comprehensive reports. Later maps are all monochrome blue line copies without reports. Maps produced by the MDA are accompanied by comprehensive reports.

The legacy of this history of mapping is a checkerboard of geologic maps of different vintages and quality. As well, some areas have written reports that amplify and expand significantly on the map information, whereas others do not. For some areas the available map is coloured, for others it is black and white. Figures 1-5 illustrate the vintage of the mapping, presence of accompanying reports, current framework mapping project areas, and the availability of colour versus black and white maps.

CRITERIA FOR RANKING

Areas were selected for bedrock geologic mapping through assessment of relative scientific need. This included targeting areas where existing geologic information is inadequate, as well as areas to resolve specific geologic problems. Although not mutually exclusive in what they address, regional or framework (1:250 000) mapping tends to address the former need, whereas detailed (1:50 000) mapping is more suited to the latter. Areas were ranked by group consensus in terms of high, medium, and low priority corresponding to relative immediacy of attention they should receive. Unranked areas are presently considered adequate in terms of their geoscience information base. It was recognized that unforeseen

Fig. 1


Most recent map publication date
1942-1969
1971-1976
1977-1994 (exclude 1981-82)
81*
1981-1982
*numbers indicate publication date
81
REISCHEL ISLAND DEMARCATION POINT 117D/117C
BLOW RIVER DAVIDSON MOUNTAINS 117A/117B
OLD CROW 116O/116N
BELL RIVER 116P
PORCUPINE RIVER 116J/116K
EAGLE RIVER 116I
TRAIL RIVER 106L
MARTIN HOUSE 106K
82
OLGIVIE RIVER 116G/116F
HART RIVER 116H
WIND RIVER 106E
SNAKE RIVER 106F
72
74
89
NIDDERY LAKE 105O
84
CARMACKS 115I
87
TAY RIVER 105K
SHELDON LAKE 105J
94
NAHANNI 105I
78
LAKE LABERGE 105E
77
QUIET LAKE 105F
FINLAYSON LAKE 105G
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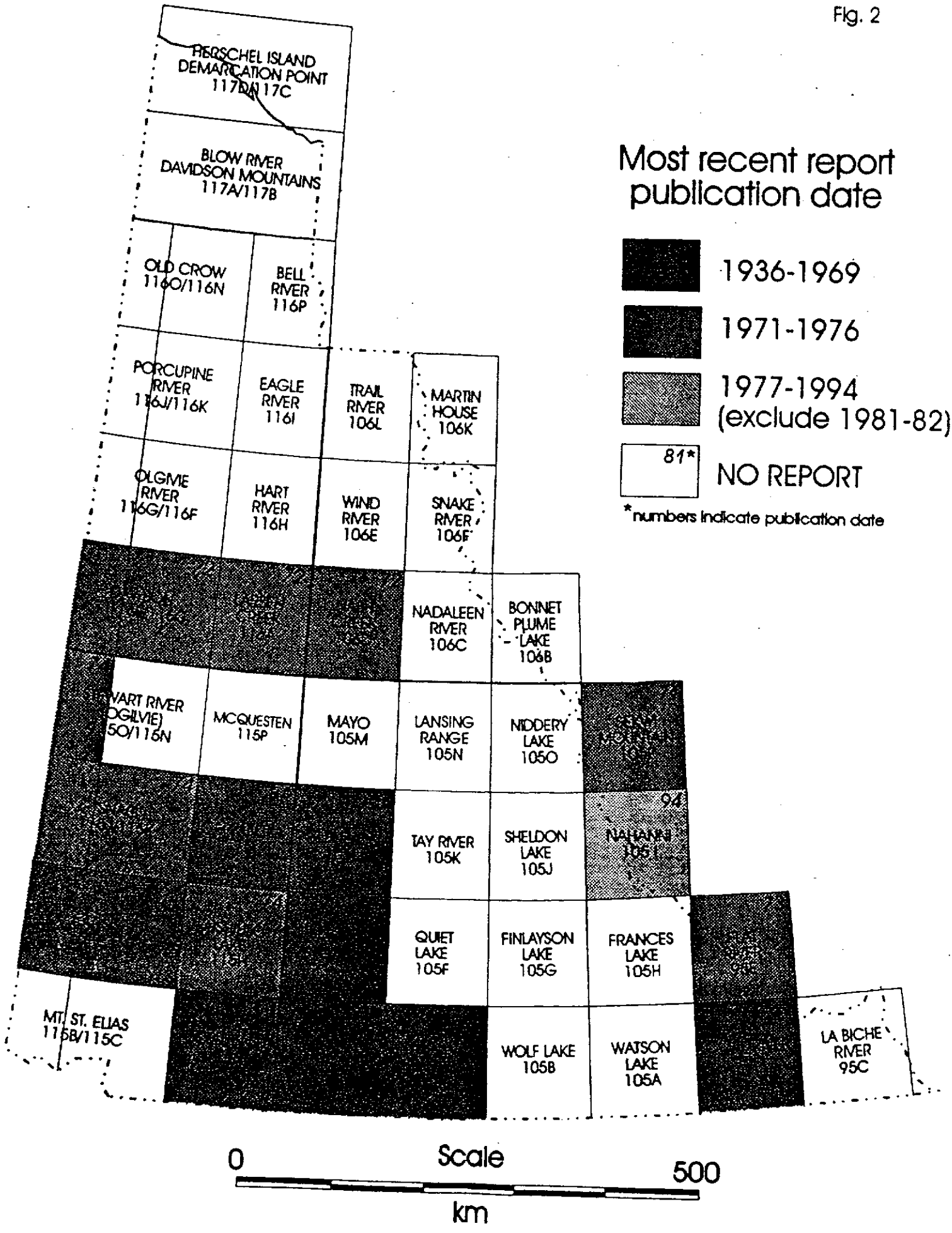
MT. ST. ELIAS 115B/115C
TESLIN 105C
0
Scale
500
km

Fig. 2


HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
BLOW RIVER
DAVIDSON MOUNTAINS
117A/117B
OLD CROW
116O/116N
BELL
RIVER
116P
PORCUPINE
RIVER
116J/116K
EAGLE
RIVER
116I
TRAIL
RIVER
106L
MARTIN
HOUSE
106K
OGILVIE
RIVER
116G/116F
HART
RIVER
116H
WIND
RIVER
106E
SNAKE
RIVER
106F
NADALEEN
RIVER
106C
BONNET
PLUME
LAKE
106B
VART RIVER
OGILVIE)
5O/116N
MCQUESTEN
115P
MAYO
105M
LANSING
RANGE
105N
NIDDERY
LAKE
105O
94
NAHANNI
105I
TAY RIVER
105K
SHELDON
LAKE
105J
QUIET
LAKE
105F
FINLAYSON
LAKE
105G
FRANCES
LAKE
105H
MT. ST. ELIAS
115B/115C
WOLF LAKE
105B
WATSON
LAKE
105A
LA BICHE
RIVER
95C
Most recent report publication date
1936-1969
1971-1976
1977-1994
(exclude 1981-82)
81*
NO REPORT
*numbers indicate publication date
0
Scale
500
km

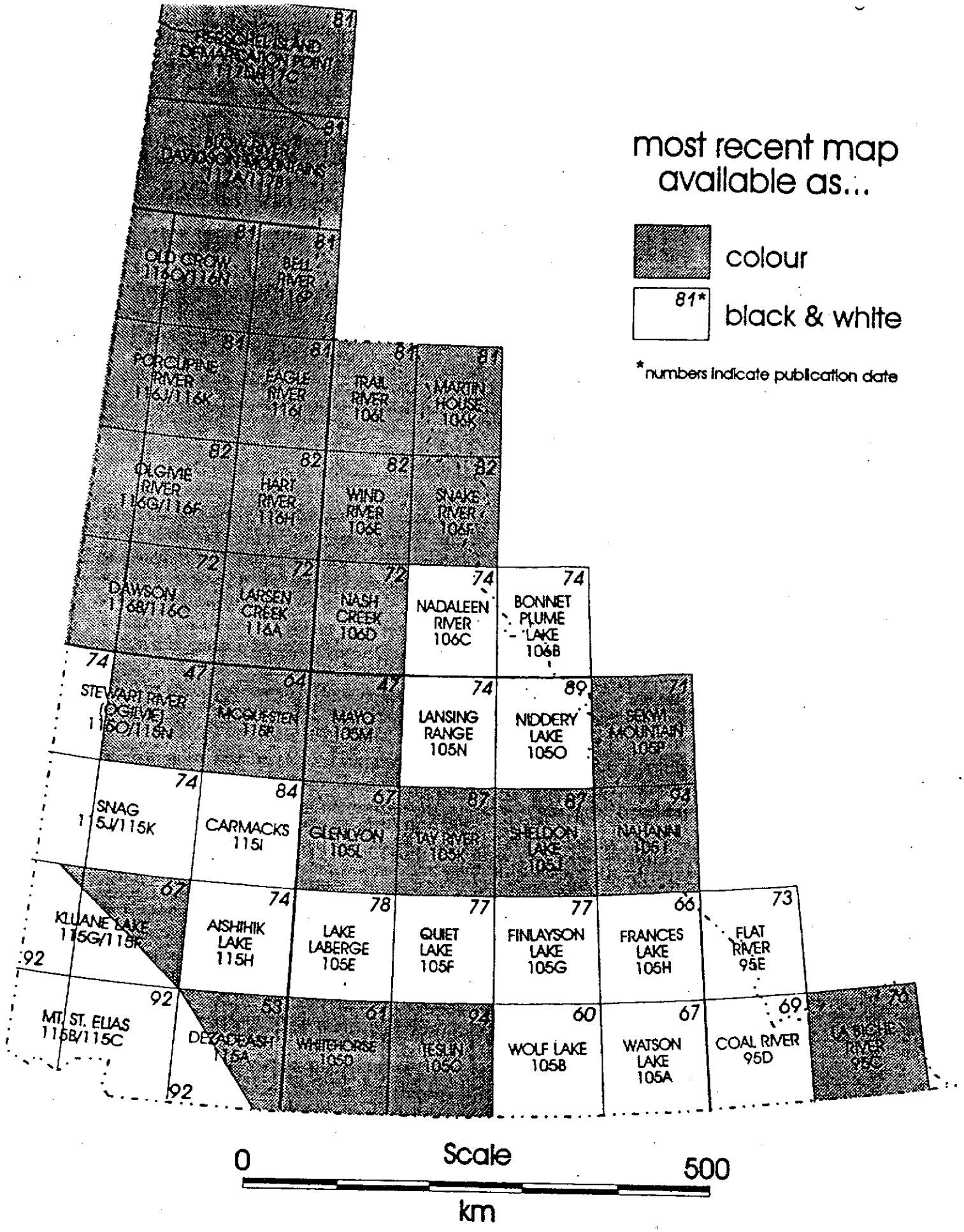
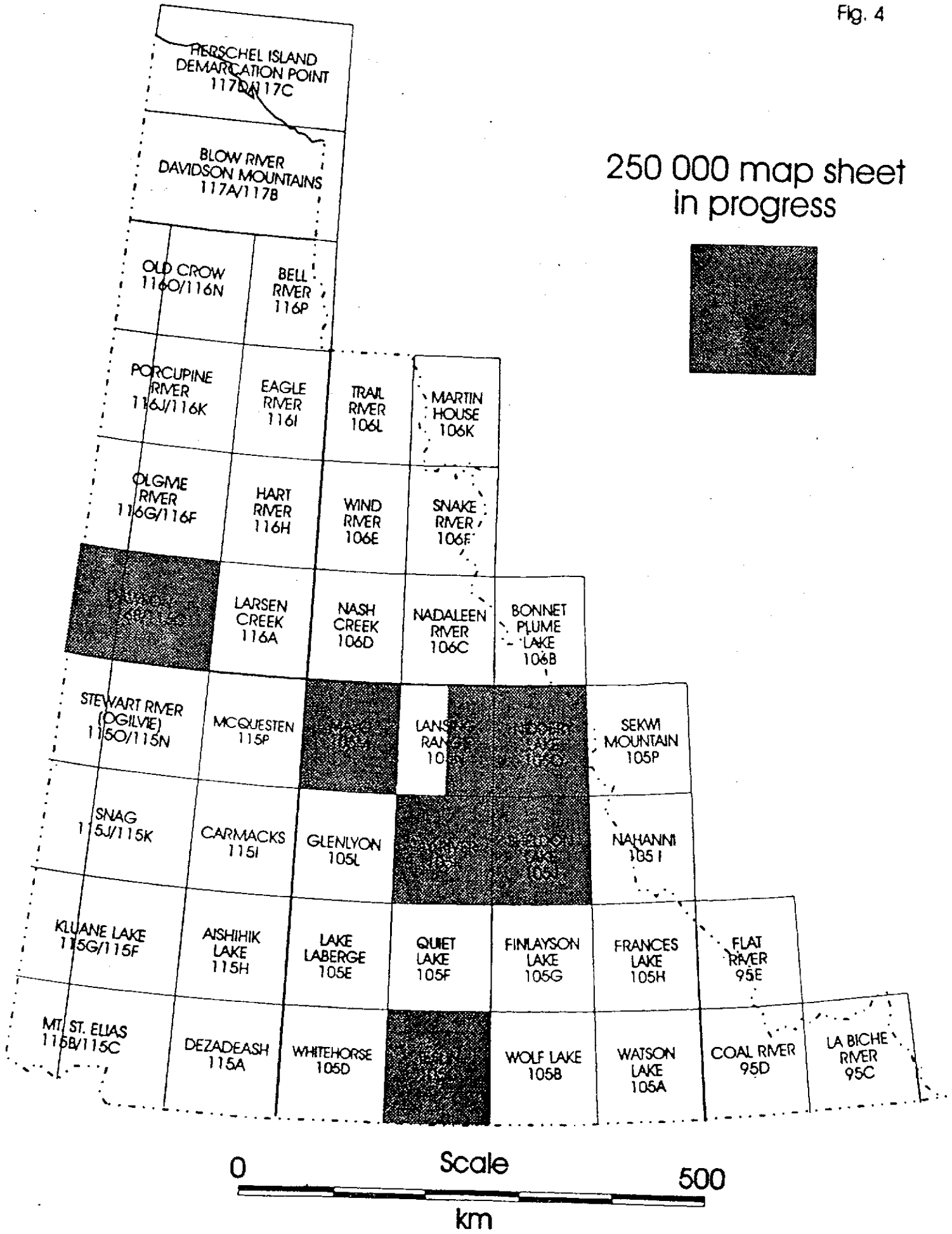

most recent map available as...
colour
81*
black & white
*numbers indicate publication date
81
PERSHEL ISLAND DEMARCATION POINT 117B/117C
81
FLOOD RIVER DAWSON MOUNTAINS 117A/117B
81
OLD CROW 116O/116N
81
BELL RIVER 116P
81
PORCUPINE RIVER 116J/116K
81
EAGLE RIVER 116I
81
TRAIL RIVER 106L
81
MARTIN HOUSE 106K
82
OGILVIE RIVER 116G/116F
82
HART RIVER 116H
82
WIND RIVER 106E
82
SNAKE RIVER 106F
72
DAWSON 116B/116C
72
LARSEN CREEK 116A
72
NASH CREEK 106D
74
NADALEEN RIVER 106C
74
BONNET PLUME LAKE 106B
74
STEWART RIVER (OGILVIE) 116O/116N
47
MCQUESTEN 116P
47
MAYO 105M
74
LANSING RANGE 105N
89
NIDDERY LAKE 105O
74
SELKIRK MOUNTAIN 106P
74
SNAG 115J/115K
84
CARMACKS 115I
67
GLENLYON 105L
67
TAY RIVER 105K
67
SHELDON LAKE 105J
94
NAHANNI 106I
67
KLUANE LAKE 115G/115F
74
AISHIHIK LAKE 115H
78
LAKE LABERGE 105E
77
QUIET LAKE 105F
77
FINLAYSON LAKE 105G
66
FRANCES LAKE 105H
73
FLAT RIVER 95E
92
92
MT. ST. ELIAS 115B/115C
93
DEZADEASH 115A
61
WHITEHORSE 105D
94
TESLIN 105C
60
WOLF LAKE 105B
67
WATSON LAKE 105A
69
COAL RIVER 95D
70
LA BICHE RIVER 95C
92
0
Scale
500
km

