SEDIMENT-HOSTED, DISSEMINATED GOLD DEPOSITS RELATED TO ALKALIC INTRUSIONS IN THE HOWELL CREEK STRUCTURE, SOUTHEASTERN BRITISH COLUMBIA (82G/2, 7)

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KEYWORDS: Sediment-hosted, disseminated gold, Carlin-type, Alkalic epithermal, Flathead syenite intrusions, Crowsnest Formation, Howell Creek Structure.

INTRODUCTION

This paper describes occurrences of low grade, disseminated gold in sedimentary rocks and alkalic intrusions in the vicinity of the Howell Creek Structure (HCS; Price,1964) of southeastern British Columbia. The study is part of the B.C. Geological Survey's ongoing Sediment-hosted Gold Project, which is examining occurrences throughout the province which may have similarities to gold deposits in the Carlin district of Nevada. Brown spent two weeks examining the general setting of mineralization and sampling diamond drill core. Much of the paper is based on results of numerous exploration programs undertaken by Cameron for Dome Exploration Canada, Limited, Placer Dome Inc. (now Placer Dome Canada Limited) and Phelps Dodge Corporation of Canada, Limited (Cameron, 1989).

The geology map compiled at 1:1 000 scale, whole rock, trace element and rare earth element lithogeochemical data, PIMA short-wave infrared analysis results, and scanned photographs, are available in digital form from Brown.

Location and access

The study area lies 40 kilometres southeast of Fernie, British Columbia and 25 kilometres north of the British Columbia-Montana border, in the headwaters of Howell and Twentynine Mile creeks (Figure 1). The terrain varies from broad, U-shaped, drift covered valleys to precipitous headwalls of extensive outcrops (Plate 1), between 1490 m and 2400 m elevation. This area lies within the MacDonald range of the Front Ranges of the southern Rocky Mountains. Access to the region is by logging roads leading from the locality of Morrissey, thirteen kilometres south of Fernie on Highway 3, for a distance of 50 kilometres following the Morrissey, Lodgepole and Harvey Forest Service roads. An extensive network of secondary logging roads and drill trails provides access to much of the study area.

History

The Flathead area is geologically unique within the Canadian segment of the Rocky Mountains and has sparked considerable interest and study since Price (1962) first mapped the area. The HCS in particular has been the subject of many studies including Jones (1964), Oswald (1964), Labreque and Shaw (1973) and others including a recent description by Legun (1993).

Gold exploration has been a focus of work since 1983 when Cominco Limited staked the Howell claim block along the ridge separating Howell Creek and Twentynine Mile Creek. Dome Exploration Canada, Limited completed regional sampling programs in 1984 and staked the Flathead claims covering Trachyte Ridge and the Howe claims adjacent to the Howell claim block. Additional work by Dome and Placer Dome Inc. in subsequent years led to drill programs on Trachyte Ridge, the Howell property, optioned from Cominco Limited, and the Howe property. Phelps Dodge Corporation of Canada Limited, acquired the properties in 1992 and continued with additional drill programs in 1993 and 1994. Recently, Eastfield Resources Limited conducted a prospecting program on the Trachyte Ridge area and staked the former Howe claim block south of Twentynine Mile Creek.

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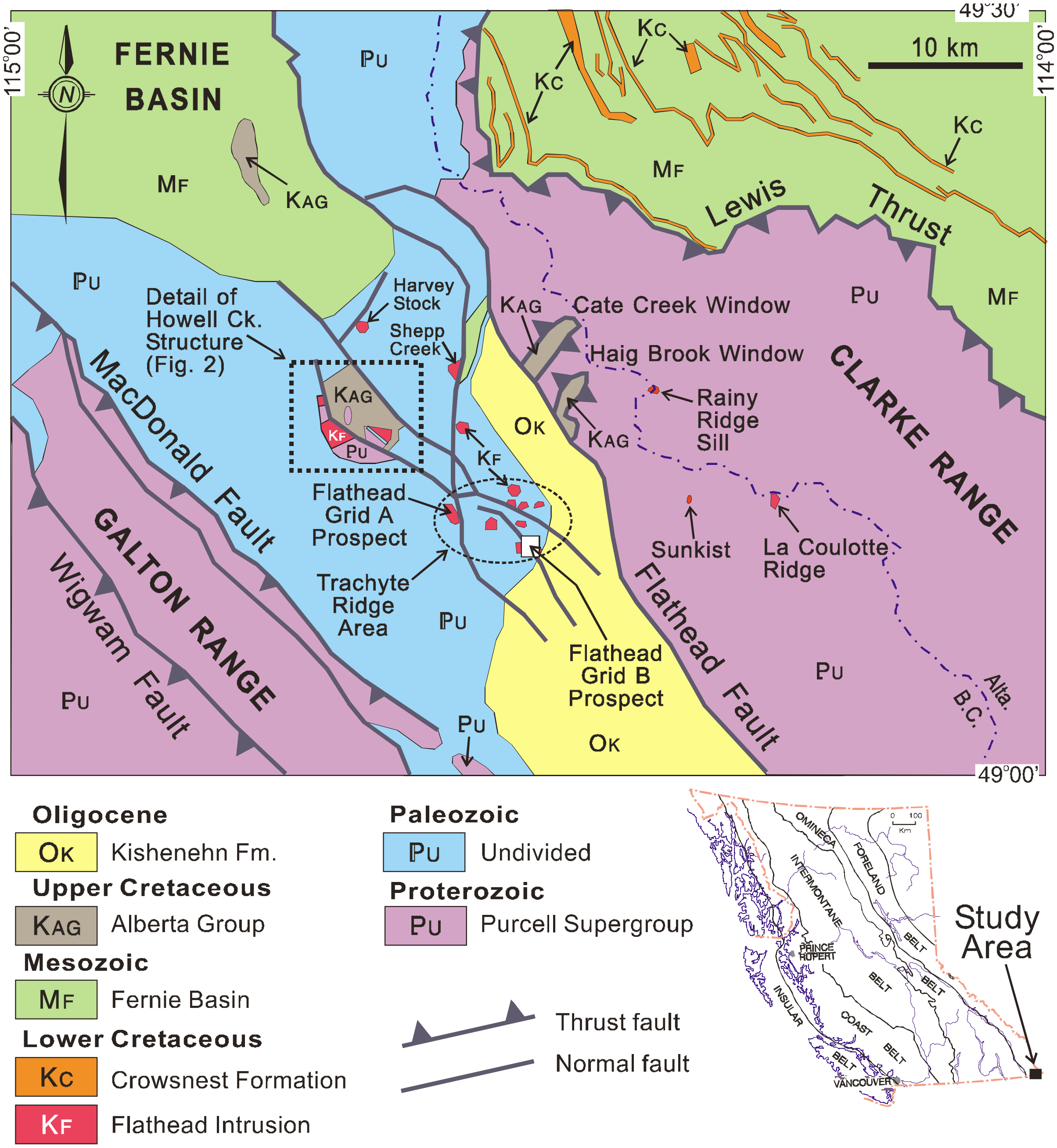


Figure 1. Regional setting of the Howell Creek Structure and distribution of Early Cretaceous syenite intrusions in southeastern British Columbia relative to the coeval Crowsnest Formation in Alberta (modified from Price, 1962).

