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Preliminary interpretations of mid-Jurassic volcanic and sedimentary facies in the east Telegraph Creek map area[1]

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Abstract: On the basis of regional-scale and reconnaissance mapping, strata similar in age and character to those hosting the Eskay Creek precious-metal-rich, volcanic-hosted massive sulphide deposit are considered to project northward into the east Telegraph Creek map area. Detailed volcanic- and sedimentary-facies mapping in that area in 2003 has identified a variety of subaqueous volcanic and sedimentary facies of probable Lower or Middle Jurassic age. Subaqueous volcaniclastic and nonvolcanic clastic rocks dominate the field area. Coherent volcanic and associated volcaniclastic facies occur in several areas and are considered to indicate proximity to volcanic centres. The presence of marine fossils, sediment gravity-flow deposits, and pillow basalt provide evidence for a submarine environment; the lack of shallow-water sedimentary structures indicate that the environment of deposition was below wave base.

Résumé : Si l'on se base sur des travaux de cartographie régionale et de reconnaissance, des strates d'âge et de nature semblables à celles dans lesquelles loge le gisement d'Eskay Creek, gisement de sulfures massifs riches en métaux précieux encaissé dans des roches volcaniques, se prolongeraient vers le nord dans la région cartographique de la partie est du ruisseau Telegraph. La cartographie détaillée des faciès volcaniques et sédimentaires dans cette région en 2003 a permis de reconnaître une gamme de faciès volcaniques et sédimentaires subaquatiques datant probablement du Jurassique inférieur ou moyen. Des roches volcanoclastiques et des roches clastiques non volcaniques subaquatiques prédominent dans la région à l'étude. Des faciès volcaniques cohérents et des faciès volcanoclastiques associés se rencontrent dans plusieurs secteurs et indiqueraient la proximité de centres volcaniques. La présence de fossiles marins, de dépôts de coulées gravitaires et de basaltes en coussins témoigne d'un milieu sous-marin; l'absence de structures sédimentaires d'eau peu profonde indique que le milieu de sédimentation se trouvait au-dessous du niveau de base des vagues.

[1] Contribution to the Targeted Geoscience Initiative (TGI) 2000–2003

INTRODUCTION

In 2003, a two-year collaborative project between the Geological Survey of Canada and the British Columbia Geological Survey was initiated in the Telegraph Creek and Iskut River map areas in northern British Columbia. The project focus is the upper Hazelton Group strata, which host the precious-metal-enriched Eskay Creek volcanic-hosted massive sulphide (VHMS) deposit. Targeted regional and detailed mapping and geochemical and geochronological studies aim to identify favourable stratigraphy for future exploration. Funding is provided by the Geological Survey of Canada's Targeted Geoscience Initiative and the Geological Survey Branch of the British Columbia Ministry of Energy and Mines. Related publications include Alldrick et al. (in press a, b).

This paper summarizes field characteristics of volcanic and sedimentary facies along a transect within the Hazelton Group rocks in the east Telegraph Creek area (NTS 104 G/8; Fig. 1, 2).

Figure 1. *Location map showing the study area. The areas covered by the Telegraph Creek (104 G) and Iskut River (104 B) 1:250 000 NTS map sheets are shown. Inset map shows in detail the location of the study area (rectangle) with respect to known geographic features.*

GEOLOGICAL SETTING

The field area is located within the Stikine Terrane in northern British Columbia (Fig. 1). This area was last mapped and described by Souther (1972). The Stikine Terrane includes upper Paleozoic metavolcanic and metasedimentary strata of the Stikine Assemblage; Upper Triassic volcanic-arc rocks of the Stuhini Group; Lower to lower Middle Jurassic island-arc and associated sedimentary rocks of the Hazelton Group; and sedimentary strata of the Middle Jurassic to Lower Cretaceous Bowser Lake Group.