Fig. 4


HERSCHEL ISLAND
DEMARCATION POINT
117B/117C
BLOW RIVER
DAVIDSON MOUNTAINS
117A/117B
OLD CROW
116O/116N
BELL
RIVER
116P
PORCUPINE
RIVER
116J/116K
EAGLE
RIVER
116I
TRAIL
RIVER
106L
MARTIN
HOUSE
106K
OLGMIE
RIVER
116G/116F
HART
RIVER
116H
WIND
RIVER
106E
SNAKE
RIVER
106F
LARSEN
CREEK
116A
NASH
CREEK
106D
NADALEEN
RIVER
106C
BONNET
PLUME
LAKE
106B
STEWART RIVER
(OGILVIE)
115O/115N
MCQUESTEN
115P
SEKWI
MOUNTAIN
105P
SNAG
115J/115K
CARMACKS
115I
GLENLYON
105L
NAHANNI
105I
KLUANE LAKE
115G/115F
AISHIHIK
LAKE
115H
LAKE
LABERGE
105E
QUIET
LAKE
105F
FINLAYSON
LAKE
105G
FRANCES
LAKE
105H
FLAT
RIVER
95E
MT. ST. ELIAS
115B/115C
DEZADEASH
115A
WHITEHORSE
105D
WOLF LAKE
105B
WATSON
LAKE
105A
COAL RIVER
95D
LA BICHE
RIVER
95C
250 000 map sheet
in progress
0
Scale
500
km

opportunities such as desired logistical and scientific coordination with other projects, availability of experienced personnel or expertise, as well as budgets, may alter the order in which the suggested projects are accomplished. Mineral industry representatives stressed that a coherent plan to improve the geoscience information base must be followed, and that areas of work focus should not be predicated upon currently hot exploration areas.

SELECTION OF AREAS FOR FRAMEWORK MAPPING (1:250 000 SCALE)

The Yukon Territory is underlain by diverse geological terranes. To date most mineral exploration and geological mapping has been concentrated in the lower half of the Yukon, south of 65°30'N. This is partly for logistical reasons and partly because most of the North Yukon has been off limits to oil and mineral exploration for the last 20 years, pending the settlement of land claims. In the North Yukon, almost all geological work has been carried out by GSC Calgary.

(a) South of 65°30'N

In North American margin strata south of 65°30'N, two main areas were assessed as high priority (Figure 7).

(1) The northern area includes Nadaleen River (106C), Nash Creek (106D) and Larsen Creek (116A) and parts of Lansing (105N) areas (Figure 4). A lack of understanding of Proterozoic stratigraphy and of platform to basin facies changes in Paleozoic strata are the main geological problems in the first three areas mentioned. The Lansing area (105N) includes poorly understood latest Proterozoic and Paleozoic strata. The west half of the area has previously not seen more than one field season of reconnaissance mapping in total, so that stratigraphic and structural understanding of the region at framework mapping scale is singularly poor. Nadaleen River (106C) and west Lansing (105N) areas have the least information available (black and white map only; no reports or marginal notes) and were considered of highest priority within this group.

(2) The second area within North American margin strata is southeast Yukon. This area has not seen geologic work since the initial rapid reconnaissance mapping in the mid-sixties. The understanding of Late Proterozoic and Paleozoic stratigraphy, the distribution of rock units and structural interpretations for this entire area are lacking. Within this group the Frances Lake (105H) and Wolf Lake (105B) areas were considered of highest priority. Geologic relationships more easily deduced in these relatively well exposed areas would provide a better knowledge base with which to tackle the remaining parts of this region. In addition, these areas include parts of Yukon Tanana, Slide Mountain and Dorsey terranes whose compositions and relationships to North American margin strata are enigmatic. Geologic information from the Wolf Lake area and to a lesser extent the Frances Lake area will be critical to evaluating seismic data which will be obtained near these areas by the Lithoprobe SNORCLE transect. About three-eighths of the Wolf Lake area has seen previous 1:50,000 scale mapping. The focus in this area would be to examine those parts not covered at a detailed scale, and to revisit selected localities where previous work can be re-compiled and integrated with the new work into a consistent structural and stratigraphic framework.

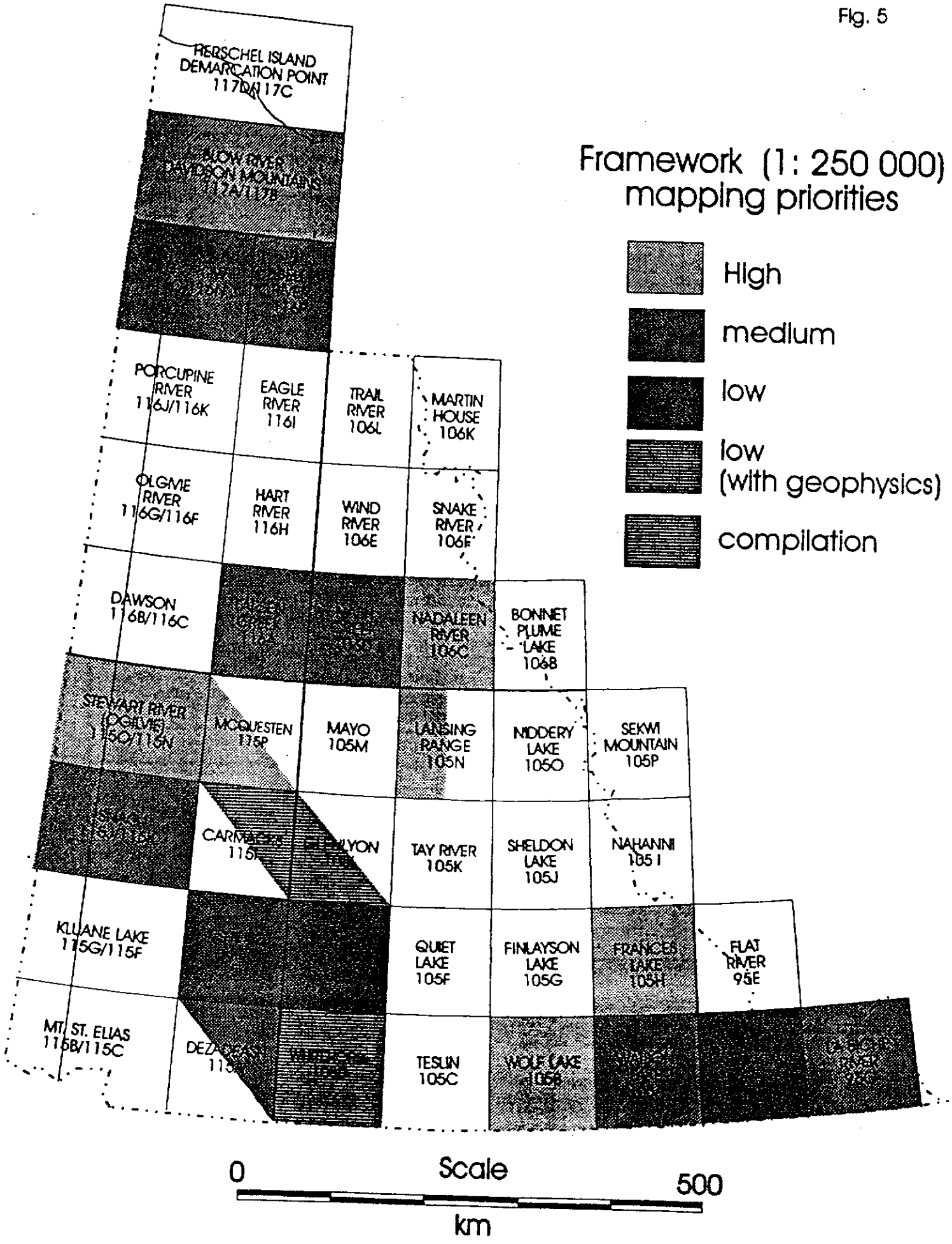
(3) The third high priority area addresses the most poorly understood element of Yukon geology, the Yukon Tanana terrane. This area is underlain by poorly dated Late Proterozoic, Paleozoic and ?Mesozoic sheared and metamorphosed pelitic rocks, marble, quartzite, schist, metavolcanic and metaplutonic rocks. The Yukon-Tanana Terrane is currently of great interest because of Cominco's recent massive sulphide discovery in metavolcanic rocks in the Finlayson Lake area. Prior to the Cominco discovery, the mineral potential of this area was largely overlooked because existing 1:250 000 mapping had failed to separate out the volcanic stratigraphy.

TABLE 3. SUMMARY, FRAMEWORK MAPPING

PRIORITY	NTS	NAME	RATIONALE/PROBLEMS
		North Yukon	
HIGH	117A-D	Blow River	Poorly understood Proterozoic/Paleozoic stratigraphy, revisions necessary to Mesozoic and Tertiary stratigraphy and structure; oil and gas potential; mineral potential, land use planning, Park Boundary and First Nation issues
MEDIUM	116N,O,P	Old Crow	Issues similar to above; lower priority due to poor surface exposure
		North American margin	
HIGH	106C	Nadaleen	Poorly understood Proterozoic/Paleozoic stratigraphy and Mesozoic structure; no available reports.
	105N	Lansing	West half; minimal description and subdivision of late Proterozoic and Paleozoic stratigraphy; no reports; establish continuity between Lansing (east half) and Mayo areas.
	105H	Frances	Late Proterozoic/Paleozoic stratigraphy, Mesozoic structure; relations with Yukon-Tanana and Slide Mountain terranes; well-exposed; unclear relations of Mt Billings batholith as possible core complex; linked to Lithoprobe SNORCLE transect.
	105B	Wolf	Relationship of Dorsey, Yukon-Tanana, Slide Mountain terranes to North America; part new field work, part compilation of pre-existing detailed coverage; critical to Lithoprobe SNORCLE seismic data interpretation.
MEDIUM	106D	Nash	Poorly understood Proterozoic/Paleozoic stratigraphy and Mesozoic structure; available report and interpretations inadequate.
	116A	Larsen	Poorly understood Proterozoic/Paleozoic stratigraphy and Mesozoic structure; available report and interpretations inadequate.
	105A	Watson	Poorly understood Paleozoic stratigraphy; regional correlation along northern Cassiar platform; includes elements of Yukon Tanana-Slide Mountain terranes in uncertain relationship to North America; Tertiary evolution of Liard basin could be addressed in part through geophysics; no report.
	95C	La Biche	Oil and gas interest; Beaver River fault; originally compiled from oil industry data; Paleozoic facies changes; inadequate structural and stratigraphic description; no available report.
LOW	95D	Coal	Regional stratigraphy; Paleozoic facies changes; Mesozoic structural interpretation.

Yukon Tanana Terrane			
HIGH	115N/O	Stewart	Variably sheared metamorphic rocks of poorly constrained age; poorly known distribution of rock units; modern synthesis lacking as area last examined by packhorse in mid-1930's; no report for most of area; high priority if done in conjunction with surficial studies and geophysics.
	115P	McQuesten	Southwest part: variably sheared metamorphic rocks of poorly constrained age; poorly known distribution of rock units; modern synthesis lacking as area last examined by packhorse in mid-1940's; no report; high priority if done in conjunction with surficial studies and geophysics; project could broaden to whole map area to include compilation of recent data for northeast part of McQuesten area with minimal extra fieldwork.
	115J/K	Snag	Variably sheared metamorphic rocks of poorly constrained age; distribution of rock units moderately well known, but re-evaluation of structural interpretation and more geochronology required.
	115A	Dezadeash	Northeast part; metamorphic rocks of poorly constrained age; inadequate existing bedrock information dates to mid-1940's.
LOW	115H	Aishihik	Variably sheared metamorphic rocks of poorly constrained age; distribution of rock units moderately well known; same as Snag area, but information base in better shape because of recent detailed work, so rated as lower priority.
	115INE/ 105LSW	Carmacks/ Glenlyon	Variably sheared metamorphic rocks of poorly constrained age; distribution of rock units moderately well known, but more geochronology and structural interpretation required.
Stikine Terrane			
LOW	105E	Laberge	Least well known of areas underlying Stikine terrane; requires stratigraphic re-investigation with strong paleontological and sedimentological control; includes parts of Yukon Tanana, and enigmatic units of Slide Mountain, Cache Creek? and/or Quesnel terrane affinities.
	105D	Whitehorse	Primarily a compilation project; about half of area already mapped at detail scale.

Fig. 5


Framework (1: 250 000)
mapping priorities
High
medium
low
low
(with geophysics)
compilation
HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
PORCUPINE
RIVER
116J/116K
EAGLE
RIVER
116I
TRAIL
RIVER
106L
MARTIN
HOUSE
106K
OLGIVIE
RIVER
116G/116F
HART
RIVER
116H
WIND
RIVER
106E
SNAKE
RIVER
106F
DAWSON
116B/116C
NADALEEN
RIVER
106C
BONNET
PLUME
LAKE
106B
STEWART RIVER
(DG/LVS)
115O/116N
MCQUESTEN
115P
MAYO
105M
LANSING
RANGE
105N
NIDDERY
LAKE
105O
SEKWI
MOUNTAIN
105P
TAY RIVER
105K
SHELDON
LAKE
105J
NAHANNI
105I
KLUANE LAKE
115G/115F
QUIET
LAKE
105F
FINLAYSON
LAKE
105G
FRANCES
LAKE
105H
FLAT
RIVER
95E
MT. ST. ELIAS
116B/115C
TESLIN
105C
WOLF LAKE
105B
0
Scale
500
km

Fundamental geologic problems within the Yukon Tanana Terrane include the age, distribution, and structural/stratigraphic interpretations of its constituent assemblages, and their relationships to strata of the North American margin. Regionally, the least understood part of the terrane and judged the highest priority, lies within the Stewart River map sheet (115N/O). Previous work consisted of a horse party survey in the mid-1930's supplemented by rapid helicopter reconnaissance of the west third of the area in the early 1970's. Because the area is poorly exposed, it is highly recommended that airborne (gamma ray) geophysics be flown in conjunction with mapping to delimit the subcrop extent of geological units. Without the geophysics, it would be better to leave postpone mapping this area until funding for the geophysics becomes available. The Stewart River area was also considered high priority because of potential scientific and logistical ties to placer-related surficial mapping.

