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Exploration and Geological Services Division, Yukon Region

BULLETIN 6

Geology of the McQuesten River Region, Northern McQuesten and Mayo Map Area, Yukon Territory (115P/14, 15, 16; 105M/13, 14)

Donald C. Murphy

with contributions from M. L. Bevier, D. Héon, J. A. Hunt, J. K. Mortensen, W. H. Poole and C. F. Roots

Canada

Canada/Yukon Economic Development Agreement
To strengthen and diversify the Yukon economy

Yukon
Economic Development

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Cover: View showing topographic grain following northeast-dipping bedding in Hyland Group in the eastern part of Sprague Creek and western part of Seattle Creek map areas. View to west from UTM 430905, 7087650 (115P/16).

Preface

This bulletin describes and synthesizes the geology of most of the region that Aho (1963) described as the McQuesten Mineral Belt. The economic promise of this region has been amply demonstrated since prospectors first arrived in the late 1880s. In 1898, placer gold was discovered in Duncan Creek. The initial discovery of lead and silver veins in the Elsa-Keno Hill camp was made in 1906, and silver, lead and zinc were produced almost continually between 1921 and 1988. Systematic geological mapping of the area was started by H. S. Bostock of the Geological Survey of Canada between 1938 and 1941; between then and 1972, the Keno Hill/Galena Hill area was studied intensively and a broader regional framework established. As it has been more than 20 years since the last major comprehensive study of this important region, an update is warranted.

The present study began in 1991 in conjunction with framework mapping of the Mayo map area by Dr. C. Roots of the Geological Survey of Canada, and continued between 1992 and 1995 as a separate field project. The work was funded by the Canada/Yukon Cooperation Agreement on Mineral Resource Development. Logistical support was provided by the Canada/Yukon Geoscience Office, a jointly managed project with the Department of Indian Affairs and Northern Development as scientific authority and the Yukon Department of Economic Development as administering agency.

This report includes a comprehensive description of the bedrock map units and the structural geology, and presents interpretations of the types of mineral occurrences found within this economically important part of Yukon. The findings resulting from this study with significant implications for mineral exploration are:

1. Identification of a previously unrecognized Cambrian sequence, which is potentially equivalent to the Anvil Mine sequence.
2. The Tombstone intrusions, with high potential for hosting low-grade, bulk tonnage gold deposits (Fort Knox-type), consistently have ages that fall within a very narrow range of 92±2 Ma.
3. The identification of the widespread potential for gold deposits in structurally and stratigraphically controlled zones near plutons (Brewery Creek-type).

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Préface

Le présent bulletin décrit et synthétise la géologie de la majeure partie de la région qu'Aho (1963) a dénommée «Ceinture minérale de McQuesten». Le caractère prometteur de cette région a été amplement mis en évidence depuis que des prospecteurs y sont arrivés pour la première fois à la fin des années 1880. En 1898, on a découvert de l'or placérien à Duncan Creek. La première découverte de filons plombifères et argentifères au camp d'Elsa-Keno Hill remonte à 1906; de l'argent, du plomb et du zinc ont été extraits presque sans interruption entre 1921 et 1988. H.S. Bostock, de la Commission géologique du Canada, a commencé entre 1938 et 1941 la cartographie géologique systématique de la région. Puis, jusqu'en 1972, la région de Keno Hill/Galena Hill a été l'objet de nombreuses études qui ont permis de définir un cadre régional plus vaste. Comme la dernière étude approfondie de cette importante région date de plus de vingt ans, une actualisation des connaissances s'impose.

L'étude dont il est rendu compte ici a débuté en 1991 dans le cadre des travaux de cartographie générale de la région de Mayo dirigés par C. Roots, de la Commission géologique du Canada; elle s'est poursuivie entre 1992 et 1995 à titre de projet distinct. Les travaux ont été financés par l'Entente de coopération Canada/Yukon sur l'exploitation minérale. Le soutien logistique a été fourni par le Bureau géoscientifique Canada/Yukon, projet géré conjointement avec le ministère des Affaires indiennes et du Nord canadien, qui agissait comme autorité scientifique, et avec le ministère du Développement économique du Yukon, qui en assurait l'administration.

Le présent rapport comporte une description détaillée des unités cartographiques du substratum rocheux et de la géologie structurale et expose les diverses interprétations des types de gîtes minéraux observés dans cette partie économiquement importante du Yukon. Cette étude a des implications importantes pour l'exploration minérale, notamment :

1. l'identification d'une séquence cambrienne jusqu'ici non reconnue, qui pourrait être corrélative de la séquence d'Anvil Mine;
2. une meilleure évaluation des intrusions de Tombstone, qui présentent des indices prometteurs de la présence de gisements aurifères à fort tonnage et à faible teneur (du type Fort-Knox) et dont les âges s'inscrivent systématiquement dans unintervalle très étroit (92 ± 2 Ma);
3. l'identification de nombreux indices favorables de la présence de gisements aurifères dans des zones à contrôle structural et stratigraphique à proximité des plutons (type Brewery-Creek).

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Abstract

The McQuesten River region in the northern part of the McQuesten and Mayo map areas (scale 1:250 000) is underlain by Upper Proterozoic to Mississippian rocks that were deposited in an offshelf setting during the formation of the northern Cordilleran continental margin, deformed during the Mesozoic, and intruded by pre- and post-kinematic intrusions. The Selwyn Basin phase of evolution of the continental margin is represented by ten rock units that correlate with units defined in the eastern part of Selwyn Basin, including the Yusezyu and Narchilla formations of the Upper Proterozoic-Lower Cambrian Hyland Group; a carbonate member of the Narchilla Formation; four members of the Lower to Middle (?) Cambrian Gull Lake Formation; the Upper Cambrian to Lower Ordovician Rabbitkettle Formation; and the Duo Lake and Steel formations of the Ordovician to Devonian Road River Group. Dark clastic and rare felsic metavolcanic rocks of the Devonian-Mississippian Earn Group unconformably overlie rocks of the Selwyn Basin phase and are overlain conformably by the Mississippian Keno Hill quartzite. Dark, fine-grained metaclastic rocks of unknown age locally overlie Keno Hill quartzite.

Four episodes of plutonism can be distinguished in the area, the earliest probably Early Paleozoic in age, another almost certainly mid-Triassic in age, and two phases of Cretaceous granitic magmatism. Early Paleozoic bodies are typically metre-scale, fine-grained diabasic dykes and sills intruding rocks of the Hyland Group. Mid-Triassic diorite to gabbro occurs in discontinuous pods of various sizes, primarily in the Tombstone Thrust sheet where they intrude Devonian and Mississippian rocks. The most voluminous and widespread granitic rocks are the early Late Cretaceous Tombstone intrusions (92 ± 2 Ma). Typical Tombstone intrusions are weakly porphyritic, medium-grained hornblende-biotite granite to granodiorite, but they range from syenite to granodiorite and are locally peraluminous. The latest episode of granitic magmatism, the 65 ± 3 Ma McQuesten intrusions, is not yet fully delineated but includes five stocks of peraluminous potassium feldspar megacrystic granite.

Paleozoic and Mesozoic structures occur in the region. The Sprague Creek Fault, a pre-Late Cambrian normal fault, is inferred from stratigraphic relationships. A possibly Jurassic phase of shortening is represented by west-northwest-trending, south-vergent folds that pre-date Jura-Cretaceous structures. The most pervasive and important phase of deformation is Jura-Cretaceous in age and kinematically complex. The Robert Service and Tombstone thrusts and Tombstone Strain Zone formed between the Late Jurassic and early Late Cretaceous during northward and northwestward displacement of more southerly hanging wall rocks.

The McQuesten River region has numerous mineral occurrences, a long history of mining and mineral exploration, and good potential for further discoveries. Known mineral deposit types include: 1) syngenetic stratabound barite mineralization in the Earn Group; 2) magmatic-hydrothermal veins; skarn replacement; country-rock-hosted veins, breccias, structurally controlled alteration zones and Elsa-Keno Hill vein-faults thought to be genetically associated with the Tombstone intrusions; 3) skarns, breccias and veins thought to be genetically associated with McQuesten intrusions; and 4) breccias of unknown age and association. Additional occurrences of these types are possible throughout the area. Furthermore, this study newly documents rock units in the McQuesten River region that are known to host syngenetic mineralization in other parts of Selwyn Basin, thereby establishing the potential for these kinds of deposits in the McQuesten River region. The Gull Lake Formation correlates with the rock units that host the Anvil District sedimentary exhalative deposits. The Duo Lake Formation hosts the Howards Pass sedimentary exhalative deposits of eastern Selwyn Basin. The felsic metavolcanic member of the Earn Group hosts the Marg volcanic-hosted massive sulphide deposit about 40 km northeast of the map area.

Résumé

La région de la rivière McQuesten, dans la partie nord des régions cartographiques de McQuesten et de Mayo (échelle de 1/250 000), repose sur des roches dont les âges s'échelonnent du Protérozoïque supérieur au Mississippien et qui se sont déposées dans un milieu océanique au cours de la formation de la partie nord de la marge continentale de la Cordillère; elles présentent des déformations mésozoïques et des intrusions antécinématiques et postcinématiques. La phase de l'évolution de la marge continentale qui est contemporaine de la formation du bassin de Selwyn est représentée par 10 unités lithostratigraphiques qui sont corrélées avec des unités définies dans la partie orientale du bassin de Selwyn, notamment les formations de Yusezyu et de Narchilla du Groupe de Hyland (Protérozoïque supérieur-Cambrien inférieur); un membre carbonaté de la Formation de Narchilla; quatre membres de la Formation de Gull Lake, qui s'échelonne du Cambrien inférieur au Cambrien moyen(?); la Formation de Rabbitkettle (Cambrien supérieur-Ordovicien inférieur); et les formations de Duo Lake et de Steel, du Groupe de Road River (Ordovicien-Dévonien). Des roches clastiques sombres et de rares roches métavolcaniques felsiques du Groupe d'Earn (Dévonien-Mississippien), reposent en discordance sur des roches de la phase contemporaine de la formation du bassin de Selwyn et sont recouverts en concordance par le quartzite mississippien de Keno Hill. Des roches métaclastiques sombres à grain fin et d'âge indéterminé recouvrent par endroits le quartzite de Keno Hill.

On distingue quatre épisodes de plutonisme dans la région; le plus ancien date vraisemblablement du Paléozoïque précoce et l'autre, presque certainement du Trias moyen. Suivent deux phases de magmatisme granitique crétacé. Les corps du Paléozoïque précoce sont généralement des dykes et filons-couches de diabase à grain fin d'échelle métrique recoupant des roches du Groupe de Hyland. Des roches de composition dioritique à gabbroïque du Trias moyen se présentent en amas fusiformes discontinus de tailles variées, surtout dans la nappe de charriage de Tombstone, où elles recoupent des roches dévoniennes et mississippiennes. Les roches granitiques les plus volumineuses et les plus répandues sont les intrusions de Tombstone, qui datent du début du Crétacé tardif (92±Ma). Les intrusions de Tombstone sont constituées le plus souvent de granites-granodiorites à hornblende-biotite à grain moyen faiblement porphyriques; cependant, elles couvrent tout l'éventail entre la syénite et le granodiorite et sont par endroits hyperalumineuses. Le dernier épisode de magmatisme granitique, celui des intrusions de McQuesten (65±3 Ma) n'est pas encore tout à fait délimité, mais il comprend cinq stocks de granite mégacristallin à feldspath potassique hyperalumineux.

On rencontre dans la région des structures paléozoïques et mésozoïques. La présence de la faille de Sprague Creek, une faille normale antérieure au Cambrien tardif, est inférée à partir des données stratigraphiques. Une phase de raccourcissement, qui pourrait dater du Jurassique, est représentée par des plis de direction ouest-nord-ouest à vergence sud antérieurs aux structures du Jurassique-Crétacé. La déformation la plus pénétrative et la plus importante remonte au Jurassique-Crétacé et est cinématiquement complexe. Les âges des chevauchements de Robert Service et de Tombstone et ceux de la zone déformée de Tombstone se situent entre le Jurassique tardif et le début du Crétacé tardif, période au cours de laquelle les roches du compartiment soulevé, plus au sud, ont subi des déplacements vers le nord et le nord-ouest.

La région de la rivière McQuesten renferme de nombreuses occurrences minérales. Elle est depuis longtemps le théâtre de travaux d'exploration et d'exploitation minière, et recèle un potentiel prometteur de futures découvertes. Parmi les types de gîtes minéraux connus figurent : 1) une minéralisation de barytine stratoïde syngénétique dans le Groupe d'Earn; 2) des filons magmatiques-hydrothermaux, des zones de remplacement par du skarn, des filons inclus dans la roche encaissante, des brèches, des zones d'altération contrôlées par la structure et les filons-failles d'Elsa-Keno Hill qu'on suppose génétiquement apparentés aux intrusions de Tombstone; 3) des skarns, des brèches et des filons auxquels on attribue une parenté génétique avec les intrusions de McQuesten; et 4) des brèches d'âge et de parenté inconnus. D'autres occurrences de ces types de minéralisations pourraient se rencontrer dans la région. Cette étude fait en outre état pour la première fois de la présence, dans la région de la rivière McQuesten, d'unités lithostratigraphiques dont on sait qu'elles renferment des minéralisations syngénétiques ailleurs dans le bassin de Selwyn; il s'ensuit que des gisements de ce type pourraient être présents dans la région de la rivière McQuesten. La Formation de Gull Lake est corrélée avec les unités lithostratigraphiques contenant les gisements exhalatifs sédimentaires du district d'Anvil. Les gisements exhalatifs sédimentaires de Howards Pass du bassin de Selwyn oriental sont inclus dans la Formation de Duo Lake. Enfin, le membre métavolcanique felsique du Groupe d'Earn renferme le gisement de sulfures massifs à roche encaissante volcanique de Marg, situé à une quarantaine de kilomètres au nord-est de la région cartographique.

Introduction

The western part of Yukon's Selwyn Basin* (Figure 1), centred on the McQuesten River watershed, is endowed with a complex geological foundation, an abundance and diversity of mineral occurrences, and high potential for the discovery of new deposits. The area has been explored for minerals since the 1885 discovery of fine gold in gravel bars of the Stewart River below the mouth of the McQuesten River (Bostock, 1964). Placer gold and lode silver were the early interests in the area following discoveries of gold in the late 1800s and silver in 1906. During the First and Second World Wars, tungsten was a strategic mineral and the area was explored for it, especially around felsic intrusions of known or presumed mid-Cretaceous age. During a period of elevated tin and tungsten prices in the 1970s and early 1980s, the area was re-examined for these minerals. Since the late 1980s, the same mid-Cretaceous intrusions have again been the focus of exploration, this time for low-grade, bulk-tonnage, gold deposits like Fort Knox near Fairbanks, Alaska. Most recently, the exploration focus has broadened to include structurally controlled replacement deposits (Carlin-like) peripheral to the intrusions (cf. Poulsen, 1996).

Unlike the eastern part of the basin, where a substantial amount of recent geological work has been done (Gordey and Anderson, 1993; Cecile, 1982, 1997; Abbott, 1983; Cecile and Abbott, 1992; Abbott et al. 1986; Gordey et al. 1987) and where the geological framework is relatively well understood, little work has been done recently in the western part of the region and consequently neither the distribution, age, structure and evolution of geological units nor the geological setting of mineral occurrences of this region are understood in detail. The western part of Selwyn Basin was therefore selected for geological mapping and related studies to be conducted under the 1991-1996 Canada/Yukon Economic Development Agreement (EDA). This report presents the

Selwyn Basin is used here in the geographical sense, comprising the area underlain by rocks that were deposited in an offshelf setting during the Late Proterozoic–mid-Paleozoic formation of the northern Cordilleran continental margin.

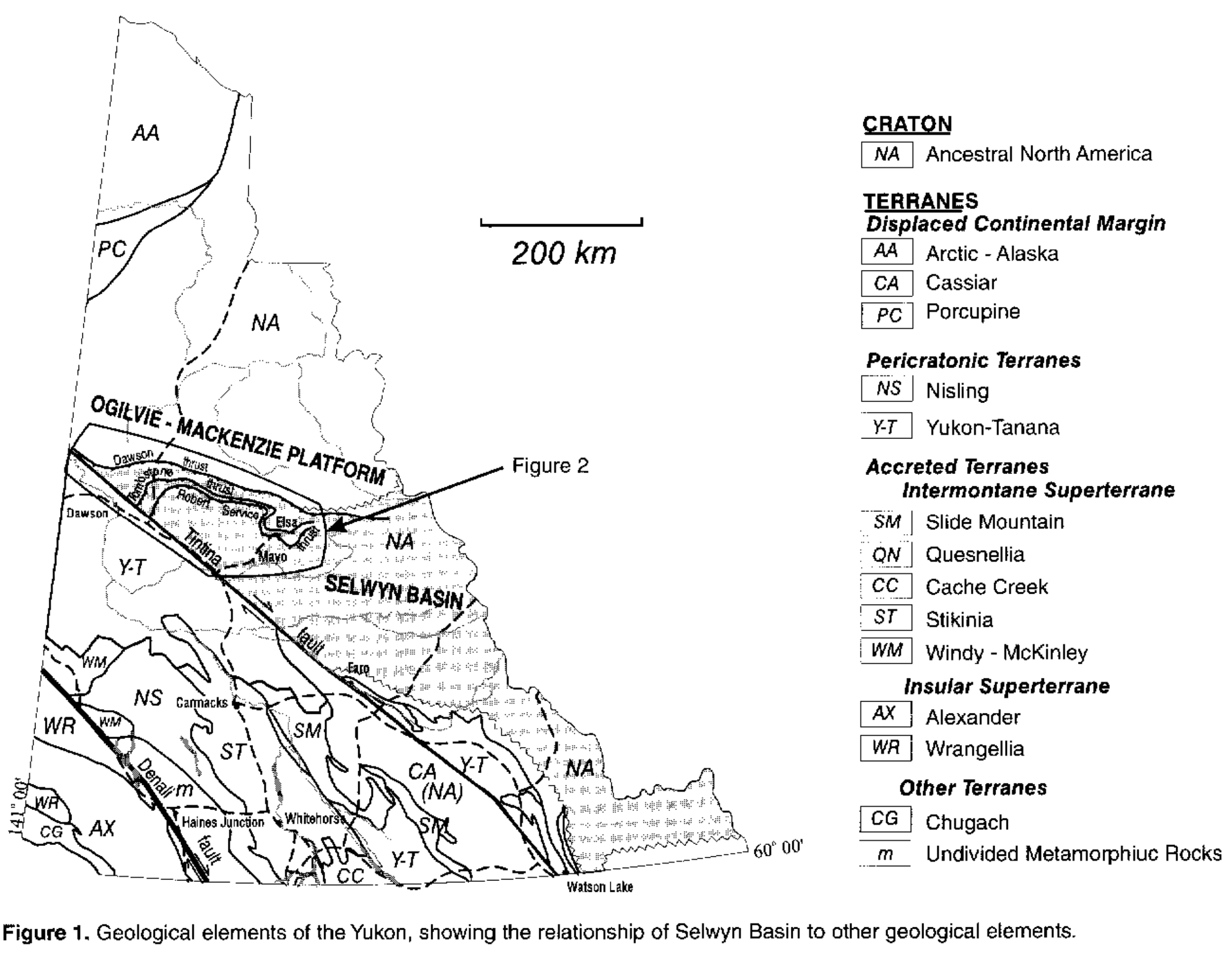
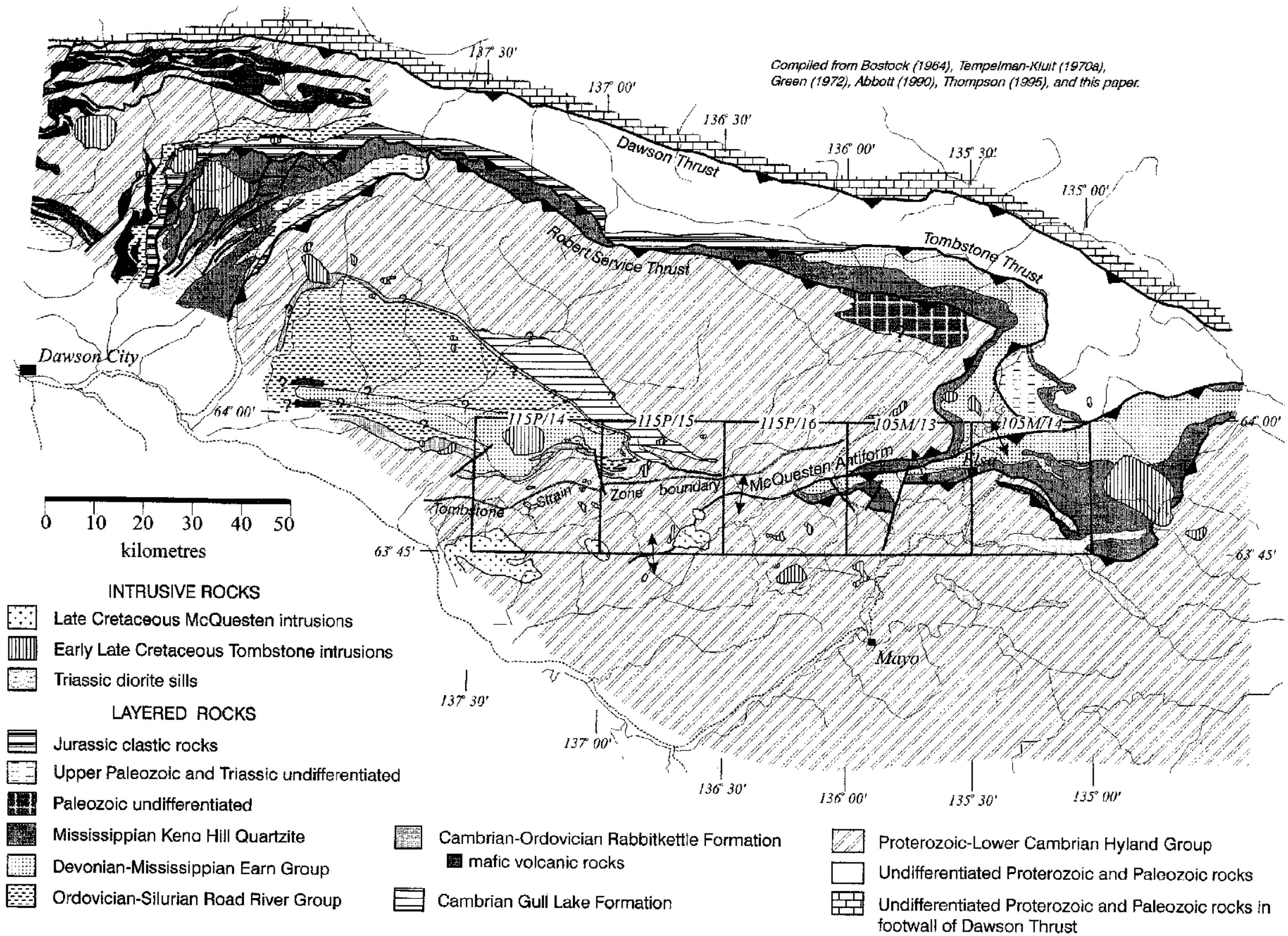


Figure 1. Geological elements of the Yukon, showing the relationship of Selwyn Basin to other geological elements.

Figure 2. Geological features of the western part of Selwyn Basin, showing locations of map areas.



results of four years of investigation of the area shown in Figure 2. Five new geological maps (scale 1:50 000) accompany this report (Geoscience Maps 1996-1 to 1996-5, in pocket) and together supercede interim open-file maps and reports (Murphy and Roots, 1992; Murphy et al. 1993a, b; Hunt et al. 1993; Murphy and Héon, 1994a, b; 1995a, b).

The field work for this report was done during the summers of 1991 to 1995. The 1991 field work in the Keno Hill (105M/14) and Mt. Haldane map areas (105M/13) was done in collaboration with Dr. Charlie Roots of the Geological Survey of Canada (GSC) as part of revision mapping of the Mayo map area (105M; scale 1:250 000). Subsequent field work in Clear Creek, Sprague Creek and Seattle Creek map areas was done by Danièle Héon and myself, with assistance in the Clear Creek map area from Julie Hunt. The Mt. Haldane map (105M/13) is a compilation by Julie Hunt of W. H. Poole's (GSC) 1964 field work, Roots and my 1991 field work, and 1992 field work by Hunt, Roots, Héon and myself.

Acknowledgements

Numerous people have played roles in my appreciation of the geology of central Yukon. Grant Abbott (Indian and Northern Affairs Canada and Canada/Yukon Geoscience Office), Steve Gordey (GSC) and Charlie Roots (GSC and Canada/Yukon Geoscience Office) generously shared their extensive knowledge, ideas and experience in Selwyn Basin geology. The regional geological framework established by the Geological Survey of Canada, in particular by Hugh Bostock, Lew Green, Jim Roddick and Dirk Tempelman-Kluit, provided a firm basis from which to undertake mapping at a scale of 1:50 000. Jim Mortensen (University of British Columbia: UBC) and Bob Anderson (GSC) generously shared their broad experience on the intrusive suites of the northern Cordillera. Anderson's various reports and Diane Emond's (Indian and Northern Affairs Canada) report on the intrusions of the McQuesten River region aided me tremendously in the analysis of the region's felsic intrusions. Danièle Héon's (Canada/Yukon Geoscience Office) participation in and contribution to all aspects of this project were greatly appreciated; in addition to contributing to the academic side of our project, her explorationist's experience, economic perspective, and attention to detail, ensured industry interest in the results of our work. Discussions with Jim Mortensen (UBC); Howard Poulsen (GSC); Al Doherty (Aurum Geological Consultants Inc.); Trevor Bremner (Indian and Northern Affairs Canada); Tom Heah, Roger Hulstein, and Eric Finlayson (all of Kennecott Canada); Jim McFaull (Yukon Revenue Mines Inc.); Rick Diment and Travis Adam (Loki Gold Corp.) and Mike Phillips (United Keno Hill Mines) have led to a more comprehensive appreciation of the region's mineralization. All of the new intrusive ages reported herein were determined by Jim Mortensen, M. L. Bevier (now at UBC; dating done while at the GSC), and staff at UBC's Geochronometry Laboratory, all of whose contributions are greatly appreciated.

Safe, efficient and uneventful flying services were provided by Trans North Air and Capital Helicopters. Special thanks go to pilots Will Thomson, Gene Lesage, Brian McPherson, Harman Keyser, and Dave Holden.

This report was greatly improved by the conscientious and insightful editorial efforts of Charlie Roots, who provided those efforts while immersed in writing his own report, and Linda Reynolds of Ampersand Editorial Associates Ltd., who did a rigorous final technical edit. Jay Timmerman provided valuable drafting, word processing and spreadsheet assistance during the final days of writing this report. Final layout and desktop publishing was done by Patricia Halladay Graphic Design.

Location and access

The maps accompanying this report encompass about 2800 square kilometres (km) of the central part of the Yukon Territory, in the region north of Mayo and east-southeast of Dawson City (Figures 1, 2). The area includes parts of the watersheds of the McQuesten, Little South Klondike and Stewart rivers. The area has no full-time inhabitants, although placer miners operate in several of the creeks during the summer. Much of the area is accessible by a network of summer roads built to service the numerous historical and currently operating placer and lode mines. Access to the western part of the region is by the Clear Creek road, which leaves the North Klondike Highway near Barlow Lake, about 70 km northwest of Stewart Crossing. Roads branching off the Clear Creek road provide good access to much of the Clear Creek map area (115P/14). Some of these continue as rough 'cat' tracks into parts of the Sprague Creek map area (115P/15). Road access to the Seattle Creek map area (115P/16) is via the Highet Creek and McQuesten River-Haggart Creek roads. The Highet Creek road leads to Sabbath and Johnson creeks, with branches to Scheelite Dome and Morrison and Seattle creeks. The McQuesten River-Haggart Creek road provides access to the South McQuesten River valley to the confluence with the North McQuesten River and leads to roads into Ross, Rodin, Goodman, and Secret creeks. The road to Elsa, the McQuesten River-Haggart Creek road and numerous side roads and 'cat' trails provide access to the Mt. Haldane and Keno Hill map areas (105M/13, 14).

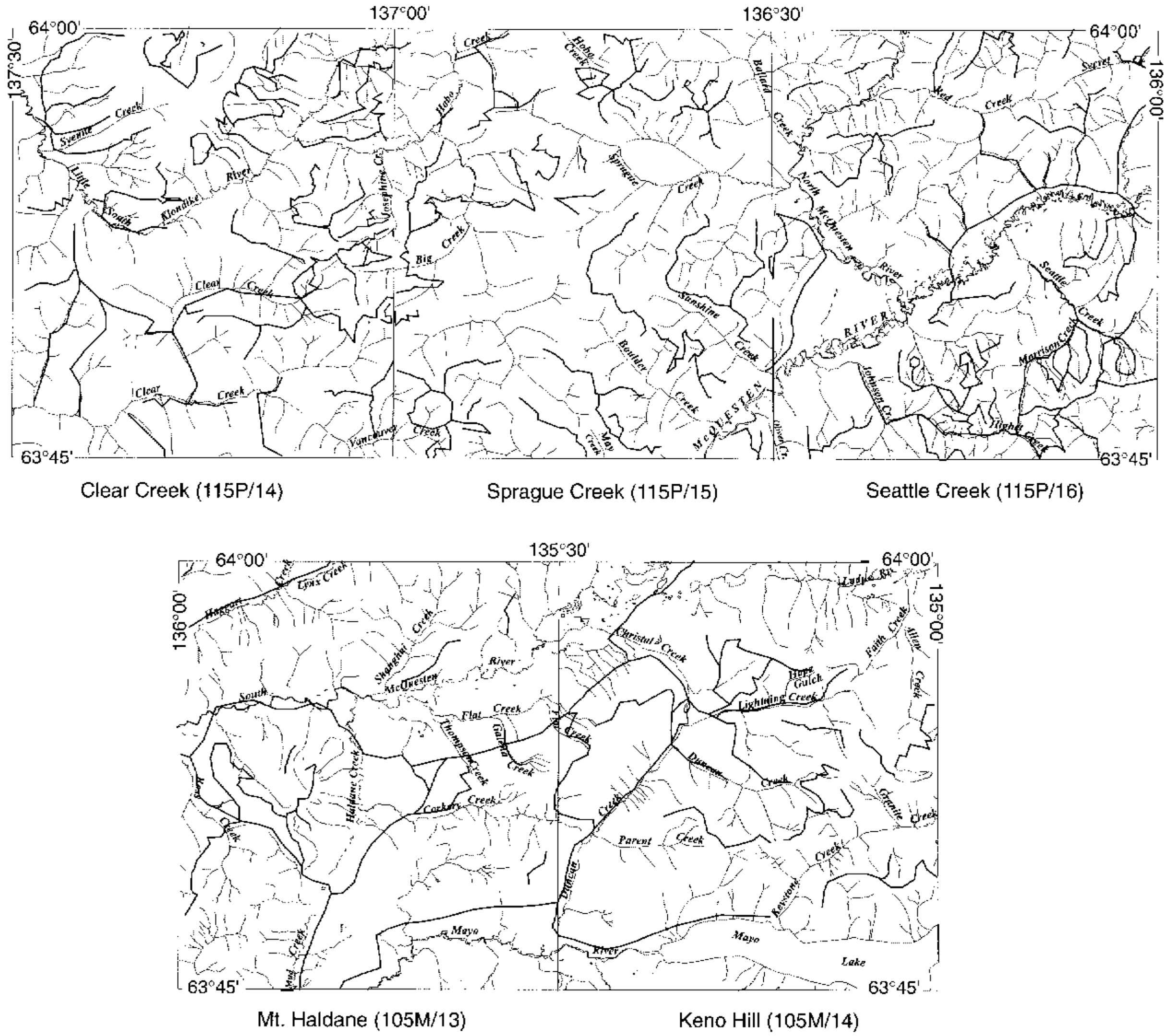


Figure 3. Locations of traverses along which the observations recorded in this report were made.

In spite of relatively good road access, most of the region is only accessible by helicopter. During the project, most bedrock outcrops were reached by foot from camps placed by helicopter (Figure 3). The closest base, although seasonal and subject to demand, is in Mayo.

Physiography and glaciation

The area lies in the northern part of the Stewart Plateau physiographic subdivision (Bostock, 1948a; Matthews, 1986). It is generally characterized by moderate elevations (2000 to over 6000 feet (610 to over 1829 metres) above sea level), moderate local relief, and little area above the 4000 to 5000 foot (1219-1524 metre) treeline. The northern part of the subdivision has variable topography with the broad rounded uplands more typical of the southern part of the subdivision being punctuated by alpine uplands, such as the Syenite Range, the East and West ridges, Scheelite Dome, Mt. Haldane and the Keno Hill-Galena Hill-Gustavus Range massif (Geoscience Maps 1996-1 to 1996-5, in pocket). Upland areas generally coincide with the resistant rock types: 1) felsic intrusions, 2) their associated hornfels zones, and 3) the Keno Hill quartzite.

Three major rivers cross the region: the South McQuesten River crosses the southeast corner of the Sprague Creek map area and cuts diagonally from southwest to northeast across the Seattle Creek, Mt. Haldane and Keno Hill map areas; the North McQuesten River crosses the northern half of the Seattle Creek map area from north to south; and the Little South Klondike River crosses the northern part of the Clear Creek map area and the eastern part of the Sprague Creek map area. Between the major drainages are networks of interconnected ridges dissected by second- and third-order drainages (e.g., East and West Ridge of the Sprague and Clear Creek map areas). Drainage patterns reflect a bedrock structural control with strong north-, northeast-, and northwest-trending grains in different parts of the region (Figure 4). The valley of the South McQuesten River hosts a fault associated with the McQuesten Antiform, one of the main structures controlling the distribution of rock units in the area.

Rock exposure varies throughout the region with little outcrop continuity except along ridgetops above the treeline and along the edges of some valley bottoms. Moderately well exposed areas with good continuous outcrop are the East and West ridges of the Clear Creek and Sprague Creek map areas, the Syenite Range of the Clear Creek map area, the upper reaches of the Sprague Creek map area, Scheelite Dome and the area north of Red Creek in the Seattle Creek map area, Mt. Haldane in the Mt. Haldane map area, and Keno Hill, Mt. Hinton, Galena Hill, and other alpine to subalpine areas of the Keno Hill map area.

The area lies inside the western limit of continental glaciation. At least one generation of glacial and periglacial deposits are locally preserved at elevations above the modern valley floors (Bostock, 1964; Morison, 1983a, b; 1985). Poorly consolidated sequences of sand, gravel, clay, and organic material are found in many of the creek valleys, some of which contain gold and various tin- and tungsten-bearing minerals.

Previous geological work

Since 1906, the McQuesten River region has been the focus of numerous geological studies by the Geological Survey of Canada (GSC). Most of this work occurred in the northern part of Mayo and southern part of Nash Creek map areas near the Elsa-Keno Hill silver camp and the Duncan and Haggart Creek placer gold camps. Early GSC reports and some maps are reprinted in Bostock (1957). The first systematic regional map (Upper McQuesten River, 1 inch to 4 miles) was published in 1943 (Bostock, 1943) and a preliminary map of Mayo map area soon followed (Bostock, 1947). Bostock (1948a) included some description of the physiography and glacial features of the northern Stewart Plateau. During the 1950s and 1960s, the next generation of regional geological mapping was undertaken, and systematic geochemical surveys were initiated. McTaggart (1950, 1960) published a geological map of the Elsa-Keno Hill mining camp. Preliminary geological maps of Mayo Lake, Scougale Creek, and McQuesten Lake map areas (scale 1:50 000) were published by Green (1957, 1958a, b, c). Green and McTaggart (1960) published a paper on the structure of the area around the Keno Hill mines. Kindle (1955, 1962) published a 1 inch to 1 mile geological map of Keno Hill map area. A comprehensive overview of the geology, geochemistry and mineralization of the Keno Hill-Galena Hill area was presented in Boyle (1965), synthesizing the large amount of information found in preceding reports (Boyle, 1955a,b, 1956, 1957, 1961, 1963, 1964; Boyle and Cragg, 1957; Boyle and Jambor, 1963; Jambor and Boyle, 1962; Boyle et al. 1955a, b, 1956). A report and sketch maps of Mt. Haldane and Dublin Gulch map areas were published by Poole (1965). Hughes et al. (1969) and Hughes (1982) reported on glaciation in the region. Systematic characterization of the geochemical environment in the map areas around the Elsa-Keno Hill mines appeared in Gleeson (1965; 1966a,b,c,d; 1967a,b,c,d, e; 1968a, b,c,d) and was interpreted in Boyle and Gleeson (1972) and Gleeson and Boyle (1976, 1977, 1978). Boyle et al. (1970a,b) and Tempelman-Kluit (1970b) discussed the sulphur isotope geochemistry

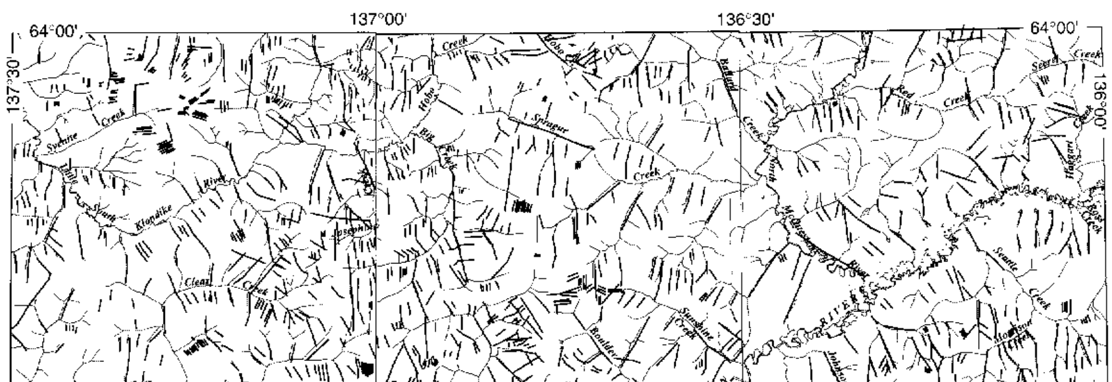


Figure 4. Topographic lineaments noted on air photos.

of Elsa-Keno Hill ore minerals. Little (1959) described some of the tungsten occurrences in the McQuesten River region. More recently, Tempelman-Kluit (1970a) and Green (1971) presented interpretations of the geology of the northern part of Mayo map area based on work in nearby areas. Systematic stream water and sediment geochemical surveys of Mayo and McQuesten map areas were completed in 1988 (Hornbrook and Friske, 1988; Friske and Hornbrook, 1988). Roots and Murphy (1992a), an open-file map of Mayo map area; Roots and Murphy (1992b), a short summary report; and Murphy and Roots (1992), a compilation of Keno Hill map area, are the latest contributions by the GSC in this area.

Numerous topical reports, such as university theses and reports, and journal articles, have been written on the Elsa-Keno Hill mine area. Johnston (1920), Smitheringale (1950), Johnston and Powelson (1951), Carmichael (1957), Aho (1963), Lemieux (1964), Franzen (1986), Watson (1986) and Lynch (1986, 1989a) reported on the geological and economic characteristics of the Elsa-Keno Hill mining area. Theses include: Kania (1926) on the silver-lead ores of the Mayo district, Bacon (1938) on glaciation in the Mayo district, Aho (1949) on the mineralogy of heavy minerals in the McQuesten River area, Wright (1951) on the geology of the Besner Milosovich property, Blackadar (1951) and Read (1957) on the mafic intrusions of the Elsa-Keno Hill mining camp, Arnold (1953) on the rock types of Keno Hill, Zajac (1957) on the No. 6 vein, Jambor (1957) on the ore mineralogy of the Calumet mine, Tempelman-Kluit (1964) on the geology around the Dublin Gulch and Haggart Creek silver and tungsten occurrences, Tessari (1979) on the lead isotopes and whole rock geochemistry of the Elsa-Keno Hill veins, and Lynch (1989b) on the hydrothermal zoning in the Elsa-Keno Hill camp. Thompson (1945) reported on cassiterite occurrences in the Dublin Gulch area. Sinclair et al. (1980) published K-Ar age determinations on the Keno Hill veins. Unpublished student reports on the mineralogy of ores from mineral occurrences or heavy mineral concentrates were done by Grove (1953), Coates (1960), Tempelman-Kluit (1962), and Armour-Brown (1963).

In contrast to the volume of work in and around the Elsa-Keno Hill and Haggart Creek mining areas, relatively little work has been done in neighbouring areas. A preliminary map of the neighbouring McQuesten map area was produced by Bostock (1948b) and the full colour A-series map appeared in 1964 (Bostock, 1964). Preliminary geological maps (scale 1:250 000) of Dawson, Larsen Creek and Nash Creek map areas were published by Green and Roddick (1962) followed by A-series maps and a report in 1972 (Green, 1972). Topical studies of different aspects of the geology of McQuesten map area include Steffler (1980) and Kuran et al. (1982) on the geology and geochronometry of the Scheelite Dome mineral occurrences; Emond (1985, 1986), Potter (1987), and Emond and Lynch (1992) on various aspects of vein, breccia, and skarn occurrences in the McQuesten River region; Abercrombie (1990) on the **Zeta** (Yukon MINFILE #115P 47; INAC, 1995) silver-tin greisen veins and the petrology, isotopic characteristics, and age of the Lost Horses syenite; and Emond (1992) on the igneous geochemistry and petrography of felsic intrusions in the McQuesten River region and relationship of igneous geochemistry to mineralization. Morison (1983a,b; 1985) mapped and described the surficial geology and sediments in the Clear Creek drainage basin. Many mineral assessment reports include geological observations. Some of these are summarized in Yukon MINFILE (INAC, 1995) and Yukon Exploration (e.g., INAC, 1989; 115P), periodically updated publications by Exploration and Geological Services, Yukon, Indian and Northern Affairs Canada.

Geological Framework

Historical overview and current understanding

Early representations of the bedrock geology of the McQuesten River region portrayed a lower regionally extensive tripartite sequence of deformed metasedimentary and metaigneous rocks and an upper succession of less highly deformed and lower grade sedimentary rock units (Bostock, 1943, 1947, 1948b, 1964; Boyle, 1965; Table 1). The lower sequence consists of a lower carbonaceous schist and quartzite unit (Lower schist formation of Boyle, 1965), a massive grey quartzite unit (Central quartzite formation of Boyle, 1965), both intruded by mafic intrusions, and an upper schist, quartzite, and rare limestone (Upper schist formation of Boyle, 1965). The occurrence of this simple stacking order over a large area led early workers to conclude that the lower sequence was a normal upright homoclinal stratigraphic sequence. They correlated this sequence with the Precambrian Yukon Group of Cairnes (1916) based on its metamorphic character and apparent lack of fossils. The upper schist passes upward into a thick sequence of quartzite, locally pebbly, and schist which, in McQuesten map area (115P), is overlain by lower grade Ordovician (?) or earlier quartzite and slate with red, green and purple slate and limestone intervals (Bostock, 1948b, 1964). In Bostock's earlier work (1948b), he noted that the next overlying unit, a carbonate and phyllite unit (Unit 8), overlies different rock units in different places and he inferred an unconformity at the base of Unit 8; this conclusion was omitted from his more recent work (Bostock, 1964). His youngest unit consists of a large thickness of slate, conglomerate, quartzite, and chert in which Paleozoic, possibly Ordovician, fossils were found.

New interpretations arose (Table 2) from the increase in knowledge obtained from the detailed mapping in the Keno Hill district and the development of the regional geological framework by the GSC, industry, academia and Indian and Northern Affairs Canada. McTaggart (1960) and Green and McTaggart (1960) presented evidence for isoclinal folding and low-angle faulting in the rock units of the Elsa-Keno Hill camp. On the basis of fossil discoveries, Green and Roddick (1962) suggested a Late Paleozoic age for the Lower Schist and a Late Paleozoic age or Mesozoic age for the Central quartz-

Table 1. Rock units shown in early maps of the McQuesten River region

Inferred age	Rock types	Mayo, McQuesten, Larsen Creek, Nash Creek (parts) (Boyle, 1965a)	Mayo (Bostock, 1947)	McQuesten (Bostock, 1964)
	Upper, less deformed succession			
Paleozoic	Slate, chert, conglomerate, sandstone		Unit 11 Unit 10 Unit 9 Unit 8	Unit 10 Unit 9
	Limestone			Unit 8
	Quartzite, quartz-mica "schist", pebbly quartzite, slate, limestone	Unit 6 Unit 5 Unit 4	Unit 7 Unit 6 Unit 5	Unit 7 Unit 6 Unit 4
	Lower, more deformed succession			
Precambrian	Quartz-mica "schist", graphitic schist, quartzite, limestone	Upper schist formation (Unit 3)	Unit 4	Unit 3
	Massive thick-"bedded" quartzite and graphitic "schist"	Central quartzite formation (Unit 2)	Unit 3	Unit 2
	Graphitic and quartz-mica "schist"	Lower schist formation (Unit 1)	Unit 2	

ite. Green and Roddick (1962), Tempelman-Kluit (1970a) and Green (1972) reported Jurassic fossils in shales that they correlated with shales beneath the Central quartzite (which was renamed the Keno Hill quartzite) in the Dawson map area, a correlation substantiated by later fossil discoveries (Poulton and Tempelman-Kluit, 1982). These fossils and the inferred stratigraphic contact with the overlying Keno Hill quartzite led these authors to propose a Jurassic age for the Lower Schist and a Cretaceous age for the Keno Hill quartzite. In contrast, Blusson (1978) proposed a Late Paleozoic age for the Lower Schist and Keno Hill quartzite based on lithological similarity to dated rocks at Macmillan Pass. The age of at least part of the Keno Hill quartzite was established when Mississippian (Viséan-Namurian) conodonts were recovered from samples of the formation in Dawson map area (Orchard, 1991; Mortensen and Thompson, 1990). Mortensen and Thompson (1990) reported a mid-Triassic radiometric age for mafic sills intruding the Keno Hill quartzite in Dawson map area. Similar mafic intrusions occur throughout the Lower Schist in the Elsa-Keno Hill mining camp indicating, according to Mortensen and Thompson (1990), that either 1) the Lower Schist is not everywhere Jurassic, as previously proposed; 2) contacts of the sills with the Lower Schist in the Elsa-Keno Hill mining camp are tectonic; or 3) sills of more than one age occur. Abbott (1990a,b) corre-lated much of the Lower Schist with the Devonian and Mississippian Earn Group. Green (1971) thought the Upper Schist to be Precambrian and correlated the overlying sequence of locally pebbly quartzite and schist ("grit division") with the Precambrian to Lower Cambrian "Grit unit" of Gabrielse et al. (1973). The stratigraphic significance of the Upper Schist was brought into question by Murphy and Roots (1992) and Roots and Murphy (1992a, b) who observed within the Upper Schist intimate interfoliation of highly foliated and lineated, gritty, metaclastic rocks identical to the grit division with equally deformed grey quartzite and phyllite considered to be Keno Hill quartzite. These authors re-interpreted the Upper Schist as a zone of infolding and imbrication of these two units. Tempelman-Kluit (1970a) and Green (1972) considered Bostock's youngest unit — the slate, chert, conglomerate and quartzite unit above the grit division — to be the Ordovician and Silurian Road River Group.

Table 2. Evolution of stratigraphic and structural interpretations applicable to the McQuesten River region

Bostock's map units **(1947)**; (1964)	Green (1971, 1972) Tempelman-Kluit (1970)			Mortensen and Thompson (1990)	Abbott (1990a) Gordey (1990a)	Roots and Murphy (1992)
	Inferred age	Map unit	Inferred age	Map unit	Map unit	Map unit
9, 10; 9, 10			Devonian			Earn Group
9; 9	Ordovician-Silurian	Road River Group	Ordovician-Silurian			Road River Group
N/A, 8						
8; N/A					Earn Group	Earn Group*
5, 6, 7; 4, 6, 7		Grit unit				
4; 3	Precambrian	Upper schist	Precambrian-Cambrian **Robert Service Thrust**		Hyland Group	Hyland Group and Gull Lake Formation
3; 2	Cretaceous	Keno Hill quartzite	Mississippian	Keno Hill quartzite **Tombstone Thrust**	Keno Hill quartzite	Keno Hill quartzite
2; N/A	Jurassic	Lower schist	Jurassic and older	Jurassic Lower Schist	Devonian Earn Group **Tombstone Thrust**	Devonian Earn Group

* in footwall of backfolded Robert Service Thrust

To account for the distribution of ages in the structural sequence, two thrust faults were required. Green and Roddick (1962), and Tempelman-Kluit (1970a) observed the upper thrust (originally called the North Fork Thrust by Tempelman-Kluit (1970); name later changed by Tempelman-Kluit to Robert Service Thrust, R. I. Thompson, pers. comm. 1996) at the base of the "grit division" in the Dawson map area and extended it to the Keno Hill area. Tempelman-Kluit (1970a) inferred a zone of décollement at the base of the Keno Hill quartzite in the Dawson map area, but this zone was not considered to indicate a major thrust fault until the Keno Hill quartzite was dated as Mississippian, which necessitated defining the Tombstone Thrust (Thompson et al. 1990; Anderson, 1987; Roots, 1988). Mortensen and Thompson (1990) extended the Tombstone Thrust to the east at the base of the Keno Hill quartzite. Abbott (1990a, b) suggested that the Tombstone Thrust lies not at the base of the Keno Hill quartzite in the Keno Hill district but at a dramatic strain decrement within the Lower Schist, at the base of what is now referred to as the Tombstone Strain Zone (Murphy and Héon, 1995a, b). Abbott (1990a, b) and Gordey (1990a, b) extended both the Robert Service and Tombstone thrusts to the western edge of Lansing map area and Murphy and Abbott (1995) speculated on their continuation eastward into the Macmillan Pass area.

A modern stratigraphic and tectonic framework for the northern Cordillera was established by 1967 (Gabrielse, 1967) and the framework of the region northeast of the Tintina Trench was subsequently updated by Tempelman-Kluit (1977a), Abbott et al. (1986), Gordey et al. (1987), Tempelman-Kluit (1979), Gabrielse and Yorath (1991), and Gordey and Anderson (1993). In the current view, the northern Cordilleran region northeast of the Tintina Trench evolved from Proterozoic to Early Mesozoic extension or transtension, rifting and formation of the Cordilleran continental margin prism, to Mesozoic and Early Cenozoic compression or transpression at an obliquely convergent plate margin, finally to a transcurrent or transtensional phase in the Eocene (summarized in Gabrielse and Yorath, 1991). The northern Cordilleran continental margin prism was deposited in three stages (summarized in Gordey and Anderson, 1993): 1) a Late Proterozoic to mid-Devonian stage in which the margin consisted of a proximal platform or shelf (Ogilvie-Mackenzie Platform) that faced westward and southward (modern frame of reference) into a deeper water basin (Selwyn Basin) across a structurally controlled facies transition. During this stage, sedimentation was punctuated by periods of uplift and erosion or nondeposition, which were considered to be manifestations of intermittent extension of the continental margin. In the Silurian and Devonian, Selwyn Basin passed westward across a facies transition into shallow-water carbonate and clastic rocks of Cassiar Platform (Tempelman-Kluit, 1977a,b); 2) a mid-Devonian to Early Mississippian stage of marine transgression across the pre-existing platform-basin transition, well into the continental interior. This period was characterized by widespread deposition of basinal fine- and coarse-grained clastic rocks, chert and local centres of mafic, and more rarely felsic, volcanism, very coarse-grained clastic rocks, and sedimentary exhalative mineralization. Sedimentation in the region was likely in a back arc setting relative to a Devono-Mississippian arc that formed on the pericratonic terranes along the western margin of North America (Rubin et al. 1990) and in a foreland setting relative to the Ellesmerian fold and thrust belt of Arctic Canada (Trettin, 1991); and 3) a mid-Mississippian to Late (?) Jurassic stage during which the region returned to widespread marine shelf sedimentation. Mafic plutonism occurred in the western part of the region during the mid-Triassic. From Early Jurassic onward, the region may have been in a relatively passive back arc setting behind a deformation front associated with obliquely convergent margin tectonics; rocks in a similar outer continental margin setting in the southern Canadian Cordillera were deformed during that time (Murphy, van der Heyden et al. 1995).

At some point in the Late Jurassic, the region succumbed to oblique convergence at the plate margin, becoming broadly positive as a consequence of folding, thrust and strike-slip faulting and associated ductile deformation, and felsic magmatism. Regional deformation, metamorphism and displacement on large thrust faults, such as the Robert Service and Tombstone thrusts, occurred in the Selwyn Fold Belt between the deposition of Upper Jurassic strata and the emplacement of 90-94 Ma felsic plutons (Tombstone intrusions). Displacement on thrust faults continued (episodically?) in the Mackenzie Fold Belt until after the deposition of Paleocene rocks (Aitken and Cook, 1974). Eocene and younger displacement in this part of the Northern Cordillera appears to have been confined to strike-slip and associated transtension on the Tintina Fault and discrete accommodation structures southeast of the Tintina Trench (Newberry, Solie et al. 1995).

The Proterozoic to Mississippian stratified rocks described in this study belong to: 1) the Upper Proterozoic to mid-Devonian Selwyn Basin tectonic element, 2) the mid-Devonian to Lower Mississippian

Earn Group, and 3) the lower part of the Mississippian to Jurassic shelf sequence. In the McQuesten River region, these rocks are imbricated by the Tombstone and Robert Service thrusts (Figures 1, 2, 5). The structurally highest Robert Service Thrust sheet in this region is composed of all the Upper Proterozoic to Mississippian formations of the Selwyn Basin. The underlying Tombstone Thrust sheet in this region comprises the Upper Devonian Earn Group (Abbott, 1990a, b), Mississippian Keno Hill quartzite, and mafic intrusions, some of which are known to be mid-Triassic (Mortensen and Thompson, 1990). Regionally, the Tombstone Thrust sheet overlies an immediate footwall ranging in age from Devonian (?) to Late Jurassic (Green and Roddick, 1962; Tempelman-Kluit, 1970a; Green, 1971; Poulton and Tempelman-Kluit, 1982; Abbott, 1990a, b). Throughout the McQuesten River region, all of the rocks in the Tombstone and the lower part of the Robert Service Thrust sheets are intensely foliated and lineated. This deformation zone, the Tombstone Strain Zone, is attributed to the partitioning of some of the displacement of the Tombstone Thrust sheet into strain in the lower part of the sheet (Murphy and Héon, 1995a, b).

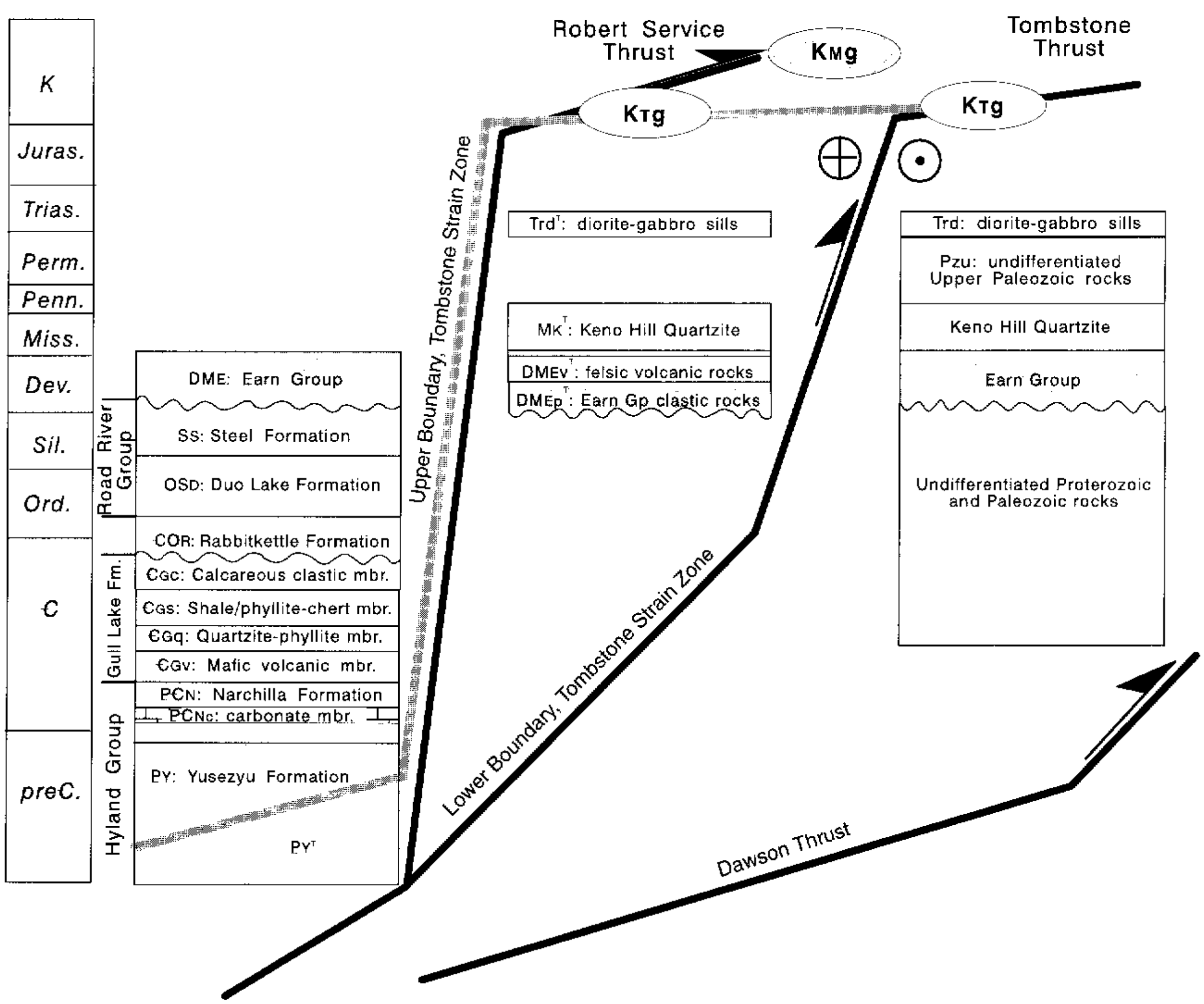
The region is part of the Selwyn Magmatic Province (Murphy, Mortensen et al. 1995) owing to the presence of numerous unfoliated felsic to intermediate intrusions. Two episodes of magmatic rocks have been identified, the Tombstone intrusions, consisting of metaluminous, locally alkalic bodies ranging in composition from granodiorite to syenite, and the McQuesten intrusions, comprising peraluminous biotite-muscovite granite and quartz monzonite. The former episode is part of the Tombstone-Tungsten Belt, a belt of coeval (broadly 92 ±2 Ma) intrusions that extends from the Tombstone Mountains east of Dawson eastward into the western Northwest Territories (Murphy, Mortensen et al. 1995). The latter set of intrusions, with 62-67 Ma U-Pb ages, has been identified only in a relatively small region north of the McQuesten River. Both episodes are post-kinematic with respect to the regional deformation associated with displacement on the Tombstone Thrust. The Tombstone intrusions have been transported on underlying Late Cretaceous and Early Tertiary thrusts that crop out in the Mackenzie Fold and Thrust Belt farther north and east; the McQuesten intrusions probably plug Late Cretaceous thrusts but might be transported on the youngest thrusts.