This paper focuses on the Hazelton Group (units 13, 14, and 15 of Souther, 1972) within the Telegraph Creek map area. The stratigraphy of the Hazelton Group is complex and characterized by rapid lateral and vertical facies changes. Formations have been described and defined in the literature for specific areas within the Hazelton Group, but correlation of these formations between areas has been a source of confusion and debate. The reader is referred to Anderson and Thorkelson (1990), Anderson (1993), and MacDonald et al. (1996) for a more detailed discussion of the stratigraphy of the Hazelton Group in the Iskut River map area. The complex stratigraphy of the Hazelton Group in this region is typical of other subaqueous volcano-sedimentary successions that host VHMS mineralization (e.g. Mount Read Volcanics, Western Tasmania; Corbett, 1989, 1992; McPhie and Allen, 1992). Considering the reconnaissance nature of mapping in Hazelton Group rocks in the Telegraph Creek map area and the economic value of mineral deposits hosted by the Hazelton Group in the Iskut River area, regional mapping and detailed volcanic facies architecture studies will provide a valuable basis for mineral exploration in the area.

FACIES DESCRIPTIONS, DISTRIBUTION, AND ASSOCIATIONS

The following rock descriptions are specific to the units shown on cross-section A-A" (Fig. 3). Additional units shown on the summary map (Fig. 2) are not described. The volcanic and sedimentary facies have been organized into the following five principal mappable units: 1) plagioclase-phyric monomictic dacite–andesite breccia unit; 2) coarse sandstone to conglomerate unit; 3) felsic volcaniclastic and subordinate polymictic breccia and mudstone unit; 4) interbedded mudstone and sandstone unit; and 5) upper basalt unit. All descriptions and interpretations are based on field observations.

Plagioclase-phyric monomictic dacite–andesite breccia unit

This unit consists of one facies, a monomictic, poorly sorted, unbedded dacite breccia. Clasts are angular (5–100 cm), with coarse (up to 1 cm) plagioclase phenocrysts in a fine-grained, grey groundmass. The monomictic composition and angularity of clasts suggest a syneruptive origin.