Snag (115J,K) and northeast Dezadeash (115B) map areas are considered of moderate priority and parts of Aishihik (115H), Carmacks (115I) and Glenlyon (105L) of lower priority compared to the Stewart area because of their relatively more up-to-date information base.

Areas within Stikine terrane underlain by Mesozoic volcanic, carbonate and sedimentary rocks were designated as low priority areas. These include the Laberge (105E) and Whitehorse (105D) areas. The northeast part of the former also includes parts of Yukon-Tanana terrane, as well as enigmatic volcanics of uncertain affinity that may belong to Slide Mountain, Quesnel or Cache Creek terranes. Half of the Whitehorse map sheet (105D) is mapped at 1:50 000 scale, so that this project would involve compilation supplemented by a relatively small field component to examine remaining portions and visit selected critical localities within areas previously mapped.

(b) North of 65°30'N

In this area the main issues recognized were mineral resources (coal, oil and gas, uranium, tungsten and molybdenum skarns and porphyries, barite, iron formations, gold and rare minerals) and land use (parks).

A large part of the area has been withdrawn from staking as a result of land claims and the creation of parks and special management areas, but huge resources of iron, phosphate, manganese and coal have been documented in the Rapid Creek area and the adjoining part of the northwest territories, and there is indicated potential for gold porphyry and syngenetic base metal deposits. A large tract of land currently withdrawn from staking is due to be released following the settlement of the Inuvialuit claim. There has been pressure to expand the National Park in this area and a proposal has been made to undertake land use planning prior to lifting the land withdrawl order. Obviously a mineral potential study should be carried out as the basis of the land use planning, and this should be accorded a high priority.

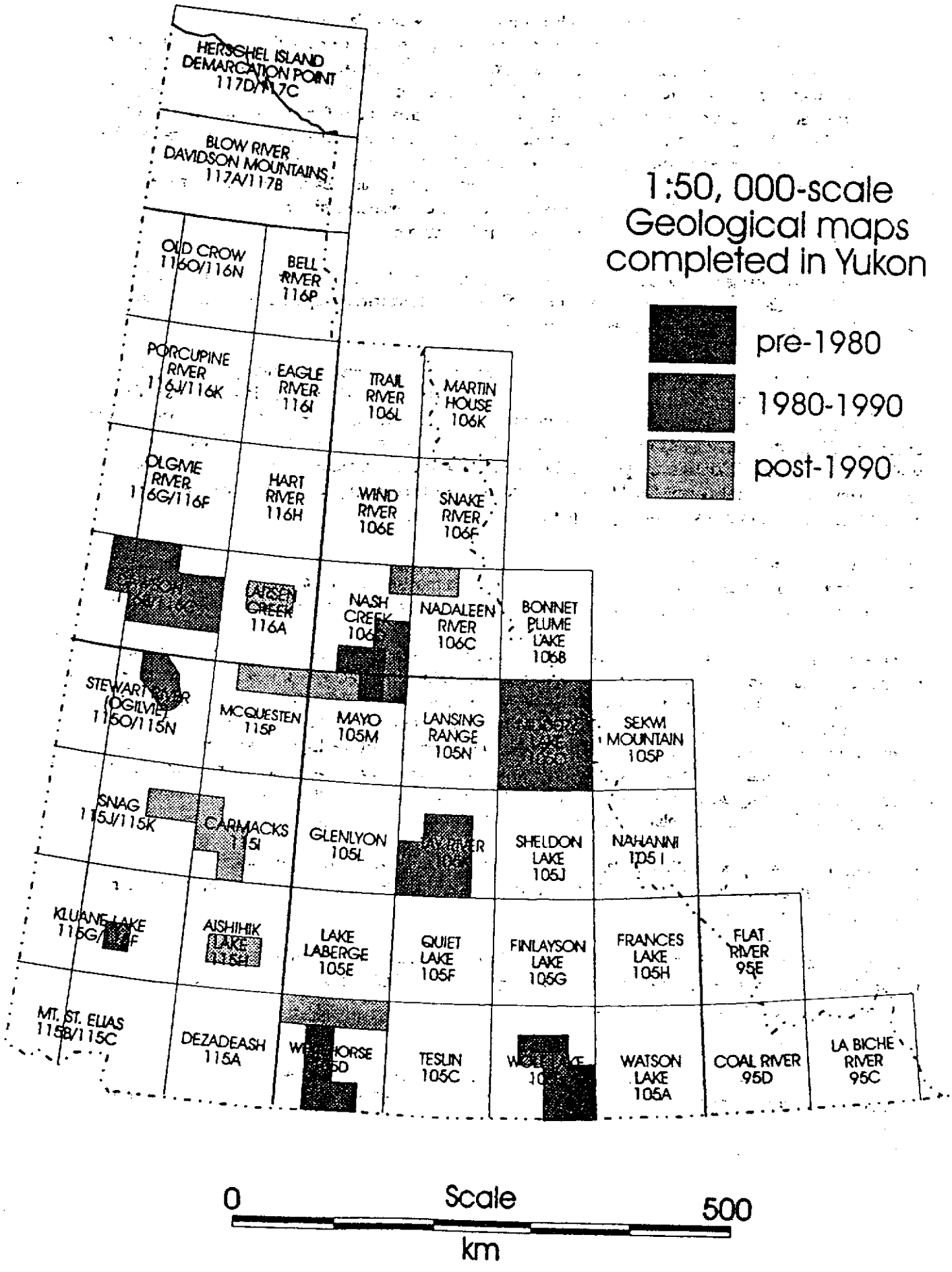
Studies of oil and gas potential in the Beaufort Sea-Mackenzie Delta Region and to a lesser extent in the Eagle Fold Belt should also be assigned a high priority based on exploration which is expected within the next 5 to 10 years.

Although the 1:250 000 scale maps of the Northern Yukon were published recently, they are only reconnaissance maps, based primarily on air photo interpretation with limited ground control. The priorities for remapping these areas are as follows:

117 A-D

High priority, based on a serious lack of understanding of the Proterozoic and Lower Paleozoic stratigraphy; significant revisions to the distribution of Mesozoic and Tertiary stratigraphy; fundamental

Fig. 6


1:50, 000-scale
Geological maps
completed in Yukon
pre-1980
1980-1990
post-1990
HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
BLOW RIVER
DAVIDSON MOUNTAINS
117A/117B
OLD CROW
116O/116N
BELL
RIVER
116P
PORCUPINE
RIVER
116J/116K
EAGLE
RIVER
116I
TRAIL
RIVER
106L
MARTIN
HOUSE
106K
OLGMIE
RIVER
116G/116F
HART
RIVER
116H
WIND
RIVER
106E
SNAKE
RIVER
106F
LAIDEN
CREEK
116A
NASH
CREEK
106
NADALEEN
RIVER
106C
BONNET
PLUME
LAKE
106B
STEWART RIVER
(DGILVIE)
115O/115N
MCQUESTEN
115P
MAYO
105M
LANSING
RANGE
105N
SEKWI
MOUNTAIN
105P
SNAG
115J/115K
CARMACKS
115I
GLENLYON
105L
SHELDON
LAKE
105J
NAHANNI
105I
KLUANE LAKE
115G/
AISHIHIK
LAKE
LAKE
LABERGE
105E
QUIET
LAKE
105F
FINLAYSON
LAKE
105G
FRANCES
LAKE
105H
FLAT
RIVER
95E
MT. ST. ELIAS
115B/115C
DEZADEASH
115A
TESLIN
105C
WATSON
LAKE
105A
COAL RIVER
95D
LA BICHE
RIVER
95C
0
Scale
500
km

revisions to the regional distribution and evolution of structures; and the significance of this area for petroleum exploration in the Beaufort-Mackenzie region, and for land use planning and management (National Parks, Inuvialuit Final Agreement).

116 N, O, P

Medium priority. The issues are similar to above; however, due to poorer exposure in the Old Crow area, and the smaller outcrop extent of older rocks throughout these map areas, the priority is lower.

116F, G, H, I; 106E, F, K, L

No priority for remapping. These maps are seen as being adequate, although detailed stratigraphic work since publication has resulted in some redesignation of Cretaceous map units. Parts of 116K and the northwest part of 116J may require further work as the adjacent maps to the north are redone.

SELECTION OF AREAS FOR DETAILED MAPPING (1:50 000 SCALE)

The selection process for detailed mapping studies was more thematic than area-oriented. Areas were identified mainly by specific geological problems whereas those identified for regional study were mainly identified by a general deficiency of knowledge. Selections were also primarily confined to areas justified by good exposure, complexity of geology, and/or mineral potential. They are listed in Table 4 and also shown in Figure 7.

In the North Yukon, detailed mapping is currently underway in 117C/1 and 117C/8, part of a USGS-GSC cooperative project to provide a basis for correlation between Alaskan and Yukon geology. Other areas of recent detailed coverage include parts or all of 117A/6, 117A/10 and 117A/11. The prinicipal driving force is the structural complexity, including both Middle Devonian and Tertiary orogenesis. Other areas with relatively high priority for 1:50 000 scale mapping include all or parts of 117A/1,117A/8, 117A/13, 117A/14, 117D/4 and 117D/5. These include areas surrounding Devonian intrusions (mineral potential as well as tectonic evolution issues); areas of extensive exposure of the sub-Carboniferous unconformity (definition of Devonian versus Tertiary deformation); the Firth River corridor (National Park, tourism and land use issues); and parts of the northern Richardson Mountains (age and style of deformation).

MINERAL DEPOSIT STUDIES

A short discussion of mineral deposits identified the following priorities.

1. District-scale metallogenic studies in which a large number of deposits are compared and contrasted is the preferred approach.

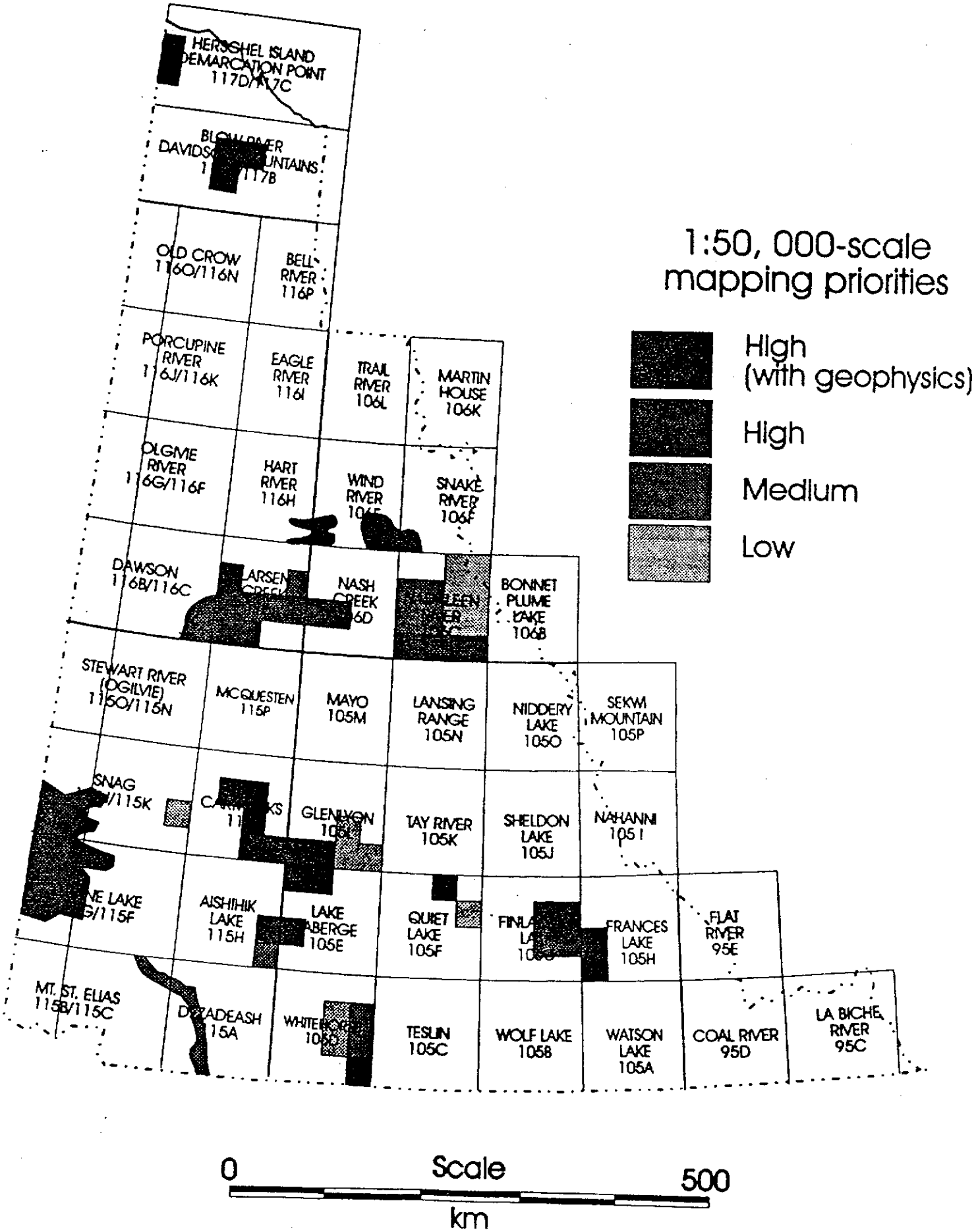
2. Involvement by government geologists in multidisciplinary studies involving university researchers and graduate students may also be possible. The Mineral Deposits Research Unit at the University of British Columbia is planning such a study of precious metal occurences of the Tombstone Plutonic Suite. The advantage of such an approach is not only to gain the benefit of collaboration by a variety of researchers, but also to leverage costs. Money provided by industry is matched by NSERC, thus providing a larger pool of funds from a number of sources.