Stratigraphic Units

The stratigraphic sequence in the McQuesten River region is regionally folded, imbricated by thrust faults, metamorphosed, locally to lower greenschist facies, and bears to varying extents structural fabrics. Stratigraphic thicknesses cannot be measured in these rocks, primary sedimentological structures are rare, and fossils rare to nonexistent, so an exhaustive study of the individual rock units was not undertaken. Age, depositional environment and tectonic setting can only be considered by comparison with correlative rock units in areas where there is little or no structural and metamorphic overprint.

This study recognizes 16 nonfossiliferous and variably deformed and metamorphosed sedimentary and volcanic rock units (Figure 5), composing a total structural thickness of over 12 km. Of these rock units, 14 are distinguished using traditional stratigraphic criteria, e.g., rock type, bedding style and features, grain size and texture; these include the Yusezyu and Narchilla formations of the Hyland Group, a carbonate member of the Narchilla Formation, four map units of the Gull Lake Formation, the Rabbitkettle Formation, the Duo Lake and Steel formations of the Road River Group, an undifferentiated unit of the Earn Group, a felsic metavolcanic member at the top of the Earn Group, the Keno Hill quartzite, and an unnamed unit overlying the Keno Hill quartzite in northern Keno Hill map area. Two units are thought to be stratigraphically equivalent to other units in the map area, but are distinguished by well developed curviplanar foliation and lineation because of their positions in the Tombstone Strain Zone. Unit PY is thought to pass gradationally downward into its more highly strained equivalent, unit PY^{T}, across the strain zone boundary that extends across the region from east to west. Unit DMEp^{T} of the Tombstone Thrust sheet is correlated with the Earn Group of the Robert Service Thrust sheet.

Figure 5. Stratigraphic units of the McQuesten River region and their relationship with regional structures and intrusive episodes. Unit designators are as shown on Geoscience Maps 1996-1 to 1996-5 (in pocket). Map units with the superscripted 'T' are those found within the Tombstone Strain Zone. See text for details.



A systematic description of formations in Nahanni map area was recently published (Gordey and Anderson, 1993) providing a firm basis for correlation of offshelf Proterozoic and Paleozoic rocks of the northern Cordillera. Except for map units defined for their structural characteristics, almost all of the map units in the McQuesten River region can be found in Nahanni map area. Although no fossils have been found in the map area to substantiate correlation with map units in Nahanni map area, the formal unit names used in Nahanni map area will be used throughout this report.

Hyland Group

Variably deformed gritty metaclastic rocks underlying most of the study area are assigned to the Hyland Group (Gordey and Anderson, 1993). Four mappable units of the Hyland Group are recognized, two of which are distinguished on traditional lithostratigraphic grounds (Yusezyu Formation, PY, Narchilla Formation, PЄN, and a carbonate member of the Narchilla Formation, PЄNC). The third unit (PY^{T}) is the highly deformed equivalent of the Yusezyu Formation in the Tombstone Strain Zone.

Yusezyu Formation (map units PY *and* PY^{T}*)*

The Yusezyu Formation is a monotonous succession of variably deformed fine- to coarse-grained metaclastic rocks. It includes both well-bedded rocks, in the northern part of the map area, and compositionally similar but highly foliated and lineated metaclastic rocks, which lie structurally deeper to the south within the Tombstone Strain Zone. The boundary zone, which has been traced over 90 km across the study area, is narrow and considered to be gradational, although the high strain of the zone may mask an earlier discontinuity. All the characteristic rock types of the Yusezyu Formation outside the strain zone are represented within it, lending support to the interpretation that the transition is continuous and that rocks within the strain zone belong to that formation.

Above the Tombstone Strain Zone, the Yusezyu Formation comprises foliated green-grey to medium grey phyllite with laminations of metasiltstone; grey or brown to tan weathering, green-grey to grey-brown medium- to coarse-grained quartzose, subfeldspathic metasandstone and pebbly metasandstone (grit, Figure 6); similarly coloured metaconglomerate (Figure 7); and grey, and less commonly black and brown, sandy marble (Figure 8). Chalky white feldspar and grey-blue quartz grains and granules are common and characteristic of the coarser clastic rocks of this unit; in pebbly metasandstone and conglomerate, dark shale clasts are common. The sparse exposure limits accurate estimates of the relative proportions of the different rock types, but phyllite is likely most common, followed by metasandstone; metaconglomerate and calcareous rocks are least common. Marble is common at the top of the Yusezyu Formation. East of the North McQuesten River in the Seattle Creek map area, on the northern limb of the Lost Horses Syncline, the uppermost coarse clastic beds of the Yusezyu Formation are interbedded with grey and brown, locally sandy marble, the uppermost of which persist along strike for over seven km (Geoscience Map 1996-3).

Typically, the coarser clastic rocks are better exposed than other rock types, commonly forming isolated ledges or topographic benches (Figure 9). Grit or sandstone beds are typically massive to graded in the lower part and grade upward to the finer grained laminated upper part of the bed; more rarely the upper part will be crosslaminated. Basal contacts

Figure 6. Yusezyu Formation: channel composed of graded pebbly sandstone cutting into underlying pelitic phyllite. Truncations of metasiltstone laminae in underlying unit visible in upper left. Bedding is upright. Photo taken immediately above the Tombstone Strain Zone upper boundary (115P/14, UTM 391694, 7086882).

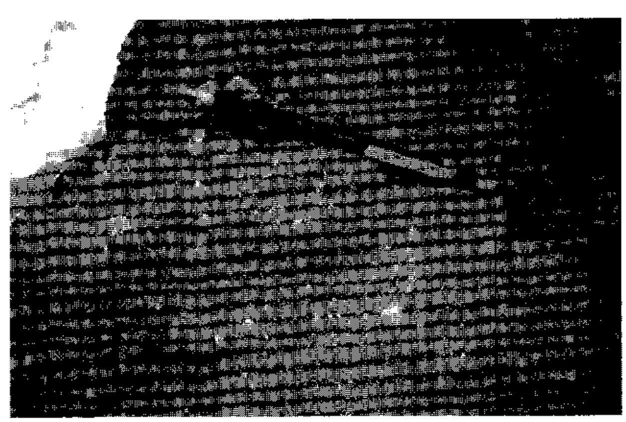


Figure 7. Yusezyu Formation: pebble conglomerate made up of pebbles of white quartz and chalky feldspar (115P/16, UTM 429375, 7094295).

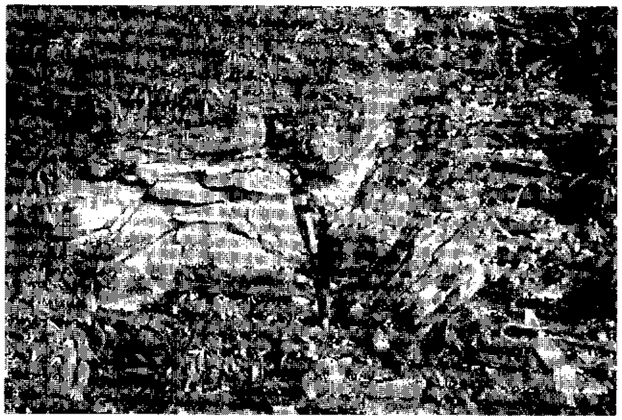


Figure 8. Yusezyu Formation: grey sandy marble in upper part of the formation (115P/16, UTM 434300, 7090700).

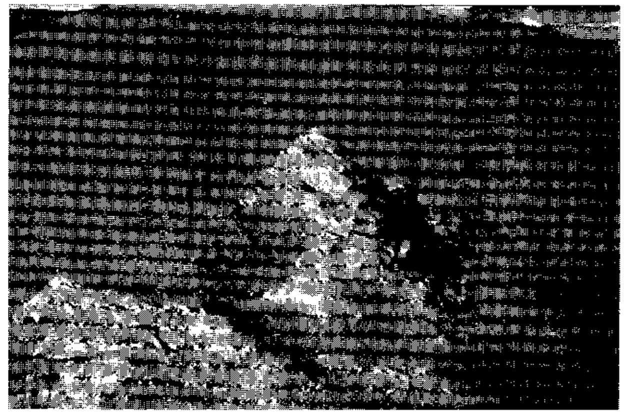


Figure 10. Yusezyu Formation: Metre-scale overturned bed of pebble conglomerate on inverted limb of Lost Horses syncline. Base of bed is planar surface dipping to left (north). (115P/16, UTM 437600, 7095900)

are typically sharp and locally show evidence of scouring. Upper contacts with shale beds are generally sharp, although in finer grained crosslaminated sandstones, transitional upper contacts occur locally. Coarser grained rocks are typically thicker bedded (metre-scale) and evidence of stacking of massive graded beds (amalgamation), such as lateral truncation of intervening thin shale beds, is common. Massive stacks of coarse-grained sandstone commonly contain shale clasts that were likely formed by scouring of intervening shale during deposition of the sand. Stacks of thick-bedded sandstones are not laterally continuous for any great distance, suggesting a lenticular or channel-form shape. Lateral and vertical variations in grain size and bed thickness extending beyond a few metres were not noted because of the generally poor quality of the exposure.

In areas of good exposure, clastic strata occur in finer-grained (shale or phyllite) and coarser-grained (metasandstone to metaconglomerate) intervals. Bed thicknesses are variable, although thicker beds (greater than 50 cm) are more common where grain size is coarser (Figure 10). No lateral or vertical trends were deduced because of lack of continuous exposure. Abundant graded bedding, channel scours (Figures 6, 11) and, more rarely, crossbedding, indicate that the section is upright on the southern limb of the Lost Horses Syncline and overturned to the southwest on the northern limb.

Within the Tombstone Strain Zone, the Yusezyu Formation (unit PY^{T}) comprises prominently foliated and lineated quartzofeldspathic and micaceous psammite (protolith: sandstone, Figure 12) and muscovite-chlorite (-biotite) phyllite (Figure 13). Less common, but locally important, are gritty or pebbly psammite (protolith: coarse grained or pebbly sandstone), metamorphosed pebble conglomerate, foliated phyllitic or sandy marble, (Figure 14) and calc-silicate rocks. Chalky white feldspar and grey-

Figure 9. View showing topographic grain following northeast-dipping bedding in Hyland Group in the eastern part of the Sprague Creek and western part of the Seattle Creek map areas. View to west from UTM 430905, 7087650, (115P/16).

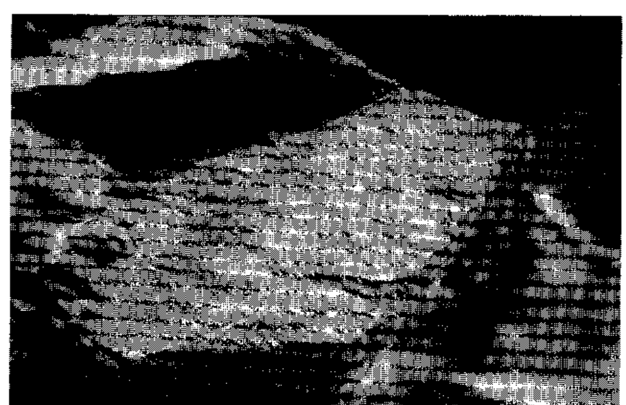


Figure 11. Yusezyu Formation: Graded (upright) bed of pebbly grit overlain by 2 cm-thick bed of phyllite. Indistinct plane lamination is visible immediately below phyllite bed at bottom of exposure (115P/16, UTM 427590, 7093240).

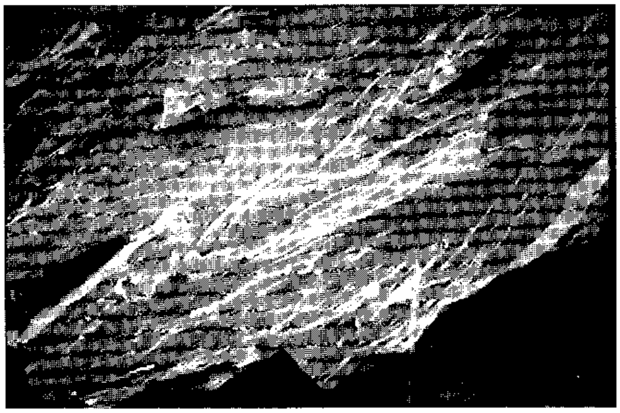


Figure 12. Yusezyu Formation, Tombstone Strain Zone: coarsely foliated to massive siliceous psammite (105M/14, UTM 483100, 7073300).

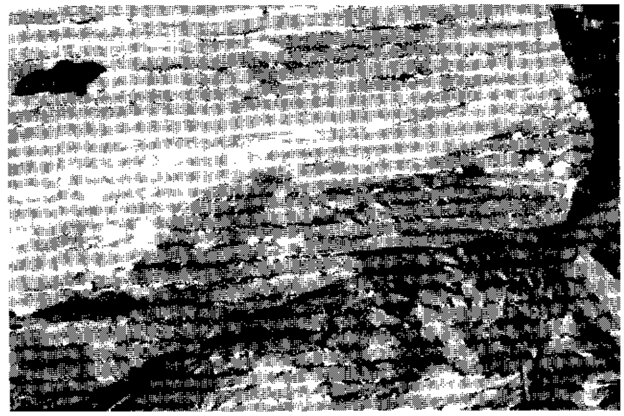


Figure 14. Yusezyu Formation, Tombstone Strain Zone: folded tan, sandy marble in carbonate-rich lower part of Yusezyu Formation (115P/15, UTM 404500, 7074905).

blue quartz grains are common in psammite and metaconglomerate. Sedimentary structures are rare, although graded bedding and channel scours have been observed in bedded rocks in the upper part of the strain zone, generally indicating upright stratigraphy. Strata that have been caught up in the Tombstone Strain Zone are compositionally transposed and do not show a simple alternation of laterally continuous bedded rock types (Figure 15). Bedding has asymmetrical boudinage structure, with psammite (metasandstone) passing both laterally and vertically into phyllite. Compositional domains are typically sigmoidal and bounded by zones of prominent foliation deflection that are interpreted as shear bands (Figures 15 and 16, see under Structural Geology).

The amounts of psammite, phyllite, and rocks of carbonate or calc-silicate composition in unit PY^T vary throughout the area, but because of structural and possibly stratigraphic complexity, mappable units cannot be subdivided at the 1:50 000 scale. Nevertheless, carbonate rocks are more common in the structurally, and possibly stratigraphically, deeper southern part of the map area than elsewhere. This carbonate-rich belt within the Yusezyu Formation extends from the Clear Creek map area in the west across Sprague Creek and into Seattle Creek map area, where it occurs just above the Robert Service Thrust (Murphy and Héon, 1994a, b; 1995a, b; Murphy et al. 1993a, b). The belt continues to the east into the Elsa-Keno Hill mining camp where numerous workers have noted the common occurrence of calcareous rocks in the Upper Schist unit above the Keno Hill quartzite (Bostock, 1947; Kindle, 1962; Boyle, 1965). Relatively well preserved oncolites occur in boudins of sandy dolomite west of Mt. Hinton, across the head of Duncan Creek (Figure 17, Geoscience Map 1996-5).

Yusezyu Formation throughout the map area is in the lower greenschist facies of regional metamorphism, characterized by the presence of fine-grained white mica (muscovite) and chlorite. Metamorphic

Figure 13. Yusezyu Formation, Tombstone Strain Zone: well foliated pelitic phyllite (115P/15, UTM 407410, 7072350).

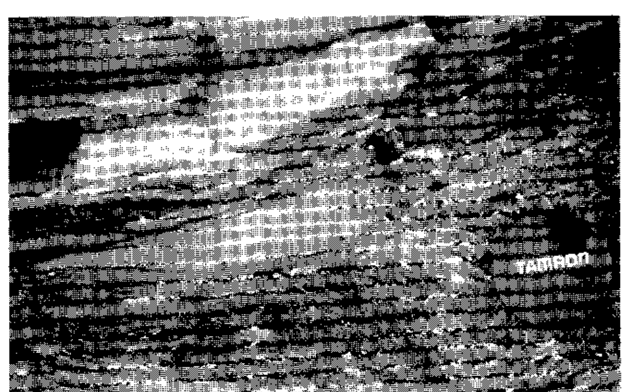


Figure 15. Yusezyu Formation, Tombstone Strain Zone: laterally discontinuous sigmoidal compositional domain typical of rocks caught up in the Tombstone Strain Zone (105M/15, UTM 495113, 7085875).

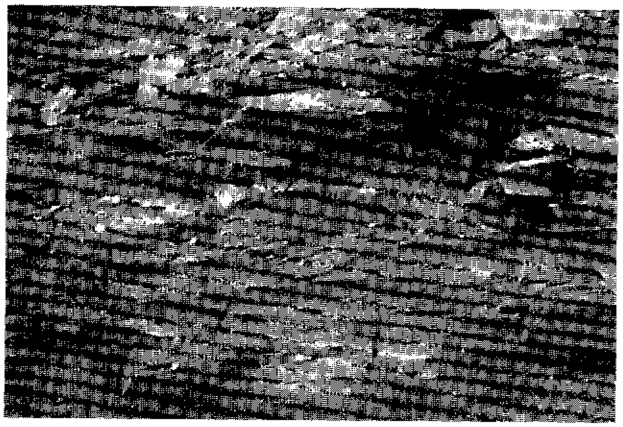


Figure 16. Yusezyu Formation, Tombstone Strain Zone: sigmoidal compositional domains (105M/14, UTM 491145, 7079120).

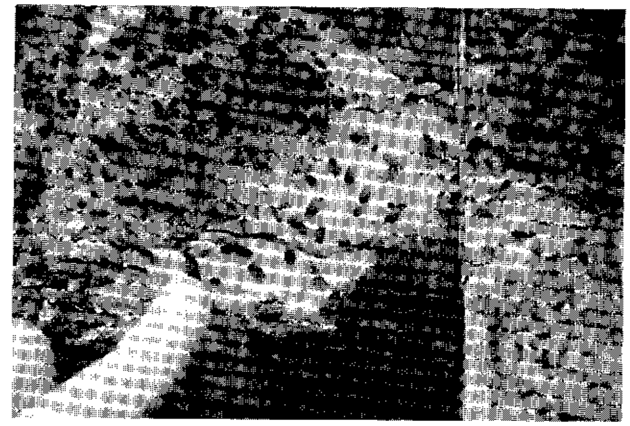


Figure 18. Yusezyu Formation, Tombstone Strain Zone: randomly oriented chloritoid porphyroblasts developed in the hornfels zone around the Late Cretaceous Vancouver Creek stock (115P/14, UTM 400028, 7074557).

grade is sub-greenschist at higher stratigraphic levels above the Tombstone Strain Zone. Near felsic intrusions, pelitic rocks are metamorphosed to cherty reddish to dark maroon biotite hornfels, and biotite, andalusite, sillimanite, cordierite, staurolite, and chloritoid occur locally within the thermal aureoles (Figures 18, 19). Rocks of calc-silicate composition become massive or banded quartz-actinolite-epidote-diopside (±garnet, axinite) calc-silicate hornfels or skarn.

The base of the Yusezyu Formation in the McQuesten River region is structural. The formation overlies the Mississippian Keno Hill quartzite along the Robert Service Thrust. The conformable stratigraphic contact with the overlying Narchilla Formation, crossed on traverses east of the North McQuesten River in the west-central part of Seattle Creek map area, is placed at the top of the relatively thick, relatively persistent limestone noted in that area, which coincides with the first appearance of the variegated phyllite of the Narchilla Formation. Elsewhere in the study area, on the southern upright limb of the Lost Horses Syncline, the Yusezyu Formation is overlain by a regionally persistent carbonate unit that has been correlated with the Upper Cambrian and Ordovician Rabbitkettle Formation (see under Rabbitkettle Formation). This contact is likely an unconformity based on the observation that this same carbonate unit overlies different rocks in the core and northern limb of the Lost Horses Syncline. The five stratigraphic units that overlie the Yusezyu Formation in the hinge and in the northern limb of the Lost Horses Syncline are missing where the Rabbitkettle Formation lies on the Yusezyu Formation in the southern limb of the syncline. This is the same unconformity that Bostock (1948b) noted in his preliminary map of the McQuesten map area.

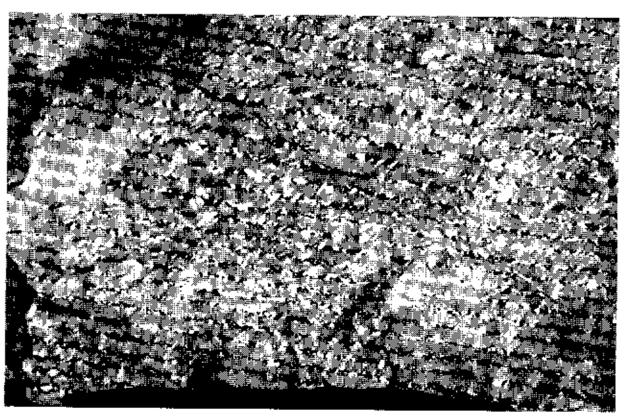


Figure 17. Yusezyu Formation, Tombstone Strain Zone: oncolites in dolomitic marble boudins in the lowest part of the Yusezyu Formation immediately above the Robert Service Thrust near Mt. Hinton (105M/14, UTM 491675, 7080800).

Figure 19. Yusezyu Formation, Tombstone Strain Zone: randomly oriented prismatic porphyroblasts (sillimanite?) developed in the hornfels zone around the Josephine stocks, along Josephine Creek (115P/14, UTM 399689, 7084576).

Local extent and thickness

The Yusezyu Formation underlies most of the southern part of the study area and extends out of the study area to the west, northwest, south and east. A stratigraphic thickness for the Yusezyu Formation has not been measured because of its state of strain. A structural thickness of at least seven km of Yusezyu Formation occurs beneath the Narchilla Formation on the overturned northern limb of the Lost Horses Syncline (section A-B-C, Geoscience Map 1996-3), above the Tombstone Strain Zone. On the southern limb of the Lost Horses Syncline, about one km of Yusezyu Formation occurs between the Rabbitkettle Formation and the top of the Tombstone Strain Zone. At least 4 km of highly deformed Yusezyu Formation occurs within the Tombstone Strain Zone.

Age

There are no direct constraints on the age of the Yusezyu Formation in the McQuesten River region. The formation is thought to be Upper Proterozoic on the basis of primitive trace fossils found in sections of the formation in Nahanni map area (Fritz et al. 1983; Gordey and Anderson, 1993; Fritz et al. 1991).

Narchilla Formation (?; map units P€N, P€NC*)*

Part of the northern Sprague Creek map area (115P/15) and the northwestern part of the Seattle Creek map area (115P/16) are underlain by a succession of metaclastic rocks differing from the Yusezyu Formation only in that they are interbedded with variegated phyllite. This unit, provisionally correlated with the Narchilla Formation of Gordey and Anderson (1993), comprises medium- to thick-bedded quartzofeldspathic metasandstone, green and green-grey phyllite, purple and maroon phyllite, pebbly metasandstone and metaconglomerate, and sandy limestone and limestone breccia. Metasandstone and gritty metasandstone are identical to the metasandstone of the underlying Yusezyu Formation (Figure 20), locally characterized by grading and plane lamination and less commonly by crosslamination. Synsedimentary shale clasts are common in coarser strata. Variegated phyllite units are made primarily of maroon phyllite with lesser green phyllite, both with buff to light green, centimetre-scale, fine sandstone and siltstone laminae. The siltstone laminae have light green to olive green selvages symmetrically disposed around them (Figures 21, 22). This pattern suggests that siltstone laminae hosted relatively more reduced fluids than phyllite during or after diagenesis.

A member of sandy white-, grey-, and tan-weathering limestone (Figure 23), coarse limestone-clast intraformational breccia (Figure 24) and lesser sandstone and phyllite occurs in the middle of the Narchilla Formation (map unit P€NC). Sandstone of this member consists of distinctive crosslaminated decimetre-scale beds of reddish white calcareous quartz sandstone (Figure 25). Variegated phyllite is interbedded throughout.

Except for variegated phyllite, most of the rock types found in the Narchilla Formation are present in the underlying Yusezyu Formation (compare Figures 10 and 20). For that reason, the base of the unit is located at the first appearance of variegated phyllite, which occurs just above the only relatively thick and persistent limestone beds in the monotonously interbedded coarse clastic rocks of the Yusezyu Formation. The contact with variegated rocks is not well exposed generally so it is not known if it is marked by limestone elsewhere in the region. The formation is overlain conformably (?) by mafic volcanic and volcaniclastic rocks of the Gull Lake Formation. The contact is well constrained in the first prominent saddle along the ridge southwest of

Figure 20. Narchilla Formation: thick-bedded, massive, graded, coarse-grained sandstone and pebbly sandstone and lesser interbedded greenish pelitic phyllite with thin grey siltstone laminae. Red Mountain in background (115P/15, UTM 417350, 7094550).

Figure 21. Narchilla Formation: light red, pelitic phyllite with millimetre- to centimetre-scale, pale green, siltstone laminae (115P/15, UTM 416720, 7094310).

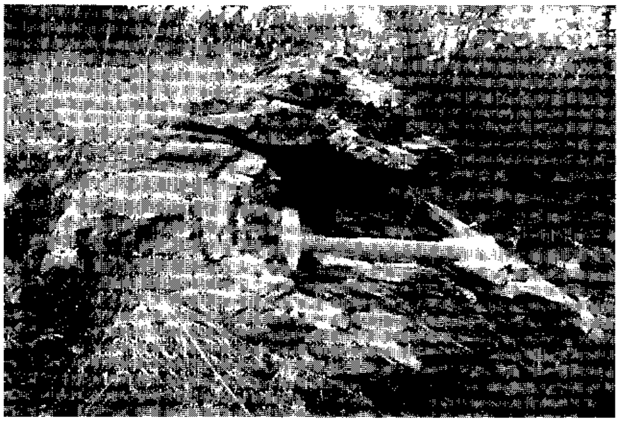


Figure 22. Narchilla Formation: folded variegated phyllite (core), whitish calcareous sandstone and greenish grey, pre-kinematic intermediate to mafic sill (left) (115P/16, UTM 432200, 7090900).

Red Mountain (north-central Sprague Creek map area, 115P/15) and in Hobo Creek (northern boundary of the Sprague Creek map area, Geoscience Map 1996-2).

Local extent and thickness

Although the Yusezyu Formation occurs throughout the McQuesten River region, the Narchilla Formation only occurs in this region in a fault block preserved beneath the unconformity thought to underlie the Rabbitkettle Formation (see under Rabbitkettle Formation). On the southern limb of the Lost Horses Syncline, west of the study area, the unit re-emerges from beneath this unconformity where Bostock (1964) traced it almost to the Tintina Fault; its northward and northwestward continuation has yet to be defined. Poole (1965) described variegated phyllite north of the East McQuesten River (part of his unit Qsl), about 25 km north of Mt. Haldane map area (105M/13). A structural thickness of over 3 km, determined from cross-section, occurs in the McQuesten River region.

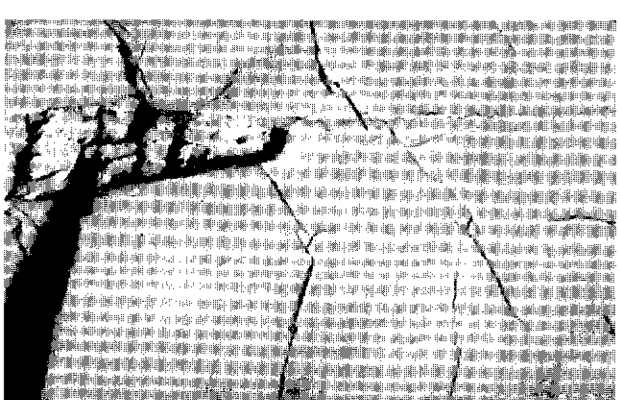


Figure 23. Narchilla Formation: beige-weathering grey sandy stylolitic limestone of the central carbonate member of the formation (115P/15, UTM 422230, 7093000).

Figure 24. Narchilla Formation: grey limestone-pebble intraformational breccia in the carbonate member of the formation (115P/15, UTM 427555, 7093455).

Age

No fossils have been found in the Narchilla Formation unit in the McQuesten River region. At its type section, it is Late Proterozoic to Early Cambrian in age (Gordey and Anderson, 1993). Fritz et al. (1983) reported Upper Proterozoic trace fossils in the basal part of the Narchilla Formation, and the Lower Cambrian trace fossil *Oldhamia* has been reported from maroon shales thought to correlate with the Narchilla Formation (Hofmann and Cecile, 1981; Hofmann et al. 1994; Mustard et al. 1988; Gordey and Anderson, 1993; Abbott and Roots, 1993a, b). In the Niddery Lake map area, the formation is overlain by a conglomerate in which some clasts contain Early Cambrian *archaeocyathids* (Cecile and Abbott, 1992; Cecile, 1997). Fritz (1982) and Fritz et al. (1991) placed an upper age limit of early Early Cambrian (Placentian) for the Narchilla Formation on the basis of its direct correlation with the Vampire Formation (see under Northern Belt).

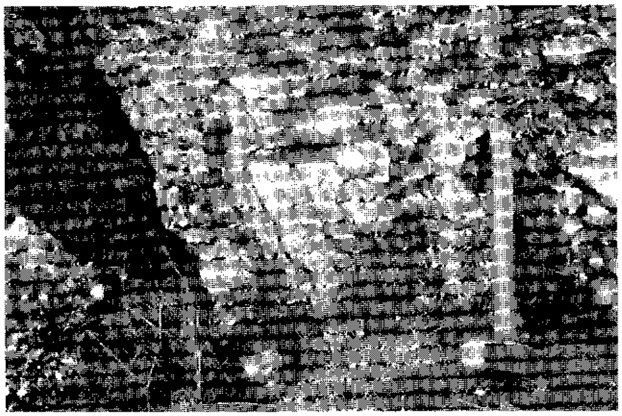


Figure 25. Narchilla Formation, carbonate member: decimetre-scale whitish-red calcareous quartz sandstone beds with thinner interbedded reddish phyllite (115P/15, UTM 438310, 7097350).

The Hyland Group in other areas

Upper Proterozoic to Lower Cambrian gritty quartzose clastic rocks and maroon and green shales of the Hyland Group occur widely throughout Selwyn Basin, from the Tintina Fault in Dawson map area eastward and southward to the British Columbia-Yukon border (Wheeler and McFeely, 1991). These strata occur in two belts, a southern belt in the Robert Service Thrust sheet and a northern belt partly in the Dawson Thrust sheet and partly north of the Dawson Thrust. The Hyland Group in the Robert Service Thrust sheet extends in a continuous belt eastward from the southeastern part of Dawson map area, underlying large parts of Larsen Creek (116A), Nash Creek (106D), McQuesten (115P), Mayo (105M), Lansing (105N), and smaller parts of Sheldon Lake (105J) and Nahanni (105I) map areas. The belt continues southeastward from Nahanni map area through Frances Lake (105H), Flat River (95E), and Coal River (95D). The northern belt extends eastward from the Tintina Fault in Dawson map area to northern Niddery Lake map area and then north into Bonnet Plume (106B) and Nadaleen (106C) map areas.

Lithologically similar rocks also occur in northern Yukon and northeastern Alaska (Neroukpuk Formation, Lane et al. (1995), and in central Alaska north of Fairbanks (Wickersham unit, Weber et al. 1992). Although the central Alaska occurrence is probably the westward continuation of Selwyn Basin offset along the Tintina Fault (Murphy and Abbott, 1995), it will not be discussed here.

Southern belt

The Hyland Group's type area is in the southern outcrop belt, in Nahanni map area (Gordey and Anderson, 1993). In that area, the Yusezyu Formation consists of over 3 km (base not observed) of monotonously interbedded quartz sandstone, grit and shale with less common quartz-pebble conglomerate and limestone. A thin, discontinuous, limestone member occurs at the top of the formation. Sandstones are generally massive, commonly graded, locally parallel-laminated at the tops of beds and moderately well sorted. The Narchilla Formation at its type section is composed primarily of *Oldhamia*-bearing dark blue-grey and pale green laminated slate with a middle orange-weathering quartz sandstone member (Gordey and Anderson, 1993). To the southwest and northwest of the type section, the formation exhibits its more 'typical' variegated maroon and green colours. In its type area, the Narchilla Formation passes laterally into the coeval siltstone and fine-grained quartz sandstone of the Vampire Formation. The Vampire Formation is overlain by rocks containing the early Lower Cambrian fossil *Parafallotaspis grata* Fritz (Fritz, 1982).

The Hyland Group continues as two distinct formations to the northwest across Sheldon Lake and Tay River map areas (Gordey and Irwin, 1987). The Narchilla Formation in these two map areas includes beds of medium- to thick-bedded quartz sandstone and quartz-pebble conglomerate. Further northwest in the southern belt, in the southeastern part of Lansing map area, the Hyland Group is somewhat different than in the type area. The limestone member at the top of the Yusezyu Formation is sufficiently thick and continuous to be elevated to formation status and, following Cecile (1997), Roots et al. (1995b) mapped it as the Algae Lake Formation. The underlying Yusezyu Formation generally consists of grit and metasandstone with interbeds of green or brown metasiltstone or phyllitic mudstone and less commonly limestone and maroon argillite (Roots and Brent, 1994a, b, c; Roots et al. 1995a, b). Locally, the unit is finer grained, more thinly bedded, and contains chloritic siltstone and sandstone and carbonaceous mudstone members. Roots et al. (1995a, b) noted that the Yusezyu Formation in the southeastern part of the Lansing map area becomes increasingly more highly strained (in the Tombstone Strain Zone?) at deeper structural levels to the southwest; and the rocks were described as quartz-muscovite schist with minor chlorite schist and quartz-feldspar gritty schist. The Narchilla Formation in the southeastern part of Lansing map area also differs from the type area by being composed of a lower member of grit and sandstone in fining- and thinning-upward sequences interbedded with three 10-m-thick beds of maroon argillite (Senoah Member, following Cecile, 1997), and an upper member of maroon, brown, black and green argillite and siltstone with lesser laminated quartz sandstone (Arrowhead Lake Member, following Cecile, 1997; Roots et al. 1995a, b).

Farther west in the southern belt, in Mayo map area, the Yusezyu Formation consists of metasandstone, phyllite, gritty phyllite and less commonly limestone (marble) and conglomerate; the formation also becomes more highly strained structurally downward to the north. A black slate member occurs near the structural base of the formation across much of northern Mayo map area (Unit 1b of Green, 1971; Roots and Murphy, 1992b; Roots, 1997) and chloritic siltstone occurs locally. In less highly strained sections, primary sedimentary structures, such as graded bedding, festoon and ripple crosslaminations, load casts, channel scours and mudstone rip-ups are common. The Narchilla Formation in this area is characterized by maroon argillite with lesser khaki and grey argillite and quartz sandstone (Roots, 1997).

Except for this study, which covers only a small part of the region, the Hyland Group at the western end of the southern outcrop belt has not been examined in detail. Bostock (1964) mapped units of varicoloured slate (unit 7) and phyllite above sandstones and gritty sandstone (unit 6, lower part). Green (1972) described maroon shale as part of his grit unit (unit 3) but did not map it as a separate unit.

Northern belt

The Hyland Group in the northern outcrop belt was described by Green (1972, unit 3), Thompson et al. (1992), Thompson (1995), Roots et al. (1995a, b), Roots and Brent (1994a), Cecile and Abbott (1992) and Cecile (1997). In the northeastern part of Niddery Lake map area, northwest of the group's type area, the Hyland Group consists of the same two formations as in the type area, but additional members are also recognized. In this area, the Yusezyu Formation consists of sandstone, grit and shale; shale in the upper part is variegated and locally thick and continuous enough to map as a separate unit (unit Hma of Cecile and Abbott, 1992). A thick, continuous limestone at the top of the Yusezyu Formation, which correlates with Gordey and Anderson's (1993) limestone member, was mapped separately as the Algae Lake Formation (Cecile and Abbott, 1992; Cecile, 1997). The Narchilla Formation was subdivided into two members, the lower Senoah Member composed mainly of grey-black shale, siltstone, quartzite and minor gritty quartzite and limestone, and an upper *Oldhamia*-bearing Arrowhead Lake Member made up of maroon and green argillite (Cecile, 1997).

The three prominent divisions of the Hyland Group, the lower sandstone and grit sequence, middle limestone and the upper variegated shale continue westward to the Tintina Fault. Cecile's (1997) Hyland Group subdivisions continue westward into the Surveys and Tasin ranges in northern Lansing map area (Roots and Brent, 1994a, b; Roots et al. 1995a, b). In this area, the top of the Narchilla Formation contains mafic flows. The Yusezyu Formation consists primarily of thin- to medium-bedded limy quartzarenite with wavy bedding or cross-stratification and interbedded mudstone. Grit is a relatively minor constituent in this area in contrast to the Hyland Group in the southern outcrop belt in Lansing map area. In the Hart River area of Nash Creek map area, Abbott (1993) and Abbott and Roots (1992, 1993a, b) described a basal unit of quartzo-feldspathic grit, quartz sandstone and dark grey, maroon and green shale passing upward into an upper unit of *Oldhamia*-bearing maroon and green shale through a transition that included at least two bands of brown-weathering sandy limestone, black fetid limestone and chert. In Dawson map area, *Oldhamia*-bearing maroon, green and grey argillite with lesser chert, sandstone and grit overlies a generally thin and discontinous but locally thick and continuous white-weathering grey limestone at the top of over 1 km (base not observed) of sandstone, gritty sandstone, siltstone and shale (Thompson and Roots, 1982; Thompson et al. 1992; Thompson, 1995). Within 100 m of the base of the limestone member the sequence becomes shale rich, and a distinctive unit of pale green chert occurs.

Comparison with other areas

The Hyland Group of the McQuesten River region differs somewhat from other areas, so the formation assignments are tentative. The Narchilla Formation in the McQuesten River region resembles the type area in that variegated shale occurs above relatively thick, relatively continuous limestone bands in the Yusezyu Formation; however, it differs in that shale is not the predominant rock type. The variegated shale-bearing sequence in the McQuesten River region resembles the upper parts of the Yusezyu Formation in the Hart River area of Nash Creek map area, the northern part of Lansing, and Niddery Lake map areas, which are locally characterized by continuous limestone bands and variegated phyllite as well as sandstone and grit. The designation of the unit as the Narchilla Formation is preferred at this time, however, because it emphasizes the occurrence of variegated shale above the limestone-rich top of a unit of monotonously interbedded gritty sandstone and phyllite. Without biostratigraphic control, the exact correlation is impossible to determine.

Depositional environment of the Hyland Group

As noted by Gordey and Anderson (1993), the Yusezyu Formation sandstone, pebbly sandstone, and conglomerate were probably deposited from turbidity currents on a rapidly forming turbidite fan. Intervening shale beds were probably deposited in an interchannel (overbank) setting. Thicker accumulations of shale might reflect basinal background sedimentation, although their pale greenish grey colour probably reflects turbidite-sourced clastic input in the water column. Darker grey shale is less common and possibly reflects basinal background sedimentation less diluted by turbidite sources.

Like those of the underlying Yusezyu Formation, the coarse clastic strata of the Narchilla Formation are inferred to be turbidites. A deep-water setting for the Narchilla Formation was suggested by Gordey and Anderson (1993) and Cecile (1997). In further support of this interpretation, Cecile (1997) cites the common occurrence of *Oldhamia* radiata in strata considered to be of deep basinal origin and the resemblance of this trace fossil to modern deep-water trace fossils.

The paleoenvironmental significance, if any, of the variegated colour of Narchilla shales is uncertain. In its type area, the Narchilla Formation passes laterally from maroon shale to dark blue-grey shale (Gordey and Anderson, 1993). Ross and Murphy (1988) interpret a similar transition between a variegated and a nonvariegated, carbonaceous facies in a marker unit of the Windermere Supergroup of east-central British Columbia as a record of a paleopycnocline separating oxidized and anoxic bottom waters.

The significance of the limestone member is unclear. All of the calcareous strata in this member are sandy and some are crosslaminated and graded, indicating a clastic origin. Coarse-grained limestone-clast breccias made up of angular clasts of sandy limestone identical to sandy limestone strata found within the member suggest deposition and re-sedimentation in an unstable slope environment.

Gull Lake Formation (?, map units ЄGv, ЄGq, ЄGp, ЄGs, ЄGc)

In the north-central part of the Sprague Creek map area (115P/15), the Narchilla Formation is stratigraphically overlain by the Gull Lake Formation, a map unit with four members, a basal mafic volcanic and volcaniclastic member (ЄGv), a quartzite and phyllite member (ЄGq, ЄGp), a phyllite (ЄGs) member and a calcareous clastic member (ЄGc).

Mafic metavolcanic member (map unit ЄGv)

Dark-weathering, dark green to grey, massive greenstone (mafic metavolcanic rock), pebbly to bouldery conglomerate with hornblende- or clinopyroxene- and feldspar-phyric basaltic or andesitic rock fragments (fragmental metavolcaniclastic rocks, Figures 26-28) and lesser turbiditic sandstone (Figure 29) and dark grey phyllite are discontinuously exposed stratigraphically above the Narchilla Formation

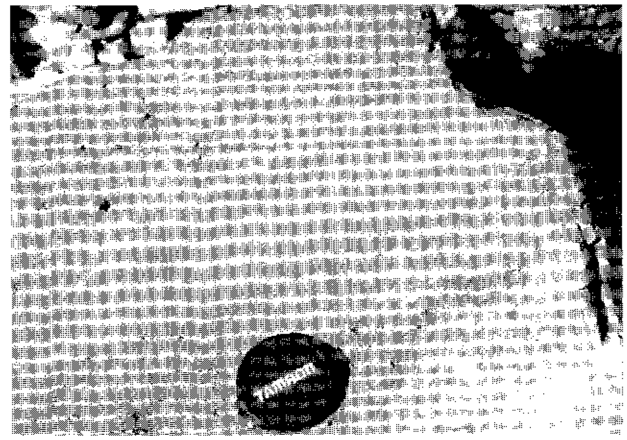


Figure 26. Gull Lake Formation, mafic metavolcanic member: large sedimentary lithic clast in mafic-volcanic-clast conglomerate. Boulder along Hobo Creek near headwaters, Sprague Creek map area.

in the Sprague Creek map area (115P/15). The contact with the underlying Narchilla Formation appears conformable, but the possibility of a disconformity cannot be ruled out (see under The Gull Lake Formation in other areas). The unit is best exposed on a spur ridge trending southeastward off the main ridge southwest of the summit of Red Mountain where a stratigraphically lower massive greenstone unit is overlain by interbedded graded medium- to coarse-grained volcaniclastic metasand-stone and medium to dark grey phyllite. Greenstone in this location is massive and structureless, possibly due to its position within the hornfels zone of the Red Mountain stock, and cut by serpentine veins. Coarse fragmental rocks occur intermittently on strike from this exposure. The mafic volcanic and volcaniclastic unit has a structural thickness of 200 m in cross-section (Section B-B′, Geoscience Map 1996-2).

Quartzite and phyllite member (map units ЄGq, ЄGp)

Overlying the mafic metavolcanic member with apparent conformity is a unit of grey quartzite (metamorphosed quartzarenite) and medium to dark grey phyllite. Quartzite was not observed at the same stratigraphic position southwest of Red Mountain, suggesting that the unit is either lenticular or erosionally truncated beneath the overlying phyllite unit.

On the ridge southwest of Red Mountain, where strata are on the inverted limb of the Lost Horses Syncline, the unit is mostly made up of two bands of massive light to dark grey quartzite and rare pebbly quartzite separated by grey phyllite. The lower quartzite band overlies (stratigraphically) a several-metre-thick unit of dark grey phyllite (map unit ЄGp), which stratigraphically overlies, and is inter-

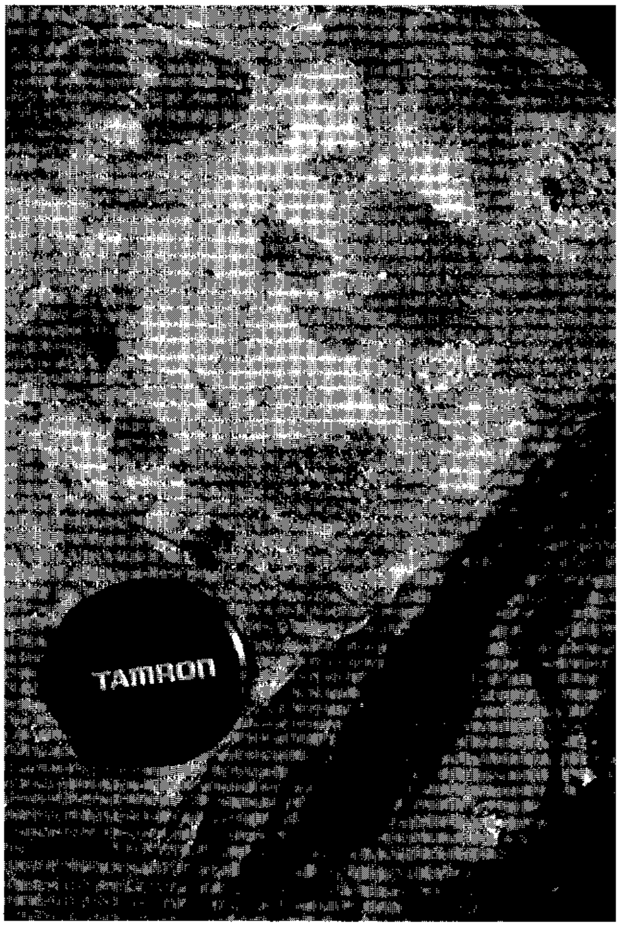


Figure 27. Gull Lake Formation, mafic metavolcanic member: conglomerate made up of assorted mafic volcanic rock clasts in a sandy matrix. Boulder along Hobo Creek near headwaters, Sprague Creek map area.

Figure 28. Gull Lake Formation, mafic metavolcanic member: large intermediate to felsic volcanic rock fragment in conglomerate. Boulder along Hobo Creek near headwaters, Sprague Creek map area.

bedded with, graded volcaniclastic sandstone of the underlying mafic metavolcanic unit. Hornfels derived from quartzite and phyllite makes up the upper part of the steep, gossanous, south-facing slope east of the Red Mountain stock. The unit has a maximum structural thickness of about 400 m, tapering down to zero southeast of Red Mountain.

Shale (Phyllite) and chert member (map unit ЄGs*)*

The quartzite unit is overlain and possibly in part laterally continuous with a monotonous sequence of drab greenish grey to medium grey phyllite, locally with millimetre-to-centimetre-scale, greenish grey, graded and laminated siltstone laminae and greenish, thin-bedded chert. Metre-scale beds of graded greenish grey calcareous sandstone and pebbly sandstone become increasingly more common within a few tens of metres of the top of the unit (Figure 30). Several tens of metres of thinly bedded (centimetre- to decimetre-scale) chert and phyllite occur west of Gem Creek at or near the same stratigraphic level as the quartzite bands described above. The lower part of the steep, gossanous slopes south of Red Mountain and the ridge southeast of the Red Mountain stock are underlain by pelitic hornfels of unit ЄGs. The best nonhornfels exposure of the shale-rich part of this unit occurs in the floor of Hobo Creek where placer miners have excavated to bedrock. The only chert locality lies on the east side of a north-trending tributary into Sprague Creek west of Gem Creek. A structural thickness of about 1.5 km appears in cross-section.

Calcareous clastic member (map unit ЄGc*)*

Conformably and transitionally above the shale (phyllite) and chert member is a unit of thinly bedded laminated and crosslaminated calcareous siltstone and fine sandstone; massive, shale-chip-bearing calcareous sandstone; calcareous mudstone and limestone. Locally, calcareous mudstone weathers tan to brown and is wispy laminated and bioturbated, strongly

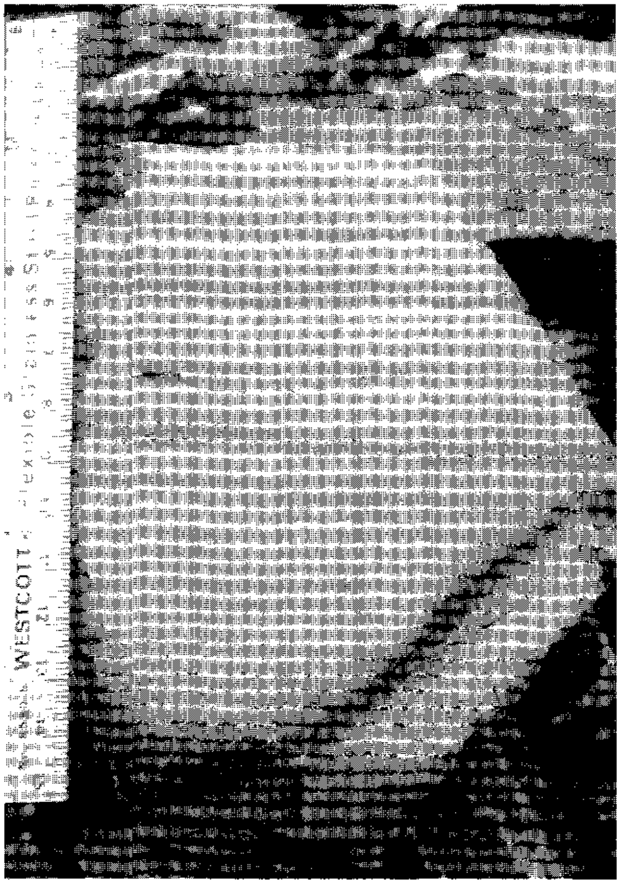


Figure 29. Gull Lake Formation, mafic metavolcanic member: graded mafic volcanic sandstone beds with lesser grey phyllite. Boulder along Hobo Creek near headwaters, Sprague Creek map area.

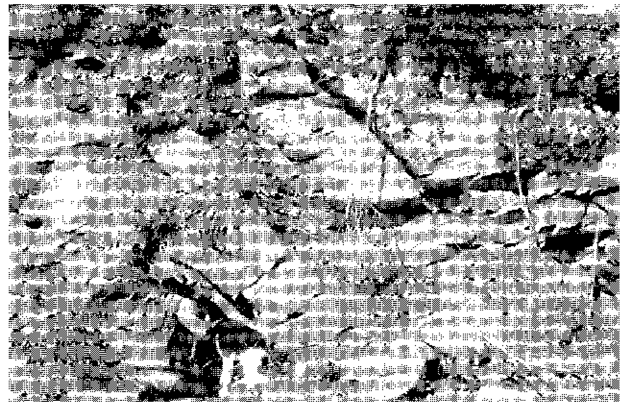


Figure 30. Gull Lake Formation, shale/chert member: metre-scale massive to graded pebble conglomerate and calcareous sandstone beds with lesser interbedded medium-grey, laminated phyllitic shale. Rocks in this location are on the northern inverted limb of the Lost Horses syncline: graded beds are upside-down and the prominent cleavage verges to the northeast. Beds are located near the top of the member, becoming more common but finer grained upward (115P/15, UTM 407300, 7097100).

resembling the distinctive rock types of the Steel Formation of the Road River Group (see under Steel Formation). Near felsic intrusions, this unit is metamorphosed to a layered, locally cherty calc-silicate hornfels and sandy marble with relict clastic quartz grains. The unit has been observed in outcrop along Hobo Creek in the northwest corner of the Sprague Creek map area (115P/15) and the northeast corner of the Clear Creek map area (115P/14) and traced discontinuously in outcrops to where it is thought to be truncated by the Sprague Creek Fault. The contact with the underlying shale unit in Hobo Creek is transitional with increasing amounts of sandstone appearing at the top of the shale unit. The contact with the overlying Rabbitkettle Formation in Hobo Creek appears conformable. A structural thickness of about one km appears in cross-section (Section A-A´, Geoscience Map 1996-2).

Local extent and thickness of the Gull Lake Formation

The succession of members has been traced from the northern boundary of the Sprague Creek map area (115P/15) southward around the Lost Horses Syncline and ends south of Sprague Creek where rocks of the Yusezyu Formation underlie the Rabbitkettle Formation. The contact between the Yusezyu and the Gull Lake formations in this area is thought to be a normal fault that was active before the deposition of the Rabbitkettle Formation: the Sprague Creek Fault. All members of the Gull Lake Formation and the Narchilla Formation are truncated to the south at the Sprague Creek Fault. The extent of the formation northwest of the study area is not known. The structural thickness of the whole formation is about 3 km.

Age

No fossils have been recovered from this unit in the McQuesten River region. The units in this sequence are considered to be Lower to Middle Cambrian, based on correlations with fossil-bearing sections elsewhere (see next section).

The Gull Lake Formation in other areas

A Lower to Middle Cambrian shale-dominated unit is intermittently preserved throughout Selwyn Basin. The name "Gull Lake Formation" was applied to this unit by Gordey and Anderson (1993) in the Nahanni map area. Fritz (1992), Gordey and Anderson (1993), Cecile and Abbott (1992), Roots and Murphy (1992b), Roots et al. (1995a, b), and Cecile (1997) show its extent throughout much of eastern and central Selwyn Basin. The Gull Lake Formation in its type area consists of three members: a basal, thin, discontinuous archaeocyathid-clast-bearing limestone conglomerate, which sits directly on the Narchilla Formation; a middle orange-brown- to rust-brown-weathering, locally bioturbated slate, siltstone, and very fine-grained sandstone member; and an upper, thick-bedded, locally wispy, laminated, bioturbated siltstone and mudstone member. Mudstone of this middle unit ranges from calcareous to noncalcareous and dolomitic.

The age of the Gull Lake Formation in its type area is Early Cambrian to possibly middle Late Cambrian, based on the occurrence of archaeocyathid-clast-bearing, limestone conglomerate at the base of the unit and its position beneath the Rabbitkettle Formation, which overlies a sub-Franconian (middle Late Cambrian) unconformity in much of Selwyn Basin. Gordey and Anderson (1993) consider the type Gull Lake Formation to be the basinal equivalent of the Lower Cambrian Sekwi Formation. The transition between the Gull Lake and Sekwi formations was described by Cecile (1997).

Volcanic rocks do not occur in the type locality of the Gull Lake Formation, but are described in similar sequences in Niddery Lake map area, Lansing map area, and the Hart River area in the central part of Nash Creek map area. In Niddery Lake map area (Cecile and Abbott, 1992; Cecile, 1997), mafic flows and tuffs occurring above the maroon and green phyllite of the Arrowhead Lake member of the Narchilla Formation are thick and extensive enough to be distinguished as the Old Cabin Formation. These are locally archaeocyathid-bearing and therefore Early Cambrian. In its type locality, the Old Cabin Formation consists of up to 500 m of hyaloclastic breccias, massive and pillowed flows, lapilli tuffs, epiclastic rocks, sills and dykes (Hart, 1986; Cecile, 1997). Mafic volcanic rocks in this area are intercalated with slate and siltstone of the Gull Lake Formation, which also includes chert, quartzarenite, grit and limestone.

In Sheldon Lake and Tay River map areas, the Gull Lake Formation consists of recessive, brown-weathering, noncalcareous, dark grey to black slate and siltstone and metamorphic equivalents (Gordey and Irwin, 1987). The Anvil District massive sulphide deposits of Tay River map area occur in the transitional upper part of the Mt. Mye formation, a metapelitic unit, which has been correlated with the Gull Lake Formation (Jennings and Jilson, 1986; Pigage, 1991). The Mt. Mye formation consists of noncalcareous, locally carbonaceous phyllite; marble and calc-silicate rock; minor psammite and metabasite. On the basis of lithological similarity and stratigraphic position, Jennings and Jilson (1986) correlated the Mt. Mye formation with drab Lower Cambrian shale mapped in the eastern part of Selwyn Basin by Blusson (1966), Gabrielse et al. (1973) and Gordey (1978), which has since been formalized as the Gull Lake Formation (Gordey and Anderson, 1993).

In the Lansing map area, the Gull Lake Formation comprises green, brown and olive, laminated mudstone and siltstone, dark brown, nodular shale and minor fine-grained sandstone and grit (Roots et al. 1995a, b). Mafic flows, tuffs and volcanic sandstone are found locally.

In the Hart River area of the Nash Creek map area (Abbott and Roots, 1992, 1993a, b; Abbott, 1993), maroon and green shale of the Narchilla Formation are overlain by extensive one- to fifty-metre-thick mafic flows and tuffs. These are succeeded by a unit of dark-weathering, grey and greenish grey phyllite, sandstone and quartzarenite, which may in part laterally interfinger with the volcanic unit, as phyllite and sandstone locally directly overlie the Narchilla Formation. Overlying the phyllite and sandstone unit is a unit of drab, brown-weathering, thinly laminated and locally intensely bioturbated shale and siltstone with a thin, distinctive clastic limestone marker at its base (Gull Lake Formation? of Abbott, 1993). The latter basal clastic limestone unit consists of yellowish-brown-weathering calcareous siltstone and sandstone, sandy limestone, dark grey-brown shale and limestone conglomerate. Upper Lower Cambrian *Bonnia-Olenellus* zone trilobites were collected from the limestone conglomerate, supporting a correlation with the similar basal archaeocyathid-clast-bearing limestone conglomerate of the type section (Abbott, 1993). The occurrence of *Bonnia-Olenellus* trilobites (Abbott, 1993) near the base of the section implies a correlation with the upper part of the Sekwi Formation. A late Early Cambrian age for the base of the Gull Lake Formation also suggests the possibility of a subtle intra-Lower Cambrian disconformity, where these rocks sit directly on the Narchilla Formation (G. Abbott, pers. comm. 1994).

Comparison with other areas

The name "Gull Lake Formation" has been applied in the study area to the sequence of units between the Narchilla and Rabbitkettle formations. Although broadly similar to the succession of units in the same stratigraphic position elsewhere, there are differences. The mafic volcanic member probably correlates with the Old Cabin Formation of the Niddery Lake map area and mafic volcanics overlying the Narchilla Formation in the Hart River area. The interfingering relationships between mafic volcanic rocks and the other rock types of the Gull Lake Formation observed in the Niddery Lake map area and possibly present in the Hart River area of the Nash Creek map area have not been observed in the

McQuesten River region. Other differences are the apparent lack in the study area of the basal limestone conglomerate and the amount of coarser calcareous clastic material at the top.

Depositional environment

Much of the Gull Lake Formation is dark, laminated shale suggesting deposition in a basinal setting. Mafic volcanism and deposition of clean quartzite at the onset of basinal sedimentation possibly reflect local rifting and uplift and erosion of first-cycle sediments deposited on the basin flanks. The appearance upward of increasing amounts of calcareous clastic rocks might represent the outgrowth of platformal areas at the basin margin, shedding turbiditic debris into basinal regions.

Rabbitkettle Formation (map unit ꞒOR)

A prominent, laterally continuous, white-weathering carbonate marker unit (Figure 31) has been traced throughout the Clear Creek and Sprague Creek map areas, overlying different rock units in different areas. This unit, Bostock's (1964) map unit 8, likely correlates with the Rabbitkettle Formation that occurs extensively throughout Selwyn Basin (Gabrielse et al. 1973; Fritz et al. 1991; Abbott et al. 1986; Gordey and Anderson, 1993; Cecile, 1997).

