



MINERAL PROPERTY EXAMINATIONS

SOUTHEAST BRITISH COLUMBIA

DIATREME BRECCIAS IN THE SOUTHERN ROCKY MOUNTAINS (82 G and J)

By D. A. Grieve

INTRODUCTION

Intrusive breccias in southeastern British Columbia are a relatively recent discovery. Hovdebo (1957) described the Crossing Creek diatreme (Fig. 32) found during work with a California Standard field party under the supervision of G.G.L. Henderson. The ultrabasic nature of the intrusion was not recognized at that time. G. B. Leech noted the locations of several diatreme breccias in the west half of map sheet 82J (Leech, 1964, 1965) and included their locations on his open file map of the area (Leech, 1979). A Cominco Ltd. exploration party became interested in the Crossing Creek intrusion in 1976. After tentative identification of the rock as a kimberlite, an ambitious exploration program was launched, which succeeded in discovering approximately 40 other diatremes (Roberts, *et al.*, 1980). Subsequent exploration by Cominco and others has turned up other similar intrusions.

The intrusions are dispersed sporadically along a north-south zone roughly 90 kilometres long and 20 kilometres wide. They are clustered in the drainages of the Bull River in the south and the White and Palliser Rivers in the north (Roberts, *et al.*, 1980). An exception is the Crossing Creek diatreme, which is in the drainage system of the Elk River, approximately 20 kilometres east of the centreline of the zone containing the other intrusions. Most of the diatremes are in rugged topography with limited or poor access, a factor which has contributed to their elusiveness.

REGIONAL SETTING

The diatremes are within the northwest-southeast-trending main and western ranges of the southern Rocky Mountains. This part of the Rockies is characterized by southwest-dipping thrust faults and associated folding and overfolding. The region is underlain by predominantly Cambrian through Permian carbonate and clastic sedimentary rocks. According to Roberts, *et al.* (1980) all except the Crossing Creek diatreme were intruded into Middle Devonian and older strata. The Crossing Creek diatreme lies within Permian rocks.

Other igneous rocks in the same zone include: the 'Bull River amygdaloid' (Leech, 1979), an intermediate or basic volcanic rock of unknown age; the 'White River diabasic sill complex, with associated breccia (diatremic) dykes' (Leech, 1979); and small intrusions of quartz monzonite, monzonite, and granodiorite (Leech, 1960). Alkalic igneous rocks are found outside the zone; these include the Ice River complex in Yoho National Park, and the alkalic Crownsnest volcanic and associated Howell Creek intrusive rocks, from the Crownsnest and Flathead regions respectively. The Ice River complex is Devonian and has been dated at