TABLE 4. SUMMARY, 1:50 000 MAPPING

NTS	PRIORITY	GEOLOGICAL PROBLEM
117A1,8,13,14 117D4,5	HIGH	Structural complexity related to Middle Devonian and Tertiary orogenesis. Mineral potential including porphyries associated with Devonian intrusions, phosphate iron formations and coal. National Park and Land Use issues.
106E/1 & parts of 106E/2,7,8 & 106F4	HIGH	Stratigraphy , structure and mineral potential of Proterozoic inliers to Mackenzie Platform. Contains most significant Wernecke Breccia mineral occurrences. Contiguous with existing MDA mapping project.
Parts of 106E/4 and 116H/1	HIGH	Stratigraphy, structure and mineral potential of Proterozoic inliers to Mackenzie Platform.
106C/1,2,3,4	HIGH	Possible to document the transition from platform to basin along the northern margin of Selwyn Basin. High concentration of base and precious metal occurrences.
106D5/6 116A/3,4,5,6,7,8,12	HIGH	Recent work along the northern margin of Selwyn Basin has identified large areas underlain by previously unrecognized strata which are favourable hosts for sedex zinc-lead deposits, and complex stratigraphy and structure. Contiguous with existing MDA mapping project.
105H/4,5 105G/6,7,9,10	HIGH	Crosses the eastern margin of the Yukon-Tanana Terrane, Slide Mountain Terrane, and extends into Ancestral North America. This area includes the best exposed parts of the Yukon-Tanana Terrane and it should be possible to elucidate the tectonic history of the accreted terranes. Recent discovery of the Kudz Ze Kayah VMS deposit in the Yukon-Tanana Terrane has greatly enhanced the perceived mineral potential of the area.
105F/15	HIGH	The structure and stratigraphy of the shale belt along the inner margin of Cassiar Platform and its precise relationship to the Platform proper are poorly understood. Several sedex zinc-lead occurrences are known along the belt.
105D/1	HIGH	Well exposed area with potential for mesothermal shear zone hosted gold deposits.
105E/5, 105H/8	HIGH	Contains the Division Mountain coal deposit, and crosses the poorly understood boundary between Stikinia and Nisling Terrane. Contiguous with existing MDA mapping project.
105E/13,14 105L/3,4 115I/6,7	HIGH if combined with airborne geophysical survey	Poorly exposed area with high mineral potential. Includes Minto and Williams Creek copper deposits, and Tantalus Butte coal deposit. Crosses the poorly understood boundary between Stikinia and Nisling Terrane.

Parts of 115G/13,14 115F/1,7,.8 115J/5,12	HIGH	Poorly exposed area underlain by Windy-McKinley Terrane, the least well understood area in Yukon. Potential for VMS deposits. The level of exposure is too poor to allow for a typical 1:50 000 project. A more wide-ranging thematic study is envisaged.
115F/7,8,9,10,15,16 115G/5,12 Between Kluane Park and Alaska Highway only.	HIGH	Land use issues paramount. High potential for magmatic copper-nickel deposits, copper-gold skarns, copper in mafic lavas. Scenic values with high tourism potential. Buffer zone between Kluane Park and Alaska Highway. Possibilities for enhancing tourism with interpretive studies.
105C/5,6,11,12	MEDIUM	Stratigraphy, structure and mineral potential of Proterozoic inliers to Mackenzie Platform.
106D/6,12 116A/9	MEDIUM	Stratigraphy and structure of Proterozoic inliers to Mackenzie Platform. Correlation of strata in this area with Fifteenmile and Pinguicula Groups elsewhere is problematic. Setting of Hart River VMS deposit and Blende-type zinc-lead deposits may be elucidated. Contiguous with existing MDA mapping project.
105D8/9	MEDIUM	Contiguous with existing MDA mapping project. High potential for mesothermal shear zone-hosted gold deposits, and contains several known occurrences.
115H/1	MEDIUM	Crosses the poorly understood boundary between Stikinia and Nisling Terrane. Contiguous with two existing MDA mapping projects and will provide critical information that will allow correlation between the two areas.
115J/8	MEDIUM	Contiguous with existing MDA mapping project. Contains relatively well exposed volcanic sequence related to nearby porphyry copper-gold systems, including the Casino deposit.
Parts of 115A/2,3,6,11,13 115B/16	MEDIUM	Land use issues paramount. High potential for placer and lode gold occurrences, VMS copper deposits. Scenic values with high tourism potential. Buffer zone between Kluane Park and highway. Possibilities for enhancing tourism with interpretive studies, both outside and inside the Park (Dezadeash Group mainly).
106C/7,8,9,10,15,16	LOW	Stratigraphy and structure of Proterozoic and Paleozoic strata along the Snake River fault. High concentration of zinc-lead occurrences.
105F/9	LOW	Same as 105F/15.
105D/7,10	LOW	Well exposed area which includes City of Whitehorse and Whitehorse Copper Belt. Land use issues paramount. Contiguous with existing MDA mapping project.

Fig. 7


1:50, 000-scale mapping priorities
High (with geophysics)
High
Medium
Low
HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
OLD CROW
116O/116N
BELL RIVER
116P
PORCUPINE RIVER
116J/116K
EAGLE RIVER
116I
TRAIL RIVER
106L
MARTIN HOUSE
106K
OLGMIE RIVER
116G/116F
HART RIVER
116H
WIND RIVER
SNAKE RIVER
106F
DAWSON
116B/116C
NASH CREEK
106D
BONNET PLUME LAKE
106B
STEWART RIVER (OGILVIE)
116O/116N
MCQUESTEN
115P
MAYO
105M
LANSING RANGE
105N
NIDDERY LAKE
105O
SEKWI MOUNTAIN
105P
SNAG
GLENLYON
TAY RIVER
105K
SHELDON LAKE
105J
NAHANNI
105I
AISHIHIK LAKE
115H
LAKE
QUIET LAKE
105F
FRANCES LAKE
105H
FLAT RIVER
95E
MT. ST. ELIAS
115B/115C
TESLIN
105C
WOLF LAKE
105B
WATSON LAKE
105A
COAL RIVER
95D
LA BICHE RIVER
95C
0
Scale
500
km

3. Although detailed studies of specific mineral deposits were generally felt to be the responsibility of industry, it was agreed that mineral occurrence data should be placed into the public domain. Otherwise basic information is not widely available and is in danger of being lost forever. Data is best gathered by visits to mineral deposits by government geologists and from data provided in assessment reports. Both *MINFILE* and the *Yukon Exploration and Geology* series can be used to disseminate this information.

4. Metallogenic syntheses and deposit models are needed.

Ranking of Deposit Types and Districts

In the time available, it was only possible to identify the various deposit types and/or significant mineral camps known to occur in the Yukon, and to rank them into high, medium and low priority. Rank was based on economic significance and/or the present level of knowledge. No attempt was made to define the type and scope of study most suitable for each. The rankings are given in Table 5. At the present time, the highest priorities are gold porphyries associated with the Tombstone Plutonic Suite, copper-molybdenum-gold porphyry deposits in the Dawson Range, volcanogenic massive sulphide deposits in the Yukon-Tanana Terrane, and high grade silver-lead veins in the Keno Hill District.

PRODUCT DELIVERY

1. Digital products are the way of the future, but in-house resources are needed to enable viewing and interpretation of files by the public.

2. Prices of digital files are prohibitive for many individuals, but one solution is to provide flexible product formats such as paper copies, and single maps on disks rather than 20 maps on a compact disk.

3. More basic data (ie. traverse locations and areas of outcrop) which allow the user to assess the accuracy and reliability of data is desirable on geological maps. This is now possible with digital files, as the information can be placed on a separate layer that can be turned off if desired, thereby not cluttering the maps.

4. With the proliferation of detailed information on 1:50 000 scale geological maps, compilations are becoming essential to allow users to interpret the geology of large regions. The problem could be eased by providing simplified versions of each 1:50 000 scale map at a 1:250 000 scale that can be integrated with existing 1:250 000 scale maps. A proposal to compile a geological map of the Yukon at 1 000 000 scale in time for the 100th anniversary of the discovery of gold in the Klondike was enthusiastically supported.

TABLE 5. PROPOSED MINERAL DEPOSIT STUDIES

RANKING	DESCRIPTION
HIGH	Precious metals associated with Tombstone Plutonic Suite (e.g. Brewery Creek)
	Porphyry Cu-Au systems in the Dawson Range (e.g. Casino)
	Volcanogenic massive sulphide deposits in Yukon-Tanana Terrane (e.g. Kudz Ze Kayah)
	Keno Hill Camp
MEDIUM	Mesothermal shear zone-hosted gold deposits
	Wheaton River gold district
	Mantos (e.g. Ketza-Seagull gold district, Sa Dena Hes zinc-lead-silver deposit
	Industrial minerals
LOW	Wernecke breccias
	Magmatic copper-nickel-platinum deposits
	Tungsten skarns
	Coal
	Epithermal gold deposits along the Tintina Fault
	Copper-gold skarns
	Mississippi Valley zinc-lead deposits
	Blende-type epigenetic zinc-lead-silver deposits
	Sedex nickel deposits
	Dimension stone
	Jade
	Asbestos
	Tin
	Sedimentary iron formations
	Uranium
	Rare earth elements

SURFICIAL, PLACER, AND ENVIRONMENTAL GEOLOGY

INTRODUCTION

The following comments and recommendations come from discussions among the following participants: Steve Morison (DIAND), Ted Fuller (Canada-Yukon Geoscience Office), Fran Hein (University of Calgary), Stuart Schmidt (President, Klondike Placer Miners' Association), Bill Lebarge (DIAND), Lionel Jackson (Geological Survey of Canada, Vancouver), Alejandra Duk-Rodkin (Terrain Sciences Division, GSC, Calgary), Hugh Copland (DIAND), Bob Garrett (Geological Survey of Canada, Ottawa), and Rod Hill (Government of Yukon). Jim Mortensen (University of British Columbia) provided input on gold geochemistry. Comments on till geochemistry were supplied by Alain Plouffe (Geological Survey of Canada, Ottawa).

The group reviewed the status of GSC regional surficial geology programs, academic research, and surficial geology related programs of the Canada-Yukon Geoscience Office and DIAND. Comments and recommendations which followed the presentation of this review to the larger geoscience workshop were incorporated into the proposals for future surficial geology-related projects that appear in this report.

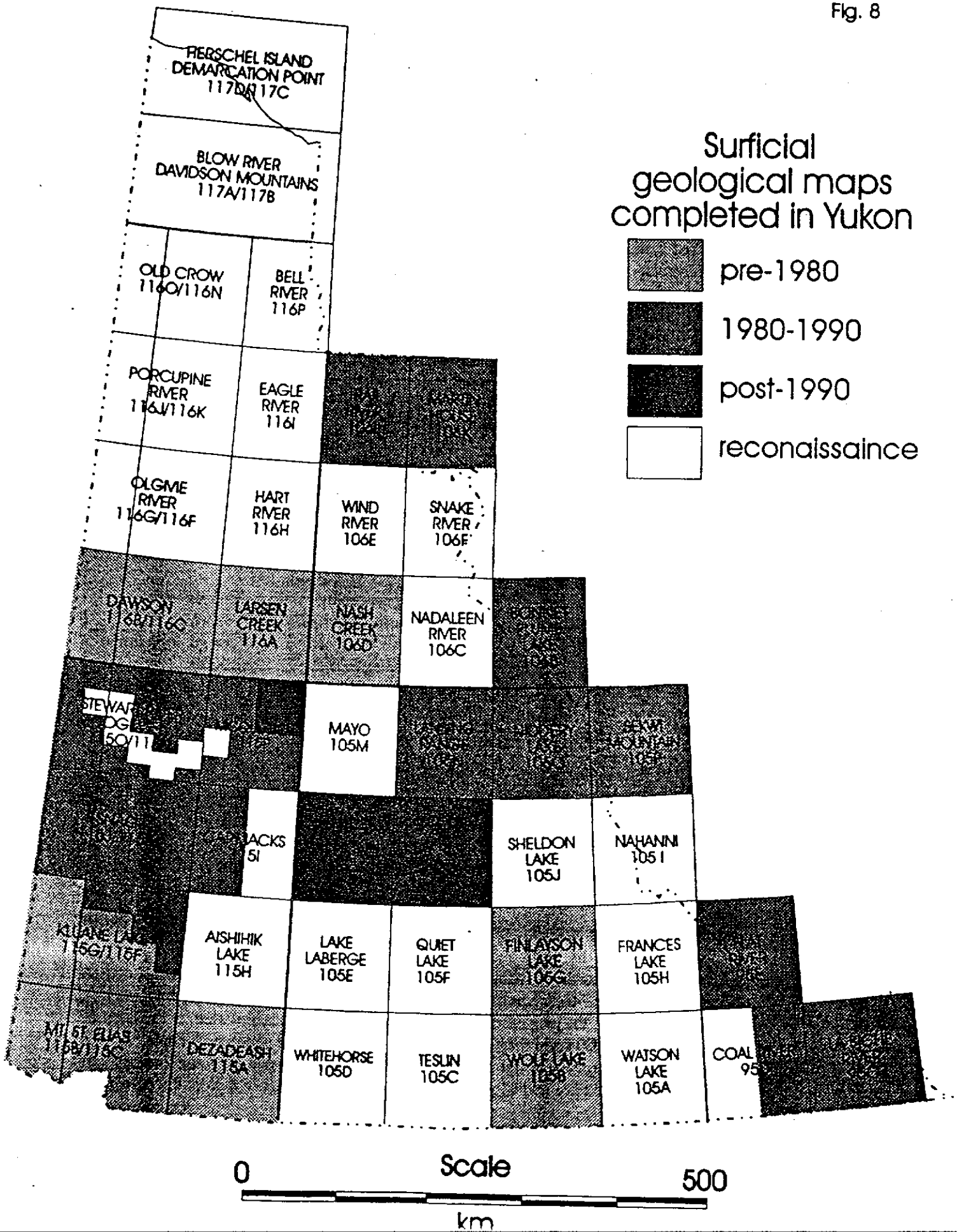
SURFICIAL GEOLOGY MAPPING COVERAGE IN YUKON

Quaternary surficial studies have been pursued in Yukon for as long as geological investigations have been carried out. G.M. Dawson and R.G. McConnell did the earliest work in late 1880's during which they noted the limits of glaciation. McConnell did the first comprehensive investigation of placer geology in the Klondike district. H.S. Bostock, during his bedrock mapping beginning in the 1920's to 1960's, recognized multiple glaciations in central Yukon and established a four-fold division of glacial deposits: from youngest to oldest, McConnell, Reid, Klaza and Nansen. The McConnell is now known to occur during the interval 10 000 to 25 000, the Reid 200 000 to 800 000 and the oldest two greater than 800 000 years ago. These oldest two events have been collectively lumped together as pre-Reid glaciations.

O.L. Hughes (Geological Survey of Canada) was the first geologist to dedicate himself fully to surficial geology work beginning in the early 1960's. Other Geological Survey of Canada geologists (e.g. Campbell, Roddick, Wheeler, Muller, Green) continued to contribute to knowledge of surficial geology while carrying out regional bedrock surveys. By 1969, the reconstruction of ice limits during the McConnell, Reid, and pre-Reid glaciations and paleo ice flow directions had been compiled for the Yukon south of 63 degrees.