The Rabbitkettle Formation in this area is composed primarily of platy thin- to medium-bedded limestone (marble) (Figures 32, 33) and lesser yellowish white to light grey calcareous (locally dolomitic) phyllite (Figure 34). Limestone-pebble metaconglomerate and nodular limestone occur locally (Figure 35). The best exposures of the unit are in the cliffs north of the Little South Klondike River, east of its

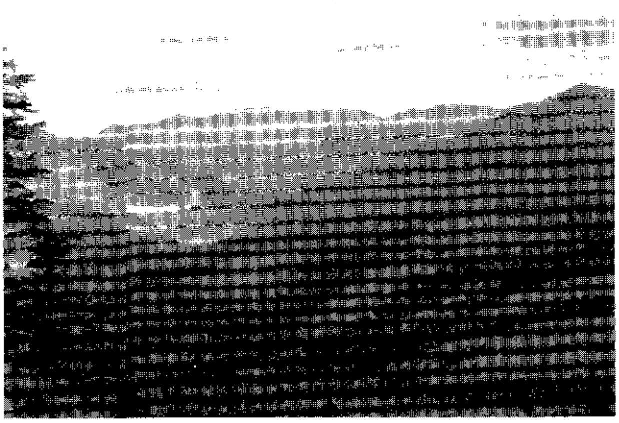


Figure 31. Rabbitkettle Formation: light-coloured cliff-forming limestone outcrops along the Little South Klondike River east of the confluence with Lost Horses Creek. The formation passes upward at the top of the cliffs into chert and shale of the overlying Duo Lake Formation. Higher ground in the background is underlain by phyllite and shale and coarser clastic rocks of the Earn Group. Clear Creek map area (115P/14).

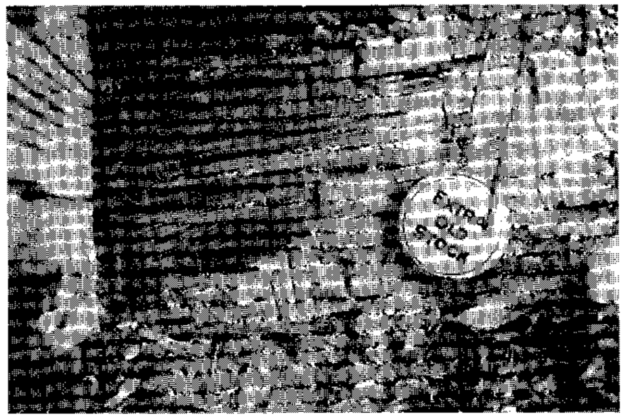


Figure 32. Rabbitkettle Formation: millimetre-scale laminated and crosslaminated marble (115P/14, UTM 391957, 7090130).

confluence with Lost Horses Creek (Geoscience Map 1996-1), on the ridge east of Josephine Creek south of its junction with the Little South Klondike River (both sites visible in Figure 31), and in cliffs on the north side of a small tributary of Big Creek north of its confluence with Granite Creek (Geoscience Map 1996-2).

The Rabbitkettle Formation overlies the Hyland Group on the southern limb of the Lost Horses Syncline and the calcareous clastic member of the Gull Lake Formation on the northern limb, suggesting an unconformable relationship. On the northern limb of the Lost Horses Syncline, where calcareous rocks are juxtaposed, the basal contact of the Rabbitkettle Formation is placed above the last appearance of sandy limestone (marble). These two units locally occur together near felsic intrusions (Hobo Creek stock, Sprague Creek stock) and both are metamorphosed to cherty calc-silicate hornfels and gold- and tungsten-bearing garnet-diopside skarn; relict sand grains preserved in the underlying unit permit their differentiation.

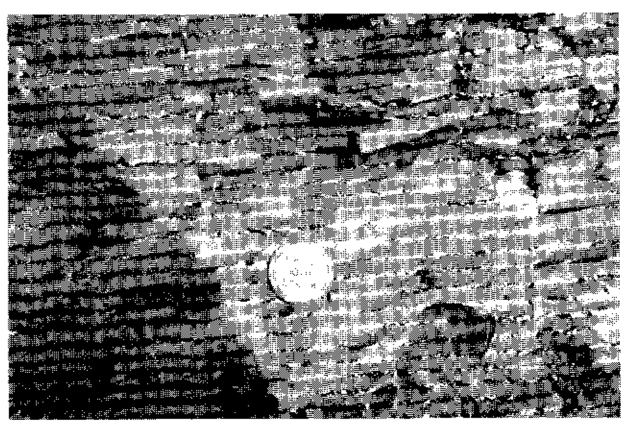


Figure 33. Rabbitkettle Formation: thin-bedded argillaceous marble and interbedded calcareous phyllite (115P/14, UTM 391957, 7090130).

Local extent and thickness

The Rabbitkettle Formation has been mapped from the western edge of the Clear Creek map area eastward to the hinge of the Lost Horses Syncline in the Sprague Creek map area and then back northwestward to the northeast corner of the Clear Creek map area. Its northwestward continuation into the southern part of the Larsen Creek map area is not known. Bostock (1964) extends the unit westward nearly to the Tintina Trench from the western boundary of the Clear Creek map area. A structural thickness of 140 to 200 m occurs on the long upright limbs of map-scale parasitic folds on the lower upright limb of the Lost Horses Syncline (Section A-A´, Geoscience Map 1996-2).

Age

Fossils have not been found in the Rabbitkettle Formation in this region so it is not possible to determine its age directly. Bremner (pers. comm. 1996 of conodont age determined by M. J. Orchard) and Thompson et al. (1992) report Cambro-Ordovician fossils from a similar unit in the Robert Service Thrust sheet in the southeastern Dawson map area. If correct, the correlation with the Rabbitkettle Formation implies a Late Cambrian-Early (locally Middle; Gordey and Anderson, 1993) Ordovician age.

The Rabbitkettle Formation in other areas

The Rabbitkettle Formation occurs extensively throughout the eastern part of Selwyn Basin (Gordey and Anderson, 1993; Cecile and Abbott, 1992; Fritz et al. 1991; Cecile, 1997). At its type locality in the southern Selwyn Mountains, the formation consists of about 1200 m of thin-bedded, wavy banded limestone, silty limestone and siltstone (Gabrielse et al. 1973). In the Misty Creek Embayment, the unit consists of thin-bedded, silty limestone, limestone, spectacular intraformational carbonate breccias, shale and dolostone (Cecile, 1982). In the Nahanni map area, the Rabbitkettle Formation consists of grey-orange-weathering, blue-grey to black, fine crystalline, argillaceous limestone to silty limestone, grey-weathering, grey, finely crystalline, nodular limestone and green-to orange-weathering, green volcanic tuff and tuffaceous shale (Gordey and Anderson, 1993). In the northeastern part of the Niddery Lake map area (Cecile, 1997), the Rabbitkettle Formation is mostly yellow-weathering, argillaceous to silty, medium- to thick-bedded limestone with lesser black calcareous shale. Limestone is internally laminated and has abundant bedding-parallel feeding traces.

Carbonate units correlative with the Rabbitkettle Formation have been reported locally in the western part of Selwyn Basin. Gordey and Irwin (1987) correlate a unit of grey- to buff-weathering, laminated to thin-bedded, locally nodular, shaly limestone to calcareous phyllite and lesser massive to thin-bedded dark grey limestone with the Rabbitkettle Formation. The Vangorda formation of the Anvil District (Jennings and Jilson, 1986) consists of calcareous phyllite, metabasite, carbonaceous phyllite, chloritic phyllite and minor marble. The Anvil District ore deposits occur in a stratigraphic transition zone between the Mt. Mye formation and the Vangorda formation. Although correlating the Vangorda formation with the Rabbitkettle Formation, Jennings and Jilson (1986) point out that the Vangorda formation is more argillaceous than the Rabbitkettle and unlike many of the occurrences of the Rabbitkettle, there is no evidence for an unconformity at the base of the formation. Thompson et al. (1992) and Thompson (1995) described carbonate breccia, thin-bedded limestone, and silty limestone above the

Figure 34. Rabbitkettle Formation: well foliated and lineated calcareous phyllite in upper part of formation. Pencil in centre of photograph for scale. Pencil lies just beneath and parallel to fold hinge (115P/14, UTM 397709, 7091458).

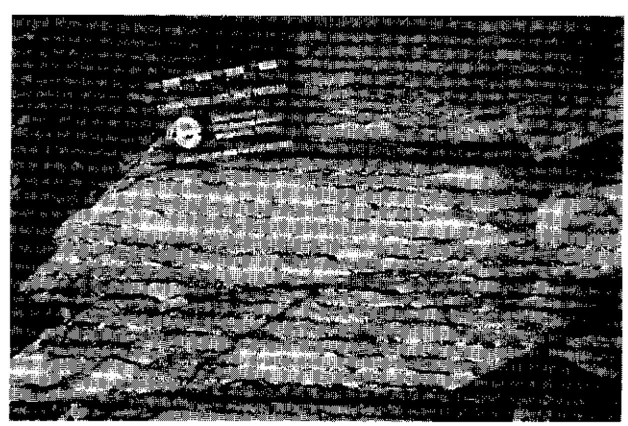


Figure 35. Rabbitkettle Formation: well foliated intraformational limestone-pebble meta-conglomerate (115P/14, UTM 382946, 7086806).

Hyland Group near Antimony Mountain in the southeastern part of the Dawson map area. Cambrian and Ordovician conodonts have been obtained from this unit, implying a correlation with the Rabbitkettle Formation. Elsewhere in the Dawson map area, discontinuous Early Ordovician conodont-bearing pods of white- or grey-weathering limestone are interbedded with pillow basalts, subaqueous pyroclastic breccias, debris flows, and submarine tuffs (Roots, 1988).

Comparison with other areas

The proposed correlation of the carbonate unit in the study area with the Rabbitkettle Formation is based on its stratigraphic position, lithological similarity and its unconformable relationship with underlying rocks. Regionally, the unit unconformably overlies older rock units (Fritz et al. 1991) although Fritz et al. (1991) and Cecile (1997) documented areas where the lower contact of the formation is transitional with underlying rocks. Mafic volcanic rocks intermittently associated with the Rabbitkettle Formation are absent in the McQuesten River region, but have been reported in a similar stratigraphic position at the Brewery Creek deposit in the southeastern part of the Dawson map area (Diment, 1996).

Depositional environment

Because of deformation, recrystallization and poor preservation of primary features, it is not possible to determine a depositional environment for the Rabbitkettle Formation in the study area. Gordey and Anderson (1993) and Cecile (1997) inferred a quiet water, offshelf setting from fine grain size, fine lamination, lack of traction features and a position west of shallow-water carbonate strata. Cecile (1982) reported voluminous intraformational breccias within the Rabbitkettle Formation of the Misty Creek Embayment, where the formation is likely in a transitional slope setting between the eastern shallow-water platform and the western basinal deposits.

Road River Group

The Rabbitkettle Formation is overlain in the Clear Creek and Sprague Creek map areas by dark, shaly rocks correlated with the Ordovician and Silurian Road River Group. The use of the term "Road River Group" follows that of Gordey and Anderson (1993); the group comprises two units: the basal Duo Lake Formation (Cecile, 1982), and the Steel Formation (Gordey and Anderson, 1993).

Duo Lake Formation (map unit OSD*)*

The Duo Lake Formation comprises grey to black to brown shale (phyllite), cherty shale (phyllite), chert, and rarely quartz-augen phyllite. Shale (phyllite) is fissile and finely laminated with millimetre- to centimetre-scale, silvery brown, fine siltstone beds. Massive siliceous shale (phyllite) occurs locally in metre-scale thicknesses. Weathered surfaces of chert are matte grey to dark green and fresh surfaces grey to black. The chert is recrystallized and generally bedded on a centimetre to decimetre scale (Figure 36). Chert units of more than a few metres in thickness are rare. Brown-weathering, waxy, grey-green, fissile phyllite with millimetre-scale grains of quartz and chalky feldspar occur rarely and are interpreted as felsic tuff.

The unit is generally recessive, although chert members locally form cuestas as found two km northeast of the confluence of Lost Horses Creek and the Little South Klondike River in the Clear Creek map area. Good exposures of the Duo Lake Formation are found above the cliffs formed by the Rabbitkettle Formation along the Little South Klondike River, east of the confluence with Lost Horses Creek (Geoscience Map 1996-1, Figure 31) and on the ridge east of Josephine Creek, southeast of its junction with the Little South Klondike River (Geoscience Map 1996-2).

Figure 36. Duo Lakes Formation: centimetre-scale beds of grey chert and shale (115P/14, UTM 393251, 7095937).

The lower contact of the Duo Lake Formation with the Rabbitkettle Formation is apparently conformable. The unit is overlain either conformably by the Steel Formation or unconformably by the Earn Group. As dark shale (phyllite) and chert also occur in the Earn Group, its distinction from the Duo Lake Formation is difficult.

Local extent and thickness

The Duo Lake Formation occurs in the northern Clear Creek and Sprague Creek map areas (Geoscience Map 1996-1, 2). It has been traced around the hinge of the Lost Horses Syncline and on the syncline's northern limb continues northwest of the map area into the southern Larsen Creek and Dawson map areas, where it was mapped by Green (1972, part of his unit 9). The Duo Lake Formation ranges from 100 to 200 m thick on long upright limbs of the second-order folds parasitic on the southern limb of the Lost Horses Syncline (Section B-B′, Geoscience Map 1996-1, Section A-A′, Geoscience Map 1996-2).

Age

The age of the Duo Lake Formation in the McQuesten River region is not known. Green (1972) found graptolites ranging in age from Early Ordovician to Middle Silurian north and northwest of the study area. Regionally, the unit is Early Ordovician to Silurian, based primarily on graptolite data (Gordey and Anderson, 1993; Cecile, 1997).

Steel Formation (map unit SS*)*

The Steel Formation consists primarily of locally limy or dolomitic mudstone or phyllitic mudstone and siltstone, with lesser fine-grained, calcareous, quartz sandstone and thin, sandy limestone. It weathers a distinctive beige-orange colour, is generally massive, locally well bioturbated with relict burrows, locally well laminated, and less commonly ripple crosslaminated (Figures 37, 38). Dark grey chert

Figure 37. Steel Formation: plane laminated tan- to orange-weathering dolomitic mudstone (115P/14, UTM 398839, 7091373).

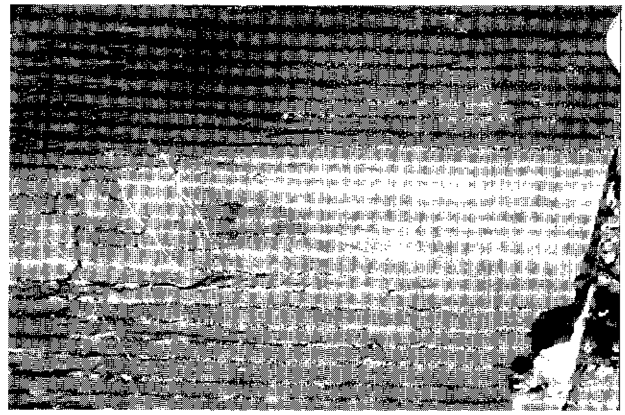


Figure 38. Steel Formation: decimetre-scale (part of Canadian one-dollar coin visible in upper right) bed of crosslaminated weakly dolomitic siltstone or fine sandstone within dolomitic mudstone (115P/14, UTM 399095, 7092539).

(cryptocrystalline silica) in the form of lenses and crosscutting veins occur locally. One such chert occurrence is in the Clear Creek map area northeast of the confluence of the Little South Klondike River and Lost Horses Creek (Figure 39, Geoscience Map 1996-1). At this locality, chert lenses are up to 2 cm thick and extend for more than a metre.

The Steel Formation is well exposed in cliffs northeast of the junction of Big and Hobo creeks where it structurally overlies Earn Group rocks along a south-vergent thrust (Geoscience Map 1996-2, Figure 40). It is also well exposed along the Little South Klondike River north of its confluence with Syenite Creek (Geoscience Map 1996-1).

Local extent and thickness

The Steel Formation occurs intermittently throughout the northern Clear Creek and Sprague Creek map areas on both the northern and southern limbs of the Lost Horses Syncline. Although not recognized by Green (1972), the unit continues to the northwest on both limbs of the syncline into the southern Larsen Creek and Dawson map areas. It was reported at the Brewery Creek mine in the southeastern part of the Dawson map area where it is locally silicified and mineralized (Diment, 1996; Poulsen, 1996).

The intermittent occurrence of the Steel Formation is in part due to the unconformable nature of the overlying Earn Group. The Steel Formation is completely missing beneath this unconformity throughout much of the Sprague Creek and Clear Creek map areas, and the Duo Lake Formation is locally missing in the Clear Creek map area north of the Little South Klondike River where the Earn Group is thought to sit directly on the Rabbitkettle Formation. The structural thickness of the Steel Formation under the

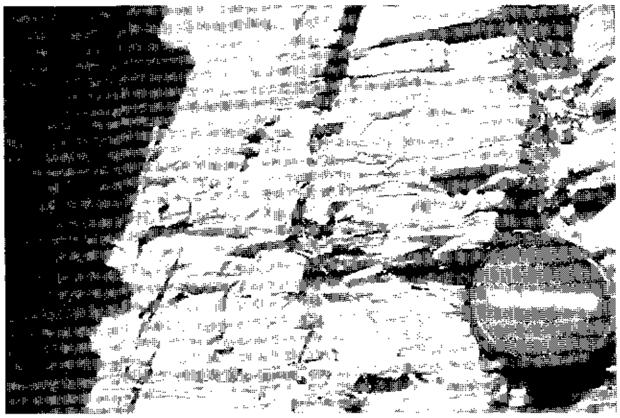


Figure 39. Steel Formation: concordant lenses (just below lens cap) and discordant veins (filling cracks to left of lens cap) of dark grey jasperoidal silica cutting blocky weathering dolomitic mudstone (115P/14, UTM 399095, 7092539).

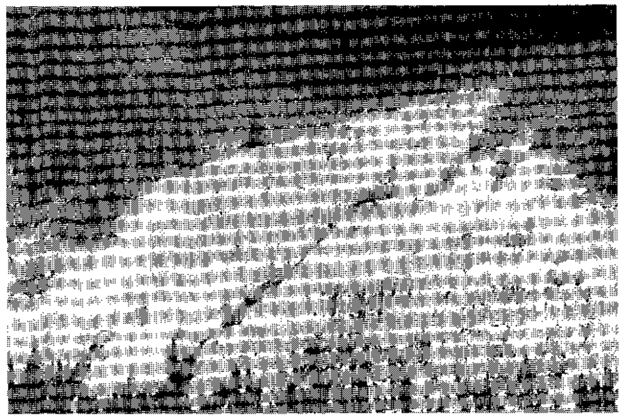


Figure 40. Steel Formation: view of cliff face of massive, beige- to orange-weathering mottled and bioturbated dolomitic mudstone. Outcrops are near confluence of Big and Hobo creeks, western Sprague Creek map area (115P/15).

base of the Earn Group ranges from zero to as much as 350 m (Section B-B′, Geoscience Map 1996-1, Section A-A′, Geoscience Map 1996-2).

Age

The age of the Steel Formation in the McQuesten River region is not known. In its type locality in the Nahanni map area, the unit contains early Late Silurian (Lludlovian) graptolites, but a late Early Silurian (late Wenlockian) to earliest Devonian age range is possible (Gordey and Anderson, 1993). In the Niddery Lake map area (Cecile, 1997), the Steel Formation ranges in age from Early Silurian to earliest Devonian.

The Road River Group in other areas

Dark, fine-grained basinal strata of Ordovician to Devonian age occur extensively throughout the northern Cordillera (see Cecile and Norford (1993) for a recent summary). The Duo Lake Formation was defined in the Bonnet Plume map area, where it consists of a basal unit of thin-bedded limestone and graptolitic shale and an upper unit of graptolitic siliceous shale and minor chert (Cecile, 1982). The formation in Nahanni map area is similar to the type area, though perhaps with less limestone (Gordey and Anderson, 1993; Cecile, 1997). In the Niddery Lake map area, the formation is composed of calcareous shale, shale, siliceous shale, and minor dolomitic shale and chert (Cecile, 1997). The Duo Lake Formation in the northeastern part of the Niddery Lake map area laterally intertongues with mafic volcanic rocks of the Marmot Formation; as well, it passes laterally to the southeast into a more carbonaceous and chert-rich facies — the Elmer Creek Formation — and is in part correlative with the argillite of the Steel Formation (Cecile, 1997). In the Sheldon Lake and Tay River map areas, the Duo Lake Formation consists of black chert and black graptolitic shale (Gordey and Irwin, 1987). In the Finlayson Lake map area on the western side of Selwyn Basin, the unit equivalent to the Duo Lake Formation consists of Lower to Upper Ordovician recessive, fissile, black graptolitic slate with lesser thin beds of medium-grained orthoquartzite, thin flows of intermediate volcanic rocks, thin dolomitic mudstone and lenses of crinoidal wackestone (Tempelman-Kluit et al. 1976).

Orange-weathering Silurian mudstone and siltstone similar to the Steel Formation also occur widely throughout the northern Cordillera (Gordey and Anderson, 1993; Cecile and Norford, 1993). The type locality of the Steel Formation is in the Nahanni map area, where it consists of variably dolomitic yellowish brown-, dull olive-grey-, or dark yellowish brown-weathering, light to dark grey mudstone commonly with dark grey, wispy laminations. Argillaceous dolostone occurs locally. The characteristic weathering colour of the formation is due to disseminated pyrite. In the Niddery Lake map area, the Steel Formation consists of rusty-orange-weathering green argillite with a prominent bed of bright orange-weathering grey dolostone and some shale with wispy laminations (Cecile, 1997).

The Steel Formation and similar units occur on the western side of Selwyn Basin in the Tay River, Sheldon Lake, and Finlayson Lake map areas. In the Tay River and Sheldon Lake map areas, the Steel Formation consists of orange-weathering, thin-bedded, burrowed, dolomitic, grey-green mudstone, siltstone and chert; black chert and rare black graptolitic shale (Gordey and Irwin, 1987). In the Finlayson Lake map area, Silurian orange-buff-weathering, resistant, medium grey, thin- to medium-bedded, finely laminated and crosslaminated, calcareous, quartz siltstone and sandstone with lesser brown slaty phyllite and orthoquartzite overlies black graptolitic slate (Tempelman-Kluit, 1977b; Jennings and Jilson, 1986) and likely correlates with the Steel Formation. This unit is viewed as transitional between the shale-dominated Selwyn Basin and the carbonate-dominated Cassiar Platform (Tempelman-Kluit et al. 1976).

Comparison with other areas

The poor quality of exposure in the study area and the lack of fossils precludes direct correlation with other sections but broad similarities and some differences are apparent. The Duo Lake Formation in the McQuesten River region is broadly similar to the Duo Lake Formation of the Nahanni map area, also having less carbonate than in the type area. It also resembles the Elmer Creek Formation of the Niddery Lake map area by comprising carbonaceous chert and shale. The Steel Formation in the McQuesten River region is sandier and perhaps more limestone rich than in eastern Selwyn Basin. It is more reminiscent of the laminated and crosslaminated dolomitic siltstone unit on the eastern margin of Cassiar Platform. Perhaps the coarser grain size of the Steel Formation in the McQuesten River region signals a westward transition to a more platformal environment.

Depositional environment

The Road River Group is thought to have formed in a deep basinal environment that lay between the coeval shallow marine Ogilvie-Mackenzie and Cassiar platforms (Abbott et al. 1986; Fritz et al. 1991; Cecile and Norford, 1993). The carbonaceous fine-grained and cherty nature of the Duo Lake Formation suggests that it was deposited in a clastic-sediment-starved, euxinic, marine basinal setting. Light-coloured mudstone of the Steel Formation in the study area is also likely to be a basinal deposit (Gordey and Anderson, 1993). Its noncarbonaceous character and evidence of benthic infauna suggests oxygenated bottom waters. Crosslaminated siltstone, fine sandstone, and silty or sandy limestone are traction current deposits, indicating the sporadic presence of bottom currents. The formation in the McQuesten River region is coarser grained than at its type locality, suggesting that it might represent a higher energy, possibly shallower environment than at the type locality.

Earn Group (units DMEe, DMEp^T, DMEv^T)

The Earn Group comprises mostly dark grey to black shale (phyllite) with subordinate and variable amounts of chert, siltstone, sandstone, limestone, bedded barite, baritic limestone, chlorite-muscovite phyllite, and chert-pebble conglomerate. Sandstones are massive to graded wackes, thin- to medium-bedded, and light to dark brown on fresh and weathered surfaces (Figure 41). Chert-pebble conglomerate is generally massive, although ubiquitous lichen makes it difficult to discern any features (Figure 42). Clasts are mostly chert of different colours, but primarily brown, green and black. Shale or phyllite is medium to dark grey and locally striped with siltstone laminae. Thin- to medium-bedded chert is locally important, as along the hinge of the Lost Horses Syncline north of Black Canyon Creek (Geoscience Map 1996-1). Bedded barite, baritic limestone and grey shale (phyllite) at the **Omega** occurrence (Yukon MINFILE #115P 45, INAC, 1995) are thin bedded and dark grey to black (Figure 43). In the Tombstone Thrust sheet, map unit DMEv^T, a laterally persistent greenish white-weathering chlorite-muscovite phyllite member thought to be felsic metavolcanic rock, occurs at or near the top of the group beneath the Keno Hill quartzite. This metavolcanic unit has been traced over 120 km to the east into weakly foliated to massive quartz-feldspar meta-porphyry (Figure 44, Roots and Murphy, 1992a; Roots, 1997).

The base of the Earn Group is inferred to be an unconformity. In the Clear Creek and Sprague Creek map areas, the Earn Group overlies different stratigraphic units in different places. North of the Little South Klondike River and west of the junction with Lost Horses Creek, dark shale with coarse sandstone thought to be Earn Group directly overlies white-weathering marble of the Rabbitkettle Formation. In the same area, but east of the confluence of

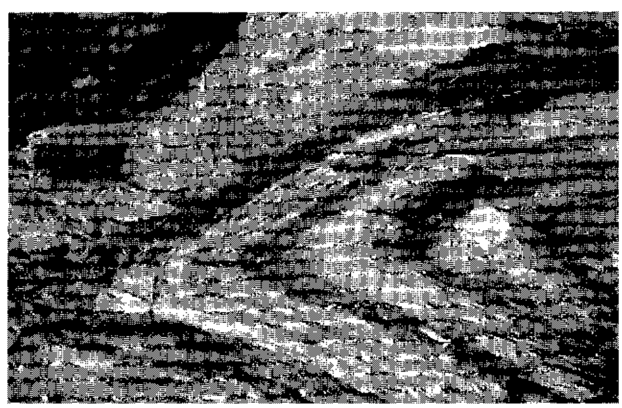


Figure 41. Earn Group: tightly folded beds of graded, calcareous sandstone (lower limb is upright) and lesser grey phyllite. (105M/14, UTM 477360, 7088460).

Figure 42. Earn Group: chert-pebble conglomerate characteristic of unit. Clasts are up to about 1 cm in long dimension and are primarily light brown chert (115P/14, UTM 387496, 7087634).

Lost Horses Creek, both formations of the Road River Group intervene between the Rabbitkettle Formation and the Earn Group. Between these two areas, the base of the Earn Group cuts down across the Road River Group. Where the Steel Formation is cut out beneath the Earn Group, the location of the base of the group is somewhat arbitrary because both units are generally poorly exposed and consist primarily of dark shale or phyllite. There are no biostratigraphic data with which to locate the unconformity.

The Earn Group is generally poorly exposed although chert-pebble conglomerate members locally form prominent strike ridges and cuestas (Figure 45). The lack of exposure and structural complexity both in the core of the Lost Horses Syncline and the Tombstone Strain Zone make further subdivision of the group difficult. The only regionally mappable unit is the chlorite-muscovite phyllite found near the top of the unit in the Tombstone Thrust sheet.

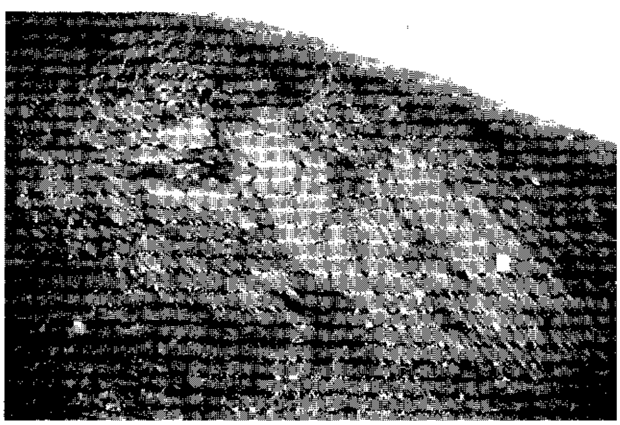


Figure 43. Earn Group: folded thin-bedded barite, baritic carbonate, chert and grey phyllite, Omega occurrence (Yukon MINFILE #115P 045, (115P/14, UTM 393740, 7097159)).

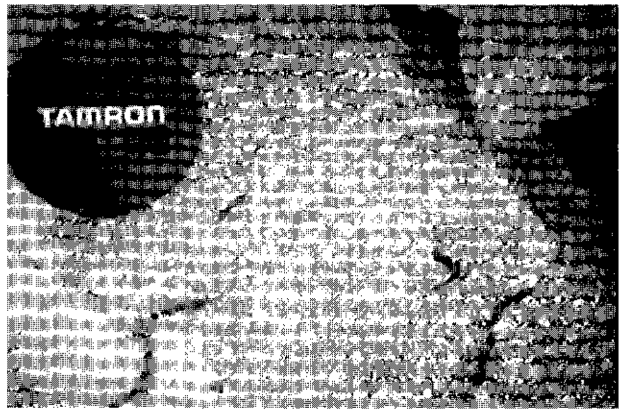


Figure 44. Earn Group: weakly deformed porphyritic felsic metavolcanic rocks at top of Earn Group (unit $DMEv^{T}$). Patterson Range, northern Mayo Lake map area, Mayo map area (105M/15, UTM 516200, 7090575).

Local extent and thickness

The Earn Group occurs in two structurally and geographically distinct parts of the region. It occurs in the western part of the region in the Lost Horses Syncline, at the highest part of the Robert Service Thrust sheet (in the Clear Creek map area and the northwestern part of the Sprague Creek map area). It occurs at deeper structural levels in the east, underlying the Keno Hill quartzite in the Tombstone Thrust sheet (Seattle Creek, Mt. Haldane, and Keno Hill map areas). In the Keno Hill map area, rocks of the Earn Group were recently traced in a belt to the east through Mt. Westman (106A/1; Abbott, 1990a, b) and Tiny Island Lake (105M/16; Gordey, 1990a, b) map areas. The continuation of this newly defined belt to the southeast is uncertain, although it likely connects with occurrences of the group in the east

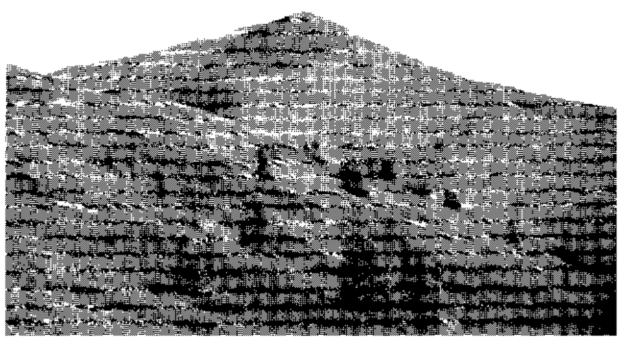


Figure 45. Earn Group: typical exposure of Earn Group in McQuesten River region. The subtle ridge in the centre of the photograph that lies under the top of the high point and terminates at the gully consists of a band of more resistant chert-pebble conglomerate. View is to the east from a point in the eastern part of Clear Creek map area (115P/14).

half of the Lansing map area (Roots et al. 1995a, b). West of the study area, chert-pebble conglomerate correlated with the Earn Group occurs at the Brewery Creek mine (T. Bremner, pers. comm. 1993; Diment, 1996), on strike with the Earn Group in the Lost Horses Syncline. Northeast of the study area, rocks that likely belong to the Earn Group have been mapped in a synformal keel in the Dublin Gulch map area (106D/4; Poole, 1965). Devonian-Carboniferous conodonts have been extracted from fetid limestone in this sequence (identification by T. Uyeno, GSC, fossil report MP15 TTU 72 to W. Poole).

As neither the stratigraphic top in the Lost Horses Syncline nor the stratigraphic bottom in the Tombstone Thrust sheet are known, a stratigraphic thickness cannot be determined. Complex deformation has resulted in a structural sequence in the Keno Hill map area several km thick (Geoscience Map 1996-5).

Age

No new biochronological or geochronological data constraining the age of the Earn Group in this region are available. Poorly preserved fossil leaves were the only fossils found in the region but have not yet been analyzed. An imprecise Middle Devonian U-Pb zircon age determination was obtained from the quartz feldspar augen phyllite unit in the Mayo Lake map area east of Keno Hill (J. Mortensen and M. L. Bevier, pers. comm. 1993).

At its type locality (see under Earn Group in Other Areas), strata of the Earn Group contain Lower Mississippian and possible Pennsylvanian fossils (Campbell, 1967). Fossil collections from Earn Group strata in Nahanni and Niddery Lake map areas range in age from Early to Late Devonian. Rocks overlying the Earn Group in the Nahanni map area (Tsichu formation) and in the Niddery Lake map area (Tsichu Group) are as old as Early Mississippian. On the basis of available paleontological information, the possibility of the Earn Group in this area ranging into the earliest Mississippian cannot be ruled out (Gordey and Anderson, 1993).

Earn Group in other areas

Rocks of the Earn Group occur throughout much of the northern Canadian Cordillera northeast of the Tintina Fault (Abbott et al. 1986; Gordey et al. 1982; Gordey et al. 1991). The type locality of the Earn Group is in Glenlyon map area, where it consists of four map units (Campbell, 1967). The lower unit is dark grey, dull brownish grey or black chert and cherty argillite; grey or black quartzite and grit, and dark grey, finely crystalline limestone. The lower unit is overlain by the Crystal Peak Formation, which consists of thick-bedded and massive chert-pebble conglomerate. The Crystal Peak Formation is overlain by the grey- and buff-weathering, dark grey to black, fetid limestone of the Kalzas Formation. The uppermost unit of the type Earn Group includes chert, quartzite, argillite and minor limestone and chert conglomerate. Lower Mississippian fossils were collected above and below the Crystal Peak Formation and probable Pennsylvanian fossils were collected from the unnamed upper unit. Although the type Earn Group includes four map units ranging in age from probably Devonian to Pennsylvanian, the more recent use of the name Earn Group would restrict its application to parts of the lower two, dark, chert-bearing clastic units of the type area (Gordey et al. 1982; Cecile, 1997).

The Earn Group in the Nahanni map area consists of two formations (Gordey and Anderson, 1993), the lower of which rests unconformably and diachronously on older rocks. The lower Portrait Lake Formation comprises a lower member of dark-brown-weathering silty shale and shale with minor siltstone and chert quartz sandstone, a middle member of black-weathering, massive, chert-pebble conglomerate, and an upper member of black, platy siltstone and rare, black, crystalline limestone. A regionally extensive barite horizon occurs near the top of the formation. The upper Prevost Formation consists of a basal member of mostly dark grey medium- to coarse-grained sandstone and rare chert-granule to pebble conglomerate, a middle member of dark grey, thin-bedded shale and siltstone, and an upper member of massive coarse-grained chert sandstone and chert-pebble conglomerate, which makes up most of the formation.

Gordey and Irwin (1987) subdivided the Earn Group in the Sheldon Lake and Tay River map areas into five map units. The lowest unit is the Portrait Lake Formation, which consists of black, gun-blue or silvery-white-weathering, thin-bedded, siliceous, black siltstone, slate, and chert. This unit is overlain by an unnamed unit of brown-weathering, thin-bedded, laminated blue-grey to black shale, siltstone and minor sandstone. The overlying Prevost Formation comprises recessive, brown-weathering, thin-bedded, laminated, dark blue-grey to black slate and thinly to thickly interbedded fine- to medium-grained chert-quartzarenite and wacke and chert-pebble conglomerate. This unit is overlain by resistant, dark-grey-weathering, massive chert-pebble conglomerate, chert quartz sandstone and minor shale of the Crystal Peak Formation. The upper Earn Group in this area is an unnamed unit of recessive, dark-brown-weathering, thin- to medium-bedded, calcareous, dark grey to brown siltstone, sandstone, shale, dark grey limestone and bioclastic limestone.

In the Niddery Lake map area, the Earn Group also consists of two formations, the lower Misfortune Formation and the upper Thor Hills Formation; the two formations together are thought to correlate with the Portrait Lake Formation of the Nahanni map area (Cecile, 1997). The Misfortune Formation consists of two members, a lower, black shale member and an upper, black siliceous shale member. The Thor Hills Formation consists of brown-weathering dark shales and coarse sandstone and conglomerate.

Comparison with other areas

The types of rocks found in the Earn Group in the western part of the study area are generally the same as found elsewhere. However, poor exposure, structural and probably stratigraphic complexity, and the lack of fossil data preclude subdivision and direct comparison and correlation with other areas. Felsic volcanic rocks of Devonian or Mississippian age are not common in the Upper Paleozoic sequences of ancestral North America; other occurrences in the Yukon include Devono-Mississippian alkalic volcanic rocks and subvolcanic intrusions in the Pelly Mountains (Wheeler et al. 1960; Gordey, 1977; Mortensen, 1979, 1982) and felsic tuffs in the Tay River map area (S. P. Gordey, pers. comm. 1993). Without more precise age control, correlation with these other areas would be speculative. In contrast to the paucity of volcanic rocks in the Earn Group of ancestral North America, felsic volcanic and plutonic rocks of Devonian and Mississippian age are common in the Yukon-Tanana Terrane (Mortensen, 1992).

Depositional environment

Structural complexity and poor exposure preclude any rigorous assessment of the depositional environment of the Earn Group in the study area. Its generally dark, fine-grained, locally cherty nature suggest deposition in a deep marine basinal environment. Coarse clastic rocks have sedimentary structures characteristic of turbidites. On the basis of information from eastern Yukon, the Earn Group is inferred to have been deposited in a deep marine basin broken by tensional or transtensional rifts, which controlled deposition of coarse clastic detritus (Abbott et al. 1986; Gordey et al. 1987; Abbott and Turner, 1990). The Earn Group basin would have been paleogeographically complex, lying in a foreland setting with respect to the Ellesmerian orogenic highlands in the Arctic region, and in a back arc setting relative to a Devonian-Mississippian arc preserved in the pericratonic Yukon-Tanana and Kootenay terranes, and possibly represented by felsic volcanic rocks locally occurring in the Earn Group.

Keno Hill quartzite (map unit MK^T)

The Keno Hill quartzite in the study area comprises massive to well foliated and lineated, medium to dark grey quartzite (Figure 46) and phyllitic quartzite and medium to dark grey, locally carbonaceous phyllite (Figure 47). Quartzite is locally calcareous and quartz- and feldspar-pebble quartzite occurs rarely (Figure 48). Like other rock units within the Tombstone Strain Zone, original bedding has been transformed by isoclinal folding, foliation formation, and asymmetrical boudinage into sigmoidal and lenticular compositional domains. On the outcrop scale, massive quartzite passes laterally, up-section and down-section into siliceous phyllite, which may either have been thinner bedded quartzite or massive quartzite that has lost silica by pressure solution during the formation of the foliation. The relative amount of quartzite and grey phyllite in the Keno Hill quartzite is highly variable, a feature that probably has as much to do with deformational processes as original stratigraphic diversity. Folded and planar white quartz veins and pods commonly cut the quartzite, giving it a mottled appearance.

Figure 46. Keno Hill quartzite: massive grey quartzite folded in antiform overturned northward. Near original portal of the Silver King mine, Galena Creek (105M/13, UTM 472025, 7085280).

Figure 47. Keno Hill quartzite: grey phyllite, siliceous phyllite and thin quartzite cut by en-echelon vein arrays, Galena Creek upstream of locality in Figure 46 (105M/13, UTM 472055, 7084995).

Near the top of the Keno Hill quartzite is a unit of light grey to green siliceous muscovite-chlorite phyllite up to 200 m thick and locally including grey marble. This unit occurs south and west of Mt. Hinton in the Keno Hill map area (105M/14) and near the top of the ridge south of the South McQuesten River between the Seattle and Ross creeks in the Seattle Creek map area (115P/16). Rare quartz 'eyes' in the phyllite suggest that it is of volcanic origin. A similar unit occurs near the top of the Keno Hill quartzite in the Patterson Range across the Keno Ladue River northeast of Keno Hill. This similar unit can be traced to the northeast to where it lies along trend with strata hosting the **Marg** volcanogenic massive sulphide deposit (Yukon MINFILE #106D 009; INAC, 1995) in the southeastern corner of the Mt. Westman map area (106D/1). It is not known whether these occurrences are infolds of the underlying Earn Group felsic metavolcanic rocks or are younger metavolcanic rocks that were deposited as part of the Keno Hill quartzite. Limestone or marble

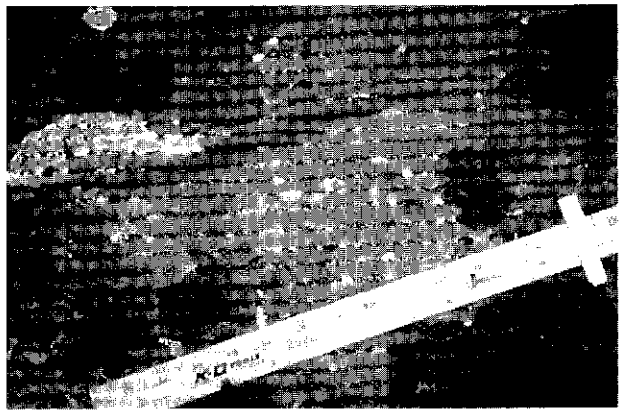


Figure 48. Keno Hill quartzite: angular feldspar clasts in rare pebble conglomerate (105M/14, UTM 487825, 7091075).

is not known to occur with the underlying Earn Group felsic metavolcanic unit, suggesting that the chloritic phyllite near the top of the Keno Hill quartzite is a younger unit.

Local extent and thickness

The Keno Hill quartzite occurs in the eastern part of the study area, on both limbs of the McQuesten Antiform. The exposures of the Keno Hill quartzite in the Seattle Creek map area are on the southern limb of the antiform, forming the western end of the belt of quartzite that extends eastward across Mt. Haldane map area through the Elsa-Keno Hill mining camp, around the Mayo Lake Antiform into the northeastern corner of the Mayo map area (Bostock, 1947; Murphy and Roots, 1992). The unit is truncated at its western end by the fault in the valley of the South McQuesten River, but reappears north of the fault east of Haggart Creek, where it extends initially northward and then westward in a nearly continuous belt into the Tombstone Mountains near Dawson (Tempelman-Kluit, 1970a; Green, 1972).

Complex and intense deformation of the Keno Hill quartzite precludes the determination of its stratigraphic thickness. About two km of quartzite occurs between the top of the Earn Group and the Robert Service Thrust.

Age

No new biochronological or geochronological data are available with which to constrain the age of the Keno Hill quartzite in this area. Viséan-Namurian conodonts were obtained from strata assigned to the Keno Hill quartzite in the Dawson map area (Mortensen and Thompson, 1990; Orchard, 1991). Imprecise Early Mississippian U-Pb ages have been obtained from felsic metavolcanic rocks hosting the **Marg** deposit (Abbott and Turner, 1990; J. Mortensen, pers. comm. 1993).

Keno Hill quartzite in other areas

The Keno Hill quartzite of the study area extends laterally and continuously to the west to the Tombstone River region where it was described in detail by Tempelman-Kluit (1970a). Between the two areas the unit passes out of the Tombstone Strain Zone and in the latter area, primary sedimentary features are have been described. According to Tempelman-Kluit (1970a), the formation in the Tombstone River region comprises "remarkably uniform, massive, grey, thick-bedded and fine-grained submature orthoquartzites" with several horizons of black slate and cherty slate and a member of sandy limestone in its upper part. Black slate makes up about one quarter of the formation. Burrows are locally apparent as are lamination, crossbedding, slump structures and ripple marks.

Mississippian quartz-rich clastic rocks are also found in the Nahanni, Niddery Lake and Lansing map areas of the eastern part of Selwyn Basin. The Selwyn Basin occurrences are the Tsichu formation of the Nahanni map area (Gordey and Anderson, 1993) and the Tsichu Group of the Niddery Lake map area (Cecile, 1997). The Tsichu formation consists of quartzarenite, shale and limestone. The Tsichu Group consists of four formations, the lower of which, the Heritage Trail Formation, correlates with the Keno Hill quartzite and the quartzite member of the Tsichu formation. The Heritage Trail Formation consists of massive to blocky, buff to grey-white quartzite with rare, thin shale and calcareous quartzite. Like the Keno Hill quartzite, the Heritage Trail Formation is Visćan to Namurian in age. In Lansing map area, the Keno Hill quartzite consists of grey-brown-weathering, banded dark grey and black, fine-grained quartzite and lesser black shale and siliceous argillite (Roots et al. 1995a, b). Quartzite occurring within the type Earn Group of the Glenlyon map area (Campbell, 1967; map unit 13) could correlate with the Keno Hill quartzite.

Comparison with other areas

Protoliths for rock types of the Keno Hill quartzite include mature quartzarenite, carbonaceous shale, calcareous quartzarenite, and felsic metavolcanic rock (?). With the exception of felsic metavolcanic rock, all of these rock types are found in other Mississippian quartzite units. The lack of primary stratigraphic information in the McQuesten River region precludes a more precise comparison.

Depositional environment

Intense deformation has overprinted the primary characteristics of the Keno Hill quartzite in the McQuesten River region. Tempelman-Kluit (1970a) infers a variably energetic shallow marine setting for much of the Keno Hill quartzite in the Tombstone River area, based on the occurrence of Cruziana trace fossils. In this area, the presence of plant fossils in the upper part might indicate a change up-section to a nonmarine setting. Gordey and Anderson (1993) inferred a shallow marine bar setting for quartz sandstone of the Tsichu formation in the Nahanni map area. Cecile (1997) inferred a complex paleogeography with shallow-water environments flanked by deeper water. In this area, quartz-sandstone-bearing strata pass laterally into coeval chert-bearing strata (Cecile and Abbott, 1992).

Map unit Pzu

Dark phyllite, siltstone and quartzite overlying the Keno Hill quartzite on the southern flank of the Davidson Range have been placed in map unit Pzu (map unit 7 of Green, 1971; map unit 17 of Green, 1972). This unit occurs only in the footwall of the Tombstone Thrust, north of the McQuesten River in the northern part of the Keno Hill map area (Geoscience Map 1996-5). A detailed description cannot be presented here as exposures of this unit were not visited during this study.

Age and correlation

Neither the age nor correlation of this unit are known. Noting the lithological similarities of this unit with the Lower Schist division underlying the Keno Hill quartzite, Green and McTaggart (1960) and Green (1971, 1972) placed it in that unit and Green (1972) inferred that it was Jurassic in age. Green (1971) pointed out the differences between the rocks overlying the Keno Hill quartzite in the Davidson Range and those overlying the Keno Hill quartzite everywhere else (Upper Schist, now thought to be Upper Proterozoic Yusezyu Formation) although no explanation of this discrepancy was offered.

The more recent information on the age and structure of units in the area adds new constraints on the age and correlation of this unit, although none are unequivocal. Two possible scenarios exist:

1) The sequence is isoclinally folded with the Keno Hill quartzite in the core and, as previously interpreted, the rocks above and below the Keno Hill quartzite are the same. In this case, unit Pzu would be Devonian.
2) Unit Pzu depositionally overlies the Keno Hill quartzite and is therefore post-Mississippian and pre-mid-Triassic. Both possibilities explain the difference between the rocks that 'overlie' the Keno Hill quartzite in the Davidson Range and those in the same position elsewhere. The first possibility requires a regional-scale isoclinal fold, for which little evidence exists — although with the degree of structural complexity in the region,

one cannot be ruled out. The second possibility implies a correlation of unit Pzu with Upper Paleozoic strata overlying the Keno Hill quartzite in the Upper Klondike River region (Tempelman-Kluit, 1970a; Green, 1972). However, Upper Paleozoic strata in this area are mottled maroon and green chert and shale with a thin section of dark shale and siltstone above. Another important difference is that these strata are not intruded by Triassic mafic sills as is unit Pzu in the Davidson Range. However, in spite of these differences, and for structural reasons discussed under Structural Geology, the last interpretation is preferred at the time of writing.

Bostock's (1964) map unit 18 (Tertiary and Later Selkirk Group)

Rocks mapped by Bostock (1964) as Tertiary or later volcanic rocks are exposed near the northern edge of the map area, north of Hobo Creek. These rocks are enigmatic, composed of unsorted silt- to boulder-sized angular to subrounded lithic clasts and locally strained monocrystalline quartz fragments embedded in a felted greenish-grey matrix of uncertain origin. They are generally massive and unstructured, except for cryptic and rare clast-size sorting. Numerous subcircular voids of various sizes occur in the rock, resembling vesicles. In thin section, the margins of the voids are lined by fine-grained greenish prismatic minerals (probably tourmaline) suggesting either a reaction relationship or open space filling. These might be vesicles or plucked lithic fragments.

These rocks might be of volcanic origin as proposed by Bostock (1964) or, alternatively, not volcanic but brecciated and tourmalinized Hyland Group. They occur near intensely fractured and quartz-injected Hyland Group grit and phyllite hornfels and mid-Cretaceous granitic rocks. The zone of fracturing and quartz injection extends for several km along strike to the east-southeast. Near the mid-Cretaceous stock, tourmaline and quartz with lesser arsenopyrite occur ubiquitously in fractures. In this area, the amount of tourmaline in both fractures and in the enigmatic rocks above is considerable. A felsite dyke cutting the enigmatic rocks has yielded an imprecise mid-Cretaceous age of around 92 Ma (see under Intrusive Rocks), showing that they are not Tertiary or later.

Intrusive Rocks

Intrusive rocks in the McQuesten River region comprise volumetrically minor foliated intermediate to mafic bodies and numerous widespread, locally sizable (up to 60 sq. km) unfoliated and discordant felsic to intermediate bodies. Bostock (1947, 1964) mapped many of the larger of these intrusive bodies and noted the spatial coincidence of many of the lode occurrences in the region with felsic plutons. Blackadar (1951) and Read (1957) investigated the mafic 'sills' (greenstones) of the Elsa-Keno Hill mining area. Individual unfoliated felsic to intermediate intrusions were studied by Abercrombie (1990, Syenite Range stock), Steffler (1980) and Kuran et al. (1982; both on the Scheelite Dome stock). Emond (1992) investigated the petrology and geochemistry of the felsic and intermediate plutons in the McQuesten River area and the relationship of igneous geochemistry to associated mineralization.

In this study, the contacts of known bodies were mapped at 1:50 000 scale, new intrusions were documented, whole rock geochemical data were collected, and high-precision U-Pb age determinations were obtained for many of the intrusions in the region. These new age determinations were performed by J. K. Mortensen at the Geochronometry Laboratory at the University of British Columbia.

Foliated intrusions

Two sets of deformed intermediate to mafic igneous rocks occur in the McQuesten River region, one set intrusive into the Hyland Group and the other into Keno Hill quartzite and Earn Group of the Tombstone Thrust sheet. Pre-kinematic intrusions into the Hyland Group comprise rare small foliated and folded bodies of fine- to medium-grained, dull green, rarely porphyritic, quartz-feldspar-chlorite-biotite rocks (Figure 49). Above the Tombstone Strain Zone, where primary stratification and structures are still preserved, sills and dykes have both been observed, most commonly intruding the Narchilla Formation. Dykes are clearly discordant with respect to bedding, are locally finer grained at the margin (chilled?) and locally have a thin biotite porphyroblast aureole extending a few cm into the wall rock. Within the Tombstone Strain Zone, pre-kinematic metaigneous rocks are discontinuous, foliation-conformable domains of foliated and lineated plagioclase-actinolite-biotite-chlorite rock. Although these bodies are similar in composition to those outside the zone, it is not known if they are of the same episode of magmatism. Because of the degree of deformation within the zone, it is not even clear that these are intrusive rocks.

The age(s) of these bodies is (are) not known. Minerals appropriate for U-Pb dating were not present in two samples. Such bodies have not been documented above the Narchilla Formation, so they are thought to be the feeders to the immediately overlying Gull Lake mafic metavolcanic member.

Lenses of foliated and lineated mafic metaigneous rocks are abundant within the Keno Hill quartzite and the underlying Earn Group (map unit Td^T; Bostock, 1947; McTaggart, 1950, 1960; Blackadar, 1951; Read, 1957; Kindle, 1962; Boyle, 1965: Murphy and Roots, 1992). These bodies range from metre-scale to hundred metre-scale in thickness (Figure 50) and can be traced from several tens of metres to several km. Typically they are chloritic phyllite on their margins and massive to foliated hornblende-plagioclase diorite to gabbro internally.

The mafic lenses are thought to be remnants of once-continuous sills that were pulled apart in the Tombstone Strain Zone. Thick, laterally continuous mafic sills substantially inflate the stratigraphic thickness of the Keno Hill quartzite in the southern Ogilvie Mountains, outside the Tombstone Strain

Figure 49. Pre-kinematic intrusive rocks of unknown age: foliated porphyritic felsic to intermediate meta-intrusion cutting Yusezyu Formation (115P/15, UTM 414175, 7082290).

Figure 50. Triassic metadiorite sill: mega-boudin of meta-diorite outlined in snow in cliff at head of MacNeil Gulch, Keno Hill map area (105M/14).

Zone (Tempelman-Kluit, 1970; Mortensen and Thompson, 1990). The Ogilvie Mountain sills are mid-Triassic in age (Mortensen and Thompson, 1990) and although there are no independent age data, it is thought that the lenses in the McQuesten River region are the same age.

Unfoliated intrusions

Unfoliated felsic to intermediate intrusive rocks occur throughout the McQuesten River region, in bodies ranging from metre-scale dykes to stocks several square km in area. Emond (1992) noted in this area that three compositionally distinct sets of intrusions occur in two geographically distinct belts. The northern belt contains biotite-hornblende quartz monzonite, granite and granodiorite and hornblende-biotite syenite, quartz syenite, quartz monzonite and granite, associated with tungsten and gold occurrences. A southern belt of intrusions comprises primarily biotite-muscovite granite, associated with tin and silver occurrences. Fine- to coarse-grained, generally porphyritic dykes are widespread, most commonly near the larger bodies. No volcanic rocks associated with either of the two sets of intrusions have been found. All intrusions and metamorphic minerals in hornfels zones cross-cut folds and foliations associated with all phases of regional deformation. The intrusions are cut by topographic lineaments of unknown age.

The two sets of intrusions differ in age. The northern set of intrusions, here called the Tombstone intrusions, are mid-Cretaceous and part of the newly defined Tombstone-Tungsten Belt (TTB), which extends eastward across the Yukon from the Tombstone River area east of Dawson to the western Northwest Territories near Macmillan Pass (Mortensen et al. 1995). The southern peraluminous intrusions are Late Cretaceous and make up the newly defined McQuesten intrusions, which so far are only known to occur, in Yukon, in the McQuesten River region. Both sets of intrusions also occur in Alaska across the Tintina Fault about 450 km to the northwest (Newberry, Layer et al. 1995; Newberry, McCoy et al. 1995; McCoy et al. 1997).

Historically, intrusive bodies have acquired informal names, either after local geographic features or after the name of a nearby mineral occurrence. In this report, bodies are named (or renamed) primarily after geographic features; the names of associated mineral occurrences are used only in the absence of local place names.

Tombstone intrusions (map unit KTg*)*

The Tombstone intrusions are the most widespread intrusions in the region and together with their hornfels zones underlie the most prominent topography in the region. The name "Tombstone Plutonic Suite" was initially applied to compositionally diverse, alkalic, undersaturated, and post-tectonic mid-Cretaceous intrusions in the Tombstone Mountains east of Dawson (Anderson, 1987). More recently, Mortensen et al. (1995) extended the name "Tombstone Phutonic Suite" to all of the mid-Cretaceous undersaturated to saturated, metaluminous, and post-tectonic intrusions that extend eastward across central Yukon to the O'Grady Batholith in the Northwest Territories.

The Tombstone intrusions in the McQuesten River region include two compositional and textural types. The first type, represented solely by the biotite-hornblende-pyroxene syenite and quartz syenite of the zoned Syenite Range stock, is quartz-absent to quartz-poor, massive and coarse-grained. This type corresponds to Emond's (1992) hornblende-biotite syenite, quartz syenite, quartz monzonite, and granite group. The remainder of the Tombstone intrusions in the region are quartz-bearing, weakly porphyritic, medium- to coarse-grained granite and granodiorite. These intrusions correspond to Emond's (1992) biotite-hornblende quartz monzonite, granite, and granodiorite group.

Tombstone intrusions occur at all stratigraphic and structural levels in the map area and the lack of textural variability suggests that most intrusions crystallized at a similar shallow crustal level. Pelitic metamorphic minerals in thermal aureoles are low pressure assemblages and include andalusite, sillimanite, cordierite, pyrrhotite, and biotite; garnet occurs in placer concentrates from streams draining aureoles, but has not been observed in metapelite. Calc-silicate minerals include diopside, actinolite, garnet, and sulfides. Miarolitic cavities occur locally (Figure 51). Contacts are sharp (Figure 52).

Many of the intrusions are associated with aeromagnetically prominent metamorphic aureoles

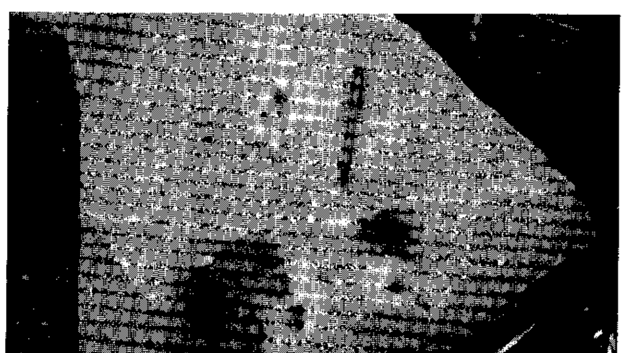


Figure 51. Tombstone intrusions: miarolitic cavities and quartz veins developed in the Scheelite Dome stock, Seattle Creek map area (115P/16, UTM 437200, 7073710).

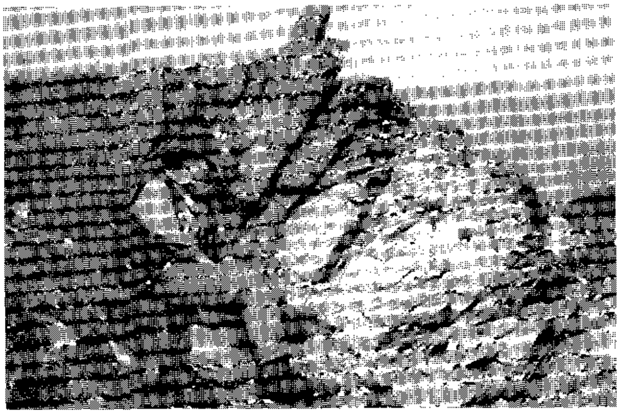


Figure 52. Tombstone intrusions: sharp discordant contact between foliated marble rocks of the Yusezyu Formation and unfoliated quartz monzonite of the Sprague Creek (Mahtin) stock. The intrusion is dark and blocky; the marble, to the right, is light-coloured. The marble's foliation and layering dip from right to left into the contact (115P/15, UTM 412505, 7089245).

ranging from under 100 m to several km wide. The aeromagnetic signature of hornfels zones is most apparent where carbonaceous rocks are intruded, such as the Earn Group (e.g., Syenite Range stock) and locally within the Yusezyu (e.g., Pukelman stock) and Gull Lake formations (Red Mountain stock). The intrusions themselves are variably magnetic.