REGIONAL GEOLOGICAL SETTING

The geology of the Flathead area is characterized by Laramide structures, comprising thrust faults and open folds that have been modified by Tertiary normal faults. Strata exposed in the Flathead area include Proterozoic Purcell Supergroup clastics, Paleozoic carbonate and clastic rocks, Mesozoic clastic sequences and coal beds and Tertiary fault scarp units related to normal faults. Cretaceous alkalic intrusions comprising stocks, dikes and sills intrude layered rocks, and are generally restricted to areas of Tertiary faults.

The sediment-hosted gold occurrences in the region lie within the HCS, an enigmatic feature of the southern Rocky Mountain fold and thrust belt (Figure 1). The HCS is located southeast of the Fernie Basin in a zone of northwest-trending normal faults. The HCS described by Price (1965), Oswald (1964) and others is a feature in which Upper Cretaceous marine sedimentary

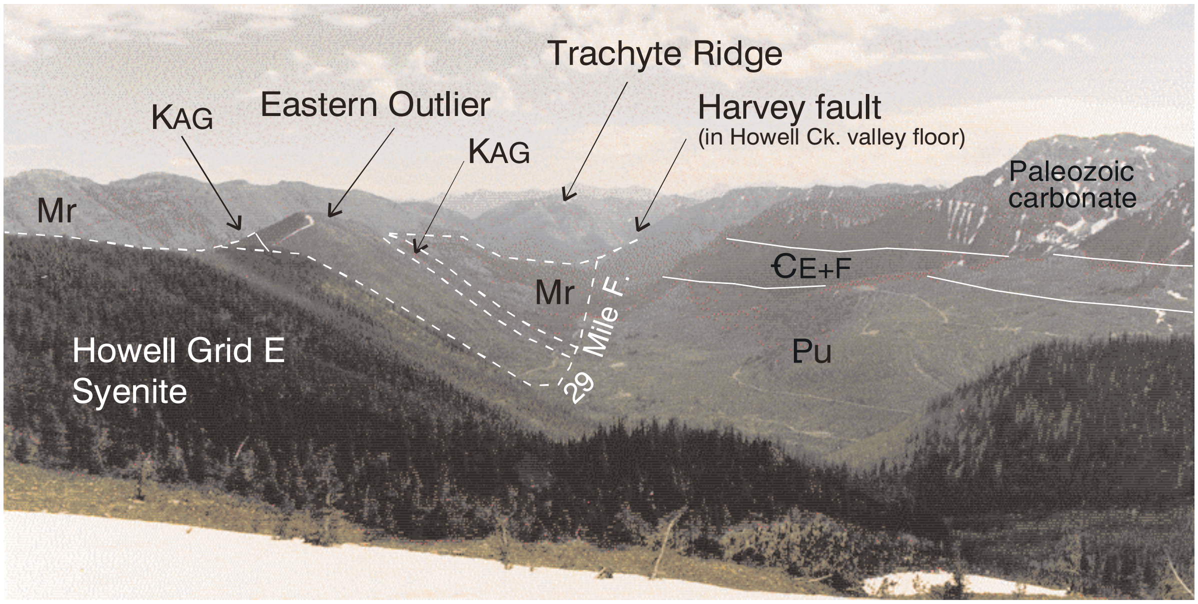


Plate 1. Overview looking east down Watluk and Twentynine Mile creeks to the southern portion of the Howell Creek Structure, the Eastern Outlier and Paleozoic carbonates to the south.

rocks of the Alberta Group occur within a fault-bounded window surrounded by Proterozoic to Mesozoic strata that have been intruded by bodies of Early Cretaceous syenite. The structural position of the Upper Cretaceous Alberta Group strata with respect to the regional Lewis Thrust fault is the subject of many studies and structural interpretations. The nature of the HCS is further complicated by the presence of two outliers of Proterozoic to Mesozoic rocks that structurally overlie the Alberta Group within the window.

GEOLOGY OF THE HOWELL CREEK STRUCTURE

Stratigraphy

Detailed descriptions of the regional stratigraphy are presented in Price (1962, 1965) and are summarized on Figure 2. The oldest unit exposed is the upper part of the Proterozoic Purcell Supergroup including the Gateway, Phillips and Roosville formations. These units are exposed south and west of Twentynine Mile Creek and within the Western and Eastern Outliers. More extensive Purcell Supergroup exposures lie to the west in the Galton Range and to the east in the Clark Range (Figure 2).

The Paleozoic sequence in the HCS includes the Cambrian Flathead Formation quartz arenite, the transitional Elko Formation green shale and carbonate, massive middle to upper Paleozoic carbonate sequences, and ridge-forming dolomitic sandstone units of the Rocky Mountain Group. A single occurrence of Triassic Spray River Group siltstone with thin coal beds is present in the footwall of the Howell Creek fault.

Recessive weathering and poorly exposed Upper Cretaceous Alberta Group occupies the core of the HCS. The Alberta Group comprises fissile dark grey shale, siltstone (Plate 2), and minor quartz arenite. Lesser pebbly grit contains abundant dark coloured chert clasts and local clasts of alkalic intrusive rocks. Belly River Formation sandstone overlies the Alberta Group (Figure 2).

Flathead Intrusions

Intrusive rocks are commonly exposed in the valleys of Twentynine Mile Creek and Howell Creek and on Trachyte Ridge with a few outlying bodies in the Clark Range and on Shepp Creek to the east and north. Intrusions vary from equant stocks and plugs, ranging from 100 to >1200 m in diameter, to small irregular dikes and sills. The emplacement depth of the intrusions was relatively shallow, 3 to 5 kilometres, based on the minimum stratigraphic interval between the uppermost syenite at Shepp Creek, where it intrudes the Triassic Spray River Group, to the extrusive equivalents of the syenites, the Crowsnest Formation.