Regional mapping has been expanded in the 1970s and 1980s through the efforts of Geological Survey of Canada and Department of Indian and Northern Affairs. Some of the mapping was done under the influence of pressing economic demands. Consequently, surficial geology map coverage in the Yukon is highly variable in quality. For example, the proposed Alaska Highway gas pipeline stimulated reconnaisance coverage of eight 1:250 000 scale map sheets over two summers. In contrast, surficial geology mapping in the northeast Yukon, carried out under the impetus of the proposed McKenzie valley gas pipeline, was done at a much slower pace and is generally of higher quality. Figure 8 plots the current

Fig. 8


Surficial geological maps completed in Yukon
pre-1980
1980-1990
post-1990
reconaissaince
HERSCHEL ISLAND DEMARCATION POINT 117D/117C
BLOW RIVER DAVIDSON MOUNTAINS 117A/117B
OLD CROW 116O/116N
BELL RIVER 116P
PORCUPINE RIVER 116J/116K
EAGLE RIVER 116I
OLGMIE RIVER 116G/116F
HART RIVER 116H
WIND RIVER 106E
SNAKE RIVER 106F
DAWSON 116B/116C
LARSEN CREEK 116A
NASH CREEK 106D
NADALEEN RIVER 106C
MAYO 105M
SHELDON LAKE 105J
NAHANNI 105I
AISHIHIK LAKE 115H
LAKE LABERGE 105E
QUIET LAKE 105F
FINLAYSON LAKE 106G
FRANCES LAKE 105H
DEZADEASH 115A
WHITEHORSE 105D
TESLIN 105C
WATSON LAKE 105A
0
Scale
500
km

status of surficial geology mapping in Yukon regardless of mapping quality. The Canada-Yukon Mineral Development Agreement, signed in 1990, led to 1:50 000 mapping focused primarily on areas of interest to the placer mining industry in central Yukon (Black Hills Creek, lower Stewart River and Yukon River) by Fuller. The latest project to be funded by the MDA involves an investigation of the placer potential and drainage history of the Dawson map area by Duk-Rodkin (GSC).

RECOMMENDATIONS FOR FUTURE WORK

Several categories of surficial geology surveys naturally developed from the group discussions. These include: (1) regional terrain inventory/surficial geology mapping to be done in conjunction with bedrock or other geological/geophysical surveys; (2) regional surficial geology projects to be carried out as a lead activity; (3) placer potential mapping, and (4) till geochemistry. Till geochemistry surveys should be considered as an essential adjunct to all future surficial mapping. Information on till geochemistry has been contributed by Alain Plouffe, who was unfortunately unable to attend the sessions.

(1) Terrain inventory/surficial geology surveys in conjunction with bedrock mapping

Figure 8 summarizes the 1:250,000 map areas for which no surficial geology mapping has been carried out or existing surveys are inadequate. Many of these areas are remote and current economic realities preclude carrying out surficial geology surveys without the benefit of shared logistics with other ongoing surveys such as bedrock or geophysical surveys.

Priorities

Priorities assigned to bedrock mapping of these proposed areas should set the priority for surficial geology mapping. Surficial geology is regarded as a supporting activity to aid prospecting and development in these areas (e.g. aggregate for road building and identifying permafrost and landslide hazards).

Proposed activities

Terrain inventory mapping is proposed at 1:100 000 scale, with digital and traditional releases of maps, field notes, analytical data and reports. Ideally surficial and bedrock maps could be incorporated into a GIS for each map area covered (Fig. 9).

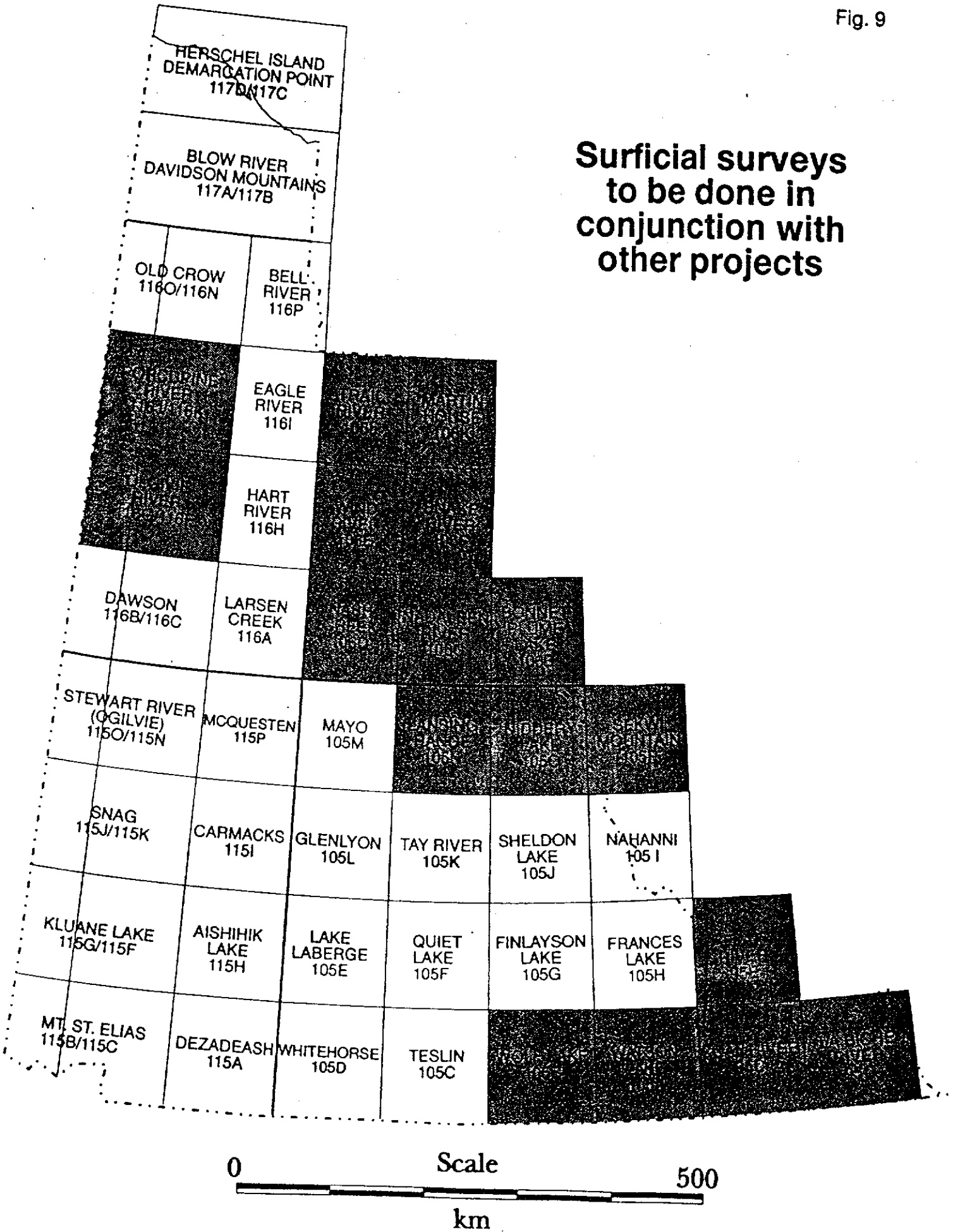
(2) Terrain inventory/surficial geology surveys as a single purpose activity

Significant oil and gas reserves are anticipated in Bell River (116P) and Eagle River (116I) areas (Figure 3). No surficial geology mapping has ever been carried out in this area of Yukon. Almost continuous permafrost underlies this area of extensive bog and organic deposits. The significant scenic and wildlife resources, as well as traditional lifestyles of the aboriginal population, set the stage for significant land use conflicts. It is reasonable to expect that pipelines and construction activities will likely encounter problems similar to those experienced in the Mackenzie Valley. Terrain inventory mapping would be essential for evaluating impact and determining the least hazardous routes for pipeline roads and structure locations. Sources of aggregate are sparse and surficial mapping would help in the evaluation of sources of construction materials. A surface geochemical sampling program would establish predevelopment baseline conditions.

Proposed activities

Two primary activities are proposed. First, regional surficial geology mapping will be carried out at a scale of 1:100 000 (Fig. 10). Mapping at a 1:50 000 scale will be done where warranted. Secondly,

Fig. 9



Surficial surveys to be done in conjunction with other projects

surface geochemical sampling will be done in order to establish baseline environmental conditions prior to development.

Products

Products would include digital terrain maps and digitizing of existing bedrock mapping so that the two can be overlaid with geochemical data in order to produce derived maps as required. A summary report would describe the history and origin of surficial deposits, natural hazards dealing with permafrost, and interpretation of geochemical data based on surficial and bedrock geology.

(3) Placer potential mapping

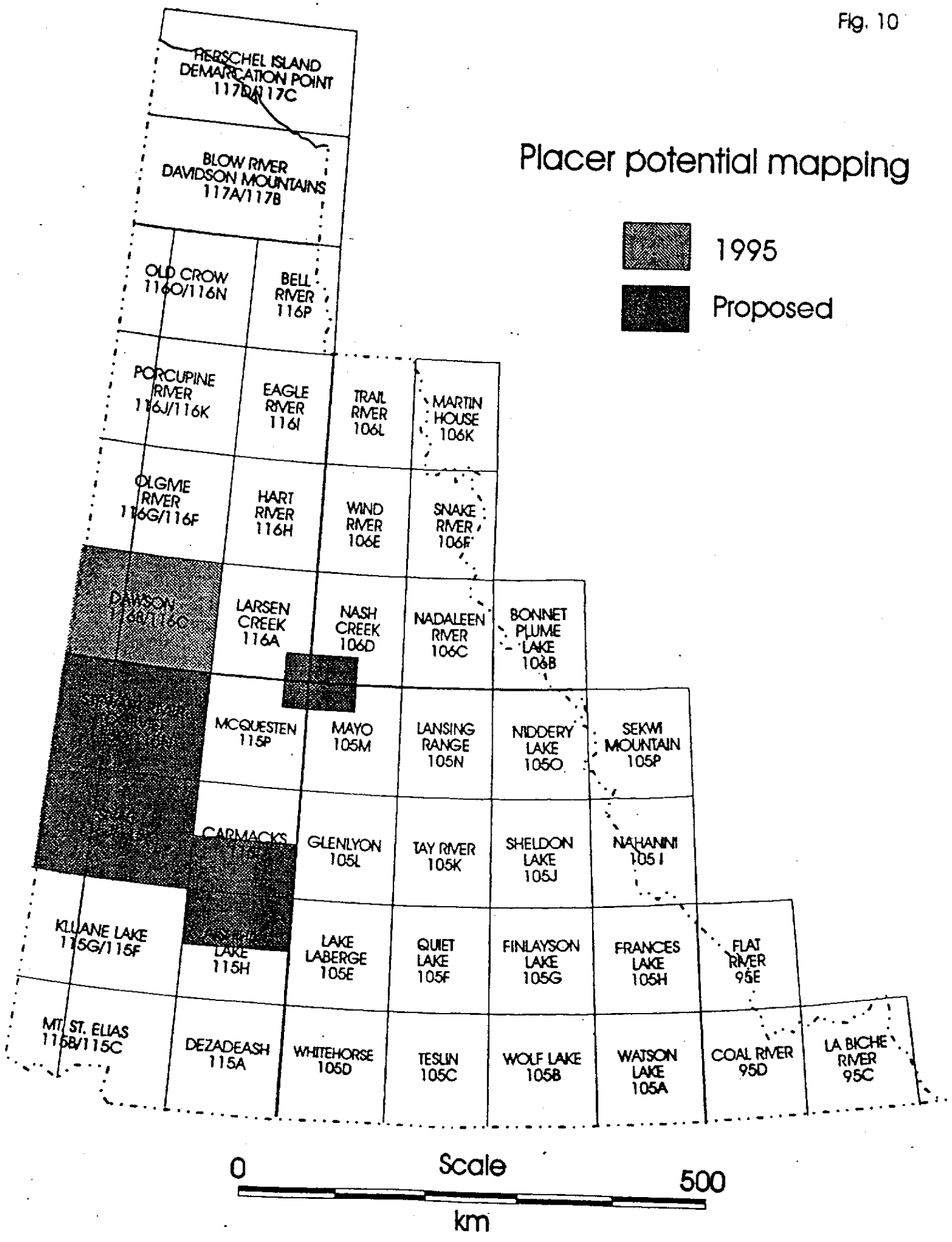
This is a new type of multidisciplinary thematic investigation aimed at evaluation of placer potential in frontier placer districts. These areas include west central Yukon beyond the limit that glacial ice reached during Reid glaciation and away from presently developed placer districts. Also included are mountainous areas which projected above the limits of ice during the McConnell glaciation and have not been glaciated since the Reid or pre-Reid glaciations.

Much of the west central Yukon is thought to have significant potential for gold placers for the following reasons:

- present understanding of bedrock geology suggests that as many as four sources of gold may have contributed to placer deposits in this region (quartz veins, Klondike schist, felsic volcanic rocks, and geologically recent hydrothermal activity)
- although not much is known about the glacial history of this area, glaciation could not have occurred any more recently than 800 000 years ago. This long period of ice free conditions has allowed sufficient time to form significant gold bearing placers.
- Since the last glaciation of this area, one or more periods of deep weathering have occurred creating favourable conditions for liberation of gold from rock.
- Incursion of glacial ice in these areas led to major drainage diversions, isolation and subsequent burial of placer deposits.

Within west central Yukon, two adjacent regions are identified as placer potential study areas, notably the Dawson Range (115I, 115H, SE corner of 115J) and the Snag (115J/K) and Stewart River map areas (115N/O) (Fig. 11). The Dawson Range has the best demonstrated relationship between bedrock lode gold sources and stream placers. The present state of knowledge indicates that placers are derived from Mount Nansen Group volcanics and their plutonic equivalents. However, existing geological mapping has been hampered by lack of exposures due to widespread colluvial and bog cover. Geophysical and geochemical studies are the most apparent solution to supplementing bedrock exposures and establishing the limits and occurrences of Mount Nansen Group. In the Snag and Stewart River areas, the relationship between bedrock sources and placers is poorly known and geophysical and geochemical investigations are important in relating gold source areas to potential placer streams.

