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HYDROTHERMAL ALTERATION AND BRECCIATION UNDERLYING THE ESKAY CREEK POLYMETALLIC MASSIVE SULPHIDE DEPOSIT (104B/9W)

By Art D. Ettlinger
Mineral Deposit Research Unit, The University of British Columbia

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INTRODUCTION

The Iskut River area of northwestern British Columbia (Figure 6-7-1) has been a centre of extensive mineral exploration activity since the discovery of the Eskay Creek polymetallic massive sulphide-gold deposit during late 1988. Since that time, over 650 diamond-drill holes in the 21A and 21B ore zones at Eskay Creek, have identified a geologic reserve in excess of 3 million ounces of gold and 125 million ounces of silver (Northern Miner, Jan. 28, 1991). This makes Eskay Creek one of the most significant exploration discoveries in western Canada in the past ten years.

Most of the exploration activity, including surface and underground diamond drilling and bulk sampling for metallurgical studies, has focused on the 21B zone which contains the bulk of quoted geologic reserves. The 21A zone (*see* Roth and Godwin 1992; this volume), which lies approximately 0.5 kilometre along strike to the southwest of the 21B zone (Figure 6-7-1), displays similar hydrothermal alteration and brecciation, but contains a trace element association enriched in mercury, antimony and arsenic that is not commonly observed in the 21B zone. Both zones are hosted by a similar lithologic sequence and occur at the same stratigraphic level. A distinct style of brecciation and hydrothermal alteration appears to be associated with spectacular gold assays on core from several mineralized intercepts in diamond-drill hole CA89-109 (Prime Capital Corporation, News Release #44, 21 Sept. 1989). Hole CA89-109 is located within the 21B zone, near the centre of the deposit (Figure 6-7-1).

The observations presented in this paper are the result of logging approximately 3800 metres of diamond-drill core from the 21A and 21B zones, and surface sampling followed by limited petrographic analysis. This work is part of an ongoing study of Iskut River metallogenesis by the Mineral Deposit Research Unit, The University of British Columbia. Further research at Eskay Creek will more completely address questions relating to the distribution and significance of the different alteration patterns and their relationship to gold-sulphide mineralization.

ESKAY CREEK GEOLOGY

The Eskay Creek deposit is situated within the Stikine Terrane on the eastern margin of the Coast Plutonic Complex. A framework for the geology of the Iskut River district has been established by researchers of the Geological Survey of Canada (Anderson, 1989; Anderson and Bevier, 1990; Anderson and Thorkelson, 1990) and the British Columbia Geological Survey Branch (Alldrick and Britton, 1988; Alldrick *et al.*, 1989, 1990). These workers place the hostrocks of the deposit within the Lower Jurassic Hazelton Group, a heterogeneous, bedded sequence of predominantly marine sedimentary and volcaniclastic rocks.

Early descriptions of the ore deposit and surrounding geology are given by Idziszek *et al.* (1990), Blackwell (1990), and Britton *et al.* (1990). The bulk of base metal sulphide and precious metal mineralization forming the 21 zone deposits is hosted by laminated, carbonaceous argillite and underlying rhyolite breccia (Britton *et al.* 1990). Stratiform sulphides in the "contact unit" (Blackwell, 1990), occur at the base of a flow-sill complex, informally known as the hangingwall andesite unit. The hangingwall sequence largely consists of fine-grained, medium-green pillowed flows, flow breccia and hyaloclastite. Sills, with chilled aphanitic contacts, are massive and commonly porphyritic. These submarine volcanic rocks contain numerous, discontinuous lenses of fossiliferous, laminated black argillite. Volcanic flow structures and mud infilling in underlying flow-top breccias indicate the sequence youngs upwards.

An unbedded, intensely altered accumulation of rhyolite and rhyolite breccia underlies the stratiform sulphides and is the host to stockwork and disseminated base metal sulphide and gold-silver mineralization (Blackwell, 1990). The rhyolite varies in thickness from 30 to 110 metres, averaging 80 metres (Britton *et al.*, 1990). Due to alteration, primary volcanic textures are rare. This felsic volcanic sequence, informally known as the footwall rhyolite (Blackwell, 1990), is underlain by dacitic ash and lapilli tuff, volcanic agglomerate and epiclastic rocks in excess of 100 metres thick. This sequence, referred to as the footwall dacite unit, is widely pyritic and locally contains base metal massive sulphides, but is not currently known to host economic gold-silver mineralization.

