GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

PROGRAM AND ABSTRACTS / PROGRAMME ET SOMMAIRES

CONTRIBUTIONS OF THE GEOLOGICAL SURVEY OF CANADA,
CORDILLERAN AND PACIFIC GEOSCIENCE DIVISION

CONTRIBUTIONS DE LA COMMISSION GEOLOGIQUE DU CANADA,
DIVISION GEOSCIENTIFIQUE DE LA CORDILLERE ET DU PACIFIQUE

CORDILLERAN GEOLOGY AND EXPLORATION ROUNDUP
FORUM SUR L'EXPLORATION ET LA GEOLOGIE DE LA CORDILLERE

February 7-10, 1989 / 7-10 février, 1989
Hotel Vancouver / Hôtel Vancouver
Vancouver, B.C. / Vancouver C.B.

Energy, Mines and Resources Canada — Énergie, Mines et Ressources Canada

Canada

CORDILLERAN GEOLOGY AND EXPLORATION ROUNDUP

HOTEL VANCOUVER

February 7-10, 1989

Program - February 7

8:45 a.m.-12:30 p.m. Geological Survey of Canada, and Geological and Exploration Services, Department of Indian Affairs and Northern Development, Yukon

GSC

8:45 **Mr. Bruce Howe**, Deputy Minister, Department of Energy, Mines and Resources, Canada

8:55 **E.A. Babcock**, Assistant Deputy Minister, Geological Survey Sector, EMR

9:10 **C.W. Jefferson, W.A. Spirito, S.M. Hamilton, F.A. Michel**, D. Paré
- Stream sediment and groundwater geochemistry in resource assessment of the South Nahanni River area, Yukon and NWT

9:30 **T. Christie and S. Gordey**
- The Tintina Fault and gold: Grew Creek, Yukon

9:45 **M. Journeay**
- Late Mesozoic and Cenozoic fault systems of the southern Coast Belt; implications for Cu-Au-Ag mineralization in the Harrison Lake region

10:05 COFFEE

10:30 **L.C. Struik**
- Exploration model for the Cariboo

10:50 **F. Robert and B. Taylor**
- Structural and geochemical studies at Mosquito Creek gold mine, Cariboo District, B.C.

11:10 **R.G. Anderson and R.V. Kirkham**
- Geological overview of B.C.'s "Gold Triangle": GSC mapping and research in the Iskut map area, northwest B.C.

DIAND

11:35 **S.R. Morison**
- 1988 Yukon mining and exploration update and overview of D.I.A.N.D. field activities

11:55 **J.G. Abbott**
- Geological highlights from the 1988 exploration season

12:30 - 2:00 Luncheon

1:00 - 5:00 **POSTERS** (Room shared by DIAND, GSC and University students)

FORUM SUR L'EXPLORATION ET LA GÉOLOGIE DE LA CORDILLERE

HOTEL VANCOUVER

7-10 février 1989

Programme du mardi 7 février 1989

8 h 45 - 12 h 30 — Commission géologique du Canada, et Services de la géologie et de l'exploration, Ministère des Affaires indiennes et du Nord canadien, Yukon

CGC

8 h 45 — **M. Bruce Howe**, Sous-ministre, Ministère de l'Énergie, des Mines et des Ressources, Canada

8 h 55 — **E.A. Babcock**, Sous-ministre adjoint, Secteur de la Commission géologique du Canada, EMR

9 h 10 — **C.W. Jefferson, W.A. Spirito, S.M. Hamilton, F.A. Michel et D. Paré**
- Apport de la géochimie des sédiments de ruisseau et de l'eau souterraine dans l'évaluation des ressources de la région de la rivière South Nahanni, Yukon et T.N.-O.

9 h 30 — **A. Christie et S. Gordey**
- L'or et la faille de Tintina: Grew Creek, Yukon

9 h 45 — **M. Journeay**
- Réseaux de failles du Mésozoïque supérieur et du Cénozoïque dans la partie sud de la chaîne côtière; leur rôle dans la formation de la minéralisation en Cu-Au-Ag de la région du lac Harrison

10 h 05 — PAUSE CAFÉ

10 h 30 — **L.C. Struik**
- Modèle d'exploration appliqué au centre de la C.-B.

10 h 50 — **F. Robert et B. Taylor**
- Études structurales et géochimiques à la mine d'or de Mosquito Creek, dans le secteur de Cariboo, C.-B.

11 h 10 — **R.G. Anderson et R.V. Kirkham**
- Aperçu géologique du "triangle aurifère" de la C.-B. : travaux de cartographie et de recherche effectués par la CGC dans la région de la rivière Iskut, nord-ouest de la C.-B.

M.A.I.N.

11 h 35 **S.R. Morison**
- Mise à jour et revue des activités d'exploitation et d'exploration en 1988 et activités de terrain du M.A.I.N.

11 h 50 **J.G. Abbott**
- Faits saillants de la période d'exploration de 1988

12 h 30 - 14 h 00 Dîner

13 h 00 - 17 h 00 **VISITE DES KIOSQUES** (Salle partagée par le M.A.I.N., la CGC et des étudiants universitaires.)

ABSTRACTS OF TALKS

SOMMAIRES DES PRÉSENTATIONS ORALES

Geological overview of B.C.'s "golden triangle": G.S.C. mapping and research in the Iskut map area, northwest B.C.

Robert G. Anderson[1] and R.V. Kirkham[2]

British Columbia's newest "Golden Triangle" connects the Premier-Sulphurets-Johnny Mountain/Snip/Bronson Creek precious metal camps within the Iskut River map area (56-57°N, 130-132°W; NTS 104 B). The Lower Jurassic Hazelton Group and alkaline members of the cogenetic Early Jurassic Texas Creek plutonic suite have proved the most productive and prospective for precious metal lodes. These metallotects developed as part of a 400 million year geological evolution recorded in four tectonostratigraphic assemblages: 1) Paleozoic Stikine assemblage; 2) Triassic-Jurassic volcano-plutonic complexes of Stikinia which generally host the ore; 3) Middle and Upper Jurassic Bowser overlap assemblage; and 4) Tertiary Coast Plutonic Complex. The paper presents an overview of the stratigraphic, structural, plutonic and metamorphic framework and an outline of detailed mineral deposit research on the Sulphurets camp.

Early Devonian to Early Permian coralline limestone reef and mafic to felsic volcanic rocks make up the Stikine assemblage and include some of the most intensely deformed rocks in the region.

Distinctive porphyritic dykes link Upper Triassic (Stuhini Group) and metallogenically-important Lower Jurassic (Hazelton Group) volcanics with their plutonic equivalents (Late Triassic Stikine and Early Jurassic Texas Creek plutonic suites). Basinal sedimentary and distal tuffaceous rocks of the Lower and Middle Jurassic Spatsizi Group mark the end of Triassic-Jurassic volcanism.

Fossiliferous Upper Triassic Stuhini Group and Lower to Middle Jurassic Spatsizi Group strata provide recognizable, biostratigraphically restricted, bounding markers. They define the economically important but mainly unfossiliferous and heterogeneous Lower Jurassic volcanic strata of the Hazelton Group metallotect.

Fine and medium grained siliciclastics of the Middle and Upper Jurassic Bowser Lake Group are a distal facies of an overlap assemblage. To the north, coeval, chert-bearing conglomerate demonstrably links Stikinia and Cache Creek terranes. Bowser Lake Group rocks are deformed into distinctive, orthogonal cross folds.

Unconformities seem to bound the major stratigraphic assemblages. Stratigraphic relationships among members of the Stikine assemblage are poorly known. A regionally extensive Permo-Triassic event is marked by local polymict conglomerate, a regional decrease in conodont colour alteration index with age and, possibly, an angular unconformity between recumbent, isoclinally folded Lower Permian limestone and overlying Upper Triassic(?) mafic volcanics(?). A regionally important sub-Toarcian unconformity and a local but metallogenically important Pliensbachian unconformity characterize the Lower Jurassic strata in the area.

An intrusive and structural contact separates Tertiary Coast Plutonic Complex (CPC) and Stikinia along the international border and Stikine River. Tertiary, post-tectonic, fresh, felsic plutons (Hyder plutonic suite, in part) characterize CPC. Younging of strata from west to east, abrupt westerly increase in metamorphic grade across the Stikine River and local zones of high strain along CPC's eastern margin attest to its intrusion and uplift.

[1]Geological Survey of Canada, 100 West Pender St., Vancouver, B.C. V6B 1R8
[2]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

LEGEND

MIDDLE AND UPPER JURASSIC BOWSER LAKE GROUP

- greywacke
- shale

TOARCIAN AND BAJOCIAN? SPATSIZI GROUP

- siliceous shale
- submarine tuff
- sandy limestone and limy sandstone

LOWER JURASSIC HAZELTON GROUP

- welded tuff and tuff breccia
- maroon volcanic conglomerate and breccia
- massive green andesite and minor shale

UPPER TRIASSIC STUHINI GROUP

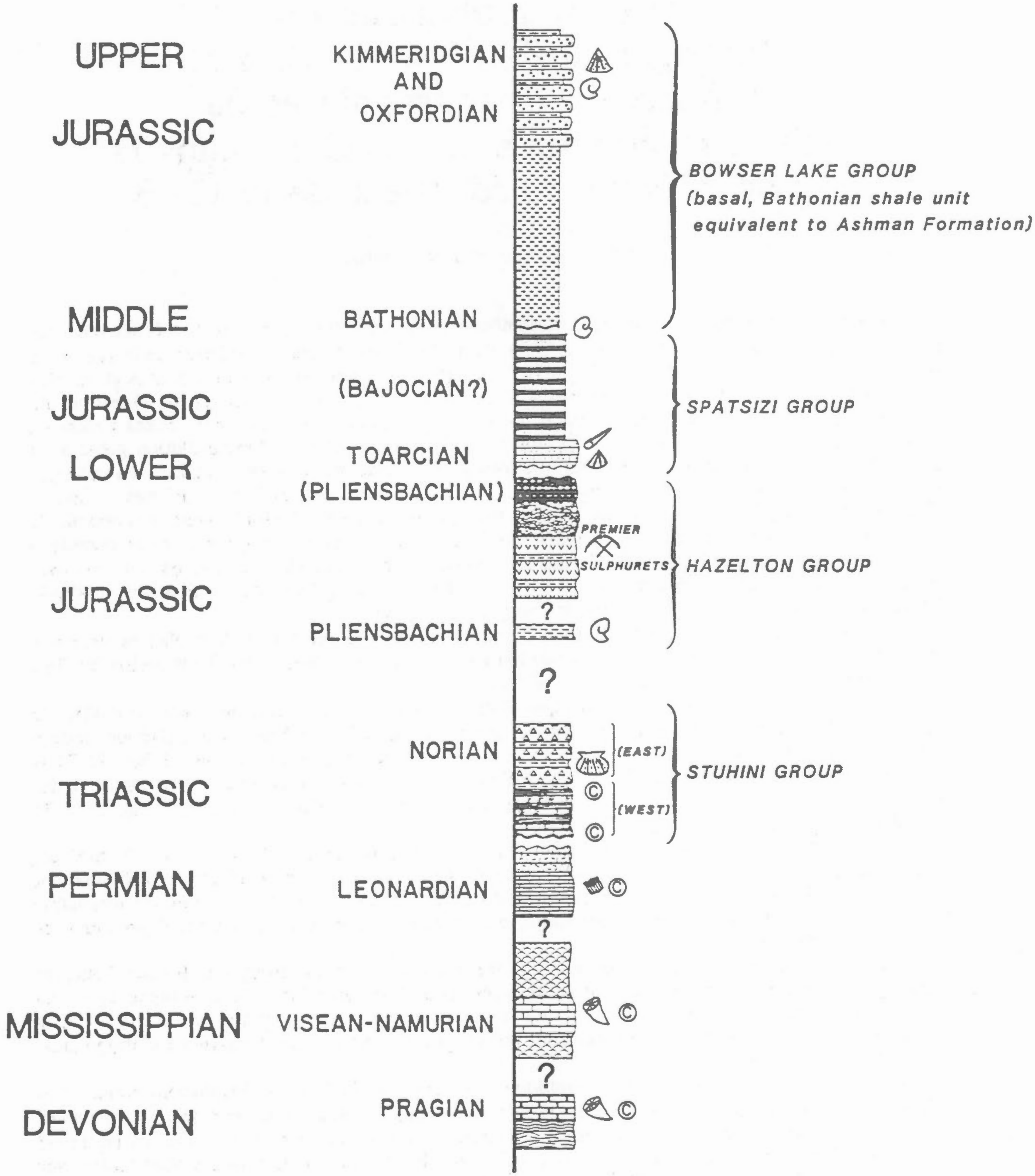
- clinopyroxene-phyric volcaniclastic rocks (eastern volcanic facies)
- shale and argillite
- clinopyroxene-phyric mafic tuff and flow rock; felsic tuff (western volcanic facies)
- grey sparry limestone and chert-limestone conglomerate

PALEOZOIC STIKINE ASSEMBLAGE

- green intermediate to felsic volcaniclastic rock and tuff (PERMIAN)
- thin bedded coralline limestone (L. PERMIAN)
- pillowed basalt and hyaloclastite (MISSISSIPPIAN)
- medium to thick bedded coralline limestone (MISSISSIPPIAN)
- deformed coralline limestone (L. DEVONIAN)
- schistose mafic volcaniclastic rock (L. DEVONIAN?)
- schistose felsic tuff (L. DEVONIAN?)

SYMBOLS

- ***Buchia***
- ammonite
- belemnite
- ***Weyla***
- ***Minotis*** or ***Halobia***
- tabulate coral
- rugose coral
- ? unknown stratigraphic relationship
- unconformity
- mineral deposit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Aperçu géologique du "triangle aurifère" de la C.-B. : travaux de cartographie et de recherche effectués par la CGC dans la région d'Iskut, nord-ouest de la C.-B.

R.G. Anderson[1] et R.V. Kirkham[1]

Le nouveau "triangle aurifère" de la Colombie-Britannique relie les camps de métaux précieux de Premier-sulphurets-Johnny Mountain/Snip/Bronson Creek, situés à l'intérieur de la région de la rivière Iskut (56-57°N, 130-132°W; S.N.R.C. 104 B). Les unités les plus productives et les plus intéressantes quant à leur potentiel en métaux précieux filoniens sont le Groupe du Hazelton, du Jurassique inférieur, et les membres alcalins de la série plutonique cogénétique de Texas Creek, du Jurassique inférieur. Ces métallotectes se sont formés dans le contexte d'une évolution géologique de 400 millions d'années dont on retrouve des évidences dans quatre assemblages tectonostratigraphiques : 1) l'assemblage paléozoïque de Stikine; 2) les complexes volcano-plutoniques de Stikinia, du Trias au Jurassique, qui renferment habituellement le minerai; 3) l'assemblage de chevauchement de Bowser, du Jurassique moyen à supérieur et 4) le complexe côtier de roches plutoniques, du Tertiaire. Notre article présente un aperçu du contexte stratigraphique, structural, plutonique et métamorphique ainsi qu'une description des méthode détaillées de prospection minérale dans le camp de Sulphurets.

L'assemblage de Stikine est constitué de récifs calcaires coralliens et de roches volcaniques mafiques à felsiques du Dévonien inférieur au Permien inférieur et renferme aussi des roches qui font partie des unités les plus déformées de la région.

Des dykes porphyriques caractéristiques relient les roches du Trias supérieur (Groupe de Stuhini) et les roches volcaniques du Jurassique inférieur, d'un intérêt métallogénique certain (Groupe de Hazelton) avec leurs équivalents plutoniques (séries plutoniques de Stikine, du Trias supérieur, et de Texas Creek, du Jurassique inférieur). Des roches sédimentaires de bassin et des roches tuffacées distales du Groupe de Spatsizi, du Jurassique inférieur et moyen, marquent la fin du volcanisme triasique-jurassique.

Des strates du groupe fossilifère de Stuhini, du Trias supérieur, et du groupe de Spatsizi, du Jurassique inférieur à moyen, présentent des repères limites distinctifs et biostratigraphiquement restreints. Ils délimitent les strates volcaniques du groupe métallotecte de Hazelton, du Jurassique inférieur, qui présentent un intérêt économique certain mais sont principalement dépourvues de fossiles et hétérogènes.

Des roches siliciclastiques finement et moyennement grenues du Groupe de Bowser Lake, du Jurassique moyen et supérieur, constituent le faciès distal d'un assemblage de chevauchement. Au nord, un conglomérat contemporain et cherteux relie sans équivoque les secteurs de Stikinia et Cache Creek. Les roches du Groupe de Bowser Lake ont été transformées en plis transverses orthogonaux, facilement identifiables.

Les principaux assemblages stratigraphiques semblent être limités par des discontinuités. Les relations stratigraphiques entre les membres de l'assemblage de Stikine ne sont pas bien connues. Un événement permo-triasique d'extension régionale se traduit par la présence d'un conglomérat polygénique local, une décroissance régionale de l'indice de couleur d'altération des conodontes avec l'âge et, peut-être bien, une discontinuité angulaire entre les plis isoclinaux couchés constitués de calcaire du Permien inférieur et les roches volcaniques mafiques(?) sus-jacentes du Trias supérieur(?). Une importante discontinuité sub-toarcienne d'extension régionale ainsi qu'une discontinuité pliensbachienne, locale mais présentant un intérêt métallogénique, caractérisent les strates du Jurassique inférieur de la région.

Un contact intrusif et structural sépare le complexe plutonique Côtier du Tertiaire et lecomplexe de Stikinia le long de la frontière internationale et de la rivière Stikine. Des plutons felsiques, non altérés, post-tectoniques et d'âge tertiaire (série plutonique de Hyder en partie) caractérisent le complexe plutonique Côtier. L'âge des strates qui décroît de l'ouest vers l'est, l'accroissement rapide vers l'ouest du degré de métamorphisme de part et d'autre de la rivière Stikine et des zones locales de fortes contraintes le long de la bordure orientale du complexe plutonique Côtier témoignent de son caractère intrusif et de son soulèvement.

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[1] Commission géologique du Canada, 100, W. Pender Street, Vancouver, C.-B., Canada, V6B 1R8
[2] Commission géologique du Canada, 601, rue Booth, Ottawa, Ontario, Canada, K1A 0E8

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SYMBOLS

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Weyla

Minotis **or *Halobia***

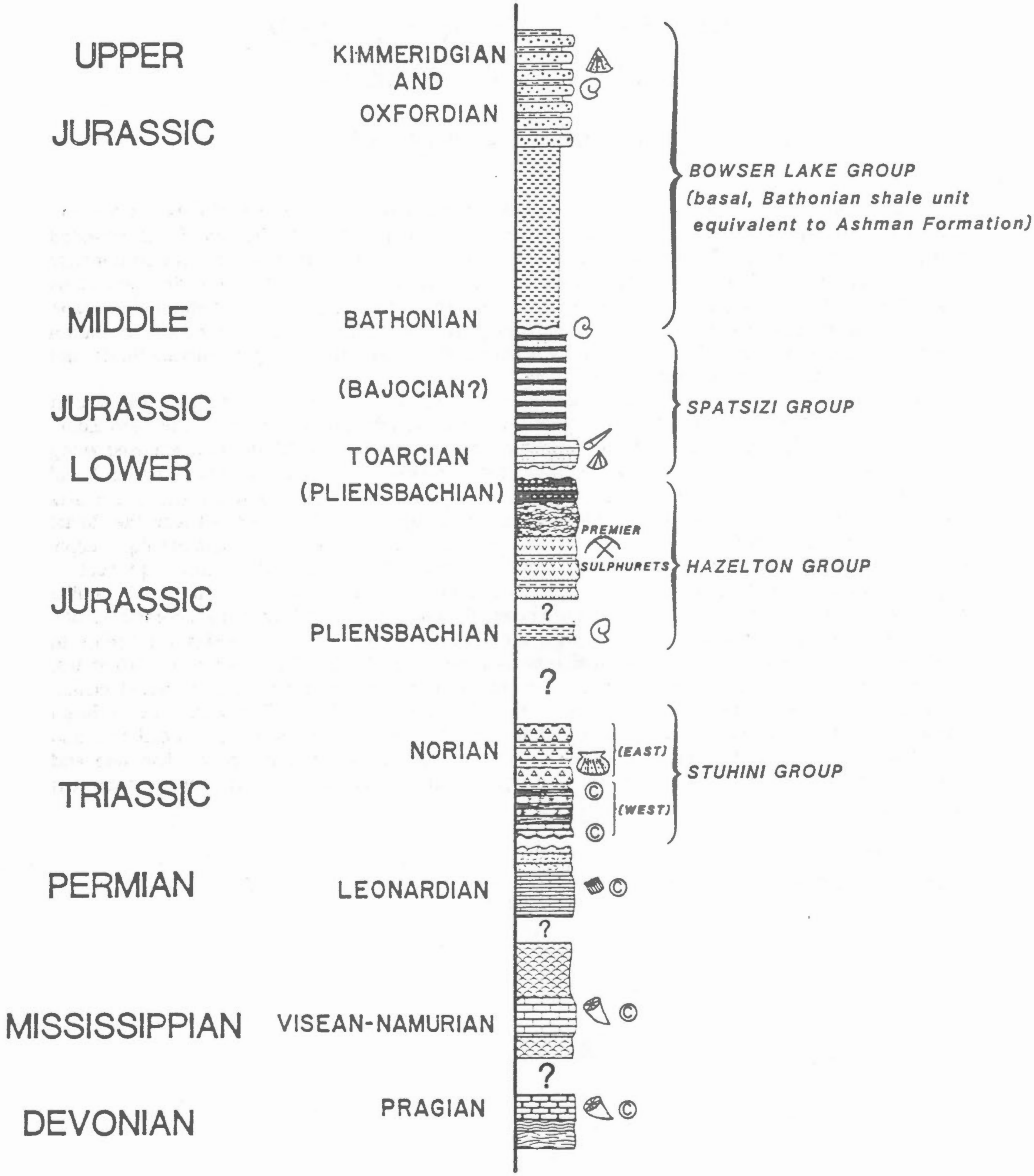
tabulate coral

rugose coral

? unknown stratigraphic relationship

unconformity

mineral deposit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The Tintina Fault and gold: Grew Creek, Yukon

A.B. Christie[1] and S.P. Gordey[1]

The Tintina fault zone was the locus of dextral transcurrent movement of between 500 km and perhaps as much as 900 km during the Late Cretaceous and early Tertiary. Fault-bounded panels of folded and tilted Eocene fluvial sediments and bimodal volcanic rocks are preserved locally within braided parts of the fault zone. Deposition of these strata may have been within pull-apart basins formed through transcurrent faulting; their deformation was linked to contemporaneous and later transcurrent movement. The Tintina fault zone provided an ideal environment for the formation of epithermal deposits: high heat flow, local volcanism, abundant faults to tap circulating fluids, and preservation of near surface stratigraphic levels.

The Grew Creek gold deposit near Ross River, Yukon occurs in Eocene volcanic rocks within the fault zone. Rhyolite flows host an eastern section of mineralization, known as the Tarn Zone, and these grade westward into rhyolite pyroclastic rocks that contain the Main Zone, exposed along Grew Creek and to the west. The rhyolitic rocks are juxtaposed against a sequence of cyclic fluvial sediments, to the north, by an east northeast trending fault. Within the Main Zone, a quartz feldspar porphyry dike is intruded for part of the way along the fault contact between the fluvial sediments and the rhyolitic rocks. The pyroclastic rocks, dike, fault, and sediments dip steeply northwards. Andesite dikes and/or flows occur within the volcanic and sedimentary sequences.

The volcanic and intrusive rocks are hydrothermally altered to propylitic and argillic assemblages, whereas the fluvial sediments are generally unaltered, apart from some sporadic argillic alteration adjacent to the fault contact with the volcanic rocks. The mineralization occurs in stockwork quartz veins and hydrothermal breccias, and consists of quartz, adularia, carbonates, quartz pseudomorphs after calcite, pyrite, marcasite, arsenopyrite, chalcopyrite, argentite, electrum, silver selenides, galena, and sphalerite. Additionally, fluorite occurs in the Tarn Zone. In the Main Zone, the ore grade mineralization is found in an elongate zone, trending east northeast and bounded to the north by elevated concentrations of pyrite, arsenic and mercury. The vein and breccia textures, volcanic host rock setting, and geochemical signature, indicate that the deposit is epithermal.