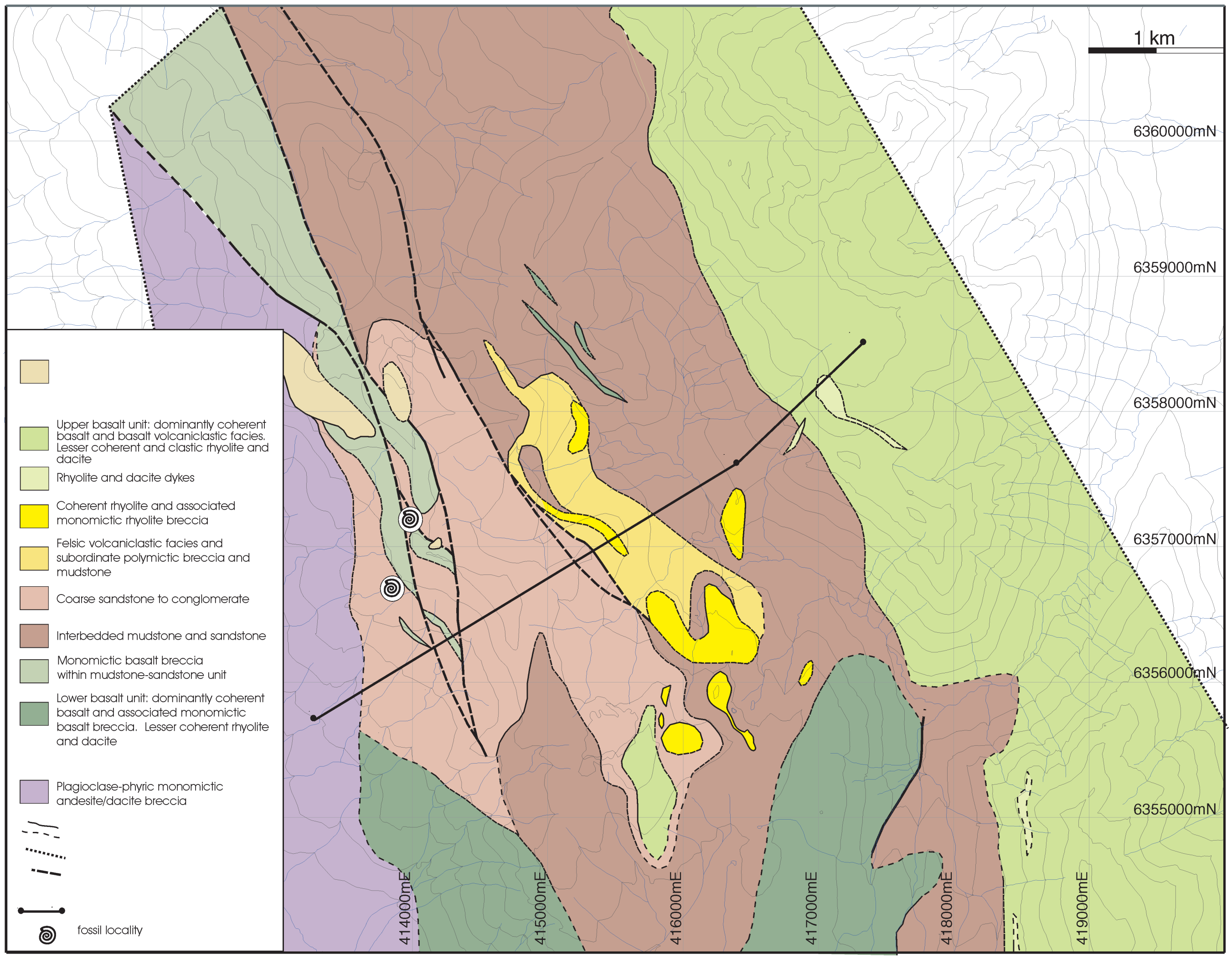


Figure 2. *Geology of the study area with the location of cross-section A-A".*

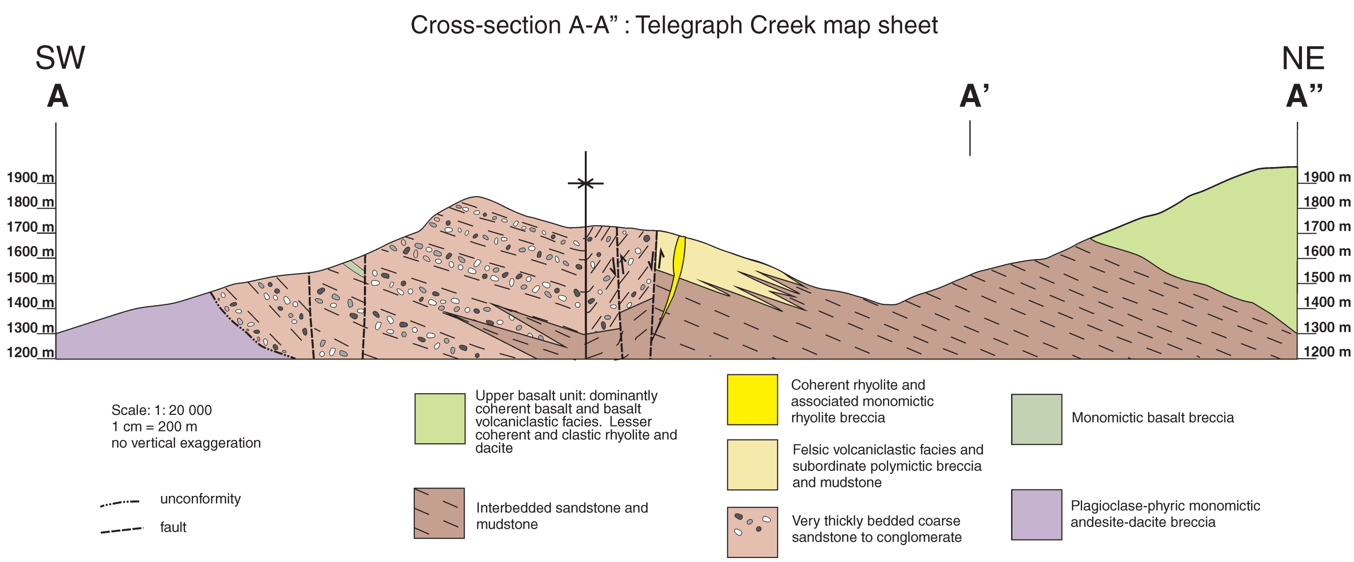
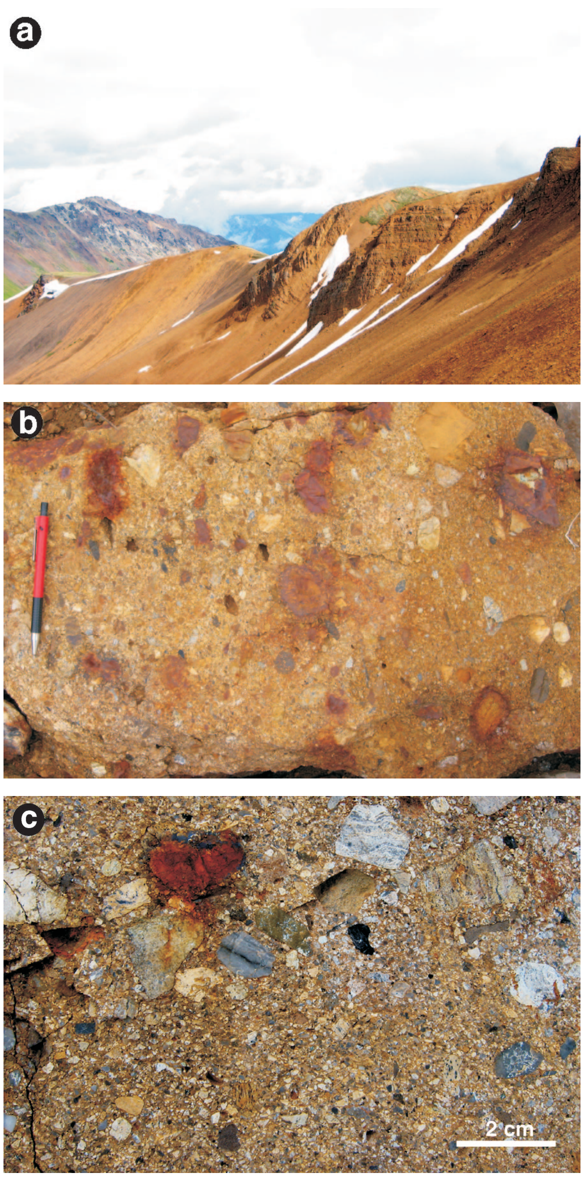


Figure 3. *Cross-section A-A" illustrating the structural complexities and stratigraphic relationships in the study area. The location of the cross-section is shown in Figure 2.*

Associated with the breccia are minor, discontinuous, poddy, apparently coherent domains that appear to be of the same composition as and are texturally identical to the clasts in the breccia. The two facies are interpreted to represent the coherent and brecciated (autoclastic) facies of a lava flow, dome, or shallow-level intrusion. The lack of jigsaw-fit textures in the breccia may indicate that the breccia was resedimented, which supports an extrusive versus intrusive emplacement interpretation. The basal contact was not observed and the upper contact is unconformably overlain by the coarse sandstone to conglomerate unit.