PRIMARY DEPOSITIONAL TEXTURES

Hydrothermal alteration and related brecciation have destroyed much of the original rock fabric and volcanic minerals within the footwall rhyolite. A volumetrically small amount of rock, displaying primary flow, pyroclastic or epiclastic textures, is preserved. Massive flow-banded rhyolite, autoclastic flow-breccia and heterolithic tuff-breccia are the most common volcanic features observed (Plate 6-7-1a, b, c). Most of the footwall consists of a mottled light grey, massive featureless rock which is very hard and intensely silicified (Plate 6-7-1d). It is uncertain

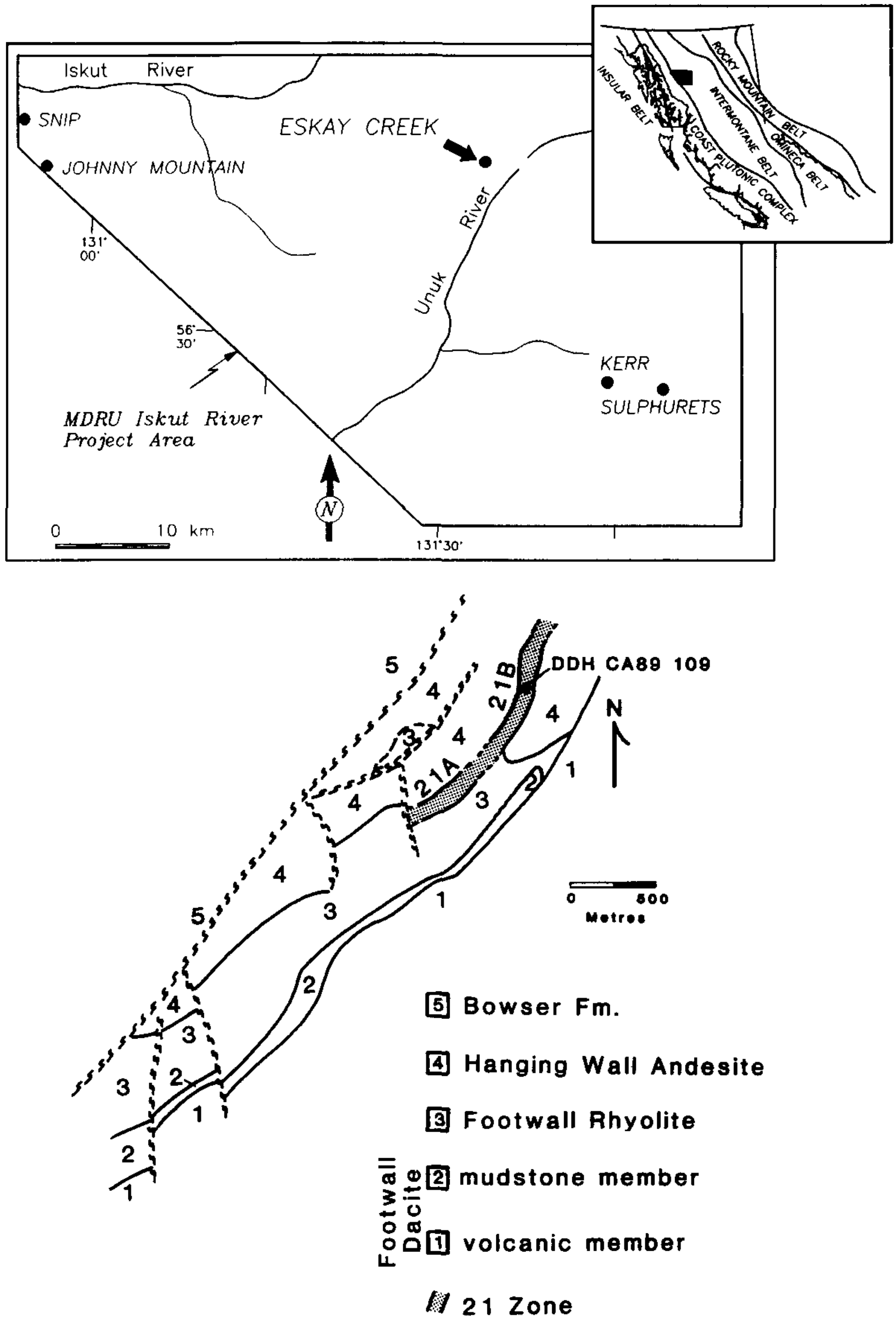

Figure 6-7-1. Location map and general geology of the Eskay Creek deposit.
Geology adapted from Rebagliati and Haslinger, 1991.