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[1] Geological Survey of Canada, 100 West Pender St., Vancouver, B.C. V6B 1R8

L'or et la faille de Tintina: Grew Creek, Yukon

A.B. Christie[1] et S.P. Gordey[1]

La zone de faille de Tintina a été le siège, au Crétacé supérieur et au Tertiaire inférieur, de décrochements dextres dont l'amplitude varie entre 500 et 900 km. Des blocs délimités par des failles et constitués de roches sédimentaires fluviatiles et de roches volcaniques bimodales, plissées, inclinées et datant de l'Éocène, sont localement conservées à l'intérieur des sections anastamosées de la zone de faille. La sédimentation de ces couches a pu se produire à l'intérieur de bassins d'extension formés par décrochement; leur déformation est liée à des mouvements de décrochement contemporains et postérieurs. La zone de faille de Tintina constituait un milieu idéal en ce qui a trait à la formation de gîtes épithermaux : forte circulation de chaleur, volcanisme local, nombreuses failles pouvant capter les fluides et conservation des unités stratigraphiques de surface.

Le gîte aurifère de Grew Creek, près de la rivière Ross, au Yukon, est contenu dans des roches volcaniques éocènes qui se trouvent à l'intérieur de la zone de faille. Des coulées rhyolitiques renferment la partie orientale de la minéralisation, connue sous le nom de zone Tarn. Ces coulées passent vers l'ouest à des roches rhyolitiques pyroclastiques qui contiennent la zone principale, qui affleure le long du ruisseau Grew et plus à l'ouest. Une faille d'orientation E-NE accole les roches rhyolitiques avec une succession de roches fluviatiles cycliques, situées au nord. A l'intérieur de la zone principale, un dyke porphyrique quartzo-feldspathique a partiellement été mis en place le long de la faille qui met en contact les roches fluviatiles et rhyolitiques. Les roches pyroclastiques, le dyke, la faille et les roches sédimentaires possèdent un fort pendage vers le nord. On observe des dykes ou des coulées d'andésite dans les successions volcaniques et sédimentaires.

Les roches volcaniques et intrusives ont été transformées par altération hydrothermale en assemblages propylitiques et argilliques, tandis que les roches fluviatiles sont généralement non altérées, sauf quelques rares occurrences d'altération argillique en bordure du contact avec les roches volcaniques. La minéralisation se trouve à l'intérieur de veines de quartz en stockwerk et de brèches hydrothermales et se compose de quartz, d'adulaire, de carbonates, de calcite pseudomorphisée en quartz, de pyrite, de marcassite, d'arsénopyrite, de chalcopyrite, d'argentite, d'electrum, de séléniures d'argent, de galène et de sphalérite. La zone Tarn renferme de plus de la fluorite. Dans la zone principale, on trouve de la minéralisation à teneur exploitable dans une zone allongée, d'orientation E-NE et limitée au nord par de fortes concentrations de pyrite, d'arsenic et de mercure. Les textures de la veine et de la brèche, le contexte de l'encaissant volcanique et les caractéristiques géochimiques indiques que le gîte est de nature épithermale.

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[1]Commission géologique du Canada, 100 West Pender Street, Vancouver, C.-B. V6B 1R8

Geochemistry of stream sediments, bedrock and groundwater in resource assessment of the south Nahanni River area, Yukon and N.W.T.

C.W. Jefferson[1], W.A. Spirito[2], S.M. Hamilton[3], F.A. Michel[3] and D. Paré[4]

Assessment of non-renewable mineral resource potential in proposed extensions to Nahanni National Park Reserve has involved i) local mapping of bedrock and surficial geology, ii) study of mineral occurrences and iii) regional geochemistry of stream silts, heavy mineral concentrates (HMC), bedrock samples, hot to cold spring-waters and tufa precipitates. Simplified geology, mineral occurrences and geochemical data from over 300 sites were digitized and are being interpreted with the aid of computer integration.

Research spun-off from the assessment work has studied:

1. relative effectiveness of the geochemical sampling media,
2. techniques to produce HMCs from gravels and 2-4 kg of silt;
3. a computer program to statistically analyze data with observations below detection limit;
4. lowering the detection limit of W and Mo in spring-waters; and
5. relating the geochemical associations of spring-waters and stream sediments to nine geologic domains.

The following selected results are related to the above, by number.

1. HMCs (and silts) are essential; till geochemistry, spring-waters and lithogeochemistry provide localized data but are also useful in regional geochemical reconnaissance of this area.
2. A Wilfey/Deister type table with black deck can separate up to 100 % of the >55 u free gold from a partly panned field concentrate, giving critical immediate results before chemical analyses for gold.
3. A program developed by C.F. Chung is useful in calculating statistics without arbitrary assignment of values (e.g. 66% of detection limit) to analyses below detection limit;
4. Inductively coupled plasma atomic emission spectrometry and inductively coupled plasma mass spectrometry (G.M. Hall) have detection limits for W and Mo in spring-waters of 1.2 and 0.4 ug L-1 (ppb) respectively. Three of four distinctly anomalous (>15 ug L-1 W) hot springs are spatially associated with Cretaceous granites and known scheelite-bearing skarns or wolframite occurrences.

5a. Gold anomalies of unknown source (?glacial / precious metal veins / chemical reconcentration from shales?) were detected in HMCs, but not in standard silts, in the Nahanni Karst-Tlogotsho Plateau area.

5b. Tungsten and gold in HMCs are (i) correlated with each other, (ii) locally associated with Zn anomalies in stream sediments near Ag-Pb-Zn veins of the Prairie Creek (Cadillac) mine area, and (iii) are not associated with anomalous Zn in other regional samples.

5c. Zinc anomalies in silts and HMCs are associated with anomalous Zn-Cd-Ni-Co-Cu-U in waters, of newly discovered hot and cold springs, in the Meilleur River area. For the resource assessment this suggests potential in the Meilleur River area for the existence of undiscovered Ag-Pb-Zn veins similar to those of Prairie Creek mine.

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[1] Geological Survey of Canada, 601 Booth St., Ottawa, Ont. K1A 0E3
[2] Geology Department, U. of Western Ont., London, Ontario N6A 5B7
[3] Department of Geosciences, Carleton U., Ottawa, Ontario K1S 5B6
[4] Consor Mines Ltd., 89 Eddy Street, Hull, Québec J8Z 2E9

Géochimie des sédiments fluviatiles, des roches en place et de l'aquifère pour l'évaluation des ressources de la région du sud de la rivière Nahanni, Yukon et Territoires du N.O.

C.W. Jefferson[1], W.A. Spirito[2], S.M. Hamilton[3],
F.A. Michel[3] et D. Paré[4]

L'évaluation du potentiel économique minéral non-renouvelable dans les extensions proposées au parc national de Nahanni a compris i) la cartographie des roches en place et sédiments non consolidés, ii) étude des gîtes minéraux et iii) géochimie régionale des limons alluvionnaires, concentrés de minéraux lourds (CML), échantillons de roches, eaux de sources chaudes et froides, et précipités de travertin. La géologie simplifiée, gîtes minéraux et données géochimiques de plus de 300 sites ont été numérisés et sont interprétés à l'aide d'intégration à l'ordinateur.

La recherche se rapportant au travail d'évaluation a compris l'étude de

1. l'efficacité relative de la méthode d'échantillonnage géochimique
2. les techniques de séparation de CML à partir du gravier et limons
3. les techniques d'analyse statistique des données avec observations en dessous de la limite de détection
4. diminution de la limite de détection de W et Mo dans les eaux de source; et
5. le rapport entre les associations géochimiques des eaux de source et des sédiments alluvionnaires avec neuf domaines géologiques.

Les résultats qui suivent se rapportent au point ci-dessus par numéro

1. CML (et limons) sont essentiels; la géochimie des limons, des eaux de source et des roches procurent des données localisées mais sont aussi utiles pour la géochimie de reconnaissance régionale de la région.
2. Une table de gravité de type Wilfey/Deister à surface noire peut séparer jusqu'à 100% de l'or libre >50u à partir d'un concentré partiellement lavé à la battée sur le terrain donnant ainsi immédiatement des données critiques. La plupart de l'or libre restant (y compris <50u) est concentré dans le CML qui est alors analysé pour l'or et autres éléments par activation neutronique.
3. Un programme déloppé par C.F. Chung est utile dans le calcul statistique sans assigner arbitrairement des valeurs aux analyses tombant en dessus de la limite de détection (par ex. 66% de la limite de détection).
4. La spectrométrie d'émission atomique par plasma à couplage inductif et spectrométrie de masse par plasma à couplage inductif (G.M. Hall) ont des limites de détection pour le W et Mo dans eaux de source de 1.2 et 0.4 ug L' (ppb) respectivement. Trois des quatre sources chaudes anomales (>15 ug L-1W) sont associées à des granites du Crétacé et à des gîtes de skarn à scheelite ou gîtes de wolframite.

5a. Des anomalies d'or de source inconnue (transport glacial? veines? reconcentration chimique à partir d'argile?) ont été détectées dans les CML mais non dans les limons standards de la région du Karst de Nahanni.

5b. Le tungsténe et l'or des CML sont i) associés l'un à l'autre, ii) associés localement avec des anomalies de Zn des sédiments alluvionnaires prés des veines d'Ag-Pb-Zn de la région de la mine Prairie Creek (Cadillac) et iii) ne sont pas associés au Zn ailleurs.

5c. Les anomalies de Zn des limons et CML sont associées à des anomalies de Zn-Cd-Ni-Co-Cu-U des eaux de sources froides et chaudes récemment découvertes dans la région de la riviére Meilleur. Pour l'évaluation des ressources, ceci suggére l'existence possible de veines d'Ag-Pb-Zn dans la région de la riviére Meilleur semblables à celles de la mine de Prairie Creek.

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[1] Commission géologique du Canada, 601 rue Booth, Ottawa, Ontario K1A 0E8
[2] Département de géologie, U. de Western Ont., London, Ontario N6A 5B7
[3] Département de géosciences, U. de Carleton, Ottawa, Ontario K1S 5B6
[4] Mines Consor limitée, 89 rue Eddy, Hull, Québec J8Z 2E9

Late Mesozoic and Cenozoic fault systems of the southern Coast Belt; implications for Cu-Au-Ag mineralization in the Harrison Lake region

M.J. Journeay[1]

The Coast Belt (CB) of southern British Columbia records a complex history of deformation, metamorphism and igneous activity that can be linked in part to progressive shortening and transcurrent displacements along the continental margin of North American since Early Cretaceous time. Shortening began along the eastern flank of the CB with thin-skinned imbrication and SW-directed thrust faulting of volcanic arc and flanking oceanic sequences of the Northwest Cascades System (NCS), and culminated in the L. Cretaceous with thick-skinned imbrication and westward overthrusting of the Cascade Metamorphic Core (CMC). Shear zones associated with fault systems of both the NCS and CMC are characterized by localized domains of high strain and non-cylindrical folding in which mylonitic foliations and associated down-dip stretching lineations are well-developed. Asymmetric fault zone fabrics indicate an upper plate to-the-southwest sense of displacement and support a thrust imbrication model for early assembly of the CB.

The leading edge of the NCS-CMC thrust system is cut by high-angle NW-striking faults of the Harrison Lake Shear Zone (HLSZ), a right lateral transcurrent fault which splays northward into an imbricate fan of high-angle brittle faults. Displacement increases along strike to the southeast across a network of mylonitic shear zones which most likely feed into major dextral transcurrent faults of the northwest Cascades. HLSZ is interpreted to be the leading tip of this transcurrent fault system and appears to have been initiated in Late Cretaceous and/or Early Tertiary time.

Tertiary fault structures which cross-cut HLSZ comprise a system of NE-striking dextral transcurrent faults and conjugate, NW-striking high-angle reverse faults. These structures are part of a regional fault system within the southern CB, and may record crustal shortening associated with eastward subduction of oceanic lithosphere.

HLSZ is recognized to be an important structure in localizing economic gold deposits within SW British Columbia. The gold belt is associated primarily with brittle fault systems along the western margin of the shear zone, and is most likely offset to the north by younger NE-striking transcurrent faults. These NE-striking transcurrent faults may also be important structures in controlling the emplacement of epizonal Late Tertiary plutons and in tapping associated hydrothermal systems. It follows that these transcurrent faults may be providing the necessary structural control for localizing economic concentrations of both base and precious metals within the region. This hypothesis is supported by observed spatial relationships between NE-striking transcurrent faults, post-Miocene plutons and present day hydrothermal systems.

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[1]Geological Survey of Canada, 100 West Pender St., Vancouver, B.C. V6B 1R8

Réseaux de failles du Mésozoïque supérieur et du Cénozoïque de la partie sud de la chaîne côtière; leur relation avec la minéralisation en Cu-Au-Ag de la région du lac Harrison

M.J. Journeay[1]

La chaîne Côtière du sud de la Colombie-Britannique conserve des évidences d'une histoire complexe de déformation, de métamorphisme et d'activité ignée pouvant être partiellement reliée au raccourcissement progressif et aux décrochements survenus le long de la marge continentale de l'Amérique du Nord depuis le Crétacé inférieur. Le raccourcissement a débuté le long du flanc est de la chaîne Côtière avec une imbrication des unités de couverture et la formation de failles de chevauchement dirigées vers le sud-ouest affectant l'arc volcanique et les successions océaniques adjacentes de la partie nord-ouest des monts Cascade. Le raccourcissement a été maximal au Crétacé inférieur et se caractérisait par une imbrication des unités de couverture et du socle et un chevauchement vers l'ouest affectant le noyau métamorphique des monts Cascade. Les zones de cisaillement associées aux réseaux de failles de la partie nord-ouest et du noyau métamorphique des monts Cascade sont caractérisées par des domaines locaux de fortes contraintes et un plissement non cylindrique dans lequel les foliations mylonitiques et les linéations d'étirement d'aval-pendage associées sont bien développées. Des fabriques asymétriques de zone de failles indiquent un déplacement dans le sens d'une plaque supérieure vers le sud-ouest et appuient un modèle d'imbrication par chevauchement pour ce qui est des premiers stades d'évolution de la chaîne Côtière.

Le front du réseau de failles de chavauchement de la partie nord-ouest et du noyau métamorphique des monts Cascade est recoupée par des failles, de direction NW et à fort pendage, de la zone de cisaillement de Harrison Lake, un décrochement à déplacement latéral vers la droite qui s'élargit vers le nord et pénètre dans un éventail de failles cassantes à fort pendage. L'ampleur du déplacement s'accroît vers le sud-est, selon la direction des couches, de part et d'autre d'un réseau de zones de cisaillement mylonitique qui passe fort probablement à d'importants décrochements dextres dans le nord-ouest des monts Cascade. Il est généralement admis que la zone de cisaillement de Harrison Lake constitue le front de ce réseau de décrochements. Elle semblerait s'être activée au Crétacé supérieur ou au Tertiaire inférieur.

Les structures de failles tertiaires qui recoupent la zone de cisaillement de Harrison Lake comprennent un réseau de décrochements dextres d'orientation NE et de failles inverses conjuguées, d'orientation NW et à fort pendage. Ces structures font partie d'un réseau de failles régional situé dans la partie méridionale de la C.-B. Elles pourraient contenir des évidences de raccourcissement de la croûte associées à une subduction vers l'est de la lithosphère océanique.

On admet que la zone de cisaillement de Harrison Lake présente un grand intérêt dans la localisation de gîtes aurifères exploitables économiquement dans le sud-ouest de la C.-B. La ceinture aurifère est principalement associée à des réseaux de failles cassantes le long de la bordure occidentale de la zone de cisaillement et est vraisemblablement déplacée vers le nord par des décrochements plus résents vers le NE. Ces derniers peuvent aussi exercer un contrôle important dans le localisation de plutons hypabyssaux du Tertiaire supérieur et le captage des réseaux hydrothermaux associés. Il s'ensuit que ces décrochements peuvent constituer le contrôle structural nécessaire au dépôt de concentrations exploitables de métaux de base et de métaux précieux dans la région. Cette hypothèse est étayée par la présence de relations spatiales entre les décrochements vers le NE, les plutons post-miocènes et les réseaux hydrothermaux actuels.

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[1] Commission géologique du Canada, 100 West Pender Street, Vancouver, C.-B., V6B 1R8

An exploration model for central British Columbia

L.C. Struik[1]

Could the precious metal showings in central British Columbia be part of a much larger series of deposits that could yield 200,000,000 ounces silver and 15,000,000 ounces gold?; - equal in size to one of the smaller gold and silver mining camps of the Basin and Range of southern California, Arizona and Nevada. Many of the precious metal deposits of the Basin and Range formed during crustal extension that was a consequence of strike-slip plate motions. During strike-slip plate motion the strike-slip fault (plate boundary) is often en echelon, and the motion is transferred from one leg of the boundary to the other across a zone of compression or extension. The extension zones are called pull-aparts. Within the pull-aparts the crust is extended or stretched. The ductile lower crust becomes thinned and rises as the brittle lower-grade rocks of the upper crust are pulled out of the area of the pull-apart along shallow faults. The result is an altogether thinner crust and the juxtaposition of cold upper crustal rocks and hot lower crustal rocks. The source of heat at relatively shallow depth generates circulation of meteoric and metamorphic water (mineral brines) that rise to shallow depths along the extension faults. The brines precipitate minerals in suitable environments along and near the shallow extension faults. Within the McLeod Lake map area (93J) the Wolverine Metamorphic Complex appears to have been uplifted as a result of extension; perhaps in a pull-apart basin that transferred plate motion between the Northern Rocky Mountain Trench and Pinchi faults during the early and middle Tertiary. Gold showings and antimony anomalies in stream sediments are located around the periphery of the Wolverine Complex. The concentrations may have been produced by extension driven fluid convection, and the rocks overlying the Wolverine Complex may be good exploration targets for precious metals.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Modèle d'exploration appliqué au centre de la Colombie-Britannique

L.C. Struik[1]

Les indices de métaux précieux du centre de la C.-B. feraient peut-être partie d'un ensemble de gisements beaucoup plus imposant qui pourrait produire 200 000 000 d'onces d'argent et 15 000 000 d'onces d'or; cet ordre de grandeur correspondrait à la dimension d'un camp minier parmi les plus petits d'entre ceux qui exploitent l'or et l'argent dans le bassin et le chaînon du sud de la Califormie, de l'Arizona et du Nevada. De nombreux gîtes de métaux précieux du bassin et du chaînon se sont formés lors de l'extension de la croûte qui a suivi les mouvements tectoniques de coulissage. Lorsque des mouvements de ce type se produisent, la faille de décrochement (bordure de la plaque) se présente souvent en échelon et le mouvement est transféré d'un côté de la plaque à l'autre, de part et d'autre d'une zone de compression ou d'extension. La croûte est étirée à l'intérieur des zones d'extension. La croûte inférieure, de nature ductile, s'amincit et se déplace vers le haut tandis que les roches de la croûte supérieure, de nature cassante et moins métamorphisées, sont poussées en dehors de la zone le long de failles peu profondes. Cette activité se traduit par une croûte plus mince et par la juxtaposition de roches froides de la croûte supérieure et de roches chaudes de la croûte inférieure. La source de chaleur à des profondeurs relativement faibles amorce la circulation d'eau météorique et métamorphique (saumures minérales) qui parviennent près de la surface en empruntant des failles d'extension. Les saumures peuvent déposer des minéraux dans des environnements favorables, le long des failles d'extension de faible profondeur et à proximité de ces dernières. Le complexe métamorphique de Wolverine, situé dans le secteur du lac McLeod (93J), semble avoir été soulevé en réponse à des forces d'extension, peut-être dans un bassin d'extension qui a transféré les mouvements de plaque entre le nord du sillon des Rocheuses et les failles Pinchi, durant le Tertiaire inférieur et moyen. Des indices aurifères et des anomalies d'antimoine dans les sédiments de ruisseau sont situés en périphérie du complexe de Wolverine. Les concentrations ont pu être obtenues par un mouvement convectif des fluides amorcé par des forces d'extension.

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[1]Commission géologique du Canada, 100 West Pender Street, Vancouver, C.-B., V6B 1R8

Structural and geochemical studies at the Mosquito creek gold mine Cariboo District, British Columbia

B.E. Taylor[1] and F. Robert[1]

The Mosquito Creek Gold mine (MCGM)near Wells, east-central British Columbia, comprises Au-bearing pyritic lenses and quartz veins in the Barkerville Terrane. The low metamorphic grade (greenschist facies) host rocks include clastic sedimentary rocks with subordinate carbonate rocks and meta-volcanic rocks. The 15+ km long Cariboo Gold Belt (CGB) follows the NW-SE striking contact between the pale quartzite, phyllites, and minor limestone and mafic volcanic rocks of the "Baker Member" (to the NE), and the dark quartzite and phyllites of the "Rainbow Member" (to the SE). This sequence dips 30-60° NE, is interpreted to comprise the overturned SW limb of a regional anticline. Asymmetric, Z-shaped folds with shallow NE-dipping axial planes and with hinges plunging 20° to the NW, parallel to the prominent regional lineation.

The Mosquito Creek, Island Mountain and Cariboo Gold Quartz mines produced about 40 tonnes of Au along a 3.5 km segment of the CGB. Gold was produced from quartz-pyrite veins concentrated in the "Rainbow member", and from pyritic lenses (so-called "replacement" ore) commonly associated with asymmetric fold hinges in limestone bands near the Baker- Rainbow contact. The deposits resemble (other) mesothermal type vein deposits (high ave. Au:Ag ratio of 8.5; similar vein fluids) but differ somewhat in geological setting (mostly metasedimentary wallrocks; veins not clearly associated with a major fault).

The two principal types of gold-bearing veins are: (1) diagonal quartz-pyrite-sericite veins (070-090; subvertical), oblique (at high angle) to the prominent lineation, and (2) orthogonal quartz-carbonate- pyrite-galena-sphalerite veins, perpendicular to the lineation. Both are extensional in origin. The orthogonal veins are younger and crosscut variably deformed diagonal veins. Structural analysis suggests that these veins formed during late stages of deformation of the terrane.

The origin of the pyritic orebodies has generally been considered post-folding replacement of limestone along fold hinges intersected by diagonal veins. Dolomitization and/or silicification of the limestone does occur on the fringes of orebodies, and scheelite occurs in both diagonal veins and pyritic orebodies. However, detailed studies at MCGM indicate that: (1) pyritic ore predates the crosscutting diagonal veins which include fragments of pyritic ore; and (2) the pyritic ore predates at least some of the asymmetric folding, as they are themselves folded, and locally transposed by the axial cleavage of these folds. These relationships suggest that perhaps not all the sulphides are of the same age; pyrite deposition may have originally predated much or all of the deformation.

Preliminary fluid inclusion and stable isotope (O, C, H and S) studies indicate that: (1) low salinity, H_2O-CO_2 fluids formed both types of veins; and (2) fluids record extensive water/rock reaction (and had high $\delta^{18}O$). Deformation, fluid-flow, and at least some mineralization and alteration were all interrelated.

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[1]Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8

Études structurales et géochimiques à la mine d'or de Mosquito Creek, dans le secteur de Cariboo, C.-B.

B.E. Taylor[1] et F. Robert[1]

La mine d'or de Mosquito Creek, près de Wells, dans le centre est de la Colombie-Britannique, est constituée de lentilles pyriteuses aurifères et de veines de quartz situées dans le "Barkerville Terrane". L'hôte faiblement métamorphisé (faciès des schistes verts) se compose de roches sédimentaires clastiques et de quantités accessoires de roches carbonatées et méta-volcaniques. La ceinture aurifère de Cariboo, d'une longueur de plus de 15 km, longe le contact, d'orientation NW-SE, entre, d'une part, la quartzite et les phyllites pâles ainsi que des quantités mineures de calcaires et de roches volcaniques mafiques du Membre de Baker (au NE) et, d'autre part, les quartzites et phyllites foncées du Membre de Rainbow (au SE). Cette séquence présente un pendage de 30 à 60° vers le NE et se situe sur le flanc SW déversé d'un anticlinal régional. On observe également des plis asymétriques en forme de Z comprenant des plans axiaux à faible pendage vers le NE et des charnières plongeant à 20° vers le NW. Ces plis sont parallèles à la linéation régionale dominante.

Les mines d'or de Mosquito Creek, d'Island Mountain et de Cariboo Gold Quartz ont produit environ 40 tonnes d'or le long d'un segment de 3,5 km le long de la ceinture aurifère de Cariboo. L'or était exploité dans des veines de quartz pyriteuses concentrées dans le Membre de Rainbow et dans des lentilles pyriteuses (dans ce cas, on parle de minerai de remplacement) généralement associées à des charnières de plis asymétriques affectant des bancs de calcaire près du contact Baker-Rainbow. Ces occurrences ont des caractéristiques semblables à celles des gisements filoniens de type mésothermal (rapport moyen Au/Ag de 8,5; fluides filoniens semblables) mais reflètent un environnement géologique quelque peu différent (l'encaissant est principalement métasédimentaire et les veines ne sont pas clairement associées à une faille majeure).