Quartz-absent to quartz-poor type: Syenite Range stock

The Syenite Range stock (Lost Horses batholith of Abercrombie, 1990; Lost Horses stock of Murphy et al. 1993a, b) is a subcircular, concentrically zoned mafic alkaline body intruding Earn Group north of the Little South Klondike River in the Clear Creek map area (Geoscience Map 1996-1). It and its hornfels zone make up the majority of the Syenite Range, one of the more prominent massifs in the region. More than three-quarters of the stock is composed of an outer phase of massive coarse-grained, locally megacrystic, biotite-hornblende-pyroxene (both clinopyroxene and orthopyroxene) alkali feldspar syenite (Figure 53). The outer phase passes transitionally inward with increasing quartz content into coarse-grained, locally megacrystic, biotite-hornblende-pyroxene quartz syenite and then into a coarse-grained granite (Abercrombie, 1990). The contact between syenite and quartz syenite is located at the first appearance of visible quartz. The transitional quartz syenite-granite contact was not systematically mapped. A small body of muscovite-bearing orbicular tourmaline granite occurs with sharp contact within the granite; common slickensided surfaces with tourmaline striae suggest that intrusion occurred when the body was semicrystallized. Fine-grained, locally porphyritic dykes of

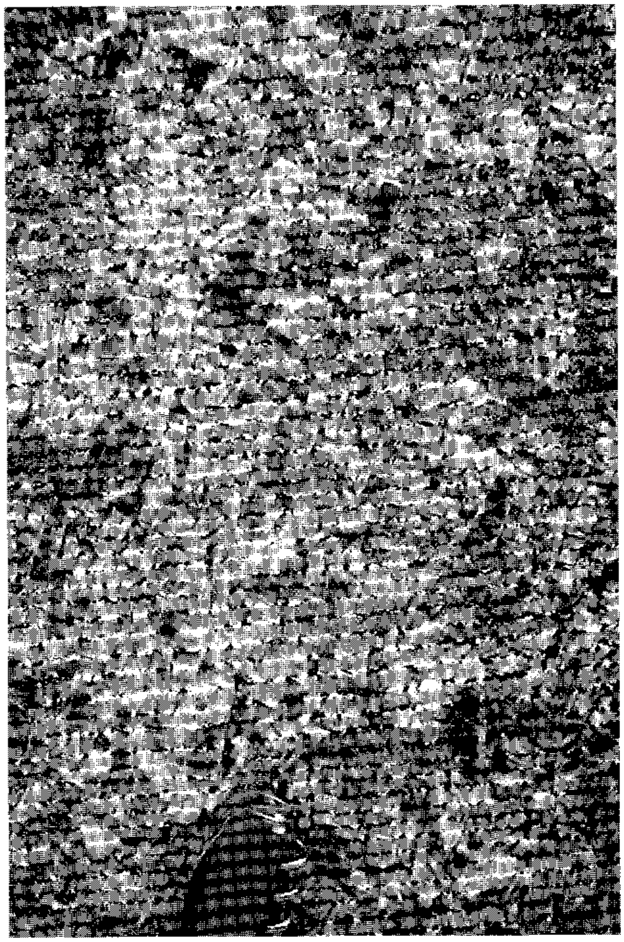


Figure 53. Tombstone intrusions: weakly aligned, crowded potassium feldspar crystals in coarse-grained hornblende-biotite-clinopyroxene syenite, Syenite Range stock (115P/14, UTM 391093, 7092871).

granitic and syenitic composition cut both the intrusion and the metamorphosed Earn Group country rock. The stock is prominently jointed with strong east-west and northeast-southwest trends visible on aerial photographs.

The Syenite Range stock contains the **Zeta** (Yukon MINFILE #115P 045, INAC, 1995) silver-tin greisen. Mineralization of this type differs from the more typical gold-tungsten-molybdenum-bismuth-silver-arsenic-antimony mineralization of other Tombstone intrusions. Weakly to strongly anomalous antimony, arsenic, molybdenum, and weak gold values occur in sediments in streams draining the western side of the intrusion.

Detailed information on the modal composition, textures, igneous geochemistry, and associated mineral occurrences of the Syenite Range stock is found in Abercrombie (1990).

Quartz-bearing type: all others

Quartz-bearing Tombstone intrusions include the West Ridge intrusions (Josephine, Pukelman, Rhosgobel, Big Creek, and Barney stocks) in the Clear Creek map area (Geoscience Map 1996-1); the Sprague Creek, Red Mountain, Ballard Creek west, and Bos stocks of the Sprague Creek map area (Geoscience Map 1996-2); the Scheelite Dome, Morrison Creek and Minton Creek stocks of the Seattle Creek map area (Geoscience Map 1996-3); and numerous smaller dykes and sills occurring in and around all the map areas. These intrusions are broadly similar mineralogically to the Syenite Range stock, but with different modal proportions. They consist primarily of massive, salt-and-pepper grey, biotite (±hornblende) granite, granodiorite, and less commonly quartz syenite with one- to three-cm-sized potassium feldspar (rarely quartz and plagioclase) phenocrysts in a medium-grained matrix of quartz, plagioclase, potassium feldspar, biotite and lesser hornblende (Figures 54 and 55). Aegerine-augite or augite is a ubiquitous minor component, commonly partly replaced by hornblende. Titanite (sphene) is also ubiquitous and locally coarse-grained (2-4 mm in size). Individual stocks are apparently compositionally and texturally homogeneous, although sufficient data were not collected to subdivide intrusions at the 1:50 000 scale. Decimetre- to metre-scale porphyritic and aplitic dykes cut both intrusions and host rocks (Figures 56 and 57).

Quartz-bearing Tombstone intrusions locally exhibit quartz ± potassium feldspar ± scheelite-sulfide veins that are commonly anomalous in gold, silver, bismuth, arsenic, tungsten, molybdenum and antimony. Veins range from cryptic 'dry' hairline cracks (Figure 58) to veins up to 5 cm in width (Figure 59) and are locally thick, extensive and dense enough to be considered as candidates for bulk tonnage gold deposits. Sulfides include arsenopyrite, molybdenite, pyrite, and chalcopyrite. Tourmaline occurs locally. Sheeted veins are most common, although stockworks have been observed (e.g., Saddle Zone of small stock northwest of the Pukelman stock, Figure 60).

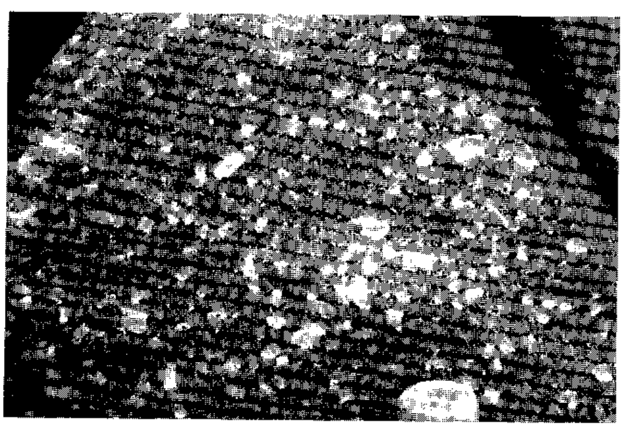


Figure 54. Tombstone intrusions: potassium feldspar porphyritic quartz monzonite, Pukelman stock, Clear Creek map area (115P/14, UTM 398300, 7083810).

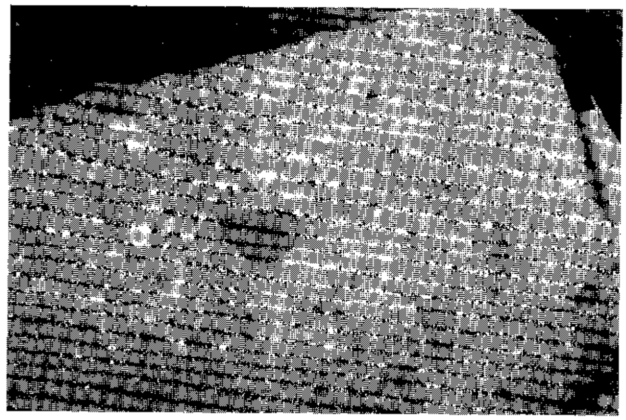


Figure 55. Tombstone intrusions: uncommon fine-grained mafic inclusions, Rhosgobel stock (115P/14, UTM 398206, 7080239).

Tombstone intrusions are locally cut by rare, punky, light grey-weathering, calcareous, brown, biotite-rich "lamprophyre" dykes (Figure 61). Ultramafic xenoliths have been observed within these dykes (Figure 62). Their spatial coincidence with Tombstone intrusions and preliminary age data suggest that these mafic dykes are part of the intrusive suite.

Alteration

Intrusions of the Tombstone Suite are commonly weakly and locally strongly altered. White mica occurs as a shreddy alteration product of potassium feldspar in most of the thin sections examined, and some calcite and epidote alteration of plagioclase feldspar has been observed. Biotite, hornblende and locally clinopyroxene are locally chloritized. The extent of the alteration within individual plutons is not known; many of the intrusions, however, have topographically recessive portions, suggesting the potential for extensive zones of strong alteration.

Geochemistry

Geochemical analyses were part of studies by Steffler (1980) on the Scheelite Dome stock, by Abercrombie (1990) on the Syenite Range stock, and by Emond (1992) on many of the intrusions in the McQuesten River region. Steffler (1980) and Abercrombie (1990) showed that the Syenite Range and Scheelite Dome stocks are characterized by high initial strontium (Sr^{87}/Sr^{86}) ratios, indicating a magma derived in large part from the melting of old sialic crust. Abercrombie (1990) also studied neodymium (Nd) and lead (Pb) isotopes from the Syenite Range stock, which affirmed a crustal magmatic source.

Figure 56. Tombstone intrusions: late felsic dyke (beneath pencil) cutting early quartz (with some potassium feldspar) vein within the Scheelite Dome stock. Uncommon, rounded, fine-grained mafic inclusion below dyke. Seattle Creek map area (115P/16, UTM 437250, 7073700).

Neodymium data suggest that up to 30% of the melt was formed from the melting of crustal material. Emond (1992) characterized those intrusions here recognized as Tombstone intrusions as felsic, poorly evolved, clinopyroxene to nepheline and corundum normative, subalkaline, and peraluminous. Emond (1992) further concluded that trace element patterns from these intrusions supported the conclusions of Steffler (1980) and Abercrombie (1990) of a sialic crustal source for the melt feeding these intrusions.

Eighteen new whole rock geochemical analyses of major, minor and trace element composition were obtained from 12 of the larger known or suspected (based on proximity to dated intrusions) Tombstone intrusions (Appendix 1). Eight new analyses of dykes were also obtained. Data from the larger dated bodies were combined with similar data from Abercrombie (1990), Emond (1992), and Steffler (1980) and plotted in Figure 63. These data show that the Tombstone intrusions are felsic to intermediate (55 to

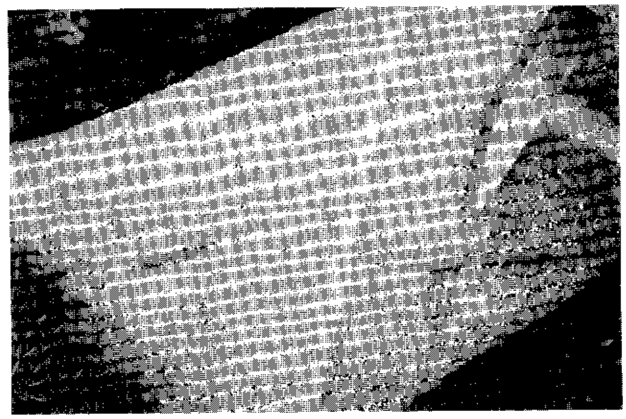


Figure 57. Tombstone intrusions: dyke-vein relationship in the Scheelite Dome stock opposite to that in Figure 56 with quartz veins cutting felsic dykes. Relationships illustrated in Figures 56 and 57 permit a late magmatic interpretation for intrusion-hosted gold-bearing quartz veins in the Tombstone intrusions (115P/16, UTM 438020, 7073200).

74% SiO_2, with most 65 to 70%), predominantly metaluminous, and calcic to calc-alkalic in composition. Normative plots show that Tombstone intrusions range in composition from syenite to granodiorite, but are predominantly monzogranite; this same range is reflected in modal mineral compositions estimated from thin sections. Harker diagrams (Figure 64) show typical major element trends with Al_2O_3, CaO, MgO, FeO*, MnO, TiO_2, and P_2O_5 decreasing with increasing SiO_2 content. K_2O and Na_2O do not vary with SiO_2.

Age of the Tombstone intrusions

High-precision U-Pb age determinations have been obtained for 15 Tombstone intrusions in and near the map area, revealing a very narrow range of ages between 90 and 94 Ma (Table 3; Figure 65; Appendix 2). The age assignments are based on

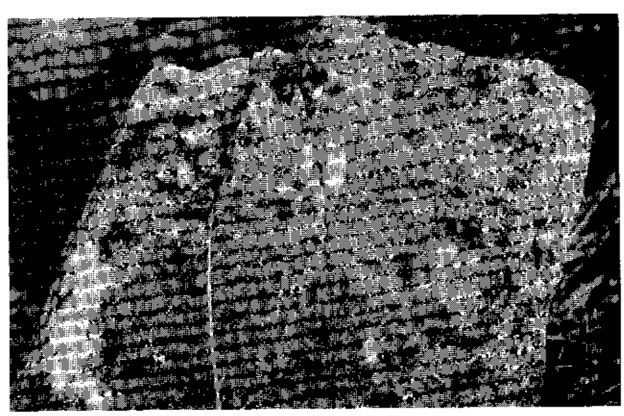


Figure 58. Tombstone intrusions: narrow quartz vein cutting potassium feldspar megacryst, Sprague Creek stock. Note thin alteration selvage extending about a centimetre into host rock (115P/15, UTM 410910, 7086350).

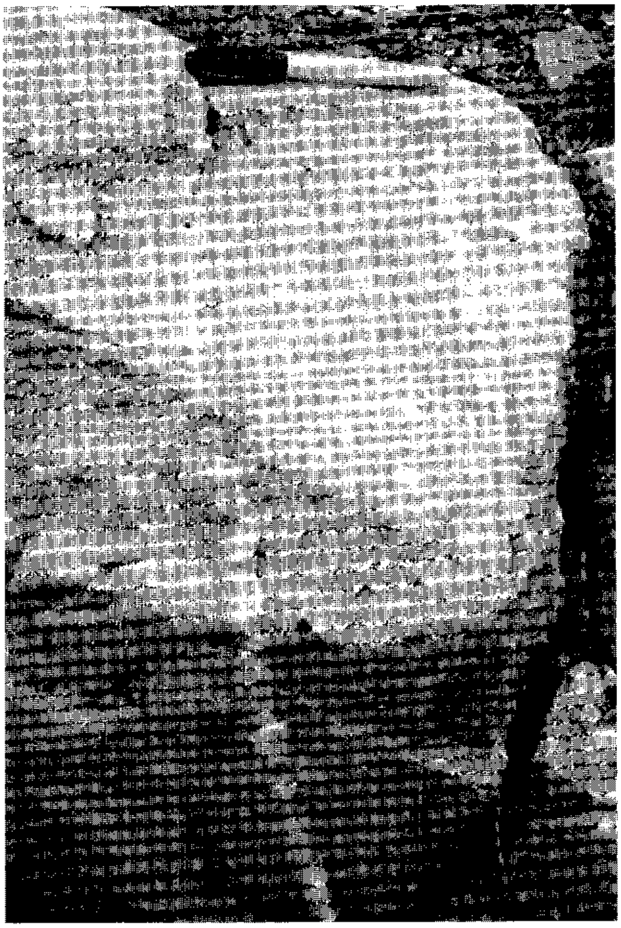


Figure 59. Tombstone intrusions: parallel sheeted quartz-potassium-feldspar (scheelite, gold, tourmaline) veins cutting the Pukelman stock (115P/14, UTM 398206, 7080239).

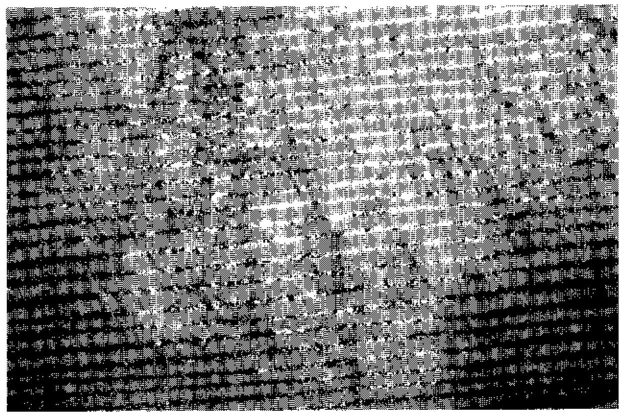


Figure 60. Tombstone intrusions: 'stockwork' of gold-bearing quartz veins, Saddle Zone, unnamed stock northwest of the Pukelman stock. Prominent vein in centre of photograph is about 3 cm wide. Larger veins form a sheeted array; later, smaller veins are more irregular and randomly oriented. Clear Creek map area (115P/14, UTM 396996, 7085700).

analyses of zircon, titanite, and baddeleyite. Age determinations based on zircon data vary in precision because of the combined effects of an inherited lead component and post-crystallization lead loss. However, with judicious sample treatment (selection for clearest, most prismatic crystals, abrasion, use of tips) and analysis of titanite and baddeleyite, high-precision concordant analyses were obtained for most samples.

Table 3. New U-Pb age determinations on Tombstone intrusions of the McQuesten River region

Intrusion	U/Pb date (Ma)	Minerals
Syenite Range stock		
marginal phase	92.1±0.2	zircon, baddeleyite
orbicular granite	90.6±0.3	zircon
Pukelman stock	91.5±0.6	titanite, zircon
Rhosgobel stock	91.4±0.3	zircon,
Sprague Creek stock	91.0±0.2	zircon
Red Mountain stock	92.3±0.8	titanite, zircon
Red Mountain dyke	91.6±0.6	zircon
Unnamed dyke near Hobo Creek	ca. 92	zircon
Bos stock	92.9±0.3	zircon
Scheelite Dome stock	91.2±0.9	titanite, zircon
Morrison Creek stock	92.5±2.5	titanite, zircon
Black Hill stock	92.3±0.3	zircon
Unnamed dyke near Secret Creek	91.0±0.3	zircon
Minton Creek stock	92.2±0.3	zircon
Dublin Gulch stock	92.8±0.5	titanite, zircon

Figure 61. An almost 2-m-wide recessive, calcareous, punky grey, biotite-rich lamprophyre cutting an unnamed stock northwest of the Pukelman stock (same stock as in Figure 60). Differentially weathered inclusions visible between the legs of the geologist on the left. Clear Creek map area (115P/14, UTM 396996, 7085705).

McQuesten intrusions (map unit KMg*)*

The McQuesten intrusions that are presently known include the Two Sisters batholith and the Vancouver Creek, Boulder Creek, Sunshine Creek and Oliver Ridge stocks. These bodies define a short east-northeast-trending belt between the Tintina Trench and Sunshine Creek. McQuesten intrusions generally comprise medium- to coarse-grained, potassium-feldspar-megacrystic, biotite ± muscovite granite and quartz monzonite. The only exception is the small Oliver Ridge stock, which is fine grained and porphyritic (quartz and potassium feldspar phenocrysts). In contrast to the topographically prominent Tombstone intrusions, the McQuesten intrusions commonly underlie low-lying ground and are dissected by some of the major drainage features. The metamorphic aureoles of the McQuesten intrusions are narrower than those associated with the Tombstone intrusions and are aeromagnetically indistinct. The lack of aeromagnetic signature is likely due to the noncarbonaceous nature of the Hyland Group country rock; all McQuesten intrusions intrude noncarbonaceous siliciclastic rocks.

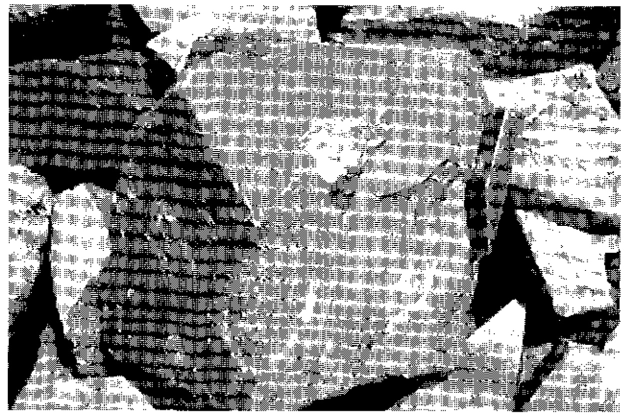


Figure 62. Ultramafic xenoliths in biotite-rich lamprophyre near location in Figure 61, Clear Creek map area (115P/14).

Typical McQuesten intrusions are composed of coarse potassium feldspar or oligoclase phenocrysts (tabular megacrysts up to several cm across, locally glomeroporphyritic clusters of both feldspars) in a medium- to coarse-grained matrix of quartz, plagioclase and potassium feldspar and biotite (Figure 66). Muscovite is a common but not ubiquitous igneous component. Rounded smoky grey quartz phenocrysts and glomerophenocrysts occur locally. Monazite is a ubiquitous accessory mineral. Composite clots of tourmaline crystals up to several cm across are common in the Two Sisters batholith and the Vancouver Creek stock.

McQuesten intrusions are spatially associated with silver-tin breccia zones (**Bix (Sunshine)**, #115P 031 and **Oliver**, #115P 023; INAC, 1995). Galena-quartz veins occur near the Vancouver Creek stock.

Geochemistry

Whole rock geochemical analyses of major, minor and trace element composition were obtained from six known or suspected (based on proximity to a dated intrusion) McQuesten intrusions ranging in size from large stocks to metre-scale dykes (Appendix 1). These data and data from Emond (1992), plotted in Figure 67, show that the larger McQuesten intrusions are predominantly felsic (60 to 75% SiO_2 with most 70 to 75%), peraluminous, and calcic in composition. Normative plots show that the McQuesten intrusions are compositionally more restricted than the Tombstone intrusions, ranging from monzogranite to granodiorite, but that they are predominantly monzogranite. Harker plots (Figure 68) of major and minor element variation with respect to SiO_2 are typical.

The peraluminous character of the McQuesten intrusions suggest that they too were the result of

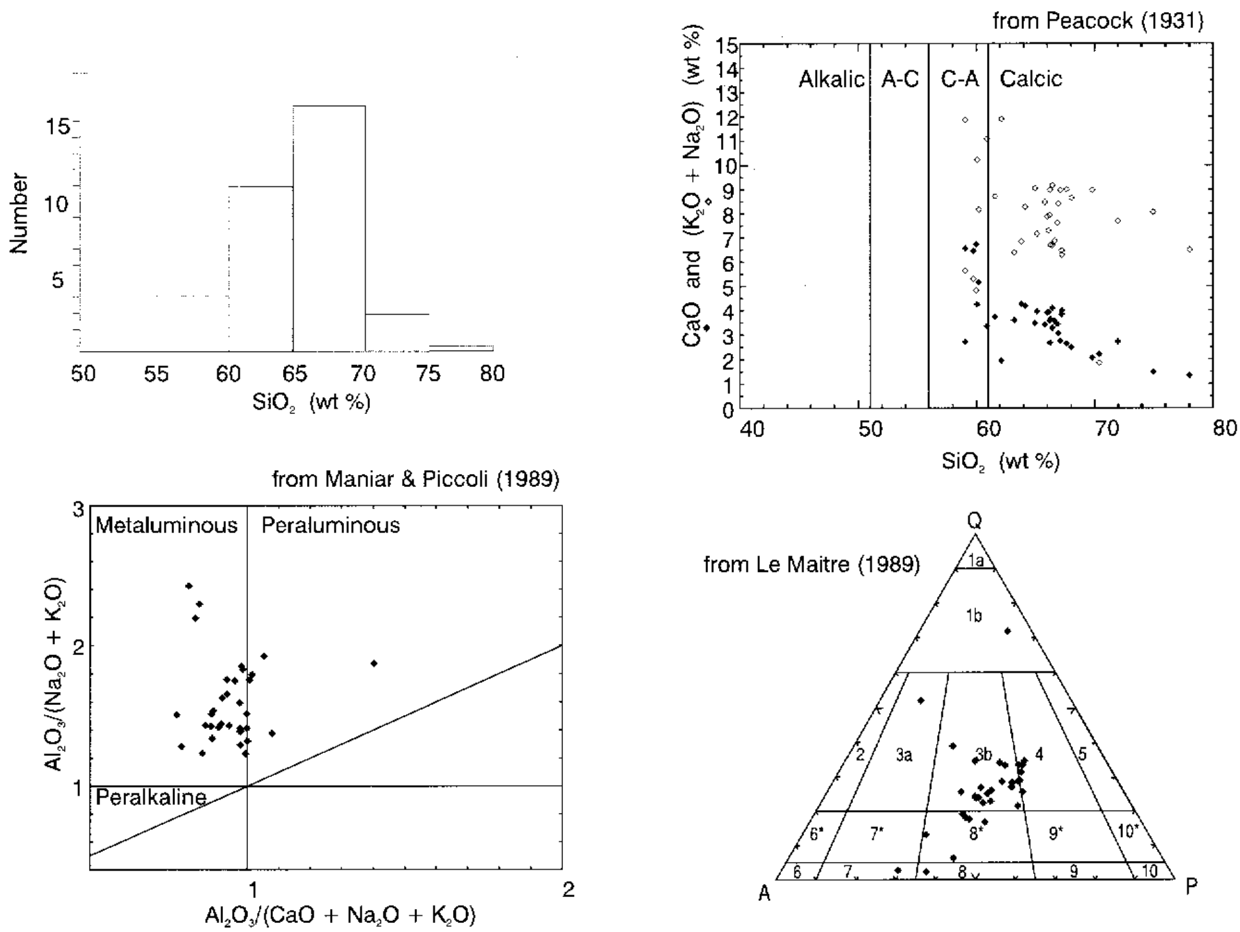


Figure 63. Plots of whole rock geochemical data used to characterize the Tombstone intrusions. Upper left, histogram of silica content; upper right, alkali-silica diagram; lower left, Shand index; lower right, modal quartz-alkali feldspar-plagioclase feldspar plot: 1a, quartzolite; 1b, quartz-rich granitoids; 2, alkali feldspar granite; 3a, syeno-granite; 3b, monzo-granite; 4, granodiorite; 5, tonalite; 6*, quartz alkali feldspar syenite; 6, alkali feldspar syenite; 7*, quartz syenite; 7, syenite; 8*, quartz monzonite; 8, monzonite; 9*, quartz monzodiorite–quartz monzogabbro; 9, monzodiorite–monzogabbro; 10*, quartz diorite–quartz gabbro–quartz anorthosite; 10, diorite–gabbro–anorthosite.

sialic crustal melting. This conclusion is supported by the ubiquitous presence of inherited lead in zircons analyzed for age determination.

Age of the McQuesten Intrusions

Five new high-precision U-Pb age determinations were obtained for the McQuesten intrusions. These fall in a narrow range from 64 to 67 Ma (Table 4, Figure 69, Appendix 2). As with the Tombstone intrusions, the pattern of discordance reflects the presence of lead inherited from the presumably sialic crustal source. Precise ages were determined using monazite analyses.

Table 4. New U-Pb age determinations on McQuesten intrusions of the McQuesten River region

Intrusion	U-Pb date (Ma)	minerals
Two Sisters batholith	64.0±0.8	monazite, zircon
Vancouver Creek stock	66.8±0.5	monazite, zircon
Sunshine Creek stock	64.8±1.0	monazite, zircon
Boulder Creek stock (south of McQuesten River)	65.1±1.1	monazite
Oliver Ridge stock	64.6±0.1	zircon

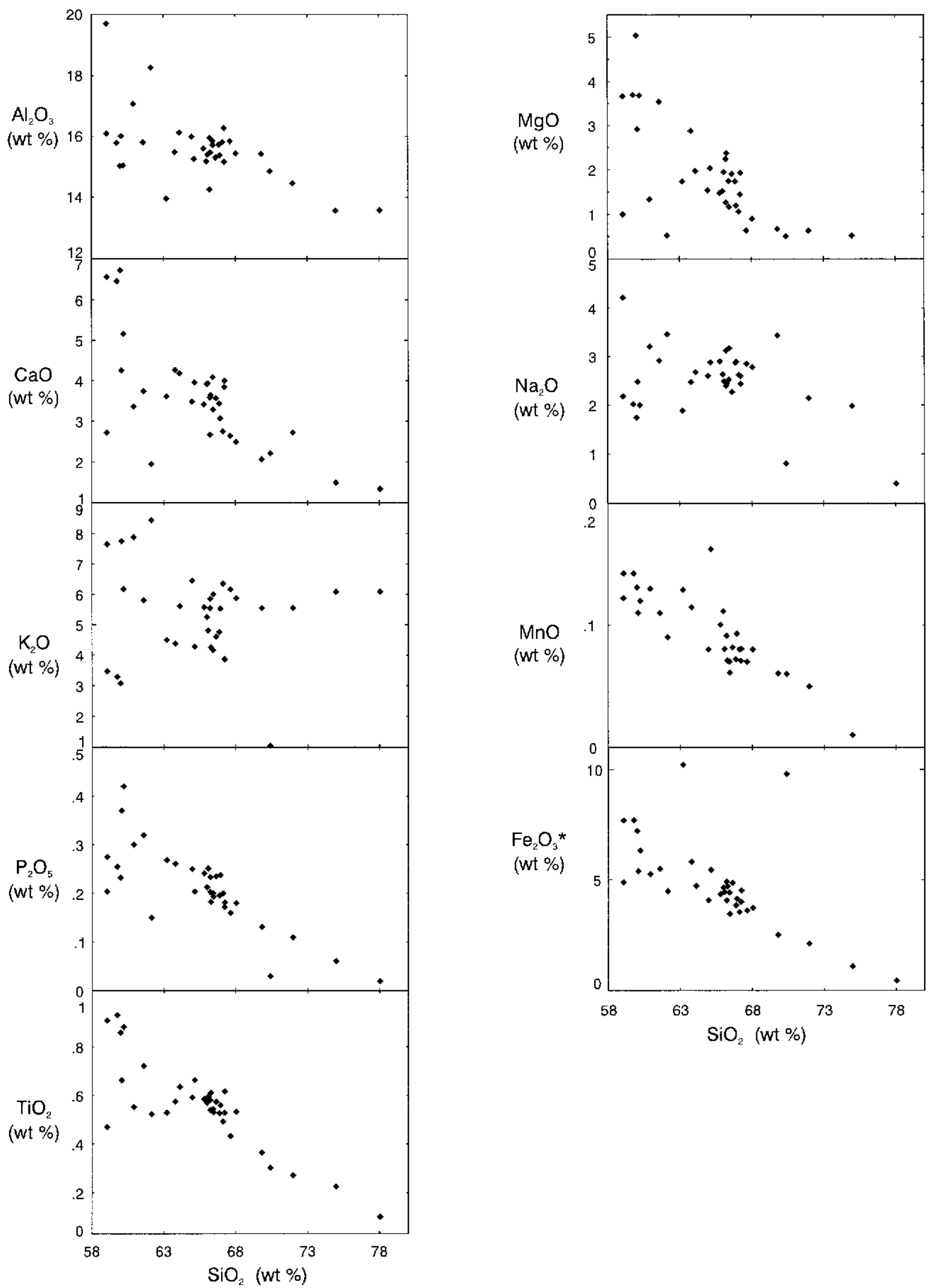


Figure 64. Harker diagrams showing trends of various oxides with increasing silica content, Tombstone intrusions.

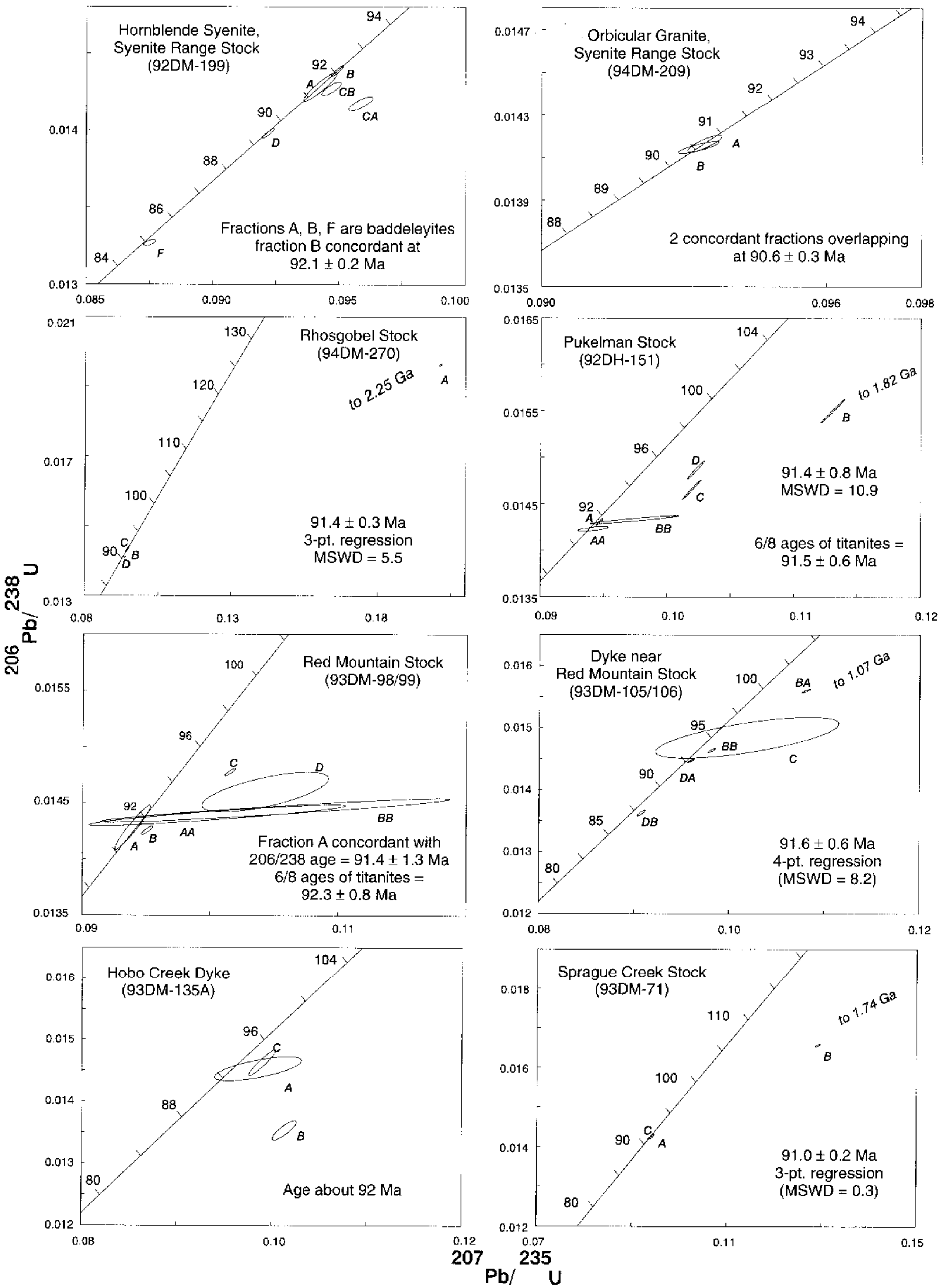
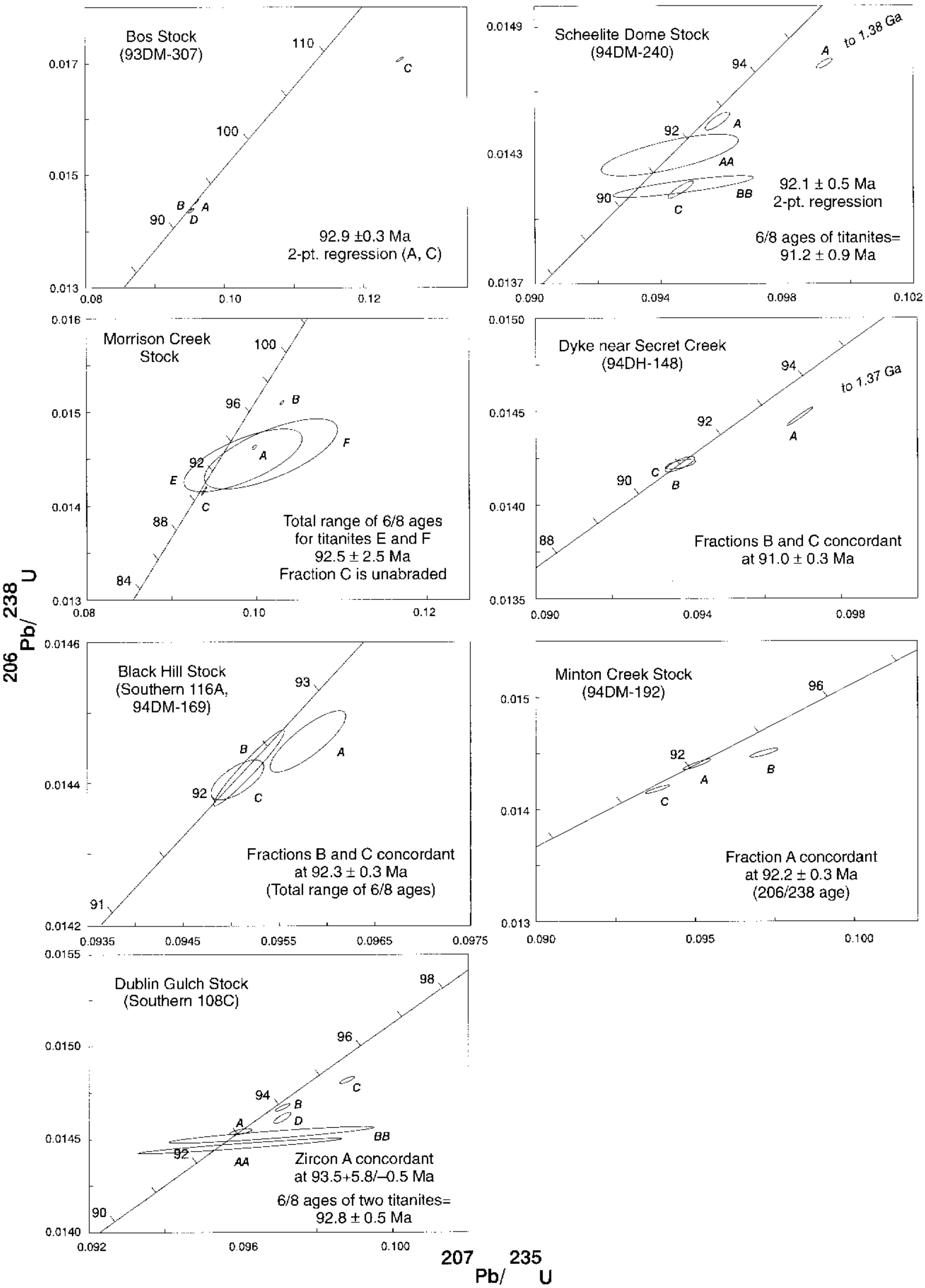


Figure 65 (this page and over). U-Pb concordia plots of age data for the Tombstone intrusions dated in this study.


Bos Stock
(93DM-307)
92.9 ±0.3 Ma
2-pt. regression (A, C)
Scheelite Dome Stock
(94DM-240)
to 1.38 Ga
92.1 ± 0.5 Ma
2-pt. regression
6/8 ages of titanites=
91.2 ± 0.9 Ma
Morrison Creek
Stock
Total range of 6/8 ages
for titanites E and F
92.5 ± 2.5 Ma
Fraction C is unabraded
Dyke near Secret Creek
(94DH-148)
to 1.37 Ga
Fractions B and C concordant
at 91.0 ± 0.3 Ma
Black Hill Stock
(Southern 116A,
94DM-169)
Fractions B and C concordant
at 92.3 ± 0.3 Ma
(Total range of 6/8 ages)
Minton Creek Stock
(94DM-192)
Fraction A concordant
at 92.2 ± 0.3 Ma
(206/238 age)
Dublin Gulch Stock
(Southern 108C)
Zircon A concordant
at 93.5+5.8/–0.5 Ma
6/8 ages of two titanites=
92.8 ± 0.5 Ma
206Pb/238U
207Pb/235U

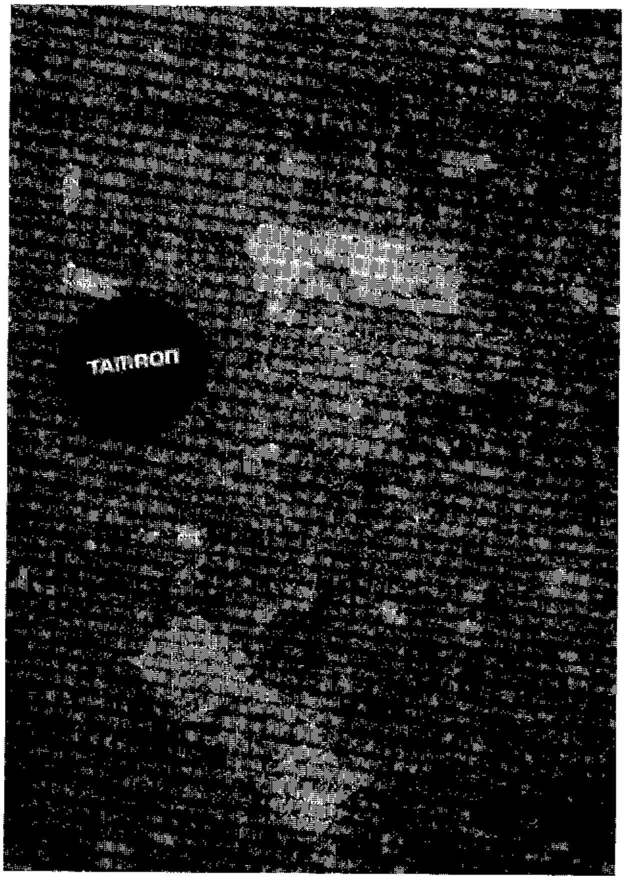


Figure 66. McQuesten intrusions: potassium feldspar megacrystic granite, Vancouver Creek stock (115P/15, UTM 403446, 7070989).

Distinguishing Tombstone and McQuesten intrusions

The two sets of intrusions are difficult to distinguish in the field because the grains of the diagnostic hornblende or muscovite are not always coarse enough to be recognized. Both sets contain prominent, locally megacrystic potassium feldspars. However, the crystal size distribution of the McQuesten intrusions is generally more distinctly bimodal. McQuesten intrusions usually exhibit large, smoky quartz phenocrysts and milky equidimensional feldspars. In contrast, feldspars in the Tombstone intrusions are generally glassier and more tabular. Tombstone intrusions generally have a bluish grey cast on fresh surfaces.

Geological setting of the Tombstone and McQuesten intrusions

The Tombstone-Tungsten Belt (TTB), of which the Tombstone intrusions are part, is one of the most laterally extensive and economically important of the mid-Cretaceous plutonic belts in the northern Cordillera. Made up of some of the intrusions belonging to the Selwyn and Tombstone Plutonic suites of Anderson (1982, 1983, 1987, 1988), the TTB extends over 600 km westward from the western Northwest Territories near Macmillan Pass to near Dawson City, Yukon, where it is truncated by the Tintina Fault. It reappears on the southwest side of the Tintina Fault, over 400 km to the northwest in east-central Alaska, and continues westward into and beyond the Fairbanks mining district (McCoy et al. 1997). Intrusions in the belt range in size from metre-scale dykes to small batholiths over 250 square km in area and are generally homogeneous, although composite and zoned varieties are not uncommon.

The TTB in Yukon is composed of two partly overlapping compositional suites. Extending from the Tintina Fault east to the O'Grady Batholith in the western Northwest Territories are the metaluminous intrusions of the Tombstone suite, including those of the McQuesten River region. The Tombstone suite is primarily composed of medium- to coarse-grained, weakly porphyritic biotite>>hornblende monzogranite but ranges from mafic syenite to granodiorite. Overlapping the eastern end of the Tombstone suite and extending to the eastern end of the belt is the peraluminous Tungsten suite. The Tungsten suite is primarily composed of biotite and biotite-muscovite granodiorite, quartz monzonite, and granite (Gordey and Anderson, 1993).

Isotopic age determinations show that the TTB intruded over a narrow time interval. Eighteen high-precision U-Pb age determinations from the western end of the Tombstone suite (Ft. Knox, Brewery Creek, several intrusions in the McQuesten River region) are between 90 and 94 Ma (Figure 70). Most K-Ar, Rb-Sr and U-Pb age determinations from the Tombstone and Tungsten intrusions at the eastern end of the belt are in this age range (Gordey and Anderson, 1993). The presence of inherited lead in zircons, the radiogenic nature of lead and strontium isotopes, and neodymium isotopic characteristics all indicate that the parent magmas of the TTB were derived in large part from the melting of continental crust. The eastward change to more peraluminous compositions might reflect increasing amounts of crustal melting associated with the eastward change from "transitional" crust underlying Selwyn Basin to continental crust underlying Mackenzie Platform.

The Tombstone-Tungsten Belt formed during the early stages in the evolution of the northern Cordillera fold-and-thrust belt. All intrusions are unfoliated and cross-cut country rock foliations formed during complex (both orogen-normal and dextral orogen-parallel) Early Cretaceous displacement on the Tombstone Thrust and associated faults (Murphy, Mortensen and Bevier, 1995). Subsequent Late Cretaceous and Early Tertiary orogen-normal shortening in the foreland regions of the fold-and-

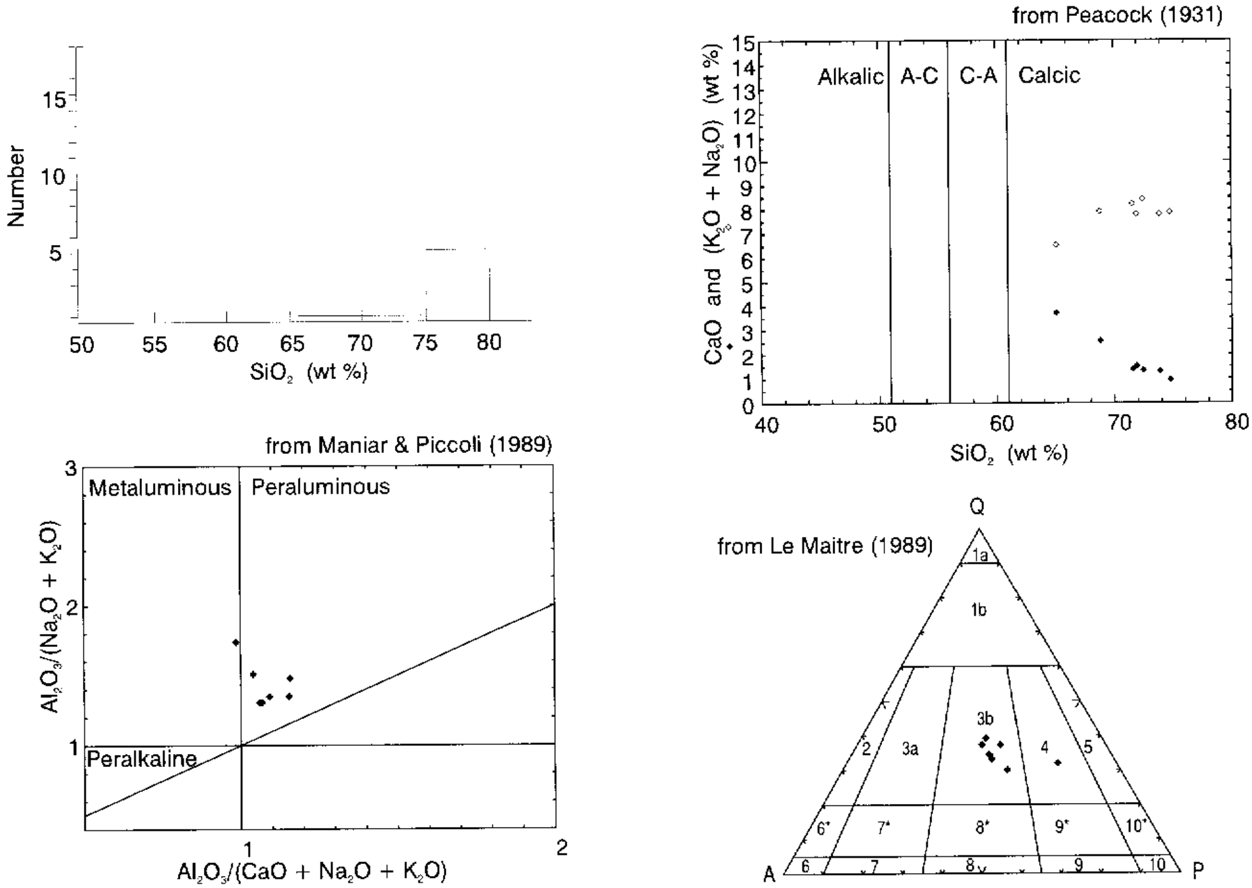


Figure 67. Plots of whole rock geochemical data used to characterize the McQuesten intrusions. Upper left, histogram of silica contents; upper right, alkali - silica diagram; lower left, Shand index; lower right, modal quartz-alkali feldspar-plagioclase feldspar plot: 1a, quartzolite; 1b, quartz-rich granitoids; 2, alkali feldspar granite; 3a, syeno-granite; 3b, monzo-granite; 4, granodiorite; 5, tonalite; 6*, quartz alkali feldspar syenite; 6, alkali feldspar syenite; 7*, quartz syenite; 7, syenite; 8*, quartz monzonite; 8, monzonite; 9*, quartz monzodiorite–quartz monzogabbro; 9, monzodiorite–monzogabbro; 10*, quartz diorite/quartz gabbro/quartz anorthosite; 10, diorite/gabbro/anorthosite.

thrust belt transported the plutonic belt northeastward from its crustal source area.

The geodynamic setting of the TTB is unclear. The belt is the innermost and youngest of three Early and mid-Cretaceous magmatic belts that are superimposed on the deformed Early Cretaceous continental margin (Mortensen et al. 1995). The relative importance of melt produced by subduction-related processes and melt produced by structural thickening and heating during crustal shortening is not known. Anderson (1988) and Woodsworth et al. (1991) proposed that the peraluminous intrusions of the Selwyn Plutonic Suite (i.e., the Tungsten intrusions) formed by crustal anatexis due to structural thickening during convergent tectonics and that the metaluminous and alkalic Tombstone Plutonic Suite (i.e., the alkalic Tombstone intrusions) resulted from subsequent extension, possibly in a strike-slip setting. Such an explanation may be valid, although as the Tombstone and Tungsten intrusions are coeval, these two tectonic settings must be active simultaneously and side by side. Recently and alternatively, Newberry and Solie (1995), Newberry, McCoy et al. (1995) and McCoy et al. (1997) presented primarily geochemical evidence in support of a continental magmatic arc origin for mid-Cretaceous intrusions of the northern Cordillera, including trace element discrimination plots (Pearce et al. 1984). Although this question cannot be resolved with current data, the influence of crustal loading might be reflected in the spatial coincidence of the TTB and the trace of the Tombstone Thrust and related faults.

The geological setting of the McQuesten intrusions is unclear. Only five intrusions of this age have been documented, all in the McQuesten River region. Similar age rocks occur in east-central Alaska, offset from the McQuesten River region along the Tintina Fault (McCoy et al. 1997). Their radiogenic, peraluminous nature suggests melting of old crustal source material; the geodynamic setting of melting at this time is essentially unconstrained.

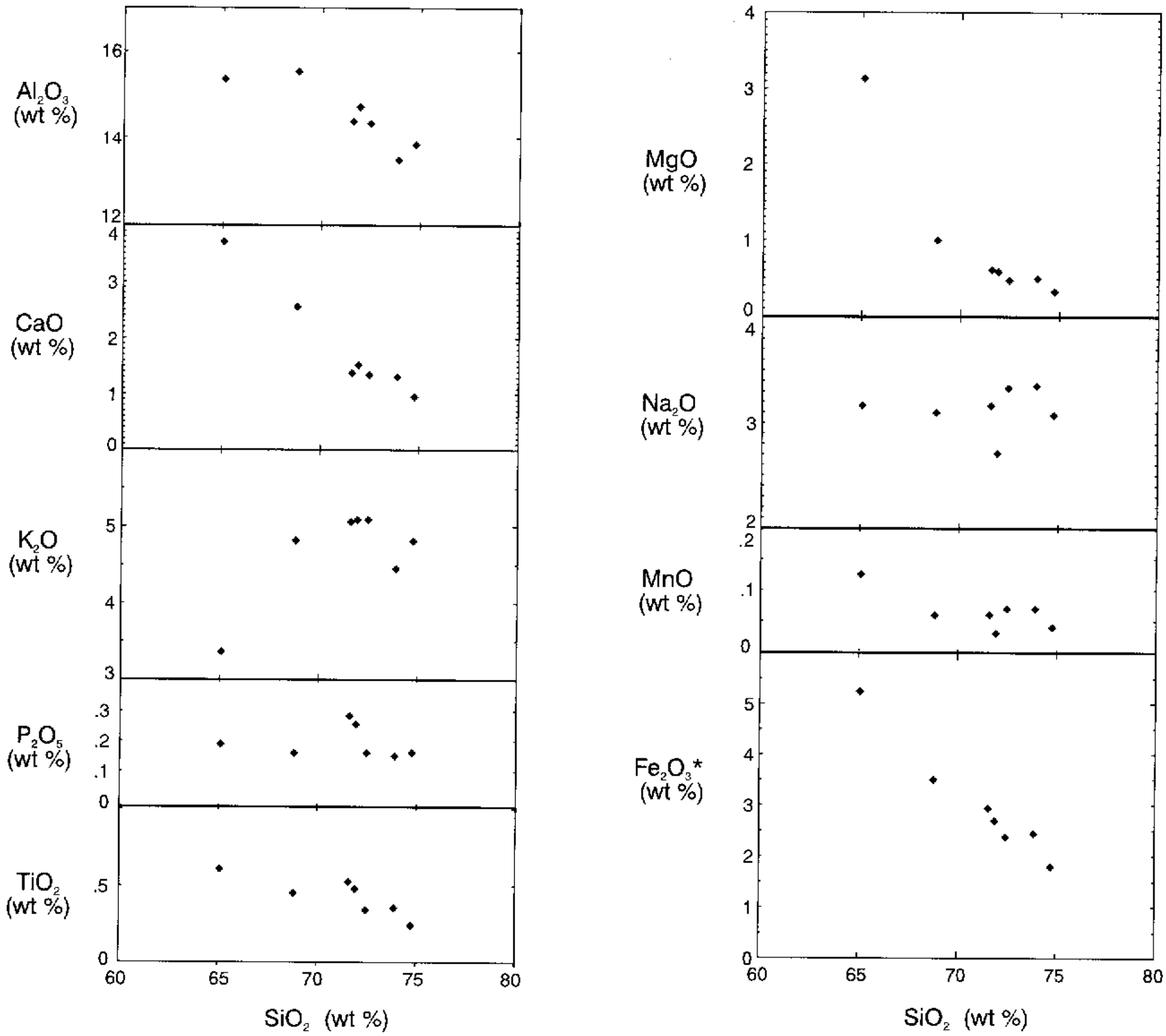


Figure 68. Harker diagrams showing trends of various oxides with increasing silica content, McQuesten intrusions.

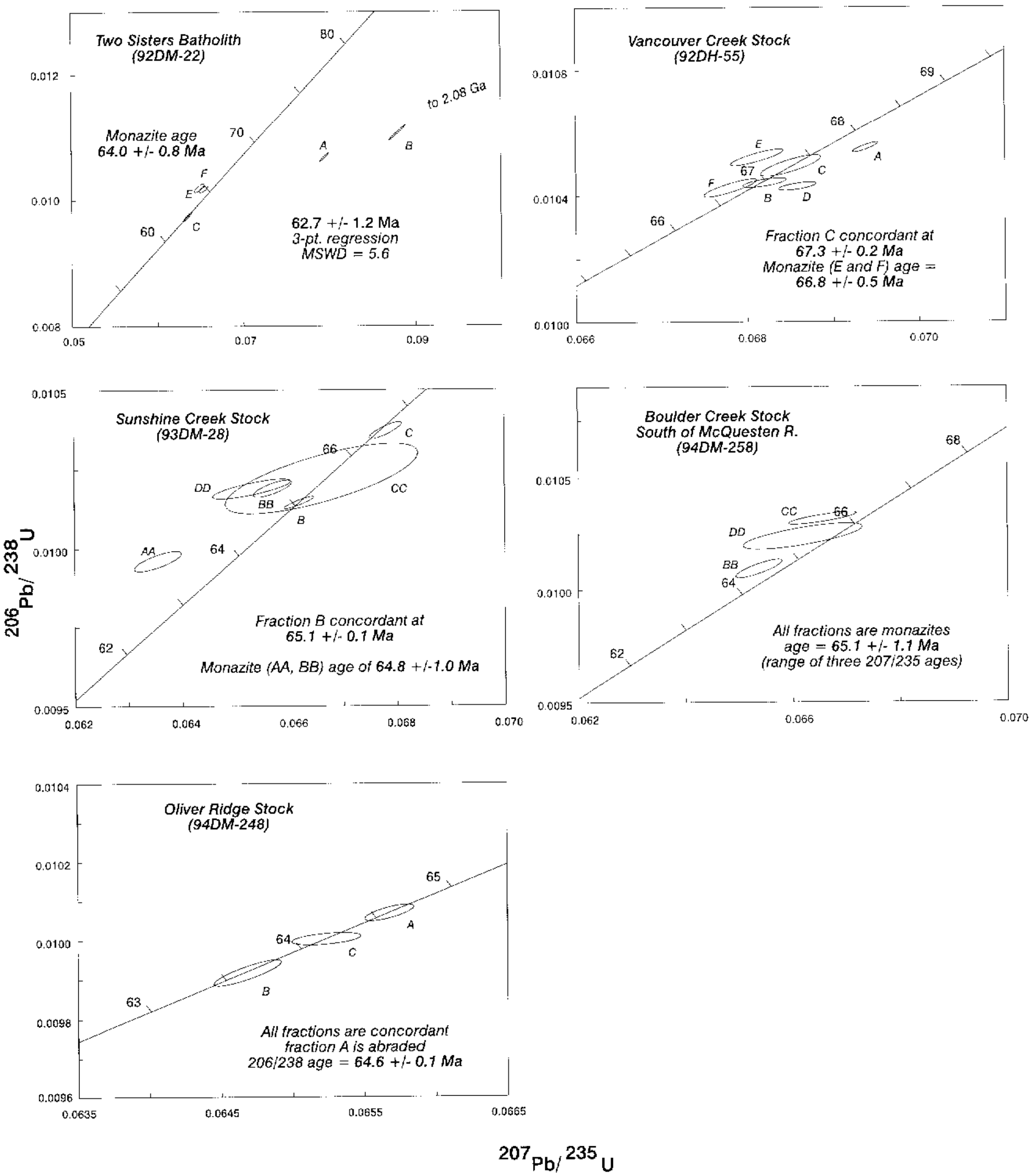


Figure 69. U-Pb concordia plot age data for the McQuesten intrusions dated in this study.