whether this facies represents original, massive silicic lava or some other intensely altered protolith.

FOOTWALL ALTERATION

Several styles of hydrothermal alteration and brecciation are present in the footwall beneath the Eskay Creek deposit. Silicification of the footwall rhyolite is intense and widespread, both immediately below, and extending away from the ore zones. Phyllosilicate alteration is in part related to silicification, with a second style limited to the area of massive sulphide mineralization. Fine-grained pyrite occurs with the silicification and phyllosilicate alteration. Solid hydrocarbons, scattered throughout all lithologies hosting 21-zone mineralization, appear most abundantly in the footwall rhyolite underlying the 21B zone.

Breccia textures are common in the footwall rhyolite. Brecciated rocks are present throughout the sequence, but they appear to be most abundant in the upper half of the rhyolite, underlying the contact argillite.

SILICIFICATION AND PHYLLOSILICATE ALTERATION

Quartz is by far the most abundant alteration mineral underlying the Eskay Creek deposit. Virtually all of the rhyolite underlying the 21 zone, as exposed in drill core and on the surface, is intensely silicified. In rare cases, an intense stockwork of millimetre-wide quartz veinlets is developed (Plate 6-7-2). In most of the footwall, however, quartz flooding results in a very hard, mottled grey rock, with little recognizable texture or fabric preserved (Plate 6-7-1d). The timing of silicification is uncertain; earliest silicification appears to be associated with brecciation (see below) and persists temporally through deposition of at least some of the sulphides.

At least two styles of phyllosilicate alteration are present. Petrographic analysis indicates sericite is a persistent component in silicified zones throughout the footwall. It commonly occurs with pyrite, forming a widespread quartz-sericite-pyrite alteration blanket underlying the 21 zone. Preliminary x-ray diffraction analysis indicates muscovite and illite are the major sericite components. Small amounts of phlogopite and clinochlore are also present.

A more intense phase of phyllosilicate alteration, resulting in a soft, highly incompetent rock, appears to be spatially related to semimassive and massive sulphide mineralization. Zones of intense, sheared sericite and dark green to black clinochlore (Blackwell, 1990) alteration are most abundant within the upper half of the footwall rhyolite, directly beneath the 21A and 21B zones. Scattered, disseminated sphalerite is generally associated with the clinochlore alteration.

ALTERATION BRECCIAS

Breccia textures are a common feature of the footwall rhyolite. Other than the volcaniclastic tuff breccias noted above, brecciation may also result from hydrothermal alteration of the rhyolite. The distribution and intensity of these "alteration breccias" are highly variable. These textures can be identified and distinguished from true pyroclastic rocks, by the following criteria:

- Fragments are monolithic with individual fragments appearing to be in-place. This results in a mosaic fabric to the rock.
- Fragments have highly irregular or finely scalloped margins, resorption textures or gradational boundaries with the breccia matrix.
- Fragments and unbrecciated hostrock, are cut by stockwork veinlets of similar composition to the enclosing matrix.
- Breccia distribution is highly irregular and discontinuous, making correlation between adjacent drill holes difficult or impossible.

Plate 6-7-3a and b illustrate the process by which the hydrothermal breccias form. As a precursor to actual breccia formation, massive, silicified rhyolite is cut by a stockwork of black, very hard veinlets which consist dominantly of black silica (Plate 6-7-3a). In some cases, migration of veinlet material into the wallrock along subparallel offshoots is observed. In areas of increased stockwork veining, discrete rhyolite fragments are formed, bounded on all sides by veinlet material (Plate 6-7-3b). At this early stage of breccia formation, individual fragments are commonly cut by veinlets of similar colour, hardness and texture as the matrix (Plate 6-7-3b).