Les deux principaux types de veines aurifères sont : (1) des veines de quartz-pyrite-séricite diagonales (070-090; subverticales), fortement discordantes par rapport à la linéation dominante et (2) des veines de quartz-carbonate-pyrite-galène-sphalérite orthogonales, qui recoupent la linéation à angle droit. Ces deux types de veines ont été formés par extension. Les veines orthogonales sont les plus récentes et recoupent les veines diagonales, qui présentent un degré de déformation variable. L'analyse structurale semble indiquer qu'elles se seraient formées durant les derniers stades de déformation du terrain.

Il est généralement admis que les corps minéralisés pyriteux proviennent du remplacement des calcaires, après le plissement, le long de charnières de plis recoupées par des veines diagonales. La dolomitisation ou la silicification du calcaire sont restreintes aux bordures des corps minéralisés. La scheelite est présente dans les veines diagonales et les corps minéralisés pyriteux. Toutefois, les études détaillées effectuées à la mine d'or de Mosquito Creek indiquent : (1) que le minerai pyriteux est antérieur aux veines diagonales qui le recoupent et qui comprennent des fragments de minerai pyriteux et (2) que le minerai pyriteux est antérieur au moins à certains plis asymétriques, puisque le minerai est plissé, et qu'il est localement transposé par le clivage axial de ces plis. Ces relations laissent supposer que les sulfures pourraient ne pas être tous du même âge; la précipitation de la pyrite pourrait à l'origine s'être effectuée avant une grande partie ou la totalité de la déformation.

Des études préliminaires sur les inclusions fluides et les isotopes stables (O, C, H et S) indiquent : (1) que des fluides, à H_2O-CO_2 et de faible salinité, sont à l'origine des deux types de veines et (2) que les fluides reflètent une réaction eau/roche intense et avaient une forte teneur en $\delta^{18}O$. La déformation, l'écoulement des fluides et, dans une certaine mesure, la minéralisation et l'altération étaient tous interdépendants.

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[1]Commission géologique du Canada, 601 rue Booth, Ottawa, Ontario K1A 0E8

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(VERSION FRANCAIS DISPONIBLE SUR DEMANDE)

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COMMISSION GÉOLOGIQUE DU CANADA

CORDILLERAN GEOLOGY AND EXPLORATION ROUNDUP

FORUM SUR L'EXPLORATION ET LA GEOLOGIE DE LA CORDILLERE

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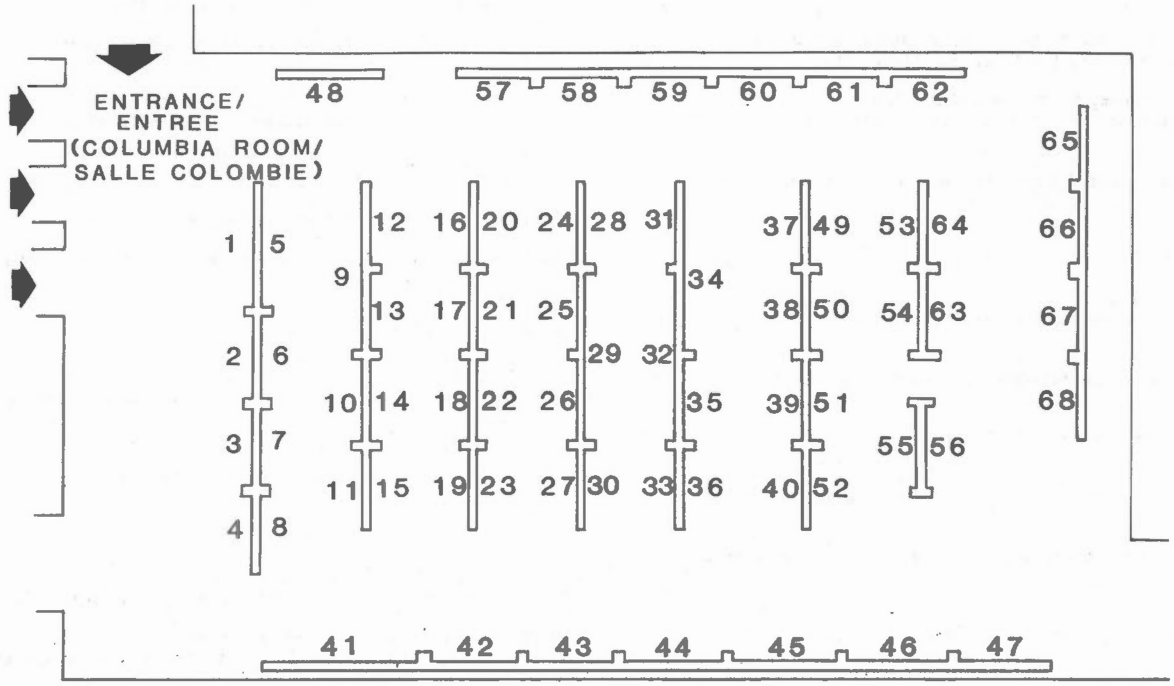

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GEOLOGICAL SURVEY OF CANADA

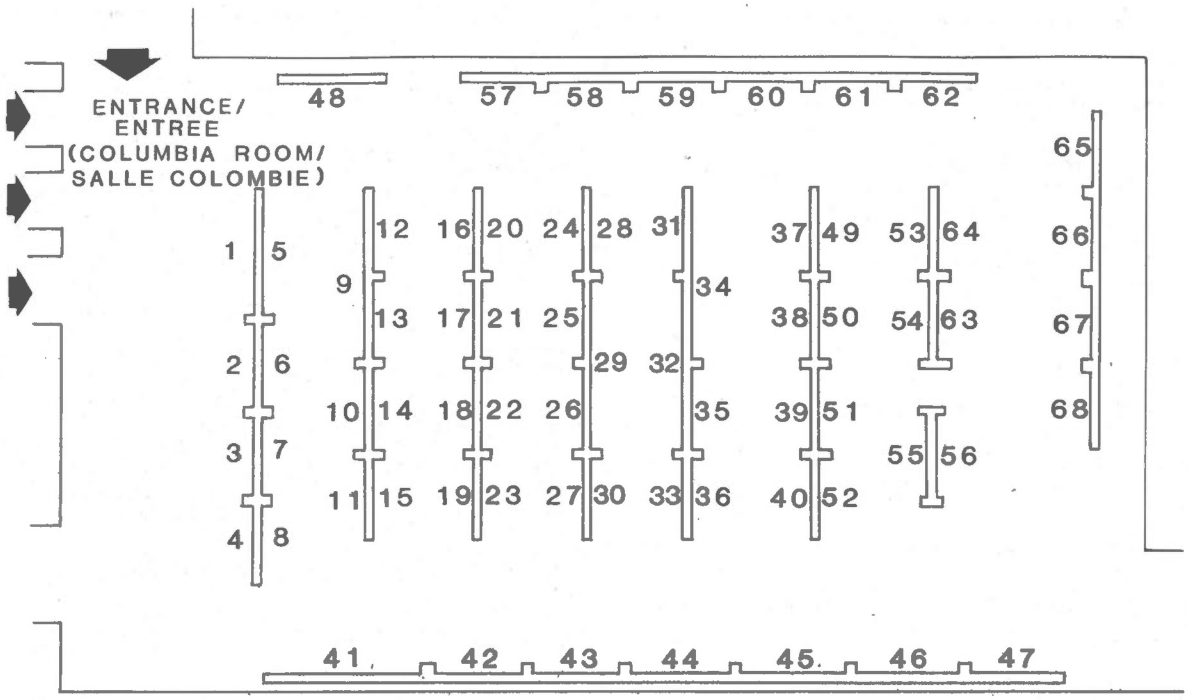
COMMISSION GÉOLOGIQUE DU CANADA

CORDILLERAN GEOLOGY AND EXPLORATION ROUNDUP

February 7, 1989

FORUM SUR L'EXPLORATION ET LA GEOLOGIE DE LA CORDILLERE

Le 7 février, 1989



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Geological overview of B.C.'s "golden triangle": G.S.C. mapping and research in the Iskut map area, northwest B.C.

Robert G. Anderson[1] and R.V. Kirkham[2]

British Columbia's newest "Golden Triangle" connects the Premier-Sulphurets-Johnny Mountain/Snip/Bronson Creek precious metal camps within the Iskut River map area (56-57°N, 130-132°W; NTS 104B). The Lower Jurassic Hazelton Group and alkaline members of the cogenetic Early Jurassic Texas Creek plutonic suite have proved the most productive and prospective for precious metal lodes. These metallotects developed as part of a 400 million year geological evolution recorded in four tectonostratigraphic assemblages: 1) Paleozoic Stikine assemblage; 2) Triassic-Jurassic volcano-plutonic complexes of Stikinia which generally host the ore; 3) Middle and Upper Jurassic Bowser overlap assemblage; and 4) Tertiary Coast Plutonic Complex. The paper presents an overview of the stratigraphic, structural, plutonic and metamorphic framework and an outline of detailed mineral deposit research on the Sulphurets camp.

Early Devonian to Early Permian coralline limestone reef and mafic to felsic volcanic rocks make up the Stikine assemblage and include some of the most intensely deformed rocks in the region.

Distinctive porphyritic dykes link Upper Triassic (Stuhini Group) and metallogenically-important Lower Jurassic (Hazelton Group) volcanics with their plutonic equivalents (Late Triassic Stikine and Early Jurassic Texas Creek plutonic suites). Basinal sedimentary and distal tuffaceous rocks of the Lower and Middle Jurassic Spatsizi Group mark the end of Triassic-Jurassic volcanism.

Fossiliferous Upper Triassic Stuhini Group and Lower to Middle Jurassic Spatsizi Group strata provide recognizable, biostratigraphically restricted, bounding markers. They define the economically important but mainly unfossiliferous and heterogeneous Lower Jurassic volcanic strata of the Hazelton Group metallotect.

Fine and medium grained siliciclastics of the Middle and Upper Jurassic Bowser Lake Group are a distal facies of an overlap assemblage. To the north, coeval, chert-bearing conglomerate demonstrably links Stikinia and Cache Creek terranes. Bowser Lake Group rocks are deformed into distinctive, orthogonal cross folds.

Unconformities seem to bound the major stratigraphic assemblages. Stratigraphic relationships among members of the Stikine assemblage are poorly known. A regionally extensive Permo-Triassic event is marked by local polymict conglomerate, a regional decrease in conodont colour alteration index with age and, possibly, an angular unconformity between recumbent, isoclinally folded Lower Permian limestone and overlying Upper Triassic(?) mafic volcanics(?). A regionally important sub-Toarcian unconformity and a local but metallogenically important Pliensbachian unconformity characterize the Lower Jurassic strata in the area.

An intrusive and structural contact separates Tertiary Coast Plutonic Complex (CPC) and Stikinia along the international border and Stikine River. Tertiary, post-tectonic, fresh, felsic plutons (Hyder plutonic suite, in part) characterize CPC. Younging of strata from west to east, abrupt westerly increase in metamorphic grade across the Stikine River and local zones of high strain along CPC's eastern margin attest to its intrusion and uplift.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

LEGEND

MIDDLE AND UPPER JURASSIC BOWSER LAKE GROUP

- greywacke
- shale

TOARCIAN AND BAJOCIAN? SPATSIZI GROUP

- siliceous shale
- submarine tuff
- sandy limestone and limy sandstone

LOWER JURASSIC HAZELTON GROUP

- welded tuff and tuff breccia
- maroon volcanic conglomerate and breccia
- massive green andesite and minor shale

UPPER TRIASSIC STUHINI GROUP

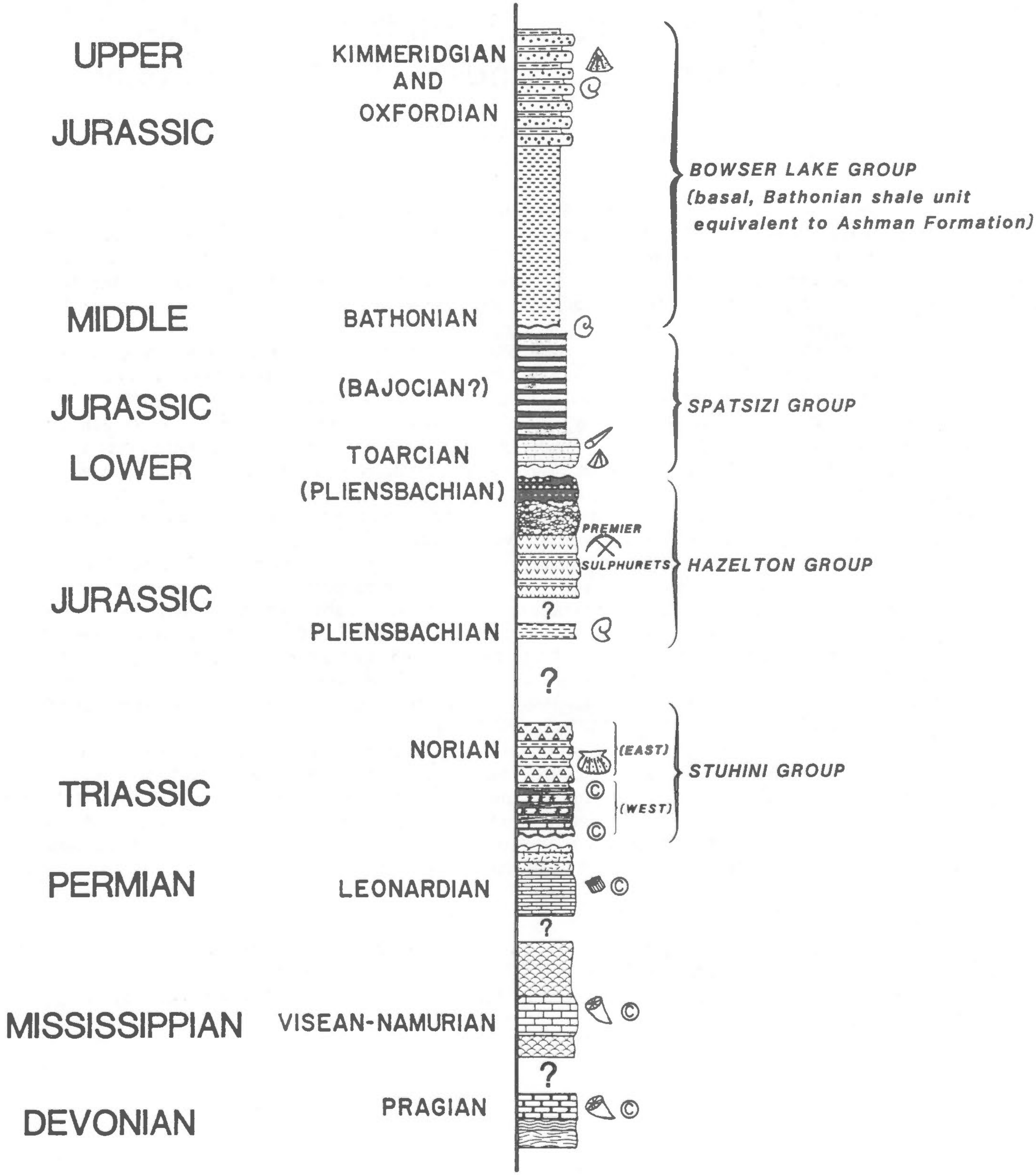
- clinopyroxene-phyric volcaniclastic rocks (eastern volcanic facies)
- shale and argillite
- clinopyroxene-phyric mafic tuff and flow rock; felsic tuff (western volcanic facies)
- grey sparry limestone and chert-limestone conglomerate

PALEOZOIC STIKINE ASSEMBLAGE

- green intermediate to felsic volcaniclastic rock and tuff (PERMIAN)
- thin bedded coralline limestone (L. PERMIAN)
- pillowed basalt and hyaloclastite (MISSISSIPPIAN)
- medium to thick bedded coralline limestone (MISSISSIPPIAN)
- deformed coralline limestone (L. DEVONIAN)
- schistose mafic volcaniclastic rock (L. DEVONIAN?)
- schistose felsic tuff (L. DEVONIAN?)

SYMBOLS

- *Buchia*
- ammonite
- belemnite
- *Weyla*
- *Minotis* or *Halobia*
- tabulate coral
- rugose coral
- ? unknown stratigraphic relationship
- unconformity
- mineral deposit


UPPER
JURASSIC
KIMMERIDGIAN
AND
OXFORDIAN
BOWSER LAKE GROUP
(basal, Bathonian shale unit
equivalent to Ashman Formation)
MIDDLE
BATHONIAN
(BAJOCIAN?)
JURASSIC
SPATSIZI GROUP
LOWER
TOARCIAN
(PLIENSBACHIAN)
PREMIER
SULPHURETS
HAZELTON GROUP
JURASSIC
?
PLIENSBACHIAN
?
NORIAN
(EAST)
STUHINI GROUP
TRIASSIC
(WEST)
PERMIAN
LEONARDIAN
?
MISSISSIPPIAN
VISEAN-NAMURIAN
?
DEVONIAN
PRAGIAN

Jurassic and Tertiary plutonism in the Queen Charlotte Islands, British Columbia

R.G. Anderson[1], I. Reichenbach[2] and C.J. Greig[3]

Overmaturation of Upper Triassic and Lower Jurassic Kunga Group potential source rocks accompanied intrusion of Middle to Late Jurassic (160-169 Ma) and Tertiary (27-46 Ma) plutonic suites along eastern Queen Charlotte Islands. Two Middle to Late Jurassic and one Tertiary plutonic suites encompass the calc-alkaline, I-type plutonism and are distinguished by differing plutonic and structural styles: the Middle to Late Jurassic San Christoval (SCPS) and Burnaby Island (BIPS) plutonic suites; and Tertiary Kano plutonic suite (KPS).

SCPS (K-Ar: 148-166 Ma; U-Pb: 168-169 Ma) is homogeneous, medium grained, foliated diorite and quartz diorite which contain common deformed inclusions but few dykes. Coeval BIPS (K-Ar: 145-164 Ma) is heterogeneous (gabbro, diorite, quartz monzodiorite, quartz monzonite and trondhjemite), unfoliated and pervasively brittly fractured and veined. BIPS crosscuts Middle Jurassic and older strata and is nonconformably overlain by Lower Cretaceous Longarm Formation. Advective heat transfer to Upper Triassic and Lower Jurassic Kunga Group occurred via Middle Jurassic to Early Cretaceous veins marking expulsion of hydrothermal fluids from BIPS plutons. The veins, which crosscut and extend beyond narrow contact metamorphic aureoles in the Kunga Group host, fostered cospatial copper-iron skarn mineral deposits.

KPS includes two northwest-trending, subparallel belts of (quartz) monzodiorite and lesser diorite and granite stocks. Fine grain size, unfoliated and homogeneous character, small pluton size, presence of orthopyroxene, and common miarolitic cavities distinguish KPS. The oldest KPS plutons are bimodal or are characterized by north-trending, cogenetic porphyry dyke swarms indicative of Late Eocene (ca. 44-46 Ma) extension which may herald opening of the Queen Charlotte basin. K-Ar (24-40 Ma range) and U-Pb (27-46 Ma range) isotopic ages refine chronometry of south to north time-transgressive plutonism as three distinct plutonic episodes of decreasing periodicity: 40-46 Ma, 32 Ma and 27-28 Ma.

Jurassic and Tertiary plutonic suites overlap in composition and share calc-alkaline ("average" K), cafemic-rich, metaluminous, and cordilleran I-type geochemical affinities. Heterogeneity in a suite's geochemical variation mirrors its map scale homogeneity; BIPS and KPS are the most heterogeneous. Some variation diagrams indicate mafic phases within BIPS and the Tertiary two-pyroxene diorite plutons are tholeiitic. A compositional "gap" in geochemical variation within the largely bimodal KPS is mimicked by samples of cospatial and coeval dykes.

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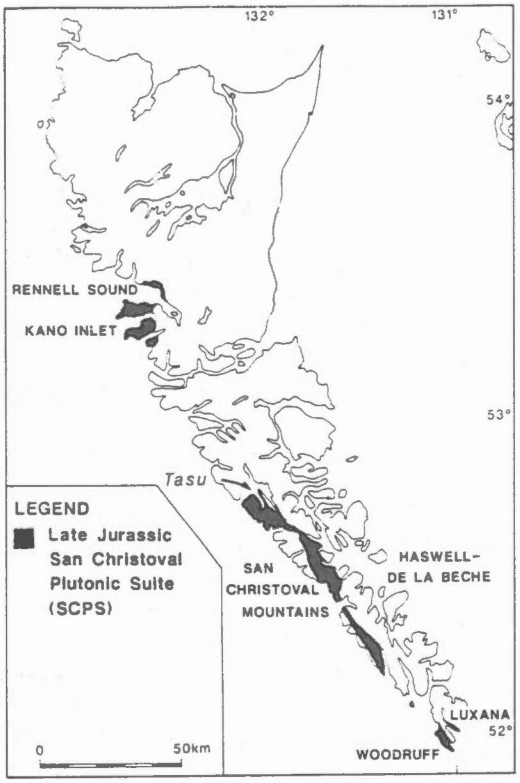
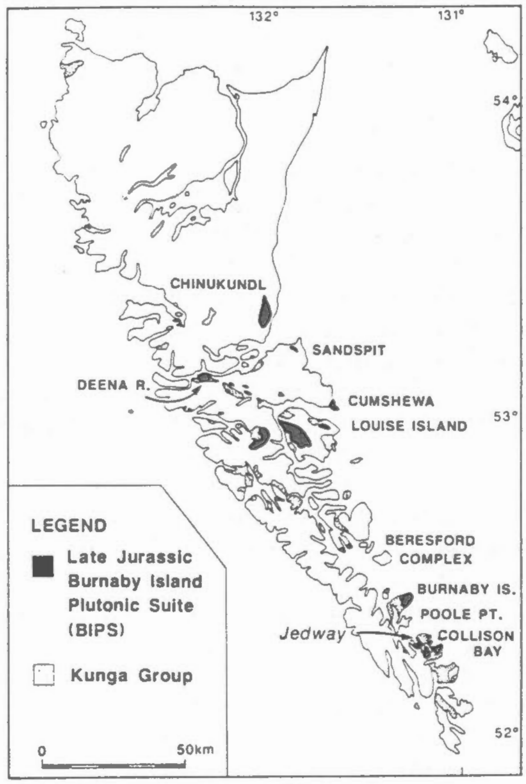
[1]Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8
[3]Department of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 2B4


132°
131°
54°
53°
52°
RENNELL SOUND
KANO INLET
Tasu
SAN CHRISTOVAL MOUNTAINS
HASWELL-DE LA BECHE
LUXANA
WOODRUFF
LEGEND
Late Jurassic San Christoval Plutonic Suite (SCPS)
0
50km


132°
131°
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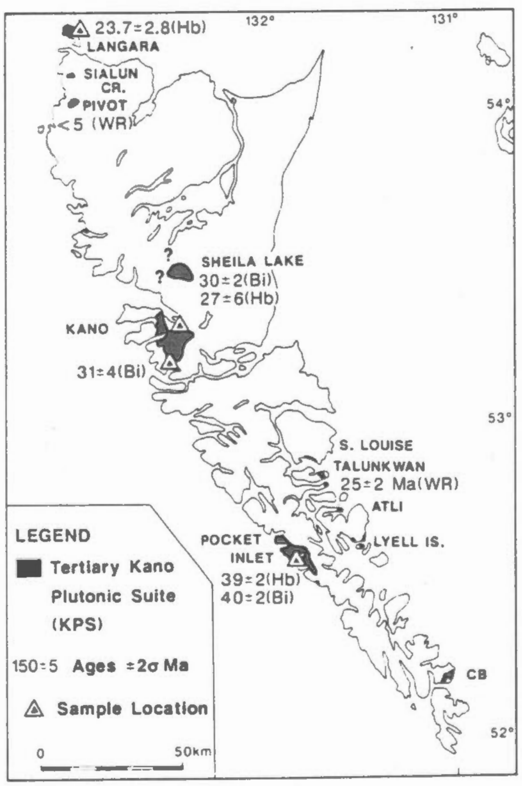
CHINUKUNDL
SANDSPIT
DEENA R.
CUMSHEWA
LOUISE ISLAND
BERESFORD COMPLEX
BURNABY IS.
POOLE PT.
Jedway
COLLISON BAY
LEGEND
Late Jurassic Burnaby Island Plutonic Suite (BIPS)
Kunga Group
0
50km


23.7±2.8(Hb)
LANGARA
SIALUN CR.
PIVOT
<5 (WR)
132°
131°
54°
53°
52°
SHEILA LAKE
30±2(Bi)
27±6(Hb)
KANO
31±4(Bi)
S. LOUISE
TALUNKWAN
25±2 Ma(WR)
ATLI
POCKET INLET
LYELL IS.
39±2(Hb)
40±2(Bi)
CB
LEGEND
Tertiary Kano Plutonic Suite (KPS)
150±5 Ages ±2σ Ma
Sample Location
0
50km

Paleomagnetism - measurements and results

J. Baker[1], W.A.M. Hill[1], G.C. Horel[1], E. Irving[1],
G. Wallace[2], P. Wheedon[1] and P.J. Wynne[1]

Paleomagnetism can be used to date rocks, and to measure large-scale displacements and rotations. It can also be used to measure tilts in rocks which themselves contain no geological evidence of paleohorizontal-tilting of plutons and high-grade metamorphic rocks for instance. To illustrate the variety of problems that can be tackled, several examples are shown (E. Irving): the determination of 30-40° tilts in plutons and core-complex rocks of southeast British Columbia; the determination of latitudinal displacement of the Whitehorse Trough since the Late Cretaceous; the dilemma (referred to as Beck's dilemma) of gross translation or tilt posed by data from mid-Cretaceous rocks of the western Cordillera; the constraints on age provided by paleomagnetic data from the Energex deposit in the Toodoggone.