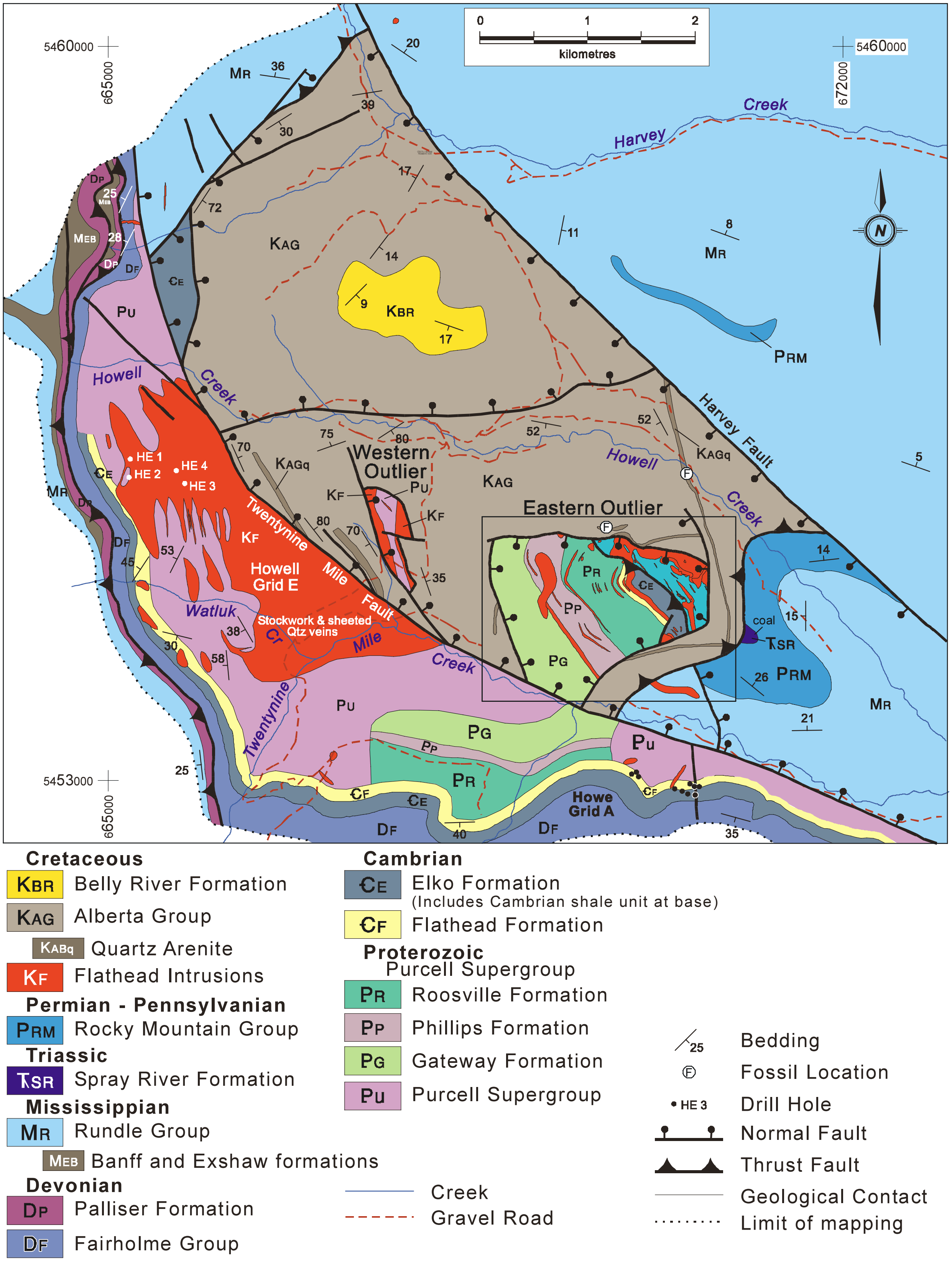


Figure 2. Geology of the Howell Creek structure and adjacent area (modified from Cameron *et al*. (unpub. map), Legun (1993) and Price (1965)).

Plate 2. View east to the sub-horizontal Mississippian Rundle Group on the northeast side of the Harvey Fault. Recessive Alberta Group shale and siltstone underlie the foreground within the Howell Creek Structure; the photograph illustrates the juxtaposition of these units. Inset: Typical Alberta Group, dark grey thin bedded siltstone exposure with prominent, widely-spaced limonitic concretions along a bedding plane.

The best age constraint for the Flathead intrusions comes from an unpublished U-Pb date of 98.5 ± 5 Ma from syenite collected from Trachyte Ridge (collected by Dave Grieve; reported in Skupinski and Legun, 1989). In addition, there are several conventional K-Ar dates that range from 72 to 119 Ma (in Treves *et al*., 1993): Rainy Ridge sill 119 Ma (whole rock) and 111 Ma (hornblende); Trachyte Ridge 67 - 105 Ma (Gordy and Edwards, 1962); and Sunkist Mountain 79 - 95 Ma.

The Flathead Intrusions are coeval and have similar chemistry to the Lower Cretaceous Crowsnest Formation exposed 28 km to the northeast in Alberta. The Crowsnest Formation comprises pyroclastic and volcaniclastic rocks and flows of trachyte and phonolite composition (Adair and Burwash, 1996; Peterson *et al*., 1997). Sanidine from these flows yielded a K-Ar age of 96 Ma (Folinsbee *et al*., 1957) and bentonites of the Viking Formation produce an average K-Ar age (biotite and sanidine) of 98 Ma (Tizzard and Lerbekmo, 1975). Fossil determinations also constrain the volcanics to the Albian (Norris *et al*., 1965).

Intrusive rocks of the HCS are subdivided into five types: syenite and alkali feldspar syenite, foid syenite, megacrystic syenite, gabbro and intrusive breccia (Figure 3). These divisions use the plutonic nomenclature of Le Maitre *et al*. (1989), and therefore differ somewhat from those proposed by previous authors. A total alkali - silica variation diagram (Figure 4) illustrates the alkaline affinity of the syenites and petrographic descriptions can be found in Skupinski and Legun (1989).

Syenite, Alkali Feldspar Syenite

Fresh exposures of syenite are rare; most are rusty weathering, limonite and jarosite(?) stained, irregularly fractured and recessive. They are commonly pyritized and argillically altered (i.e. clay and carbonate-altered). Fracture-controlled fluorite and quartz stockworks are common in the Howell Grid E area. The syenites are porphyritic with aligned potassium feldspar phenocrysts from 5 mm to 2 cm or more in length.