Matrix-supported breccias represent completion of the brecciation process (Plate 6-7-4a, b). Plate 6-7-4a is an example of the mosaic fabric formed by clusters of fragments displaying jigsaw-like boundaries. Plate 6-7-4b shows the highly irregular, finely scalloped nature of fragment margins. Some of the larger fragments are surrounded by the faint outlines of smaller rhyolitic fragments, resulting in the appearance of a somewhat gradational boundary with the matrix. In each of these cases, the breccias are monolithic and adjacent fragments share similar characteristics of colour, hardness, texture and alteration. They appear continuous on a megascopic scale.

A distinct style of brecciation and subsequent silicification is observed in core from diamond-drill hole CA89-109, and surrounding drill holes. Both footwall and hangingwall rocks are fragmented, with individual fragments showing displacement or rotation. Within the footwall, rhyolitic and sulphide fragments are coated with white sparry quartz (Plate 6-7-5) which can be observed growing into open vugs now filled with black silica. This open-space filled texture appears to be unique to this part of the 21 zone.

PYROBITUMEN

Solid, relatively hard hydrocarbons, assumed to be pyrobitumen, occur throughout the Eskay Creek deposit. In most cases, the pyrobitumen is filling late fractures within both hangingwall and footwall units. It also occurs with quartz or carbonate and has a black, resinous lustre, commonly with a conchoidal fracture. Fractures filled with pyrobitumen are most common in silicified rhyolite underlying mineralization in the area of drill-hole CA89-109 (Plate 6-7-6).