A paleomagnetic database for Canada is in the process of preparation and typical outputs are shown (G.C. Horel and P. Wheedon).

Included in the exhibit is what is believed to be the first fully automated spinner magnetometer which is now operating at Pacific Geoscience Centre (G. Wallace, W.A.M. Hill, J. Baker). This automation of a standard industry magnetometer has been carried out by Robotics Systems International, Sidney, B.C. Such systems measure the magnetization of specimens and store data unattended. The system frees the operator for other tasks (e.g. analyzing or thinking about the data). Alternately the operator can handle two systems running simultaneously. The systems will routinely measure specimens with intensities down to 0.5×10^{-6} cgs (0.5×10^{-3} A/m). Their sensitivity using very long time constants has not yet been tested, but a lower limit of 0.1×10^{-6} cgs can be anticipated. The majority of rocks in the Cordillera have intensities which are within the range of this instrument.

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[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2
[2] Robotics Systems International, #107 - 9865 West Saanich Road, Sidney, B.C. V8L 3S1

Some Canadian Cordillera examples of epithermal precious metal breccias: mineralogy and geochemistry

S.B. Ballantyne[1], D.C. Harris[1] and D.A. Walker[1]

Breccias are an important aspect of hydrothermal-epithermal precious metal systems. Our study combined lithogeochemistry, scanning electron microscope (image analysis) and electron microprobe investigations to examine:

1. near surface phreatic hydrothermal features including McLaughlin style hot spring siliceous sinter breccia, eruption-vent breccia and ejecta of possible Eocene age (Germaine and Hunker creeks, Dawson, Yukon);
2. multi-stage quartz, Mtn-carbonate breccia bodies and veins in which the ore minerals include diaphorite, pyrargyrite stannite and cassiterite (Cody Ridge-Mount Mye, Faro, Yukon);
3. quartz-adularia microbreccia associated with acanthite-native silver mineralization within the Bennett Lake cauldron subsidence complex (Bennett and Partridge Lake, B.C.);
4. chalcedonic-opaline-breccia containing 2-10 micrometres sized sulphides, barite and lead-antimony sulphosalts (Graham Creek, west of Atlin, B.C.);
5. structurally complex precious metal quartz-breccia systems containing argentian tetrahedrite, pyrargyrite, polybasite, electrum, acanthite, native silver (Sulphurets Creek-Brucejack Lake, north of Stewart, B.C.).

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[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Late Permian and Triassic conodonts from the Marble Canyon Formation, Cache Creek, Group south-central British Columbia

Joanna M. Beyers[1] and Michael J. Orchard[2]

Prominent ridge forming limestones (Marble Canyon Formation) of the Cache Creek Group in its type area are the subject of an ongoing conodont biostratigraphy study. In the northern outcrop area three conodont faunas have been identified. The oldest beds contain a fauna that consists of a **Neogondolella - Iranognathus - Hindeodus** association. The presence of members of the **I. nudus** and **N. subcarinata** groups, known otherwise only from China and transcaucasia, suggest a post-Guadalupian, Late Permian age for these rocks. Separated from them by a covered interval are strata which contain **Ellisonia**-like elements. This second fauna is succeeded by a third, characterized by Spathian **Neospathodus.** These conodont occurrences, which record the presence of very young Permian and Early Triassic strata, are supplemented by **Hindeodus parvus**, a marker for the basal Triassic (Griesbachian), recovered from beds located 20 km away. Together they show that the Permian-Triassic boundary is contained within Marble Canyon Formation carbonates. Farther south, in limestones near the classic Cache Creek fusulinid locality, Late Permian **'Sweetognathus'** is found associated with the fusulinacean **Yabeina**, and represents an older Permian fauna. Early Triassic strata are widespread in this area but are thought to lie disconformably on the Permian. Dienerian sediments, recognized by common **Neospathodus dieneri**, include probably reworked Permian elements. Further south, **Neogondolella milleri** and a single specimen of **Platyvillosus** occur in clastic sediments. Middle and Late Triassic **Neogondolella** and **Epigondolella** are also known from bedded chert and carbonates in this area. The widespread distribution of Triassic sediments in a formation once thought to be entirely Paleozoic in age, together with the mix of lithologies encountered, provides the impetus for a review of Cache Creek Group stratigraphic nomenclature.

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[1] Department of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver B.C. V6T 2B4
[2] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Late Cenozoic geology of the northern Rocky Mountain Trench, B.C.

Peter T. Bobrowsky[1]

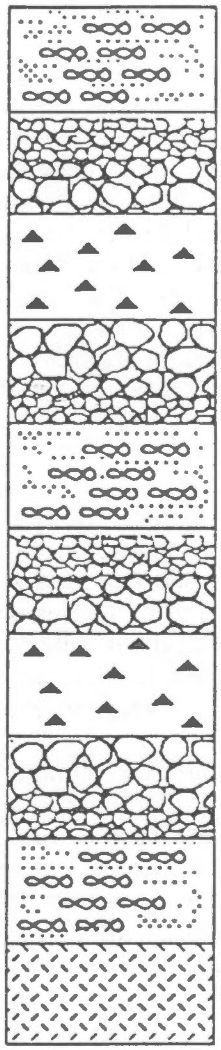
Detailed sedimentological analysis of unconsolidated sediments along the Finlay River in the northern Rocky Mountain Trench was undertaken as part of a stratigraphic study of the Quaternary of northeastern British Columbia. Study was restricted to the examination of sediments exposed at 18 major river exposures (bluffs). Fifteen sediment types were identified and classified within four broad textural groups: diamicton, gravel, sand, and fines. The diamicton group consists of: 1) structureless diamicton; 2) diamicton with clastic intrabeds; and, 3) stratified diamicton. Gravels are represented by the following sediment types: 1) massive gravels; 2) normal/inverse graded gravels; 3) stratified gravels; 4) disrupted gravels; and, 5) inclined gravels. The sand group consists of: 1) structureless and graded sands; 2) horizontally laminated sands; 3) trough-cross stratified sands; 4) planar cross-stratified sands; and 5) ripple laminated sands. Fines are represented by two sediment types, silt and clay. A variety of environmental facies are represented by the 15 sediment types. Genetic interpretations range from till and subaqueous sediment gravity flow deposition to glaciolacustrine and braided stream deposits.

Paleomagnetic samples (discontinuous suite) were removed from several bluff exposures. Analysis of these samples indicates normal polarity was in existence during their deposition (late Pleistocene). Unit average declinations (northern hemispheric) range from 322° eastward to 31°. Inclinations determined range from 20° to 68°. Fossils retrieved from the study area include one trace fossil (annelid burrow), several freshwater snail shells, and numerous wood fragments (**Picea** sp.). C14 dating of the wood specimens provided a number of dates ranging from circa 15,000 to 40,000 years B.P. Amino acid racemization analysis provided aspartic acid ratios ranging from 0.1818 to 0.2957. The C14 dates correlate well with the amino-acid racemization values obtained from the same samples.

The results of this study indicate that the northern Rocky Mountain Trench was glaciated twice during the Quaternary. The penultimate glaciation was probably pan-provincial, owes its source area to the coastal mountains of B.C., and extended eastward across the Rocky Mountains into the foothills region. The timing and duration of this glaciation could not be established, but definitely occurred before 44,000 years B.P. A nonglacial interval starting before 44,000 years B.P. and ending approximately 15,000 years B.P. followed the penultimate glaciation. Pollen data from this interval indicate a northern boreal environment typified the area (dominated by black and white spruce). The second and final glaciation began approximately 15,000 years ago, ended before 10,000 years B.P. and corresponds to the Late Wisconsinan. This glaciation was localized in extent and probably consisted of a confined valley glacier, whose furthest eastward progression is marked by the Portage Mountain moraine near Hudson Hope. Associated sediments preceding and postdating till deposited during the two glaciations indicate a predictable cycle of sediment associations can be expected in the future. This study concludes that an extensive ice-free-corridor was in existence throughout the Quaternary.

[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2

COMPOSITE STRATIGRAPHIC COLUMN



SEDIMENT PACKAGE	DOMINANT PROCESSES AND ENVIRONMENT
K. UPPER STRATIFIED SEDIMENTS	Distal braided river sedimentation
J. POST-UPPER DIAMICTONS STRATIFIED SEDIMENTS	Proximal and distal braided river, ice contact, deltaic, glacilacustrine, and sediment gravity flow sedimentation
I. UPPER DIAMICTONS	Lodgment till, and proglacial sediment gravity flow deposition
H. PRE-UPPER DIAMICTONS STRATIFIED SEDIMENTS	Proximal and distal braided river, ice contact, and sediment gravity flow sedimentation
G. MIDDLE STRATIFIED SEDIMENTS	Distal braided river and subaerial sediment gravity flow sedimentation
F. POST-LOWER DIAMICTONS STRATIFIED SEDIMENTS	Proximal and distal braided river, ice contact, deltaic, glacilacustrine, and sediment gravity flow sedimentation
E. LOWER DIAMICTONS	Meltout, lodgment till, and sediment gravity flow deposition
D. PRE-LOWER DIAMICTONS STRATIFIED SEDIMENTS	Proximal and distal braided river, ice contact, proglacial, and sediment gravity flow sedimentation
C. LOWER STRATIFIED SEDIMENTS	Distal braided river sedimentation
B. BEDROCK	Conglomerate, sandstone, and shale

Schematic composite stratigraphic column for the Late Cenozoic geology of the northern Rocky Mountain Trench, British Columbia. Primary sediment packages to left of column, and dominant sedimentary processes to the right.

Grew Creek gold deposit, Tintina Trench, Yukon (105K)

Anthony B. Christie[1], Jesse Duke[2] and Ralph Rushston[3]

The Grew Creek gold deposit occurs in Eocene volcanic rocks preserved in a graben within the Tintina Trench. Rhyolite flows host an eastern section of mineralization, known as the Tarn Zone, and these grade westward into rhyolite pyroclastic rocks that contain the Main Zone, exposed along Grew Creek and to the west. The rhyolitic rocks are juxtaposed against a sequence of cyclic fluvial sediments, to the north, by an east-northeast trending fault. Within the Main Zone, a quartz feldspar porphyry dike is intruded for part of the way along the fault contact between the fluvial sediments and the rhyolitic rocks. The pyroclastic rocks, dike, fault, and sediments dip steeply northwards. Andesite dikes and/or flows occur within the volcanic and sedimentary sequences.

The volcanic and intrusive rocks are hydrothermally altered to propylitic and argillic assemblages, whereas the fluvial sediments are generally unaltered, apart from some sporadic argillic alteration adjacent to the fault contact with the volcanic rocks. The mineralization occurs in stockwork quartz veins and hydrothermal breccias, and consists of quartz, adularia, carbonates, quartz pseudomorphs after calcite, pyrite, marcasite, arsenopyrite, chalcopyrite, argentite, electrum, silver selenides, galena, and sphalerite. Additionally, fluorite occurs in the Tarn Zone. In the Main Zone, the ore grade mineralization is found in an elongate zone, trending east-northeast and bounded to the north by elevated concentrations of pyrite, arsenic and mercury. The vein and breccia textures, volcanic host rock setting, and geochemical signature, indicate that the deposit is epithermal.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Noranda Exploration Co. Ltd., 1050 Davie Street, Vancouver, B.C. V6E 1M4
[3] Department of Geology, University of Alberta, Edmonton, Alberta T6G 2E3

Cinola gold deposit, Queen Charlotte Islands, B.C. (103F)

Anthony B. Christie[1] and Neil V. Froc[2]

Epithermal gold and silver mineralization occurs at Cinola in quartz veins, hydrothermal breccias, and disseminated in silicified wall rocks. The mineralization is localized near the Specogna Fault and hosted by Late Tertiary coarse clastic sediments (Skonun Formation), Late Cretaceous shale (Haida Formation), and an intrusive porphyritic rhyolite stock. Rocks within the ore zone are extensively silicified and flanked to the east by a zone of argillic alteration. Overprinting and leaching textures record local changes in the hydrology and hydrothermal fluid type. Stockwork, asymmetrically multibanded, symmetrically simple banded, and breccia veins occur and contain a variety of different silica types and late calcite. Hydrothermal brecciation occurs as silica cemented crackle and mosaic breccias of Haida mudstone and intrusive rhyolite, and as silica cemented, matrix supported, heteromictic breccias. The heteromictic breccias are concentrated in an elongate, steeply dipping, zone in the hanging wall of the Specogna fault. Several episodes of brecciation occurred.

The style of mineralization at Cinola is characteristic of the hot springs type of epithermal deposits, with repeated sealing and fracturing of fluid conduits.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

[2] City Resources (Canada) Limited, #2000 - 666 Burrard Street, Vancouver, B.C. V6C 2X8

Saint Elias Project

Chris J. Dodds[1]

The Saint Elias Project, undertaken by the Geological Survey of Canada, involved the bedrock mapping of the Saint Elias Mountains of northwesternmost British Columbia and southwesternmost Yukon. The mountains, Canada's highest and youngest, are underlain by parts of major fault bounded allochthonous terranes which include Yakutat, Chugach, Alexander, and Wrangellia. New evidence suggests a pre-Middle Pennsylvanian amalgamation of Wrangellia and Alexander Terrane. Different overlap assemblages or plutons present, indicate Mesozoic to Cenozoic ages for various terrane accretions to the continental margin. Uplift and deformation of widespread Mio-Pliocene Wrangell lava cover rocks, initially deposited on gentle, low elevation surfaces, reveals that tectonism involved in the rise of the Saint Elias Mountains was mostly Plio-Pleistocene in age. Major seismicity resulting from movements along the transform-subduction Fairweather-Saint Elias faults, suggests that mountain-building processes are still active there today. Mineral exploration is feasible in the less rugged parts of the Saint Elias Mountains outside the limits of Kluane National Park. Significant mineral prospects in the region include Windy Craggy massive sulphide (Cu, Co, Zn, Au) and Wellgreen mafic-ultramafic (Ni, Cu, Pt) deposits. Other known smaller deposits include: Ba, polymetallic massive sulphides; Ag, Cu, Pb, Zn skarns; porphyry Cu-Mo; Ag, Pb, Zn, Cu and Au quartz-carbonate veins; bedded gypsum-anhydrite; and placer Au-(Pt).

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Patterns of glaciations in the MacKenzie Mountains

Alexandra Duk-Rodkin[1]

During the Pleistocene the Mackenzie Mountains were affected by a series of glaciations. Through all the glaciations a single pattern seems to have been repeated: there was a Cordilleran ice sheet to the west of the mountains and only mountain valley glaciers to the east. The humid air masses moving northeastward from the Pacific Ocean released most of their moisture on the windward side of Selwyn Mountains, to nourish the Cordilleran ice sheet then crossed to the east side of the mountains with barely enough moisture to form valley glaciers. There were two types of glaciers in the Mackenzie Mountains: main valley glaciers that headed from the glacial divide and much smaller glaciers headed from the highest peaks of the Canyon Ranges. During the late Wisconsinan McConnell glaciation the ice followed major valleys that headed in the glacial divide region and extended toward the mountain front. Glaciers moving down the slope extended tongues into lateral valleys, with tongues from adjacent valleys sometimes joining. Patterns of glaciations (glaciofluvial and moraine ridges mainly) are well defined in the lower reaches of former ice tongues. These patterns are particularly clear in Keele, Twitya and Mountain rivers. Also, erratics derived from the glacial divide are found in lateral and frontal moraines of former valley glaciers. These erratics are: 1) white granites, originating in plutons in the upper reaches of Twitya and Keele rivers; 2) volcanic rocks derived from occurrences in headwaters of Mountain and Arctic Red rivers.

Patterns of glaciations along the mountain front and lower reaches of mountain valleys are very complex. Ice marginal features and shield erratics are found up to 47 km up major valleys. These evidences were left by the Laurentide ice sheet as it moved along the mountain front extending tongues up mountain valleys.

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[1] Geological Survey of Canada, 3303 - 33rd Street N.W., Calgary, Alberta T2L 2A7

Airborne and surface biogeochemical surveys for precious metals in the Cordillera

Colin E. Dunn[1]

GOLD

QR Deposit, near Quesnel: Tree-Top Sampling from a Helicopter

Numerous studies have shown that trees can accumulate precious metals. The metals are heterogeneously distributed in and among species, and are concentrated in specific plant organs. Most conifers have highest concentrations of precious metals in their extremities - outer bark and twigs. Few data are available on the chemistry of twigs at tree tops, but studies conducted by the author indicate that this acropetal (i.e. tip-ward migration) tendency extends to the very tops of trees. With this knowledge, a project was conducted this year to collect tree tops from the vicinity of a known poorly exposed gold deposit. The intention was to determine: a) if the mineralization could be detected from the chemical analysis of tree tops; and b) if the method is a viable and cost-effective means of exploration.

Douglas-fir (**Pseudotsuga menziesii**) tops were collected from 94 sites within a six square kilometre area, centred on the Main Zone of gold mineralization of the QR deposit. In one hour, tree top samples from over 50 sites, spaced at 200 m or more, were collected by a three-person helicopter crew. The doors on the pilot's side of the helicopter were removed, and as the helicopter settled over the spire of the selected tree the sampler leaned out to snip off the top half metre. Sampling time varied from 2 to 10 seconds.

Samples were returned to the GSC laboratories in Ottawa where they were dried, the needles removed, and the twigs ashed at 470°C. The ashes were encapsulated and analyzed for 35 elements by instrumental neutron activation (INAA). Background levels of gold are similar to those found elsewhere in twigs of many conifer species - about 10 ppb Au. Extreme gold enrichment (748 ppb Au) was found in one tree located approximately 400 m down-ice from the Main Zone. At the seven sites surrounding this high value, all tree tops yielded Au concentrations of over 5 times background. The biogeochemical anomaly extends for over 500 m down-ice from the Main Zone, and for a similar distance up-ice (but down a steep slope) as a result of hydromorphic dispersion of Au.

Extreme enrichments of As also occur in the tree tops throughout the study area. Background concentrations in ash are over 1000 ppm As, with up to 5300 ppm As. The spatial relationship of As in the trees to known Au mineralization is less distinct than the biogeochemical pattern of Au.

The study demonstrates that the analysis of tree top samples may provide a cost- and time-effective method of screening a heavily forested or rugged area, in order to identify ground follow-up targets. Details of the methods and results of the survey are given in Dunn and Scagel (in press).

Nickel Plate Mine, Hedley: Bark Survey

An orientation study conducted in 1987 around the abandoned French Mine, near Hedley, indicated that skarn-hosted gold mineralization could be delineated by a biogeochemical survey. Therefore, in July, 1988, a detailed program of sample collection (approximately 200 sites), was

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[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

undertaken over the extensive skarn that has pervaded Lookout Mountain, immediately north of the Nickel Plate open pit. Outer bark scales of Lodgepole Pine (**Pinus contorta**) were selected as the prime sample medium, supplemented by samples of other common species that could be collected conveniently.

Samples were obtained from approximately 150 sites within an area 2 km^2, uphill to the north and east of a point 500 m north of the pit. Additional samples were collected at wider intervals over a much larger area. Bark scales scraped from the trees were processed for analysis in a similar manner to that described above. Whereas background levels in conifer bark are normally less than 10 ppb Au, the entire area sampled has over 20 ppb Au, ranging up to 724 ppb Au. There is a strong zonation, away from the open pit, of decreasing Au concentrations in the bark, suggesting that the high values may be due to wind-blown dust contamination. However, some samples that were thoroughly cleaned in an ultrasonic separator yielded the same high gold concentrations as those that were not washed. Furthermore, in the author's experience, airborne dust that coats trees tends to dilute rather than enrich vegetation in trace metals, since it comprises primarily silicates. The inference is that the gold in the pine bark has been introduced by way of the root systems, rather than adhering dust particles.

There is additional evidence to suggest that the gold in the vegetation comes from the substrate. When gold in vegetation is compared to gold in soil profiles from about 1 km south of the open pit, it is found that the correlation improves with depth (soil data from S. Sibbick, University of British Columbia, pers. comm., 1988). This suggests that Au entering the tree is derived from the C horizon, in which most of the plants' roots occur.

Arsenic shows a similar zonation of decreasing concentrations northward from the open pit, with values ranging from 12 to 320 ppm As. Weak enrichment of Sb occurs locally, but other elements for which data were obtained by the INAA package are not present in anomalous amounts. Bismuth analyses conducted on a few samples indicate slight enrichment of this element.

The survey shows that the outer bark of Lodgepole Pine is sensitive to the presence of Au and As, which appear to derive from the substrate. There is an unusually large biogeochemical anomaly surrounding the Nickel Plate mine. Preliminary evidence from a few widely scattered samples suggests that the areal extent of the anomaly is at least 20 km^2. The implication is that gold is disseminated throughout the pervasive skarnitization which characterizes the area (cf. Ray et al., 1988).

Carolin Mine, near Hope: Conifer twig survey compared to lithogeochemical survey.

A lithogeochemical survey of the steep slopes which surround the Carolin gold mine (Ray et al., 1986) provided an ideal data base for comparison of data derived from a biogeochemical survey. Twigs of the dominant species of the area, Western Hemlock (**Tsuga heterophylla**) and Pacific Silver Fir (**Abies amabilis**), were collected at or close to the sites of the rock samples obtained earlier. Dominant features of the lithogeochemical survey were strong enrichments of Au, As and Na surrounding the ore deposit (Ray et al., 1986).

Biogeochemical surveys were conducted in May, 1986, and July, 1987. The reasons for repeating the survey were: a) to test the reproducibility of element enrichment patterns revealed by the first survey; and b) to examine the seasonal variations in element concentrations for these species in this environment.

Results show a strong concentration of Au in the vegetation, with up to 3000 ppb Au, compared to background levels of only a few ppb Au. The repeat survey established that the patterns of metal distribution remained the same, but by sampling later in the growing season the Au concentrations were, on average, 30% lower in 1987. This is consistent with seasonal variations in chemistry which have been noted by numerous authors.

A comparison of the lithogeochemical and biogeochemical patterns shows that the former are more localized. The zones of biogeochemical enrichment extend over larger areas, primarily because of strong hydromorphic dispersion down-slope from the main zone of mineralization. Conifers throughout the whole survey area are enriched with Au, such that by taking a few twig samples from the hillside it is possible to identify the area as gold-bearing. It is apparent that the biogeochemical method is effective in rapidly locating broad areas of Au enrichment for focusing exploration efforts by more traditional geological, geochemical and geophysical methods. Details of this comparative study are currently being compiled (Dunn and Ray, in prep.).

PLATINUM

Tulameen: Multi-media survey

Little information is available on the uptake by plants of platinum associated with platiniferous chromitites. In order to determine the potential value of biogeochemistry to the exploration for this type of platinum mineralization, a suite of vegetation samples were collected from the slopes of Grasshopper Mountain, near Tulameen. Samples were taken from areas with no known mineralization, and as close as possible to zones of platiniferous chromitites.