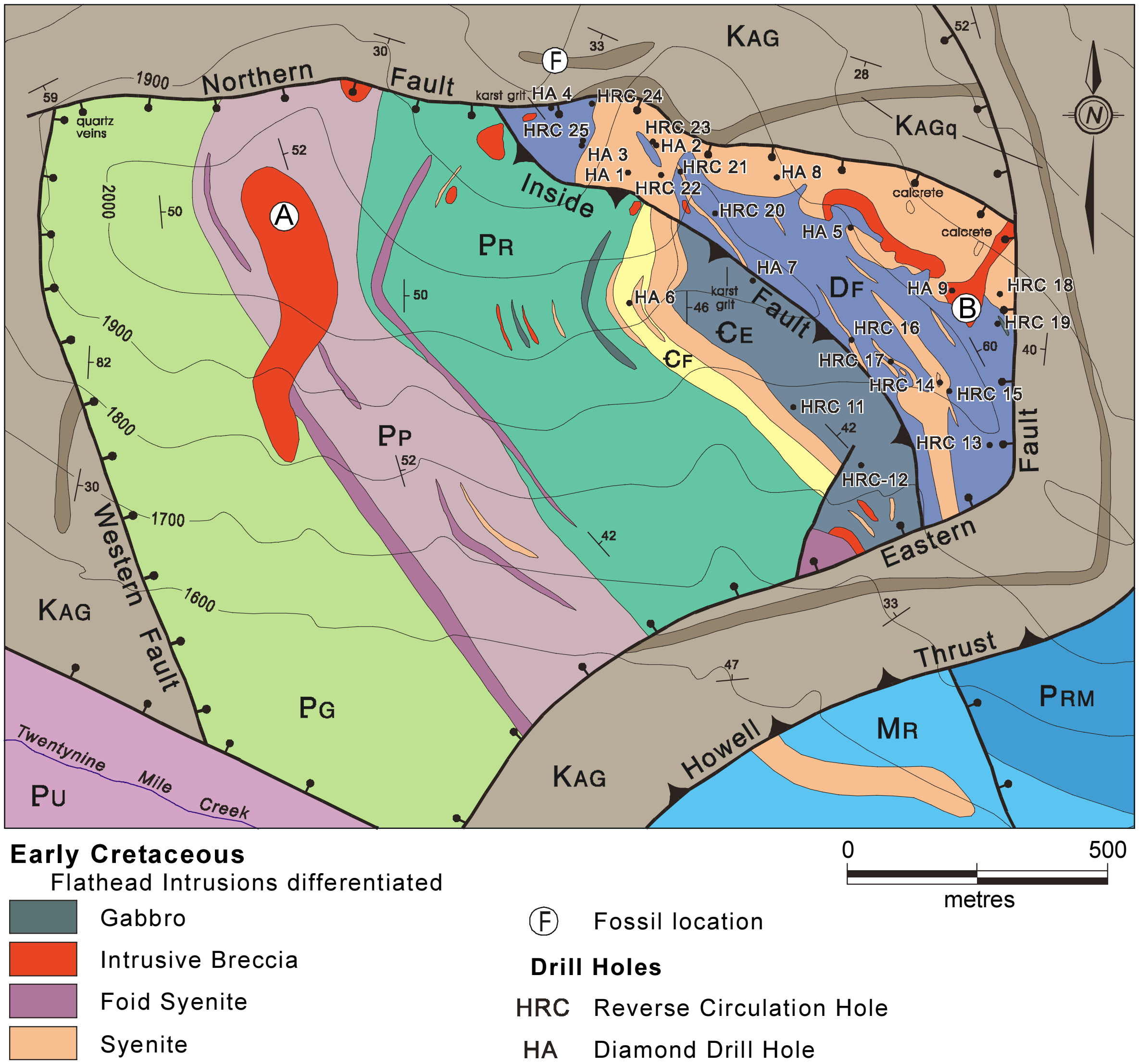


Figure 3. Detailed geology of the Eastern Outlier illustrating syenite and breccia distribution within the Proterozoic and Paleozoic strata (modified from Cameron *et al*. (unpub. map), and Legun (1993)). Drill hole locations are indicated. See Figure 2 for unit descriptions.

Foid Syenite

Foid syenite sills are characterized by a pale to dark green fresh surface with trachitoid texture defined by lath-shaped K-feldspar (1mm to 2 cm). Feldspathoids are present as equant subhedral crystals (1-5 mm, buff to red) that weather as recessive pits (Plate 3A and 3B). Analcime and nepheline have been positively identified (Skupinski and Legun, 1989) and nosean is suspected.

Megacrystic syenite

Megacrystic syenite comprises tan to grey, porphyritic syenite containing aligned orthoclase phenocrysts up to 7 cm in length (Plate 3C and 3D). Surface exposures are unaltered and the unit is observed crosscutting altered syenites.

Gabbro

Narrow sills of dark green to black gabbro are present on the Eastern Outlier and south of Twentynine Mile Creek and are volumetrically the least common intrusive rock. They are magnetic, display a felted texture and have a unique composition relative to the other syenite varieties, plotting in the alkali basalt (has normative nepheline), tephrite, and basaltic trachy-andesite fields of the total alkali vs. silica diagram (Figure 4).