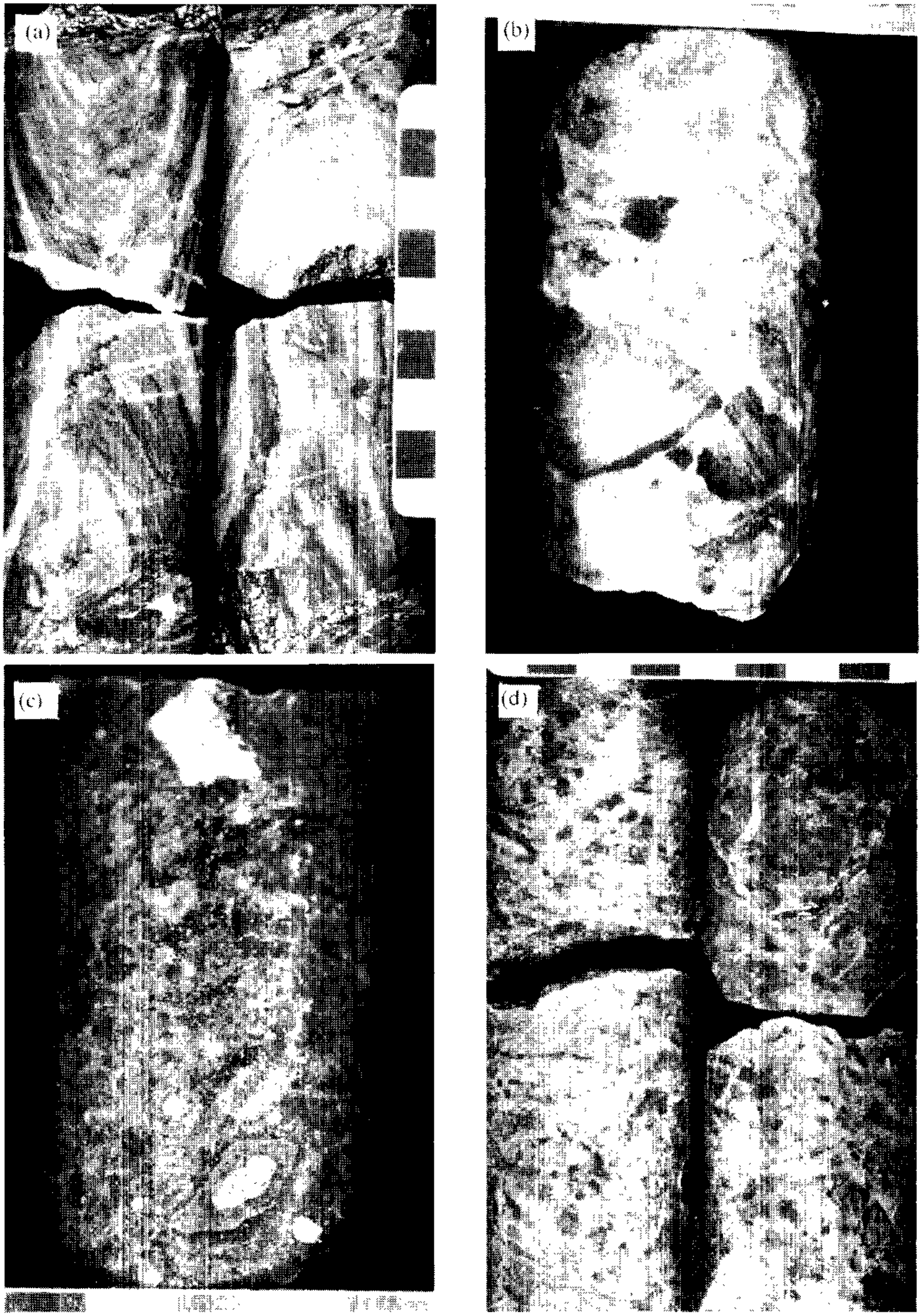

Plate 6-7-1. Primary depositional features observed in the footwall rhyolite. A. Massive flow-banded rhyolite, 21B zone (CA90-490-205.7). B. Autoclastic flow-breccia, note discordance in flow banding between individual fragments, 21B zone (CA90-273-156.6). C. Heterolithic tuff-breccia containing variably altered rhyolitic and exotic lithic fragments, 21B zone (CA90-345-184.2). D. Typical massive, featureless silicified rhyolite, 21B zone (CA90-271-140.6). NQ-size drill core in each photograph.

Petrographic analysis indicates pyrobitumen is a ubiquitous, finely disseminated phase in the hangingwall. In the footwall, it appears to coat sericite folia within the quartz-sericite-pyrite alteration zone beneath the deposit. Other habits include fine stringers associated with intensely silicified rhyolite, and coarse, broken clots in quartz-sulphide veins cutting footwall rhyolite. A wide range of reflectance values (R_0=0.81–13.98) indicates a variety of hydrocarbon maturity levels (Ettlinger and Roth, 1991).

DISCUSSION

The identification of primary volcanic textures in the footwall to sulphide-gold mineralization at Eskay Creek is complicated by intense hydrothermal alteration and related brecciation overprinting these rocks. Devitrification of felsic volcanic rocks can also result in the formation of breccia textures in rocks that were originally massive, relatively homogenous lavas. Allen (1988) describes several false pyroclastic textures found in silicic lavas hosting zinc-copper-lead massive sulphide deposits in the Benambra area of southeastern Australia. Pseudopyroclastic breccias con-

Plate 6-7-2. Closely spaced stockwork quartz veinlets in footwall rhyolite, 21A zone (CA90-273-152.6). NQ-size drill core.