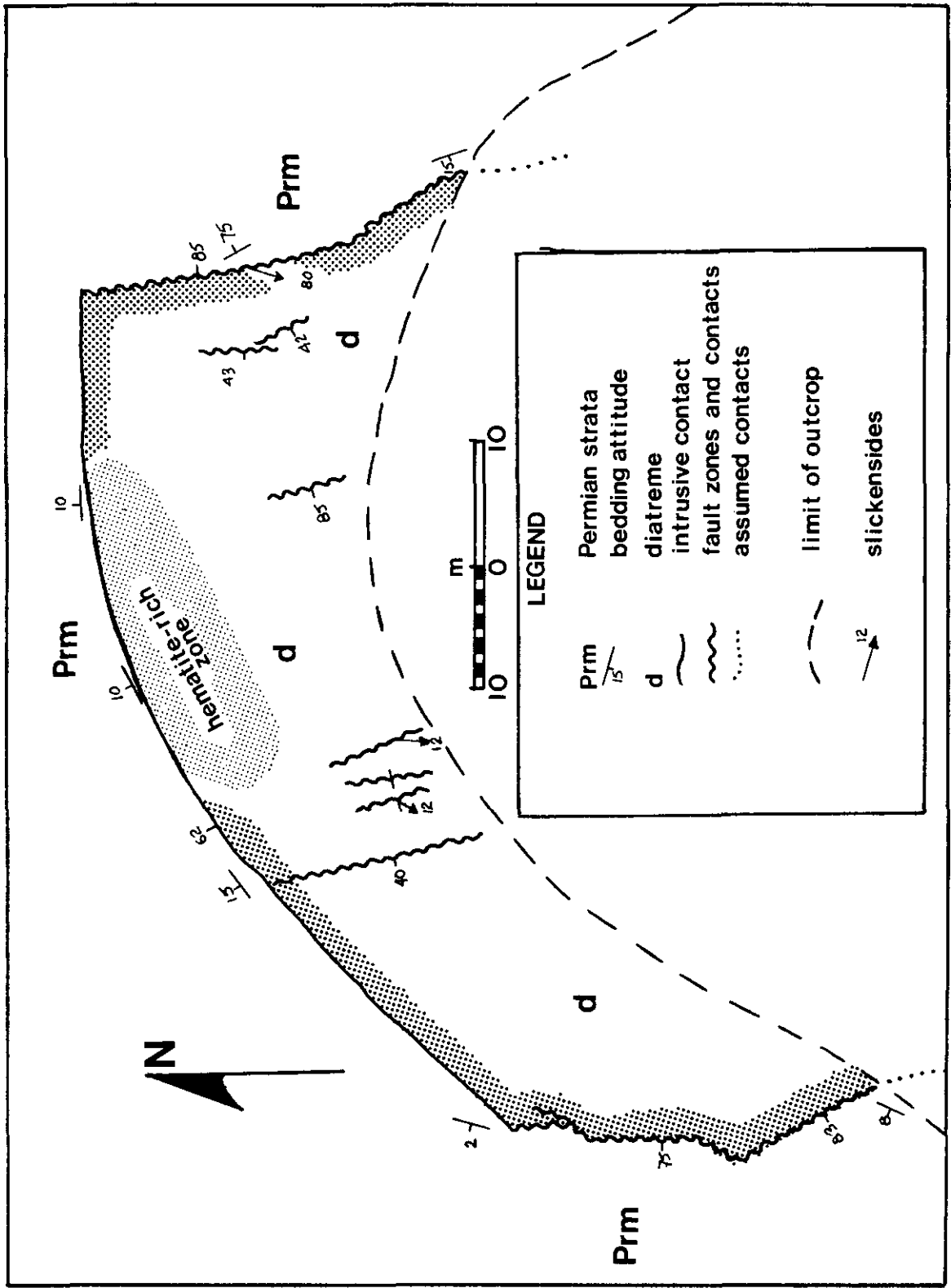


Figure 33. Geologic map of the Cross diatreme, NTS 82J (Prm = Permian Rocky Mountain Group).

between 327 and 390 Ma, while the Crowsnest and Howell Creek are of Late Cretaceous age (Currie, 1976; Gordy and Edwards, 1962).

The nearest known kimberlitic diatremes occur in north-central Montana (Hearn, 1968) and in the boundary area of Wyoming and Colorado (McCallum and Mabarak, 1976).

FIELD AND LABORATORY WORK

Diatremes at Crossing Creek, Quinn Creek, and Summer Creek were examined (Fig. 32) and geological mapping of the Crossing Creek exposure was carried out (Fig. 33). All three were sampled for petrography, geochemistry, X-ray diffraction, and age dating. Follow-up laboratory work has so far included minor thin-section analysis and X-ray diffraction and spectrographic analysis of a garnet crystal (at the British Columbia Ministry of Energy, Mines and Petroleum Resources laboratory in Victoria). A potassium-argon age date on phlogopite samples from Crossing Creek has been obtained from the Department of Geological Sciences at the University of British Columbia.

CROSSING CREEK (CROSS) DIATREME

The Cross diatreme is located at 2 200 metres elevation on the steep south-facing slope on the north side of the Crossing Creek valley, 8 kilometres northwest of Elkford (Fig. 32). It may be reached via the Crossing Creek road and an old access road or by helicopter. A helicopter landing pad has been constructed at the exposure.

The outcrop of the Cross diatreme is approximately 70 metres by 60 metres (Fig. 33). The trace of the diatreme downward into Crossing Creek has been mapped by Cominco geologists (Pighin, 1980, personal communication), although below the exposure described here only highly weathered material can be found.