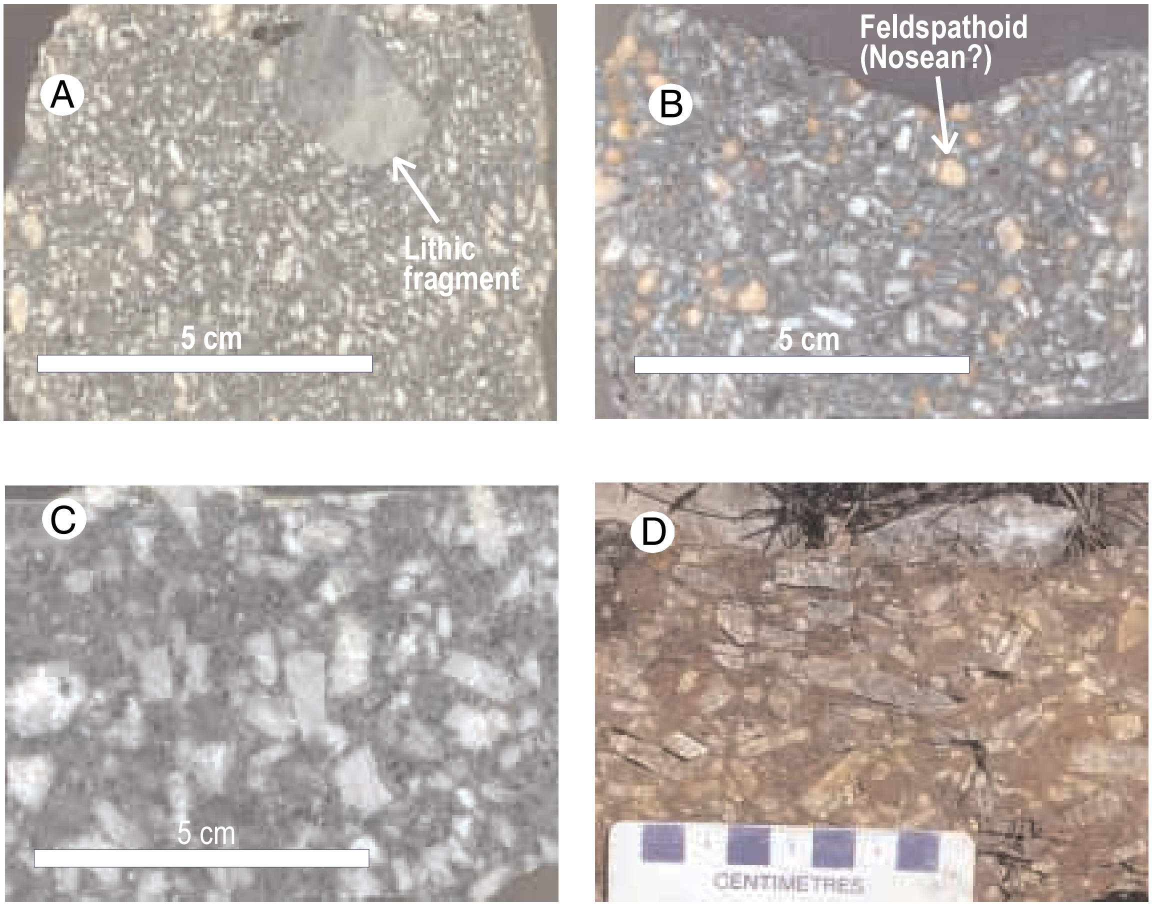


Plate 3. Syenite phases in and adjacent to the Howell Creek Structure: (A) Foid syenite from the Eastern Outlier with angular mudstone lithic fragment; (B) Foid syenite from Eastern Outlierwith equant, brown rimmed mineral (possibly nosean?). Fine dark specks are probably melanite garnet; (C) K-feldspar megacrystic syenite that cuts syenite on Howell Grid E; and (D) Tabular K-feldspar megacrystic syenite sill in the Eastern Outlier.

Intrusive breccias

Intrusive breccia bodies are common throughout the HCS. Discordant and crudely stratabound breccia bodies characterize the Eastern Outlier. The largest breccia body, about 1000 m by 300 m, cuts strata at an acute angle but becomes semi-concordant in the middle of the Phillips Formation, at higher elevations (Breccia A on Figure 3). This body contains angular to rounded clasts of porphyritic syenite, and grey limestone.

A large, irregularly shaped reddish-brown weathering breccia, located at the northeast corner of the Eastern Outlier (Breccia B on Figure 3), also changes from discordant to concordant at higher elevations. The breccia cuts syenite and then flares out parallel to bedding within Fairholme Formation limestone below a prominent syenite sill. The competent core of the Breccia B pipe is composed of angular syenite

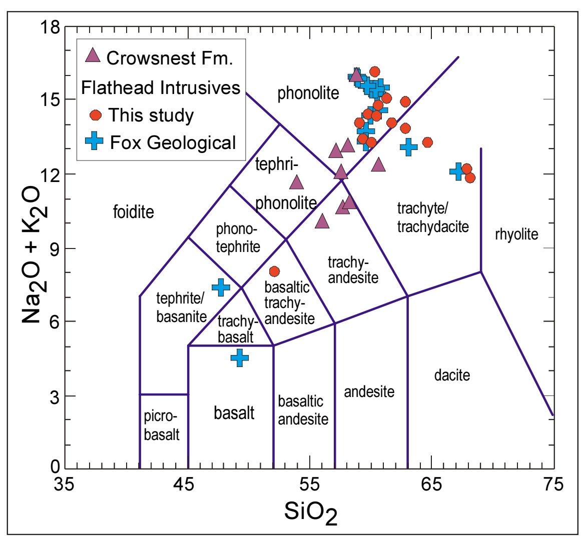


Figure 4. Total alkali versus silica variation diagram (after LeBas *et al*., 1986) displaying the alkaline character of the Flathead Intrusions and how they compare with Crowsnest Formation volcanic rocks (Crowsnest data from Peterson *et al*., 1997).

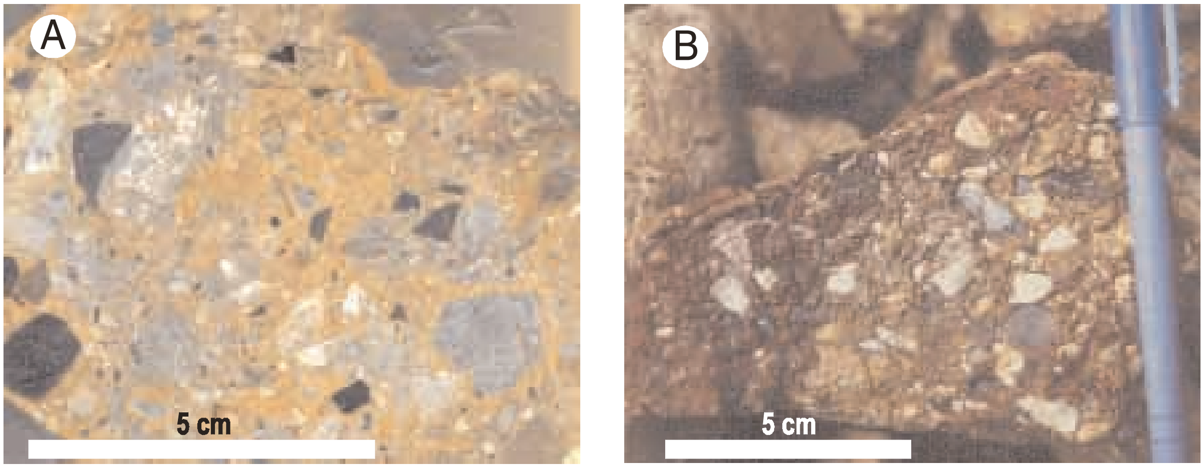


Plate 4. Examples of breccia types in Breccia B of the Eastern Outlier: (A) heterolithic intrusive breccia with angular, matrix-supported limestone and syenite fragments; (B) Discordant, limonitic weathering heterolithic breccia containing subangular limestone and lesser syenite fragments. Partially recessive matrix is carbonate-rich.

fragments within a feldspar crystal-rich matrix. Limestone fragments comprise less than 15% of this part of the breccia. This part of the breccia grades laterally and vertically into a heterolithic breccia with syenite, limestone, quartz arenite and siltstone fragments up to 30 cm (average 2-8 cm; Plate 4A). Peripheral to the main body is a hematitic weathering, limestone pebble breccia with a carbonate-rich matrix (Plate 4B). Adjacent country rock is fractured and locally crackle breccias have developed.