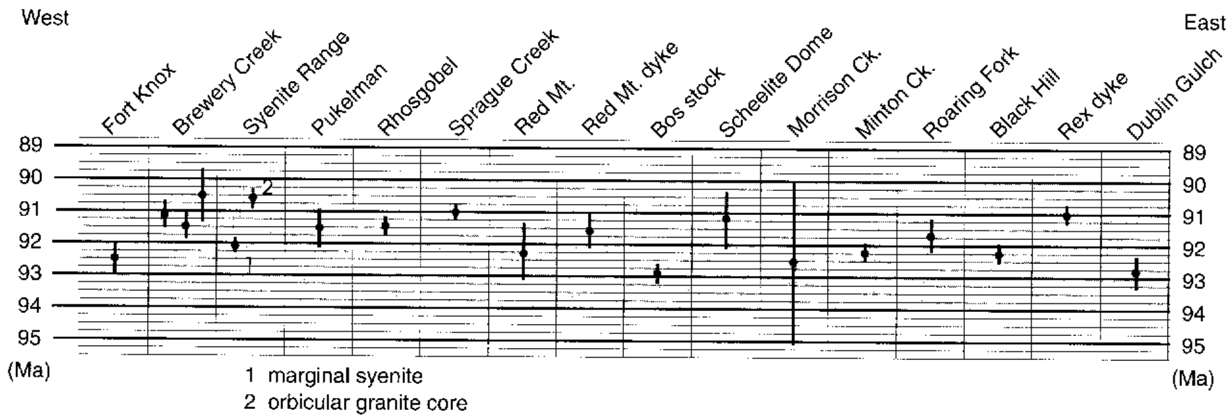


Figure 70. West (left) to east (right) variation in age of the Tombstone intrusions; paleodistance from Fort Knox to Dublin Gulch (with Tintina Trench displacement restored) is about 350 km.

Structural Geology

Rocks of the McQuesten River region exhibit a wide variety of structural features. On the outcrop-scale, rocks are ubiquitously foliated, variably lineated, and commonly show evidence of polyphase deformation. Map-scale structures include faults, strain zones, folds, and some of the larger vein-faults that are mined in the Elsa-Keno Hill district. The overall structure of the region is that of a broad, warped and faulted, southwest-trending arch of previously formed thrust sheets and associated structural fabrics, here called the McQuesten Antiform (McQuesten anticline of Bostock, 1964). Because of the antiform's moderate southwest plunge, the surface view portrays an oblique cross-section of the antiform. Deeper structural levels are exposed in the core of the McQuesten Antiform at the northeast end of the region and progressively shallower structural levels appear downplunge to the southwest. Furthermore, a fault along much of the antiform's axial-surface trace has uplifted deeper levels on its south side.

The oblique cross-sectional view displays critical relationships from which the region's structural history can be reconstructed. At the top of the structural stack on the northern limb of the McQuesten Antiform are the youngest, least deformed rocks in the region. The spatial relationships between the Rabbitkettle, Gull Lake, Narchilla and Yusezyu formations suggest a pre-Late Cambrian normal fault. Also at this level, these and younger formations are folded by west-northwest-trending, regional-scale folds that verge to the south-southwest (Lost Horses Syncline and related structures). Passing downsection, these structures are overprinted by the east-northeast-trending Tombstone Strain Zone, with structures and fabrics that, although complex, suggest early northeastward, subsequent northwestward, and late northeastward displacement of shallow structural levels with respect to deeper levels. Tombstone Strain Zone structures and fabrics also deform the Robert Service Thrust, along which the Hyland Group has been thrust over the Keno Hill quartzite. At the deepest structural levels, Devonian Earn Group strata with Tombstone Strain Zone fabrics overlie less highly deformed rocks of probable Devonian and younger age; this strain decrement is the Tombstone Thrust (Abbott, 1990a,b). Structures associated with displacement on the Tombstone Thrust are folded by open, regional-scale folds such as the McQuesten Antiform, intruded by Tombstone and McQuesten intrusions and cut by faults and fracture arrays, some of which are associated with the intrusions.

Paleozoic structures

Early to Middle Cambrian faulting: Sprague Creek Fault

A pre-Late Cambrian normal fault is inferred in the Sprague Creek map area (Geoscience Map 1996-2) on the basis of geometrical considerations and depositional relationships. The Narchilla and Gull Lake formations on the northern limb of the Lost Horses Syncline (see below) extend to the south and west around the hinge of the syncline and then trend directly into, and are truncated by, the Yusezyu Formation. Space limitations require the contact between these various rock units to be a discontinuity, here called the Sprague Creek Fault. On the northern limb of the syncline, the Rabbitkettle Formation is deposited on the calcareous clastic member of the Gull Lake Formation, while on the southern limb, the Rabbitkettle is deposited directly on top of the Yusezyu Formation, and the Narchilla and Gull Lake formations are missing. These relationships are best explained by a south-side-up normal fault, active before the deposition of the Rabbitkettle Formation (Figure 71). The location of the Sprague Creek Fault is inferred, based upon juxtaposed units, from its termination against the Rabbitkettle Formation east-southeastward to the south side of Sprague Creek where it intersects the Tombstone Strain Zone.

Mesozoic structures

South-southwest-vergent folding

Hyland Group and younger strata in the northern part of the region are folded into a regional syncline. This structure, the Lost Horses Syncline, is a composite, tight to isoclinal, south-southwestward overturned syncline outlined by the mirror-image repetition of the rock sequence and the appropriate change in vergence of parasitic folds and cleavage-bedding relationships. North of its axial-surface trace, stratigraphic sequence and facing criteria indicate that the sequence is overturned to the south; parasitic folds and cleavage-bedding relationships on this limb verge to the northeast (see Figure 10). Parasitic folds and cleavage-bedding relationships on the upright southern limb of the syncline verge to the south-southwest (Figures 72, 73). The southwest-vergent anticline-syncline pair outlined by the stratigraphically upright Rabbitkettle Formation southeast of the Syenite Range stock (Geoscience Map 1996-1) is a second-order structure parasitic on the lower limb of the Lost Horses Syncline. The axial-surface cleavage is characterized by parallel orientation of the long axes of grains in metaclastic rocks, stylolites and other pressure-solution seams in metacarbonates and

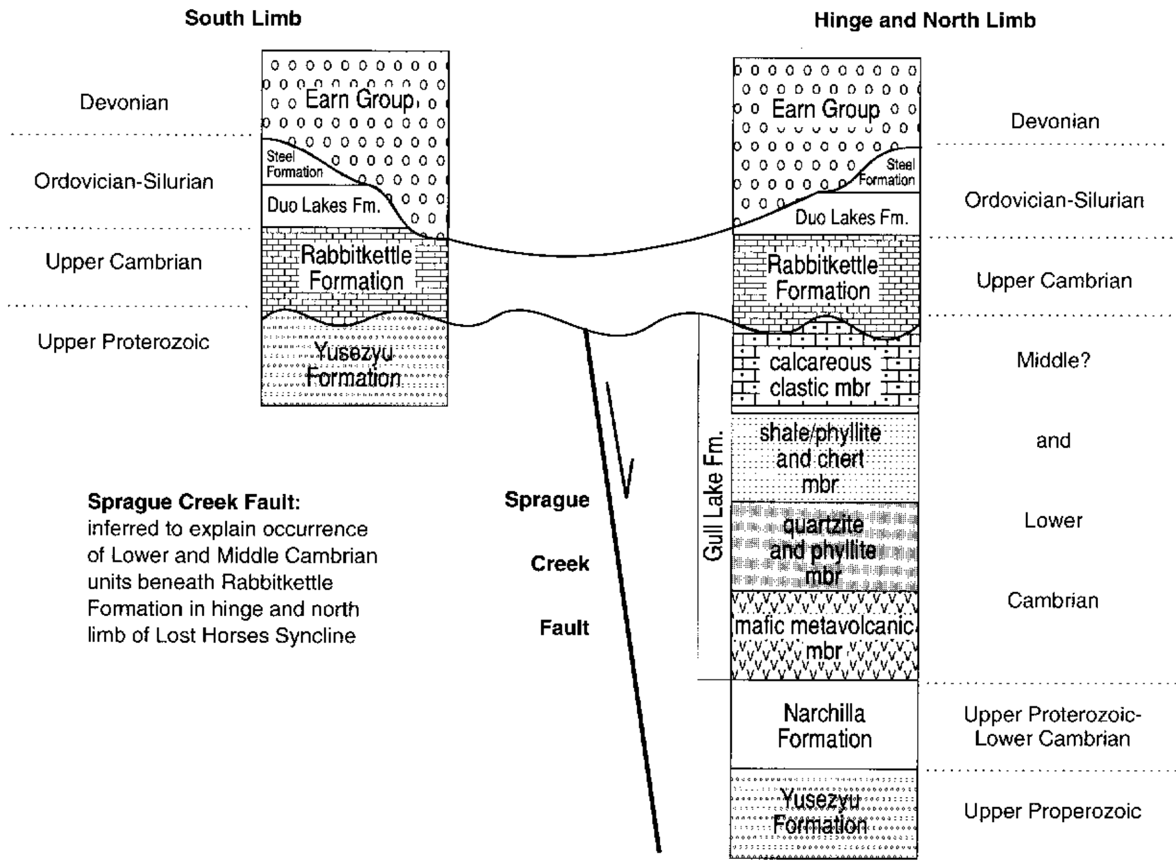


Figure 71. The stratigraphic relationships around the Lost Horses syncline used to infer the presence of the pre-Late Cambrian Sprague Creek Fault.

metapelitic rocks, and long axes of fine-grained synkinematic white mica in metapelitic rocks. A west-northwest-trending lineation defined by the intersection of bedding and cleavage occurs on bedding and cleavage surfaces.

Apart from being overturned to the south-southwest, the Lost Horses Syncline is half of a south-southwest-vergent fold pair. The complementary anticline is inferred to the north on the basis of known upright stratigraphy (Green, 1972). The interpretation of south-southwest vergence for the anticline-syncline pair is based on the vergence of second-order folds and cleavage-bedding relationships on upright fold limbs.

Figure 72. Southwest-vergent cleavage-bedding relationship developed in phyllite and meta-siltstone, Earn Group (115P/14, UTM 378009, 7087431).

Figure 73. Southwest-directed thrust fault folded by open southwest-vergent fold developed in thin-bedded limestone and calcareous phyllite, Rabbitkettle Formation (115P/14, UTM 391957, 7090136).

The age of south-southwest-vergent deformation is broadly bracketed. The youngest rocks folded by the Lost Horses Syncline are Devonian; the axial-surface trace of the syncline is intruded by the 92.1±0.2 Ma Syenite Range stock.

Robert Service Thrust

First recognized in the southern Ogilvie Mountains east of Dawson City where the Upper Proterozoic to Lower Cambrian Hyland Group is thrust over Paleozoic and Mesozoic rocks (Tempelman-Kluit, 1970a), the Robert Service Thrust has been traced eastward across the Larsen Creek map area, across the southwestern corner of the Nash Creek map area, across the northeastern corner of the McQuesten map area and the northern part of the Mayo map area (Tempelman-Kluit, 1970a; Green, 1972; Roots and Murphy, 1992a, b; Figure 1). In the McQuesten River region, the contact between the Hyland Group and the Keno Hill quartzite is the Robert Service Thrust.

The Robert Service Thrust is a discrete near-planar fault surface along most of its trace. In the Mayo map area, however, it is deformed within the Tombstone Strain Zone, the hanging wall shear zone of the underlying Tombstone Thrust. On a traverse southwest of Mt. Hinton in the Keno Hill map area (Geoscience Map 1996-5), the trace of the Robert Service Thrust was crossed several times, implying either fault imbrication or folding of the thrust surface. As the Keno Hill quartzite and underlying Earn Group are folded into tight-to-isoclinal north-east-vergent folds in this same area, the repetition of the trace of the Robert Service Thrust is inferred to be due to the same type of folding.

Neither the displacement direction nor the relationship of the Robert Service Thrust to other structural features has been determined.

The age of the Robert Service Thrust is Jura-Cretaceous, bracketed by the Late Jurassic (Oxfordian (Green and Roddick, 1962; Poulton and Tempelman-Kluit, 1982)) age of rocks in the fault's immediate footwall near the Dempster Highway east of Dawson City and a 142±6 Ma K-Ar age on muscovite in the cross-cutting Tombstone Strain Zone (J. Mortensen and D. Murphy, unpublished data). The fault is cross-cut by post-kinematic intrusions as old as the 93.0±0.6 Ma Roop Lake stock (Roots, 1997).

Tombstone Thrust and Tombstone Strain Zone

Like the Robert Service Thrust, the Tombstone Thrust is one of the more prominent structural features in central Yukon, extending eastward for over 200 km from where it was initially recognized in the North Klondike River region (Thompson et al. 1990; Figure 1). At its western end in the North Klondike River region, the thrust has a north-northeast strike and juxtaposes a stack of imbricated Mississippian to Jurassic rocks against Upper Jurassic footwall rocks. Across the southern Larsen Creek map area, the fault is east-striking, juxtaposes progressively older rocks in both hanging and foot walls, and a high-strain zone appears in the hanging wall. The thrust fault generally lies north of the McQuesten River region until the Keno Hill map area where it is inferred to underlie the Keno Ladue River valley (Roots and Murphy, 1992a; Geoscience Map 1996-5). The fault is inferred to track northeastward into Mt. Westman map area of the southeastern part of the Nash Creek map area where Abbott (1990a, b) mapped it at a dramatic strain decrement where highly deformed dark phyllite of the Earn Group in the hanging wall overlies weakly deformed dark phyllite of unknown but pre-Triassic age. The nature and trend of the Tombstone Thrust east of the Mt. Westman map area are unclear; the thrust probably links into west-northwest-striking dextral strike-slip faults of the Macmillan Pass area (Murphy and Abbott, 1995; Abbott and Turner, 1990; Roots et al. 1995a, b).

The Tombstone Strain Zone refers to a thick and areally extensive volume of highly deformed rock in the hanging wall of the Tombstone Thrust. Rock in the Tombstone Strain Zone is characterized by prominent foliations and lineations, a lenticular rather than bedded character, asymmetric boudinage, isoclinal similar folding, and generally slightly higher regional metamorphic grade than rocks outside the zone. The zone is several km thick, extending upward from the Tombstone Thrust through the Tombstone Thrust sheet into the lower part of the overlying Robert Service Thrust sheet. The Earn Group and Keno Hill quartzite of the Tombstone Thrust sheet and the lower part of the Yusezyu Formation of the Robert Service Thrust sheet are deformed in the Tombstone Strain Zone.

Less intensely deformed rocks above the Tombstone Strain Zone pass gradationally downward into the zone across a thin (<200 m thick) transition. This upper boundary, which has been traced eastward across the McQuesten River region for over 60 km, is not a physical discontinuity in this area but a narrow transition zone. The rock types of the Yusezyu Formation within the strain zone are the same as those above it, only more highly strained. Just above the boundary, the axial surfaces of south-southwest vergent folds on the southern limb of the Lost Horses Syncline are coaxially folded into north-northeast-vergent folds. Across the transition zone, bedding is gradually modified into laterally discontinuous, sigmoidal, mica-rich (phyllite) and mica-poor, quartzofeldspathic (psammite) compositional domains. A foliation defined primarily by the parallel orientation of fine-grained micas and secondarily by the shape fabric of strained clastic grains in psammite lies subparallel to the boundaries of compositional domains (S_p; Figure 74). Northwest-vergent folds of compositional layering are common, with an axial-planar foliation similar to the foliation it folds (gleitbrett folds of Green and McTaggart, 1960; McTaggart, 1960; Green, 1971; Figures 74, 75, 76). The sigmoidal shape of the compositional domains is imparted by systematic down-to-the-northwest deflection and thinning of compositional domains and foliation across discretely spaced, northwest-, southwest- or west-dipping axial surfaces (S_p'). These axial surfaces are discontinuous, merging both up- and down-dip into the main foliation (Figures 77, 78). Deeper into the strain zone, both S_p and S_p' are folded by gently inclined, neutral to south-vergent, open to tight crenulations (F_c). The intensity of folding of S_p and S_p' increases with depth and to the south to the extent that an axial-planar solution cleavage, S_c, develops and becomes the most prominent planar fabric (Figure 79). At the deepest observed structural levels in the Robert Service Thrust sheet, S_c is itself folded by gently inclined, tight, neutral to south-vergent folds (F_c+). At this level, it is impossible to distinguish different phases of folding and foliation development (Figures 80, 81). At all structural levels, S_p, S_p, and S_c contain L_p, a prominent west-northwest-trending elongation, quartz fibre, and mineral-streaking lineation (Figures 82, 83). L_p is sub-perpendicular to tension cracks and the long axes of boudins. Where S_c and later folds are prominent, hinge line and intersection lineations occur, trending slightly but consistently more westward than the west-northwest-trending L_p (Figure 84).

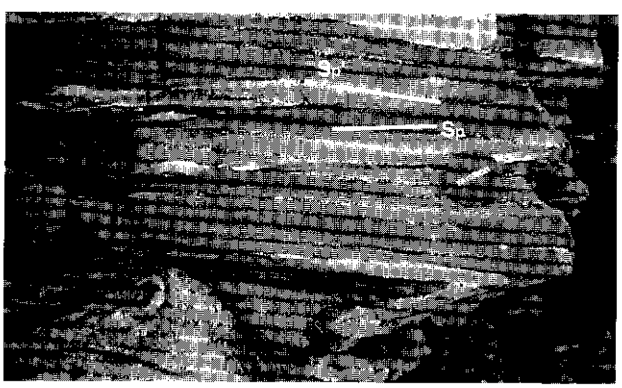


Figure 74. Tombstone Strain Zone: strongly foliated and tightly folded carbonate and phyllite in Keno Hill quartzite. Note boudinage of quartz vein at top of photo and asymmetric boudins at left of centre and beneath large boudin at top. Asymmetric boudin beneath the larger boudin at top is bounded by top-to-the-northwest shear band (S_p'). Boudins at left of centre are bounded by foliation surfaces that are axial planar to the prominent northwest-vergent fold of foliation (here S_p) and compositional layering at bottom. View is to the southwest (105M/14, UTM 491890, 7082675).

The lower part of the Tombstone Strain Zone, including the lower part of the Robert Service Thrust sheet and all of the Tombstone Thrust sheet, is characterized by most of the structural features described above, with some differences. South-vergent F_c and later folds were not observed in this domain. Instead, map-scale northeast-vergent folds (McTaggart, 1950, 1960; Green and McTaggart, 1960) of planar structural elements (S_p, S_p') and rare northeast-vergent shear zones occur. McTaggart (1950, 1960) inferred that these folds, with south- to southeast-plunging hinges, are responsible for the laterally discontinuous outcrop pattern of the Keno Hill quartzite on Keno Hill. An alternative theory was proposed by Boyle (1957, 1965), who inferred that the lateral discontinuity of the quartzite reflected stratigraphic facies changes. The present mapping (Roots and Murphy, 1992b; Geoscience Map 1996-5) shows that the base of the quartzite on Keno Hill is folded around the hinge of at least one southeast-trending and plunging, northeast-overturned isoclinal antiform. The structur-

Figure 75. Tombstone Strain Zone: isoclinal northwest-vergent folds of quartz vein cutting strongly foliated calcareous psammite in the lower Yusezyu Formation. View is to the southwest (105M/14, UTM 490705, 7078990).

Figure 76. Tombstone Strain Zone: isoclinal northwest-vergent folds of quartz veins and S_p in the Yusezyu Formation a few tens of metres above the Robert Service Thrust (115P/16, UTM 445560, 7074650).

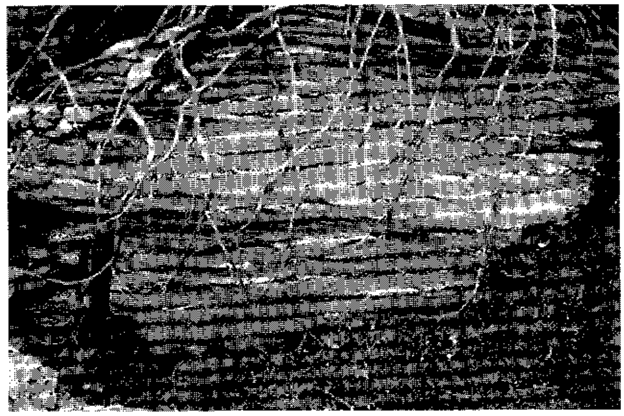


Figure 78. Tombstone Strain Zone: metre-scale, down-to-the-northwest shear band-bounded sigmoidal domain in the Yusezyu Formation about 150 m above the Robert Service Thrust (115P/16, UTM 441495, 7080400).

ally inverted limb of the antiform is characterized by southeast-trending and plunging, southwest-vergent folds ranging in scale from decimetre-scale to 1:50 000 scale (Figure 85). The inverted limb trends back toward Keno Hill where it is folded back to the southeast by a closure mapped by McTaggart (1960) east of Wernecke. The base of the quartzite passes through a second antiform-synform pair before it re-emerges into a long, structurally upright limb that strikes northeastward into the Patterson Range in the northeastern part of the Mayo map area.

Northeast-vergent folds or shear zones are responsible for the curvilinear trace of the Robert Service Thrust west of Mt. Hinton (Geoscience Map 1996-5; Roots and Murphy, 1992a, b). In this area,

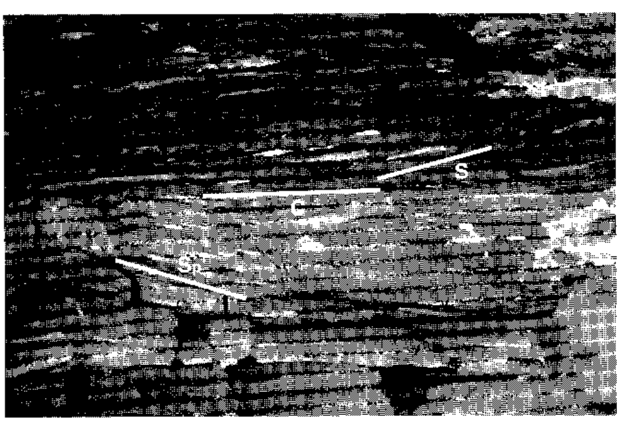


Figure 77. Tombstone Strain Zone: intensely foliated carbonate and phyllite unit within the Keno Hill quartzite. A lower lighter-coloured domain characterized by sigmoidally boudinaged quartz veins between down-to-the-northwest shear bands (S_p) is overlain by a domain of planar boudins lying within "S" foliation planes bounded by "C" planes (dark domain at top). Both classic structures indicate top-to-the-northwest shear parallel to the northwest-trending streaking and elongation lineation contained within all foliations (105M/14, UTM 490705, 7078990).

the trace of the Robert Service Thrust is repeated, either by folding or imbrication along thrust faults or shear zones. As continuous folds of the base of the Keno Hill quartzite are documented a few km away to the northeast, folding is preferred as the mechanism by which the trace of the Robert Service Thrust was repeated in this area.

The structural fabrics of the Tombstone Strain Zone and their sequence of development are typical of those documented in well studied shear zones elsewhere and can be used to infer a sense of displacement across the zone (Figure 86). S_p' planes are morphologically identical to shear bands or extensional crenulation cleavages. The relationship of L_p to boudinage, tension cracks, and shear bands suggests that it is parallel to the direction of finite extension and is therefore likely to closely approximate the sense of displacement across the shear zone. The sense of inclination of S_p' to S_p consistently indicates top-to-the-northwest displacement parallel to L_p (McTaggart, 1960; Abbott, 1990a, Roots and Murphy, 1992b). This sense of displacement is further supported by the sense of truncation of L_p fibres on S_p, the vergence of asymmetric folds of compositional layering, the sense of subtle obliquity of tension cracks to L_p, the geometry of rare sigmoidal tension gash arrays, and difference in style of deformation of differently oriented pre-and syn-kinematic veins.

The northeastward vergence of folds in the upper transition into the zone and in the lower part of the zone and the southward vergence of F_c and F_{c+} folds at intermediate levels do not easily fit into a model of northwest-directed displacement. Perhaps the upper set of northeast-vergent folds reflects early northeast-directed (cratonward) displacement that is progressively overprinted by later northwest-directed fabrics and the lower set of northeast-vergent folds reflects

Figure 79. Tombstone Strain Zone: asymmetric south-vergent F_c folds of S_p with spaced S_c cleavage developed on short limbs. S_c is sub-parallel to S_p on long limbs making it difficult to distinguish the two fabrics where hinges are absent. View is to the west. Yusezyu Formation just above the Robert Service Thrust (105M/14, UTM 491675, 7080800).

re-establishment of cratonward vergence. The southward vergence of F_c and F_{c+} might reflect lateral ramping within the zone resulting in the formation and subsequent strain of obliquely inclined fabrics.

The age of displacement on the Tombstone Thrust and Tombstone Strain Zone is Jura-Cretaceous, constrained by the Late Jurassic age of the youngest rocks in the immediate footwall of the thrust near the Dempster Highway east of Dawson City (Oxfordian (Green and Roddick, 1962; Poulton and Tempelman-Kluit, 1982)) and the 93.0±0.6 Ma age of the Roop Lakes stock, the oldest unfoliated intrusion to cut fabrics of the Tombstone Strain Zone (Murphy, Mortensen and Bevier, 1995). Muscovite in the Tombstone Strain Zone yielded a 142±6 Ma K-Ar age (J. Mortensen and D. Murphy, unpublished data).

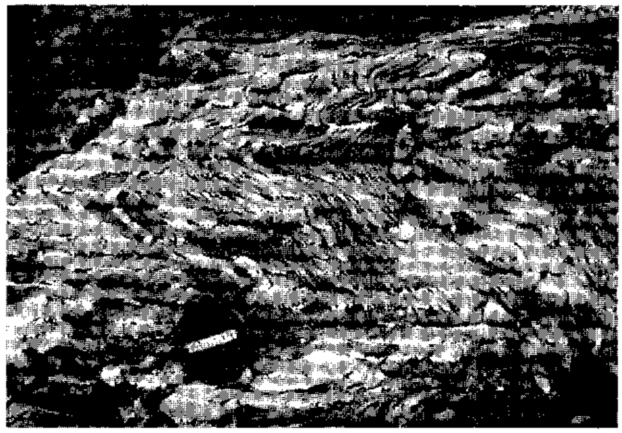


Figure 80. Tombstone Strain Zone: F_{c+1} folds of S_c in the lower Yusezyu Formation. Prominent fabric being folded is a domainal crenulation cleavage formed by the folding of S_p (see Figure 81; 115P/15, UTM 404750, 7079780)

McQuesten Antiform

The McQuesten Antiform is a broad, faulted, west-southwest-plunging arch of older planar features including bedding, the Robert Service and Tombstone thrusts, and foliations of the Tombstone Strain Zone. North of the axial-surface trace, planar elements dip predominantly to the north-northwest, and south of the axial-surface trace, planar elements dip predominantly to the south-southeast (Figure 87). The antiform's axial-surface trace lies in the South McQuesten River valley between a point north of Elsa and the confluence of the North and South McQuesten rivers (Geoscience Maps 1996-1 to 1996-5). Southwest of the confluence, the axial-surface trace trends northwestwardly out of the valley and, after a few kilometres, returns to its southwestward strike. The axial-surface trace has been mapped along this trend to the southwest corner of the Sprague Creek

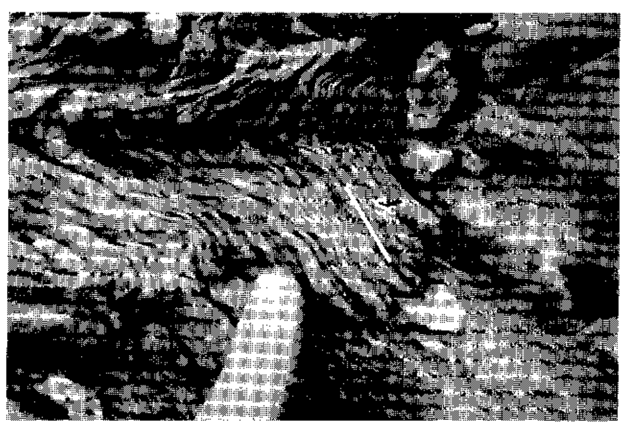


Figure 81. Tombstone Strain Zone: closer view of portion of Figure 80 showing that the prominent fabric being folded is S_c. S_p is visible between spaced S_c cleavage about 2 cm just above the fingertip at the bottom of the photo (115P/15, UTM 404750, 7079780).

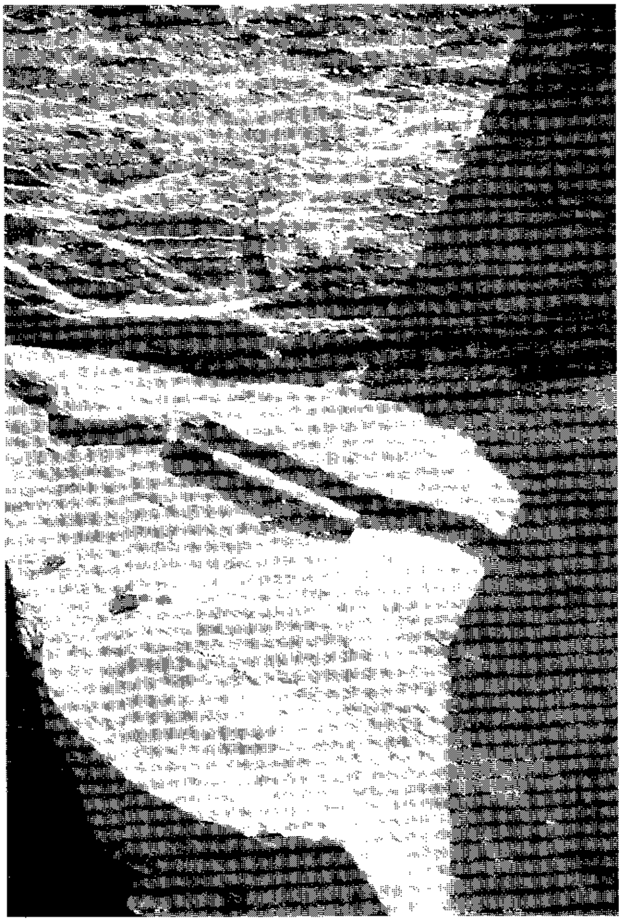


Figure 82. Tombstone Strain Zone: prominent mineral-streaking lineation (L_p) on S_p foliation surface. Note subtle cracks normal to the lineation and open F_c fold of S_p beneath eraser. Hinge of F_c fold is inclined at about 40 degrees to L_p (115P/15, UTM 404750, 7079780).

map area, where it loses definition in a region of subhorizontal orientations.

The axial-surface trace of the McQuesten Antiform is inferred to be faulted by a south-side-up reverse fault along much of its trace in the Keno Hill, Mt. Haldane and Seattle Creek map areas (Bostock, 1947; Tempelman-Kluit, 1970; Green, 1971). As a simple cylindrical fold cannot completely account for the distribution of Keno Hill quartzite on both sides of the McQuesten River and there is no evidence of a more complex fold style, the fault interpretation is accepted here. If present, however, the fault extends only as far as the confluence of the North and South McQuesten rivers because there is no evidence of a fault where the axial-surface trace is exposed west of the North McQuesten River.

The McQuesten Antiform and associated fault are considered to be out-of-sequence structures splaying off the Tombstone Thrust. The antiform is inferred to be a fault-propagation fold associated with

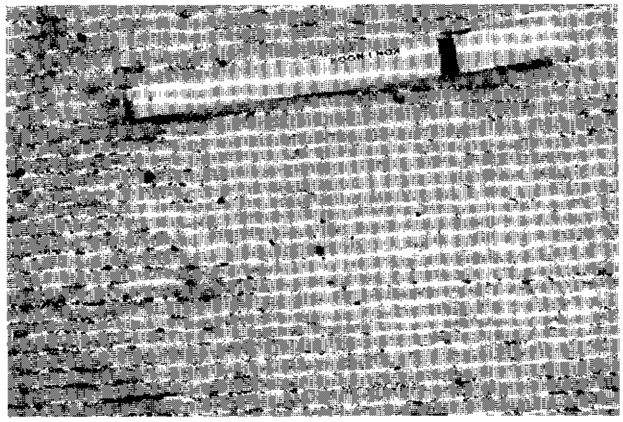


Figure 83. Tombstone Strain Zone: clast-elongation lineation (L_p) in S_p foliation. Elongate light-coloured domains are feldspar clasts in pebble metaconglomerate, Yusezyu Formation (115P/16, UTM 441690, 7080560).

and breached by the fault. The fault is inferred to branch off the Tombstone Thrust near the divide between the McQuesten and Keno Ladue rivers in the Keno Hill map area. It is inferred to lose displacement to the southwest, ultimately dying in the continuous closure of the McQuesten Antiform.

The moderate plunge of the McQuesten Antiform is somewhat steeper than that typical for a fault-propagation fold in a fold-and-thrust belt setting. One explanation is that the plunge increased during displacement on younger, structurally deeper thrusts. In such a scenario, ramps and other variations in the shape of underlying thrust surfaces or variations in the thickness of the underlying thrust sheet induce distortion in higher thrust sheets as those sheets mould to the shape of the underlying rocks. The latter situation may apply in the case of the McQuesten Antiform. In the Davidson Range along

Figure 84. Tombstone Strain Zone: view of top of S_p foliation surface exhibiting L_p (arrow with NW at head) and L_{pxc}, the lineation defined by the intersection of S_c and S_p, systematically inclined about 35° counterclockwise from L_p, similar to F_c hinge line in Figure 82 (115P/16, UTM 438760, 7071150).

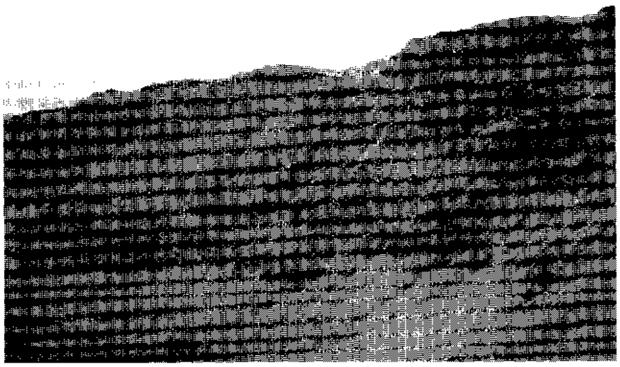


Figure 85. Tombstone Strain Zone: southwest-vergent fold on overturned limb of larger northeast-vergent fold of Keno Hill quartzite, deep structural levels of the Tombstone Strain Zone. View is to the south of cliff-face on south side of major tributary of Glacier Creek, sharing a drainage divide with Allen Creek, east side of the Keno Hill map area (105M/14).

the trend of the McQuesten Antiform, the footwall of the Tombstone Thrust is thicker than elsewhere because of the unusual occurrence of a thick, isoclinally folded (northwest-vergent, Green and McTaggart, 1960) section of Keno Hill quartzite in the thrust's footwall. This thicker section would have caused the overlying thrust sheet to arch as it moved on underlying thrusts, increasing the plunge of any structure on the flanks of the arch. The McQuesten Antiform and Mayo Lake Antiform (Bostock, 1947; Roots, 1997) both plunge moderately and radially away from the Davidson Range, further attesting to the influence of this structurally thickened section on the development of these structures.

The age of the McQuesten Antiform and associated fault is broadly Jura-Cretaceous. It is bracketed loosely by the 142±6 Ma age of Tombstone Strain Zone fabrics folded by the antiform and the 92.9±0.3 Ma age of the cross-cutting Bos stock in the Sprague Creek map area. The age of the McQuesten Antiform plunge development is not known, but if associated with displacement on younger thrusts below the Tombstone Thrust, it could have formed at any time between the formation of the McQuesten Antiform and the Early Tertiary cessation of thrusting in the fold-and-thrust belt.

Other folds of Tombstone Strain Zone fabrics

In addition to the McQuesten Antiform, smaller, somewhat disharmonic, long-wavelength, low-amplitude folds deform Tombstone Strain Zone foliations. The strike of Tombstone Strain Zone foliations changes continuously from east-west to northeast-southwest, to northwest-southeast across the study area, on both limbs of the McQuesten Antiform (Figure 87). Dip domain boundaries are narrow and sharp and strike predominantly north but range from northeast to northwest. Dip domain boundaries locally branch along their traces suggesting a box-fold shape. Neither their age nor their relationship, if any, to the McQuesten Antiform are known.

Steeply dipping crenulations of Tombstone Strain Zone foliations are ubiquitous in the study area. The variety of orientations preclude simple relationships of these small structures to regional-scale changes in orientation of Tombstone Strain Zone foliations.

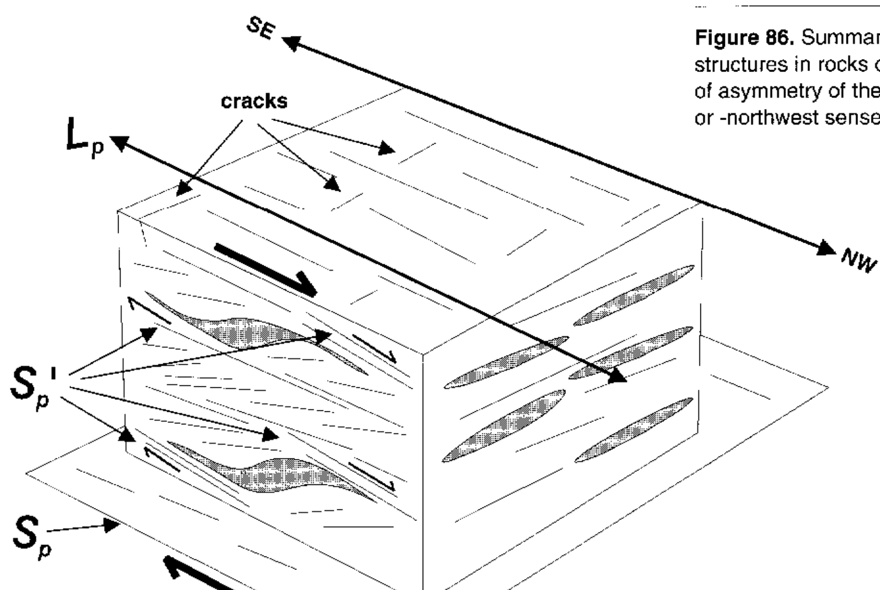


Figure 86. Summary diagram illustrating outcrop-scale structures in rocks of the Tombstone Strain Zone. The sense of asymmetry of these features indicates a top-to-the-west or -northwest sense of displacement for the strain zone.

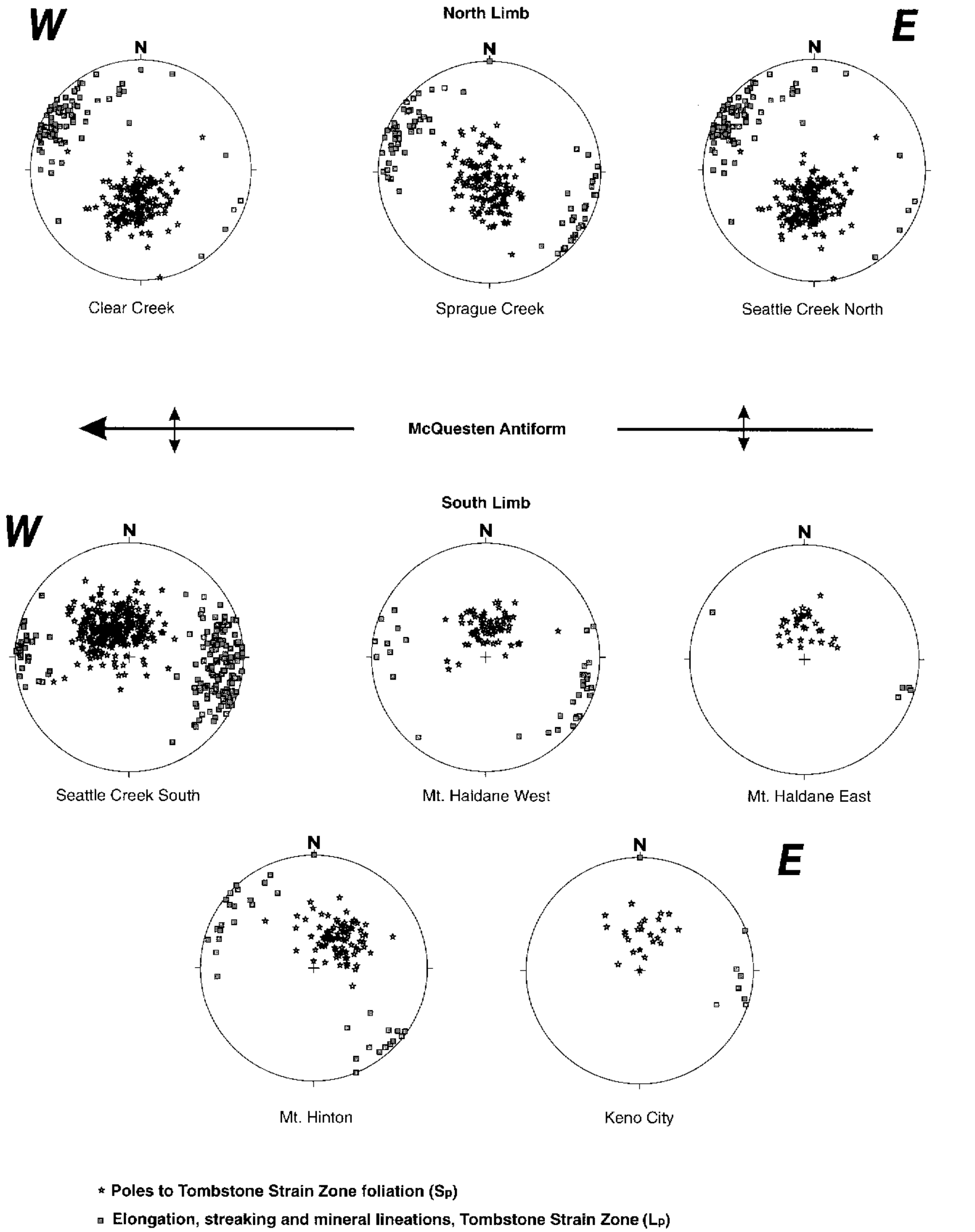


Figure 87. Equal-area stereoplots of measured orientations of the prominent foliation (S_p) and lineation (L_p) characterizing the Tombstone Strain Zone. The north to south change from north-dipping to south-dipping foliations in the McQuesten River region defines the McQuesten Antiform. East to west variations in orientation of S_p also occur, defining late warps of the Tombstone Strain Zone.

Structures associated with emplacement of Tombstone intrusions

Various structures within and near the Tombstone intrusions are thought to be coeval with intrusion. These include mineralized (quartz ± arsenopyrite, pyrite, chalcopyrite, molybdenite, scheelite, stibnite, potassium feldspar) late-magmatic veins within intrusions and dyke-filled fractures, veins, breccia zones, faults and fracture zones around intrusions. Intra-intrusion veins range in width from 'dry' fractures to decimetre-scale and are variably spaced. Potassium feldspar-rich alteration envelopes occur around some veins. Sheeted systems (Figure 59) are more common than stockworks (Figure 60); sheeted systems have a wide range of orientations although east-southeast trends seem most common (Figure 88). A late-magmatic relative age for veins is inferred from their mineralogy and mutual cross-cutting relationships with dykes (see Figures 56, 57).

Dykes up to about three m thick occur around the Tombstone intrusions. Individual dykes are most common but clusters have been noted east of the Sprague Creek and Rhosgobel stocks. Dyke orientations are variable but, like syn-intrusive veins, east-southeast trends seem most common (Figure 88).

Faulting, intense fracturing, brecciation and quartz veining in the host rock are found around several stocks. The western and northern contacts of the Sprague Creek stock in the central Sprague Creek map area are northeast- to east-striking north-side-down normal faults (Geoscience Map 1996-2). These faults cannot be traced beyond the immediate area of the stock and might have been formed to accommodate emplacement of the stock. Small dykes around the Pukelman and Rhosgobel stocks in the Clear Creek map area are surrounded by quartz-vein-injected Hyland Group (Figures 89, 90). Quartz-injected country rock is found locally around the Morrison Creek stock in the Seattle Creek map area. Southeast of a small unnamed stock north of Hobo Creek (BX claims) in the Sprague Creek map area is a zone about 2 km wide of fracturing, oxidation and quartz veining in the Narchilla Formation. Tourmaline veining is common nearer the intrusion; pervasively tourmalinized and brecciated country rock occurs just northeast of the intrusion (see under Stratigraphic Units, section on Bostock's (1964) map unit 18). Brecciation, tourmalinization and faulting also occur in the northern part of the Seattle Creek map area peripheral to an unnamed stock in the southern Larsen Creek map area (**Black Hill** occurrence). These occurrences are discussed in more detail under Mineral Occurrences.

The most extensive area of deformation yet identified around the Tombstone intrusions is around the Scheelite Dome stock in the southeast corner of the Seattle Creek map area. Hyland Group rocks around the stock are cut by a zone of fracturing and alteration locally containing quartz-arsenopyrite mineralization. The deformation zone encompassing brittle features around the Scheelite Dome stock strikes approximately east-west, is several km wide and extends at least as far as the width of the Seattle Creek map area. Veins, vein-faults, and fractures

Figure 88. Equal-area stereoplots of measured orientations of Tombstone intrusion-hosted quartz veins and Tombstone dykes intruding metasedimentary host rocks.

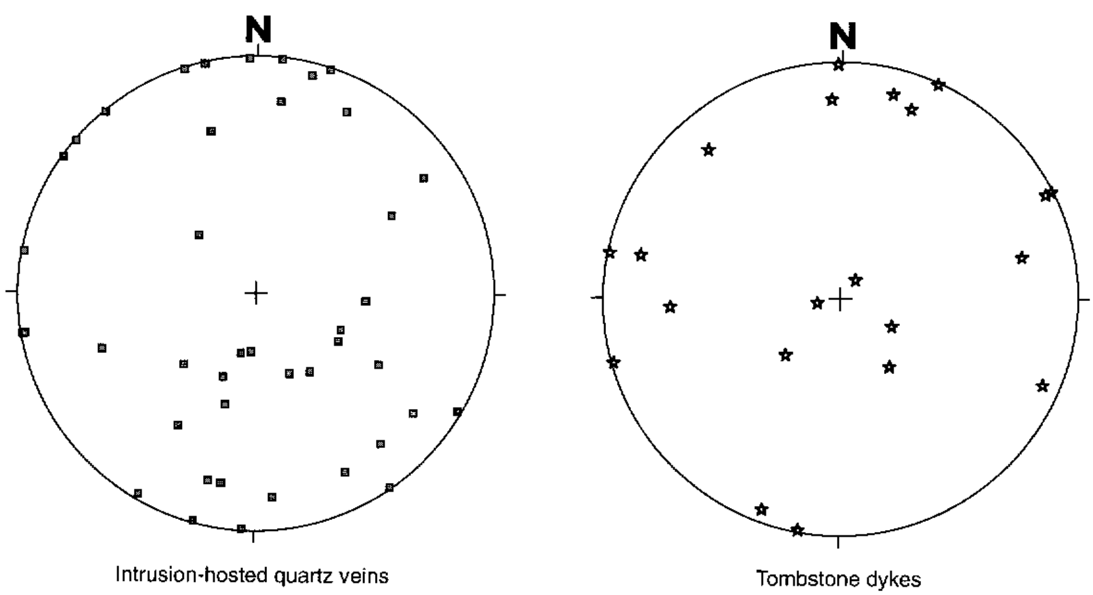


Figure 89. Quartz vein arrays cutting coarse sandstone, grit and pebble-conglomerate of the Yusezyu Formation northwest of Pukelman stock (115P/14, UTM 391694, 7086882).

within the zone occur in a variety of orientations. The **Hawthorne** vein-fault (#115P 003, INAC, 1995) is a northwest-striking, northeast-dipping normal fault; smaller veins in the zone strike west-southwest and range from shallow to steeply northwest dipping (SC claims between Bennett and Highet creeks, **Highet** occurrence, #115P 033, INAC, 1995). Vein geochemistry is similar to the geochemistry of veins in the Scheelite Dome stock.

Veins in the brittle deformation zone around the Scheelite Dome stock are cut by an array of north- to northwest-striking faults marked by pronounced topographic lineaments. These faults have slickenlines and other features in gouge zones indicating normal down-to-the-west displacement (Figures 91, 92). Quartz-arsenopyrite mineralization locally occurs in the gouge zones and for that reason, these faults are tentatively thought to be part of the array of structures associated with the Tombstone intrusions. Alternatively, this mineralization may have been remobilized from earlier veins by post-Tombstone intrusion faulting (see last section before Mineral Occurrences).

Faulting in the Elsa-Keno Hill mining camp

Silver-lead-zinc mineralization in the Elsa-Keno Hill mining camp (Keno Hill and Mt. Haldane map areas) occurs in north-northeast- to east-northeast-striking, steeply southeast-dipping vein-faults lying within a 23-km-long, six-km-wide, northeast-striking belt. Mineralized vein-faults (Figure 93) cut Earn Group, Keno Hill quartzite and Triassic meta-diorites on the south-dipping limb of the McQuesten Antiform; the richest deposits are found in vein-faults cutting the Keno Hill quartzite. Boyle (1965) documented the productive vein-faults known at that time; much of the following description is derived from his classic work.

Figure 90. Quartz veins cutting lineated grit of the Yusezyu Formation (115P/16, UTM 445570, 7074650).

Vein-faults in the Elsa-Keno Hill camp are brittle displacement zones that exhibit complex variations in style along their length. Along the vein-fault structure, narrow discrete planar fault segments pass into zones of tensional veining or zones of comminuted and shattered rock, brecciation, and stockwork veining. Early-formed vein minerals are commonly deformed and recemented by subsequent mineralization, attesting to contemporaneous mineralization and faulting. Northeast-striking "longitudinal" vein-faults are commonly networks of discontinuous structures and displacement is thought to transfer to other "longitudinal" vein-faults via more north-striking extensional transfer zones defined by "transverse" veins and vein-faults. Vein-faults are commonly ornamented by more north-striking laterally tapering apophyses (hangingwall and footwall breaks, M. Phillips, pers. comm. 1995) containing a gold-bearing quartz-pyrite-arsenopyrite mineral assemblage rather than the typical siderite-quartz-galena-sphalerite assemblage of the vein-faults. Boyle (1965)

Figure 91. North-striking down-to-the-west normal fault and associated fracture array offsetting quartz-arsenopyrite veins, DH showing on Ben occurrence near Highet Creek (115P/16, UTM 444218, 7071667).

determined that, on the scale of the entire camp, the gold-bearing veins formed early in the mineralization sequence, pre-dating the main silver-lead-zinc veins. Vein-faults also commonly splay into south-dipping foliation planes.

A number of features indicate that the vein-faults result from sinistral displacement with an oblique normal component (McTaggart, 1960). Longitudinal vein-faults are left-stepping through transverse vein and vein-fault arrays; an oft-quoted example is the transfer between the Main Fault and No. 6 deposits through the No. 9 vein and vein-fault array on Keno Hill (Lynch, 1989a and references therein). Slickenlines on exposed transverse vein-faults of the No. 9 array indicate normal, down-dip displacement. Longitudinal vein-faults have prominent gently northeast-plunging slickenlines on steep southeast-dipping footwalls; fibre truncations indicate that the south side moved northeastward and downward. As well, hanging wall and footwall quartz-pyrite-arsenopyrite veins can be interpreted as early en echelon tension

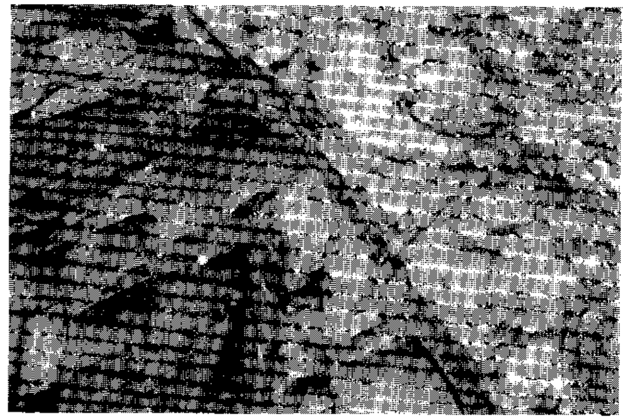


Figure 92. Down-to-the-west normal fault in highly fractured Yusezyu Formation near the Scheelite Dome (115P/16, UTM 439450, 7072670).

gashes that slightly pre-dated the main vein-faults; their orientation is compatible with sinistral-oblique normal displacement.

The variation in style of deformation within the vein-fault structures is readily explained by an initial anastamosing trace. Right-stepping bends will be deformed in a sinistral system by compressional structures: gouge, comminution, shattering, thrust faulting, development of strike-slip duplexes. At left-stepping bends, dilation will occur and normal faults and tensional veins would be expected to form.

Other structures that are probably coeval with vein-faulting in the Elsa-Keno Hill camp include the north-striking fault inferred to underlie the valley of Mud and Haldane creeks and the similarly oriented fault hosting the silver-lead-zinc mineralization in Bighorn Creek west of Mt. Haldane (Geoscience Map 1996-4). The sinistral and dextral apparent offsets along these structures can be explained by down-to-

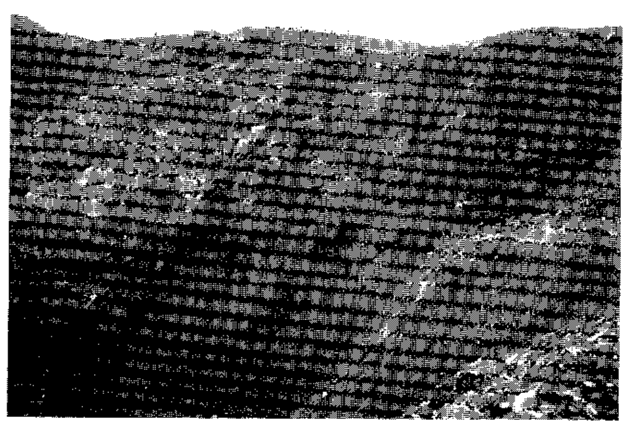


Figure 93. Steeply southeast-dipping Keno-Hill-style vein-fault, 115 pit, Galena Hill. View is along strike to west-southwest. Massive Keno Hill quartzite above and below vein-fault, which lies in dark rubbly zone in centre of photo (105M/14).

the-east and down-to-the-west normal faults, isolating the Mt. Haldane massif as a horst. Normal faulting on north-striking faults is compatible with the overall sinistral nature of the Keno Hill zone.

Post-mineralization faulting occurs within the Elsa-Keno Hill mining camp, on both the mineralized vein-faults and on two sets of nonmineralized faults. Cross-faults strike west-northwest to north-northwest; vein-faults are offset in such a way as to indicate normal and dextral senses of displacement. Post-mineralization displacement on "bedding" — probably foliation surfaces — is also described (McTaggart, 1960; Boyle, 1965; Watson, 1986; Lynch, 1989a).

The age of the Keno Hill vein-fault system and possible relationship to plutonism is an important unresolved question. Germane to this issue are the following geological relationships: 1) vein-faults cut and therefore post-date Tombstone Strain Zone fabrics; 2) vein-faults cut across dip domain boundaries formed during late warping of Tombstone Strain Zone fabrics; 3) vein-faults likely post-date the McQuesten Antiform as they occur on both limbs with similar orientations and structural characteristics; the veins could pre-date the plunge of the McQuesten Antiform, however (see under Mineral Occurrences); 4) vein-faults cut variably altered porphyritic intrusions that are locally associated with gold mineralization (e.g., **Wayne** occurrence, #105M 029, INAC, 1995), and although undated are likely to be Tombstone intrusions approximately 92 Ma in age; 5) K-Ar whole rock dates on wall rock adjacent to vein-faults are 85-90 Ma (Sinclair et al. 1980); and 6) the evolution from early gold-bearing quartz-pyrite-arsenopyrite tension gashes to silver-lead-zinc-bearing, siderite-galena-sphalerite-quartz veins is similar to that observed at the nearby Dublin Gulch intrusive-hosted gold deposit where early Au-Bi-As-W-bearing quartz veins are overprinted by sericitic alteration and associated lead-zinc veins (H. Smit, pers. comm. 1995). These factors together suggest that the Elsa-Keno Hill vein-faults formed during the cooling of the Tombstone intrusions, after the intrusion of at least some Tombstone dykes and emplacement of higher temperature gold-bearing fluids into en echelon tension gash arrays.

If the Elsa-Keno Hill vein-faults formed during cooling of the Tombstone intrusions, the regional state of stress must have changed from that present during the emplacement of the Tombstone intrusions. Syn-intrusive veins and dykes consistently hover around east-west strikes, parallel to the overall orientation of the TTB, implying regional north-south dilation. In contrast, sinistral displacement on the northeast-striking Elsa-Keno Hill vein-faults implies a north-trending, moderately north-plunging principal compressive stress, nearly perpendicular to the principal compressive stress necessary to cause the north-south dilation. A north-trending principal compressive stress would be compatible with northward displacement on younger thrust faults that outcrop in the fold-and-thrust belt to the north and northeast.

Structures associated with emplacement of McQuesten intrusions

East-northeast-striking silver- and tin-mineralized breccia zones are spatially associated with the McQuesten intrusions in the Sprague Creek map area (Emond and Lynch, 1992; Emond, 1985). Silver-tin-bearing quartz-tourmaline-chlorite veins and breccias cut the Yusezyu Formation and granite within a 2-km-wide, east-northeast-striking zone of intense fracturing along the northwestern margin of the Sunshine Creek stock (**Bix (Sunshine)** breccia occurrences, #115P 031, INAC, 1995). Fractures are steeply dipping and are not ornamented by slickenlines, suggesting an origin in which hydrothermal fluids filled dilatational fractures of purely tensional origin. Similar breccias occur peripheral to the Boulder Creek stock southeast of the South McQuesten River (Figure 94; **Oliver**, #115P 030, INAC, 1995; Emond, 1985; Emond and Lynch, 1992).

Structures of unknown age post-dating McQuesten intrusions

The youngest set of structures in the McQuesten River region are undated faults and topographic lineament swarms. North-trending linear stream segments and topographic features occur throughout the Clear Creek, Sprague Creek and Seattle Creek map areas (Figure 4). Linear features range from northeast- to northwest-striking and vary in spacing. The closest spacing occurs in the western part of the

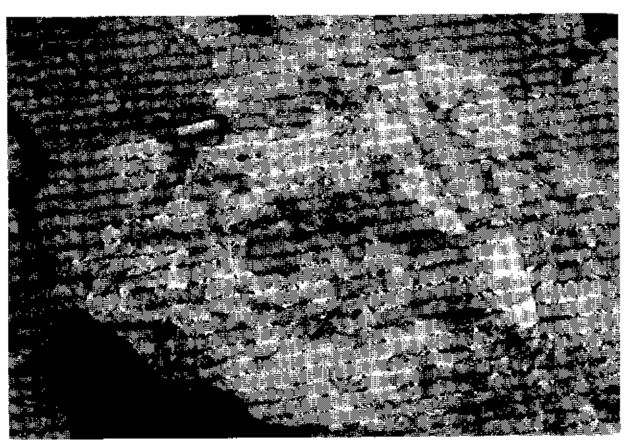


Figure 94. Quartz-cemented breccia made up of clasts of Yusezyu Formation country rock and vein quartz, West Zone trench, Oliver occurrence (115P 030; 115P/15, UTM 424571, 7070856).