Fig. 10


Placer potential mapping
1995
Proposed
PIERSCHEL ISLAND DEMARCATION POINT 117D/117C
BLOW RIVER DAVIDSON MOUNTAINS 117A/117B
OLD CROW 116O/116N
BELL RIVER 116P
PORCUPINE RIVER 116J/116K
EAGLE RIVER 116I
TRAIL RIVER 106L
MARTIN HOUSE 106K
OLGMIE RIVER 116G/116F
HART RIVER 116H
WIND RIVER 106E
SNAKE RIVER 106F
DAWSON 116B/116C
LARSEN CREEK 116A
NASH CREEK 106D
NADALEEN RIVER 106C
BONNET PLUME LAKE 106B
MCQUESTEN 115P
MAYO 105M
LANSING RANGE 105N
NIDDERY LAKE 105O
SEKWI MOUNTAIN 105P
CARMACKS
GLENLYON 105L
TAY RIVER 105K
SHELDON LAKE 105J
NAHANNI 105I
KLUANE LAKE 115G/115F
LAKE 115H
LAKE LABERGE 105E
QUIET LAKE 105F
FINLAYSON LAKE 105G
FRANCES LAKE 105H
FLAT RIVER 95E
MT ST. ELIAS 115B/115C
DEZADEASH 115A
WHITEHORSE 105D
TESLIN 105C
WOLF LAKE 105B
WATSON LAKE 105A
COAL RIVER 95D
LA BICHE RIVER 95C
0
Scale
500
km

Proposed activities

Although final publication scale of surficial geology mapping for these areas would be 1:50 000, the intensity of field mapping would vary from 1:250 000 scale in some areas with little variation in surficial geology and geomorphology to 1:50 000 in areas of stream diversions, terraces, and buried channels, where more detailed work is warranted. The surficial mapping component would subdivide streams in the region as those affected by past glaciation and those unaffected by past glaciation. This would separate streams which have Neogene histories of incision and concentration of placers from those that only had the last 800 000 years to do so. This investigation would also locate potential sites of buried placers and provide a first estimate of overburden thickness. Neotectonism is known to have deformed river terraces in this area and its role in drainage changes would also be investigated. The bedrock geology of the area would be re-evaluated with the use of high resolution airborne magnetometer and gamma ray surveys.

This information would be used to identify potential bedrock gold sources and further indicate placer potential of streams draining these areas. Placer gold geochemistry would be investigated throughout the area to determine the nature of bedrock sources. This information would be used to test and refine the relative placer potential values that have been assigned to streams.

Test drilling of streams regarded as having high potential would be carried out to further evaluate the placer potential model. Stuart Schmidt (KPMA) proposed that drilling could be carried out on a cost-shared arrangement with placer miners interested in grass roots exploration on their claims, with all data to be made publically available. This might involve a 50/50 split between industry and Yukon Government, using Yukon Mining Incentives Program funding. Current policy would have to be changed, as the Yukon Mining Incentives Program presently provides funding for explorers but not miners. Such a program would enable more drilling to be done. Quality control of drilling would be checked during visits by the YTG placer geologist. Tephras occurring in overburden will be identified and dated and paleoenvironmental studies of overburden sediments will be carried out in order to document the geomorphic evolution of the region during the Pleistocene and identify sedimentological factors that may have controlled the formation of placer deposits. A pilot study funded by the MDA will be carried out by Duk-Rodkin (GSC) in summer 1995.

Potential products

All maps and data will be combined in a geographic information system (GIS), from which a series of digital placer potential and traditional paper maps and reports will be generated. These reports are intended to be highly readable and useful to the placer mining community. Every attempt will be made to minimize geologic jargon which might act as a barrier to the use of this information.

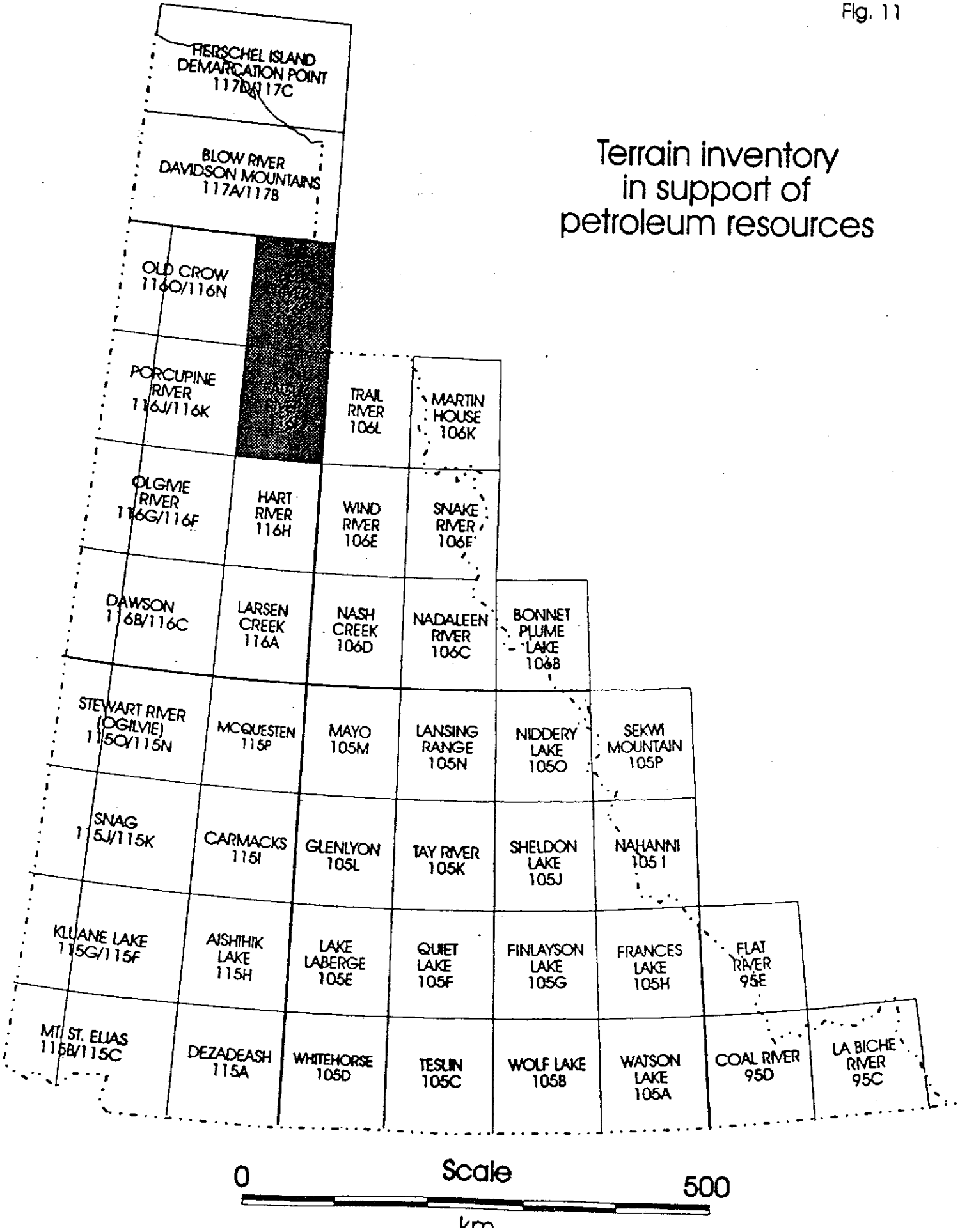
Along with the placer potential studies, a placer-focused MINFILE database will be created and maintained in order to close the placer information gap that exists in the Yukon. Work in this direction has been initiated by Dr Fran Hein (University of Calgary). This database will include gold values and volume of placer mines in Yukon where that data can be obtained. A map showing distribution of White Channel gravel and glaciofluvial outwash should be constructed for central Yukon.

(4) Placer deposits at Dublin Gulch

Colluvial placers at Dublin Gulch, north of Mayo, have been known for decades but are still poorly understood, as are the bedrock sources of the gold. This area was a nunatak during the McConnell glaciation (an upland that stood above but was surrounded by the ice sheet). The proposed study is centred in the four corners area (106D, 115P, 105M, 116A) (Fig. 11), and will work toward understanding the

Fig. 11

Terrain inventory in support of petroleum resources



processes by which these placers form.

Activities

Mapping would be undertaken at 1:50 000 scale and would be accompanied by stratigraphic investigations as well as soil geochemistry which targets gold indicator elements (Bi, As, W). Heavy mineral studies would also be carried out. The resulting data would be analysed to determine how the occurrence of colluvial placers might be used to locate bedrock lode gold and determine how these placers formed. We wish to look at the glacial history and timing of glaciation. The small area to be covered by this study and its highly focused objectives make it a good candidate for a PhD research project.

(4) Till Geochemistry

It is recommended that all surficial mapping programs in glaciated areas should in future be accompanied by reconaissance till geochemistry. For a minimal increased cost, a geochemical component is added which greatly increases the value of the mapping. For example, reconnaissance till sampling in the Tintina Trench outlined geochemical anomalies corresponding to several mineral known mineral deposits, and other multi-element anomalies which may be related to concealed mineralization. Till geochemistry differs from soil geochemistry in unglaciated areas in that metal concentrations in the till result from glacial comminution and transport rather than from in-situ weathering of bedrock. Thus, the till anomaly is located down-ice from the source and an understanding of the geomorphology and glacial history is necessary to interpret it. This combination of surficial geology and till geochemistry is a new tool which can be used to find mineral deposits which have no surface expression.

Reconnaissance till geochemistry also allows the determination of natural metal levels in the surficial environment which may be unrelated to the underlying bedrock. This is important for environmental assessment purposes. New legislation governing the development and abandonment of new mines will require the determination of background metal levels at the surface, both near and away from known mineralization, in order to set reasonable environmental standards for the operation. Disturbances other than mining (road construction, oil and gas exploration, hydro dams) can also liberate toxic metals into the environment, and till geochemistry is also necessary to help set environmental standards for these.

In unglaciated areas, surficial sediment samples are an excellent indicator of mineralization in situ or close by, and an understanding of the surficial geology of the area can be critical to the interpretation of a routine soil geochemical survey.

SUMMARY

Three natural subdivisions occur in future surficial geology surveys in Yukon. These include: (1) Regional terrain inventory/surficial geology mapping in conjunction with bedrock or other geological/geophysical surveys; (2) regional surficial geology projects to be carried out as a lead activity and (3) placer potential mapping.

The current quality of surficial geology coverage in the Yukon is variable. Because of the expense of these surveys, initial mapping of unmapped areas or remapping of older areas would be prioritized based on the need for bedrock geology maps in the area. Surficial geology mapping should share logistics with regional bedrock mapping and till geochemistry programs.

A stand alone surficial geology survey accompanied by an environmental geochemistry survey is warranted prior to oil and gas exploration and development in the Bell River and Eagle River map areas.

Placer potential mapping is proposed for the Dawson Range and Snag/Stewart River areas in west central Yukon. Present understanding of bedrock and surficial geology suggests that significant gold placers should exist in this area. Placer potential mapping is a new type of multidisciplinary thematic investigation aimed at evaluation of frontier placer districts. Although surficial geology is a lead activity, placer potential mapping should be done in conjunction with bedrock mapping, geochemistry, and airborne geophysical surveys.

Till geochemistry is important an important indicator of mineral deposits buried beneath glacial overburden, and is also important in establishing background levels of metals in the surficial environment against which the effects of development can be measured. Till geochemistry and surficial geology mapping complement each other, in that the geochemical data adds important quantitative information to the map, while the map is critical to interpreting the geochemical results. Therefore, in glaciated areas, till sampling should be carried out in conjunction with surficial mapping at all scales.

REGIONAL GEOCHEMISTRY AND GEOPHYSICS

INTRODUCTION

This working sub-group consisted of co-chairs Steve Johnston (Canada-Yukon Geoscience Office) and Rob Shives (Geological Survey of Canada) along with participants D. Teskey (GSC), Robert Stroshein (YGC Resources Ltd), Roger Hulstein (Kennecott Canada Inc.), John Kowalchuk (Canada-Yukon Geoscience Office), Carl Schultz (Hemlo Gold Mines), Bob Garrett (GSC) and Gordon MacKay (MacKay, Falkiner and Associates). Additional input was received from Mike Power (Yukon Prospectors' Association) and from Trevor Bremner, DIAND. Alain Plouffe (Terrain Science Division, GSC) was unable to attend the planning session, but has subsequently provided valuable input regarding quaternary geochemical and mapping studies (p. 35-36).

Regional geochemical and geophysical surveys are recognized as fundamental geoscientific tools, which:

- provide relatively inexpensive baseline data over large areas, for a wide range of end users (mappers, explorationists, environmentalists, planners, policy-makers)
- assist exploration by identification of geochemical and geophysical anomalies
- improve 1:250 000 and 1:50 000 scale geological mapping
- identify large (crustal scale) geological features
- map cryptic lithological features not easily recognizable by geological mapping
- yield regionally coherent, quantitative digital databases with very long shelf lives

Through informal discussions, existing aeromagnetic, gamma ray-mag-VLF, and NGR survey coverage was reviewed. Participants discussed benefits, limitations or problems relating to these techniques and identified areas for future work. Additional geochemical and geophysical techniques were also discussed and a list of needs was prepared. This list was compiled and ranked independently by each participant. The next day, these results were reported to the main working group, and are presented here in Table 6.

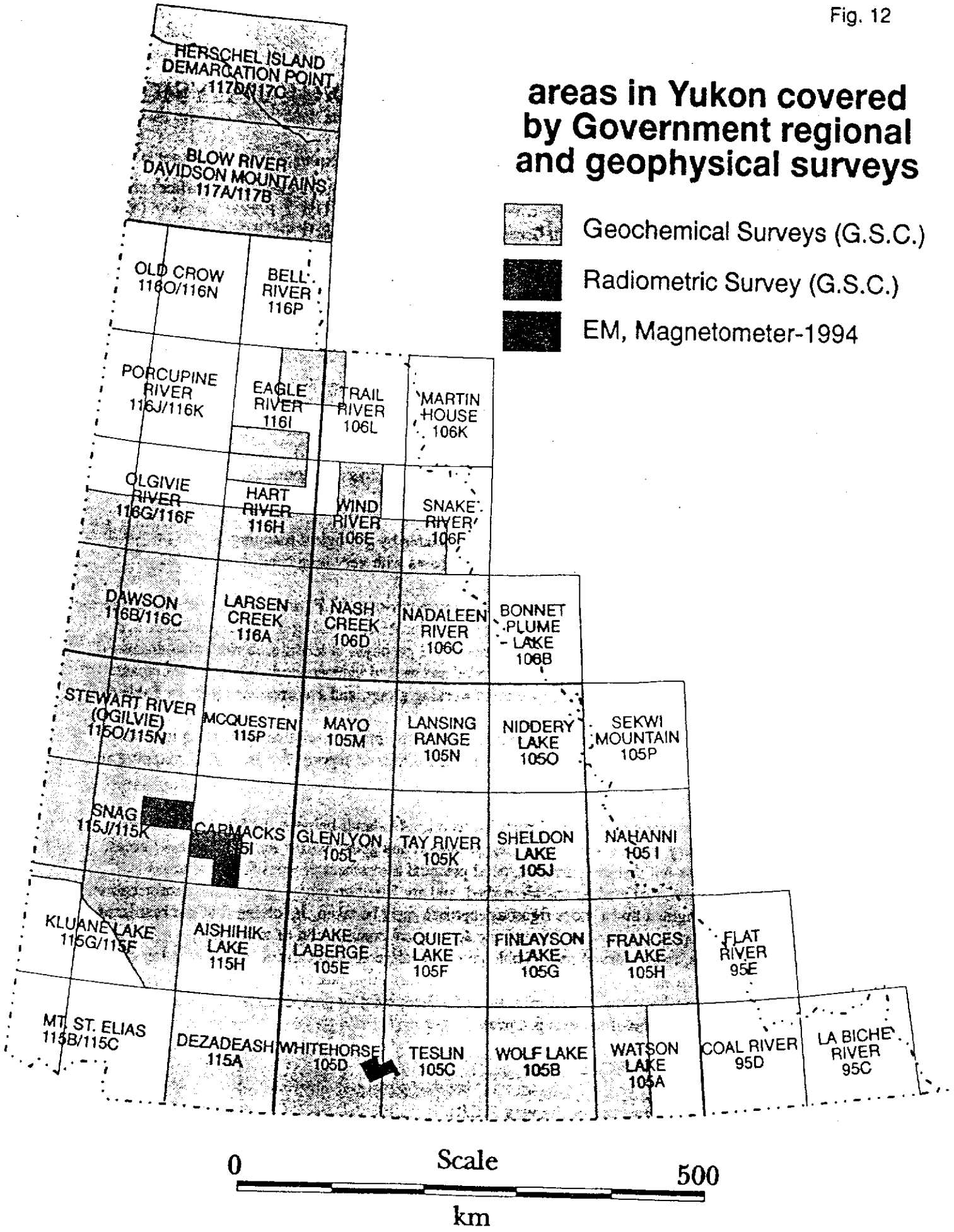
The recommendations of the sub-group are summarized below by major discipline, according to scale of work required, as either regional baseline coverage at 1:250 000 or as support for geological mapping and exploration at 1:50 000.