Structure

Detailed mapping of the HCS, in particular the Eastern Outlier, has documented the relationship between many of the bounding faults and the upper Cretaceous strata exposed in the core of the window. The current juxtaposition of units is attributed to high angle normal faults related to the Flathead Fault (Figure 1). The parallel eastern boundary fault of the Eastern Outlier and the Howell Thrust to the east could represent low angle structures.

ECONOMIC GEOLOGY

Gold mineralization related to the Flathead Intrusions has been an exploration focus in the area since 1983. Gold mineralization has been identified throughout this region defining a district scale mineralizing event. The sediment-hosted gold on the Eastern Outlier at Howell Creek is the focus of this paper. However, three other areas of mineralization are also briefly discussed: Syenite-hosted quartz stockwork/sheeted veins (Howell Grid E), Pb-Zn manto-style mineralization (Howe Grid A), and Syenite-hosted Au (Trachyte Ridge).

Sediment-hosted Au: Eastern Outlier

Gold mineralization within the Eastern Outlier was explored extensively by detailed soil and rock geochemical surveys, induced polarization surveys and three drill campaigns. Key elements of the occurrence are summarized below. The focus of work was the carbonate rocks exposed on the eastern end of the outlier. Here, various syenite and breccia bodies intrude limestone of the Elko and Fairholme formations. A prominent gold, arsenic, silver and antimony soil anomaly coincides with the extent of the carbonate rocks and guided early drilling. Drilling in reverse circulation drill hole HRC 25 (Figure 3), near a soil sample station that graded 1800 ppb gold, returned a 58 m intersection grading 1.3 g/t Au from pyritic silicified limestone. Results from additional drilling, over an area of 1300 m by 800 m, returned widespread elevated gold within both limestone and intrusive rocks.

Key elements of sediment-hosted gold occurrences in the Eastern Outlier:

- extensive pyritization of syenite and sedimentary rocks, including carbonate and siliciclastic units;

- carbonatization of syenite;
- rare barite/fluorite veining;
- patchy silicification of limestone;
- argillic alteration of limestone (green clay, illite), syenite-destruction of feldspars;
- high zinc zones- manto or pod-like bodies adjacent to sills but in limestone;
- late hydrothermal or Intrusive breccias; soil anomalies- Au, Ag, As, Sb, Mo, V, Pb, Zn;
- best result: 59 m of 1.3 g/t Au in HRC 25 from weakly silicified limestone.

Alteration

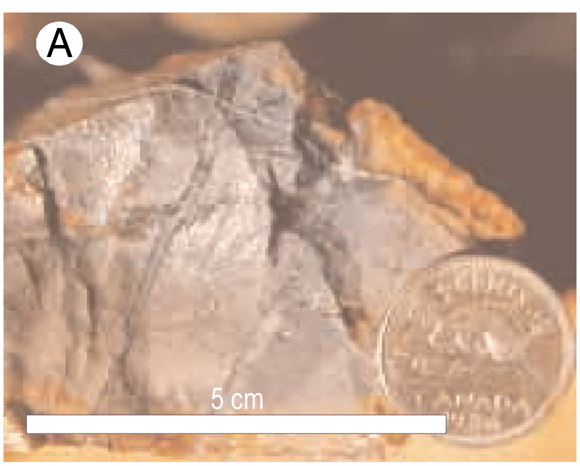
Alteration of bedrock in the Eastern Outlier is pervasive. All layered rocks are pyritized including carbonate and siliciclastic lithologies as well as all intrusive varieties except the foid syenite sills. Pyrite within the intrusions is fine to medium grained with local concentrations to several percent occurring as disseminated grains and masses and along fractures. Pyrite within carbonate lithologies is generally fine grained and is present as disseminations and fracture-controlled concentrations (Plate 5A). Intrusive rocks, dominantly the syenite variety, are carbonate-altered and effervesce with dilute hydrochloric acid. Weak silicification is evident within the carbonate rocks where a general light coloured bleaching is observed emanating from fine fractures (Plate 5A). Argillic alteration is present in intrusive rocks where feldspar has been variably altered to clay and carbonate. Clay species identified by PIMA short wave infrared analysis include illite and minor kaolinite with possible smectite (Thompson and Robitaille, 1998). Argillic alteration (illite) of carbonate host rocks imparts a pervasive pale green colour. Surface exposures of mineralized limestone are not visually distinct from unaltered varieties elsewhere.

Lithogeochemistry

Downhole lithogeochemistry for drill hole HA-3 is presented in Figure 5 and compiled in Table 1 (Figure 2 and 3 give drill hole locations). Elements were determined by ICP except for gold, which was determined by fire assay techniques. Results for some elements are partial and do not reflect total abundance. Gold correlates strongly with arsenic, antimony and tungsten and weakly with silver, vanadium and lead. A negative correlation with aluminum suggests gold mineralization is not introduced with argillic alteration. A silver to gold ratio between 6:1 (median) and 9:1 (average) exists for gold bearing rock containing greater than 200 ppb gold. These relationships hold true for both stream and soil geochemical results.

Syenite-hosted quartz stockwork/sheeted veins

A large syenite intrusion located west of the Twentynine Mile fault (Figure 2) and straddling the divide between Twentynine Mile and Howell



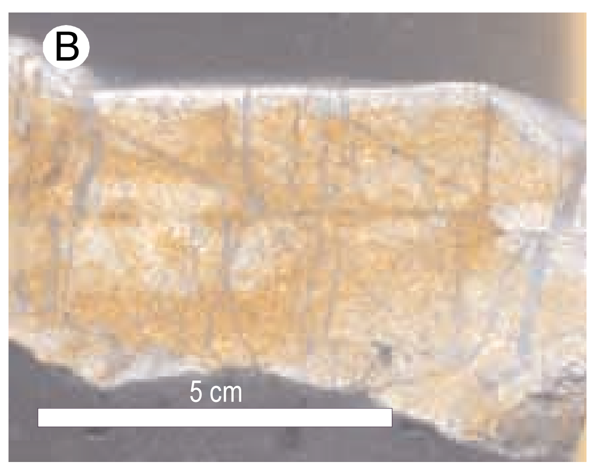


Plate 5. Examples of mineralized and altered rocks: (A) narrow quartz veinlets with partially silicified envelopes and very finely disseminated pyrite hosted in limestone; (B) Quartz stockwork developed in argillic-altered syenite offset by late fractures from Howell Grid E.