Sprague Creek and the eastern part of the Clear Creek map areas, along and in a north-northwest-striking zone straddling the Josephine Creek Fault and linking segments of the fault. Two discontinuous segments of the fault have been mapped, both having an apparent offset of about 2 km. The segment in Josephine Creek offsets stratigraphic contacts and the segment in Forty Mile Creek offsets the axial-surface trace of the McQuesten Antiform. Between these two segments is a north- to northwest-striking, en echelon array of closely spaced topographic linear features inferred to be an extensional transfer zone. These linear features coincide on the ground with vuggy, rusty, silicified breccias locally anomalous in gold (see under Mineral Occurrences). Linear features occurring outside of the zone straddling the Josephine Creek Fault are less closely spaced and do not seem to be associated with a master structure.

The age of these features is unknown. The Sunshine Creek and Boulder Creek stocks are cut by prominent northwest-trending lineaments showing that at least some of the lineaments are younger than about 65 Ma. No younger age bracket exists.

As previously discussed, the age of the north-striking faults and topographic lineaments around the Scheelite Dome stock in the southeastern part of the Seattle Creek map area is not known. They are tentatively thought to be associated with the Tombstone intrusions because mineralization along them shares a common geochemical signature with intrusion-hosted mineralization. However, it is equally plausible that faulting post-dates the Tombstone-age mineralization and remobilized the earlier mineralization. Until these structures are dated, their age and relationship with other lineaments in the region is speculative.

Mineral Occurrences

A great number and variety of mineral occurrences have been discovered in the McQuesten River region (Figure 95, Table 5) since the late 1800s and early 1900s. Aho (1963) recognized the extent and variety of mineralization and the great potential of this region, calling it the McQuesten Mineral Belt. Of the 195 total mineral occurrences recorded in Yukon MINFILE for the entire Mayo and McQuesten map areas (INAC, 1995; 115P, 105M; including the 51 occurrences under the United Keno Hill Mines holdings), 152 are from the five map sheets of the McQuesten River region described in this study.

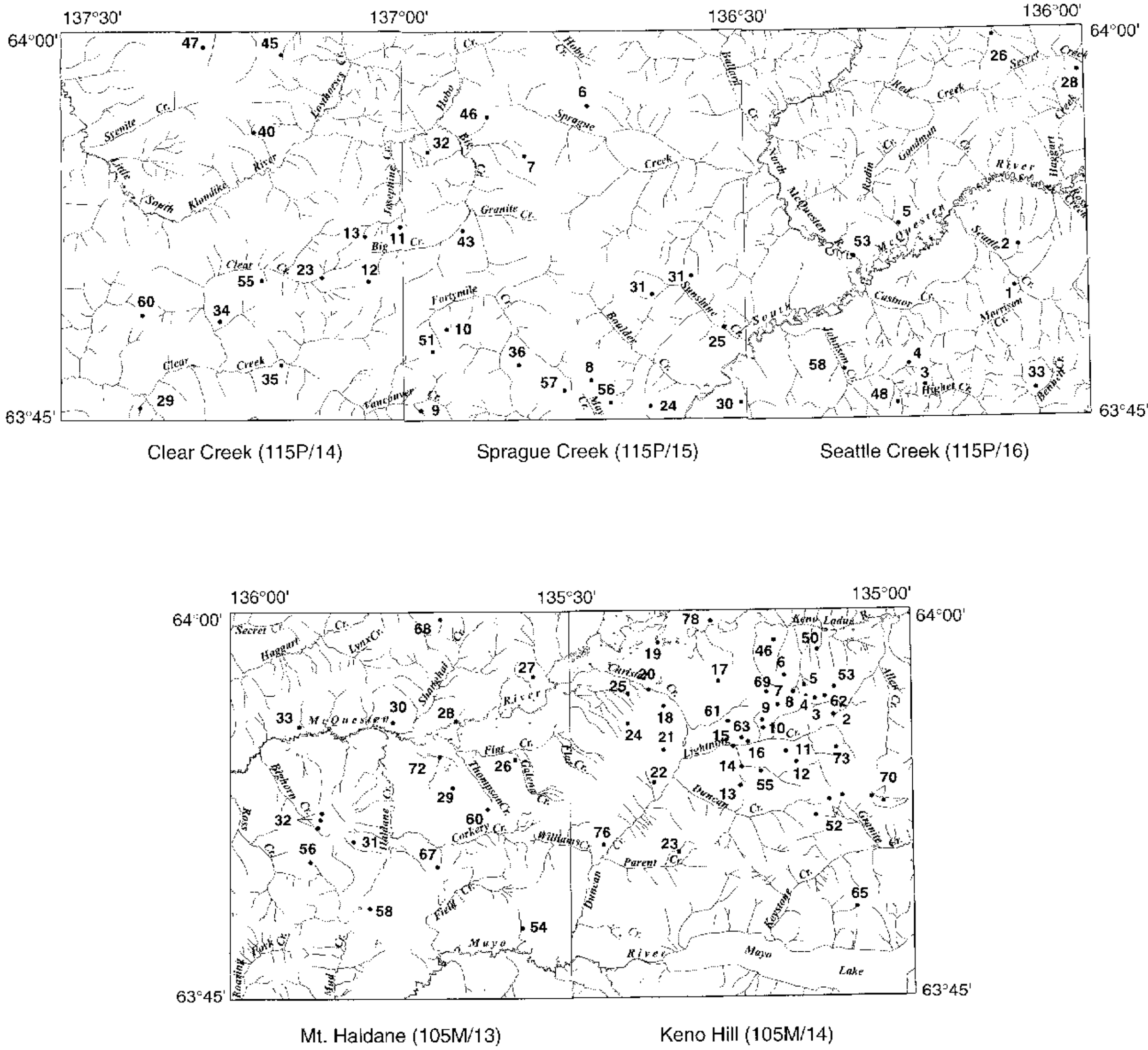


Figure 95. Mineral occurrences in the McQuesten River region as enumerated in Yukon MINFILE (INAC, 1995) and Table 5.

Table 5. Mineral occurrences and descriptions according to Minfile numbers

No.	Name	Brief description (modified from INAC, 1995)
Clear Creek map area (115P/14)		
11	Josephine	Gold occurs with arsenopyrite in east-west striking veins and shears which cuts medium to coarse grained porphyritic granite of the mid- Cretaceous Josephine stock (Tombstone plutonic suite), and hornfelsed quartzite and argillite of the Yusezyu Formation in the upper part of the Tombstone Strain Zone.
12	Rhosgobel	Scheelite and gold-bearing arsenopyrite in quartz veins in and around mid-Cretaceous Rhosgobel stock (Tombstone plutonic suite) as well as in diopside skarns along the margins of the stock.
13	Pukelman	Sheeted quartz-K-feldspar veins with scheelite, molybdenite and pyrite in the mid-Cretaceous Pukelman stock (Tombstone plutonic suite), which intrudes Yusezyu Fm. within Tombstone Strain Zone. Au-bearing arsenopyrite, galena and scheelite occur in sheeted quartz veins and argillically-altered stockwork zones peripheral to the stock.
23	Lewis	Claims cover semi-massive pyrite-sericite mineralization on both sides of a steeply dipping, east-striking gouge-filled fault. Gold values of 9.22 g/t over 1.0 m and 18.41 g/t over 0.49 m have been reported. Fault cuts Yusezyu Formation in Tombstone Strain Zone west of mid-Cretaceous Rhosgobel stock (Tombstone plutonic suite).
29	Thoroughfare	Claims underlain by the Two Sisters batholith (McQuesten plutonic suite) and thick Pliocene stream gravels.
34	Barney	Iron-stained quartz-muscovite greissen veins and breccias with minor cassiterite in Yusezyu Fm. schist and phyllite in the Tombstone Strain Zone. Near Barney stock (Tombstone plutonic suite).
35	Clement	Claims underlain by post-glacial stream deposits and micaceous schist of the Yusezyu Formation in Tombstone Strain Zone.
40	Fiona	Claims cover dark Earn Group metaclastic rocks and Rabbitkettle Fm. marble that are intruded by the mid-Cretaceous Syenite Range stock (Tombstone plutonic suite) and younger dykes.
45	Omega	Two bedded barite occurrences in dark Earn Group metaclastic rocks. Occurrences are overlain by black graphitic argillite and underlain by a thin bedded mixture of barite, limestone and witherite.
47	Zeta	Argentiferous galena veins straddle the contact between Earn Group metaclastic rocks and the mid-Cretaceous Syenite Range stock (Tombstone plutonic suite). Main zone straddling the contact contains tourmaline quartz greisen veins with varying amounts of pyrite, arsenopyrite, cassiterite, sphalerite, jamesonite, conellite, chalcocite and stannite. Second zone lies in the hornfels and mineralization is much more erratic.
55	Left	Claims underlain by Yusezyu Fm. metaclastic rocks in Tombstone Strain Zone
60	Lost Horses	Claims underlain by Yusezyu Fm metaclastic rocks and marble about 3 km north of the Late Cretaceous Two Sisters batholith (McQuesten plutonic suite)..
Sprague Creek map area (115P/15)		
6	Hobo	Minor arsenopyrite, molybdenite and chalcopyrite occur as disseminations and along dry fractures within the mid-Cretaceous Red Mountain stock (Tombstone plutonic suite). Au-Ag-bearing quartz-arsenopyrite veins occur in hornfels zone.
7	Sprague (Mahtin)	Diopside, quartz, chalcopyrite, arsenopyrite, pyrite and pyrrhotite with minor silver skarn and hornfels zones are developed in Rabbitkettle Fm. marble, adjacent to the Sprague Creek granitic stock (Tombstone plutonic suite) and related dykes. The stock is also cut by sheeted veins and quartz-carbonate-galena-arsenopyrite veins.
8	East Ridge	Claims underlain by psammite, phyllite, grit and marble of Yusezyu Formation in Tombstone Strain Zone and three granodiorite and quartz monzonite stocks and related dacite dykes. Both mid- (Tombstone plutonic suite) and Late Cretaceous (McQuesten plutonic suite) intrusions are present. Mineralization consists of 1) cassiterite in topaz and tourmaline-rich breccia zones; 2) argentiferous tourmaline-arsenopyrite veins; 3) brecciated quartz veins with argentiferous galena, sphalerite and chalcopyrite; and, 4) skarn containing sphalerite wtih lesser chalcopyrite, pyrrhotite and cassiterite.
9	Lugdush	Pyroxene-quartz-calcite, garnet-epidote, pyroxene-garnet and wollastonite-quartz-calcite skarn assemblages within a calc-silicate hornfels zone near the Late Cretaceous Vancouver Creek stock (McQuesten plutonic suite). The garnet-bearing varieties contain little or no tungsten. Galena-bearing quartz veins occur near stock.
10	Ridge (Sterling)	Galena and sphalerite occur with pyrite and tourmaline in quartz veins cutting Yusezyu Formation psammite, phyllite, grit and marble in the Tombstone Strain Zone.
24	Boulder	Claim underlain by Yusezyu Formation psammite, phyllite, grit and marble near both the Late Cretaceous Boulder Creek stock (McQuesten plutonic suite) and the mid-Cretaceous Bos stock (Tombstone plutonic suite). Mineralization is related to the intrusive rocks and consists of veins, breccias and stockworks of tin-tungsten, gold-silver-lead-zinc vein and silver-lead-antimony, as well as disseminations of base and precious metals within skarn zones.

25	Toth	Claim underlain by Yusezyu Formation psammite, phyllite, grit and marble near the margin of the Late Cretaceous Sunshine Creek stock (McQuesten plutonic suite).
30	Oliver	Claims cover the Late Cretaceous Boulder Creek stock (McQuesten plutonic suite) that intrudes Yusezyu Formation metaclastic rocks and marble in the Tombstone Strain Zone. Mineralization occurs as cassiterite and sphalerite with silver values in chlorite-tourmaline matrix breccias in quartzite and schist. Ag and Sn mineralization is also hosted by actinolite-pyrrhotite-chlorite skarn.
31	Bix (Sunshine Creek)	Quartz-limonite breccia zones cutting Yusezyu Fm. contain tourmaline, pyrite, tin and silver mineralization. Breccia associated with a quartz-feldspar dyke also contains silver values. Near margin of Late Cretaceous Sunshine Creek biotite-muscovite granite (McQuesten plutonic suite).
32	Mozi	Vuggy, rusty breccias near quartz-feldspar porphyry dykes (probably mid-Cretaceous) intruding Road River and Earn groups. Soils anomalous in Mo, Zn, Ag and Cu.
36	Bander	Claims underlain by Yusezyu Formation phyllite, grit, psammite and marble near the margin of the mid-Cretaceous Bos stock (Tombstone plutonic suite). Quartz-carbonate veins locally contain galena and arsenopyrite; soils are moderately anomalous in silver, arsenic and zinc.
43	Cortin	Claims cover Yusezyu Formation metaclastic rocks in the Tombstone Strain Zone east of mid-Cretaceous Big Creek stock (Tombstone plutonic suite).
46	Weiz	Claims are underlain by calcareous metasandstone and phyllite of the upper member of the Gull Lake Formation.
51	Jabberwock	Claims are underlain by Yusezyu Formation in the Tombstone Strain Zone north of the Late Cretaceous Vancouver Creek stock (McQuesten plutonic suite). Black cassiterite occurs in dry fractures or veinlets while the most common tin-bearing structures are vuggy quartz veinlets with iron oxide coatings and euhedral, dark brown to translucent cassiterite crystals and traces of chalcopyrite. Individual veins are up to 15 cm wide and specimens have assayed up to 8.8% Sn and 64 ppm Ag.
55	Left	Greisen veined and brecciated Yusezyu Formation psammite near margin of mid-Cretaceous Barney stock (Tombstone plutonic suite) contain anomalous levels of Au, As and Sb.
56	May Creek	Northeast-striking vein-fault cutting Yusezyu Formation metaclastic rocks and marble in the Tombstone Strain Zone contains irregular lenses of manganese stained quartz with galena, anglesite, pyrite, limonite and minor chalcopyrite. On southern margin of mid-Cretaceous Bos stock.
57	Quest	Veins cutting Yusezyu Formation metaclastic rocks and marble in the Tombstone Strain Zone contain lenses of galena, pyrite, sphalerite, arsenopyrite, chalcopyrite and tetrahedrite in a quartz-siderite gangue. Also oxidized limonite-galena-siderite veins. On southern margin of mid-Cretaceous Bos stock.

Seattle Creek map area (115P/16)

1	Jaybee	Claims underlain by metaclastic rocks and marble of the Yusezyu Formation in the Tombstone Strain Zone near the Robert Service Thrust. Galena float was found in the area but the source was not located.
2	Seattle	Claims underlain by Keno Hill quartzite near the Robert Service Thrust. Galena float assaying 40.3% Pb and 1556.5 g/t Ag was found in the area; bulldozing uncovered a poorly mineralized northeast-trending vein-fault.
3	Hawthorne	Stibnite, arsenopyrite and minor galena occurs in irregular, lensoidal, northwest-trending quartz veins cutting Yusezyu Formation in the Tombstone Strain Zone near the mid-Cretaceous Scheelite Dome stock (Tombstone plutonic suite). The veins are cut by a later quartz-stibnite breccia. Veins are anomalous in Au, Sb, Ag, and As with sporadic high-grade values.
4	Scheelite Dome	Gold, tin and tungsten occur in skarn formed at the contact between Yusezyu Formation marble and amphibolite and a high level biotite-quartz monzonite stock of mid-Cretaceous age (Scheelite Dome stock, Tombstone plutonic suite). The stock is porphyritic, with feldspar megacrysts up to 5 cm long. Skarn mineralization consists of disseminated pyrrhotite, scheelite and chalcopyrite in a wollastinite-quartz-tremolite gangue developed in an amphibolitic horizon in massive marble. The stock is also cut by 0.5 to 5 cm-wide quartz-feldspar veins striking north-south and east-west and with traces of arsenopyrite, molybdenite and scheelite along their edges. These are variably anomalous in Au, As, Bi, and Sb.
5	Rodin	Claims underlain by Yusezyu Formation metaclastic rocks with limy sections in the Tombstone Strain Zone.
26	Ortell	Claim underlain by Yusezyu Formation metaclastic rocks above the Tombstone Strain Zone.
28	Secret	Claims underlain by a sequence of schist, phyllite and psammite of the Yusezyu Formation near the upper boundary of the Tombstone Strain Zone. Geochemical survey outlined a number of tungsten, silver, tin and gold anomalies.
33	Highet	Claims underlain by oxidized, veined and fractured Yusezyu Formation phyllite, psammite and grit cut by probably mid-Cretaceous porphyry dykes (Tombstone plutonic suite). Veining, fracturing and oxidation occurs in a several kilometre-wide zone extending at least across the width of the Seattle Creek map area. Mineralization consists of at least two sets of sheeted quartz-arsenopyrite veins that are variably anomalous in Au, Bi, As, and Sb. Veins are offset by younger north-striking, down-to-the-west normal faults that locally remobilize(?) quartz-arsenopyrite mineralization. Limy sections of the Yusezyu Formation are locally replaced by arsenopyrite.

48	Potter	Claims underlain by psammite, grit and phyllite of the Yusezyu Formation within the Tombstone Strain Zone near the northern margin of the mid-Cretaceous Minton Creek stock (Tombstone plutonic suite). Tin-bearing skarn is reported from the claims, as are unconfirmed reports of high-grade gold veins.
53	Castnor	Claims underlain by psammite, phyllite, marble and grit of Yusezyu Formation in the Tombstone Strain Zone.
58	Paw	Claims underlain by psammite, grit, marble and phyllite of Yusezyu Formation in the Tombstone Strain Zone.
Mt. Haldane map area (105M/13)		
26	Gerlitzki	A strong transverse-type (north-northeast-striking) vein-fault which cuts the Keno Hill quartzite and is weakly mineralized with galena, sphalerite and minor tetrahedrite.
27	Titan	Claims underlain by Keno Hill quartzite which is structurally overlain by phyllite and psammite of the Yusezyu Formation, both in the Tombstone Strain Zone on the north limb of the McQuesten Antiform. Evidence of at least one strong vein includes vein breccia and siderite gangue float in overburden and one bedrock exposure 1.8 m wide.
28	Shanghai	Transverse (north-northeast-striking) branching vein-fault cutting Hyland schist and Keno Hill quartzite on north side of McQuesten Antiform. Mineralization consists of considerable sphalerite and discontinuous lenses of galena and tetrahedrite.
29	Wayne	Branching, north-striking vein(-fault?) cutting Yusezyu Formation and Keno Hill quartzite mineralized with galena, sphalerite and tetrahedrite in a carbonate gangue. Also on the property are stratiform gold-tungsten-bearing skarn and replacement bodies, and gold-bearing pyritic zones in felsic intrusions.
30	Argent	Transported limonite gossan with high geochemical values in zinc were found, leading to trenching of three unmineralized veins cutting Keno Hill quartzite(?).
31	Strebchuk (Joumbira)	Mineralized quartz veins are associated with a 30.5 m-thick rhyodacite porphyry dyke (86 Ma K-Ar age suggests that the dyke is part of the Tombstone plutonic suite) which cuts the Mississippian Keno Hill quartzite. Mineralization consists of galena stringers, quartz-pyrrhotite-arsenopyrite veins, tin and tungsten veins, tourmaline veinlets containing cassiterite with minor fluorite and quartz-muscovite veins containing tourmaline, sphalerite, arsenopyrite and galena.
32	Mt. Haldane (Lookout)	Three main mineralized zones along branches of a north-trending transverse vein-fault system which cuts the Mississippian Keno Hill quartzite. Best mineralized Middlecoff zone contains erratic lenses of galena, sphalerite and minor tetrahedrite.
33	Laysier	Brecciated vein float containing galena on northeast-striking topographic lineament which cuts schist and phyllite of the Yusezyu Formation. Two vein-faults are inferred.
54	Chance	Stibnite is reported to be present in a narrow quartz vein which cuts phyllite and psammite of the Yusezyu Formation.
56	Sundown	Area underlain by phyllite and psammite of the Yusezyu Formation which structurally overlies Keno Hill quartzite of Mississippian age along the Robert Service Thrust about a kilometre to the north. Chloritized and sericitized porphyry dyke cut by tourmaline veins and hosting disseminated arsenopyrite is anomalous in Ag, Pb, W and Sn.
58	Halfway	Although covered by extensive glacial drift, claims probably underlain by Yusezyu Formation phyllite and psammite cut by north-striking fault. Zones of anomalous scheelite and gold were identified through overburden drilling. A mercury soil anomaly has also been outlined coincident with east-striking structures identified with a MaxMin survey.
60	Newry	Property underlain by Yusezyu Formation phyllite, psammite, grit and marble. Carbonate bodies locally host diopside-actinolite-scapolite-quartz-carbonate-plagioclase-epidote skarn with scheelite, arsenopyrite and minor pyrite, pyrrhotite and chalcopyrite. These are variably anomalous in Au, As, W, Bi, Cu, Pb and Zn.
67	Corkery	Claims underlain by Yusezyu Formation phyllite and psammite.
68	Weasel	Claims underlain by Keno Hill quartzite which is intruded by a small Cretaceous stock and overlain by graphitic schist, minor quartzite and limestone of the Hyland Group.
72	Beley	Drilling in the overburden-covered McQuesten River valley intersected graphitic schist, bedded quartzite, graphitic phyllite, argillite and schist of the Earn Group and massive Keno Hill quartzite. These units are intruded by gabbroic or dioritic sills and lamprophyre dykes of Triassic age and small Cretaceous granite to quartz monzonite stocks. Sphalerite-bearing vein-faults intersected in the drilling assayed 6.0%Zn, 18.2 ppm Ag and 0.1% Pb.

Keno Hill map area (105M/14)

1	United Keno Hill	United Keno Hill refers to over 50 individual mineral deposits and prospects (indicated individually on Geoscience Map 1996-5). Ag-Pb-Zn-Cd-Au mineralization occurs in vein-faults 0.3 to 30 m wide mainly in the Keno Hill quartzite. Mineralization occurs in both longitudinal (east-northeast-striking, sinistral) vein-faults and transverse (north-northeast-striking, normal or tensional fissures) vein-faults. Ore minerals comprise argentiferous galena, freibergite (argentiferous tetrahedrite), and pyrargyrite (ruby silver) along with sphalerite, pyrite and minor polybasite, stephanite, argentite and native silver. The silver to lead ratio varies from 3:1 to 11:1 depending on the tetrahedrite content. Siderite is the main gangue mineral. Two stages of veining are recognized. The earlier stage deposited quartz, pyrite, some arsenopyrite, sulphosalts and a trace of gold prior to movement on the vein faults. After the movement on the faults, siderite, galena, sphalerite, pyrite, freibergite and pyrargyrite were deposited. [see Boyle (1965), Watson (1986), Franzen (1986), Lynch (1988), INAC (1995) and Roots (1997) for more detailed information on these and other deposits]
2	Faith	Minor amounts of galena and secondary lead minerals are present in a transverse vein(-fault?) cutting Keno Hill quartzite and phyllite.
3	Duncan	Galena and tetrahedrite occur in siderite gangue on the dumps. The vein cuts Keno Hill quartzite and phyllite and is transverse between longitudinal vein(-faults).
4	Gold Queen	Typical longitudinal vein-fault cutting Keno Hill quartzite believed to be an extension of the Porcupine vein with only minor galena and tetrahedrite.
5	Silver Basin	Minor galena and tetrahedrite occur with arsenopyrite in quartz-siderite gangue in a typical longitudinal vein system cutting Keno Hill quartzite and phyllite. Notable for Au values.
6	Nabob	Three transverse veins mineralized with galena and tetrahedrite in a siderite gangue cut Earn Group metavolcanics and greenstone beneath the Keno Hill quartzite. Notable for Au values.
7	Monument (Ladue Fraction)	Galena, sphalerite, tetrahedrite and arsenopyrite occur in quartz-siderite gangue within the Nabob-Main vein longitudinal vein-fault system cutting Earn Group carbonaceous and felsic metavolcanic phyllites and Triassic greenstone.
8	Comstock	Mineralization consists of galena, tetrahedrite and sphalerite plus considerable oxide material in two showings on the Porcupine vein which cuts Triassic greenstone and Earn Group schist overlying the Keno Hill quartzite on the inverted limb of an isoclinal fold.
9	Apex	Galena, sphalerite and arsenopyrite occur erratically in a longitudinal-type quartz vein the is probably part of the Comstock vein system.
10	Vanguard	Mineralization consists of galena and tetrahedrite in a carbonate gangue. Vein is a transverse vein-fault cutting the Keno Hill quartzite.
11	Homestake	Erratic lenses of arsenopyrite and galena in a quartz carbonate gangue in a longitudinal vein-fault and tetrahedrite and galena in a transverse vein with carbonate gangue. Both cut Keno Hill quartzite.
12	Christine	Erratic lenses of galena in a longitudinal vein-fault cutting Keno Hill quartzite.
13	Mo	Two weak transverse veins cutting Yusezyu Formation near the Robert Service Thrust contain minor galena and tetrahedrite.
14	Mayburn	An extension of the Bellekeno transverse vein system. Galena, tetrahedrite and sphalerite occur with siderite gangue in erratic lenses within a vein that cuts Keno Hill quartzite.
15	Hogan	Galena and tetrahedrite occur in a narrow transverse-type vein cutting Keno Hill quartzite. Mineralization occurs in erratic lenses.
16	Runer	Galena, tetrahedrite and sphalerite occur with pyrite in siderite gangue within a transverse vein cutting Keno Hill quartzite.
17	Wernecke	Weakly mineralized galena and tetrahedrite transverse veins in schists (probably Earn Group felsic metavolcanic unit) and greenstone below Keno Hill quartzite.
18	Formo	Erratic narrow lenses of galena, sphalerite and minor tetrahedrite occur in carbonate gangue within a typical narrow, north-trending, transverse veins cutting Earn Group carbonaceous phyllite and Triassic greenstone beneath the Keno Hill quartzite.
19	Nomad	Anomalous tin, tungsten and molybdenum values in overburden where intrusive stocks are suspected to occur.
20	Paddy	Multi-branching, transverse vein zone cuts Earn Group carbonaceous phyllite and Triassic greenstone beneath the Keno Hill quartzite. Arsenopyrite with lesser pyrite, galena and sphalerite in a quartz gangue occurs in some veins, locally with good Au values. Siderite veins containing narrow, discontinuous lenses of galena, tetrahedrite and sphalerite also occur, also with good Au values in addition to Ag, Pb and Zn.
21	Eagle	A strong transverse vein-fault cutting Keno Hill quartzite near the Robert Service Thrust contact with Yusezyu Formation. Vein-fault mineralized with erratic lenses of galena, tetrahedrite and sphalerite.
22	Fisher	Float of vein material containing galena and tetrahedrite on Yusezyu Formation bedrock.
23	Parent	Anomalous heavy metal content in stream silts.
24	Cream and Jean	Erratic lenses of galena and sphalerite, with lesser amounts of tetrahedrite and chalcopyrite, occur in carbonate gangue within a transverse vein that cuts Triassic greenstone sills.

25	Nord	A typical narrow traverse-type vein-fault cutting Earn Group carbonaceous phyllite and Triassic greenstone underlying Keno Hill quartzite.
46	Moon	A longitudinal type vein cutting Triassic greenstone and Earn Group carbonaceous phyllite. Mineralization comprises arsenopyrite in quartz gangue with minor galena. Fragments of galena and sphalerite in a carbonate gangue also noted.
50	Nero	Claims underlain by Earn Group carbonaceous phyllite. Several quartz veins with weak galena mineralization were located.
52	Mt. Hinton	Thirty five northeast-striking veins mineralized with arsenopyrite, galena, jamesonite, pyrite, sphalerite, siderite and gold in quartz gangue occur mainly at contacts between Keno Hill quartzite and Triassic greenstone sills and in footwall bedding faults marked by graphitic schist. Notable Au values.
53	Avenue	Narrow vein containing minor argentiferous galena cuts Keno Hill quartzite(?) and phyllite. Some pyrrhotite vein mineralization.
55	Yono	Minor amounts of argentiferous galena occur in a narrow vein cutting the Keno Hill quartzite.
61	Christal	West end of east-trending longitudinal No. 6 vein cutting Earn Group felsic metavolcanic unit and mineralized with galena, sphalerite, tetrahedrite, arsenopyrite and pyrite in a siderite-quartz gangue.
62	Segsworth	Longitudinal and transverse vein-types mineralized with minor galena, tetrahedrite and sphalerite. Located in Earn Group felsic metavolcanic rock and carbonaceous phyllite.
63	Ironclad	A narrow transverse-type vein cutting Keno Hill quartzite is poorly mineralized with galena, tetrahedrite and sphalerite in a pyrite-siderite gangue.
65	Nadar	Claims underlain by psammite and phyllite of the Hyland Group.
69	Gambler	Longitudinal vein (northern extension of the Shamrock vein?) cutting Keno Hill quartzite and mineralized with pyrite, arsenopyrite, galena, sphalerite and freibergite in quartz-siderite gangue.
70	Havrenak	150 m-long galena (+?) vein parallel to the foliation in the enclosing Keno Hill quartzite.
73	Bema	Three veins cut the Keno Hill quartzite. Two are minor quartz stockworks with disseminated galena and the third is a quartz vein containing minor disseminated arsenopyrite. Notable gold values.
76	Goldrock	Claims underlain by psammite and phyllite of the Yusezyu Formation.
78	Feed	Claims underlain by dark phyllite thought to be part of the Earn Group.

In the 1880s, prospectors followed up placer gold in sand and gravel bars along the lower Stewart River (Mayo Historical Society, 1990). Placer gold is still mined in Clear, Arizona, Haggart, Highet, Johnson, Seattle, and Duncan creeks and tributaries. The 1906 discovery of rich silver-bearing veins in the Elsa-Keno Hill camp led to numerous mines and widespread prospecting throughout the region (see Boyle (1965) for details on the pre-1965 and Watson (1986) for the 1965-1986 periods as well as the Mayo Historical Society (1990) for further details on the mining history of the Keno Hill district). Tin and tungsten were the focus of exploration at various times, primarily around felsic intrusions. Lode gold is currently of considerable interest in the region, stimulated by the recent discovery and development of intrusion-hosted gold at Fort Knox, Alaska (Bakke, 1996 and references therein) and intrusion-related, Carlin-like (Poulsen, 1996, Poulsen et al. 1997) gold at Brewery Creek, Yukon (Diment, 1996) both in geological settings likely to exist in the McQuesten River region.

Known lode mineral occurrences in the McQuesten River region can be divided into at least four categories based on type and age: syngenetic stratabound barite mineralization in Earn Group strata; mineral occurrences associated with Tombstone intrusions (including intrusion-hosted, magmatic-hydrothermal veins; skarns/replacements; country-rock-hosted veins, breccias, structurally controlled alteration zones and Elsa-Keno Hill vein-faults); skarns, breccias and veins associated with McQuesten intrusions; and breccias of unknown age and association. Most of the mineral occurrences in the area are thought to be related to the Tombstone intrusions. This conclusion is based on spatial coincidence, cross-cutting relationships, inferences from new isotopic information, and consideration of the geochemical evolution of hydrothermal systems.

With the evolution of geological understanding of mineral occurrences elsewhere in Selwyn Basin has come the recognition that certain types of mineral deposits are associated with particular rock units. Several rock units associated with certain types of mineral occurrences in other parts of Selwyn Basin are now known to occur in the McQuesten River region as a result of this study. Thus, the region has geologically indicated potential for types of mineralization that are currently not known there.

The numerous placer deposits of the region will not be considered in this report. They are summarized by Kreft (1993), LeBarge (1996), and periodic reviews of Yukon's placer mining industry published by Indian and Northern Affairs Canada.

Syngenetic barite occurrences in the Earn Group

Three, bedded barite showings, two on the **Omega** occurrence (MINFILE #115P 045) and one on the nearby **Zeta** occurrence (#115P 047), are known from the McQuesten River region. The **Omega** occurs in folded and faulted Earn Group strata in the northern part of the Clear Creek map area, about six km northwest of the confluence of Lost Horses Creek and the Little South Klondike River (Geoscience Map 1996-1). The main showing, tested by six drill holes, consists of a 4.9 to 38.0 m thick, finely laminated barite bed with minor argillite interbeds. It is overlain by black carbonaceous argillite and underlain by thin-bedded barite, limestone and witherite. A second showing, 3 km downstream, consists of a single bed of barite and baritic carbonate. The bed is approximately 10 m thick where penetrated by a single drill hole and is anomalous in Ba, Ag, and Zn. Barite on the **Zeta** occurrence occurs in Earn Group interlaminated with chert and is associated with a Cu, Zn and Ag stream-sediment anomaly.

The complexity of deformation and the poor exposure in this area limits the assessment of the stratigraphic level of baritic horizons within the Earn Group, their sedimentary facies, presence or absence of controlling structures, or any association with volcanic rocks. Nevertheless, the known barite occurs nearly along strike from the pre-Late Cambrian Sprague Creek Fault. Although significant re-activation of the fault in the Devonian seems unlikely, given the continuity of the Rabbitkettle Formation across the fault trace, the sub-Earn Group unconformity cuts most deeply down into the underlying stratigraphy along strike from the fault, perhaps implying some level of influence. In this area, the Earn Group rests directly on the Rabbitkettle Formation; to both the north and south, the Earn Group sits on the Steel Formation. This erosional 'channel' is exposed in only two dimensions, so it is not possible to determine its orientation. The coincidence of this locus of downcutting and barite mineralization along strike from the Sprague Creek Fault, however, suggests a possible relationship to the fault or some basement weakness.

Mineral occurrences associated with the Tombstone intrusions

Intrusion-hosted magmatic-hydrothermal veins

Tombstone intrusions throughout the region host quartz veins and 'dry' fractures anomalous in various combinations of Au, W, Bi, As, Ag, Pb, Zn, Mo, Sn, Sb, Cu and Te (Table 6). Intrusion-hosted vein networks at most occurrences are parallel, sheeted systems (Figures 58, 59) although stockworks occur locally (e.g., Saddle zone at Josephine, Figure 60). Shear zones that cut both intrusion and host rock have been described at the **Josephine** and **Scheelite Dome** occurrences, but have not been noted elsewhere. Individual planar structures range in thickness from relatively common 'dry' fractures with no appreciable vein filling, to less common cm-scale veins, and occur with variable spacing. Quartz is the principal vein mineral, occurring with one or more of potassium feldspar, tourmaline, chlorite, arsenopyrite, scheelite, molybdenite, stibnite, pyrite, calcite, sericite, chalcopyrite, bismuthinite and pyrrhotite. Narrow potassic alteration selvages occur locally around veins. Veins within intrusions are likely to be late-magmatic, based on their igneous mineralogy and cross-cutting relationships with felsic dykes (Figures 56, 57).

The orientations of intrusion-hosted veins in the McQuesten River region occurrences vary between steep northeast-striking to steep southeast-striking, with an east-southeast strike locally dominant (Figure 88). Veins have the same general orientation as dykes and associated breccia zones in the surrounding country rock, so they probably reflect the influence of a regional stress on a mostly frozen intrusive mass.

Most Tombstone intrusions in the area are gold-mineralized, despite differences in composition, texture and nature of host rock. The intrusions hosting gold mineralization (Josephine, Pukelman, Rhosgobel, Big Creek, Red Mountain, Sprague Creek, and Scheelite Dome stocks) are all metaluminous, calcic, medium-grained, and weakly porphyritic biotite± hornblende monzogranite to granodiorite. They are typically associated with aeromagnetically prominent aureoles. Intrusion-hosted vein systems throughout the belt have similar compositions, styles and orientations. The general parallelism of mineralized structures with the overall east-west strike of the belt of Tombstone intrusions in the Tombstone-Tungsten Belt (see under Intrusive Rocks) suggests a regional structural control, perhaps reflecting pre-existing basement structure.

Tombstone intrusions are generally associated with gold mineralization, having a style as described above. One exception is the Syenite Range stock, which hosts the Zeta silver-tin-bearing greisen vein system (veins associated with muscovite-tourmaline-topaz-fluorite alteration) along its northern border. As described by Abercrombie (1990), steep, northeast- to east-striking quartz-sulphide-tourmaline-chlorite-limonite-kaolinite greisen veins cut the outer syenite phase of the composite zoned stock. Some veins are sulphide-rich and tourmaline-poor, others

Table 6. Mineral occurrences associated with the Tombstone intrusions of the McQuesten River region

Intrusion-hosted

Occurrence	MINFILE#	Map area	Intrusion
Scheelite Dome	115P 004	115P/16	Scheelite Dome stock
Hobo (includes BX)	115P 006	115P/15	Red Mountain stock, Unnamed at BX
Sprague (Mahtin)	115P 007	115P/15	Sprague Creek stock
Josephine	115P 011	115P/14	Josephine stocks
Rhosgobel	115P 012	115P/14	Rhosgobel stock
Pukelman	115P 013	115P/14	Pukelman stock
Big	115P 061	115P/15	Big Creek stock
Wayne	105M 029	105M/13	Unnamed dyke

Skarn

Occurrence	MINFILE #	Map area	Associated intrusion	Host strata	Metals
Rhosgobel	115P 010	115P/14	Rhosgobel stock	Yusezyu Fm.	W
Sprague (Mahtin)	115P 007	115P/15	Sprague Creek stock	Gull Lake and Rabbitkettle fms.	Sn, W, Au
East Ridge	115P 008	115P/15	Bos stock	Yusezyu Fm.	Sn, W, Au, Zn, Cu, Ag
Scheelite Dome	115P 004	115P/16	Scheelite Dome stock	Yusezyu Fm.	W, Au
Newry	105M 067	105M/13	Not exposed	Yusezyu Fm.	Au, W
Wayne	105M 029	105M/13	Unnamed dyke (?)	Yusezyu Fm.	W, Au

Vein and breccia

Occurrence	MINFILE #	Map area	Associated intrusion	Anomalous metals
Hawthorne	115P 003	115P/16	Scheelite Dome stock	Au, Ag, Sb, Pb
Hobo	115P 006	115P/15	Red Mountain stock	Au, Ag, Cu, Sn, Pb, Sb, Te
Lewis	115P 023	115P/14	Rhosgobel or Pukelman stocks	Au
Highet	115P 033	115P/16	Scheelite Dome?	Au
Bander	115P 036	115P/15	Bos stock	Pb (Ag)
Big	115P 061	115P/15	Big Creek	Au, Ag, Pb, W
Mt. Hinton	105M 052	105M/14	Roop Lakes?	Au, Ag, Pb, Zn, Cu, Sb

are sulphide-poor and tourmaline-rich. Textures indicative of open-space filling such as comb-textured quartz, tourmaline rosettes and colliform tourmaline occur in both types. Kaolinite-sericite-chlorite-tourmaline-limonite alteration selvages extend outward for distances up to ten times the vein width. Veins are inferred to be genetically associated with the core phase of the stock, a biotite-muscovite orbicular tourmaline granite with rare fluorite. Drill-indicated reserves of 98 248 t grading 557 g/t Ag occur in the Main zone of the Zeta occurrence (INAC, 1995).

The silver-tin mineralization of the Syenite Range stock is more typical of McQuesten intrusions. However, the orbicular tourmaline granite thought to be associated with the mineralization is the same age as the Tombstone intrusions (see under Intrusive Rocks), K-Ar dates on both the mineralization and the granite phase of the stock are nearly identical, and Pb isotope data from jamesonite are similar to those of the host intrusion (Abercrombie, 1990). Nevertheless, more recent Pb isotope data from **Zeta** ore minerals are closer to those of McQuesten intrusion mineralization than other mineralization associated with the Tombstone intrusions (J. Mortensen, pers. comm. 1995). A buried McQuesten intrusion possibly lies beneath the **Zeta** occurrence, but more work is necessary to test this hypothesis.

If the **Zeta** silver-tin mineralization and the Syenite Range stock are coeval, the mineralization might be a consequence of the stock's degree of differentiation. Tin mineralization is typically associated with more highly evolved peraluminous granites, such as the McQuesten intrusions. The peraluminous orbicular tourmaline biotite-muscovite± fluorite granite in the core of the Syenite Range stock is the most differentiated Tombstone intrusion in this part of the TTB and the silver-tin mineralization might reflect this degree of differentiation.

Country rock-hosted veins, breccias, alteration zones, and vein-faults

Two settings are distinguished for this discussion: 1) gold-bearing veins, breccias, and alteration zones (Table 6); and 2) Ag-Pb-Zn-bearing vein-faults of the Elsa-Keno Hill mining camp. Veins, breccias and structurally controlled alteration zones are structures that are primarily dilational in origin, and space thus created is filled with vein minerals or host-rock fragments. Structurally controlled alteration zones are hundreds of metres to km in size, with abundant veins and alteration selvages. Country rock can be extensively altered where veins are closely spaced and vein selvages coalesce. Vein-faults are essentially faults with curviplanar surfaces; vein minerals or host-rock fragments are deposited in dilational jogs caused by irregularities in the fault surface.

Gold-bearing veins, breccias and alteration zones

These occurrences typically consist of centimetre- to metre-scale veins and/or breccias and structurally controlled alteration zones anomalous in gold and a number of other elements, including Ag, W, Bi, Mo, Te, As, Sb, Cu, Pb, Sn, and Zn. Quartz is the principal vein mineral; accessory minerals include arsenopyrite, pyrite, chalcopyrite, galena, stibnite, cassiterite, orthoclase, tourmaline, scheelite, chlorite and sphalerite. Vein margins are variably altered, locally showing significant amounts of alteration, including oxidation and phyllic and sericitic alteration. If vein density is sufficiently high, alteration selvages can coalesce and large volumes of country rock can be affected. Breccias also consist of vein minerals, but country-rock fragments make up a significant proportion of the fracture-filling material.

Breccias associated with the Tombstone intrusions are the crystalline matrix type of Emond and Lynch (1992). They are commonly characterized by high limonite content (1-22% Fe); variable amounts of porosity; fragments of angular to rounded vein quartz or locally hematized, clay-altered, tourmalinized or limonite- and/or manganese-coated metasedimentary rock; and local cockscomb-textured quartz.

Veins and breccias commonly occur together and reflect multiple episodes of mineral deposition and fracturing. Vein quartz fragments are locally common in breccias, and tourmaline and euhedral smoky quartz locally cements breccia fragments. Veins and breccias generally show evidence of a purely dilational origin, including the lack of offset across the structures and between fragments, and coxscomb-textured quartz in vugs. Evidence of shear offsets is generally lacking. Breccias of this type occur commonly in tourmaline-rich hornfels zones and commonly envelope felsic dykes. Veins and breccias mostly strike from northeast to southeast, similar to the orientation of intrusion-hosted systems.

Veins and breccias locally cluster into structurally controlled systems of mappable extent. Hyland Group rocks in an east-west striking brittle deformation zone centred on the Scheelite Dome stock in the southeast corner of the Seattle Creek map area (SC claims on **Highet**, #115P 033) are commonly rusty, punky, and cut by an array of quartz-arsenopyrite veins, veinlets, vein-faults and breccias locally containing gold mineralization. Structures defining the zone occur in a variety of orientations: the **Hawthorne** (#115P 003) vein on the southeast flank of Scheelite Dome is a normal-displacement vein-fault striking northwest and dipping steeply northeast; smaller veins and veinlets on the SC claims between Bennett and Highet creeks strike west-southwest and dip gently to steeply north-northwest. These are cut by later north-striking, west-side-down normal faults that form prominent topographic lineaments. Although gouge along these faults contains quartz and arsenopyrite and is locally anomalous in gold, it is unclear whether this mineralization occurred during the north-striking faulting or if the earlier vein mineralization was remobilized into the younger faults (see under Structural Geology). The brittle deformation zone defined by these features is more than 3 km wide and extends at least as far as the width of the Seattle Creek map area. The geochemistry of veins in this zone is similar to that of veins in the Scheelite Dome stock, suggesting that the stock was the source of the fluids.

On the BX claims north of the Red Mountain stock (**Hobo,** #115P 006), a 2-km-wide zone of fracturing, alteration and dense quartz veining extends southeast from a small Tombstone intrusion. Rock underlying about one square kilometre northeast of the intrusion is vuggy, fragmental, and punky and was originally mapped as Tertiary or younger volcanic rock (Bostock, 1964; Murphy and Héon, 1994a, b; see under Stratigraphic Units). These rocks are now viewed as a highly altered and tourmalinized hydrothermal breccia associated with the intrusion. Part of the intrusion is locally highly altered. Gold occurs sporadically throughout this zone; the controls on its distribution are, as yet, unknown.

The **Black Hill** occurrence of Murphy and Héon (1995a, b) at the northern edge of the Seattle Creek map area is made up of an extensively tourmalinized hornfels around a small Tombstone intrusion, which crops out in the southern part of the Larsen Creek map area (Bostock, 1948b). Numerous veinlets and small faults with breccias occur in the hornfels zone, some of which are anomalous in Au, Bi, As and Sb (e.g., sample 94DH-89b, Appendix 3). Tourmalinized rocks, and calc-silicate and pelitic hornfels are also found west of the North McQuesten River, opposite the **Black Hill** occurrence.

Silver-lead-zinc-bearing vein-faults of the Elsa-Keno Hill mining camp

Between 1913 and 1989, over 6600 t of silver, 35 000 t of lead, and 21 000 t of zinc were extracted from the extensive and numerous vein-faults of the Elsa-Keno Hill mining camp (M. Phillips, United Keno Hill Mines, pers. comm. 1995). A detailed description of the characteristics of most of the productive systems was provided by Boyle (1965). Ore minerals were deposited in dilational sites generated during sinistral displacement along irregular fracture surfaces and networks, primarily in the Keno Hill quartzite. Silver ore minerals are argentiferous galena, argentiferous tetrahedrite (freibergite), native silver, polybasite, stephanite and pyrargyrite; galena is the most important lead mineral and sphalerite, the most important zinc mineral. Cadmium and gold (1800 t and 100 kg, respectively) were also recovered after about 1960. Ore minerals are contained in a gangue of manganiferous siderite and lesser quartz and calcite. Some of the deposits are oxidized, locally to depths of over 150 m.

Two stages of mineralized veins or vein-faults were recognized in the camp (Boyle, 1965). Early en echelon and stockwork quartz-arsenopyrite-sulphosalt-sphalerite-chalcopyrite veins formed before the main silver-bearing vein-faults. Early veins are similar to veins peripheral to the Tombstone intrusions (higher temperature than silver-bearing veins?) and locally anomalous in gold. They represent the first tapping of hydrothermal fluids as the Keno Hill quartzite underwent brittle dilation in response to applied stress and initial displacement. Subsequent displacement of the quartzite is marked by complete failure along major fractures and the development of extensive porosity and permeability. The rich Ag-Pb-Zn mineralization was precipitated during this stage and succeeding ruptures.

Various geochemical and mineralogical criteria have been used to suggest that the widely dispersed veins of the Elsa-Keno Hill camp formed in different parts of a zoned hydrothermal system. Franzen (1986) used production metal ratios projected into a cross-section to suggest that the hydrothermal system was zoned from deep structural levels in the east to shallow levels in the west and formed by upwelling hydrothermal fluids. Lynch (1986, 1989a, b) noted regional variations in vein mineralogy and composition of tetrahedrite to show that the deposits are zoned from high temperature deposits in the east to distal lower temperature deposits in the west. Lynch interpreted the zoning pattern in terms of lateral fluid flow seismically pumped away from a heat source through zones of enhanced permeability. The pattern of zoning is used to support the hypothesis that the Mayo Lake Batholith (Roop Lake stock of current terminology; 93.0± 0.6 Ma, Roots, 1997) was the heat engine driving hydrothermal circulation.

Both of these interpretations are fraught with uncertainty. The metal-ratio-depth profiles of Franzen (1986) do not support his depth zoning hypothesis. Metal ratios do not change simply with restored depth (see Figures 7-10 of Franzen, 1986): deposits that restore to the shallowest levels, either structural or stratigraphic, have similar production metal ratios as those inferred to be at the deepest levels. Similarly, when the data are plotted in map view, no pattern is apparent. The mineralogical zoning model of Lynch (1986, 1989a, b) is hampered by the unknown ages of the veins beyond the mining area and relative age control on veins within the mining camp.

The best case for a zoned hydrothermal system is the continuous systematic change in tetrahedrite composition from high Ag/Cu and Fe/Zn in the west, to lower values in the east (Lynch, 1989a, b). But are these data sufficient to support the conclusion of an original laterally zoned, laterally flowing hydrothermal system? An alternative explanation is that the system formed before the development of the plunge of the McQuesten Antiform and the original zonation was subsequently tilted as the plunge of the antiform developed. In such a scenario, the eastward end of the camp would have been deeper and more proximal to the heat source than the western end, as suggested by Franzen (1986). The zoning apparent in Lynch's tetrahedrite chemistry would then be a product of upward-flowing as well as laterally outward-flowing fluids.

Lynch's (1989a, b) implication of the Roop Lakes stock in vein-fault mineralization in the Elsa-Keno Hill camp would require a hydrothermal circulation system extending over 35 km from the exposed margin of the pluton. As Roop Lakes is one of the larger stocks in the region, perhaps a hydrothermal network of this magnitude is reasonable. Alternatively, the stock might have an apophysis that extends closer to the camp, or a completely different stock might underlie the camp. Given the somewhat tenuous connection between vein-fault mineralization and the Tombstone intrusions, it is possible that any hidden stock may not even be a Tombstone intrusion. Murphy and Héon (1994a) suggested a possible (now considered unlikely) relationship between the Sunshine Creek breccia zone associated with the McQuesten intrusions and Elsa-Keno Hill vein-fault mineralization.

Skarn and replacement occurrences

Skarn and calc-silicate hornfels are developed in the region wherever carbonate-bearing rocks have felsic intrusions. Carbonate-bearing protoliths occur in the Yusezyu Formation (especially in the lower part), the Narchilla Formation, and the Gull Lake, Rabbitkettle and Steel formations. The Duo Lake Formation and Earn Group contain rare limestone.

Skarn (garnet-pyroxene calc-silicate hornfels) or carbonate replacement occurrences make up about 5% of the total number of mineral occurrences in the McQuesten River region (Tables 6 and 7). Most of these occurrences were described and interpreted by Emond and Lynch (1992) and Yukon MINFILE (INAC, 1995). Additional skarns around the Tombstone intrusions were identified 1) in the Rabbitkettle Formation south of the Syenite Range stock (Geoscience Map 1996-1); 2) in the carbonate member of the Narchilla Formation along the southwestern contact of the Ballard Creek west stock (Geoscience Map 1996-2); 3) in the Rabbitkettle Formation on the eastern contact of the Hobo Creek stock (Geoscience Map 1996-2); and 4) in Yusezyu Formation carbonate west of the small unnamed intrusion west of the Bos stock (Geoscience Map 1996-2, Murphy and Héon, 1994a, b). Prominent gossans occur at the localities near the Syenite Range and Ballard Creek west stocks, but no mineralization was detected. Anomalous values of Zn, Pb and Ag were obtained from sphalerite-bearing samples of skarn west of the Bos stock (sample 93DM-310b, Appendix 3). Skarn samples around the Tombstone intrusions in the McQuesten River region are usually anomalous in one or more of W, Au, As and lesser Sn (Emond and Lynch, 1992; Murphy and Héon, 1994a, b; Appendix 3). Pb, Zn, Ag, Bi and Cu are variably anomalous.

Mineralization associated with the McQuesten intrusions

Far fewer mineral occurrences are known within or adjacent to the McQuesten intrusions (Table 7). Two occurrences lie within intrusions; others are skarn and breccias or veins. The recently discovered **Cobble** (#115P 062) occurrence in the Boulder Creek stock includes malachite-stained, fine- to medium-grained granite cut by fractures coated with quartz, calcite and white mica. A grab sample of stained and fractured granite at this showing is weakly anomalous in Au, Ag, Cu, Pb and Zn (sample 93DH-19, Appendix 3). A limonitic breccia with quartz and sulfide-coated fractures in the Sunshine Creek stock (part of **Bix (Sunshine Creek)**, #115P 031, see below) is weakly anomalous in Ag, Cu, Pb, Zn, As, Sb, Mo, Bi and Cd (sample 93DH-26d, Appendix 3). Skarn occurs where the Vancouver Creek (**Lugdush**), Sunshine Creek (reported in Emond and Lynch (1992), but not named) and Boulder Creek (**Boulder** and **Oliver**) stocks cut calcareous metaclastic rocks and marble in the Hyland Group. Mineralized skarns are anomalous in W, Sn, Ag, Zn, Cu, and rarely Au. **Lugdush** is classified as a W skarn, and **Oliver** and **Boulder**, as Sn skarns (Emond and Lynch, 1992).

Table 7. Mineral occurrences associated with the McQuesten intrusions, McQuesten River region

Intrusion-hosted

Occurrence	MINFILE#	Map area	Intrusion
Bix	115P 031	115P/15	Sunshine Creek stock
Cobble	115P 062	115P/15	Boulder Creek stock

Skarn

Occurrence	MINFILE #	Map area	Associated intrusion	Host strata	Metals
Lugdush	115P 009	115P/14	Vancouver Creek stock	Yusezyu Formation	W
Boulder	115P 024	115P/15	Boulder Creek stock	Yusezyu Formation	Sn
Oliver	115P 030	115P/15	Boulder Creek stock	Yusezyu Formation	Sn, Ag, Au

Vein and breccia

Occurrence	MINFILE #	Map area	Associated Intrusion	Anomalous metals
East Ridge	115P 008	115P/15	Boulder Creek stock	Ag, Sn, Pb, Zn, Au
Lugdush	115P 009	115P/15	Vancouver Creek stock	Ag, Pb
Boulder	115P 024	115P/15	Boulder Creek stock	Ag, Sn, W, Au, Pb, Zn, Sb
Oliver	115P 030	115P/15	Boulder Creek stock	Ag, Sn, W, Zn, Cu
Bix	115P 031	115P/15	Sunshine Creek stock	Sn, Ag
Jabberwock	115P 051	115P/15	Vancouver Creek stock	Ag, Sn
Veins and breccias of unknown association				
Van	115P 063	115P/15	?	Au, Ag, Cu, Pb, Zn, W
Chance	105M 054	105M/13	?	Sb

The **Bix (Sunshine Creek,** #115P 031) and **Oliver** (#115P 030) breccias are spatially associated with the Sunshine Creek (former) and Boulder Creek (former and latter) stocks. At the **Bix** occurrence, quartz-orthoclase-tourmaline-pyrite-cassiterite-limonite-cemented breccias and veins occur within a 2-km-wide, northeast-striking corridor of closely spaced northeast-striking fracturing and brecciation and associated tourmaline alteration and veinlets. The breccias contain tin and silver mineralization and are locally anomalous in Sb, Pb, Zn, As, Au, Cu, Bi, and W (Emond and Lynch, 1992; INAC, 1995). The southwestward extension of this zone of fracturing encompasses the Tee vein (**East Ridge,** #115P 008) and **Boulder** (#115P 024) vein and breccia systems, which have similar silver and tin mineralization and polymetallic anomalies.

The **Oliver** occurrence lies southeast of the McQuesten River on the southeast side of the Boulder Creek stock. Silver-tin mineralization occurs in breccias in an east-northeast-striking, steep south-dipping fault gouge and breccia zone within and just outside the stock's hornfels zone (Emond, 1985; Emond and Lynch, 1992). Chlorite is the dominant matrix material in silver-tin-bearing breccias, with lesser tourmaline, rutile, biotite, muscovite, sphalerite, chalcopyrite, pyrite, pyrrhotite and native silver. The chlorite matrix encompasses clasts of metaclastic country rock, vein quartz, vein tourmaline, vein chlorite, and cassiterite. Breccias cemented by tourmaline, quartz, biotite, muscovite, kaolinite and calcite also occur but are less important in terms of their metal content (Figure 94). Stockwork veins with similar mineralogical characteristics to the breccias are very dense immediately outside the breccia zones, but have lower metal values. Country-rock alteration is intense within the stockwork zone.

The **Jabberwock** (#115P 051) occurrence consists of a series of steep mineralized northeast-striking fractures locally anomalous in Sn, Ag, Au, Pb, Zn, Bi and W. Although equidistant from both Tombstone (Big Creek stock) and McQuesten (Vancouver Creek stock) intrusions, the silver- and tin-rich nature of the mineralization has more in common with the McQuesten intrusions. Furthermore, the occurrence is on the west side of the fracture array accommodating about 2 km of displacement along the Josephine Creek Fault; restoration of this displacement places this showing nearly on strike from the **Bix (Sunshine Creek)** breccia zone associated with the Sunshine Creek stock.

Mineral occurrences of unknown age

The common north- and northwest-striking topographic lineaments in the Sprague Creek map area (Figure 4) are locally marked by limonitic, vuggy quartz-cemented breccias. A sample from one breccia, the **Van** occurrence in the western part of the Sprague Creek map area, is anomalous in Au, Ag, As, Pb and Zn (sample 93DM-200a, Appendix 3). The age of these breccias is not known; topographic lineaments near the occurrence cut the Boulder Creek and Sunshine Creek stocks, indicating that they are younger than 65 Ma.

North-striking topographic lineaments in the Seattle Creek map area are marked by west-side down normal faults. Gouge locally contains arsenopyrite and is anomalous in Au. As previously discussed, it is not clear whether gold mineralization in gouge is associated with faulting or is remobilized from earlier gold-mineralized west-southwest-striking veins. North-striking topographic lineaments cut the Scheelite Dome stock and are therefore younger than 92 Ma. No spatial or temporal relationship of these lineaments to lineaments in the Sprague Creek map area is apparent.

Regional context, geological controls on mineralization and implications

Syngenetic mineralization

Lower Paleozoic rocks of Selwyn Basin and Devonian rocks of the Earn Group form an extensive province for sedimentary exhalative-type syngenetic Zn-Pb-Ba (-Ag) massive sulphide mineralization (Abbott et al. 1986). Cambrian strata near the western transition of Selwyn Basin into Cassiar Platform host a cluster of important deposits in the Anvil camp. Ordovician rocks host some of the showings in the Gataga camp in northeastern British Columbia. Silurian strata host the large Howards Pass deposit in the eastern part of Selwyn Basin and showings in the Gataga camp. Earn Group strata host the important Macmillan Pass deposits in eastern Yukon, the larger deposits in the Gataga camp, and the Clear Lake deposit in central Yukon. Smaller massive sulphide and barite showings are common throughout these strata.