The shape of the intrusion is pipe like, and steep-dipping contacts with the host limestones, cherts, and black shales of the Permian Rocky Mountain Group are well exposed (Fig. 33). Strata adjacent to the western and northern contacts are nearly flat lying and undisturbed, whereas the eastern contact is marked by a vertical zone of highly contorted and sheared strata (Fig. 33). Numerous slickensided shear zones occur within the exposure; most are subparallel to the contacts. These zones often mark the contact between different lithologies within the intrusion. No thermal metamorphic effects are evident adjacent to the contacts.

Based on field observation, the outcrop is composed of at least three distinct lithologies. The spatial relationship of these lithologies was not mapped in detail, with the exception of the hematite-rich zone in the upper portion of the outcrop (Fig. 33). This latter zone is characterized by visible phlogopite, altered olivine, hematite, and calcite, in a dark bluish green calcareous groundmass. Xenoliths are generally small (up to 5 centimetres), well rounded to subangular, and include limestone, argillite, and serpentized ultrabasic material.

A second lithology occurs at the western portion of the outcrop and in sheared zones. It consists of xenoliths up to 2 metres in diameter and hematite pods up to 2 centimetres in diameter, in a pale green friable and earthy groundmass; apparently it represents severe weathering of intrusive material. Xenoliths consist of sedimentary and ultrabasic material, including limestone, chert, argillite, serpentized ultrabasic

material, relatively fresh peridotite, and ultrabasic breccia. The last is identical to portions of the diatrema. Xenoliths tend to weather out of the groundmass, and generally have rounded and polished surfaces.

A third gross lithology, found generally in the central portions of the outcrop, includes massive dark green calcareous groundmass with phenocrysts (<5 millimetres) of phlogopite, altered olivine, calcite, green chrome diopside, and rare red-brown garnet. Rounded xenoliths of sedimentary and ultrabasic material (up to 15 centimetres in diameter) are identical in composition to those described previously. A variation of this lithology is a rock which has a massive black groundmass with 1 to 2-millimetre phenocrysts in which xenoliths are less than 1 centimetre in diameter.

Fibrous calcite is common within shear zones, where it coats fractures.

A thin section of a sample from the hematite-rich zone shows a fine groundmass of carbonate, serpentine, phlogopite, hematite, and other opaques, with xenocrysts and/or phenocrysts of carbonate, phlogopite, serpentine, hematite, and rare pyroxene. Xenoliths include: serpentized ultrabasic rocks with relict mosaic textures; material identical to surrounding groundmass; carbonate rock; and altered garnet-bearing ultrabasic rocks (peridotite ?) with garnet, serpentine, chlorite, phlogopite, spinel, and opaques. Reaction rims occur with many of the xenoliths and are composed of combinations of serpentine, carbonate, chlorite, and mica. In certain portions of the section, hematite appears to have replaced the entire groundmass assemblage. Microveins of serpentine and carbonate are also present.

A garnet crystal was determined, by X-ray diffraction, to be of composition: pyrope (65 per cent); almandine (15 per cent); and grossular and uvarovite (20 per cent). Chrome content of the same crystal was determined as greater than 2 per cent by semiquantitative spectrographic analysis.

A spurious age of 595 ± 15 Ma was obtained by potassium-argon method on a phlogopite concentrate. This age apparently reflects the gas-assimilating capabilities of phlogopite, and the gas-rich nature of kimberlite magma (McCallum and Mabarak, 1976), which have resulted in anomalously high argon contents.

QUINN CREEK (QUINN) DIATREME

The Quinn diatrema is located at 2 030 metres elevation on the east-facing slope near the head of a small tributary of Quinn Creek, 60 kilometres northeast of Cranbrook (Fig. 32). The diatrema is clearly visible from a trail which follows the east side of the tributary.

The diatrema is exposed over an elevation change of at least 70 metres. It is pipe like in nature and cuts the country rock. Host carbonates of the Ordovician-Silurian Beaverfoot-Brisco Formation (Leech, 1960) dip shallowly to the northwest, whereas the intrusive contact plunges steeply to the southwest. As was the case with the Cross diatrema, there is no evidence of thermal metamorphism along the contact.