	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	
	Au	***Ag***	***As***	***Sb***	***Ba***	***V***	***W***	***Mo***	***Cu***	***Pb***	***Zn***	***Fe***	***Ca***	***Al***	***Ag/Au***
Mean	247	3.38	100.22	8.20	54.76	12.30	1.18	1.97	15.98	17.86	45.72	0.91	25.05	0.21	22.50
Median	153	1.50	85.00	5.00	39.00	11.00	1.00	1.00	12.00	14.00	42.00	0.90	25.49	0.12	7.41
Mode	340	0.10	29.00	2.00	13.00	8.00	1.00	1.00	9.00	11.00	42.00	0.89	27.69	0.06	12.50
Std. Dev.	327	6.70	72.27	7.44	65.85	8.25	0.82	3.62	14.83	11.36	25.72	0.46	7.74	0.26	70.89
Minimum	6	0.10	5.00	2.00	8.00	3.00	1.00	1.00	1.00	2.00	8.00	0.09	1.11	0.02	0.78
Maximum	2820	56.30	437.00	39.00	565.00	104.00	10.00	42.00	96.00	57.00	139.00	3.26	39.13	1.41	738.36
Count	181	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00

	Au	*Ag*	*As*	*Sb*	*Ba*	*V*	*W*	*Mo*	*Cu*	*Pb*	*Zn*	*Fe*	*Ca*	*Al*
Au	1.00													
Ag	0.18	1.00												
As	**0.49**	0.19	1.00											
Sb	**0.71**	**0.37**	**0.77**	1.00										
Ba	0.02	-0.05	-0.07	-0.06	1.00									
V	**0.27**	**0.29**	0.10	0.11	0.02	1.00								
W	**0.46**	0.03	0.17	**0.29**	-0.01	0.09	1.00							
Mo	-0.06	**0.53**	-0.02	-0.06	0.03	0.14	0.01	1.00						
Cu	0.18	**0.52**	0.18	**0.23**	-0.02	**0.44**	0.09	0.21	1.00					
Pb	**0.28**	0.18	**0.47**	**0.42**	-0.05	0.04	0.18	0.01	0.10	1.00				
Zn	0.06	0.02	**0.32**	0.20	0.09	0.08	0.08	0.04	0.03	**0.52**	1.00			
Fe	0.08	**0.24**	**0.55**	**0.37**	-0.10	**0.24**	0.19	0.21	**0.28**	**0.46**	**0.47**	1.00		
Ca	0.11	-0.20	-0.06	0.02	0.07	-0.17	-0.12	-0.17	-0.16	**-0.45**	**-0.35**	**-0.51**	1.00	
Al	**-0.25**	0.07	**-0.37**	-0.37	0.12	**0.26**	0.04	**0.50**	0.12	-0.10	0.17	0.19	**-0.37**	1.00

Table 1. Element abundance's and correlation matrix for carbonate-hosted gold mineralization in drill hole HA-3.

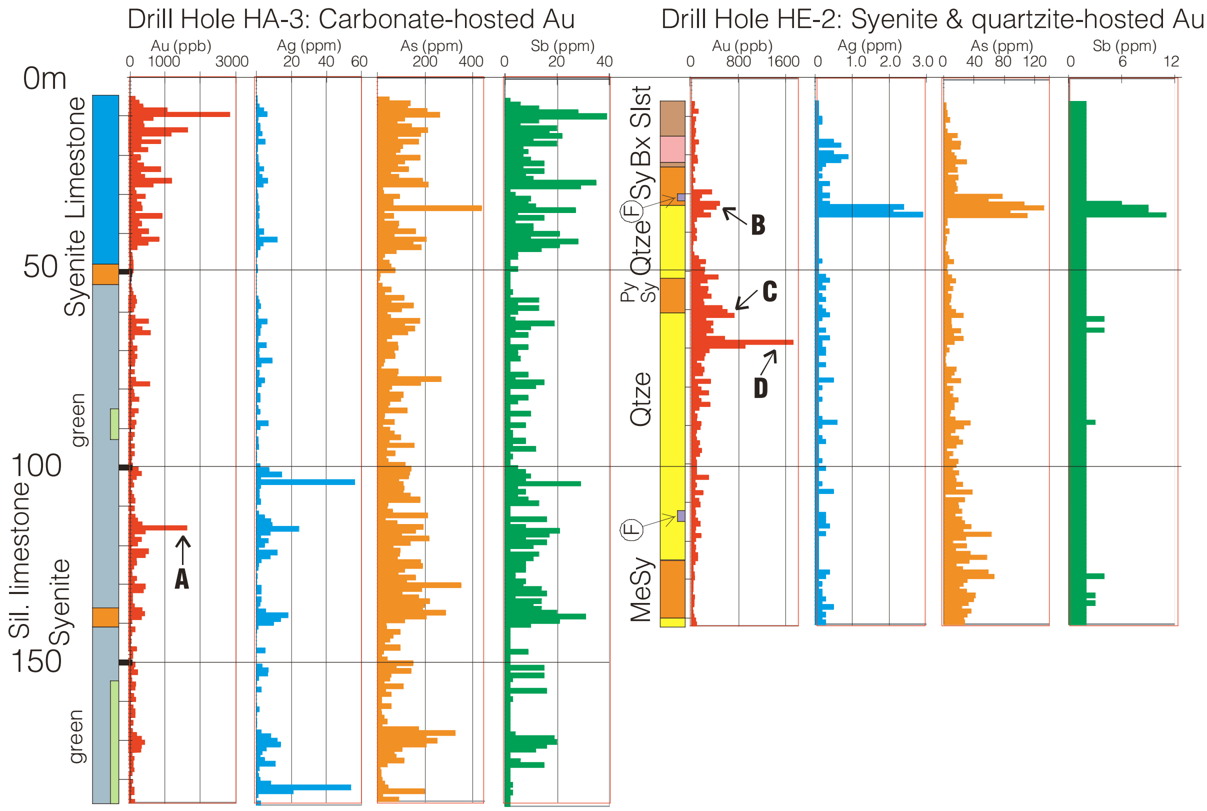


Figure 5. Comparison of downhole variations of Au, Ag, As and Sb values relative to lithology for a diamond drill hole from the Eastern Outlier (HA-3) and Howell Grid E (HE-2). One metre sample interval. The higher concentrations of As and Sb in carbonate units is clearly apparent. Lithologic detail for some of the anomalous gold intervals: (A) pyritic-clay gouge; (B) pyritized contact between syenite and quartzite and lesser crackle breccia; (C) bleached, clay-altered syenite adjacent to quartzite; (D) fluorite- and pyrite-rich quartzite. Abbreviations: Bx = breccia, F = fluorite, MeSy = megacrystic syenite, Sil = silicified, Slst = siltstone; Py = pyritic, Qtze = quartzite; Sy = syenite.

creeks hosts a large quartz stockwork. The stockwork is characterized by narrow, closely spaced quartz veins hosted by fine grained, bleached and argillically altered syenite, and megacrystic syenite. Silica forms stockworks and sheeted zones (Plate 5B), in which veinlets (<8 mm across) dominate with lesser large quartz veins up to 15 cm wide. The veins locally comprise up to 20% of rock volume. Elevated molybdenum in soils corresponds to the quartz stockwork zone.