Sixteen different plants or plant parts were analyzed by ICP-mass spectrometry, using a tellurium co-precipitation procedure developed in the laboratories of the Geological Survey of Canada in Ottawa (Hall et al., in press). None of the samples yielded significant concentrations of the platinum group metals (PGM). Background levels for each of Pt, Pd, and Rh are less than 2 ppb. Several sample media contained 3 - 6 ppb Pt, but less than 2 ppb Pd and Rh. A notable exception was the bark of Douglas-fir (**Pseudotsuga menziesii**) with up to 15 ppb Pt, 18 ppb Pd, and 12 ppb Rh. One sample of subalpine fir (**Abies lasiocarpa**) yielded 9 ppb Pt. The small flowering plant known as the umbrella plant (**Eriogonum ovalifolium**) had the highest Pt content (21 ppb Pt), corroborating the findings of Harry Warren (UBC) that this plant can concentrate Pt (pers. comm., 1988).

Evidence obtained to date suggests that biogeochemistry may not assist significantly in helping to locate platinum associated with chromite, presumably because it remains structurally incorporated in the crystal lattice.

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Landslides and economic development in the Canadian Cordillera

Stephen G. Evans[1]

A number of catastrophic landslide hazards have been documented in the Cordillera. They include highly mobile rock avalanches, rainfall-induced debris flows, large-scale landsliding in Pleistocene sediments, destructive landslide-induced waves, and outburst floods caused by the failure of natural dams.

The economic and social infrastructure of the Cordillera, which includes mining and energy production facilities as well as strategic transportation corridors, is highly vulnerable to landslides. Landslides have been responsible for 360 deaths in the Cordillera since 1856 and it is estimated that the total direct and indirect costs of landslides in the region are in excess of $100 M per annum. This figure includes the damage to the Fraser River salmon fishery which between 1951 and 1978 experienced losses of $96 M per year directly attributable to the rockfall which partially blocked the Fraser River in 1914.

An analysis of a data base of known damaging landslide events indicates that the most damaging landslide types, both in terms of deaths and economic impact are frequent small scale (less than $0.1 \times 10^6 m^3$) precipitation triggered debris flows and low magnitude rockslope movements. Together these landslide types make up 61% of known damaging landslides in the period 1856 to 1983. This is despite the fact large scale rock avalanches and other major rockslope movements are comparatively common in the sparsely peopled Cordillera.

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[1]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Timing and structural style of the Skeena Ranges fold belt, north-central British Columbia

C.A. Evenchick[1]

A large part of north-central British Columbia is underlain by the Mesozoic sedimentary fill of the Bowser and Sustut basins. The strata of the basins now comprise an impressive fold belt that is the result of considerable northeasterly contraction during Cretaceous and perhaps latest Jurassic time. The foldbelt is called the Skeena Ranges Fold Belt because it occupies the Skeena Ranges of north-central British Columbia. The deformation provides a record of shortening of the cover of Stikinia, and at least part of Stikinia, at about the same time as shortening in the Foreland Belt to the east, and probably the Coast Belt to the west. The following summary of the timing and style of the fold belt are from interpretations of the geology at the boundary of the Bowser and Sustut basins, in Spatsizi map area.

Strata of the Bowser Basin, called the Bowser Lake Group, are Middle Jurassic to Cretaceous in age and were deposited on Lower Jurassic volcanic rocks (Cold Fish volcanics) and sedimentary rocks (Spatsizi Group). Strata of the Sustut Basin are called the Sustut Group and range in age from Middle Albian to Maastrichtian (mid- to Late Cretaceous). The age of the two formations of the Sustut Group is based on palynological work by A.R. Sweet (G.S.C.).

TIMING OF DEFORMATION

Three types of data constrain the timing of deformation of the Skeena Ranges Fold Belt:

1. Structural and stratigraphic relationships

The Sustut Group was deposited on a structurally complex basement of Bowser Lake Group, Cold Fish volcanics and Spatsizi Group. A structural interpretation of the geology below the unconformity (Fig. 1) suggests that the Cold Fish volcanics and Spatsizi Group were thrust onto the Bowser Lake Group and that the thrust fault was offset by normal faults prior to deposition of the Sustut Group. Because the thrust fault is overlapped by the unconformity, it must have predated deposition of the basal Sustut Group (Middle Albian).

The Bowser Lake Group includes rocks as young as mid-Cretaceous, but the Bowser Lake Group strata demonstrably involved in the pre-Middle Albian deformation are Oxfordian (Upper Jurassic). From the above relationships, the oldest recognized contractional structures of the fold belt formed sometime between Oxfordian (Late Jurassic) and Middle Albian (mid-Cretaceous) time.

2. Age of the youngest rocks that are deformed

The Sustut Group consists of two formations. The Tango Creek Formation ranges in age from Middle Albian (mid-Cretaceous) to Campanian (Late Cretaceous); the Brothers Peak Formation ranges in age from Campanian to Maastrichtian (Late Cretaceous). The lower part of the Tango Creek Formation is intensely deformed and the upper part is less intensely deformed. The Brothers Peak Formation is either flat, or moderately to steeply dipping where it forms a monocline at its southwest limit of exposure (Fig. 1). Tilting of the Brothers Peak Formation indicates that folding was as late as latest Cretaceous time, and possibly continued into the Tertiary.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

3. Sedimentology of the Sustut Group

The Sustut Group consists of more than 2000 m of fluvial sediments. Eisbacher (1974) measured paleocurrents and did provenance studies that can be used to interpret the tectonic setting for the period of most of the deformation. Clast type and paleocurrents for the lower part of the Tango Creek Formation suggest that it was deposited by rivers that flowed southwesterly from the Omineca Belt, carrying the first metamorphic detritus across the northern Intermontane Belt. Clast types and paleocurrents for the upper part of the Tango Creek Formation suggest a change to a southwesterly source. Clast types and paleocurrents for the Brothers Peak Formation indicate sources to both the northeast and southwest; rivers were constrained by topography on both sides of the basin, and flowed longitudinally southeast down the basin. The topography on the southwest side of the basin beginning during deposition of the upper part of the Tango Creek Formation is interpreted to be a result of crustal thickening by folding and thrust faulting of the Bowser Lake Group and lower part of the Sustut Group.

Although there are insufficient data to identify pulses of deformation during the Cretaceous, paleocurrent and provenance studies suggest that deformation was either continuous or periodic throughout the late Cretaceous, rather than limited to one episode of latest Cretaceous or early Tertiary deformation.

STYLE OF DEFORMATION

The dominant structures are northwest-trending folds which plunge gently except where they interfere with local, northeast-trending folds, and plunge up to 35 degrees. Fold geometry varies from open to tight, and upright to gently inclined. Folds are northeast-verging, with angular to rounded hinges. Cross-sections where folds are well-exposed show that the beds have been shortened by folding up to half of their original length (Fig. 2). The large amount of northeasterly contraction accommodated by folds must be matched by detachments, but major thrust faults are difficult to recognize within the Bowser Lake Group in the absence of widespread marker units. Thrust faults with unequivocally large displacement can be identified near the boundary of the Bowser and Sustut basins. There, three separate thrust faults have enough stratigraphic throw to repeat map units. The greatest stratigraphic throw occurs where the Early Jurassic Cold Fish volcanics lie structurally on the mid-Cretaceous Sustut Group. This relationship also demonstrates that the early Mesozoic basement of the Bowser and Sustut basins (Stikinia) is involved in the contractional deformation.

If the shortening at the northern common boundary of the Bowser and Sustut basins is representative of the rest of the Bowser Basin, then the basin, now only 200 km across structural trend, was at least 400 km across before folding, and the western boundary was at least as far west as the west side of the Coast Mountains.

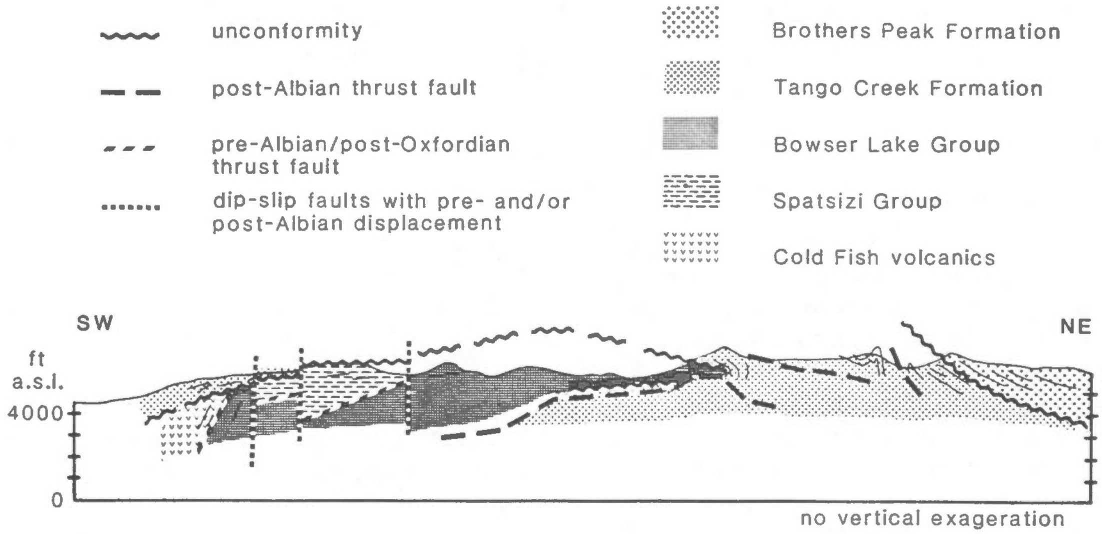

Figure 1

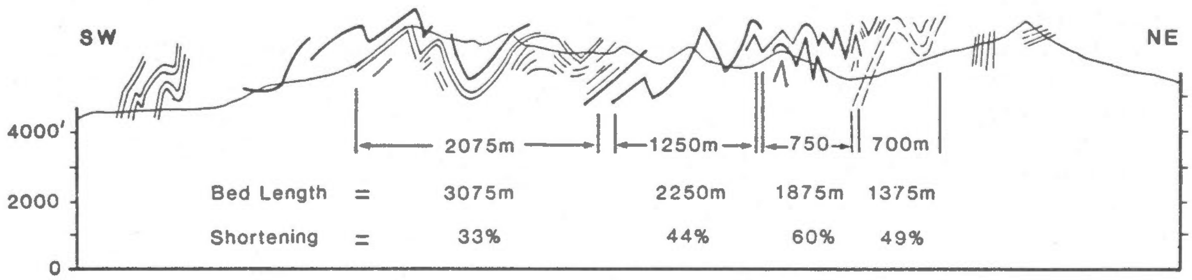

Figure 2

Plutonic suites and mineral deposits, north-central British Columbia

H. Gabrielse[1]

Seven distinct plutonic suites ranging in age from Late Triassic to Eocene have been recognized in the Cassiar region of north-central British Columbia. The older suites are clearly related to specific terranes whereas the younger ones may overlap several terranes. Three additional suites of Early Proterozoic, Late Devonian(?), and Permian ages, respectively are not discussed herein.

The various plutonic suites and, in some cases, related volcanic assemblages, are associated with particular kinds of mineral deposits, presumably resulting from a combination of the ultimate origin of the magmas, the nature of the intruded rocks, and the level of intrusion. Late Triassic ultramafic rocks, mainly confined to Quesnellia, have potential for platinum group elements and host copper and nickel sulphides in the Turnagain ultramafic pluton. Late Triassic and Early Jurassic plutons and related volcanic rocks of the Stikine and Black Lake suites host numerous copper deposits in Quesnellia and Stikinia and Late Triassic volcanics contain the large Kutcho copper-zinc deposit in the Cache Creek Terrane. In addition, Lower Jurassic volcanic rocks, in part correlative with the Black Lake plutonic suite include important epithermal gold-silver deposits in the Toodoggone area. Middle Jurassic plutons of the Three Sisters Suite in Stikinia are associated with small copper and molybdenum occurrences in the Hotailuh and Klastline areas. The areally important mid-Cretaceous Cassiar Suite seems to have few unequivocally related mineral deposits. High-level plutons of the Late Cretaceous Surprise Lake Suite are present in all terranes and are related to many mineral deposits, particularly molybdenum and tungsten. High-level, fluorine-bearing, miarolitic Eocene plutons are commonly associated with tungsten and fluorite deposits but have localized, also, lead and zinc minerals on the east limb of the McDame Synclinorium. Eocene dacitic to rhyolitic volcanics in the Kechika and Northern Rocky Mountain trenches have potential for precious metal concentrations.

Isotopic ages on alteration minerals in the Midway and Erickson camps are not compatible with ages of nearby plutons. The Midway ages suggest the possibility of an underlying Late Cretaceous pluton. The Erickson ages (Late Cretaceous), on the other hand, may reflect magmatic and tectonic events that affected adjacent Quesnellia in Early Cretaceous time.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Mineralogical and chemical zonation of a fossilized submarine hydrothermal vent complex in a sedimentary basin, TOM deposit, Yukon

Wayne D. Goodfellow[1], John W. Lydon[1], Kate Grapes[1] and Jennifer Shaw[1]

The TOM deposit at Macmillan Pass occurs in siliceous and carbonaceous shales of the Middle to Upper Devonian Lower Earn Group near the eastern margin of the Selwyn Basin. The deposit consists of the West Ore Zone and East Ore Zone which together comprise 15 million tonnes of ore averaging 7% Zn, 4.6% Pb and 49 g/tonne Ag. The deposit is situated in a structurally anomalous east-west-trending zone known as the Macmillan Fold Belt. The West Ore Zone occurs on the steeply dipping west limb of a north-south-trending anticline and is separated by a fault from complexly folded and faulted lenses that comprise the East Ore Zone on the eastern limb of the anticline.

Sedimentary barite-sphalerite-galena mineralization occupies a stratigraphic position near the contact between a succession of argillaceous-arenaceous turbidites, chert pebble conglomerates and sedimentary breccias, and an overlying sequence of pyritic and carbonaceous siliceous shales and cherts. Near the southern limit of the West Ore Zone, a brecciated vent complex is associated with scarp talus breccias suggesting that both the hydrothermal vents and abrupt southerly termination of stratiform mineralization was controlled by synsedimentary faults.

The West Ore Zone consists of four distinct ore facies which are zoned with respect to the hydrothermal vent complex. These facies, from south to north away from the vent complex, are: 1) Stockwork Facies; 2) Pink Ore Facies; 3) Grey Ore Facies; and 4) Black Ore Facies. The different ore facies are distinguished from each other by the relative proportions of hydrothermal and epiclastic minerals, sulphide textures and the degree of replacement of earlier formed hydrothermal sediments above and adjacent to the vent.

The Stockwork Facies consists of a dense vein network of pyrite, pyrrhotite, galena, sphalerite, siderite, ankerite and quartz with variable but generally minor chalcopyrite, arsenopyrite and tetrahedrite. Early formed bedded sulphides, barite and epiclastic sediments have been extensively replaced by ferroan carbonates. In some samples, sulphides have been brecciated, possibly by the rapid discharge of fluids or by a sudden volume expansion accompanying the release of CO_2 from the fluid. The low ratio of epiclastic to hydrothermal components and the complex vein paragenesis indicate multiple episodes of hydrothermal discharge from the same vent complex and rapid fluid evolution during venting. This facies is distinguished from other facies by its vein stockwork and replacement textural characteristics, high ore metal (i.e., Zn, Pb and Ag), As and Sb contents, high Pb/Zn and CO_2/S ratios, and relatively low Ba and SiO_2 contents.

The Stockwork Facies is underlain by an anastomosing network of ferroan carbonate and sulphide veinlets which cut the underlying sedimentary sequence and become less abundant with depth below the paleo-seafloor. Clastic sedimentary units cut by this vein network are cemented and partially replaced by ankerite, sericite, pyrite and minor chalcopyrite and sphalerite.

The Pink Ore Facies consists of bedded grey to white barite and grey chert with wispy bands and laminae of pink and yellow sphalerite, ferroan carbonate, galena, pyrite, witherite and Ba-feldspar. The barite and chert in this facies may retain original sedimentary textures such as

[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

sharp bedding contacts but are often overprinted by wispy sphalerite bands and crystalline galena. This facies is characterized by high Ba/Al, Zn/Al and Hg/Zn ratios, moderately high ore metal, Fe and CO_2 contents, and low Cu, As and Sb contents. Pb/Zn ratios are moderately high.

The Grey Ore Facies is composed of grey chert interbedded with grey to white barite, cream sphalerite, galena and barium feldspar. Sedimentary textures, such as sharp bedding contacts, are well preserved. Compared to the Pink Ore Facies, this ore-type has generally lower Ba/Al, Zn/Al, Pb/Al and Pb/Zn ratios, dramatically lower Hg/Zn ratios, and lower contents of ore metals, Cu, As and Sb.

The Black Ore Facies, the most distal facies, consists of carbonaceous chert and cherty mudstone interlaminated with grey to white barite, cream sphalerite, fine grained galena, framboidal pyrite, black calcite and Ba-feldspar. Bedding contacts are generally sharp. Compared to other facies, this unit has higher contents of SiO_2, Al_2O_3 and Se, and lower contents of ore metals, Ba, As, Sb, Hg and CO_2.

The zonal distribution of ore facies in the West Ore Zone is due mainly to the reworking, infilling and replacement of hydrothermal and epiclastic sediments by vent fluids and, to a lesser degree, the relative proportion of hydrothermal and epiclastic components, both of which reflect distance from the vent complex. In the most proximal Stockwork Facies which directly overlies the vent, earlier formed sedimentary sulphides, barite and chert have been extensively replaced by ferroan carbonate, galena, sphalerite, pyrrhotite, pyrite, chalcopyrite, arsenopyrite and tetrahedrite during the protracted flow-through of hydrothermal fluids. This has resulted in a marked increase of ore metal grades, Pb/Pb+Zn ratios and As and Sb contents, and a depletion of SiO_2 and Ba. The lateral migration of hydrothermal fluids from the vent zone has resulted in the partial replacement of hydrothermal sediments by pink, Hg-rich sphalerite, crystalline galena and ferroan carbonate (Pink Ore Facies) and the destruction of organic matter (Pink and Grey Ore Facies). Altered sediments typically display a more diffuse banding due to the overprinting of bedding planes by generally coarser grained hydrothermal replacement assemblages. Only the Black Ore Facies represents hydrothermal and marine basinal sediments which have not been significantly affected by hydrothermal alteration.

New bedrock geologic mapping project in Yukon

S.P. Gordey[1]

The Geological Survey is planning a new five-year regional mapping project for the Yukon, in either the Mayo (105M)/Lansing (105N) or Teslin (105C)/Wolf Lake (105B) region. Fieldwork will begin in 1989. The GSC welcomes advice in choosing between these or other map areas in Yukon.

The Mayo/Lansing area is located in east-central Yukon and forms part of the Selwyn Basin known for large deposits of stratiform Pb-Zn and Pb-Zn-Ag, W and Sn skarns, and Ag-bearing veins. Strata range from Proterozoic through Jurassic and were deposited along the North American margin. Northeasterly directed deformation in the Early Cretaceous produced large scale thrust faults, folds, and locally intense imbrication and crumpling. Post-tectonic mid-Cretaceous granite and granodiorite intrude this deformed sedimentary succession. Mineral deposits within the Mayo/Lansing area include Pb-Zn-Ag veins, Sn stockwork, W skarns, small hardrock and placer gold showings. Regional geologic mapping will establish a stratigraphic framework, regional stratigraphic correlation, and structural interpretation that is critical for understanding the setting of mineral deposits. For most of Lansing map area and the southern part of Mayo map area previous work is so "thin" that map coverage will be essentially new.

The Teslin/Wolf Lake area is located in southern Yukon and transects several Cordilleran terranes known regionally for their deposits of Sn and W skarns, vein Pb-Zn-Ag, manto Pb-Zn-Ag and Au, asbestos, and lode and placer gold. The Teslin Fault, a major crustal break, separates this region into two halves of contrasting geological history. Northeast of the fault are late Proterozoic to Triassic strata that were deposited along the margin of ancient North America. These are overlain structurally by several allochthonous assemblages (Nisutlin, Slide Mountain, Quesnel). Southwest of the fault are oceanic and arc terranes (Cache Creek, Stikine) that were accreted to and displaced northward along the North American margin in the Mesozoic. Igneous rock suites ranging in age from Jurassic to Tertiary occur within the Teslin/Wolf Lake area and immediately to the south. Jura-Cretaceous deformation led to northeast-directed folding and thrusting in the North American strata and emplacement of allochthonous assemblages above them. Southwest of Teslin Fault, structures are poorly understood. The main types of mineral deposits in this region include Sn-W skarns, asbestos, porphyry W-Mo, vein Pb-Zn-Ag and placer gold. Regional mapping will provide a modern structural, tectonic, biostratigraphic, and igneous framework in which to better understand the setting of mineral deposits, and will provide a regional data base for future more detailed work.

Final products for either region will be a summary publication including a comprehensive report and two coloured maps at 1:250,000 scale for both component map areas, and 1:50,000 scale maps of selected areas. Progress reports will be produced yearly and will include brief reports and geologic maps at 1:125,000 or 1:50,000 scale.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

The Tertiary volcanic Masset Formation, Queen Charlotte Islands

C.J. Hickson[1]

The Masset Formation is composed of intercalated, mafic to felsic lava flows and pyroclastics. Chemically, the volcanic rocks are subalkaline and span a compositional range of basalt to rhyolite. The phenocryst assemblage is limited to feldspar, with minor pyroxene, magnetite and rarely quartz in the most felsic rocks. Many of the rocks are aphyric and all are aphanitic. Felsic vent areas appear to have been localized in a belt parallel to and just inland of the west coast. These areas are often altered and potentially associated with epithermal mineralization. Mafic flows may have originated from fissure eruptions coincident with this trend. The eruptions climaxed from 20 to 25 Ma (based on K-Ar dating) with contemporaneous extrusion of both felsic and mafic magmas; mafic magmas are volumetrically dominant and travelled further from vent areas.

The Masset Formation rest with angular unconformity on Mesozoic strata. The formation is cut by steeply dipping normal faults, otherwise there is little evidence of internal deformation or structural complexity. Along the eastern margin of Masset exposures the normal faults trend north and dip east.

Dominantly mafic lavas, with minor intercalated felsic pyroclastic flows, underlie eastern Graham Island and interdigitate with sediments of the Skonun Formation. Mafic lavas found in offshore drill holes in Queen Charlotte Sound and Hecate Strait are lithologically distinct from Masset rocks on Graham Island in that they contain hornblende and biotite phenocrysts. These volcanics may be coeval with Late Cretaceous volcanic rocks found within the Honna Formation on Graham Island.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

The Chilcotin-Nechako region, central British Columbia: a new onland Frontier Geoscience Project

C.J. Hickson[1], R.M. Bustin[2] and P.A.H. van der Heyden[1]

The Chilcotin-Nechako Basin of central British Columbia consists of a thick and varied sedimentary succession of Jurassic through Eocene strata cut by syn- and post-depositional faults.

The Chilcotin-Nechako Region has seen limited hydrocarbon exploration. In the early 1950's oil seeps from Tertiary volcanics were reported. The first hydrocarbon exploration well was drilled in 1932 but serious exploration did not begin until 1958 and culminated in the drilling of two wells in 1960. In the early 1970's, while undertaking mineral exploration work west of Vanderhoof, Vital Pacific Resources Ltd. observed oil in shallow (less than 600 m) mineral exploration wells. Canadian Hunter Exploration Ltd. began work in the southern part of the basin in 1980. They drilled four exploration holes between 1981 and 1986 and completed detailed seismic and gravity work.

Basin geometry, distribution of stratigraphic facies, and identification of possible source rocks are problems that continue to frustrate exploration. The quality of petroleum source rocks is largely unknown and possible overmaturation of any source rocks present remains a concern. Analyses obtained to date show that maturation levels range from immature (with respect to petroleum generation) to overmature. A varied tectonic and thermal history of this part of the Cordillera is implicit. Preliminary pyrolysis analysis indicates that source rock quality is variable: moderate to good quality (TOC >2%) source rocks occur locally, particularly in Upper Jurassic strata.

This five year project will address these problems and attempt to establish basin evolution from the Mesozoic to the Tertiary.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Department of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 2B4

Architecture of the Queen Charlotte Basin fill, and implications for tectonic history and petroleum exploration

R. Higgs[1]

Seventeen exploratory boreholes were drilled onshore and offshore in the Tertiary Queen Charlotte Basin (QCB), mostly in the 1950s and 1960s. These wells, and onshore outcrops, have shown that the basin fill comprises sediments (Skonun Formation) and volcanics (including the Masset Formation).