The largest Selwyn Basin deposits occur in dark, fine-grained, deep basinal clastic rocks thought to have been deposited during attenuation and early rifting of the Cordilleran margin (Abbott et al. 1986). The Anvil Pb-Zn-Ag deposits (Jennings and Jilson, 1986; Pigage, 1991) occur in a polydeformed succession of graphitic and calcareous phyllites metamorphosed to amphibolite grade. They are associated with a carbonaceous facies straddling the contact between the lower Mt. Mye formation (graphitic phyllite) and overlying calcareous phyllite of the Vangorda formation (Jennings and Jilson, 1986). Metabasite occurs throughout the sequence, but has been interpreted as feeder dykes to younger Menzie

Creek volcanics (Pigage, 1991). The two ore-hosting formations correlate with the Gull Lake (Mt. Mye) and Rabbitkettle (Vangorda) formations of Selwyn Basin and the Kechika Group of Cassiar Platform (Tempelman-Kluit, 1972; Jennings and Jilson, 1986). Although the structural and metamorphic overprint obscures primary relationships, in particular the presence of a feeder zone, the deposit is thought to have formed by synsedimentary precipitation from hot metalliferous brines exhaled along basin-forming faults into reduced bottom waters during Middle or Late Cambrian rifting (Jennings and Jilson, 1986). The Howards Pass deposits are hosted by Early Silurian black carbonaceous cherty mudstone and lesser argillaceous limestone of the Duo Lake Formation of the Road River Group (Gordey and Anderson, 1993). Although direct evidence for active Early Silurian rifting is sparse, the deposits are thought to have formed in a rift setting similar to that of the Anvil deposits. Characteristics seemingly unique to Howards Pass are lack of barite and low temperature of formation; as with the Anvil camp, a feeder zone has yet to be identified (Goodfellow and Jonasson, 1986). Howards Pass deposits are thought to have formed from low-temperature sulphur-poor brines emanating into sulphidic bottom waters of a stratified water column (Goodfellow and Jonasson, 1986).

In contrast to the relatively quiescent deep marine environments of both the Anvil and Howards Pass deposits, deposits hosted by the Earn Group are associated with synsedimentary faults, coarse-grained and poorly sorted debris flow deposits derived from fault scarps, soft-sediment deformation structures, rapidly changing sedimentary facies and, locally, basaltic volcanism. At Macmillan Pass, according to Abbott and Turner (1990, p. 99), "Variations in thickness, internal stratigraphy, and external stratigraphic relations in the Earn Group record a complex history of repeated uplift and subsidence that indirectly suggest Devonian extension, rifting and wrench faulting ...". The Tom and Jason deposits are thought to have formed from high temperature hydrothermal fluids emanating from a vent complex developed along an active fault, which also controlled local intrusion and extrusion of basaltic magma. Basaltic volcanic rocks occur at the Boundary Creek deposit and the latest flows are thought to have coincided with mineralization (Abbott and Turner, 1990). With the exception of the local association with basaltic volcanic rocks, the Earn-Group-hosted deposits in the Gataga district of northeastern British Columbia share many of the features of the Macmillan Pass deposits and a similar setting is inferred.

Except for the Boundary Creek deposit, syngenetic deposits of the Earn Group lack an association with volcanic rocks. Another exception is the **Marg** volcanogenic massive sulphide deposit in the southeastern part of the Nash Creek map area (#106D 009). The deposit occurs in complexly folded, possibly faulted, and highly strained Keno Hill quartzite and rocks thought to be Earn Group (Turner and Abbott, 1990). A locally coarse-grained quartz-feldspar augen phyllite thought to be felsic metavolcanic rock occurs near the top of the Earn Group; another muscovite-chlorite unit with millimetre-scale quartz and feldspar 'eyes' occurs with carbonate in an ambiguous, structurally higher position sandwiched between bands of Keno Hill quartzite. The **Marg** deposit occurs within the latter band. Turner and Abbott (1990) inferred that the upper metavolcanic unit was an infold or thrust repetition of the underlying metavolcanic unit. However, carbonate has yet to be found within the lower felsic horizon, and the upper horizon has been intermittently observed at the same relative position within the Keno Hill quartzite southwest of Mt. Hinton in the Keno Hill and Seattle Creek map areas. These observations suggest the possibility that the **Marg** horizon is stratigraphically part of the Keno Hill quartzite rather than the Earn Group.

If the interpretation that the Earn Group lay in a complex back-arc position behind a magmatic arc on the western edge of North America (Rubin et al. 1990) is tenable, then volcanic rocks and perhaps volcanogenic massive sulphide deposits would be expected to be more common in the western part of the basin. Alkalic volcanic rocks occur in the Pelly Mountains where Earn Group strata onlapped Cassiar Platform (Gordey, 1977, 1981; Mortensen, 1979, 1982) and voluminous coeval intrusions and volcanic rocks occur throughout the pericratonic Yukon-Tanana terrane (Mortensen, 1992 and references therein). Volcanic-hosted massive sulphide mineralization is found in the Pelly Mountain volcanic rocks (e.g., MM; INAC, 1995) and throughout the Yukon-Tanana Terrane of Yukon, British Columbia and Alaska (Johnston and Mortensen, 1994; Mortensen, 1992, Newberry et al. 1997).

The above considerations have the following implications for the McQuesten River region:

1. Regionally, syngenetic massive sulphide deposits are associated with Lower to mid-Paleozoic stratigraphic units that occur in the McQuesten River region. The Gull Lake and Rabbitkettle formations correlate with the Anvil mine stratigraphy. The Duo Lake Formation, which hosts the Howards Pass deposit, and the Earn Group, which hosts numerous deposits in Yukon and British Columbia, occur in the McQuesten River region. Hence, the region has favourable stratigraphy for sedimentary exhalative-type (sedex) deposits.

2. As is evident in the foregoing discussion, synsedimentary faults with sufficient displacement to form sedimentary basins and to localize heat flow and volcanism are key characteristics of the geological setting of northern Cordilleran sedex deposits (Abbott et al. 1994). In the McQuesten River region, the Narchilla and Gull Lake formations are preserved in the downdropped block of the Sprague Creek Fault, which was active before the deposition of the Rabbitkettle Formation. The lower member of the Gull Lake Formation is a coarsely fragmented basaltic metavolcanic unit. Although displacement on the Sprague Creek Fault cannot be proven to be synsedimentary or synvolcanic, perhaps the combination of faulting and volcanism indicates the sort of setting favorable for sedex deposits. As discussed in the previous section, the Sprague Creek Fault might have influenced sedimentation and syngenetic mineralization in the Earn Group, thus highlighting its potential importance as a basin-forming feature.
3. Basin-forming or -bounding faults are key features in genetic models of sedex deposits. In addition to the Anvil deposits, numerous small sedex deposits occur in the southwestern part of Selwyn Basin along or near the transition to Cassiar Platform (Abbott et al. 1986), implying that this transition is structurally controlled and affirming its potential to host more deposits of this type. The lithological characteristics of some of the stratigraphic units in the McQuesten River region suggest they were deposited near this promising southern or western edge of the basin. The Rabbitkettle Formation is a more massive and continuous carbonate unit and has a more platformal aspect than is described in the Mayo map area (Roots, 1997) to the east. The Steel Formation is coarser grained and more carbonate-rich than in its type area and resembles coeval units of Cassiar Platform. These stratigraphic characteristics combined with the evidence of Early to Middle Paleozoic structure presented above highlights the potential for sedex deposits in the western part of Selwyn Basin.
4. Because of the occurrence of felsic metavolcanic rocks and associated volcanogenic massive sulphide mineralization in the Earn Group and possibly in the Keno Hill quartzite (Marg), the part of the McQuesten River region underlain by these rock units should be considered favourable for more deposits of this type (Abbott et al. 1994).

Mineralization associated with Tombstone intrusions

In the Tombstone-Tungsten Belt (TTB), metaluminous intrusions of the Tombstone suite extend from the 'type' area in the Tombstone River region east of Dawson City, Yukon, as far east as the O'Grady Batholith in the western Northwest Territories (Gordey and Anderson, 1993). Before displacement on the Tintina Fault, the belt extended southwestward from the Tombstone River region; its offset continuation is the belt of mid-Cretaceous intrusions in east-central Alaska, extending southwest from the Tintina Fault at least as far southwest as the Fairbanks district (Newberry, McCoy et al. 1995; McCoy et al. 1997). The eastern end of the TTB, trending south and east from the O'Grady Batholith to around Tungsten, NWT, is dominated by the peraluminous Tungsten intrusions.

The Tombstone intrusions within the TTB exhibit a diversity of styles of intrusion-hosted mineralization. At the type locality of the Tombstone intrusions in the Tombstone Mountains east of Dawson City, composite, predominantly syenitic stocks host uranium mineralization in diverse settings: 1) disseminated in a feldspathoidal syenite (tinguaite; with fluorite, molybdenite, galena, sphalerite and dark brown, Fe-rich biotite, (Anderson, 1988)); 2) in shear zones in the tinguaite (Olade and Goodfellow, 1978), and in veins cross-cutting the tinguaite and probably associated with the subsequent intrusion of the 'younger' sphene- and fluorite-bearing alkali feldspar syenite (Anderson, 1987). Miarolitic cavities with arsenopyrite and chalcopyrite occur in syenite near the contact with the tinguaite (Tempelman-Kluit, 1969; Anderson, 1987) and narrow Au- and Ag-bearing quartz± arsenopyrite, pyrite, chalcopyrite, sulphosalt veins cut the syenite adjacent to the tinguaite (**Tombstone** #116B 151, INAC, 1995). Scheelite is locally disseminated in late monzonite; minor fluorite, molybdenite and chalcopyrite occur in late trachyte dykes; and pyrite and chalcopyrite occur in late oxidized shear zones (Anderson, 1988).

Most of the gold mineralization at **Brewery Creek** (#116B 160, 18.2 Mt at 1.55 g/t, Diment, 1996), 76 km east of Dawson City, is hosted by altered and fractured high-level Tombstone intrusions (about 91.5 Ma, J. Mortensen, pers. comm. 1995; Diment, 1996). Intrusions occur as gently dipping, sill-like bodies, less commonly as more steeply dipping bodies along steep shear zones, and as larger stocks. The highest gold grades occur in fine-grained pyrite and arsenopyrite with quartz in highly fractured and phyllically altered intrusive rocks. Intrusion and mineralization are thought to be controlled by thrust faults and kinematically related steep, possibly wrench, faults (T. Bremner, unpublished mapping; Diment, 1996).

The syn-intrusive nature of gold mineralization is possibly most clearly expressed in the syenitic Emerald Lake stock in the Niddery Lake map area near the eastern end of the TTB (Smit, 1984; Smit et al. 1985). Au-Ag-Bi-Te-W-Mo mineralization occurs in miarolitic cavities as well as in sheeted veins. Cavities are decimetre-scale to metre-scale and appear to pass laterally upward into sheeted veins (J. Mortensen, pers. comm. 1995).

Tombstone-intrusion-hosted gold deposits are currently being developed at **Dublin Gulch** (#106D 025; Hitchins and Orssich, 1996; Smit et al. 1996) and mined at Fort Knox, Alaska (Bakke, 1996). **Dublin Gulch**, just north of the Mt. Haldane map area, is a large, low-grade gold deposit (inferred and potential resource of 98.6 Mt at 1.19 g/t Au, Smit et al. 1996) currently under development. At **Dublin Gulch**, gold-bearing veins consist of milky white to grey quartz with ubiquitous sericite and potassium feldspar and less commonly scheelite as accessories. The veins are sheeted, striking from 065° to 080° and dipping steeply to the southeast, and are not clustered in distinct shear zones. Gold mineralization at Fort Knox (158.3 Mt at 0.83 g/t Au, Bakke, 1996) is hosted in three different types of quartz veins: pegmatitic quartz± potassium feldspar, biotite and hornblende veins that pass upward and outward into grey quartz veins; milky white stockwork veins; and granulated white quartz veins in shear zones. Pegmatitic and grey quartz veins are east-west-striking and vertical to steeply south-dipping. Milky white veins are predominantly east-west-striking with no consistent dip pattern. Normal-displacement quartz-filled shear zones strike northwest-southeast and have moderate southwest dips. At both **Dublin Gulch** and Fort Knox, accessory sulphides occur in only a small percentage of the veins. W-Au skarns are found at both **Dublin Gulch** and Fort Knox.

The intrusion-hosted occurrences in the McQuesten River region are most similar to the **Dublin Gulch**-Fort Knox deposits. Host intrusions are similar in age (Fort Knox: 92.5 ± 0.5 Ma, J. K. Mortensen, pers. comm. 1994; **Dublin Gulch**: 92.8 ± 0.5 Ma, see under Intrusive Rocks), texture (weakly to strongly porphyritic, medium- to fine-grained) and composition (biotite± hornblende granite, granodiorite, quartz monzonite) to the McQuesten River region intrusions. Intrusion-hosted sheeted vein systems of the McQuesten River region resemble those of **Dublin Gulch** and Fort Knox in style and orientation. However, sulphide-poor vein systems are uncommon.

Intrusion-related occurrences peripheral to the Tombstone intrusions throughout the remainder of the TTB comprise many of the same type of occurrences as found in the study area, including skarns and replacements and veins and breccias. Some variants on these types of occurrences are as follows (summarized from INAC, 1995):

The **Peso** and **Rex** (#106D 021) vein-fault systems, located about 2.5 km west-southwest of the Dublin Gulch stock in the southwestern part of the Nash Creek map area (106D), consist of sheared and oxidized Ag-, Pb-, Sb- and locally Au-bearing quartz-siderite-pyrite-jamesonite-arsenopyrite-galena-tetrahedrite veins. The veins are northeast-trending, southeast-dipping, similar to the orientation of intrusion-hosted veins in the Dublin Gulch stock. Proven and probable reserves total 139 400 t grading 716 g/t Ag and 3.7% Pb. Gold is erratically distributed in these veins and in other veins closer to the Dublin Gulch stock (INAC, 1995; Hitchins and Orssich, 1996).

At **Brewery Creek**, in addition to that hosted by intrusions, about 15% of the gold mineralization occurs in sedimentary host rocks (Diment, 1996). Mineralization in the Blue, Pacific and Moosehead zones is hosted by brecciated, silica-flooded and veined sandstone, shale and greywacke of the Earn Group. Dolomitic siltstone of the Steel Formation is locally silicified, with modest gold grades (Poulsen, 1996). Gold mineralization is marked by anomalous As and Sb.

As in the McQuesten River region, several small Cretaceous stocks north, east and northeast of **Brewery Creek** and their hornfels zones are cut by east-striking gold-, silver-, and copper-bearing, quartz-arsenopyrite ± carbonate, pyrrhotite, chalcopyrite, pyrite veins, breccias and vein-faults (**Ida**, #116A 027; **Aussie**, #116A 031; **Bear**, #116A 033; **Index**, #116B 001; **O'Brien**, #116B 094; **Hamilton** #116A 012 and **Philp**, #116A 021). West-northwest-striking silver-, lead-, and zinc-bear-ing quartz-carbonate-pyrite-pyrrhotite-arsenopyrite-galena-sphalerite-jamesonite-chalcopyrite veins and gold-bearing quartz-sulphide lenses in a silicified and carbonatized shear zone occur at **Rimrock** (#116A 013).

The **Neve** occurrence in the Niddery Lake map area (#105O 032) shows some similarity to **Brewery Creek**. Here, gold, silver and antimony mineralization occurs in quartz-realgar-stibnite ± pyrite veins in a quartz-porphyry dyke cutting shale and siltstone of the Earn Group. Other mineralization on the property is in fractured and bleached carbonaceous shale and clay-altered, silicified, sericitized, and bleached zones associated with faults cutting both the Earn Group and porphyritic quartz monzonite.

At the **Ida** occurrence (#116A 027; INAC, 1995; Poulsen et al. 1997), silicified and bleached rocks of the Road River Group near a Cretaceous stock, host disseminated gold. The best gold grades correlate with the highest degree of silicification and Sb and Hg anomalies.

At the **Marn** occurrence in the southern Ogilvie Mountains (#116B 147; INAC, 1995), Cu-Au-Ag-Bi skarn mineralization is developed. The skarn deposit occurs beneath sills along the north side of the Mt. Brenner monzonite stock where it is in contact with limestone of the Permian Takhandit Formation (Tempelman-Kluit, 1981). Massive sulphides contained within a 30-m-thick band of pyroxene skarn consist primarily of pyrrhotite and chalcopyrite with lesser sphalerite, arsenopyrite, pyrite and trace cubanite and pentlandite. Veinlets of electrum, native bismuth, bismuthinite, bismuth telluride and silver minerals cut the sulphides. Drilling has outlined 275 000 to 330 000 t grading 8.6 g/t Au, 1% Cu, 0.1% W and 17 g/t Ag (INAC, 1995).

Although late quartz and quartz-tourmaline veins are described from several Tungsten intrusions, no significant intrusion-hosted mineralization has been reported. Tungsten intrusions are, however, associated with W-Cu (Mo, Zn) skarns, forming the Selwyn Tungsten Belt of Cathro (1969). World-class W deposits occur at Cantung and Mactung where peraluminous Tungsten intrusions intersect Cambrian-limestone-bearing units.

Geological controls on mineralization associated with Tombstone intrusions

Newberry et al. (1990), Newberry and Solie (1995), Newberry, Layer et al. (1995), Newberry, McCoy et al. (1995) and McCoy et al. (1997) recently summarized and synthesized voluminous data from Alaskan gold deposits mostly hosted by or related to mid-Cretaceous intrusions thought to be the offset extension of the Tombstone-Tungsten Belt. Data from Ar^{40}-Ar^{39} geochronological, petrographic, geochemical, stable isotopic, and fluid inclusion analyses were used to show that gold-bearing intrusions are mostly 89-93 Ma, commonly ilmenite series, alkalic to calc-alkalic, porphyritic granite, granodiorite and quartz monzonite with low primary iron oxide and I-type trace element and lead isotopic signatures. Although strongly radiogenic and likely highly contaminated by old continental crust, melts have subduction-related geochemistry. Gold is thought to have been transported in bisulfide complexes in CO_2-rich fluids fractionated from the most differentiated magmas. Temperature and pressure estimates from fluid inclusion studies suggest intrusion and mineralization at 0.5 to 1.5 kb.

Gold-associated Tombstone intrusions in the McQuesten River region and throughout the TTB in Yukon share many of the characteristics described above, highlighting the importance of petrogenetic considerations in forming of mineralizing fluids. Another primary control is structural. With the exception of skarn deposits, most gold-bearing intrusion-hosted and country-rock-hosted vein systems in Yukon hover around east-west strikes, parallel to the regional east-west strike of the Tombstone intrusions within the TTB, implying the influence of a regional structural control. Mineralization is hosted by primarily dilational features (veins) and the steep, sharp contacts, lack of inclusions, lack of doming, lack of deformation of the intrusions all imply that they filled space created in a broadly extensional realm. There is little evidence of displacement parallel to the boundaries of the belt. Perhaps both the intrusions and associated mineralization are a manifestation of dilation over re-activated, pre-existing basement structures.

The kinematics of the Elsa-Keno Hill vein-faults imply a different dynamic regime during their formation than would produce dilation in the TTB. Sinistral (with minor normal) displacement of the northeast-striking, steep southeast-dipping vein faults implies a north-trending, moderately north-plunging principal compressive stress, which is nearly perpendicular to the orientation of the compressive stress necessary to open up the east-west-striking cracks of the intrusion-related systems. Perhaps, as suggested earlier, the Elsa-Keno Hill vein-faults reflect changes in the kinematic regime of the fold-and-thrust belt during the cooling of the Tombstone intrusions.

The importance of structural controls is especially evident at the scale of the Elsa-Keno Hill camp. The interpretation of the various structures of the Elsa-Keno Hill vein-fault system presented in Structural Geology provides a basis for explaining what is known about the distribution of gold in the Keno Hill camp. In the context of the evolution of faults or brittle-ductile shear zones (e.g., Ramsay and Huber, 1987), the early en echelon and stockwork vein arrays represent the nucleation and propagation of a brittle-ductile shear zone before concentration of displacement on the main fault break. Furthermore, as faults generally lose displacement in the direction of displacement, the main vein-faults would be expected to pass laterally into a brittle-ductile shear zone occupied primarily by the low-displacement structures associated with the nucleation and propagation of the fault, i.e. en echelon and stockwork vein arrays. As displacement decreases laterally on one fault, compatibility with neighbouring regions would be maintained by transfer of displacement to other parallel structures via extensional or compressional transfer zones. In extensional transfer zones, permeability could be very high as much of the displacement can be accommodated there. Hence, as the early stockworks and en echelon arrays in the camp are gold-bearing quartz-arsenopyrite-sulphosalt veins, in this model, Ag-Pb-Zn vein-faults should pass laterally into areas with a potential for concentrations of gold. Second, lateral transfer zones, because they have accommodated much of the displacement history in a relatively small area, would show the full suite of mineralization and might also be areas of concentrated gold mineralization. Both of these implications are reflected to a certain extent in what is known about the distribution of gold in the camp. High gold grades have been reported from Silver King and Husky SW at the western end of the known camp. At the Silver King concentrations of gold and silver occur at the intersections of hangingwall and footwall 'breaks' (M. Phillips, pers. comm. 1995), which in this interpretation represent the precursor en echelon arrays that formed before the breakthrough of the main vein-fault. Gold has also been reported from the mines developed on the No. 9 transverse vein array connecting the Main Fault-Nabob and No. 6 longitudinal vein-faults (INAC, 1995).

Another controlling factor in the formation of gold deposits peripheral to the Tombstone intrusions is favourable stratigraphy for the formation of skarn and carbonate replacement deposits. It was pointed out earlier that carbonate-bearing stratigraphy conducive to the formation of skarn deposits occurs throughout the stratigraphic column in the McQuesten River region. In addition, Poulsen (1996) — using a broad definition of Carlin-type deposits as "irregular bodies of disseminated pyrite and micron-sized gold particles in de-calcified sedimentary rocks that were once carbonate-bearing" and an intrusion-related model of ore genesis — has pointed out the potential for Carlin-type deposits in the miogeoclinal portion of the northern Cordillera where overprinted by Cretaceous granitic intrusions. Poulsen notes many striking similarities in stratigraphic units, structure and structural evolution and intrusive rocks of the western portion of the Tombstone-Tungsten Belt and the Carlin district of Nevada and points to parts of the Brewery Creek deposit as 'Carlin-like'. Other deposits with Carlin-like characteristics are **Ida** and **Neve** (H. Poulsen, pers. comm. 1995).

Geological Evolution of the McQuesten River Region

New geological data collected during the course of this study suggest that the bedrock geology of the region evolved through the following stages:

1. *Deposition of Upper Proterozoic through Devonian gritty quartzose clastic rocks, carbonate rocks, dark shale, chert, and uncommon mafic volcanic rocks* during the Selwyn Basin phase of evolution of the northern Cordilleran continental margin. Intermittent periods of normal faulting, uplift and erosion during this phase of the continental margin are indicated by stratigraphic relationships in the McQuesten River region. Mafic volcanic rocks in the Cambrian part of the sequence suggest that vigorous extension and local rifting might have been a characteristic of that time.
2. *Regional uplift, erosion and deposition of dark shale, coarse-grained clastic rocks* and, locally, barite and metavolcanic rocks of the Earn Group. The continental margin's Selwyn Basin phase of evolution came to a close in Middle (?) Devonian time with regional uplift, gentle warping and erosion, followed by subsidence of the continental margin and an eastward transgression of basinal marine facies. This transition is manifested in the McQuesten River region by the sub-Earn Group unconformity, deposition of chert-pebble conglomerate and barite and the local extrusion of felsic metavolcanic rocks and formation of massive sulphide deposits. The tectonics of the region at this time probably reflected its location in a broadly foreland setting with respect to the Ellesmerian orogeny to the north and a broadly back arc setting with respect to magmatism occurring in pericratonic terranes to the west.
3. *Deposition of Mississippian Keno Hill quartzite*. The Mississippian Keno Hill quartzite is the only record of this time in the McQuesten River region, comprising primarily quartz-rich clastic rocks intercalated with carbonaceous shale and a small amount of carbonate and felsic metavolcanic rock. Intense Mesozoic deformation in the region precludes any rigorous assessment of its depositional environment. The Upper Paleozoic record elsewhere in the Selwyn Basin region is fragmentary. Post-Earn Group deposits occur sporadically throughout the region and are inferred to represent a return to relatively stable continental margin sedimentation after the Devonian instability as represented by the Earn Group (Gordey and Anderson, 1993).
4. *Intrusion of late Middle Triassic mafic sills*. A voluminous amount of Middle Triassic mafic magma intruded rocks of the Tombstone Thrust sheet between the Klondike River region and the western part of the Lansing map area and part of the Dawson Thrust sheet in the southern part of the Nash Creek map area. Triassic mafic magmatism in rocks of ancestral North American affinity is unique to this part of the northern Cordilleran miogeocline (Mortensen and Thompson, 1990). Nearby coeval sedimentary rocks are variably carbonaceous and calcareous siltstone, sandstone and limestone, apparently reflecting quiet, shallow-marine shelf deposition.
5. *Jura-Cretaceous deformation of the western part of Selwyn Basin*. At some point in the Jurassic or Early Cretaceous, deformation of the western part of Selwyn Basin started, first by shortening accommodated by south-vergent folding, then by Jura-Cretaceous displacement, direction unknown, along the Robert Service Thrust, then by complex Early Cretaceous displacement along the Tombstone Thrust and Strain Zone. The Tombstone displacement included hanging wall displacement initially to the north-northeast, subsequent main phase displacement to the northwest and final displacement to the north-northeast. Subsequent deformation of the area was relatively minor warping.
6. *Mid-Cretaceous intrusion of Tombstone-Tungsten Belt*. At around 92 Ma, an extensive, compositionally diverse episode of magmatism occurred in the Selwyn Basin region and equivalent regions in Alaska across the Tintina Fault. Metaluminous, felsic to intermediate, calcic, calc-alkalic and alkalic plutons of the Tombstone suite intruded in an east-west belt across the western part of Selwyn Basin. These intrusions have geochemical characteristics that indicate mixing of crustal and mantle sources. They are associated with most of the gold-bearing (W-As-Sb-Bi-Cu-Te) mineral occurrences in the region and have been suggested as the source for the rich silver lodes of the Elsa-Keno Hill camp. The tectonic setting of magmatism is difficult to characterize uniquely, but intrusion of the Tombstone suite is broadly synkinematic with respect to shortening of the continental margin and might represent a mixture of mantle-derived (arc, *sensu stricto*) magmas and crustally derived melts induced by structural thickening.
7. *Late Cretaceous intrusion of the McQuesten Intrusions*. At around 65 Ma, granitic melts again intruded the western part of Selwyn Basin. The McQuesten intrusions include (so far) five plutons in a short northeast-striking belt centred on the McQuesten River. McQuesten intrusions are metallogenically distinct from Tombstone intrusions, being associated with northeast-striking silver-tin-bearing breccia zones. The tectonic setting of McQuesten magmatism is unclear.

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Appendix 1. Whole-rock geochemical analyses of unfoliated intrusions in the McQuesten River region

TOMBSTONE INTRUSIONS (92±2 Ma)

	Big Creek	Barney		Josephine	Rhosgobel	Lost Horses Quartz Syenite			Sprague Cr.
	92DH-47	92DH-173	92J11-2	92DM-36	94DM-270	92DM-176	92DM-185	92DM-200	93DM-41a
SiO2	66.50	58.70	58.00	72.20	65.15	58.30	67.10	66.20	65.33
TiO2	0.49	0.88	0.86	0.24	0.53	0.64	0.38	0.35	0.49
Al2O3	16.10	15.50	15.80	14.50	14.98	14.80	14.90	16.00	15.45
FeO*	3.96	7.56	7.55	2.13	4.59	5.70	2.68	3.27	3.40
MgO	1.43	3.63	3.60	0.64	1.50	1.92	0.92	0.69	1.15
MnO	0.07	0.14	0.14	0.05	0.11	0.11	0.09	0.10	0.06
CaO	3.80	6.34	6.44	2.73	3.86	4.12	2.39	0.98	3.23
Na2O	2.57	1.98	2.14	2.15	2.60	1.94	3.12	2.48	3.12
K2O	3.83	3.23	3.40	5.57	5.18	7.58	5.92	7.27	5.90
P2O5	0.17	0.25	0.27	0.11	0.21	0.30	0.17	0.14	0.19
LOI	0.75	1.60	0.90	1.10	0.79	3.90	2.15	2.35	2.05
Total	99.67	99.81	99.10	101.42	98.71	99.31	99.82	99.83	100.37
Trace elements (ppm)									
Ag	0.55	0.55	0.64	0.58	0.50	4.29	2.81	3.03	0.96
Ba	2714.30	2225.65	2183.49	2094.90	1540.50	2888.54	1547.43	2096.67	1763.57
Be	4.04	1.94	0.65	3.32	5.50	5.93	5.86	7.81	5.27
Bi	0.05	0.16	0.17	0.29	-	0.36	0.56	0.12	2.92
Co	5.64	14.97	14.67	2.55	6.90	9.83	4.37	3.92	5.87
Cr	207.49	200.06	211.92	173.82	33.00	138.26	163.63	122.14	32.34
Cs	11.32	13.04	10.97	4.35	11.00	11.72	6.33	9.57	26.65
Cu	4.59	16.09	14.79	23.53	1.50	13.99	23.69	5.46	19.45
F	-	-	-	-	1400.00	-	-	-	-
Hf	2.07	1.02	1.53	2.42	5.40	8.92	4.84	7.28	5.78
Li	71.23	25.71	32.52	25.66	-	59.38	22.08	46.47	68.53
Mo	5.22	3.19	3.37	5.20	2.00	3.28	6.02	5.33	1.64
Nb	17.35	14.43	15.15	20.64	23.00	24.82	23.45	22.93	27.69
Ni	5.27	8.53	6.35	3.23	5.00	11.07	6.54	7.40	8.18
P	709.58	963.96	1151.43	445.30	-	1259.45	644.08	517.35	562.97
Pb	36.62	31.46	33.66	19.73	64.00	39.91	49.59	28.88	48.42
Rb	147.29	119.94	125.57	136.77	247.00	261.82	249.19	260.43	224.15
Sb	0.34	2.64	2.26	0.43	1.00	1.06	0.95	3.62	3.68
Sc	8.57	23.14	24.07	4.94	9.00	11.85	5.46	6.34	6.40
Sn	2.28	2.29	2.59	1.73	5.00	4.25	3.69	2.46	7.84
Sr	571.53	536.93	610.41	561.88	629.90	970.88	807.94	826.26	785.07
Ta	1.09	0.93	0.96	1.40	2.00	1.43	1.26	1.33	1.70
Th	21.04	15.28	16.92	17.70	18.70	32.06	21.93	38.62	26.33
Ti	2978.14	5104.31	5294.08	1558.82	-	3762.67	2187.29	2060.65	2303.99
Tl	1.38	1.03	1.12	0.81	2.30	3.02	2.03	2.40	2.42
U	3.80	5.23	5.55	6.96	8.20	8.79	10.19	8.43	10.89
V	37.52	134.92	137.29	16.88	53.00	96.29	42.88	37.10	50.79
W	0.72	2.27	3.15	1.07	-	1.53	3.28	7.27	7.57
Y	13.76	21.23	23.44	13.63	21.70	30.00	16.53	27.92	17.30
Zn	84.99	109.27	117.58	41.85	76.90	47.41	54.21	72.54	49.24
Zr	56.26	23.85	41.72	60.92	181.90	325.28	159.28	240.30	188.42
La	53.05	38.64	44.06	37.25	50.80	84.94	45.33	93.42	59.94
Ce	100.05	77.35	88.27	71.73	93.20	169.61	86.53	168.36	114.32
Pr	11.60	9.46	10.74	8.24	9.40	20.11	9.79	19.39	12.84
Nd	36.12	32.45	36.16	26.93	35.00	65.88	32.11	60.20	40.74
Sm	6.15	6.45	7.17	5.05	6.00	12.37	5.78	10.58	7.17
Eu	1.46	1.48	1.56	1.39	1.77	2.90	1.43	2.46	1.84
Gd	4.96	6.05	6.53	4.23	5.60	10.32	4.80	8.67	6.04
Tb	0.56	0.77	0.82	0.52	0.80	1.25	0.58	1.06	0.72
Dy	2.95	4.56	4.88	2.94	3.80	6.90	3.33	6.00	3.86
Ho	0.51	0.86	0.91	0.50	0.78	1.15	0.60	1.06	0.66
Er	1.43	2.37	2.56	1.39	2.20	3.05	1.74	2.89	1.80
Tm	0.20	0.33	0.36	0.20	0.30	0.41	0.26	0.40	0.27
Yb	1.13	2.05	2.19	1.34	1.50	2.56	1.74	2.57	1.59
Lu	0.17	0.31	0.34	0.19	0.30	0.40	0.27	0.39	0.24

Notes: 92 samples: majors and minors analyzed by XRF at X-ray Assay Labs, Toronto, Ontario; traces by ICP-MS at the University of Saskatchewan. 93 samples: majors and minors analyzed by XRF at Activation Labs, Ancaster, Ontario; traces by ICP-MS at the University of Saskatchewan.
94 samples: majors and minors analyzed by XRF; traces by ICP-MS, all at Activation Labs, Ancaster, Ontario.
FeO*, total iron; -, not analyzed; <, not detected.

Appendix 1. Whole-rock geochemical analyses of unfoliated intrusions in the McQuesten River region

TOMBSTONE INTRUSIONS (92±2 Ma)

	Sprague Cr.		Red Mt.	Hobo Creek	Bos stock		Black Hill	Minton Cr.	Scheelite D.
	93DM-42a	93DM-47a	93DM-98/99	93DM-151	93DM-298	93DM-306f	94DM-169	94DM-192	94DM-240
SiO2	69.25	61.19	64.03	65.03	66.33	73.72	65.33	66.79	65.76
TiO2	0.33	0.52	0.62	0.48	0.51	0.19	0.57	0.58	0.56
Al2O3	15.30	14.85	15.00	15.29	15.83	13.33	15.25	15.06	15.32
FeO*	2.50	5.58	5.36	3.74	4.42	1.08	4.64	4.49	4.42
MgO	0.67	2.76	2.00	1.69	1.74	0.52	2.34	1.92	1.94
MnO	0.06	0.11	0.16	0.07	0.07	0.01	0.07	0.08	0.08
CaO	2.05	4.09	3.89	3.34	4.08	1.47	3.59	3.97	3.91
Na2O	3.41	2.37	2.83	2.79	2.52	1.95	2.41	2.42	2.48
K2O	5.50	4.20	4.21	4.63	4.16	5.98	4.19	3.83	4.78
P2O5	0.13	0.25	0.20	0.19	0.20	0.06	0.18	0.18	0.25
LOI	1.78	3.69	0.74	1.59	0.90	0.60	2.20	1.28	1.18
Total	100.98	99.61	99.04	98.84	100.76	98.91	100.77	100.60	99.50
Trace elem									
Ag	0.71	0.96	0.53	0.39	0.25	0.23	0.30	<	0.50
Ba	1376.15	1813.98	2566.33	2594.56	2270.52	1410.08	1680.20	2341.90	2053.60
Be	7.11	4.92	3.38	4.61	3.65	1.93	2.00	4.00	4.00
Bi	51.06	0.48	0.18	0.25	0.09	0.06	-	-	-
Co	2.62	10.59	6.28	6.61	5.60	1.73	10.80	5.90	6.60
Cr	21.97	133.16	67.05	59.23	59.54	17.53	89.00	141.00	74.00
Cs	14.75	5.39	10.36	9.16	13.01	5.32	4.00	13.00	14.00
Cu	15.72	10.59	20.14	8.44	2.84	3.72	5.50	1.90	2.50
F	-	-	-	-	-	-	1300.00	720.00	1200.00
Hf	4.42	3.68	2.25	2.92	2.10	2.25	5.30	5.80	5.80
Li	71.95	58.87	55.56	56.40	47.24	20.74	-	-	-
Mo	3.10	0.62	0.96	0.44	0.20	0.24	9.90	2.70	1.60
Nb	25.31	16.59	19.39	21.20	19.05	7.50	17.00	17.00	16.00
Ni	4.90	10.70	15.26	12.89	7.28	6.17	14.00	266.00	6.00
P	383.20	742.47	562.20	672.75	556.50	211.00	-	-	-
Pb	47.29	76.02	59.94	48.68	27.04	49.47	38.00	52.00	38.00
Rb	282.08	164.32	155.33	210.40	184.88	185.07	126.00	184.00	210.00
Sb	2.50	3.01	2.06	2.54	0.61	0.27	5.00	<	1.00
Sc	4.24	13.56	10.00	9.58	12.76	5.67	9.00	12.60	12.00
Sn	8.25	1.86	2.02	2.88	4.13	3.17	1.00	2.00	3.00
Sr	604.62	599.20	714.77	774.00	644.57	257.87	478.00	596.30	648.00
Ta	1.54	1.23	1.22	1.61	1.14	0.70	1.00	1.00	1.00
Th	26.63	16.62	17.79	28.64	19.95	20.20	21.80	15.50	18.00
Ti	1545.17	2653.57	2268.78	2553.92	2238.40	962.41	-	-	-
Tl	3.00	1.56	1.51	1.91	1.53	1.33	1.10		2.20
U	10.13	5.57	4.22	8.21	6.02	3.99	7.40	7.50	7.90
V	29.07	88.17	58.93	52.43	69.39	17.16	50.00	54.30	67.00
W	17.75	4.68	3.05	6.11	11.67	<	-	-	-
Y	14.76	20.54	15.83	17.87	18.55	14.96	16.80	23.30	22.20
Zn	37.64	120.07	127.22	79.83	70.10	15.50	67.60	102.90	65.60
Zr	135.20	119.12	69.45	76.59	52.67	55.74	169.90	199.70	187.80
La	51.15	42.54	45.93	63.05	45.24	33.87	51.20	48.10	47.40
Ce	98.40	84.55	87.99	126.49	90.84	68.67	87.90	88.10	83.60
Pr	10.86	9.91	9.91	13.60	10.23	7.87	8.90	9.60	9.20
Nd	34.16	32.06	31.12	41.81	33.44	24.36	33.60	34.70	35.70
Sm	6.07	6.03	5.56	7.34	6.57	4.38	5.40	6.40	6.40
Eu	1.38	1.50	1.58	1.66	1.63	0.90	1.42	2.01	1.99
Gd	4.96	5.63	4.54	5.67	5.32	3.42	4.20	5.60	5.50
Tb	0.59	0.69	0.59	0.67	0.66	0.44	0.60	0.80	0.70
Dy	3.31	4.17	3.30	3.77	3.82	2.88	3.10	3.90	4.00
Ho	0.56	0.76	0.62	0.71	0.68	0.56	0.62	0.76	0.76
Er	1.53	2.15	1.66	1.89	1.91	1.71	1.60	2.20	2.10
Tm	0.21	0.33	0.24	0.26	0.29	0.26	0.30	0.30	0.40
Yb	1.44	2.08	1.54	1.76	1.77	1.77	1.40	2.10	1.60
Lu	0.21	0.31	0.23	0.26	0.25	0.27	0.21	0.30	0.30

Appendix 1. Whole-rock geochemical analyses of unfoliated intrusions in the McQuesten River region

TOMBSTONE INTRUSIONS (92±2 Ma)

	Miscellaneous dykes							
	92DM-6	92DM-22	92DM-77	93DM-9	93DM-13a	93DM-115a	93DM-302	94DM-120
SiO2	64.10	72.20	65.70	62.38	54.87	62.80	60.61	61.15
TiO2	0.508	0.341	0.47	0.29	0.74	0.62	0.57	0.64
Al2O3	15.70	14.30	15.10	14.25	14.71	15.00	14.23	14.75
FeO*	3.98	2.36	4.42	5.29	7.10	5.09	5.29	5.58
MgO	1.47	0.47	1.56	3.25	3.16	2.09	2.89	3.52
MnO	0.08	0.07	0.13	0.09	0.13	0.12	0.10	0.10
CaO	3.0	1.34	3.53	3.65	5.06	3.03	4.10	5.03
Na2O	3.16	3.32	2.87	2.00	1.74	2.06	2.18	1.88
K2O	3.58	5.07	5.20	4.51	7.05	5.75	5.28	3.45
P2O5	0.16	0.16	0.20	0.29	0.43	0.35	0.31	0.19
LOI	3.70	0.55	0.85	4.25	5.13	3.11	4.51	2.95
Total	96.44	100.18	100.03	100.25	100.12	100.02	100.07	99.24
Trace elem								
Ag	1.41	1.26	1.73	0.54	1.22	1.60	0.54	0.30
Ba	3679.85	633.02	1486.01	1843.66	3073.09	3009.36	4168.67	2116.00
Be	1.97	4.81	5.93	3.96	4.17	5.07	4.56	2.00
Bi	0.27	0.38	0.99	0.13	0.15	0.15	0.09	-
Co	5.24	2.32	10.31	13.22	13.59	5.91	11.88	14.90
Cr	100.94	198.19	249.67	211.06	82.06	53.91	114.76	143.00
Cs	8.83	16.92	16.31	9.08	8.65	21.69	14.23	18.00
Cu	6.31	3.67	18.27	12.07	31.79	11.06	20.05	9.40
F	-	-	-	-	-	-	-	1000.00
Hf	3.48	3.51	3.97	3.79	7.09	5.95	3.11	4.70
Li	46.86	163.84	54.50	75.45	59.99	59.07	45.40	-
Mo	1.94	5.24	5.93	0.59	1.17	1.26	1.84	1.70
Nb	13.68	43.02	30.25	14.46	21.51	26.24	17.31	13.00
Ni	4.29	2.37	14.70	14.67	17.17	7.65	19.47	15.00
P	696.25	587.23	881.41	944.64	1519.20	885.72	1084.67	-
Pb	45.39	32.13	44.64	32.05	30.56	110.45	31.81	15.00
Rb	124.22	355.98	239.95	190.51	274.09	243.30	244.29	146.00
Sb	0.51	0.14	0.82	2.55	3.90	5.55	0.74	2.00
Sc	9.05	5.11	8.89	15.59	17.85	11.97	16.17	18.00
Sn	1.60	7.65	3.92	2.41	3.10	2.69	1.21	7.00
Sr	601.67	122.91	693.66	480.96	1131.59	682.26	661.20	405.10
Ta	0.85	4.48	1.92	1.19	1.24	1.68	1.07	1.00
Th	16.55	31.06	16.03	16.26	29.69	28.65	17.25	14.90
Ti	3064.08	1939.17	2880.87	3390.47	3627.87	2786.15	3160.14	-
Tl	1.41	3.08	2.48	1.66	2.05	2.38	1.94	2.30
U	5.01	6.05	7.14	7.03	7.21	10.23	4.61	7.30
V	39.42	14.74	57.06	111.09	129.75	71.70	113.62	109.00
W	1.50	2.14	5.44	5.82	5.54	9.89	7.09	-
Y	13.25	18.8	19.40	19.07	28.66	24.56	17.74	20.30
Zn	96.47	49.85	90.75	82.67	78.40	136.92	85.89	105.90
Zr	100.96	102.67	118.03	115.50	264.14	192.98	88.23	150.80
La	44.02	58.18	39.73	35.65	83.16	63.93	45.99	40.70
Ce	74.70	117.75	76.36	69.05	167.87	123.61	92.59	75.30
Pr	8.93	13.31	9.17	8.47	20.06	14.48	10.90	7.90
Nd	29.42	40.53	29.90	28.42	65.62	47.09	34.53	30.70
Sm	5.20	7.18	6.00	5.52	12.75	8.20	6.34	6.00
Eu	1.37	0.66	1.63	1.28	3.10	1.93	1.45	1.57
Gd	4.25	5.63	5.30	5.25	10.07	7.18	5.67	4.70
Tb	0.47	0.74	0.68	0.63	1.18	0.85	0.67	0.80
Dy	2.66	4.24	3.94	3.94	6.39	5.08	3.91	3.60
Ho	0.46	0.71	0.71	0.72	1.10	0.91	0.71	0.82
Er	1.27	1.94	2.05	1.99	2.85	2.54	1.94	2.20
Tm	0.17	0.29	0.30	0.29	0.40	0.38	0.27	0.40
Yb	1.17	1.90	2.01	1.81	2.52	2.44	1.74	2.10
Lu	0.16	0.26	0.28	0.30	0.39	0.37	0.24	0.28

Appendix 1. Whole-rock geochemical analyses of unfoliated intrusions in the McQuesten River region

MCQUESTEN INTRUSIONS (65±2 Ma)

	Two Sisters		Oliver Ridge	Miscellaneous dykes	
	92DM-22	92DH-166	94DM-248	92DM-6	92DH-59b
SiO2	72.20	73.40	61.91	64.10	62.70
TiO2	0.341	0.354	0.58	0.508	0.766
Al2O3	14.30	13.40	14.62	15.70	15.80
FeO*	2.36	2.42	4.99	3.98	5.88
MnO	0.07	0.07	0.12	0.08	0.13
MgO	0.47	0.49	2.98	1.47	2.45
CaO	1.34	1.3	3.53	3.0	5.3
Na2O	3.32	3.33	3.01	3.16	2.53
K2O	5.07	4.42	3.20	3.58	2.74
P2O5	0.16	0.15	0.18	0.16	0.21
LOI	0.55	0.80	4.78	3.70	1.50
Total	100.18	100.13	99.90	96.44	100.01
Trace elements (ppm)					
Ag	1.26	1.45	0.50	1.41	0.59
Ba	633.02	565.68	3065.50	3679.85	2431.14
Be	4.81	7.47	2.00	1.97	4.32
Bi	0.38	0.21	<	0.27	0.28
Co	2.32	2.18	7.90	5.24	8.02
Cr	198.19	163.25	162.00	100.94	209.16
Cs	16.92	25.25	3.00	8.83	5.22
Cu	3.67	3.90	6.30	6.31	7.59
F	-	-	900.00	-	-
Hf	3.51	3.63	4.60	3.48	2.16
Li	163.84	176.13	-	46.86	28.60
Mo	5.24	4.63	1.00	1.94	4.90
Nb	43.02	45.67	14.00	13.68	13.84
Ni	2.37	2.09	13.00	4.29	6.18
P	587.23	533.00	-	696.25	867.23
Pb	32.13	28.10	107.00	45.39	16.20
Rb	355.98	347.13	117.00	124.22	108.45
Sb	0.14	0.22	2.00	0.51	0.20
Sc	5.11	5.18	15.00	9.05	15.01
Sn	7.65	11.49	1.00	1.60	9.31
Sr	122.91	115.23	462.60	601.67	614.08
Ta	4.48	4.76	1.00	0.85	0.95
Th	31.06	35.06	21.60	16.55	14.33
Ti	1939.17	2021.16	-	3064.08	4525.77
Tl	3.08	3.07	1.70	1.41	1.13
U	6.05	5.52	5.30	5.01	4.50
V	14.74	15.79	97.00	39.42	84.05
W	2.14	3.41	3.00	1.50	0.23
Y	18.8	20.55	19.70	13.25	17.68
Zn	49.85	59.92	152.60	96.47	119.74
Zr	102.67	103.61	152.80	100.96	59.09
La	58.18	60.61	50.40	44.02	37.97
Ce	117.75	121.89	90.80	74.70	73.42
Pr	13.31	13.80	9.30	8.93	8.66
Nd	40.53	42.79	33.40	29.42	29.40
Sm	7.18	7.64	6.60	5.20	5.48
Eu	0.66	0.60	1.64	1.37	1.36
Gd	5.63	5.95	4.50	4.25	5.00
Tb	0.74	0.81	0.70	0.47	0.61
Dy	4.24	4.41	3.70	2.66	3.74
Ho	0.71	0.75	0.76	0.46	0.70
Er	1.94	2.19	1.90	1.27	1.86
Tm	0.29	0.33	0.30	0.17	0.26
Yb	1.90	2.12	1.80	1.17	1.69
Lu	0.26	0.28	0.30	0.16	0.25

Appendix 2. U-Pb isotopic data, unfoliated intrusions, McQuesten River region.

Fraction	Wt[a] mg	U ppm	Pb* ppm	206Pb/204Pb	Pb[c] pg	208Pb %	206Pb/238U	207Pb/235U	207Pb/206Pb	Apparent Age (Ma) 206/238	Apparent Age (Ma) 207/206
TOMBSTONE INTRUSIONS											
SYENITE RANGE STOCK, outer syenite phase (92DM-199; 388947E, 7091482N**)											
A	0.126	3936	53	1995	219	5.0	0.014285±.33%	0.09426±.36%	0.04786±.13%	91.4	92.2+6.2/-6.2
B	0.148	3856	52	8443	59	3.6	0.014386±.13%	0.09493±.13%	0.04786±.05%	92.1	92.1+2.3/-2.3
CA	0.279	1087	19	962	289	25.5	0.014173±.17%	0.09584±.25%	0.04905±.15%	90.7	150.1+7.1/-7.2
CB	0.234	1220	21	2733	90	25.6	0.014271±.15%	0.09469±.21%	0.04812±.12%	91.3	105.3+5.9/-5.9
D	0.271	3033	54	5739	127	29.5	0.013977±.12%	0.09218±.14%	0.04783±.05%	89.5	91.1+2.4/-2.4
F	0.077	4094	60	2953	86	18.1	0.013268±.07%	0.08750±.14%	0.04783±.11%	85.0	91.0+5.2/-5.2
SYENITE RANGE STOCK, orbicular tourmaline biotite-muscovite granite (92DM-209; 386666E, 7096491N)											
A	0.126	838	12	1675	57	8.7	0.01417±.14%	0.0934±.19%	0.04783±.11%	90.7	90.9+5.1/-5.1
B	0.093	744	11	2820	22	10.4	0.01415±.10%	0.0933±.23%	0.04783±.16%	90.6	90.6+7.5/-7.5
RHOSGOBEL STOCK (94DM-270; 398870E, 7079400N)											
A	0.060	970	19	3558	19	7.6	0.019635±.08%	0.20149±.11%	0.07443±.07%	125.3	1053.1+2.8/-2.8
B	0.052	1495	20	3267	20	4.9	0.014264±.07%	0.09409±.13%	0.04784±.10%	91.3	91.5+4.6/-4.6
C	0.064	1391	19	1132	72	4.7	0.014340±.21%	0.09459±.27%	0.04784±.13%	91.8	91.3+6.4/-6.4
D	0.104	1796	24	2218	75	5.0	0.014110±.09%	0.09371±.13%	0.04817±.07%	90.3	107.5+3.5/-3.5
PUKELMAN STOCK (92DH-151; 398630E, 7083636N)											
A	0.181	2807	37	14681	31	3.3	0.014306±.14%	0.09467±.15%	0.04800±.04%	91.6	99.1+2.1/-2.1
B	0.236	1829	27	10917	38	3.8	0.015506±.43%	0.11308±.43%	0.05289±.04%	99.2	324.1+1.7/-1.7
C	0.201	2256	31	10394	40	3.6	0.014654±.37%	0.10193±.37%	0.05045±.04%	93.8	215.7+1.7/-1.7
D	0.182	1671	23	4828	59	3.9	0.014864±.33%	0.10226±.33%	0.04990±.05%	95.1	190.2+2.4/-2.4
AA	0.750	158	2	83	1720	16.5	0.01423±.09%	0.0942±.65%	0.04798±.59%	91.1	98.3 +27.7/-28.1
BB	0.640	169	3	73	1849	16.4	0.01433±.16%	0.0974±1.8%	0.04931±1.6%	91.7	162.8 +75.2/-78.9
Unnamed stock, BX claims (93DM-135A; 415850E, 7097200N)											
A	0.076	1984	27	101	1703	4.8	0.014529±.68%	0.09855±2.3%	0.04919±1.9%	93.0	157.1+87.6/-92.5
B	0.072	1176	15	1470	49	3.5	0.013533±.58%	0.10133±.63%	0.05430±.33%	86.7	383.7+14.7/-14.8
C	0.061	2300	31	5550	23	3.5	0.014630±.72%	0.09899±.72%	0.04907±.24%	93.6	151.4+11.2/-11.3
RED MOUNTAIN STOCK (93DM-98/99; 414750E, 7093550N)											
A	0.156	1730	23	1970	122	4.1	0.014283±.69%	0.09393±.74%	0.04769±.21%	91.4	84.1+10.2/-10.2
B	0.105	1910	26	3405	53	4.3	0.014256±.14%	0.09503±.24%	0.04835±.13%	91.2	116.3+6.2/-6.2
C	0.065	1857	26	3988	28	3.8	0.014778±.11%	0.10154±.20%	0.04984±.12%	94.6	187.4+5.4/-5.4
D	0.076	866	12	81	950	5.3	0.014601±.61%	0.10428±2.4%	0.05180±2.0%	93.4	276.6+89.5/-94.7
AA	0.600	72	1	38	2197	11.8	0.01439±.33%	0.1006±5.0%	0.05068±4.7%	92.1	226.4 +203.2/-232.2
BB	0.660	77	1	32	3635	12.3	0.01444±.38%	0.1051±6.5%	0.05278±6.2%	92.4	319.4 +257.7/-306.7
RED MOUNTAIN DYKE (93DM-105/106; 417300E, 7092865N)											
A	0.069	957	29	9591	13	5.2	0.030536±.10%	0.33485±.18%	0.07953±.09%	193.9	1185.4+3.7/-3.7
BA	0.062	1440	21	3042	29	3.8	0.015601±.09%	0.10809±.21%	0.05025±.12%	99.8	206.7+5.8/-5.8
BB	0.082	1818	25	7326	18	3.4	0.014639±.11%	0.09815±.20%	0.04863±.11%	93.7	129.9+5.1/-5.1
C	0.070	1175	17	62	1749	8.2	0.014845±1.1%	0.10188±4.7%	0.04977±4.0%	95.0	184.5+178.4/-200.3
DA	0.066	1784	24	7082	15	4.1	0.014474±.10%	0.09597±.19%	0.04809±.10%	92.6	103.8+4.9/-4.9
DB	0.129	1835	23	10628	19	4.1	0.013626±.17%	0.09078±.24%	0.04832±.11%	87.2	114.9+5.3/-5.3
SPRAGUE CREEK STOCK (93DM-71; 410575E, 7088325N)											
A	0.083	693	9	2600	20	4.3	0.014224±.12%	0.09394±.25%	0.04790±.18%	91.0	94.4+8.4/-8.4
B	0.058	860	14	2849	18	8.7	0.016564±.11%	0.12919±.22%	0.05657±.13%	105.9	474.7+5.7/-5.7
C	0.141	1286	17	4829	33	5.3	0.014257±.21%	0.09429±.28%	0.04797±.13%	91.3	97.7+6.0/-6.0
BOS STOCK (93DM-307; 415530E, 7072050N)											
A	0.125	1830	25	9703	21	3.3	0.014534±.14%	0.09604±.15%	0.04792±.04%	93.0	95.5+2.1/-2.1
B	0.130	1578	21	8880	20	3.8	0.014391±.06%	0.09520±.07%	0.04798±.04%	92.1	98.1+2.0/-2.0
C	0.087	1511	25	3970	36	5.3	0.017069±.13%	0.12533±.22%	0.05325±.11%	109.1	339.5+5.1/-5.2
D	0.121	1821	25	4418	45	4.3	0.014367±.16%	0.09519±.24%	0.04805±.12%	92.0	101.8+5.5/-5.5

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Fraction	Wt[a] mg	U ppm	Pb* ppm	206Pb/204Pb	Pb[c] pg	208Pb %	206Pb/238U	207Pb/235U	207Pb/206Pb	Apparent Age (Ma) 206/238	Apparent Age (Ma) 207/206
Unnamed stock at BLACK HILL occurrence (94DM-169; 440675E, 7097225N)											
B	0.185	1166	16	3613	55	6.2	0.014422±.19%	0.09519±.19%	0.04787±.05%	92.3	92.8 +2.5/-2.5
C	0.178	1230	17	2794	70	6.5	0.014405±.10%	0.09507±.14%	0.04787±.11%	92.2	92.6 +5.1/-5.1
A	0.124	1600	22	10812	17	3.1	0.014459±.15%	0.09580±.21%	0.04805±.12%	92.5	101.9 +5.6/-5.6
Unnamed dyke, northeast corner Seattle Creek map area (94DH-148; 450500E, 7097150N)											
A	0.162	1574	21	4554	51	2.4	0.014471±.17%	0.09692±.18%	0.04858±.04%	92.6	127.4+1.7/-1.7
B	0.162	1295	17	1035	186	3.5	0.014217±.15%	0.09377±.21%	0.04784±.13%	91.0	91.1+6.1/-6.2
C	0.167	1798	24	889	307	4.4	0.014217±.09%	0.09379±.21%	0.04785±.17%	91.0	91.6+8.0/-8.1
SCHEELITE DOME STOCK (94DM-240; 438550E, 7073525N)											
A	0.117	1159	16	3081	41	4.7	0.014730±.08%	0.09919±.13%	0.04884±.08%	94.3	140.1+3.7/-3.7
C	0.174	1971	26	7907	38	4.2	0.014137±.14%	0.09462±.22%	0.04854±.11%	90.5	125.8+5.1/-5.2
A	0.124	1600	22	10812	17	3.1	0.01446±.15%	0.0958±.21%	0.04805±.12%	92.5	101.9 +5.6/-5.6
AA	1.010	192	3	135	1550	15.0	0.01430±.34%	0.0943±102%	0.04782±.94%	91.5	90.5 +44.2/-45.4
BB	1.120	180	3	118	1867	14.5	0.01415±.18%	0.0947±1.2%	0.04854±1.0%	90.6	125.5 +48.0/-49.5
MINTON CREEK STOCK (94DM-192; 436920E, 7069650N)											
A	0.154	1428	19	7923	25	3.0	0.014403±.16%	0.09505±.23%	0.04786±.10%	92.2	92.5+4.9/-4.9
B	0.055	1451	19	3420	21	2.5	0.014505±.14%	0.09716±.23%	0.04858±.13%	92.8	127.6+6.2/-6.3
C	0.118	1709	23	9173	19	3.9	0.014180±.13%	0.09382±.20%	0.04799±.10%	90.8	98.5+4.9/-4.9
MORRISON CREEK STOCK (VR-7852; approximately 443300E, 7076750N)											
E	0.795	182	3	66	2817	5.7	0.014487±1.1%	0.09841±3.5%	0.04927±2.9%	92.7	160.6+128.7/-139.8
F	0.750	165	2	61	2692	6.1	0.014554±1.3%	0.10170±3.9%	0.05068±3.1%	93.1	226.3+138.1/-150.9
A	0.075	1315	18	2982	30	3.4	0.014626±.09%	0.09977±.14%	0.04947±.09%	93.6	170.3+4.4/-4.4
B	0.054	1562	22	4980	16	3.5	0.015100±.08%	0.10299±.11%	0.04947±.06%	96.6	170.2+2.8/-2.9
C	0.164	1970	26	5044	57	3.6	0.014159±.16%	0.09381±.17%	0.04805±.05%	90.6	101.8+2.3/-2.3
DUBLIN GULCH STOCK (92DM-DG; approximately 460150E, 7099825N)											
A	0.120	1096	15	1486	83	5.8	0.014541±.06%	0.09601±.15%	0.04788±.12%	93.1	93.5+5.8/-5.8
B	0.186	826	12	5121	28	5.8	0.014672±.07%	0.09710±.10%	0.04800±.05%	93.9	99.2+2.5/-2.5
C	0.231	886	13	4150	47	6.1	0.014819±.07%	0.09881±.10%	0.04836±.06%	94.8	116.8+2.7/-2.7
D	0.172	1004	14	5901	27	6.1	0.014615±.10%	0.09709±.12%	0.04818±.07%	93.5	108.2+3.2/-3.2
AA	0.530	139	2	93	938	12.9	0.01446±.14%	0.0960±1.4%	0.04813±1.3%	92.6	105.5 +58.9/-61.0
BB	0.420	110	2	93	589	11.2	0.01452±.15%	0.0968±1.4%	0.04834±1.3%	93.0	115.9 +58.6/-60.7
MCQUESTEN INTRUSIONS											
TWO SISTERS STOCK (92DM-22; 381197E, 7075774N)											
A	0.135	1526	15	5261	26	4.1	0.010674±.32%	0.07941±.33%	0.05396±.08%	68.4	369.4+3.5/-3.5
B	0.282	1534	17	5300	56	7.2	0.011061±.55%	0.08798±.56%	0.05768±.07%	70.9	517.8+3.3/-3.3
C	0.325	2687	25	3071	168	3.9	0.009742±.42%	0.06351±.44%	0.04729±.11%	62.5	63.7+5.3/-5.3
E	0.115	1203	74	671	137	85.0	0.010193±.33%	0.06489±.45%	0.04617±.25%	65.4	6.6+11.9/-12.0
F	0.049	3954	233	570	227	84.3	0.010175±.26%	0.06537±.40%	0.04660±.27%	65.3	28.7+13.1/-13.2
VANCOUVER CREEK STOCK (92DH-55; 399825E, 7073534N)											
A	0.160	3202	32	8642	39	4.0	0.010553±.07%	0.06938±.11%	0.04768±.05%	67.7	83.4+2.5/-2.5
B	0.083	606	7	1286	26	13.1	0.010441±.07%	0.06820±.19%	0.04737±.15%	67.0	68.1+6.9/-6.9
C	0.142	1069	11	1062	97	7.8	0.010495±.16%	0.06851±.26%	0.04734±.16%	67.3	66.5+7.5/-7.5
D	0.052	1280	13	2246	19	6.2	0.010430±.06%	0.06858±.16%	0.04769±.13%	66.9	84.0+6.1/-6.1
E	0.066	3060	172	3109	45	83.0	0.010522±.13%	0.06811±.23%	0.04695±.13%	67.5	46.7+6.4/-6.4
F	0.053	3881	160	3861	36	77.1	0.010425±.14%	0.06780±.23%	0.04717±.13%	66.9	57.8+6.2/-6.2
OLIVER RIDGE STOCK (94DM-248; 424950E, 7069800N)											
A	0.124	1500	14	2853	41	5.9	0.010069±.10%	0.06568±.13%	0.04730±.09%	64.6	64.6+4.2/-4.2
B	0.144	1763	17	2012	80	5.2	0.009918±.07%	0.06468±.18%	0.04730±.09%	63.6	64.5+4.5/-4.5
C	0.134	1656	16	1429	97	5.9	0.010003±.08%	0.06523±.19%	0.04730±.16%	64.2	64.2+7.8/-7.9

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BOULDER CREEK STOCK (94DM-258; 423325E, 7071550N)											
DD	0.038	3328	185	255	341	83.3	0.01024±.28%	0.0662±.84%	0.04689±.66%	65.7	43.4 +31.4/-32.0
CC	0.015	2871	226	468	80	84.7	0.01032±.13%	0.0666±.48%	0.04678±.37%	66.2	38.1 +17.7/-17.9
BB	0.050	1656	157	1363	68	83.3	0.010095±.21%	0.06537±.33%	0.04696±.19%	64.7	47.4 +9.2/-9.2
SUNSHINE CREEK STOCK (93DH-28; 420550E, 7078350N)											
B	0.109	967	9	3939	17	6.8	0.010146±.10%	0.06618±.21%	0.04731±.13%	65.1	64.9+6.1/-6.1
C	0.108	1228	12	3626	24	5.5	0.010371±.13%	0.06780±.22%	0.04741±.13%	66.5	69.9+6.3/-6.3
A	0.066	2163	20	886	103	3.4	0.009827±.15%	0.06031±.38%	0.04451±.28%	63.0	82.3+13.6/-13.7
BB	0.030	1957	134	1822	21	86.5	0.010189±.13%	0.06569±.27%	0.04676±.19%	65.4	36.8+9.0/-9.1
CC	0.062	2000	140	402	206	86.7	0.010220±.54%	0.06660±.30%	0.04726±1.0%	65.5	62.6+48.0/-49.5
AA	0.035	2157	150	992	48	87.1	0.009961±.16%	0.06355±.35%	0.04627±.24%	63.9	11.9+11.6/-11.6

Errors are one standard error of mean in % except 207/206 age errors which are two standard errors in Ma; * = Radiogenic Pb; a = Includes sample weight error of ±0.001 mg in concentration uncertainty; c = Total Common Pb in analysis; ** = Locations are given in UTM coordinates, NAD 27.