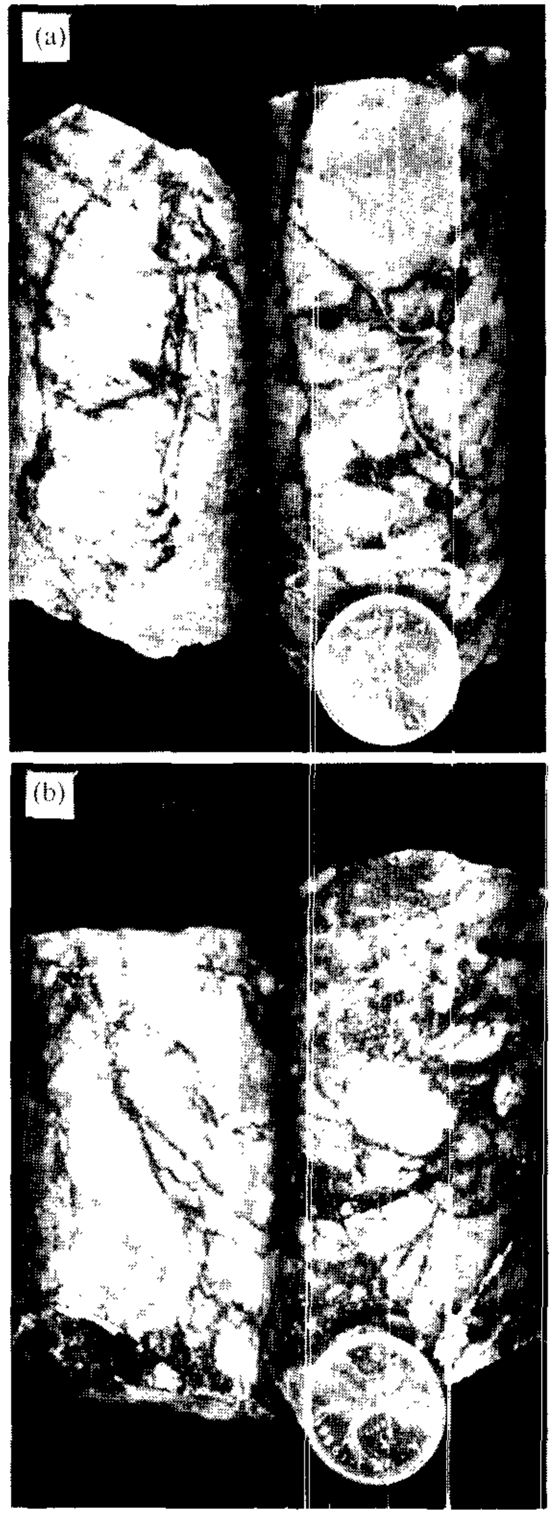

Plate 6-7-3. Early stages of hydrothermal veining and brecciation, 21B zone. A. Massive, silicified rhyolite is cut by stockwork veinlets of black silica. Top core piece also illustrates subparallel offshoots of veinlet material migrating into host rhyolite (CA90-216-121.7). B. Increased stockwork veinlet density results in formation of individual fragments, many containing veinlets of material similar in texture and composition to the matrix (CA90-421-95.6). NQ-size core.