Well-log correlations allow the basin fill to be divided into an upper and a lower stratigraphic unit. The upper unit, here named Unit II, is sedimentary and contains Miocene and Pliocene fossils. It blankets the entire offshore area and eastern Graham Island, and is up to 2 km thick. Unit II is characterized by numerous coarsening-upward (shale-sand) sequences 10-30 m thick; these are not discernible at outcrop because of poor exposure, but they are indicated on logs by upward-decreasing gamma, SP and sonic velocity. Additional sequences may be masked by the "shaly" gamma response of the (feldspathic) sandstones. Sequences can be correlated laterally for at least 175 km with little thickness change, suggesting that subsidence was by regional sagging, rather than block faulting. The regional extent of the sequences suggests that they are allogenic (tectonic or eustatic), rather than autogenic. Consequently, the sequences are interpreted as regressive cycles, and sequence boundaries as surfaces of abrupt regional transgression (i.e. time lines). Based on limited cores and exposures, sequences in the N appear to comprise tidal-shelf sands and delta-plain muds, sands and coals, while probable correlative sequences in the S are entirely shelf sands and muds; this indicates that shoreline progradation never reached the southern region. Sand bodies with reservoir potential are abundant and probably include tidal sand ridges and progradational delta-front sand fingers or sheets. The base of Unit II, which may or may not be an unconformity, is somewhat ambiguously placed below the lowest correlatable sequence.

Unit I comprises interfingering volcanics and sediments, and lacks the correlatable sequences characteristic of Unit II. Volcanics occur at outcrop (Masset Formation) and in many of the wells; they were mainly erupted subaerially. Intervals of intercalated volcanics and sediments can exceed 1 km. Sediments in Unit I include sandstone, shale, conglomerate and coal. Some wells penetrated more than 1 km of Unit I sediments before (or without) reaching volcanics. Only the Tyee well, which bottomed in pre-Tertiary intrusives, unequivocally reached basement rocks underlying the QCB; volcanics are absent here, proving that they are not a basinwide blanket. The tectonic setting inferred for Unit I, based on the discontinuous volcanics, local conglomerates, and lack of correlations, is a block-faulted terrain of active grabens or half-grabens; such structures are visible on published seismic sections. The volcanics were probably erupted via active faults. The block faulting lasted from Eocene to Miocene time, as shown by the (K-Ar) age-span of the volcanism. Fossils in Unit I strata exposed on Graham Island (Cinola) are of early to middle Miocene age. Likely reservoirs in Unit I include sandstone and conglomerate bodies associated with alluvial fans and fan deltas built against fault scarps.

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[1] Geological Survey of Canada, 9680 West Saanich Road, Sidney, B.C. V8L 4B2

The internal architecture of the basin fill thus reveals a two-stage development, whereby block faulting (Eocene to Miocene) gave way to regional subsidence (Miocene to Pliocene). Since Pliocene time, the basin has been undergoing uplift, probably due to oblique subduction of the Pacific plate. Uplift has caused: (1) emergence of the Queen Charlotte Islands; and (2) extensive erosion of Units I and II, thereby exhuming large areas of basement and Masset rocks. Uplift could also be taking place in the offshore part of the QCB, accompanied by erosion due to strong tidal currents.

The geological data presented here will assist the interpretation of seismic data recently acquired by the GSC.

The northern Cascadia subduction zone at Vancouver Island: seismic structure, tectonic history and sediment accretion processes

R.D. Hyndman[1], C.J. Yorath[1], E.E. Davis[1] and R.M. Clowes[2]

A series of new multichannel seismic lines acquired across the continental shelf to the deep sea off southwestern Canada, combined with adjacent land multichannel seismic and a wide range of other geophysical and geological data, have permitted detailed delineation of the structure, Tertiary tectonic history and accretion processes of the northern Cascadia subduction zone off western Canada. The top of the downgoing oceanic crust is imaged over much of the distance from the deep ocean basin to depths of 30 to 40 km beneath Vancouver Island. The depths are in good agreement with seismic refraction models and Benioff-Wadati seismicity. The probable oceanic crust Crescent Terrane that is defined by seismic, magnetic and gravity data and by outcropping extension on land provides a landward dipping backstop to the large sediment wedge accreted since the Eocene. The deformation front of the accretionary wedge is characterized by mainly landward dipping thrust faults that extend close to basement. This result and the mass balance of the incoming sediment compared to that present in the accreted wedge, suggest that there is little sediment subduction. The fluid expulsion and sediment consolidation associated with the accretion at the deformation front is mapped by thermal data and by the decrease in porosity inferred from seismic velocities. The Tofino Basin sediments, up to 4 km in thickness, have been deposited beneath the present continental shelf over the accreted terranes and the developing accretionary wedge.

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[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2

[2] Department of Geophysics and Astronomy and LITHOPROBE Secretariat, University of British Columbia, Vancouver, B.C. V6T 1W5

Conodont biostratigraphy of the Earn Group: constraints on Upper Devonian stratiform mineral deposits, northern British Columbia and Yukon

Steven E.B. Irwin[1]

In the Selwyn and Kechika basins of northern British Columbia and southeastern Yukon, important sedimentary exhalative barite-Pb-Zn-Ag deposits occur in the predominantly clastic Earn Group sediments at Macmillan Pass and Gataga. Resistant phosphatic conodont microfossils, extracted from calcareous Earn Group sediments, provide age constraints for the sedimentary exhalative sulphide deposits. Correlation within individual deposits and with other sulphide deposits in the Earn Group is strengthened with conodont biostratigraphy and age constraints.

The oldest Earn Group strata are found in the vicinity of Macmillan Pass where conodont faunas in strata along strike with stratiform sulphide horizons range in age from Early Devonian to middle Famennian. At Gataga, where the Earn Group spans at least lower Frasnian to middle Famennian, the sedimentary exhalative sulphide horizons are bracketed by lower to middle Famennian conodonts. At Midway, where the Earn Group rests unconformably on the McDame Group, the basal Earn Group is dated as early to middle Famennian. The only sedimentary exhalative deposits at Midway, however, are Mississippian age barite horizons.

Late Devonian sedimentary-exhalative mineralizing events were not synchronous within the miogeocline. Sedimentary exhalative deposits at Macmillan Pass appear to be Frasnian in age, whereas those at Gataga are constrained by Famennian conodonts. This may have implications for exploration strategies and Late Devonian tectonism.

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[1]Department of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 2B4

Quaternary volcanism and faulting, Fort Selkirk area, Yukon

Lionel E. Jackson[1]

A volcanic edifice near Fort Selkirk, Yukon, is almost entirely composed of hyaloclastite tuffs, breccias and pillow breccias. Pillow basalt is found near the summit of the mountain. All of these lithologies contain rounded and flatiron shape exotic pebbles. These observations indicate that it erupted beneath an ice sheet. Since deposits of the Reid Glaciation only reach the base of the mountain, the eruption must have occurred during a pre-Reid glaciation. Evidence suggesting Pleistocene faulting beneath the mountain is also discussed.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Sulphurets area, British Columbia: geology, geochemistry, and mineralogy

R.V. Kirkham[1], S.B. Ballantyne[1] and D.C. Harris[1]

The Sulphurets area in northwestern British Columbia contains large pyritic alteration zones with porphyry copper and molybdenum and several different types of gold and silver mineralization. The area is underlain by Jurassic sedimentary and volcanic rocks of the Hazelton Group which are cut by porphyritic, subvolcanic, dioritic, monzonitic, syenitic, and low-silica granitic intrusions. The main pyritic alteration zones, extensive quartz vein stockworks, and early stages of copper, molybdenum, gold, and silver deposition were spatially and probably genetically related to the emplacement of these porphyritic alkalic intrusions. However, the area has been subjected to low-grade regional metamorphism, heterogeneous penetrative deformation, and a complex post-mineral fault history, during which possible significant redistribution and/or introduction of precious metals has occurred. Quartz, sericite, pyrite schists are common in the area. Both bulk tonnage and higher grade vein and "shear zone" precious metal occurrences are present in the region. Some of the vein-stockwork systems show evidence of both brittle and ductile deformation suggesting relatively deep environments of formation.

The Geological Survey of Canada, in collaboration with exploration company and British Columbia Geological Survey Branch geologists working in the area, has been carrying out an integrated study emphasizing deposit geology, lithogeochemistry, and mineralogy. One objective of this study is to document lithogeochemical and mineralogical patterns within a large, complex, pyritic porphyry Cu-Mo-precious metal system. This study should help define the spatial and temporal relationships of different metal, mineral, and alteration zones.

Broad areas with Cu-Au, Mo-Au, Cu-Mo-Au, and As (tennantite and/or arsenopyrite)-Au associations have been identified but other Cu and Mo and iron sulphide areas without significant precious metals are also present. Other quartz (? calcite and barite)-vein-stockwork systems with Sb-polymetallic (Zn, Pb, Cu)-dominated assemblages contain electrum and silver sulphosalts with bonanza grade Au and Ag. The interrelationships of the different metal and mineral zones are not fully understood but preliminary information suggests complex multiple stages of base and precious metal deposition.

[1]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Crustal deformation measurements by satellite techniques on Canada's west coast

J. Kouba[1] and H. Dragert[2]

The Global Positioning System (GPS) is being used to study crustal deformation on central Vancouver Island in conjunction with conventional electronic distance measurements (EDM). The initial GPS survey in the Port Alberni region was conducted by the Geodetic Survey of Canada between August 20 and August 29, 1986. A network of 11 stations was observed with four TI4100 receivers in 10 daily sessions. Two stations were occupied continuously during the survey to provide scale control from one session to the next. The observed baselines varied from 18 km to 116 km in length with a maximum height difference of 1700 m. The GPS phase observations have been used in a multi-parameter solution which includes meticulous modelling of GPS atmospheric, orbital and instrumental errors. A comparison with simultaneous EDM baseline determinations shows agreement at the 0.5 ppm precision level which is consistent with the formal relative accuracy of the EDM survey. Given that current strain accumulation at the west coast of Vancouver Island has been estimated at 0.15 to 0.30 ppm per year, these results indicate that the GPS satellite technique has the potential to observe crustal strain on Vancouver Island over a decade with observations repeated at three to five year intervals.

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[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8
[2] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2

Geothermal studies in Queen Charlotte basin

T.J. Lewis[1], W.H. Bentkowski[1], M.N. Bone[1] and J.A. Wright[2]

The heat flux and the thermal properties of the sediments in Queen Charlotte Basin are needed to calculate present sediment temperatures and to model past temperatures. The magnitude of the heat flux indicates which tectonic processes are occurring at present, and variations in heat flux are related to the vertical component of fluid flows. Oil and gas accumulations, related to upward migration of fluids, are found where the heat flux is a maximum

Preliminary heat flow results on land are low (50 mW m^{-2}) on the western margin of Queen Charlotte Basin and higher (75 mW m^{-2}) on the eastern margin. The heat generation is generally low within the basin and its margins. Therefore, under the eastern margin present crustal temperatures are higher than those under the western margin of the basin. Marine techniques were used to measure the heat flux within the shallow sediments beneath Queen Charlotte Sound. To overcome the effects of large variations in the bottom water temperatures, very long probes (11 m) were used and data loggers recorded the bottom water temperatures between the three cruises over a period of nearly two years. Preliminary values of heat flux measured in the upper soft sediments are much higher (e.g., 125 mW m^{-2}) than values measured in the crystalline rocks on the margins. However, these results may be affected by processes such as erosion and/or dewatering presently occurring in the top layer of soft sediments. The lower heat flux on the western margin may be the result of oblique subduction.

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[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2
[2] Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7

Geologic hazards to hydrocarbon exploration and development: Queen Charlotte basin

J.L. Luternauer[1], J.V. Barrie[2], K.W. Conway[3] and D.Z. Zavoral[4]

Surficial geologic hazards to seabed founded structures and constraints on the engineering of such structures on the continental shelf of western Canada are seen to vary from the inner to the outer shelf.

Evidence for mass flows, slumping and seabed instability is restricted to localized areas. Adjacent to the Coast Mountain crystalline rocks debris flows have been identified. The apparent stability of most shelf areas is thought to be a result of Late Wisconsinan sea level lowering of approximately 100 m over most of the shelf which remobilized unconsolidated deposits shallower than that depth. Little sediment has reached the shelf since the Holocene transgression further reducing the potential for submarine mass movements. Shallow faulting of a syn-depositional nature has occurred along the northwest margin of Moresby Trough. This trough is one of the few places on the shelf where appreciable Holocene sediment has accumulated.

Areas subject to rapid sediment transport and erosion, identified by the presence of sand ridges, megaripples, sand waves, sand ribbons and scoured bedrock surfaces, are seen mainly on bank tops and, in some instances, bank margins. The margins of Middle Bank appear to be quite ephemeral as sandwaves up to 5 m in amplitude occur to over 200 m water depth on the northwest and northeast side of the bank. Extensive boulder fields and pavements have developed on the middle to outer shelf where till sheets have been eroding at the seabed.

Evidence of shallow gas, probably biogenic, is seen in Moresby Trough and at the mouths of sounds which open onto the shelf where fine organic matter has accumulated. Localized concentrations of craters or pockmarks, which may be due to thermogenic gas venting, are found on both Middle and, Goose Island banks.

Seven piston cores collected from Queen Charlotte Sound were examined for geotechnical properties. Sediment characteristics, despite high sensitivity and liquidity index values, indicate that most slopes are statically stable due to low slope angles and sufficient peak undrained shear strengths. However, some of the sediment samples have a low plasticity index, indicating possible susceptibility to liquefaction. Furthermore slope instability is evident in cohesionless sediments in Mitchells's Trough. Many submarine slopes may therefore by dynamically unstable.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Centre for Cold Ocean Resources Engineering (C-CORE) and Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5
[3] Geomartec Services, 1067 Clark Road, Brentwood Bay, B.C. V0S 1A0
[4] Department of Civil Engineering, University of British Columbia, Vancouver, B.C. V6T 1W5

Geoenvironmental studies of the Fraser River delta

J.L. Luternauer[1], W.D.C. Finn[2], D.J. Woeller[3], J.A. Hunter[4], S.E. Pullan[4], M. Roberts[5], J.J. Clague[1] and R.A. Kostaschuk[6]

Studies have involved several GSC agencies, universities and private contractors. Investigative techniques used on the dyked part of the delta have included shallow seismic reflection profiling, coring, and a range of state-of-the-art geophysical and geotechnical measurements. As of last summer the Municipality of Richmond on the delta contributed financially to the studies as they included an assessment of the earthquake vulnerability of a part of the Municipality's dyking system. Preliminary results suggest that the site could undergo some liquefaction during earthquakes of magnitude $Ms > 6.5$ causing peak accelerations of $a > 0.17g$.

In offshore areas of the delta studies by Geological Survey of Canada have guided placement of a major submarine sewer pipeline for the City of Vancouver, identified a site of submarine landslides that presents a potential threat to a lighthouse at the mouth of the Fraser River and helped mitigate the impact of major port construction on an important intertidal habitat.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Soil Dynamics Group, Department of Civil Engineering, University of British Columbia, Vancouver, B.C. V6T 1W5
[3] ConeTec Investigations Ltd., 2447 Beta Avenue, Burnaby, B.C. V5C 5N1
[4] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8
[5] Department of Geography, Simon Fraser University, Burnaby, B.C. V5A 1S6
[6] Geography Department, University of Guelph, Guelph, Ontario N1G 2W1

Hope and Ashcroft map areas

J.W.H. Monger[1]

Proof geological maps of Hope (92H) and Ashcroft (92J), and an explanatory sheet, produced by photo-colour separation of hand coloured manuscripts, incorporate the results of mapping in 1980, '81 and '82 and 1984, '85, and '86, as well as material from numerous studies by the B.C. Geological Survey and (mainly) the University of British Columbia. The maps will be available for purchase in March-April, 1989.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Vancouver - Georgia Basin Project

J.W.H. Monger[1] and M.J. Journeay[1]

This is a new multidisciplinary project. A small amount of bedrock mapping was carried out in 1988 in parts of Vancouver (92G) and Pemberton (92J) map areas, the results of which are reported by Journeay. A more complete program will take place in 1989, funded under the Frontier Geoscience Program, and incorporates existing and new projects of the Geological Survey of Canada. The project involves government and university scientists and cooperation with university scientists funded under LITHOPROBE and U.S. Geological Survey activities in northwestern Washington.

The project has three main objectives:-

(1) **To establish the composition and crustal structure of the Vancouver-Georgia Basin area.** This is done by geological (bedrock) mapping, and by regional geochemical, gravity and aeromagnetic surveys.

(2) **To determine the internal geology and evolution of Georgia Basin, and the processes governing generation, accumulation and preservation of hydrocarbons within it.** This is done by section measuring, paleontological collecting, correlation with borehole and seismic reflection data, organic geochemistry, pyrolysis and maturation studies.

(3) **Regional hazards and constraints on development.** The region lies within the North American Plate, 150 km from the actively subducting Juan de Fuca Plate, and consequently is a region of potential major natural hazards. Mapping of nonmarine and marine surficial sediments, together with examination of possible active faults, and an extended regional seismic network, will identify problem areas.

The region is underlain by three different geological provinces.

(1) To the west, the mid-Paleozoic to Jurassic Wrangellian terrane, with well-stratified volcanic and sedimentary rocks and terrane-specific granites, underlies Vancouver and Texada Islands. Its eastern boundary, may lie between Texada Island and the Coast Belt, or alternatively is possibly (metamorphosed and so difficult to recognize) within the western Coast Belt. (2) To the east and south, are highly disrupted Precambrian (?), Paleozoic and Mesozoic volcanic and sedimentary rocks of the western Cascades. These extend into the eastern Coast Belt in the region between Harrison Lake and the Fraser River north of Hope. (3) To the north lies the Coast Belt, with abundant Late Jurassic (?) and mid-Cretaceous granitic rocks, septa of metamorphic rock of unknown ages, and Middle Triassic to mid-Cretaceous volcanic and sedimentary strata. Relationships between these three structural provinces are unknown. The region contains evidence for major Jura-Cretaceous, mid- to Late Cretaceous, early Tertiary and mid- to Late Tertiary deformational and metamorphic episodes.

Late Cretaceous-Tertiary Georgia Basin sedimentary strata were deposited on all three geological provinces, and are thus an "overlap assemblage" linking all three, and the basin itself provides a focus for the project. In detail, relationships between the strata in various parts of Georgia Basin are puzzling. To the west Late Cretaceous Nanaimo Group strata were clearly deposited on Wrangellian rocks, and locally are reverse and thrust faulted. To the north, (with possible minor exceptions) lower Tertiary strata (Burrard, Kitsilano, Huntingdon formations) dip gently southwestwards off Coast Belt rocks. To the south and east, lower Tertiary Chuckanut rocks

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

overlie Cascade rocks and are locally highly deformed. A major part of the project is to understand the evolution of the basin.

The project will provide a complete and integrated evaluation of the geology, geochemistry and geophysics of the Vancouver area, which will be of use in mineral and hydrocarbon exploration, and for community planning for hazard evaluation. Products of this project include (1) a volume of topical studies including various aspects of Georgia Basin and surrounding areas (e.g. paleontology, sedimentology, maturation and seismic studies), Fraser Delta studies, and a series of maps of 1:250,000 and smaller scales, covering regional bedrock geology, surficial geology, seismicity, possible hazards, gravity, aeromagnetic and geochemistry.

Galena Pb isotope studies of mineralization in southwestern Dawson map area, Yukon Territory

J.K. Mortensen[1]

A wide range of styles of mineralization occurs in the Yukon-Tanana terrane in southwestern Dawson map area and adjacent portions of Stewart River map area. In this study, Pb isotopic analyses of galenas were used to help place constraints on the age and origin of the various deposit types. Over 100 analyses were obtained for galenas from mesothermal veins, epithermal(?) veins, sedex-type occurrences, skarns and ultramafic-hosted Ag-Pb-Zn occurrences. Preliminary conclusions arising from the data include:

1. Pb isotope compositions from gold-bearing mesothermal veins in the Klondike District reflect derivation from a wide range of μ environments and suggest a probable Late(?) Jurassic age of formation;
2. arsenopyrite ($\pm$gold)-bearing mesothermal veins from northern Sixtymile District (Bedrock and middle and upper Miller creeks) yield isotopic compositions that overlap the Klondike Pb data array, and are likely similar in age and origin;
3. veins and vein-breccias of probable epithermal origin hosted by Carmacks Group volcanic rocks along Sixtymile River are isotopically distinct from the mesothermal veins, and the data indicate a younger age. Galenas from veins cutting metamorphic rocks in the Mosquito Creek area also fall in this field, suggesting a genetic relationship to the epithermal occurrences;
4. galena analyses from sedex-type Pb-Zn-Ba mineralization hosted by "Nasina Series" graphitic schist and quartzite fall on the "shale curve" and indicate an age for the mineralization and host sediments of about 400 Ma (Lower Devonian);
5. galena analyses from volcanogenic massive sulphide mineralization hosted by mid-Permian Klondike Schist in the northern Klondike District and near the Yukon-Alaska boundary fall well below the "shale curve", indicating derivation from a significantly less radiogenic environment than the sedex occurrences;
6. Pb in galenas occurring in Ag-rich veins and disseminations within and adjacent to carbonatized ultramafic bodies are almost entirely upper crustal in origin, although in a few instances a minor non-radiogenic, probably ultramafic-derived component is present.

Taken together, the data provide important new insights into the genesis of mineralization in the study area, and can be used directly to constrain exploration models for specific types of mineral occurrences.

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[1]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

The Kunga Group, Queen Charlotte Islands: stratigraphy, paleontology, sedimentology and geothermometry

M.J. Orchard[1], E.S. Carter[2], A. Desrochers[3] and E.T. Tozer[4]

The results of an integrated study of the Triassic stratigraphy, paleontology, sedimentology, and conodont geothermometry of the Kunga Group, Queen Charlotte Islands is presented. Faunas of ammonoids, conodonts, and radiolarians provide a biochronologic framework through which a composite stratigraphy of the Kunga Group has been compiled, and upon which a sedimentologic/paleogeographic model of the group has evolved. Three divisions of the Kunga Group comprise the Upper Carnian "Grey Limestone", the Upper Carnian through Upper Norian "Black Limestone", and the Upper Norian through Sinemurian Sandilands Formation, a potential source for hydrocarbons. The essentially continuous Upper Triassic rock record has permitted an integrated zonation of the principal fossil groups, including new conodont zonation in the Upper Carnian, and mostly new radiolarian zonation for the whole interval. This biochronology holds great promise for geological applications elsewhere.

The "Grey Limestone" comprises bioturbated fossiliferous wackestones representing deposition on a shallow, subtidal platform, and oolitic/bioclastic grainstone to packstone sand-shoal deposits. The carbonate platform was inundated during the Late Carnian, and deeper water facies composed of pelagic/hemipelagic limestones, proximal to distal carbonate turbidites, and platform- and slope-derived carbonate breccias make up the "Black Limestone". These beds are characterized by coquinas of the bivalves **Halobia** and **Monotis**, the disappearance of which marked the onset of basinal clastic deposition of the Sandilands Formation in the uppermost Triassic.

Conodont C.A.I. values for south Moresby Island are generally 4 or higher, and show a clear increasing trend eastward toward the centre of Jurassic plutonism. Most of Moresby Island is consequently overmature. In contrast, Graham Island hosts CAI values that range from overmature in the southwest to average values of about 2 in the north where Triassic areas that fall within the hydrocarbon window are delineated.

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[1]Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2]58335 Timber Road, Vernonia, Oregon, U.S.A. 97064
[3]Department of Geology, University of Ottawa, Ottawa, Ontario, K1N 6N5
[4]Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A OE8

Ordovician conodonts from western Canada

Susanne L. Pohler[1] and Michael J. Orchard[1]

Ordovician conodonts encountered in the course of regional mapping of the western Canadian Cordillera include samples from autochthonous and parautochthonous areas and, less commonly, from allochthonous terranes. Abundant conodont faunules from autochthonous sequences were collected near the western margin of the MacKenzie Platform (Yukon) and the eastern part of the Selwyn Basin. A deep water facies composed of dominantly thin bedded limestone (Broken Skull Formation) of Lower Ordovician age interfingers and is overlain by shallow water dolomite of equivalent and younger age. The change from calcareous to dolomitic lithofacies is usually accompanied by a change-over from North Atlantic to Midcontinent conodont faunas. This pattern suggests that dolomite deposition coincides with a relative sea level drop at the edge of the North American craton during early Middle Ordovician time which enabled warm water (Midcontinent) conodont faunas to replace deeper water communities. Whether this sea level change is due to local tectonics or eustasy remains to be demonstrated but the timing coincides with postulated eustatic events in other areas (i.e. southern Rocky Mountains, Mackenzie Mountains, Arctic Canada, western Newfoundland).