The northwestern margin of the stock was the location of a four hole diamond drilling program designed to test a gold-in-soil geochemical anomaly associated with abundant fluorite veining within syenite (HE-1 to 4, Figure 2). On surface, the syenite is limonitic, rusty brown weathering with several zones of intense silicification. Drilling encountered silicified quartzite and siltite intruded by syenite, and minor dark purple fluorite-filled fractures (Figure 5).

Gold mineralization occurs within pyritic syenite and in the adjacent quartzite (Figure 5; HE-2) associated with fracture-controlled and disseminated fine-grained pyrite. Locally, pyritic gouge carries gold (for example HE-2, 219 ppb Au @ 65.5 m depth). Coarse pyrite crystals locally fill irregular fractures in quartzite of the Phillips Formation but this pyrite is barren.

Pb-Zn manto-style mineralization

Elevated Au, Pb and Zn values in soils occur in the Howe Grid A area, south of Twentynine Mile Creek (Figure 2). The area is underlain by siltite of the Roosville Formation, quartz arenite of the Flathead Formation, and the basal green shale of the Cambrian Shale Unit. In addition, replacement-type mineralization, comprising local irregular zones of sphalerite ± fluorite and minor malachite occur in coarse-grained limestone (marble) of the Elko Formation.

Syenite-hosted Au veins: Trachyte Ridge Area

A cluster of small to medium sized (up to 1200 m across) syenite stocks and dikes intrude Paleozoic carbonate and clastic rocks 12 km southeast of the HCS, in the Trachyte Ridge area (Figure 1). The Flathead Grid A prospect, just west of Howell Creek, is centred on the largest of these syenite bodies. Here, soil sampling outlined a large area of gold-arsenic-copper rich soils coincident with the stock and peripheral dikes. Narrow zones of pyritic quartz veins several centimetres in thickness returned tenors greater than 31 g/t Au.

The Flathead Grid B prospect (Figure 1) located at the south end of Trachyte Ridge comprises a long glacial dispersion train which contains cobbles to 20 centimetres in diameter of quartz-magnetite-pyrite vein fragments, locally with syenite breccia still attached. Gold grades of these cobbles are exceptionally high with gold contents more than 30 g/t Au being common. The highest gold grade obtained to date is 620 g/t Au. A limonitic quartz vein in limestone near the up-ice origin of the soil anomaly returned over 300 g/t Au. Higher gold grades are accompanied by elevated contents of tellurium.

Mineral Zoning

Observations of the wide variability of gold mineralization styles from several widely separated areas of the HCS suggest a district wide mineral and alteration zonation as summarized below.

Central Zone: large syenite plugs and intrusive breccias

- central porphyry Mo-like system-quartz stockwork in Howell Grid E;
- intense silicification of siliciclastic rocks, disseminated and vein fluorite common, extensive intrusive breccia development, local galena, sphalerite, chalcopyrite;
- extensive pyritization.

Peripheral Zone: small syenite bodies, foid syenite sills, intrusive breccias

- multiple generations and varieties of intrusive bodies;
- alteration dominated by carbonatization of intrusives, pyritization, moderate to weak silicification, argillization;
- widespread low-grade gold in limestone and intrusive.

Distal Zone: isolated small dikes, syenite and foid syenite (i.e. Howe Grid A)

- isolated and volumetrically minor dikes of syenite and foid syenite;
- minor pyritization, rare barite veining, disseminated gold in sandstone and silt stone and green shale;
- manto-style base metal mineralization-colloform sphalerite in limestone, fluorite and pyrobitumin in limestone.

SUMMARY AND DISCUSSION

The Cretaceous Flathead Intrusions lie east of more extensive, coeval calc-alkaline plutons and batholiths, perhaps occupying an extensional setting inboard of the main magmatic axis during the middle Cretaceous. This broad setting is similar to the Tombstone Intrusive Suite in the Yukon with their associated Fort Knox and Brewery Creek styles of gold mineralization. The latter is related to syenite intrusions and has many features in common with the mineralization related to the Flathead Intrusions.

Removing the 65 to 75 km of post-Albian eastward displacement on the Lewis Thrust (van der Velden and Cook, 1994) would restore the syenites to a position west of the present southern Rocky Mountain trench, in the vicinity of the extension of the Vulcan Low magnetic anomaly. This feature is interpreted to mark the suture between two Archean structural blocks (Ross *et al*., 1991), and would be an appropriate tectonic environment to localize alkalic intrusions.

Many features of the gold bearing mineralization within the HCS and surrounding area fall within the alkalic epithermal classification as described in Bonham (1988), Mutschler and Mooney (1993), and Richards and Kerrich (1993). Sillitoe (1993) prefers to categorize the alkalic epithermal class as a sub-type of the low-sulphidation epithermal deposits. The deposits of the Flathead region have also been described as alkalic intrusion-associated deposits in a continental setting by Schroeter and Cameron (1996). Similar but younger deposits can be found throughout Montana and South Dakota and include the Zortman and Landusky deposits (Wilson and Kaiser, 1988), the Golden Sunlight deposit and others within the central Montana Alkalic Province and deposits located in the Black Hills of South Dakota. Studies by Paterson (1990) and Paterson *et al*. (1989) of the Black Hills deposits describe fluids that are hotter and more saline than those attributed to typical epithermal deposits suggesting a regime transitional between mesothermal and epithermal environments.

Lefebure *et al*. (1999) describe key features of the sediment-hosted deposit type (i.e. Carlin-type) in an accompanying paper. The sediment-hosted mineralization of the HCS differs from the classic characteristics of the Carlin deposits in several respects including the direct and unequivocal association with intrusive rocks in the HCS deposits, the lack of mercury in the HCS and the higher silver to gold ratios. Whether this constitutes a fundamental difference between the deposit types is not clear.

CONCLUSIONS

This study has documented sediment-hosted gold occurrences in the Howell Creek Structure of southeastern British Columbia. The sediment-hosted mineralization is only part of a broader distribution of gold occurrences in the region related to syenite intrusions of Early Cretaceous age. The sediment-hosted occurrences are characterized by weak silicification of limestone accompanied by finely disseminated pyrite with an element association that includes arsenic, antimony, and silver. The occurrences do not directly compare with all features of the standard sediment-hosted or Carlin-type gold deposit model but enough similarities exist to warrant further study of the possible relationship.

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