The Quinn diatrema is a pale grey-green breccia, with generally small (up to 5-centimetre) clasts. Xenoliths are generally well rounded and consist of limestone, argillite, quartzite, granitic intrusive rocks, and, rarely, altered ultrabasic rocks. Phenocrysts or xenocrysts of olivine and spinel up to 5 millimetres were also noted. The matrix is calcareous, and calcite veining is common throughout.

The relatively coarse diatreme breccia is cut by a pale green, fine breccia dyke, with sharp sinuous contacts. The dyke averages 1 or 2 metres in width and can be traced over much of the exposure. It is calcareous and contains well-rounded fragments of argillite, carbonate, and quartzite.

A thin section of the coarser breccia includes rounded to angular quartz and feldspar grains, devitrified fine to vesicular volcanic fragments, carbonate, argillaceous material, and serpentine, set in a fine carbonatized groundmass. A section of the fine breccia dyke contains subrounded grains of altered plagioclase (composition approximately An_{60}), carbonate, and serpentine, with only a small amount of highly altered fine-grained matrix.

SUMMER CREEK (SUMMER 1) DIATREME

The Summer 1 diatreme is one of two small intrusive bodies found adjacent to Galbraith Creek logging road, at the intersection of Galbraith and Summer Creeks, 40 kilometres northeast of Cranbrook (Fig. 32). It is at approximately 1340 metres elevation and is readily identifiable because it weathers red brown and forms a 50-metre-high resistant knoll. Limestone outcrops on top of the knoll imply that the cap of the intrusion is preserved. Host rocks were mapped as Upper Cambrian McKay Group by Leech (1960) and include thin-bedded and argillaceous limestones.

The Summer 1 diatreme does not obviously crosscut the host strata, but a distinct foliation within the intrusion parallel to one exposure of the contact dips steeply southeast, compared with a 30-degree northeast dip on the limestone.

The diatreme is a breccia throughout. The coarsest fragments are angular limestone clasts up to 70 centimetres in length adjacent to the contact. Other portions of the intrusion consist of coarse or fine breccia with subangular to well-rounded fragments in a medium grey calcareous matrix. Xenoliths are of limestone, quartzite, argillite, granitic rocks, and rhyolite. Coarsely crystalline quartz and serpentine, believed to be xenocrysts, were also noted.

Petrographic analysis of one sample showed a completely carbonatized groundmass with patches of serpentine. Xenoliths include very fine-grained carbonatized volcanic fragments, carbonate, and serpentine-carbonate intergrowths.

Float samples from across Galbraith Creek, less than 250 metres east of the outcrop of the diatreme, contain distinctive green chrome diopside.

The smaller Summer 2 diatreme, located 1 kilometre to the west, is characterized by an abundance of phenocrysts and xenocrysts of altered chrome diopside and spinel, quartz, and calcite.

An intrusive hornblende porphyry crops out locally between the two diatremes.

DISCUSSION

The Cross, Quinn, and Summer 1 diatremes have certain features in common that may be typical of some or all the diatremes in the southern Rocky Mountains. All are apparently pipe-like intrusions discordant to bedding. All have fragmental and breccia textures, with well-rounded to subangular fragments. Xenoliths

in all cases include sedimentary rocks typical of the host and nearby Paleozoic rocks. None produced thermal metamorphic effects on the host rocks. All appear to have been carbonatized and serpentinized during intrusion.

The contrasts are fewer, at least in terms of field observation, but are definitely significant. The large quantity of ultrabasic xenoliths in the Cross diatreme is anomalous, along with the presence of phlogopite and chrome-rich pyrope-almandine garnet.

Another contrast is the apparently younger age of the Cross diatreme. Roberts, *et al.* (1980) state that a Middle Devonian conglomerate contains clasts of the intrusions and, based on the age of host rocks, postulate a pre-Middle Devonian age for all the diatremes except the Cross. As the Cross cuts Permian rocks, it must be at least 100 Ma younger than the others. Interestingly, kimberlites near the Wyoming-Colorado state line are believed to be of very Late Silurian or Early Devonian age (McCallum and Mabarak, 1976).