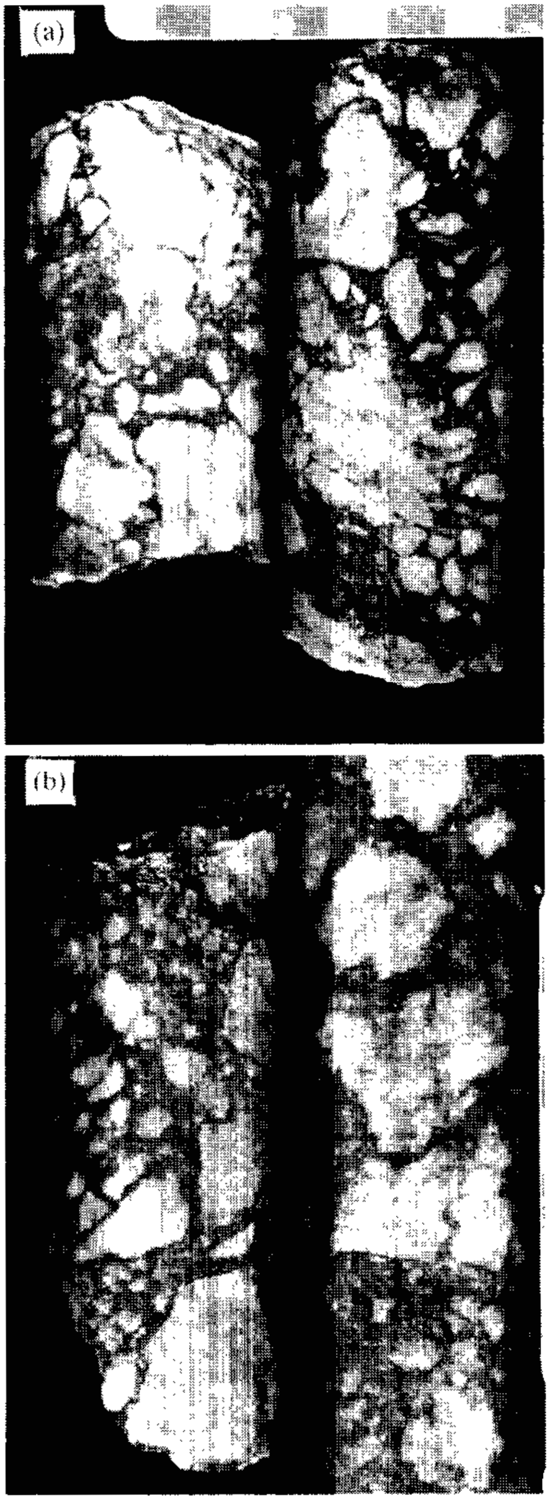

Plate 6-7-4. Matrix-supported breccia in footwall rhyolite representing advanced stages of hydrothermal alteration, 21B zone. A. Light-coloured rhyolite fragments displaying a jigsaw, mosaic fabric (CA90-437-174.4). B. Light-coloured rhyolite fragments display highly irregular, finely scalloped margins, sometimes gradational into the dark grey matrix (CA90-421-114.0). Both examples contain fragments cut by veinlets of matrix material. NQ-size drill core.

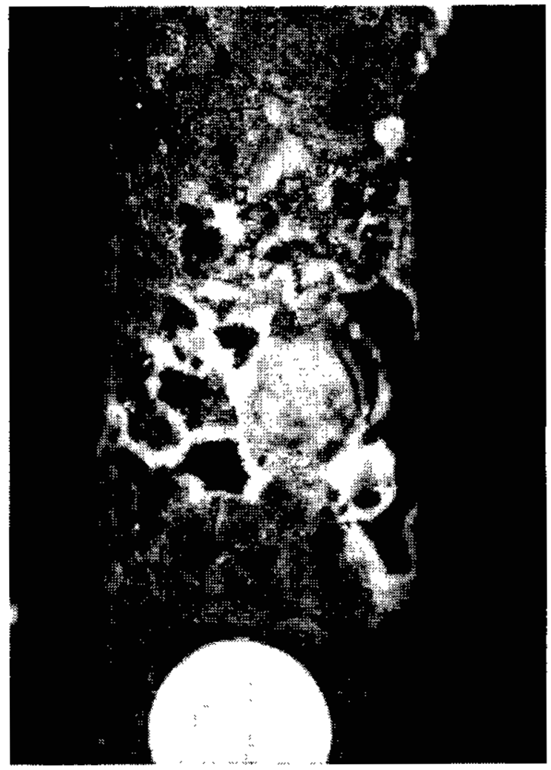

Plate 6-7-5. Footwall breccia, 109 area of 21B zone (CA90-424-173.4). White, sparry quartz coating fragments of rhyolite, sphalerite and pyrite. This quartz appears to grow into open vugs now filled with silica (black areas).

Plate 6-7-6. Pyrobitumen-filled fractures in footwall rhyolite. Diamond-drill hole CA90-627, 144 metres. NQ-size drill core.

taining apparent lithic or pumice fragments, and thinly bedded and lapilli tuffs are all shown to have formed through the process of devitrification and progressive hydrothermal alteration of mostly massive rhyolitic flows. The formation of these textures can result in misidentification of volcanic facies. Consequently, Allen suggests that the overall significance of explosive silicic volcanism in areas of volcanic-hosted massive sulphide deposits may have been over estimated.

The role devitrification processes have played in formation of the breccia textures observed at Eskay Creek is not yet known. The large amount of altered rhyolitic rock, and sporadic presence of perlitic cracks and spherulites observed in the footwall rhyolite, suggests that devitrification processes were in operation. There is, however, clear evidence that some of these breccias have formed through the process of replacement veining, where fragmental textures result from progressive replacement of the rock fabric along fractures. Unreplaced rock forms *in situ* remnant islands that resemble fragments. This is in contrast to the well known process of chemical brecciation (Sawkins, 1969) which results in hydrofracturing and generally outward movement of the fragments. Textures resulting from replacement veining are also described in skarn deposits (Ray *et al.*, 1988).

Recognition of the processes forming the footwall breccias at Eskay Creek is critical for the construction of a genetic model for this deposit. Recent descriptions of the 21B zone are characteristic of a volcanogenic massive sulphide model. The epithermal-style silicification and brecciation found in the vicinity of drill-hole CA89-109, however, suggests the classic volcanogenic model must be modified.

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