A small collection of Early to Late Ordovician age and of Midcontinent affinity is known from the parautochthonous Cassiar Terrane.

Ordovician conodonts are known from only two allochthonous terranes: Quesnellia in southern B.C. and the Alexander Terrane in northern B.C. The latter terrane has yielded several collections including some of North Atlantic affinity reported from southeast Alaska. The Quesnel locality (near Keremeos) is enigmatic and represents the oldest strata known within the Intermontane Belt.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C., V6B 1R8

Preliminary biostratigraphy of conodonts from McLeod Lake

S.M.L. Pohler[1], M.J. Orchard[1] and L.C. Struik[1]

About 60 of the 200+ conodont samples collected by one of the authors (L.C.S.) from the west half of the McLeod Lake map area have been processed and picked for conodonts. Of these 18 were productive and most produced Ordovician conodonts. Silurian and Devonian conodonts were recovered from five samples. The Ordovician samples produced Early, Middle and Middle to Late Ordovician faunas.

Early Ordovician conodonts retrieved from near Parsnip River comprise a sparse fauna with **Variabiloconus bassleri** Furnish as the only determinable index fossil. Samples collected near Seebach Creek had higher yields, yielding **V. bassleri, Rossodus manitouensis** Repetski and Ethington, and **Acontiodus propinquus** Furnish. All species are typical of North American Midcontinent Fauna C and indicate an early Canadian (late Tremadoc) age.

Middle Ordovician conodonts have been found near Chuchinka Creek in a sample comprising **Panderodus** sp., **Belodina** sp., **Leptochirognathus** sp., and **Drepanoistodus suberectus** (Branson and Mehl). One fauna from near Seebach Creek yielded **Appalachignathus** sp.

Middle to Late Ordovician samples are clustered around Chuchinka Creek. Conodont faunas recovered are dominated by species of **Panderodus** and **Belodina** along with **Drepanoistodus suberectus** (Branson and Mehl). **Plectodina** sp. and **Phragmodus** sp. are rare components of the fauna. The latter occurred in two samples from Seebach Creek together with **Protopanderodus** sp., **Dapsilodus** sp., **Belodina** sp., and **Panderodus** sp.

Determination of more precise stratigraphic levels should be possible following further taxonomic study of the conodont faunas recovered supplemented by processing of additional samples currently underway.

The two early Silurian samples collected near Chuchinka Creek are both dominated by **Panderodus** spp. but differ in their accessory species. One sample comprises species of **Pterospathodus, Walliserodus, Carniodus, Oulodus** and a new platform genus; a second, probably older sample produced similar oulodids and panderodids together with **Pterospathodus celloni** (Walliser) and **Distomodus.**

Three Devonian collections have been recovered. The largest from Tacheeda Lakes contains **Polygnathus, Icriodus and Belodella** indicating a mid-Eifelian through mid-Givetian age. A small faunule from the northwest part of the map area contains **Polygnathus** and **?Neopanderodus** of Middle Devonian age. A third collection from south of Tacheeda Lakes contains poorly preserved, but less thermally altered, icriodids and lanceolate polygnathids of probable Givetian to Frasnian age.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Seismic reflection and refraction studies in the Queen Charlotte basin

K.M. Rohr[1], G. Spence[1] and the Queen Charlotte Seismic Group[1]

As part of the Frontier Geoscience Program in the Queen Charlotte Basin a coincident seismic reflection and refraction experiment was run in July, 1988. The objectives of the survey were to define crustal structure in order to test models of Tertiary basin development and to illuminate the tectonic framework.

We collected 1000 km of 14 s marine seismic reflection data the data are 40 fold and used a 6400 in^3 airgun array. The seismic lines are regional in extent with strike and dip lines in Hecate Strait and Queen Charlotte Sound. Two of these lines cross the present plate boundaries south of Queen Charlotte Sound. Our data provide excellent images of the Tertiary sediments that have filled the Queen Charlotte basin. These sediments, the Skonun formation, vary in thickness from less than a kilometre to over 5 km in local fault bounded sub-basins. Beneath Hecate Strait the Skonun section is folded and faulted in contrast to sediments in Queen Charlotte Sound which show little deformation. Throughout the region lower crustal and Moho reflections are imaged at reflection times of 6.0 to 8.0 s.

Refractions and wide-angle reflections from the airgun array were recorded on land seismographs at ranges up to 230 km. Throughout, the region a strong secondary phase is observed beyond 40-50 km which is delayed from the first arrival by 0.5 s or more. This arrival corresponds to a mid-crustal interface or velocity gradient zone; in eastern Hecate Strait travel time modelling indicates that this phase can be interpreted as a reflection from the base of a low velocity layer at depths from 14-17 km. At greater ranges a prominent Moho reflector is recorded on most lines and modelling indicates a Moho depth of 28 km beneath western Hecate Strait.

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[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2

Turbidite-hosted gold deposits: potential in the Late Proterozoic of the northern Cariboos

G.M. Ross[1]

The northern Cariboo Mountains of eastern B.C. are underlain by a thick succession of Late Proterozoic metasedimentary rocks that include over 7 km of siliciclastic turbidites. Many of the features of this region (deformation, metamorphism, lithology, etc.) compare favourably with features associated with deposits of bedding-concordant gold-quartz veins hosted in Paleozoic turbidites of Nova Scotia, which have produced nearly 1,000,000 ounces of gold since 1861. This report briefly compares the geology of auriferous Nova Scotia turbidites with the relatively unexplored homologous strata of the northern Cariboos and identifies potential regions for gold exploration.

NOVA SCOTIA EXAMPLES

The Meguma Terrane of Nova Scotia consists of Cambro-Ordovician deep-water clastics of the sandstone-rich Goldenville Formation and overlying slate-rich Halifax Formation. The Meguma Terrane was accreted to North America during the Late Paleozoic Acadian Orogeny. The collision had a strong component of right-lateral obliquity that imparted the doubly-plunging en echelon fold style and slaty cleavage that typifies this terrane. Metamorphic grade ranges up to upper greenschist and the relationship between isograds and regional structure suggests that metamorphism was late syn- to post-kinematic. The entire terrane has been intruded by peraluminous granitoid bodies that are largely post-metamorphic (and thus post-kinematic) although pre- and syn-kinematic intrusions are present).

Auriferous quartz veins occur as bedding concordant arrays limited exclusively to the hinge zones of anticlines. Quartz is the predominant mineral in the veins along with trace amounts of carbonate (generally ankerite), white mica, chlorite, arsenopyrite, pyrite, sphalerite, galena, chalcopyrite, pyrrhotite and spectacular hematite. The spatial distribution of the auriferous veins reflects the important influence of several regional features on vein emplacement in addition to obvious structural control. These are the proximity to the Goldenville-Halifax Formation boundary, the chlorite-biotite "isograd" and contacts with granitoids. These features reflect the strong control of mechanical anisotropy (layering) in the sediments on the localization of veins in addition to metamorphic and hydrothermal(?) fluid fluxes.

THE NORTHERN CARIBOOS

In the northern Cariboo Mountains, Late Proterozoic strata consist of a thick (3 km+) sequence of turbiditic grits of the Kaza Group overlain by 4 km of the slate-rich Isaac Formation of the Cariboo Group. These rocks form the low-grade carapace to the Omineca Belt and record the structural and metamorphic effects of Mesozoic collision. At the latitude of McBride (53°N), B.C., plate collision deformed these strata into upright east-verging folds (D1) and a superposed set of west-verging structures (D2).

The Kaza Group consists of feldspathic grits with minor interbedded pelite. The overlying Isaac Formation is a slate-rich unit with subordinate grit and limestone. Pyritic black shale is common, especially in the Isaac Formation, and one black shale unit in the Kaza Group is associated with a Cu anomaly. Two distinct phases of metamorphic mineral growth are present: an early phase that was contemporaneous with D1 deformation and a younger post-tectonic (post-D2) phase. Metamorphic grade ranges from subgreenschist to upper greenschist.

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[1]Geological Survey of Canada, 3303 - 33rd Street N.W., Calgary Alberta T2L 2A7 oldest vein

Quartz veins are common throughout the region and are dominated by simple mineralogy that includes quartz, ankerite-siderite, white mica, chlorite and rare sulphides. Relationships between regional structural elements and veins indicates a range in the timing of vein emplacement. The systems comprise bedding concordant veins, up to 1 m thick, that are folded by D2 structures yet also contain breccia fragments of foliated wall rock, apparently indicating a syntectonic origin to the veins. In several major anticlinal closures close to the Kaza/Isaac boundary, vein systems are associated with pervasive carbonate (siderite) alteration of wall rock. Assayed grab samples indicate low gold values (up to 84 ppb) in the wall rock but significantly this in an order of magnitude above background. In addition, streams that drain these closures (Goat and Milk River) are known to carry placer gold. Younger veins are generally transverse to regional structures and are not associated with wallrock alteration.

PROGNOSIS

Syntectonic veins in both Nova Scotia and the northern Cariboos are inferred to have been emplaced during dilation of well-layered sediments during deformation. The strong mechanical anisotropy across the Kaza-Isaac boundary and the analogous Goldenville-Halifax boundary, apparently acted to concentrate stress and aided vein formation. In Nova Scotia fluids may have been derived from metamorphic dehydration reactions, as suggested by the spatial relationship between gold veins and the chlorite-biotite "isograd", although hydrothermal fluids derived from the peraluminous granites may have been important. In the northern Cariboos, fluids are inferred to have been derived largely from metamorphic dehydration reactions and modified by pressure solution during cleavage formation. Abrupt changes in the slope of the solubility curves for both silica and gold as a function of temperature suggest that precipitation of these species probably occurred during the cooling of fluids below ca. 400° C, the approximate temperature for the first appearance of biotite. The potential for gold mineralization in the northern Cariboos, and low grade Late Proterozoic turbidites on either side of the Southern Rocky Mountain Trench, is considered good. Exploration should be concentrated on structural-stratigraphic targets (anticlines developed close to grit-slate contacts) in regions close to (or below) the first appearance of biotite.

Gravity anomaly field
Narraway-Pine Pass region, east-central B.C.

D.A. Seemann[1] and J.F. Sweeney[2]

440 new gravity measurements are available from east-central B.C. between 54°-56°N, 120°-124°W. Station spacing is about 10 km; station positions were fixed by the Geodetic Survey of Canada's inertial surveying system.

The Bouguer anomaly field shows a ~100 km vavelength 50-to-75 mGal low trending northwestward, parallel to regional tectonic strike. The low, which lies over the detachment zone in the Foreland Belt, reflects the depression of the Moho produced by downwarping of cratonic basement beneath the load of imbricated thrust sheets.

The surveyed area is heavily covered with vegetation and Quaternary sediments. In conjunction with GSC mappers now working in the area (Struik and others), planned close-interval gravity traverses will define many of the near-surface structural/lithological trends beneath the cover.

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[1] Geological Survey of Canada, 9860 West Saanich Road, Sidney, B.C. V8L 4B2
[2] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Dyke swarms in the Queen Charlotte Islands - implications for hydrocarbon exploration

J.G. Souther[1]

Tertiary dykes in the Queen Charlotte Islands are concentrated in well defined swarms which display systematic variations in orientation and chemical composition. Those in the southern Moresby archipelago are relatively calcic and occur in north-trending, en-echelon swarms whereas those in northern Moresby and southern Graham islands have a more easterly trend and are relatively alkaline. The zone between these two domains is believed to define a boundary between discrete crustal blocks.

North-trending swarms in the southern domain are flanked on the southwest by a large dyke-free terrane on southern Moresby Island and on the northeast by Queen Charlotte Basin. The geometry is consistent with extension and dyke emplacement related to dextral movement between southern Moresby Island and the western margin of Queen Charlotte Basin. The easterly trend of dyke swarms in the northern domain suggests that the Tertiary stress field was influenced by local plate interactions.

The dyke swarms appear to have propagated outward from central igneous complexes which include major Tertiary plutons. Heat introduced by the dykes and larger intrusive bodies is believed to account for the observed overmaturation of potential source rocks in the southern Moresby archipelago.

[1]Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

British Columbia MDA Aeromagnetic Total Field Survey 1986

P. Stone[1] and J. Tod[1]

Under the Canada-British Columbia Mineral Development Agreement, an aeromagnetic total field survey was carried out over the Strait of Georgia, Queen Charlotte Strait and portions of both Vancouver Island and the Lower Mainland. The survey location is shown on the attached figure. It straddles the boundary between two of the major subdivisions of the Canadian Cordillera: the Coast Plutonic Complex and the Insular Belt. The survey results should significantly contribute to the understanding of the geology of this areas's complex structural and tectonic relationships.

The contract was awarded to Questor Surveys Limited of Toronto and the survey was flown between August and November, 1986, using a fixed wing aircraft. A proton precession magnetometer with a resolution of 0.2 nanoteslas measured the total field. The variation in elevation was accommodated by five separate flight blocks. Two were flown at 2440 m ASL and the others at 760 m, 1830 m and 2590 m. A flight line separation of 1.5 km was maintained with a control line spacing of 14 km.

Survey results are available as aeromagnetic total field contour maps at two scales, 1:50,000 and 1:250,000. In addition the digital data can be purchased for further processing and interpretation, from the Geophysical Data Centre, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario, K1A 0Y3 (telephone: 1-613-992-6438).

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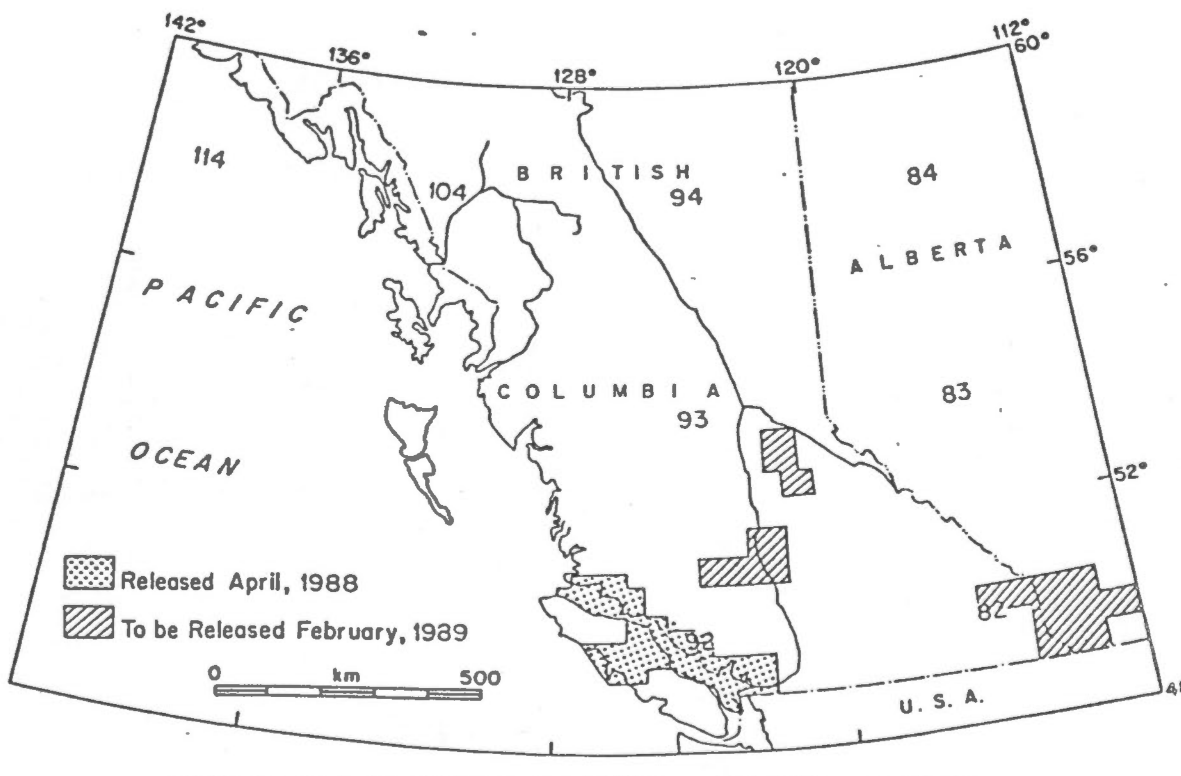
[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8



RECENT AEROMAGNETIC SURVEYS - BRITISH COLUMBIA

The McLeod Lake map area: gold and tectonics in central British Columbia

L.C. Struik[1]

Upper Cretaceous(?) to Miocene dextral strike-slip and related crustal extension (and erosion) are interpreted to have generated the present topography of the bedrock in the McLeod Lake map area. Much of that bedrock topography is now obscured by Pleistocene glacial deposits. Tertiary basalt, sedimentary rocks, and plutons were probably generated by the strike-slip and extension tectonics, and those tectonics in turn were a consequence of transform motion between North America and the Pacific plates. The results of mylonitization, brecciation and hydrothermal fluid flow mark the boundary between high-grade-metamorphic rocks of the Wolverine Complex and overlying low-grade-metamorphic basalt and greywacke of the Takla and Slide Mountain groups. Those contacts may be the locus of hydrothermal gold deposition. Crustal shortening, accommodated by thrust overlap and folds, in part preceded the Late Cretaceous and younger tectonics. The south-southeasterly throughgoing McLeod Lake Fault (dextral strike-slip) divides the McLeod Lake map area into two lithological and structural domains. The western domain has a pre-Tertiary bedrock of Triassic and Jurassic Takla Group basalt and greywacke; upper Paleozoic Slide Mountain Group basalt and sediments; Pennsylvanian Cache Creek Group limestone and basalt; and pre-Mesozoic sedimentary protolith to the Wolverine Metamorphic Complex. The structures are dominantly strike-slip and extension faults. The eastern domain consists of lower Paleozoic carbonates, sediments and minor basalts; and upper Precambrian clastic rocks, and the structural style is dominated by thrust faults and folds overprinted to various degrees by dextral strike-slip faults. Notable in the eastern domain (McGregor Plateau) are Devonian and possibly Silurian calcareous basalts and intermediate tuffs that are interbedded with limestone, dolostone and sandstone. The tuffs and some of the basalt flows and pyroclastics are in part Middle Devonian as determined from their stratigraphic position over Middle Devonian conodont-bearing limestone.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

Analysis of magnetic data over Queen Charlotte Sound, Hecate Strait and the Queen Charlotte Islands

D.J. Teskey[1] and R.G. Currie[2]

An aeromagnetic survey was flown over the Queen Charlotte Islands and Dixon entrance in 1985 as part of the Frontier Geoscience Program West Coast Task. These data were combined with an older magnetic survey flown by Barringer Ltd. in 1962, which was made available to the GSC by Shell Canada Ltd. These data sets have been combined into composite maps of the area and published as a series of 1:50,000 and 1:250,000 maps in 1987. The data have also been released in digital form and are available from the Geophysical Data Centre, Geological Survey of Canada., 1 Observatory Crescent, Ottawa, K1A 0Y3. As the first step in a regional interpretation of the magnetic data, a number of derived products such as vertical gradients, upward continuation and shaded relief have been produced. The derived maps have been proven to be very useful for the delineation of features in the basin and for outlining the basin margins. Werner deconvolution has been applied to the profile data and to selected marine magnetic data to provide estimates of depth and dip of structures which are presented as colour-coded maps. Forward modelling has also been used to investigate specific anomalies. This modelling has been partially constrained by a database of rock properties which is being compiled for the region.

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[1] Geological Survey of Canada, 610 Booth Street, Ottawa, Ontario K1A 0E8
[2] Geological Survey of Canada, 9680 West Saanich Road, Sidney, B.C. V8L 4B2

Structural history of Mesozoic strata of the Queen Charlotte Islands: implications for hydrocarbon exploration

Robert I. Thompson[1] and Peter Lewis[2]

Stratigraphic and structural histories of source and reservoir strata exposed on the Queen Charlotte Islands are key to assessing pre-Tertiary petroleum potential beneath Hecate Strait and Queen Charlotte Sound. There were two episodes of southwest-northeast compression, the first prior to Middle Jurassic volcanism, and the second after deposition of Upper Cretaceous conglomerate (Honna Formation). Extension, associated with block faulting, was episodic, beginning late in the Jurassic and lasting into the late Tertiary.

Implications with respect to petroleum exploration are many: 1) Potential source strata -- Upper Triassic and Lower Jurassic Kunga and Maude Groups - were stripped from large areas during period(s) of uplift and erosion; 2) the areal extent of potential reservoir strata - Lower Cretaceous Haida Formation - is controlled, in part, by the geometry and movement history of Late Cretaceous and Tertiary block faults; 3) reservoir strata (e.g. Lower Cretaceous Haida Formation) can overly source strata (Late Jurassic and Lower Jurassic Kunga and Maude Groups) directly; 4) block faults create potential for up- and down-side traps; 5) block faulting may have influenced the geometry and extent of sandstone facies having good primary porosity.

Folding, associated with contraction faulting, followed deposition of shelf-carbonate and -clastic rocks late in the Early Jurassic - bed length shortening measured around folds and across faults was significant. Structural grain trends west northwest to northwest, across the Islands. Uplift and erosion preceded middle Jurassic volcanism (Yakoun Formation), thereby removing the Maude Group and parts of the Kunga Group - potential petroleum sources - from large areas. Preserved thickness of the Kunga and Maude Groups varies from 0 to a maximum of 1000 m.

Episodes of block faulting, from Late Jurassic through Late Cretaceous time, prevented preservation of a thick stratigraphic succession. In cross section, aggregate thickness of Middle Jurassic through Lower Cretaceous strata does not exceed 600 m in any one place, but the age of preserved strata is different from block to block. Individual block faults were active more than once, but it is not clear how much, if any, displacement was syn-depositional.

Uplift and erosion, early in the Late Cretaceous, preceded stratigraphic overlap by the Late Cretaceous Honna conglomerate. Consequently, Honna conglomerates directly overly strata as old as Lower Jurassic.

Compression followed deposition of the Honna Formation: Broad, upright folds increase in intensity toward a narrow zone of tight, locally overturned folds transecting the central Queen Charlotte Islands.

The Honna Formation is cut by steep, northwest trending faults, each placing east side down. Their geometries are sympathetic to the Sandspit Fault. Late Tertiary extension that accounts for subsidence and sedimentation beneath Hecate Strait may be the most recent manifestation of a block faulting history that began late in the Jurassic.

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[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2] Department of Geology, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 2T4

Guidelines for the interpretation of seismic reflection data from Hecate Strait should include the following: Total preserved thickness of the Upper Triassic through Late Cretaceous stratigraphic succession is unlikely to exceed 2000 m in any one area, and may be a few hundred meters or less. Reflectors are expected from within the Kunga and Maude Groups because bed dips are steep and lithologies are uniform. Two regional unconformities may serve as acoustic reflectors: 1) The unconformity separating the Kunga and Maude Groups from overlying strata; and 2) the unconformity separating older strata (especially shale of the Skidegate Formation) from the Late Cretaceous Honna Formation (conglomerate). Northwest trending block faults cut the entire succession resulting in abrupt changes in thickness and age of mid Jurassic through Tertiary strata. Masset volcanic rocks (Tertiary) are not expected east of northern Moresby Island. Trends of major contraction and extension structures of all ages are dominantly west northwest to northwest.

Ogilvie Mountains geology - Dawson map area

R.I. Thompson[1] and C.F. Roots[1]

Soon-to-be released 1:50,000 maps of bedrock geology north of Dawson, Yukon show for the first time the internal divisions of Proterozoic stratigraphy and the considerable structural telescoping indicated by the Paleozoic rocks. We have recognized large clastic wedges deposited during extension events 750 Ma and 1.3 Ga; they are separated by thick, shallow water carbonates. The Proterozoic section in the Ogilvie Mountains is more complete and less deformed than that further south and it contains the best exposed and best understood clastic and volcanic record of early Windermere extension.

In the Ogilvie Mountains are showings of iron, copper, lead-silver, zinc, barite, uranium and high-tech metals; our enhanced understanding of the host units and regional structure allows better prediction of their distribution.

Conspicuous jasper clasts that are widely distributed in extension-related conglomerate were probably derived from red beds within the Wernecke Supergroup. These beds were initially disrupted by hematitic breccia pipes (1.27 Ga) whose setting is better understood than those in the Wernecke Mountains. The breccias are distributed along two northeast-trending faults and have associated Cu, Co and U mineralization.

Lead and zinc in veins and cavities within breccias of the Fifteenmile Group carbonates are extensive talus and karst deposits and appear stratabound.