Cominco geologists have identified the Cross intrusion as a kimberlite (Roberts, *et al.*, 1980). The presence of pyrope-almandine garnet, chrome diopside, olivine, phlogopite, and calcite, minerals which typically occur in kimberlites along with the occurrence of xenoliths of garnet-bearing ultrabasic rocks tends to support this identification. Further petrography and geochemical analyses are needed to confirm this interpretation. The Cominco staff believes that the other diatremes are limburgites, not kimberlites (Pighin, 1980, personal communication). Limburgites have olivine or pyroxene in an ultrabasic and alkaline groundmass.

The lack of thermal effects along their contacts suggests the diatremes were intruded 'cold.' Partially solid conditions are evidenced by the rounded and polished xenoliths. The forcefulness of the Cross intrusion is suggested by the contorted bedding in sedimentary rocks adjacent to the eastern contact (Fig. 33).

An upper mantle source for the Cross diatreme is suggested due to the presence of garnet-bearing ultrabasic xenoliths and the occurrence of chrome-rich pyrope-almandine garnet and chrome-bearing diopside (see, for example, McCallum and Mabarak, 1976). A deep origin for other diatremes cannot be ruled out, especially given the presence of chrome diopside, olivine, and ultramafic nodules (Pighin, 1980, personal communication). Kimberlitic affinities cannot therefore be precluded.

Taken as a group, the diatremes of southeastern British Columbia reflect a tectonic control with a north-south orientation and therefore were intruded in zones of weakness not directly related to the tectonic control of the Rocky Mountains. It is interesting to note that diatremes in Colorado and Wyoming are also aligned in a rough north-south pattern (McCallum and Mabarak, 1976). An ancient north-south-trending, deep fault system in cratonic basement rocks underlying the Paleozoic platform-continental margin assemblage may account for the spatial orientation of the diatremes.

Further conclusions on classification and derivation of the diatreme breccias of the southern Rocky Mountains must await petrographic and geochemical analyses. The study will be extended to other properties in the future.

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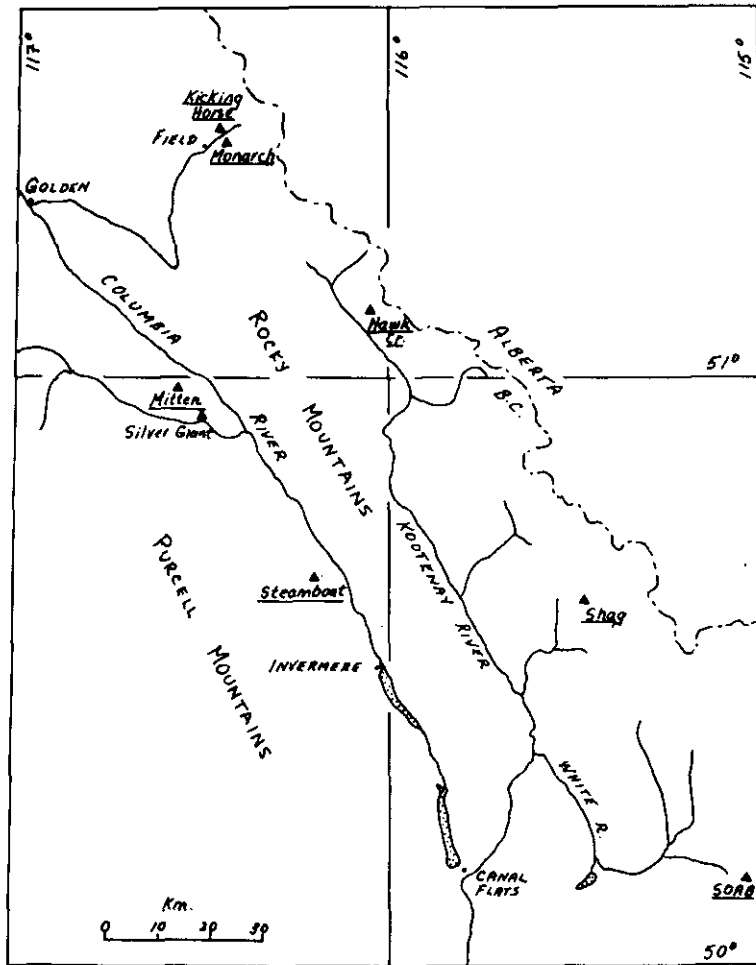


Figure 34. Location of Paleozoic lead-zinc deposits in southeastern British Columbia.