Appendix 3: Assay results for mineralized samples collected in the McQuesten River region

	UTM easting	UTM northing	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Bi ppm	Cd ppm	Co ppm	Ni ppm	Ba ppm
Det. Lim.			5	0.1	1	2	1	5	5	1	2	0.1	1	1	2
92DH-7a	398831	7085312	98	<	20	8	60	95	10	2	<	<	15	13	389
92DH-7b	398831	7085312	250	0.4	22	5	65	245	7	6	<	<	18	14	328
92DH-16	399778	7085651	110	1.3	14	7	5	225	68	?	<	<	2	6	343
92DH-28	395673	7087713	<	0.7	19	19	14	10	10	6	<	<	<	8	142
92DH-43	396486	7083580	7	0.8	43	65	263	103	6	3	<	13.9	4	6	278
92DH-57	400096	7074054	<	7.8	182	1207	494	32	10	5	4	0.9	3	16	53
92DH-59a	400189	7074213	30	0.4	70	17	81	<	8	2	25	0.3	6	10	37
92DH-62a	391140	7093179	5	0.4	11	18	88	15	8	11	<	<	11	12	173
92DH-75	387174	7096878	9	0.6	26	12	69	<	10	2	<	0.0	14	11	127
92DH-76b	387347	7097190	70	96.8	918	4276	149	37675	1118	56	<	16.2	6	11	<
92DH-77	387834	7097549	<	1.2	15	73	46	215	16	2	<	<	<	3	120
92DH-79a	387555	7096428	<	0.3	8	16	46	51	16	3	<	<	13	12	163
92DH-79b	387651	7096642	<	0.4	16	8	17	48	41	6	<	<	7	14	37
92DH-79c	388097	7097919	11	112.3	93	19064	98	15836	6620	5	<	11.2	2	5	319
92DH-79d	387002	7097133	30	19.2	1114	223	116	60408	953	16	16	0.7	60	22	<
92DH-79e	386514	7096631	<	0.7	11	130	42	470	30	12	<	<	7	4	48
92DH-79f	388097	7097919	<	0.7	11	81	121	122	36	5	<	<	7	6	13
92DH-79h	388097	7097919	<	0.3	3	31	4	29	13	<	<	<	<	4	12
92DH-80	388192	7097964	<	0.4	6	10	45	1113	10	4	<	0.2	4	4	29
92DH-90	389583	7098585	<	0.3	6	58	7	23	<	2	<	<	<	4	632
92DH-119/20	384150	7091175	<	0.5	37	7	64	7	6	2	<	0.3	6	6	143
92DH-145	398108	7083822	12	<	2	7	54	49	<	35	<	<	10	11	239
92DH-146	398219	7083864	150	0.4	10	11	37	3466	<	4	<	<	9	8	187
92DH-147	398684	7083969	8	0.7	31	12	68	136	<	6	<	<	7	13	126
92DH-148	398430	7083578	46	0.2	13	7	55	847	<	2	<	<	10	8	255
92DH-149	398411	7083491	148	0.2	6	6	42	390	<	5	<	<	9	10	174
92DH-150	398606	7083661	351	0.2	6	7	37	466	<	4	<	<	8	8	142
92DH-151	398630	7083636	960	0.3	6	8	37	1291	<	5	<	<	8	9	135
92DH-152	399040	7084326	106	0.2	13	<	52	71	<	<	<	<	16	29	157
92DH-153	399045	7084494	37	0.2	12	<	15	24	<	4	<	<	6	14	84
92DH-154	398401	7080566	2330	5.8	3	10	<	<	7	<	66	<	<	4	5
92DH-155	398396	7080562	49	0.9	6	15	22	6	<	4	3	<	4	8	43
92DH-156	398398	7080564	72	0.5	8	66	136	777	<	2	<	2.4	4	12	12
92DH-157	398277	7080752	51	18.7	7	124	6	77	9	25	89	<	2	9	36
92DH-158	398088	7080839	2330	0.4	13	11	25	53	<	10	26	<	6	10	91
92DH-159	397895	7081020	17	0.5	5	57	67	272	<	3	<	<	6	8	69
92DH-160	397880	7081069	13	1.7	3	15	4	19	<	4	9	<	<	8	12
92DH-161	397824	7081181	<	0.2	3	12	5	19	<	5	4	<	<	9	26
92DH-162	397781	7081270	<	0.2	43	3	19	62	6	2	<	<	3	15	27
92DH-163	397791	7081333	<	0.4	11	7	27	<	<	6	<	<	5	15	48
92DH-164	398433	7080531	7200	0.5	17	7	10	32	<	8	155	<	4	11	21
92DH-165	398428	7080480	14500	1.4	9	5	2	10	7	42	318	<	5	6	6
92DH-174a	389009	7080157	13	0.2	5	3	8	63	7	8	<	<	<	12	10
92DH-174/5	389078	7080360	9	<	18	31	180	28	<	3	<	<	20	11	34
92DH-176	389211	7080778	<	<	9	7	44	<	<	4	<	<	14	15	474
92DH-177	389384	7080724	<	0.6	24	29	68	35	<	4	7	0.4	12	18	53
92DM-35	400511	7084736	159	0.4	2	9	12	521	<	<	<	<	2	5	17
92DM-35c	400504	7084791	21	<	5	49	16	79	<	4	<	<	2	8	17
92DM-35/6	400266	7084855	<	0.1	8	6	34	53	<	<	<	<	7	7	476
92DM-37a	399675	7084632	16	0.1	63	5	21	245	<	<	<	<	14	15	165
92DM-37b	399675	7084632	5040	0.7	5	9	<	80776	58	9	392	<	29	16	0
92DM-123	398032	7080150	5	0.3	33	5	19	168	<	<	<	<	6	11	53
92DM-168	392124	7091746	10	0.5	24	6	10	222	<	5	<	<	12	12	67
92DM-176	391033	7092650	<	0.2	23	12	55	78	<	<	<	<	14	14	307
92DM-177	390848	7091980	<	1.7	36	18	54	31	<	3	<	<	12	18	172
92DM-179	390622	7092758	<	0.2	25	3	60	10	<	<	<	<	13	8	111
92DM-183	391025	7091030	10	0.3	47	6	34	197	<	5	<	<	11	12	66
92DM-185	390522	7091202	<	0.6	23	31	60	68	<	2	<	0.2	7	9	31
92DM-205	389234	7096022	<	0.3	<	8	14	12	6	<	<	<	<	4	42
92DM-239	400664	7091638	<	0.4	32	6	230	6	<	11	<	2.0	23	63	1377
92J1-3	394778	7095703	<	0.2	29	9	49	<	6	3	<	<	3	8	1026
92J4 -5	382217	7094523	<	0.1	11	<	14	7	8	5	<	<	2	14	71
92J4-6	381695	7094194	<	0.1	5	8	2	<	8	<	<	<	<	5	155
93DM-5	404238	7089432	6	0.2	253	10	333	10	<	8	<	0.6	4	31	171
93DM-8a	403634	7088445	8	<	151	9	82	<	7	16	<	<	2	23	163

W	Cr	V	Mn	La	Sr	Zr	Sc	Ti	Al	Ca	Fe	Mg	K	Na	P	Sn	Te	Y
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	ppm	ppm	ppm
5	1	2	1	2	1	1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10		
40	134	66	344	29	148	2	7	0.26	3.63	1.46	3.05	1.33	1.24	0.30	0.09	-	-	-
211	143	81	378	25	151	2	7	0.27	3.75	1.84	3.44	1.72	1.30	0.31	0.10	-	-	-
12	189	18	22	9	25	2	<	0.01	0.50	0.03	3.60	0.04	0.15	0.02	<	-	-	-
6	215	9	28	10	7	3	<	<	0.31	<	0.65	0.04	0.18	<	<	-	-	-
<	106	6	253	13	53	27	<	0.03	1.37	0.82	2.11	0.27	0.26	0.18	0.04	-	-	-
<	179	16	648	22	3	2	<	<	1.46	0.02	3.42	0.55	0.29	0.02	<	-	-	-
14	173	3	799	<	10	2	<	<	0.17	2.16	1.51	0.05	0.02	<	0.02	-	-	-
15	127	52	573	114	40	23	3	0.22	1.14	0.52	3.20	0.73	0.89	0.10	0.08	-	-	-
10	134	69	463	52	47	4	7	0.20	1.44	1.41	2.88	1.16	0.70	0.11	0.14	-	-	-
<	191	8	46	8	50	2	<	<	0.15	0.03	4.32	0.03	0.07	0.02	0.04	-	-	-
<	90	5	55	18	7	19	<	<	0.82	0.02	0.82	0.06	0.31	<	<	-	-	-
9	140	68	338	42	66	5	4	0.21	1.23	1.16	2.22	1.05	0.68	0.14	0.17	-	-	-
38	194	13	358	35	36	4	2	0.04	0.63	1.77	1.43	0.66	0.03	0.04	0.13	-	-	-
<	200	11	29	15	29	4	<	<	0.17	0.04	4.09	0.02	0.14	0.02	0.05	-	-	-
<	192	7	699	15	12	2	<	<	0.43	0.84	8.54	0.10	0.15	<	0.04	-	-	-
<	91	27	285	44	189	5	2	0.13	1.65	1.44	1.51	0.47	0.33	0.15	0.07	-	-	-
<	49	27	1323	46	20	5	4	<	1.72	2.60	4.12	0.94	0.05	<	0.09	-	-	-
<	225	<	99	19	74	<	<	<	0.09	2.26	0.31	0.02	<	0.02	<	-	-	-
<	155	6	237	29	63	4	<	<	0.31	1.48	1.05	0.25	0.09	0.08	0.08	-	-	-
<	94	4	16	7	8	16	<	<	0.55	0.02	0.52	0.03	0.27	<	0.02	-	-	-
<	182	19	118	11	38	6	<	0.10	0.60	0.12	1.73	0.69	0.11	0.02	0.03	-	-	-
913	150	42	587	34	61	3	5	0.11	1.36	1.03	2.65	0.74	0.61	0.10	0.08	-	-	-
165	165	40	497	29	53	4	6	0.13	1.18	0.65	2.48	0.73	0.78	0.11	0.07	-	-	-
33	192	34	406	31	32	17	4	0.08	0.97	0.33	2.23	0.51	0.38	0.06	0.07	-	-	-
22	138	44	615	32	55	6	6	0.16	1.39	0.67	2.63	0.76	0.88	0.12	0.07	-	-	-
24	152	43	510	29	56	3	6	0.16	1.36	1.10	2.52	0.76	0.89	0.10	0.07	-	-	-
6	126	40	464	28	66	4	6	0.13	1.15	1.36	2.34	0.72	0.79	0.10	0.07	-	-	-
32	132	40	475	28	67	3	5	0.12	1.20	1.33	2.37	0.74	0.72	0.08	0.07	-	-	-
707	155	61	291	22	16	2	6	0.20	2.22	0.21	3.22	1.00	1.44	0.08	0.02	-	-	-
12	196	21	213	8	6	3	2	0.06	0.75	0.08	1.09	0.27	0.34	0.06	<	-	-	-
55	263	<	27	<	<	<	<	<	0.04	<	0.33	<	0.02	<	<	-	-	-
8	154	10	235	12	13	3	<	<	0.48	0.14	1.58	0.16	0.13	0.05	0.06	-	-	-
35	114	13	44	28	4	5	<	<	0.79	0.04	2.46	0.02	0.06	<	0.03	-	-	-
42	238	<	43	6	12	2	<	<	0.16	<	1.24	<	0.10	<	<	-	-	-
1633	243	25	190	12	20	3	4	0.09	0.83	0.23	1.90	0.44	0.56	0.06	0.05	-	-	-
173	131	18	158	26	8	<	<	<	0.75	0.03	3.73	0.05	0.28	<	0.06	-	-	-
233	272	<	81	<	2	<	<	<	0.05	<	0.40	<	<	<	<	-	-	-
20	236	<	56	5	4	<	<	<	0.18	<	0.40	0.02	0.10	<	<	-	-	-
14	155	6	51	22	4	<	<	<	0.28	<	2.58	0.02	0.10	<	0.02	-	-	-
6	255	18	100	13	8	<	<	0.05	0.97	<	1.78	0.50	0.37	0.04	<	-	-	-
185	280	4	112	6	4	<	<	<	0.13	<	1.41	<	0.09	<	<	-	-	-
91	240	<	37	9	18	<	<	<	0.08	1.14	1.14	<	0.04	<	<	-	-	-
32	356	<	29	<	<	<	<	<	0.14	0.02	0.65	<	0.06	<	<	-	-	-
36	159	118	939	29	4	2	28	<	1.08	0.07	5.85	0.03	0.03	<	0.08	-	-	-
<	115	89	718	63	105	36	9	0.16	2.00	1.97	3.66	1.19	1.38	0.06	0.12	-	-	-
<	85	38	231	38	97	27	3	0.14	0.79	0.92	2.54	0.45	0.16	0.06	0.13	-	-	-
11	135	12	33	9	9	9	2	<	0.44	0.04	1.11	0.02	0.15	<	0.02	-	-	-
<	162	<	77	20	6	14	<	<	0.81	0.02	0.87	<	0.05	<	<	-	-	-
12	115	28	165	25	66	6	3	0.16	1.51	0.52	1.76	0.58	0.60	0.16	0.05	-	-	-
9	84	44	309	31	96	16	3	0.14	1.36	0.91	2.56	0.92	0.21	0.11	0.11	-	-	-
1135	255	5	35	<	12	<	<	<	0.08	0.05	7.18	0.03	0.03	0.02	<	-	-	-
277	147	12	152	17	99	3	<	0.09	0.95	2.56	0.90	0.16	0.10	0.13	0.03	-	-	-
25	115	24	117	33	74	29	2	0.16	0.47	0.75	3.36	0.13	0.19	0.09	0.10	-	-	-
7	79	62	314	40	54	14	2	0.20	1.05	0.81	2.24	0.96	1.06	0.12	0.22	-	-	-
7	91	37	394	55	75	19	2	0.12	3.45	0.90	2.18	0.87	1.37	1.65	0.14	-	-	-
<	52	75	544	49	123	13	3	0.19	2.45	1.00	2.92	0.73	1.13	0.65	0.10	-	-	-
<	83	35	297	41	90	26	2	0.13	0.86	1.52	3.80	0.43	0.18	0.10	0.12	-	-	-
<	90	19	230	35	47	28	<	0.09	0.73	0.53	2.03	0.22	0.14	0.07	0.07	-	-	-
<	72	19	19	18	118	5	3	<	1.20	0.22	0.22	0.02	0.05	<	0.11	-	-	-
<	82	62	597	32	29	7	11	0.06	2.05	0.25	4.26	0.58	0.49	0.03	0.11	-	-	-
<	183	17	44	8	120	6	3	<	0.55	<	4.38	0.03	0.19	<	0.08	-	-	-
<	226	8	31	40	26	11	<	<	0.41	0.12	0.63	0.02	0.07	0.02	0.08	-	-	-
<	303	5	26	6	7	4	<	<	0.19	<	0.45	<	0.11	<	<	-	-	-
<	146	7	47	10	11	6	<	<	0.45	0.02	1.58	0.07	0.10	<	0.03	<	-	-
<	127	32	33	5	11	4	<	<	0.30	<	6.25	0.03	0.09	<	0.16	<	-	-

Appendix 3: Assay results for mineralized samples collected in the McQuesten River region

	UTM easting	UTM northing	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Bi ppm	Cd ppm	Co ppm	Ni ppm	Ba ppm
Det. Lim.			5	0.1	1	2	1	5	5	1	2	0.1	1	1	2
93DM-39a	410548	7087636	34	<	71	13	31	135	<	5	<	<	8	12	184
93DM-39b	410548	7087636	18	<	65	14	34	54	<	4	<	<	10	10	146
93DM-53a	412760	7087198	51	<	25	8	20	6	<	5	3	<	3	7	30
93DM-53b	412760	7087198	17	<	73	14	36	17	<	5	<	0.4	48	84	23
93DM-54b	412356	7087275	16	<	94	7	22	387	<	4	6	<	14	8	207
93DM-58a	410959	7090423	10	<	40	21	21	25	<	3	<	<	16	27	108
93DM-59a	411221	7090399	13	<	27	18	35	13	<	4	<	<	18	18	164
93DM-59b	411772	7090168	13	<	32	23	20	<	<	3	<	<	5	12	113
93DM-60a	411847	7090305	8	<	52	62	62	<	<	4	<	0.5	7	11	69
93DM-61a	412217	7089844	7	<	8	26	57	19	<	2	<	3.0	7	12	910
93DM-61b	412217	7089844	44	<	13	13	64	<	6	4	<	2.0	6	10	591
93DM-66	411041	7088729	490	55.0	183	1955	5	98%	1081	77	700	<	30	10	<
93DM-68	411507	7088549	266	1.5	306	25	49	563	9	4	37	0.2	10	10	211
93DM-69a	411659	7088485	195	<	99	17	17	7.3%	70	5	59	<	40	13	<
93DM-69b	411685	7088543	166	32.5	6927	8	47	2.2%	101	7	48	<	34	12	21
93DM-69c	411704	7088388	332	15.0	1377	21	20	5.9%	206	5	285	0.3	30	13	<
93DM-70b	411845	7088404	35	<	65	8	5	658	26	2	<	<	2	3	31
93DM-70c	411890	7088384	118	<	34	53	12	757	1.4%	5	5	0.5	3	7	40
93DM-77a	415243	7093385	45	1.4	1245	12	80	64	<	13	<	1.0	7	13	30
93DM-77b	415277	7093402	750	2.2	240	22	24	6730	<	5	8	0.5	5	8	20
93DM-84c	422761	7090527	25	<	34	164	56	48	<	<	<	<	25	28	30
93DM-90a	416065	7093911	2300	3.6	825	52	14	>10000	14	4	24	<	43	7	160
93DM-91a	415950	7093882	155	0.6	172	14	20	1800	86		<	<	<	3	40
93DM-91b	415950	7093882	750	0.6	147	38	10	820	28	<	16	<	<	4	20
93DM-93a	415777	7093794	2890	1.8	157	712	8	962	136	<	32	<	<	2	20
93DM-93b	415777	7093794	950	14.8	59	134	6	484	60	<	8	<	<	25	30
93DM-94	415694	7093721	35	0.4	16	30	2	152	<	2	<	<	<	3	40
93DM-95	415537	7093517	9250	21.4	2350	>10000	190	>10000	3250	12	542	23.0	91	33	40
93DM-95a	415537	7093517	5330	1.2	25	90	8	570	8	2	<	<	12	20	80
93DM-95b	415537	7093517	95	0.6	61	414	14	1060	44	<	6	<	<	6	10
93DM-98a	414730	7093546	100	0.2	25	36	94	28	<	<	<	0.5	6	12	330
93DM-98b	414730	7093546	210	0.6	105	32	78	114	<	4	<	0.5	6	12	320
93DM-98c	414612	7093641	170	0.6	125	22	82	622	<	2	<	<	8	11	360
93DM-98d	414612	7093641	335	0.4	39	20	96	20	<	<	<	0.5	7	12	510
93DM-98e	414390	7093738	205	0.2	124	18	114	128	<	31	<	<	7	15	560
93DM-98f	414208	7093752	220	0.6	65	52	100	62	<	1	<	1.5	6	14	490
93DM-98g	414204	7093765	25	0.8	113	56	100	126	<	7	<	0.5	7	16	340
93DM-99a	413884	7093916	390	1.0	574	30	76	572	<	3	6	1.5	10	14	330
93DM-99b	413884	7093916	150	1.0	134	40	128	166	<	1	<	1.0	6	13	410
93DM-99c	413884	7093916	360	0.4	53	14	18	982	<	2	<	<	<	7	90
93DM-99d	413884	7093916	65	0.8	327	16	34	230	<	1	<	0.5	2	7	80
93DM-114	414173	7094750	527	7.1	163	29	6	1.0%	207	4	5	0.3	2	3	24
93DM-115	413935	7095456	23	2.0	76	471	208	574	510	6	<	<	8	18	19
93DM-123a	419231	7093371	27	<	23	7	21	142	47	3	<	<	<	6	8
93DM-134	417183	7097429	12	<	47	29	72	95	33	4	<	<	3	9	13
93DM-146	406825	7091822	12	<	22	69	144	103	13	5	<	1.7	11	14	414
93DM-182	422417	7090961	8	<	8	41	42	23	6	4	<	<	3	8	28
93DM-191a	420902	7094287	20	<	35	10	38	<	<	3	<	<	16	35	55
93DM-191b	420902	7094287	14	<	27	16	23	21	<	3	<	<	12	23	60
93DM-191c	420902	7094287	28	<	96	13	19	17	<	4	<	<	16	11	<
93DM-192	421301	7094584	13	<	36	17	44	73	<	6	<	<	8	12	225
93DM-194	421229	7094787	23	<	21	10	37	33	<	4	<	<	21	52	13
93DM-194a	421229	7094787	11	<	18	36	36	70	<	3	<	0.2	11	15	336
93DM-198	407422	7076541	3	0.2	14	11	6	17	<	6	7	<	2	6	17
93DM-200a	406118	7076747	118	8.7	173	3882	2211	382	17	11	<	<	7	20	32
93DM-209	403730	7075402	689	316.6	76	573	35	21330	33	4	951	1.5	3	5	39
93DM-212	402980	7075897	15	0.4	13	13	19	6367	<	2	8	<	9	5	16
93DM-212a	402980	7075897	7	0.5	43	11	104	508	<	4	7	1.0	45	12	71
93DM-212b	402980	7075897	153	83.8	63	7415	383	28952	19	4	186	10.3	5	7	<
93DM-214	401788	7076307	30	1.2	50	48	18	2182	<	6	<	1.1	2	3	186
93DM-227	402678	7073654	198	1.1	638	40	18	148	<	5	11	0.2	19	9	9
93DM-228	402811	7073767	24	<	174	22	47	19	<	3	6	0.4	7	13	9
93DM-229	402899	7074136	12	2.2	670	14	17	8	<	4	<	<	6	7	14
93DM-234	404040	7070730	6	<	114	8	14	<	<	5	<	<	2	5	20
93DM-237	403446	7070989	18	<	12	69	152	19	<	2	<	0.7	3	3	64

W	Cr	V	Mn	La	Sr	Zr	Sc	Ti	Al	Ca	Fe	Mg	K	Na	P	Sn	Te	Y
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	ppm	ppm	ppm
5	1	2	1	2	1	1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10		
<	118	61	268	28	44	3	7	0.15	1.13	1.18	2.71	1.17	0.86	0.07	0.09	<	-	-
<	103	49	333	34	25	2	5	0.14	0.89	0.75	2.35	0.79	0.35	0.04	0.09	<	-	-
<	146	10	114	4	23	<	<	0.02	0.79	0.27	1.81	0.34	0.16	0.04	<	<	-	-
<	144	14	93	8	6	4	<	<	0.92	0.05	2.25	0.49	0.12	<	0.02	<	-	-
<	83	82	157	17	34	14	9	0.19	1.99	0.31	4.10	1.35	0.60	0.06	0.08	<	-	-
<	73	28	46	10	186	5	3	0.09	4.35	2.29	2.81	0.75	0.39	0.30	0.05	<	-	-
<	98	82	192	6	134	3	5	0.24	2.74	1.69	3.39	1.18	0.42	0.16	0.10	<	-	-
<	114	19	177	3	49	4	<	0.07	0.91	0.54	1.21	0.37	0.08	0.05	0.07	<	-	-
<	100	6	219	7	103	5	<	0.06	0.97	2.36	1.08	0.21	0.04	0.08	0.02	<	-	-
<	31	20	275	19	295	3	5	0.02	1.37	17.61	1.95	0.50	0.16	0.06	0.14	<	-	-
<	37	23	540	14	57	3	4	<	0.37	19.38	2.35	0.34	0.02	<	0.05	<	-	-
<	67	9	31	4	88	3	<	<	0.11	0.69	9.77	0.02	0.07	<	0.02	88	-	-
<	90	48	223	33	33	<	<	0.18	1.09	0.82	1.84	0.73	0.59	0.06	0.10	<	-	-
36	94	57	143	23	26	2	4	0.06	0.99	0.31	8.34	0.96	0.29	0.03	0.07	<	-	-
270	88	35	93	22	14	3	3	0.08	0.78	0.24	5.31	0.55	0.28	0.03	0.08	18	-	-
18	68	10	33	9	15	6	<	<	0.17	0.11	7.39	0.06	0.13	<	0.06	28	-	-
<	79	4	40	24	8	4	<	<	0.23	0.19	0.40	0.04	0.12	<	0.04	<	-	-
<	149	4	141	5	17	<	3	<	0.10	0.59	1.38	0.18	0.06	<	<	<	-	-
<	236	6	90	30	3	<	<	<	0.39	0.12	0.85	0.07	0.10	<	<	<	-	-
6	289	4	40	10	3	<	<	<	0.38	<	1.87	0.02	0.13	<	<	<	5.5	-
<	101	7	85	<	14	<	<	<	1.04	<	6.65	0.30	0.10	<	0.02	<		-
12	194	<	15	20	20	<	<	<	0.37	<	2.12	0.02	0.09	<	0.02	<	12	-
<	96	6	10	<	4	<	<	<	0.44	<	7.42	<	0.10	<	0.03	<	0.8	-
<	336	5	20	10	3	<	<	<	0.34	<	3.30	<	0.10	<	0.02	<	1.1	-
7	203	3	10	<	<	<	<	<	0.23	<	2.75	<	0.07	<	0.02	<	1.5	-
37	419	4	20	10	<	<	<	<	0.23	<	1.68	0.02	0.09	<	<	<	1.3	-
<	245	<	15	20	4	<	<	<	0.38	<	0.59	0.03	0.17	<	<	<	0.1	-
<	185	6	15	<	6	<	3	<	0.38	<	8.82	<	0.12	<	0.12	20	6.6	-
18	130	4	130	40	6	<	<	<	0.48	<	0.41	0.02	0.16	0.02	0.04	<	0.4	-
<	427	3	20	<	5	<	<	<	0.23	<	1.30	<	0.05	0.02	<	<	0.1	-
<	116	41	325	30	26	<	3	0.19	1.43	0.39	2.08	0.81	0.68	0.07	0.07	<	0.1	-
6	212	32	300	30	33	<	3	0.15	1.37	0.35	2.46	0.69	0.68	0.09	0.06	<	<	-
8	132	39	345	40	39	<	6	0.14	1.47	0.95	2.57	0.87	0.69	0.07	0.07	<	0.1	-
7	143	41	345	40	41	<	3	0.20	1.41	0.38	2.32	0.76	0.84	0.10	0.07	<	<	-
19	150	53	390	30	31	<	4	0.24	1.57	0.40	3.25	1.03	0.98	0.09	0.08	<	0.1	-
7	147	35	460	30	40	<	3	0.14	1.35	0.35	2.42	0.74	0.40	0.07	0.07	<	<	-
<	134	44	410	30	25	<	3	0.13	1.21	0.46	2.18	0.67	0.52	0.07	0.10	<	<	-
<	134	27	365	90	55	<	3	0.06	1.02	0.89	2.08	0.59	0.23	0.08	0.08	<	<	-
6	108	36	395	40	46	<	2	0.18	1.25	0.50	2.22	0.68	0.63	0.09	0.08	<	<	-
<	357	20	75	<	7	<	2	<	0.89	0.04	1.86	0.40	0.19	<	0.16	<	0.2	-
<	202	21	135	10	3	<	2	<	1.26	<	2.43	0.59	0.19	0.02	0.13	<	<	-
<	114	4	25	18	3	<	<	<	0.09	0.06	3.37	<	0.03	<	<	<	-	-
<	138	8	288	6	4	4	<	<	0.20	0.11	7.67	<	0.02	<	0.03	<	-	-
<	109	3	39	3	2	2	<	<	0.12	<	3.47	<	<	<	0.02	<	-	-
<	89	5	53	9	6	2	<	<	0.21	0.02	6.41	<	0.04	<	0.08	<	-	-
<	137	65	386	29	71	3	4	0.21	1.81	0.72	2.68	1.07	0.70	0.11	0.10	<	-	-
<	122	7	95	4	9	2	<	<	0.19	0.05	2.43	0.06	0.06	<	0.02	<	-	-
<	82	33	356	10	25	4	6	0.02	2.55	0.19	3.67	0.97	0.46	0.08	0.02	<	-	-
<	120	45	186	18	183	3	5	0.11	3.76	1.80	2.33	0.80	0.42	0.39	0.03	<	-	-
<	73	11	378	26	141	5	<	0.06	5.69	3.52	6.96	0.09	0.03	0.15	0.07	<	-	-
<	85	21	236	39	58	7	4	0.05	1.22	1.03	2.33	0.86	0.28	0.05	0.06	<	-	-
<	89	26	236	10	13	3	5	0.03	2.41	0.05	4.60	0.83	0.22	0.04	<	<	-	-
<	91	26	172	21	68	8	2	0.15	1.23	0.62	1.30	0.68	0.43	0.12	0.07	<	-	-
<	180	<	286	4	32	2	<	<	0.09	2.29	0.60	0.03	0.07	0.02	<	<	-	-
11	25	40	63	7	18	4	2	<	0.46	<	22.43	<	0.08	<	0.02	<	-	-
<	87	3	63	3	38	5	<	<	0.09	0.02	3.70	<	0.05	<	<	37	-	-
<	65	<	61	13	38	<	<	<	0.23	0.09	1.13	0.03	0.06	0.06	<	<	-	-
<	137	<	675	24	5	3	<	<	0.13	0.05	0.64	<	0.07	<	0.02	<	-	-
<	86	5	87	<	51	2	<	<	0.06	0.07	8.23	<	0.04	<	0.02	<	-	-
<	55	<	18	22	8	27	<	<	0.48	<	1.81	<	0.25	0.02	<	<	-	-
<	140	11	80	8	53	<	2%	0.03	2.81	1.48	3.00	0.21	0.03	0.13	<	<	-	-
<	78	12	177	19	125	<	<	0.06	4.23	2.56	2.16	0.10	0.09	0.48	<	<	-	-
37	105	27	94	10	62	<	3	0.11	2.13	0.40	7.23	0.76	0.08	0.15	<	<	-	-
<	150	14	138	10	32	<	2	0.05	0.72	0.19	1.61	0.37	0.04	0.07	0.02	<	-	-
<	58	12	235	37	7	5	<	0.03	0.72	0.32	1.84	0.23	0.17	0.03	0.05	<	-	-

Appendix 3: Assay results for mineralized samples collected in the McQuesten River region

	UTM	UTM	Au	Ag	Cu	Pb	Zn	As	Sb	Mo	Bi	Cd	Co	Ni	Ba
	easting	northing	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Det. Lim.			5	0.1	1	2	1	5	5	1	2	0.1	1	1	2
93DM-237a	403446	7070989	<	<	5	40	82	10	<	2	<	<	4	3	84
93DM-239a	404116	7071349	<	70.2	14	2.5%	253	19	36	22	40	402.0	<	2	7
93DM-279	412608	7076356	36	0.2	12	3	10	402	6	4	<	0.2	<	4	7
93DM-287	414575	7073531	5	10.0	169	3559	3816	225	8	6	<	34.8	6	5	47
93DM-289a	418294	7070887	7	44.7	746	8652	2138	56	48	8	<	2.6	4	20	<
93DM-297	416326	7072097	29	48.2	1911	4567	22483	575	<	10	14	19.9	7	11	10
93DM-299	416030	7072981	19	1.7	10	2101	93	293	<	4	3	<	12	11	554
93DM-300	415795	7073103	13	<	4	870	87	45	<	7	<	<	10	10	572
93DM-307a	415452	7071954	<	2.0	43	3046	68	18	<	4	<	<	14	12	239
93DM-307g	453170	7072170	<	<	33	35	191	27	<	4	<	0.3	13	12	731
93DM-310a	415142	7074427	12	3.0	9	383	1749	130	<	9	3	14.6	12	11	116
93DM-310b	415142	7074427	58	27.5	55	1438	2.9%	297	7	14	36	300.0	21	6	48
93DM-310c	415414	7074524	9	<	49	72	289	<	<	5	3	2.4	11	8	100
93DM-312c	416083	7074920	16	<	38	47	125	227	<	3	<	0.7	15	10	251
93DM-313	416845	7074694	11	<	5	49	90	771	<	3	<	0.4	8	8	184
93DM-316a	417574	7074361	40	<	6	44	243	353	<	2	<	1.9	11	16	58
93DM-316b	417574	7074361	76	<	14	36	104	16	<	5	<	0.2	11	7	58
93DM-336a	418365	7078628	6	1.5	41	30	77	461	<	4	5	1.8	3	3	19
93DM-336b	418365	7078628	25	8.2	194	166	139	632	19	5	12	4.7	<	4	15
93DM-352a	421981	7080598	<	<	25	20	291	11	<	4	<	1.8	7	15	27
93DM-359a	420465	7080884	26	4.8	559	2378	62	3620	17	6	136	0.4	3	8	51
93DH-8	401397	7080712	20	<	45	42	92	789	62	6	<	<	8	19	53
93DH-8a	401397	7080712	377	<	9	24	64	25	<	4	<	<	10	5	687
93DH-9	401098	7080249	19	<	3	14	12	9	<	5	<	<	<	3	8
93DH-10	401404	7079902	26	<	14	8	17	7	<	3	<	<	3	9	37
93DH-11	401506	7080089	11	<	4	25	82	13	<	4	<	<	13	11	720
93DH-12a	401668	7080100	19	<	7	19	59	19	<	4	<	<	9	5	596
93DH-13	401718	7079212	435	15.3	15	242	7	88	<	4	72	<	3	8	32
93DH-13a	401718	7079212	10	24.0	2	6	9	179	<	5	<	<	2	7	69
93DH-14	402131	7079684	27	0.5	15	472	1608	484	<	8	<	17.2	17	76	48
93DH-17	403213	7079797	17	<	7	14	34	16	<	4	<	<	2	7	28
93DH-17a	403213	7079797	40	<	52	10	91	78	<	3	<	<	9	33	19
93DH-19	422090	7074065	185	3.5	295	137	669	6	<	3	<	1.2	2	4	17
93DH-20	421890	7074051	18	<	7	34	111	<	<	4	<	<	3	2	269
93DH-21a	421890	7074051	7	9.5	5	109	74	82	<	5	52	<	<	2	37
93DH-26c	421314	7077752	<	2.0	11	34	97	24	<	5	46	0.2	<	4	11
93DH-26d	421314	7077752	28	48.0	727	2.1%	2408	7879	16	11	47	24.3	5	9	52
93DH-29b	420549	7078143	11	<	191	125	94	43	<	2	<	<	38	80	50
93DH-35	423950	7079663	8	1.1	93	123	63	29	<	6	<	1.3	15	33	44
94DH-17	438811	7074256	2930	<	457	19	37	6837	<	<	68	<	38	18	31
94DH-22b	448527	7079841	25	<	12	5	9	44	<	<	<	<	5	19	20
94DH-34e	437535	7078133	<	<	25	38	33	<	<	8	<	<	2	7	18
94DH-84a	439757	7095829	<	<	7	5	6	7	<	6	<	<	<	6	3
94DH-87a	441376	7096970	6	1.5	21	205	2	4497	206	2	32	<	<	10	10
94DH-87/8	441439	7096856	41	<	33	799	13	8399	149	10	18	<	<	2	125
94DH-89a	441535	7097252	<	<	9	93	3	144	61	3	<	<	<	3	14
94DH-89b	441676	7097282	170	1.1	142	192	2	5688	136	2	31	<	4	14	133
94DH-89c	441856	7097206	7	<	77	208	39	1010	94	7	<	<	<	<	333
94DH-91	442338	7097106	<	<	130	104	74	220	1096	2	65	<	<	4	22
94DH-96a	432181	7095259	8	<	8	22	39	13	13	2	<	<	<	11	18
94DH-100a	445082	7072022	10	<	23	10	24	391	7	13	<	<	5	8	8
94DH-101	445724	7071646	33	<	7	7	18	87	<	2	<	<	4	9	54
94DH-102	444688	7072169	<	<	5	5	7	40	<	<	<	<	2	10	32
94DH-104a	444218	7071667	<	<	14	11	36	196	<	9	<	<	7	23	101
94DH-104b	444128	7071730	70	<	113	23	66	2553	<	<	<	<	4	19	50
94DH-104c	444129	7071729	3715	6.2	43	237	12	>10000	113	<	48	<	3	7	23
94DH-104d	444299	7071713	5618	2.8	50	79	9	>10000	246	8	82	<	15	15	16
94DH-125a	425973	7076459	31	11.9	45	166	44	520	<	5	22	<	<	5	16
94DH-125b	425973	7076459	17	0.4	26	154	59	137	<	2	<	<	2	14	11
94DH-125c	425973	7076459	9	<	32	8	45	96	<	9	<	<	6	12	120
94DH-125d	425973	7076459	8	<	19	5	37	<	<	3	<	<	3	5	7
94DH-125e	425973	7076459	8	<	39	4	32	<	<	<	<	<	3	10	8
94DH-131	427500	7078374	<	<	5	5	24	43	<	12	<	<	<	4	13
94DH-133	427438	7078652	<	6.6	50	107	710	429	17	4	<	<	4	8	31
94DH-140	446259	7097463	6	<	20	416	28	<	28	<	<	<	<	8	13

W	Cr	V	Mn	La	Sr	Zr	Sc	Ti	Al	Ca	Fe	Mg	K	Na	P	Sn	Te	Y
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	ppm	ppm	ppm
5	1	2	1	2	1	1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10		
<	54	17	206	33	8	7	2	0.07	0.88	0.34	1.65	0.31	0.26	0.03	0.06	<	-	-
<	137	<	43	<	17	<	<	<	0.06	<	0.47	<	<	<	<	<	-	-
6	151	<	27	9	3	<	<	<	0.20	<	1.00	<	0.03	<	<	<	-	-
15	147	<	10980	12	5	<	<	<	0.21	0.02	2.23	<	0.19	<	<	29	-	-
10	92	14	2197	10	<	<	<	<	0.99	<	7.48	0.12	0.07	<	<	<	-	-
112	99	6	1651	6	<	<	<	<	0.95	0.04	2.65	0.50	0.09	<	<	15	-	-
<	97	56	330	30	90	<	3	0.17	1.82	0.73	2.27	0.84	0.65	0.15	0.08	<	-	-
<	143	56	380	42	81	<	4	0.20	1.82	0.67	2.47	0.88	0.75	0.14	0.08	<	-	-
<	130	69	341	28	102	18	5	0.19	2.64	1.00	2.81	1.31	0.44	0.20	0.07	<	-	-
6	133	74	474	35	91	3	5	0.25	2.59	1.21	2.79	1.31	0.78	0.16	0.08	10	-	-
8	114	40	1.5%	9	18	8	5	<	2.47	0.11	8.35	0.68	0.10	0.02	0.04	<	-	-
114	151	12	4610	3	4	2	2	<	0.77	0.05	4.08	0.22	0.03	<	0.02	<	-	-
<	109	60	373	23	144	4	4	0.14	3.39	1.50	3.07	1.06	0.42	0.32	0.08	<	-	-
<	97	45	260	29	107	2	3	0.17	2	0.87	2.45	0.70	0.61	0.18	0.08	<	-	-
8	87	36	247	20	107	2	3	0.09	2.14	0.92	1.90	0.58	0.35	0.21	0.07	<	-	-
22	61	13	380	11	194	<	<	0.05	2.77	2.92	0.98	0.24	0.09	0.21	0.06	<	-	-
<	86	58	349	25	134	8	5	0.14	3.05	1.42	3.20	1.22	0.29	0.31	0.10	<	-	-
<	140	<	36	18	<	3	<	<	0.05	<	0.44	<	0.05	<	<	<	-	-
<	147	<	143	14	2	2	<	<	0.09	<	1.94	<	0.03	<	<	13	-	-
<	76	13	1208	16	<	<	4	<	0.43	<	4.47	0.03	0.18	<	0.03	<	-	-
<	98	13	36	18	4	<	<	<	0.14	<	10.52	<	0.02	<	0.04	135	-	-
<	42	21	107	14	6	2	<	<	0.36	0.03	8.93	0.03	0.13	0.02	0.07	<	-	-
6	91	30	478	29	91	2	7	0.20	2.29	0.77	3.04	0.78	0.94	0.16	0.07	<	-	-
<	200	<	39	<	2	<	<	<	0.05	0.02	0.32	<	0.02	<	<	<	-	-
<	110	5	182	3	33	<	<	<	0.73	0.44	0.87	0.18	0.04	0.03	0.07	<	-	-
<	121	68	386	14	127	4	5	0.22	3.36	1.46	2.86	1.29	1.08	0.18	0.09	<	-	-
13	99	25	480	30	53	3	5	0.17	1.69	0.72	2.60	0.68	0.85	0.10	0.06	<	-	-
303	197	3	90	<	4	<	<	<	0.09	0.13	1.15	0.03	0.03	<	<	<	-	-
21	161	4	883	7	23	<	<	<	0.22	2.08	0.98	0.11	0.12	0.02	<	<	-	-
84	73	35	534	12	3	<	2	<	0.42	0.05	15.15	<	0.14	<	0.12	<	-	-
16	143	6	458	7	5	<	<	<	0.17	<	1.39	<	0.04	<	<	<	-	-
8	59	10	152	4	6	<	<	<	0.19	<	7.03	<	0.04	<	0.03	<	-	-
8	82	5	517	17	14	4	2	<	0.53	0.57	1.27	0.09	0.16	0.03	0.03	<	-	-
8	74	23	421	35	31	19	4	<	2.03	2.69	1.98	0.31	0.99	0.25	0.08	<	-	-
536	81	<	447	11	3	4	3	<	0.31	0.22	0.80	<	0.18	<	0.04	<	-	-
136	140	4	168	<	<	<	<	<	0.11	0.06	1.12	<	0.05	<	<	<	-	-
90	96	58	758	21	6	3	3	<	0.38	0.11	5.55	0.02	0.07	<	0.08	200	-	-
<	46	91	162	9	308	<	4	0.11	4.78	2.26	3.89	1.70	0.44	0.29	0.17	<	-	-
12	60	47	76	11	155	3	<	0.10	2.16	1.42	2.71	0.27	0.07	0.27	0.28	<	-	-
598	122	22	60	18	69	-	-	-	1.96	1.26	3.53	0.45	-	-	-	-	-	4
<	199	3	772	3	63	-	-	-	0.15	1.41	0.52	0.12	-	-	-	-	-	2
<	176	8	120	12	4	-	-	-	0.64	0.02	1.65	0.22	-	-	-	-	-	<
<	271	2	27	<	<	-	-	-	0.09	<	0.67	<	-	-	-	-	-	<
<	229	<	27	21	2	-	-	-	0.10	<	0.62	<	-	-	-	-	-	2
<	224	<	25	5	22	-	-	-	0.07	<	2.48	<	-	-	-	-	-	2
<	160	4	17	<	5	-	-	-	0.08	<	1.10	<	-	-	-	-	-	<
<	247	<	23	13	5	-	-	-	0.13	<	0.82	<	-	-	-	-	-	<
<	210	11	21	43	136	-	-	-	0.65	0.08	5.14	<	-	-	-	-	-	3
<	204	3	53	7	13	-	-	-	0.24	<	5.87	<	-	-	-	-	-	<
<	223	<	48	20	2	-	-	-	0.27	0.03	0.51	0.03	-	-	-	-	-	2
<	267	2	209	2	7	-	-	-	0.10	<	1.11	<	-	-	-	-	-	<
<	160	4	388	17	4	-	-	-	0.39	0.02	1.23	0.04	-	-	-	-	-	2
<	211	3	35	14	4	-	-	-	0.24	0.03	0.48	<	-	-	-	-	-	<
<	220	12	268	18	13	-	-	-	1.05	0.17	1.74	0.41	-	-	-	-	-	6
<	187	15	398	25	26	-	-	-	1.54	0.03	3.99	0.96	-	-	-	-	-	5
<	175	<	65	4	7	-	-	-	0.11	<	3.14	<	-	-	-	-	-	<
79	212	<	33	7	26	-	-	-	0.12	<	5.15	0.02	-	-	-	-	-	<
<	211	<	105	2	<	-	-	-	0.17	0.02	0.54	<	-	-	-	-	-	3
<	282	2	60	<	2	-	-	-	0.09	0.02	0.79	0.05	-	-	-	-	-	<
<	227	21	174	15	9	-	-	-	1.39	0.05	2.24	0.69	-	-	-	-	-	3
<	175	5	604	10	107	-	-	-	0.61	0.94	1.06	0.06	-	-	-	-	-	3
<	197	3	464	7	161	-	-	-	0.67	1.61	0.96	0.12	-	-	-	-	-	3
<	231	<	35	10	4	-	-	-	0.07	<	0.51	<	-	-	-	-	-	<
<	203	6	122	4	<	-	-	-	0.21	<	2.88	0.02	-	-	-	-	-	2
<	189	2	94	4	7	-	-	-	0.25	<	4.73	<	-	-	-	-	-	<

Appendix 3: Assay results for mineralized samples collected in the McQuesten River region

	UTM easting	UTM northing	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Bi ppm	Cd ppm	Co ppm	Ni ppm	Ba ppm
Det. Lim.			5	0.1	1	2	1	5	5	1	2	0.1	1	1	2
94DH-148b	450353	7097082	<	<	21	832	239	306	233	2	<	<	2	5	74
94DH-149a	447567	7097106	<	<	12	89	112	<	6	4	<	<	2	6	8
94DH-149b	447598	7097040	<	<	23	594	1141	<	14	<	<	<	<	3	22
94DH-155a	440081	7072582	1582	<	6	13	14	4657	<	9	<	<	2	5	53
94DH-155b	440081	7072582	30	<	5	7	11	486	<	3	<	<	3	7	52
94DH-155c	440081	7072582	82	<	9	8	17	1325	7	<	<	<	3	11	66
94DH-159a	425264	7071195	<	<	48	68	173	18	<	12	<	4.5	3	6	36
94DH-159b	425264	7071195	<	2.1	46	8	18	<	<	4	13	<	2	5	17
94DH-159c	425264	7071195	<	0.5	48	79	49	<	<	2	<	<	<	11	15
94DH-159d	425264	7071195	<	<	39	13	55	6	<	10	<	<	2	4	18
94DH-159e	425264	7071195	<	1.9	423	663	3951	<	<	4	<	10.5	<	7	115
94DH-159f	425264	7071195	<	<	152	49	2409	<	<	<	<	18.7	<	6	49
94DH-160	425343	7071449	1630	34.9	2685	168	739	<	<	<	366	<	303	21	8
94DH-165a	446041	7071201	175	<	12	10	20	700	<	<	<	<	4	10	60
94DH-165b	446053	7071241	134	0.6	68	14	20	>10000	<	<	20	<	6	7	80
94DM-6b	439343	7073304	486	<	32	9	25	575	<	19	8	<	4	6	42
94DM-25b	434294	7075149	8	<	8	9	37	44	<	<	<	<	<	8	76
94DM-45a	445865	7078977	<	60.7	147	1.63%	1249	6	11	4	62	<	3	10	41
94DM-48a	445302	7079739	<	<	4	154	73	10	<	5	<	<	4	6	275
94DM-54b	443276	7076073	10	<	3	149	71	<	<	<	<	<	4	9	277
94DM-54c	443276	7076073	<	<	4	76	84	<	<	<	<	<	4	7	484
94DM-54d	443276	7076073	<	<	3	24	80	<	<	7	<	<	4	7	527
94DM-54e	443276	7076073	6	<	29	16	461	<	<	<	<	3.5	3	10	55
94DM-54f	443276	7076073	<	<	10	14	52	<	<	<	<	<	5	7	178
94DM-54g	443276	7076073	<	<	5	10	21	<	<	16	<	<	2	7	8
94DM-54h	443276	7076073	<	<	14	7	7	14	<	2	<	<	2	12	16
94DM-56	443772	7075327	<	<	<	14	69	<	<	2	<	<	3	7	456
94DM-57	443820	7075199	<	<	26	9	125	14	<	12	<	<	9	9	127
94DM-58a	443975	7074809	<	<	18	109	139	440	<	<	<	<	8	14	251
94DM-58b	443975	7074809	<	<	16	70	123	131	<	2	<	<	7	8	301
94DM-131a	429511	7088433	10	<	30	377	10	306	78	3	<	<	<	3	175
94DM-131b	429213	7088254	6	<	11	193	5	1775	43	9	<	<	<	2	94
94DM-151	436894	7091713	<	<	4	8	16	<	<	6	<	<	<	3	12
94DM-165	440316	7097312	<	<	76	15	24	7	<	3	<	<	2	11	33
94DM-166	440326	7097508	<	<	10	8	9	128	26	13	<	<	<	3	17
94DM-167	441231	7098119	28	<	77	329	16	2608	270	<	<	<	<	4	44
94DM-168	441381	7090871	17	<	36	127	20	3925	793	2	<	<	<	5	200
94DM-168a	441381	7090871	6	0.2	3	41	2	42	11	14	<	<	<	4	18
94DM-192	436880	7069634	21	<	96	16	22	3568	<	<	<	<	6	20	66
94DM-252	424584	7070788	<	5.1	220	187	518	<	<	<	<	<	2	8	34
94DM-253	424571	7070856	11	8.8	46	262	193	375	<	12	15	3.9	2	8	42
94DM-268	444532	7071846	6	<	8	11	17	129	<	<	<	<	2	10	67
94DM-269a	444493	7071675	<	<	82	10	64	7650	<	<	<	<	5	14	70
94DM-269b	444493	7071675	30	<	37	8	26	3350	2	<	<	<	1	4	60

Note: Au analyses: fire assay + atomic absorption finish; all others ICP. 92DH and 92DM samples analyzed at iPL, Vancouver, BC.
93DM and 93DH samples: Au analyzed at Northern Analytical Laboratories, Whitehorse, YT, others at iPL, Vancouver, BC.
94DM and 94DH samples analyzed at Bondar-Clegg, Vancouver, BC.

W	Cr	V	Mn	La	Sr	Zr	Sc	Ti	Al	Ca	Fe	Mg	K	Na	P	Sn	Te	Y
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	ppm	ppm	ppm
5	1	2	1	2	1	1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10		
<	90	24	51	30	22	-	-	-	0.62	0.02	4.71	0.02	-	-	-	-	-	3
<	210	2	118	7	3	-	-	-	0.17	<	1.48	<	-	-	-	-	-	<
<	167	2	2293	7	5	-	-	-	0.43	<	5.86	<	-	-	-	-	-	<
<	182	<	57	17	40	-	-	-	0.31	0.02	1.09	0.03	-	-	-	-	-	2
<	180	2	87	17	3	-	-	-	0.28	0.02	0.71	0.03	-	-	-	-	-	2
<	163	<	71	18	7	-	-	-	0.33	<	0.96	0.03	-	-	-	-	-	2
<	230	3	96	9	3	-	-	-	0.38	0.02	0.81	0.08	-	-	-	-	-	<
<	214	3	83	2	<	-	-	-	0.22	<	0.54	0.05	-	-	-	-	-	<
<	225	2	135	2	<	-	-	-	0.24	<	0.70	0.03	-	-	-	-	-	<
<	213	4	111	<	3	-	-	-	0.46	0.04	0.76	0.09	-	-	-	-	-	<
<	167	36	1499	13	15	-	-	-	2.46	0.17	5.42	0.54	-	-	-	-	-	3
<	117	11	528	9	19	-	-	-	0.65	0.83	3.63	0.20	-	-	-	-	-	3
80	157	<	3721	9	8	-	-	-	4.15	0.06	7.23	1.02	-	-	-	-	-	3
<	103	4	235	10	3	-	-	-	0.27	0.02	1.10	0.06	-	-	-	-	-	<
230	134	16	220	10	14	-	-	-	1.16	0.04	3.94	0.68	-	-	-	-	-	<
226	290	19	184	9	6	-	-	-	0.31	0.15	0.77	0.21	-	-	-	-	-	3
<	172	5	37	7	4	-	-	-	0.21	<	1.32	<	-	-	-	-	-	<
<	184	9	632	10	5	-	-	-	0.76	<	2.45	0.18	-	-	-	-	-	<
<	143	31	468	42	71	-	-	-	1.03	2.33	1.60	0.55	-	-	-	-	-	12
<	131	32	493	41	76	-	-	-	1.06	2.49	1.65	0.57	-	-	-	-	-	12
<	156	42	452	39	44	-	-	-	1.53	0.50	1.91	0.74	-	-	-	-	-	12
<	180	48	435	43	61	-	-	-	1.64	0.69	2.04	0.80	-	-	-	-	-	13
<	135	31	558	43	34	-	-	-	1.56	1.15	2.28	0.78	-	-	-	-	-	12
<	131	29	461	39	17	-	-	-	1.00	0.51	1.92	0.58	-	-	-	-	-	13
<	281	4	125	3	3	-	-	-	0.14	0.02	0.70	0.05	-	-	-	-	-	<
<	214	3	203	5	<	-	-	-	0.10	<	0.81	<	-	-	-	-	-	<
<	149	42	366	35	52	-	-	-	1.52	0.51	1.78	0.69	-	-	-	-	-	10
<	213	7	513	23	7	-	-	-	0.51	0.19	1.47	0.08	-	-	-	-	-	9
<	173	21	466	41	12	-	-	-	0.87	0.20	1.76	0.43	-	-	-	-	-	14
<	164	28	445	35	25	-	-	-	1.05	0.49	1.79	0.53	-	-	-	-	-	13
<	137	2	19	27	11	-	-	-	0.26	<	1.04	0.02	-	-	-	-	-	4
<	175	<	21	55	6	-	-	-	0.11	<	1.26	<	-	-	-	-	-	3
<	99	8	206	9	461	-	-	-	0.10	+10.00	0.57	0.12	-	-	-	-	-	<
<	206	12	95	14	5	-	-	-	0.71	0.04	1.48	0.41	-	-	-	-	-	4
<	236	<	26	12	2	-	-	-	0.15	0.02	0.90	<	-	-	-	-	-	<
<	168	12	27	6	32	-	-	-	0.15	0.02	4.97	<	-	-	-	-	-	2
<	186	12	21	38	294	-	-	-	0.45	0.03	4.62	<	-	-	-	-	-	5
<	260	2	23	12	7	-	-	-	0.12	<	0.35	<	-	-	-	-	-	<
<	190	2	181	21	17	-	-	-	0.78	0.21	2.46	0.20	-	-	-	-	-	11
<	159	13	925	16	6	-	-	-	1.42	0.03	3.51	0.26	-	-	-	-	-	2
<	207	2	471	13	2	-	-	-	0.43	0.05	0.64	0.10	-	-	-	-	-	2
<	140	2	41	21	5	-	-	-	0.31	<	0.82	0.02	-	-	-	-	-	<
<	41	16	280	20	19	-	-	<	2.23	<	3.65	0.97	-	-	-	-	-	-
<	194	9	140	<	10	-	-	<	0.7	<	2.6	0.19	-	-	-	-	-	-

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