Although the tholeiitic Mount Harper volcanics (750 Ma) are unmineralized, distal red beds of the related Harper Group are the stratigraphic equivalent of the cupriferous Coates Lake Group (Mackenzie Mountains). The massive conglomerates of the Harper Group are of alluvial and littoral origin; they provide no evidence for glaciation and are much older than the Rapitan Group (Mackenzie Mountains). Hematitic iron formation occurs in the Hyland Group, a Windermere-equivalent clastic succession that overlaps the Coal Creek Inlier along a major thrust fault.

Black shale of the Road River Group and Nation River Formation contain high lead, silver and zinc concentrations. This part of the structurally thickened northern margin of the Selwyn Basin contains numerous alkalic volcanic lenses similar to those of the Misty Creek embayment.

Between Middle Jurassic and Late Cretaceous time, the broad (several hundred kilometres) Paleozoic basin was telescoped and thrust northward in three overlapping structural sheets. Subcircular, A-type syenitic intrusions (90-110 Ma) that cut these thrusts host uranium, thorium and molybdenum showings. Strongly altered pendants within the plutons and skarns along their margins contain three types of mineralization: lead-silver veins, copper-gold replacement, and niobium in tourmaline alteration zones.

Our investigations of the regional geology have shown that the Mesozoic structural style reflects the lithologic variety and facies distribution in the Proterozoic strata, as well as prior crustal thinning along early extension faults. These old fault were commonly reactivated, and became the locus for intrusive breccia and volcanism. All exposed rock in the Southern Ogilvie Mountains have been displaced northward, however, so no inferences can be made about the underlying basement or deep crustal structure.

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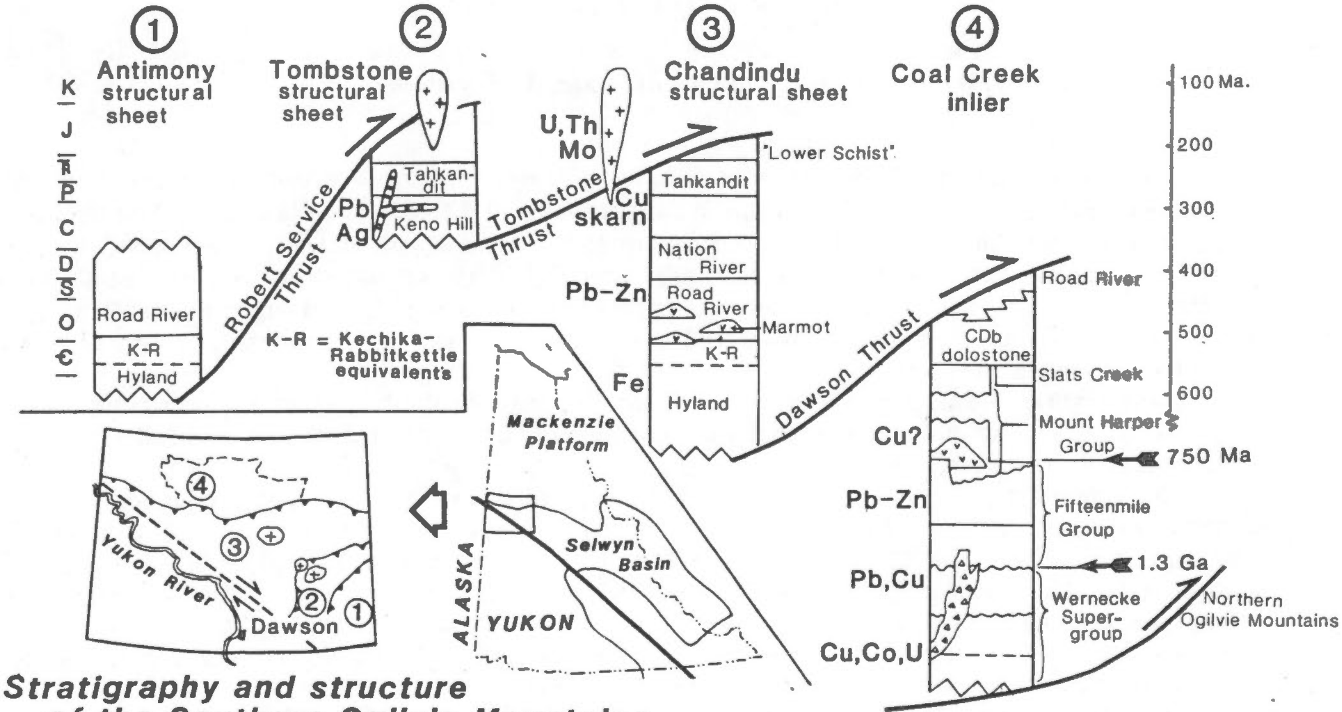
[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8



Stratigraphy and structure of the Southern Ogilvie Mountains

Lower Jurassic biostratigraphy of the Queen Charlotte Islands, B.C.

H.W. Tipper[1], P.L. Smith[1] and G. Jakobs[2]

The biostratigraphic study of Lower Jurassic ammonites of the Queen Charlotte Islands has been a continuing project for several years. The abundance, diversity and excellent preservation of the ammonites has made this study essential to the development of a North American ammonite zonation. A zonation of Pliensbachian ammonites is complete and published. The Toarcian studies are in progress with zonation as a goal. Sinemurian and Hettangian studies are barely started although much material is in hand.

The development of the Lower Jurassic zonal schemes permits a precisely defined means of world wide correlation. Radiometric dating of state boundaries has not been accomplished except for a few estimates; age dates are not yet sufficiently refined for world wide correlation. In future if zonal boundaries can be quantified radiometrically, we will have achieved a means of high resolution intercontinental correlation for the Lower Jurassic.

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[1]Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8
[2]Department of Geological Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. V6T 2B4

The character and genesis of stratiform sediment-hosted zinc-lead mineralization: Jason deposit, Macmillan Pass, Yukon

Robert J.W. Turner[1]

The Jason deposits are located in the eastern Yukon near Macmillan Pass and belong to a group of stratiform zinc-lead and stratiform barite deposits which occur in carbonaceous shales and cherts of the Middle to Upper Devonian Lower Earn Group. Stratiform Zn-Pb deposits occur adjacent to synsedimentary faults within a pull-apart basin of Late Devonian age (Turner, 1986) (Fig. 1). The pull-apart basin is bounded by northeast-trending normal faults, and by northwest-trending normal and strike-slip faults active during the Devonian. Devonian age stratiform barite deposits occur peripheral to the pull-apart basin. The Jason deposits are a member of a family of over 100 stratiform Pb-Zn and stratiform barite deposits hosted by carbonaceous shales and cherts of Late Devonian and Mississippian age that occur along the western Cordillera of North America from California to Alaska (Turner, 1988).

The Jason South/Main stratiform Zn-Pb deposit occurs in a faulted, southeast-plunging syncline. Within the syncline, conglomerate and sandstone (Unit 2) are overlain successively by siltstone (Unit 3A) and sedimentary breccias (Unit 3C). Two stratiform sulphide horizons are interbedded with Units 3A and 3C. Both sulphide horizons terminate up-dip against the Jason fault on the south side of the syncline. Isopachs of the sedimentary breccia beds form lobes that thin away from the Jason fault.

Two distinct ore types occur within the Jason deposit: (1) veined and massive iron carbonate-sulphide adjacent to the Jason fault that grades outwards into (2) widespread finely-laminated barite, sulphide, and chert (Fig. 2). A barite-sulphide facies comprise a large bulk of the Jason deposit and is composed of monomineralic and polymineralic millimetre-scale laminae of barite, chert, sphalerite or galena. Toward the Jason fault, laminae of the barite-sulphide facies are interbedded with massive beds of sphalerite+galena, or galena+pyrite (Pb-Zn-Fe sulphide facies). Erosional scour textures occur within the Pb-Zn-Fe facies and the barite-sulphide facies; sedimentary breccias locally include clasts of stratiform mineralization.

Adjacent to the Jason fault, massive pyrite (pyrite facies) is interbedded with beds of massive sphalerite-galena, and massive-veined ferroan carbonate (Fig. 2). The massive pyrite locally displays fine grained collimorphic textures, pseudomorphic after barite, and is cut by quartz-sulphide veinlets. The iron carbonate facies of the upper horizon is massive, mottled and veined rock composed of a complex assemblage of ankerite, galena, pyrite, pyrrhotite, quartz with minor fragments of silicified siltstone. On the fringe of the iron carbonate facies, barite-sulphide facies are silicified and replaced by banded and massive ankerite. In the lower horizon, siltstone strata are progressively replaced by (1) quartz and muscovite; (2) siderite; (3) pyrrhotite; and (4) ankerite-galena. A breccia pipe cuts the lower horizon and extends from the Jason fault to the sedimentary breccias overlying Unit 3A (Fig. 2). This breccia is composed of angular fragments of silicified siltstone in a variable matrix of siderite, ankerite, muscovite, pyrrhotite, quartz, galena, and pyrite. Where the breccia body cuts bedded pyrite of the pyrite facies, pyrrhotite has replaced pyrite.

The occurrence of sedimentary breccias interbedded within, and overlying, the stratiform deposit indicates movement on the Jason fault coincided with the hydrothermal activity that formed the Jason deposit. Re-sedimentation and scour textures, and graded sulphide laminae are evidence of subaqueous sulphide sedimentation. The wedge-shaped cross-sectional profile of the deposit likely reflects hydrothermal deposition within a bathymetric low adjacent to the Jason fault scarp.

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

The massive and veined proximal mineralization represents subsurface processes related to replacement of previously mineralized rocks in the upflow zone of the hydrothermal system. Brecciation and ferroan carbonate precipitation followed earlier silicification of the sediments, perhaps reflecting rupture of a silicified cap coincident with CO_2 effervescence in the hydrothermal fluids. Extensive replacement of early siderite and pyrite by pyrrhotite may indicate evolution of the hydrothermal fluids to lower $^fS_2$ and/or $^fO_2$. Early-formed alteration was both pervasive (e.g. silicification) and bedding controlled (e.g. siderite), superposed alteration (e.g. ankerite-galena) replaced early bedding-controlled alteration and developed along fractures during progressive induration of the sediments. Massive pyrite formed by in situ precipitation from rising fluids, replacing sediments immediately below the seafloor. Massive galena and sphalerite beds represent sulphide sedimentation or re-sedimentation adjacent to the vent. Barite samples, regardless of stratigraphic position within the stratiform bodies, have a narrow range of strontium isotope ratios, ($^{87}Sr/^{86}Sr$ = 0.7126-0.7144), which is distinctly higher than for Late Devonian seawater ($^{87}Sr/^{86}Sr$ = 0.7083, Burke et al., 1983). These data suggest that barite precipitated from a brine pool, in this case ponded adjacent to the Jason fault.

A comprehensive sulphur, carbon, oxygen, hydrogen and strontium isotope study is currently in progress with Wayne Goodfellow and Bruce Taylor of the GSC, Ottawa (see Turner et al., in press). Several questions critical to understanding the genesis of the Jason deposit in particular, and stratiform sediment-hosted deposits in general, will be addressed: (1) what were the primary sources of carbon and reduced sulphur; (2) what was the origin of water in the hydrothermal fluids; (3) how did the hydrothermal fluids evolve and mix with seawater; and (4) what is the genetic relationship between local and widespread ferroan carbonate alteration and the stratiform base-metal deposits.

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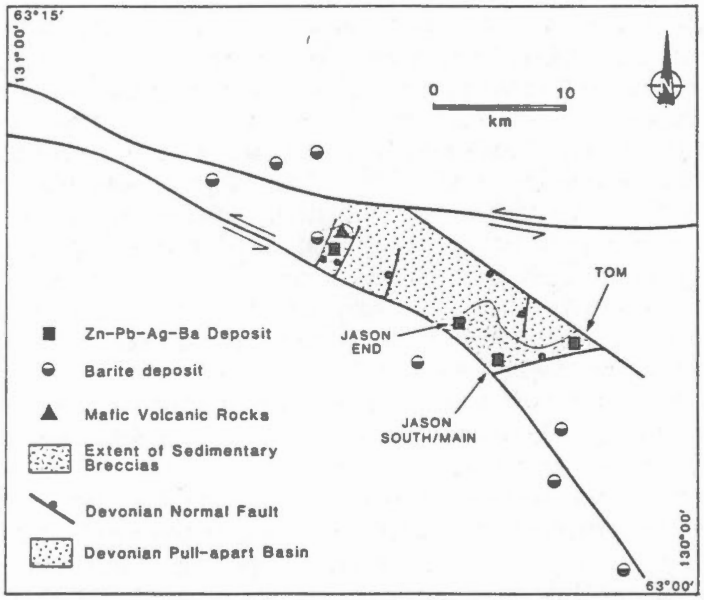
FIGURE CAPTIONS

Figure 1: Distribution of Late Devonian age faults, sedimentary breccias, stratiform Zn-Pb-Ba deposits and stratiform barite deposits in the Macmillan Pass area.

Figure 2: Restored stratigraphic cross-section across the trend of the Jason fault illustrating distribution of internal facies within the Jason South-Main stratiform deposits (Turner, 1986). Heavy black line encloses hydrothermal facies. Upper section has 6.3X vertical exaggeration; true scale cross-section shown in solid black.


63°15'
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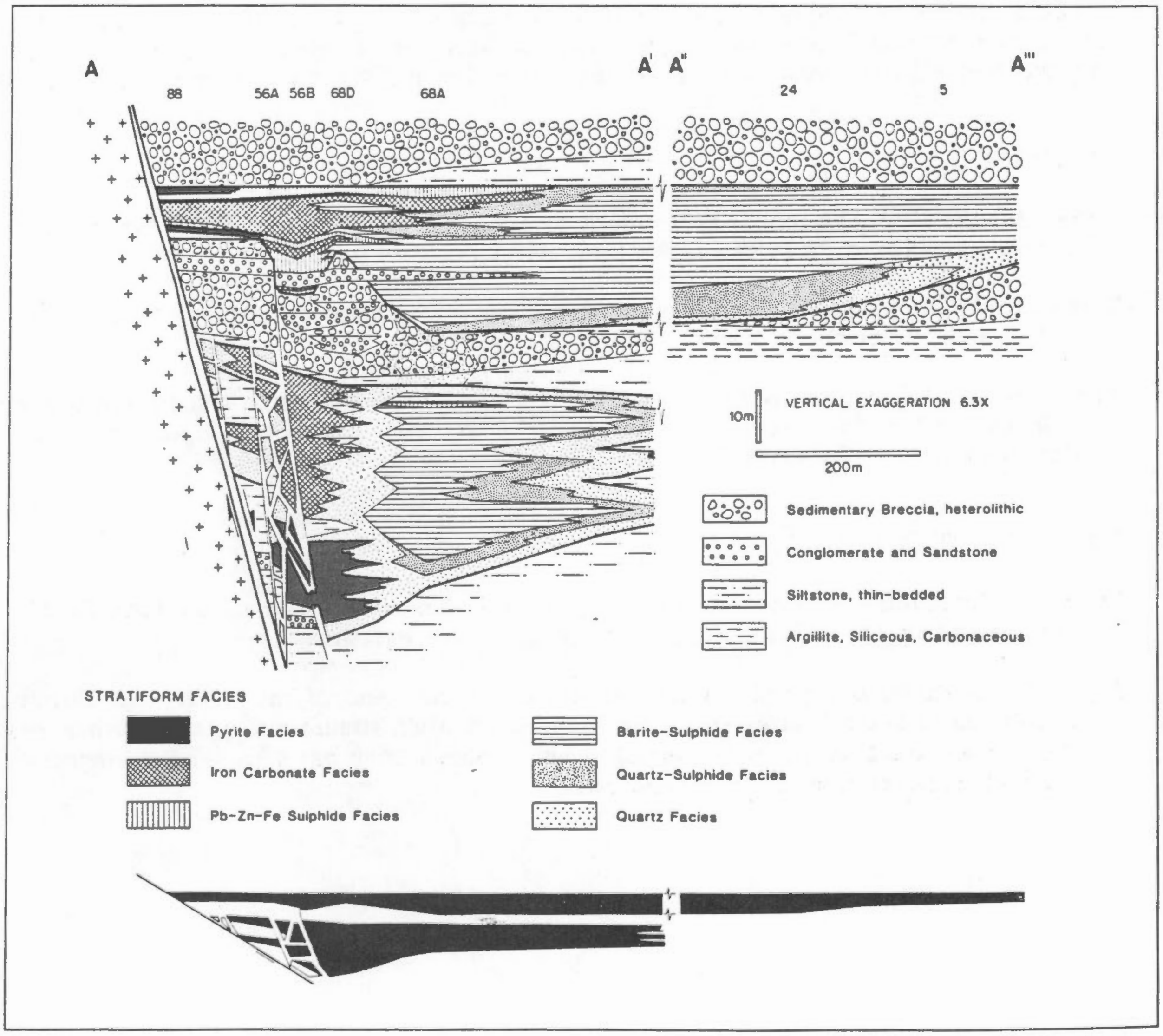
TOM
JASON END
JASON SOUTH/MAIN
Zn-Pb-Ag-Ba Deposit
Barite deposit
Mafic Volcanic Rocks
Extent of Sedimentary Breccias
Devonian Normal Fault
Devonian Pull-apart Basin
130°00'
63°00'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56A
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68D
68A
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VERTICAL EXAGGERATION 6.3X
200m
Sedimentary Breccia, heterolithic
Conglomerate and Sandstone
Siltstone, thin-bedded
Argillite, Siliceous, Carbonaceous
STRATIFORM FACIES
Pyrite Facies
Iron Carbonate Facies
Pb-Zn-Fe Sulphide Facies
Barite-Sulphide Facies
Quartz-Sulphide Facies
Quartz Facies

Distribution of Proterozoic to Miocene plutonic suites in the Canadian Cordillera

G.J. Woodsworth[1], R.G. Anderson[1], A. Brookfield[1] and P. Tercier[1]

The distribution of plutonic suites in the Canadian Cordillera is shown on eight maps, each representing a particular time interval. These maps and the accompanying text are based on material prepared for the Cordilleran DNAG volume and will be released in March as GSC Open Files 1982 and 1983.

Proterozoic and Paleozoic plutons of ancestral North America consist of Early and Middle Proterozoic granodiorite, Late Proterozoic alkalic plutons, early Paleozoic alkalic to carbonatitic suites, and Proterozoic and Paleozoic mafic sills and diatremes. The pericratonic Kootenay Terrane contains granite to quartz diorite intrusions of mainly Ordovician to Mississippian age. The Monashee Terrane has Proterozoic and Paleozoic(?) alkaline intrusions. The Slide Mountain Terrane contains a variety of Paleozoic plutons, mostly diorite, quartz porphyry, and tonalite. The Alexander Terrane includes Ordovician to Early Silurian calc-alkaline plutons; mid- to Late Silurian sodic plutons emplaced during the Klakas orogeny; and, in the Saint Elias Mountains, late Paleozoic calc-alkaline stocks and batholiths. Wrangellia has small mafic to ultramafic plutons in the Saint Elias Mountains and Devonian quartz-feldspar porphyry in southwestern British Columbia.

Late Triassic plutons are largely restricted to small, Alaskan-type ultramafic bodies in Quesnellia and Stikinia, and to a belt of tholeiitic to calc-alkaline granitoid rocks that intrude Stikinia along the Stikine Arch. Both suites are spatially and probably genetically related and are associated with Middle to Upper Triassic volcanic rocks.

In the Early Jurassic, plutonic activity occurred in Quesnellia, Stikinia, and Wrangellia. Calc-alkaline batholiths in Quesnellia and alkaline bodies there and in Stikinia show close spatial and temporal affinities with Upper Triassic to Lower Jurassic volcanic rocks. Calc-alkaline plutons in Stikinia occur on the north and south sides of the Bowser Basin and may be related to Lower and Middle Jurassic Hazelton volcanism. A poorly dated suite of plutons in Yukon Territory may in large part be related to volcanism in the Whitehorse Trough. In Wrangellia, Early to Late Jurassic, calc-alkaline, I-type plutons form a well-defined belt related to Lower Jurassic Bonanza and Middle to Upper Jurassic Yakoun volcanism. A belt of plutons of Early to Middle Jurassic age seems to extend along the east side of the Coast Plutonic Complex for much of its length and may be coeval with Lower to Middle Jurassic volcanism of the Hazelton Group.

Middle Jurassic plutons in southern British Columbia consist of an early alkaline suite that was followed by widespread calc-alkaline plutonism and then by areally restricted two-mica granites. Volcanic equivalents of these rocks are rarely preserved. Middle Jurassic plutons are also present in the Coast Belt, and in a small, distinctive group east and north of the Bowser Basin.

Late Jurassic to early Early Cretaceous plutons are common in the Coast Belt but uncommon elsewhere in the Canadian Cordillera. Plutons of this age and related to arc volcanics of the Gambier Group occur in the Coast Plutonic Complex. Late Jurassic to Early Cretaceous plutons in the Saint Elias Mountains may be the northern extension of those in the Coast Plutonic Complex. In the Intermontane Belt, the earliest Cretaceous Francois Lake Intrusions are confined to Stikinia and the Cache Creek Terrane along the Skeena Arch.

Mid-Cretaceous granitic rocks are concentrated in two broad geographic belts that coincide, roughly, with the two great zones of metamorphic rocks in the Canadian Cordillera. Those in the eastern zone, roughly along the Omineca Belt, are predominantly S-type, felsic, and have initial $^{87}Sr/^{86}Sr$ ratios greater than 0.710; those in the western belt, mainly in the Coast Belt, are I-type, felsic to mafic, and have initial $^{87}Sr/^{86}Sr$ ratios less than 0.706. In the eastern zone, the numerous

[1] Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8

discordant batholiths and stocks are mainly granite and granodiorite in composition. These appear to have been emplaced after or, in some cases, during the main periods of metamorphism and deformation in the region. Many of these plutons have no known volcanic counterparts, nor do contemporaneous syenite and quartz monzonite plutons in the western Yukon. In the Whitehorse Trough, a suite of predominantly granodiorite plutons may be subvolcanic to the mid-Cretaceous Mount Nansen volcanics. In the Foreland Belt, small alkaline intrusions are comagmatic with the mid-Cretaceous Crowsnest volcanics.

Mid-Cretaceous rocks of the western zone are concentrated mainly in the Coast Belt, where they were emplaced before, during, and after regional deformation and metamorphism. In the northern Insular Belt, calc-alkaline plutons cut rocks of Wrangellia and the Alexander Terrane and the overlapping Gravina-Nutzotin Assemblage. Alaskan-type ultramafics of mid-Cretaceous age form a linear belt extending from the Saint Elias Mountains through southeastern Alaska and possibly into the Coast Plutonic Complex of British Columbia. These may be related to volcanic rocks of the Gravina-Nutzotin Assemblage.

Late Cretaceous plutons are abundant in the Intermontane Belt and, from north to south, the western to central to eastern parts of the Coast Belt. Those in the Intermontane Belt are generally small, high-level, calc-alkaline bodies that may be comagmatic with widespread nonmarine Upper Cretaceous volcanics. In the Coast Belt, Late Cretaceous plutons range from high-level, post-tectonic intrusions to deep-seated and syn-metamorphic bodies.

Most Paleogene plutons are Early and Middle Eocene in age. This time marks the end of extensive plutonism in the Canadian Cordillera, as well as uplift and unroofing of metamorphic complexes in the Omineca and Coast belts. The bulk of Eocene plutons are in the central and eastern Coast Plutonic Complex where they may be deep-seated counterparts of high-level Intermontane Belt plutons and volcanics; most of the remainder are in the Intermontane and Insular belts. A few are in the Foreland Belt. Most Eocene plutons are small, high level, discordant stocks; many are spatially and genetically related to Eocene volcanic rocks.

Oligocene and Miocene felsic plutons are restricted to the Coast and Insular belts. Most are small, were emplaced at shallow depths, and may be genetically related to nearby volcanic rocks of the same general age and composition. Most are probably subduction related, and those in the Saint Elias Mountains are associated with regional transcurrent faults.

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Levé magnétique et de structure - Ralph Currie (356-6419)

PALÉOMAGNETISME
Paléomagnetisme - Ted Irving (356-6508) et Jane Wynne (356-6509)

MICROPALÉONTOLOGIE
Identification de fossiles - Bruce Cameron/ Marji Johns (356-6422)

LEVÉS SISMIQUES
Levés sismiques et structure - Kristen Rohr (356-6421)

TECTONIQUE DE LA COTE OUEST
Déformation de la meuge, programme de la lithosphère - Roy Hyndman (356-6428)