> NOTE: An important concern of all participants relates to lands being considered for designation as Parks. Industry is reluctant or unwilling to support any geoscientific activities in these areas. In general, it was felt that the current mineral potential assessment process for these areas is grossly inadequate, that evaluations are rushed, and are based on sparse geoscientific information. The sub-group agreed that a more rigorous approach must be taken, involving (but not restricted to) airborne geophysical surveys (comprising appropriate combination of magnetics, electomagnetics, radiometrics) and suitable geochemical/geological studies, where existing data are sparse. Acquisition costs for the required new information must be covered by the agency or group proposing withdrawal, and a minimum of 5 years must be provided for compilation, synthesis and evaluation of mineral potential.

GEOCHEMISTRY (1:250 000 SCALE)

National Geochemical Reconnaissance Surveys (NGR).

Fig. 12


areas in Yukon covered by Government regional and geophysical surveys
Geochemical Surveys (G.S.C.)
Radiometric Survey (G.S.C.)
EM, Magnetometer-1994
HERSCHEL ISLAND DEMARCATION POINT 117D/117C
BLOW RIVER DAVIDSON MOUNTAINS 117A/117B
OLD CROW 116O/116N
BELL RIVER 116P
PORCUPINE RIVER 116J/116K
EAGLE RIVER 116I
TRAIL RIVER 106L
MARTIN HOUSE 106K
OLGIVIE RIVER 116G/116F
HART RIVER 116H
WIND RIVER 106E
SNAKE RIVER 106F
DAWSON 116B/116C
LARSEN CREEK 116A
NASH CREEK 106D
NADALEEN RIVER 106C
BONNET PLUME LAKE 106B
STEWART RIVER (OGILVIE) 115O/115N
MCQUESTEN 115P
MAYO 105M
LANSING RANGE 105N
NIDDERY LAKE 105O
SEKWI MOUNTAIN 105P
SNAG 115J/115K
CARMACKS 105I
GLENLYON 105L
TAY RIVER 105K
SHELDON LAKE 105J
NAHANNI 105 I
KLUANE LAKE 115G/115F
AISHIHIK LAKE 115H
LAKE LABERGE 105E
QUIET LAKE 105F
FINLAYSON LAKE 105G
FRANCES LAKE 105H
FLAT RIVER 95E
MT. ST. ELIAS 115B/115C
DEZADEASH 115A
WHITEHORSE 105D
TESLIN 105C
WOLF LAKE 105B
WATSON LAKE 105A
COAL RIVER 95D
LA BICHE RIVER 95C
0
Scale
500
km

These will have to be discontinued in 1995, due to the cessation of funding. However, because they form a very important component of the national and international geological database, all unsurveyed 1:250 000 sheets should be completed, with highest priority south of 65°30'.

In areas where geological mapping or compilation is considered high priority, NGR data should be rigorously interpreted and incorporated into the surficial and bedrock geological framework.

Discrepancies between mapped geology and the regional geochemical patterns provide important (re)mapping and exploration opportunities.

NGR Re-analyses

Existing samples have not been analysed for important elements such as Bi, Sn. Analyses for these and possibly other elements is recommended.

GEOCHEMISTRY 1:50 000 SCALE

Fine fraction gold analyses.

Interpretation of the existing NGR stream sediment gold data is limited by gold grain size variability inherent in the -177 micron size fraction analysed. At anomalous gold sample sites, where gold is present as coarse particles, repeat analyses may not reflect the original anomalous concentration. Where the anomalous gold is present in fine particulate form (<63 microns) the NGR check assays more consistently duplicate the original anomalous results. New fine fraction silt and heavy mineral concentrate (HMC) sampling of streams is recommended in the following areas, ranked in order:

- Tombstone Suite (Brewery Creek - Mayo - Hyland Group)
- Dawson Range (Nansen - Freegold - Casino)
- Marsh Lake area
- Skukum/Wheaton River
- Others - Rancheria, Wellgreen

Fine fraction platinum analyses

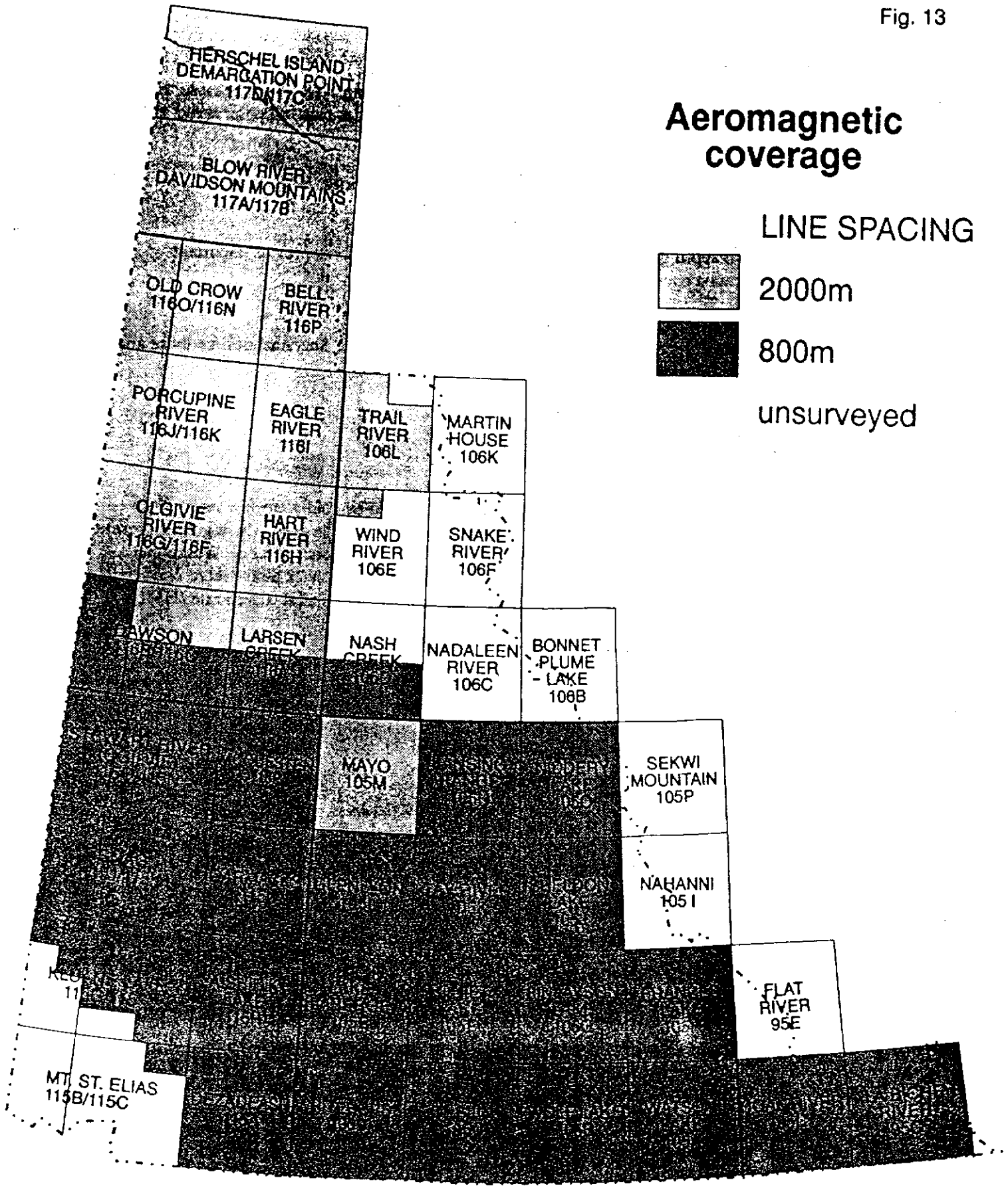
No Platinum Group Element (PGE) analyses exist within the NGR database. PGE analyses of fine fraction silts, and HMC sampling, should be conducted in the following areas:

- Wellgreen
- Pyroxenite Mtn
- Sato (Aishihik Lake area)

Concern has been expressed that detailed 1:50 000 scale geochemistry is not an appropriate role for government and should be undertaken only by industry. However, government has a useful role in undertaking orientation surveys and pioneering the methods which can be employed by mining companies at the detailed scales they require for their exploration programs.

Systematic soil geochemical surveys in unglaciated areas and drift geochemistry in glaciated areas should be undertaken with strong industry input to define dispersion of known mineralization into the broad surficial environment. This may include biogeochemistry and new methods such as selective leach soil analyses.

Fig. 13


HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
BLOW RIVER
DAVIDSON MOUNTAINS
117A/117B
OLD CROW
116O/116N
BELL RIVER
116P
PORCUPINE RIVER
116J/116K
EAGLE RIVER
116I
TRAIL RIVER
106L
MARTIN HOUSE
106K
OGILVIE RIVER
116G/116F
HART RIVER
116H
WIND RIVER
106E
SNAKE RIVER
106F
DAWSON
LARSEN CREEK
NASH CREEK
NADALEEN RIVER
106C
BONNET PLUME LAKE
106B
MAYO
105M
SEKWI MOUNTAIN
105P
NAHANNI
105 I
FLAT RIVER
95E
MT. ST. ELIAS
115B/115C
Aeromagnetic coverage
LINE SPACING
2000m
800m
unsurveyed
0
Scale
500
km

Lithogeochemistry

Systematic lithogeochemical sampling is required to characterize units and plutonic suites with high mineral potential. The data should be compiled and published as it is acquired.

GEOPHYSICS

Regional Aeromagnetic Surveys

New Coverage

In 1995, these surveys will be completed over 104 C and D in southeast Yukon. Additional coverage should be obtained over 106 B, C, D, E, F. In this area, while exploration implications of the Bonnet Plume Heritage River Management Plan were raised by industry participants, the consensus was that these concerns are secondary to the larger geoscientific needs.

The new surveys will be flown with a line spacing of 800 km. This line spacing will allow interpretation of the geology at a 1:50 000 scale even though the coverage is regional.

Fill-in Coverage

Previous aeromagnetic surveys in some areas were flown using 2 km line spacing, rather than 800 m. The 2 km data is considered inadequate for mapping and exploration, and can be cost-effectively upgraded by fill-in between the existing 2 km lines. Two areas have been identified.

- Mayo-Nadaleen River sheets
- Dawson-Larsen-Ogilvie-Hart River sheets. In this area, the 2 km lines were flown in constant elevation blocks, so that the actual height above the ground varies from zero to hundreds of metres. This means that the data, as presented, may not provide the full resolution possible. Reprocessing of the coarser 2 km data is recommended in the north halves of 116 A,B (Dawson and Larsen sheets) and the south halves of G, H to determine if artificial draping (variable downward continuation) can improve the resolution. If so, fill-in lines can be flown if required. This technique has been used with good success in south-central BC. A gamma ray-mag-VLF test survey of a 1:50,000 sheet within this area was also recommended, for comparison of its magnetic data with the reprocessed magnetic data.

Topical Multisensor Gamma ray-EM-Mag Surveys

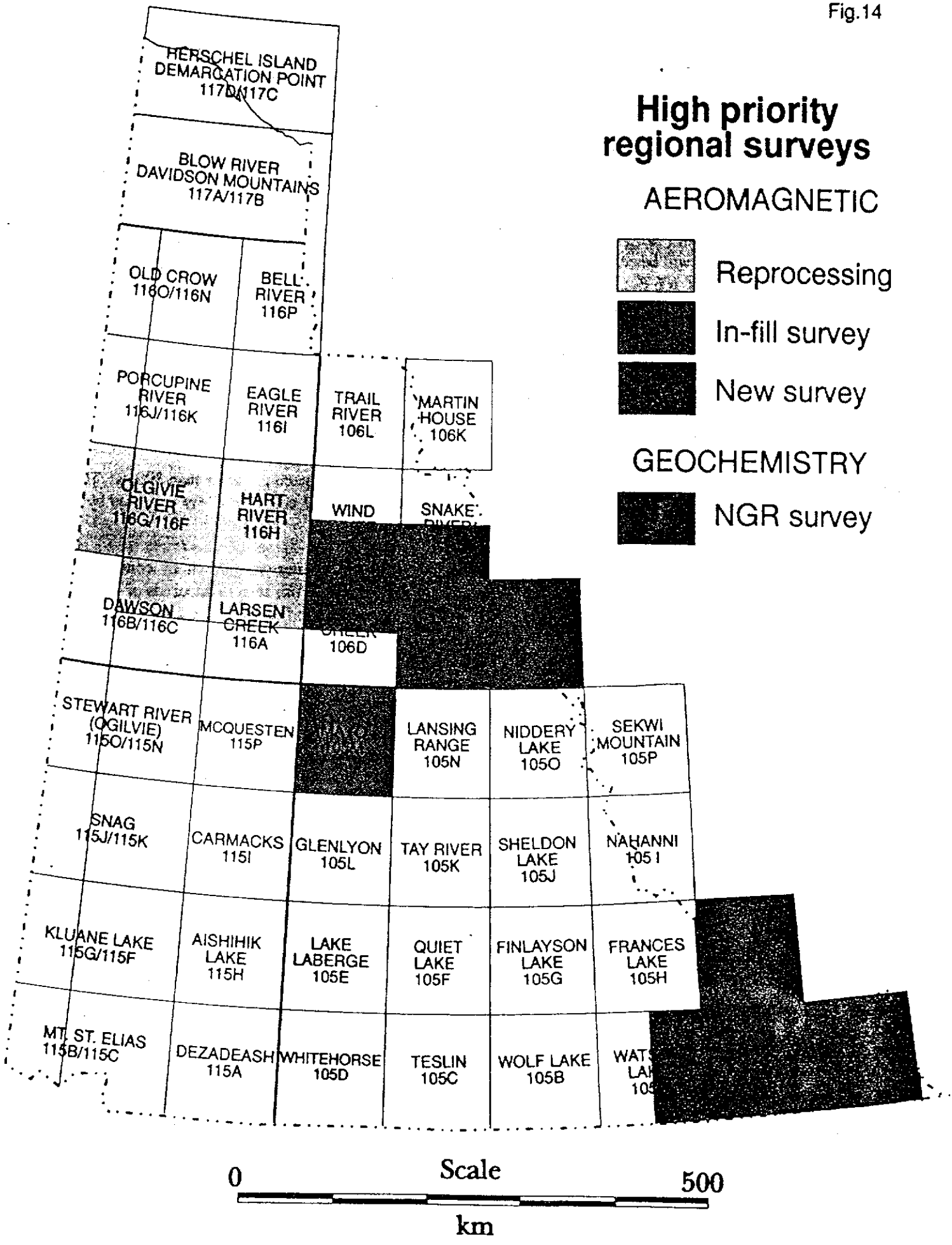
The additional cost associated with adding EM to the gamma ray-mag sensors is two-fold; not only does the line-kilometre cost increase, (see cost estimate summary) but the requirement for closer line spacing (less than 500m), to provide the continuity necessary for effective EM, affects cost per area of coverage. Obviously these surveys will be very focused on specific targets, not constrained by 1:50,000 sheet boundaries. Industry funding participation is recommended, with suitable exclusivity arrangements. Accompanying, cooperative multidisciplinary ground follow-up studies are necessary to explain patterns and develop exploration models. These surveys are recommended in the following areas:

- Tintina Trench - high mineral potential, existing infrastructure.
- Western Yukon-Tanana terrane - Snag, Steward River areas.
- Yukon-Tanana Terrane/Selwyn Basin - north of Watson Lake.
- Marg deposit area (NE of Mayo).