	Kootenay Arc	Steambot Mtn Jubilee Mountain	Western Shale facies	Monarch-Kicking Horse Shag
		McKay	McKay	Bison Creek Lyell
UE		Jubilee		Sullivan Waterfowl
ME	Nelway		Chancellor	Arctomys Pika Eldon Stephen Cathedral
LE	Laib Reno Quartzite Range	Eager Cranbrook		Mt Whyte Gog

Figure 35. Correlation of Middle Cambrian stratigraphy, southeastern British Columbia.

**LEAD-ZINC SHOWINGS IN CARBONATE ROCKS
SOUTHERN ROCKY MOUNTAINS
(82)**

By D. A. Grieve and Trygve Höy

INTRODUCTION

Carbonate rocks of the southern Rocky Mountains are often overlooked as potential host rocks for economic base metal deposits. However, numerous lead-zinc deposits and showings have been discovered over the years, the most significant of which is the Monarch – Kicking Horse (MI 82N-19, 20) at Field. Among the more recently discovered are the Shag (MI 82J/NW-2) and SOAB (MI 82J/SW-13) prospects, both of which were found as a result of reconnaissance geochemical exploration programs in the 1970's. These, and a number of other prospects, were visited in August 1980, in order to gain a general understanding of the type, distribution, and characteristics of Paleozoic lead-zinc deposits and to assess the potential for further exploration and discoveries.

The showings are within the foreland fold-and-thrust belt of the Cordillera and occur not only in the Rocky Mountains but also in the Rocky Mountain Trench. Although the structural style varies within the study area, northeast-directed thrust faults and associated folds and overfolds with northwest-southeast axes dominate.

The deposits, with the exception of the Hawk Creek showing (MI 82N-21), are in Middle to Upper Cambrian and Devonian platformal carbonates. The Monarch – Kicking Horse deposits occur in a thick succession of massive to thin-bedded limestone and dolomite of the Middle Cambrian Cathedral Formation. The Shag group was reported to be in the Cathedral Formation (Bending, 1978); however, it now appears that the host carbonate is part of the overlying Pika and Eldon Formations (Bending, 1980, personal communication). Steamboat (MI 82K/NE-65) and Mitten occur in carbonate of the Middle to Upper Cambrian Jubilee Formation within and along the western margin of the Rocky Mountain Trench. Hawk Creek is a vein deposit in limestone and shale of the Cambro-Ordovician Goodsir Group, and the SOAB prospect is in dolomite of the Palliser Formation.

Characteristically the Middle Cambrian deposits are in close proximity to carbonate bank margins. They have many features characteristic of the so-called Mississippi Valley-type deposits (Sangster, 1970). Monarch – Kicking Horse and Shag are in Middle Cambrian platformal carbonates just east of a transition to basinal shale and limestone of the Chancellor Group (Cook, 1970; Aitken, 1971). Deposits in the platformal Jubilee Formation are on an ancestral high, the Windermere, that was periodically emergent in Early Paleozoic time (Reesor, 1973).

DESCRIPTIONS OF DEPOSITS

MONARCH – KICKING HORSE (MI 82N-19, 20)

The Monarch – Kicking Horse deposits that occur in the steep cliffs on either side of the Kicking Horse River just east of the town of Field (Fig. 34) were described by Ney (1957) and Westervelt (1979). Their regional stratigraphic and tectonic setting was outlined by Cook (1970). Production from both deposits, from 1888 until their final closure in 1952, totalled 0.82 million tonnes containing 5.63 per cent lead, 8.85 per cent zinc, and 31 grams per tonne silver.