Gamma ray-mag-VLF surveys (No EM)

These surveys should be flown at 500m line spacing, using either fixed wing or helicopter platforms as

Fig.14



High priority regional surveys

AEROMAGNETIC

- Reprocessing
- In-fill survey
- New survey

GEOCHEMISTRY

- NGR survey

dictated by terrain. Again, cooperative ground follow-up will maximize returns.

- Minto - Williams Creek corridor, and adjacent area
- Tombstone Suite - McQuesten Mineral Belt
- Apex Mountain
- Mactung - Cantung
- Wernecke Breccia belt

NOTE: Although expensive, airborne EM and magnetic surveys at a 1:50 000 scale are strongly supported by the Yukon Prospectors' Association in accessible areas near known deposits. The YPA would like to see a long term commitment to systematic EM/mag coverage of accessible metallogenic belts such as the Tintina Trench. Such surveys have sparked a large amount of interest and economic activity in both NWTand Alaska, and YPA believes they will yield greater economic benefits than other kinds of surveys including gamma ray surveys. In contrast, the Yukon Chamber of Mines opposes these surveys on the grounds that they are expensive, site specific and take funds away from regional mapping and magnetic surveys which are more directly related to understanding the regional geology and structure.

Existing private sector data

Private sector geophysical surveys have been conducted for years, in many areas of Yukon. For high priority areas, it is recommended that available, accessible surveys be examined to determine feasibility, quality and costs involved to acquire and publish the data.

Assessment Reporting

Industry participants agreed that the concept of 100% filing, subject to exclusivity considerations, should be pursued. Exclusivity comfort levels ranged from 3 to 5 to 10 years, with consensus around 5 years' duration. Further debate is required.

OTHER TECHNIQUES/RECOMMENDATIONS

Heavy mineral concentrate (HMC) sampling

Low density, systematic sampling of creeks for HMC's is recommended, with follow-up INA analyses and binocular mineralogy. The aim is to define potential for tin, tungsten and other mineral resources, and to conduct mineral deposit and metamorphic terrane studies. The program could perhaps be started by collecting heavy mineral concentrates from active placer operations.

Geochron survey

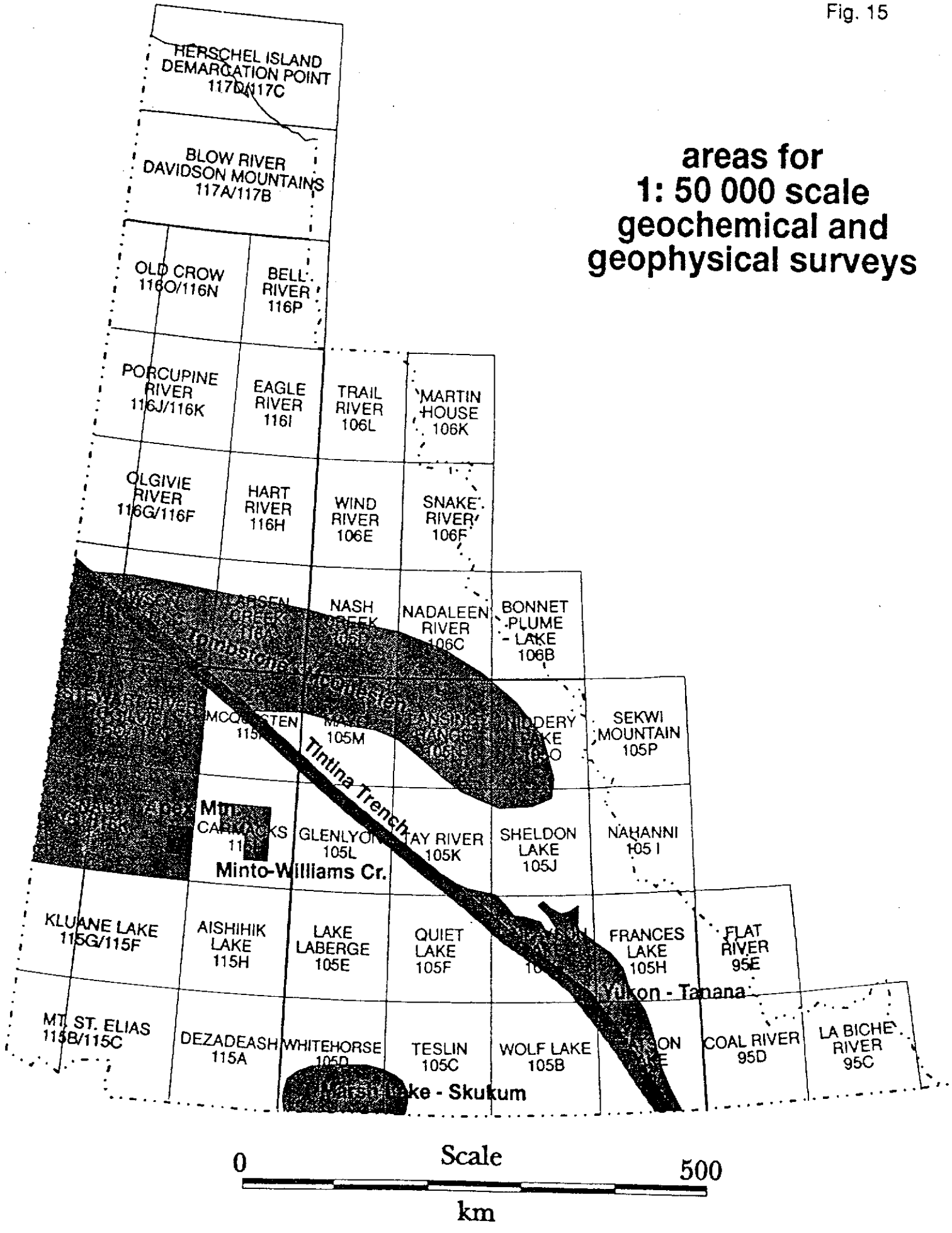
Isotopic dating of units/plutonic suites is recommended in concert with 1:50 000 mapping. Initial targets include:

- Cretaceous Tombstone suite
- Early Jurassic Aishihik suite
- Cretaceous Nansen/Carmacks suites

Remote sensing

Yukon needs better access to data. Application of Radarsat information to placers should be investigated.

Fig. 15


areas for
1: 50 000 scale
geochemical and
geophysical surveys
HERSCHEL ISLAND
DEMARCATION POINT
117D/117C
BLOW RIVER
DAVIDSON MOUNTAINS
117A/117B
OLD CROW
116O/116N
BELL
RIVER
116P
PORCUPINE
RIVER
116J/116K
EAGLE
RIVER
116I
TRAIL
RIVER
106L
MARTIN
HOUSE
106K
OLGIVIE
RIVER
116G/116F
HART
RIVER
116H
WIND
RIVER
106E
SNAKE
RIVER
106F
NASH
CREEK
105N
NADALEEN
RIVER
106C
BONNET
PLUME
LAKE
106B
Dubbsion
Tintina Trench
MAYO
105M
SEKWI
MOUNTAIN
105P
Mt.
CARMACKS
115I
Minto-Williams Cr.
GLENLYON
105L
TAY RIVER
105K
SHELDON
LAKE
105J
NAHANNI
105 I
KLUANE LAKE
115G/115F
AISHIHIK
LAKE
115H
LAKE
LABERGE
105E
QUIET
LAKE
105F
FRANCES
LAKE
105H
FLAT
RIVER
95E
Yukon - Tanana
MT. ST. ELIAS
115B/115C
DEZADEASH
115A
WHITEHORSE
105D
TESLIN
105C
WOLF LAKE
105B
COAL RIVER
95D
LA BICHE
RIVER
95C
Kluane Lake - Skukum
0
Scale
500
km

Sulfate testing
This is a simple on site technique which should be investigated. Its utility was questioned.

Biogeochemistry
Biogeochemistry has been clearly demonstrated as a useful exploration tool, especially in blind, drift covered areas. Orientation and detailed surveys should be done in appropriate, selected areas. Colin Dunn, GSC, Ottawa, was recommended to supervise such a project.

Yukon Atlas
A compilation of existing geoscience data in a series of 1:500 000 scale maps is envisaged, available both in hard copy and digital formats. A possible target date of 1998 was suggested.

Digital data work station
This would allow manipulation of lithogeochemical and geophysical data by staff and local explorationists. The work station should have GIS capability.

Education/training
This would provide short courses, workshops, talks and training aimed at educating both the technical geoscientific community and in less technical terms, the general public. Such education would foster awareness of geophysical methods and transfer techniques to Yukoners, including: GIS, magnetic, EM, gamma ray, gravity, seismic techniques and interpretation methods; proper use of portable gamma ray spectrometers by explorationists and prospectors; updates on geochemical sampling problems, new data manipulation methods, and correct application of existing NGR data.

Gamma ray calibration
A facility of this type in Yukon for calibrating both airborne and portable instruments could be provided for about $10 000 and would foster local usage.

TABLE 6. COSTS OF GEOPHYSICAL SURVEYS (CRUDE ESTIMATES)

FIXED WING	mag only	$ 8 - 10 /line-km
	gamma ray/mag	$ 15 - 25/line-km
	gamma/mag/EM	$ 50 - 70/line-km
HELICOPTER	gamma/mag	$ 35 - 50/line-km
	gamma/mag/EM	$ 50 - 95/line-km

Note that the cost of an airborne geophysical survey depends not only on the area to be covered, but also on the line spacing and other factors, i.e. it would be misleading to estimate the price of flying a given area unless the other survey parameters are known.

TABLE 7. REGIONAL SURVEY PRIORITIES

SURVEY TYPE	PRIORITY ASSESSMENT
Geochemistry	
Complete NGR compilation maps (1:250 000)	High
Fine fraction gold analyses (1:50 000)	High
NGR re-analyses (1:250 000)	Medium
Soil and drift geochemistry and mapping (1:50 000)	Medium
Fine fraction platinum analyses (1:50 000)	Low
Lithogeochemistry (1:50 000)	Low
Biogeochemistry	Low
Geophysics	
Regional aeromagnetic surveys (1:250 000)	High
Airborne gamma ray/mag/EM (1:50 000)	High
Education and training for users of geophysical data	High
Airborne gamma ray/mag/VLF (1:50 000)	Medium
Interpret existing geophysical data	Medium
Gravity along lithoprobe lines	Medium
Yukon gamma ray calibration site	Low
Other	
Assessment reports - seek 100% filing of information	High
Heavy mineral concentrates	Medium
Geochronology	Medium
Remote sensing	Low
Sulphate testing	Low
Yukon Atlas	Low
GIS work station	Low

RECOMMENDATIONS AND CONCLUSIONS

This report outlines goals and priorities for Yukon geoscience which will be used by government agencies in planning their programs and budgets over the next few years.

Several conclusions were reached regarding the type of work to be done. The importance and significance of geological mapping was stressed, along with the need to integrate geophysical and geochemical data to produce multidisciplinary maps. There was strong support for age dating studies in conjunction with bedrock mapping, and for a new series of placer potential maps.

Mineral district studies, broad metallogenic studies and comparative studies are urgently required in the Dawson Range, the Yukon-Tanana Terrane, the Tombstone Plutonic Suite and the Keno Hill District. There was some support for metallogenic synthesis and the development of mineral deposit models.

Recent discoveries at Brewery Creek and Kudz Ze Kayah clearly demonstrate the importance of geochemistry as an exploration tool and an indication of mineral potential. Geochemistry also provides critical baseline environmental data. Complete geochemical coverage of Yukon Territory south of 65° 30'N is a desirable goal which could be achieved by completing one full and 6 partial map sheets. Drift geochemistry, biogeochemistry and fine fraction gold analysis are techniques which should be employed in conjunction with 1:50 000 scale mapping and mineral district studies.

Recent low-level airborne magnetic and EM surveys in the Fairbanks area have proved that they are essential to interpreting bedrock geology in areas of poor exposure. These and radiometric surveys where applicable should be carried out during or prior to bedrock mapping in areas of high mineral potential.

The group concluded that although digital products are expensive, they are essential because of the flexibility of scale and the ease of highlighting or augmenting certain data. However, paper products still need to be offered. Digital files incorporating traverse data should be included with the maps. A 1:500 000 scale compilation of Yukon geology, geochemistry and geophysics was proposed to coincide with the centennial of the Klondike Gold Rush in 1998.

The major recommendations from this planning exercise are tabulated under each of the session summaries and in Table 1. The highlights are summarized, by area, as follows:

- All three groups identified the Snag and Stewart River map sheets as a high priority area which would benefit from a multi-disciplinary study where logistics could be shared.
- Mineral deposit and geophysical studies are recommended for the Tombstone-McQuesten Plutonic Suite and could be concurrent with surficial geology studies in the Dublin Gulch area.
- The Finlayson Lake area was identified as a high priority target for bedrock mapping, mineral deposit studies and regional geophysical surveys.
- Proterozoic rocks on the Nadaleen River map sheet were targeted for bedrock mapping and airborne magnetic surveys, and some further geochemistry is needed in this area.