Coarse sandstone to conglomerate unit

This unit consists principally of thickly to very thickly bedded coarse sandstone to conglomerate (Fig. 4a, b, c). Within individual beds, it grades from conglomerate to coarse sandstone. In general, it is poorly sorted, clast to matrix supported with rounded to subangular clasts ranging in size from 1 mm up to 5 cm. Clast types include aphyric, flow-banded felsic clasts, black mudstone clasts, vesicular basalt clasts, pyrite-rich clasts, quartz fragments, minor bedded sandstone clasts, and minor limestone clasts. In places, the coarse sandstone to conglomerate unit is interbedded with monomictic basalt breccia (Fig. 4d), which is interpreted to be the autoclastic component of lava (hyaloclastite breccia).



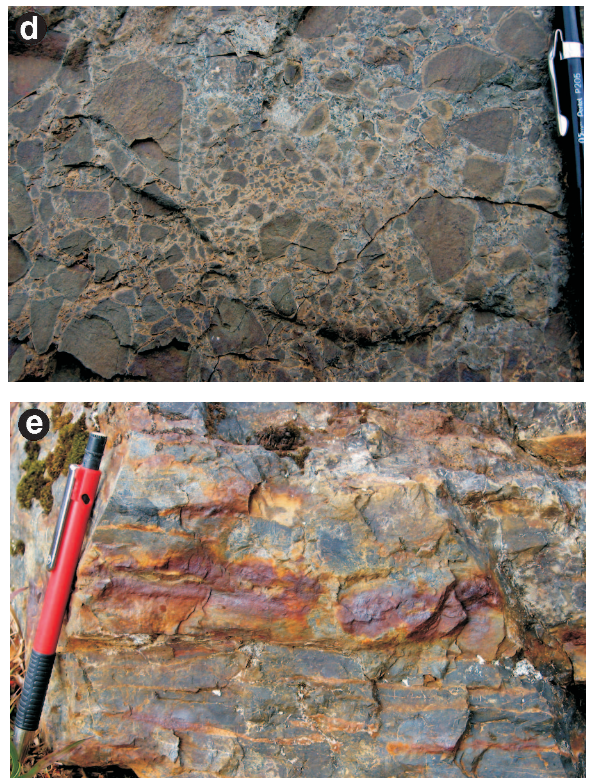


Figure 4. a*) View to the east-southeast looking toward a ridge of very thickly bedded coarse sandstone and conglomerate. The syncline shown on cross-section A-A" is in the centre of the photograph.* ***b****) Typical example of poorly sorted conglomerate within the coarse sandstone and conglomerate unit. Rusty-coloured, sulphide-rich clasts are a significant component of this unit.* ***c****) Close-up of a pebble-rich bed within very coarse to coarse sandstone.* ***d****) Monomictic basalt breccia with angular blocky clasts. Some clast margins are curviplanar, which is consistent with quench fragmentation. This unit is interbedded with the coarse sandstone to conglomerate unit.* ***e****) Sulphide-rich mudstone within the felsic volcaniclastic and subordinate polymictic breccia and mudstone unit.*

Locally, beds are fossiliferous and contain petrified wood. Several species of marine macrofossils were collected from two localities (Fig. 2). Preliminary identifications suggest that all fossils (dicoelitid belemnites, trigonids, limiids, and one ammonite) are shallow-water species (J. Haggart, pers. comm., 2003). Dicoelitid belemnites range in age from Toarcian to Middle Bajocian (~184–170 Ma; Okulitch, 2001). Thorough paleontological analyses were in progress at the time of publication.

The rounded to subrounded clast shapes and polymictic composition suggest significant reworking and incorporation of clasts from different sources. The graded bedding within coarse sandstone to conglomerate beds suggests deposition from sediment gravity flows. The coarse sandstone to conglomerate unit is interpreted to represent reworking of deposits in an above-wave-base or subaerial environment, followed by transport and deposition into a below-wave-base submarine environment.

The unit sits unconformably on the feldspar-phyric monomictic dacite–andesite breccia unit. Within the lower 1 m of the conglomerate sequence, rounded clasts occur that in outcrop appear to be compositionally and texturally very similar to the underlying dacite–andesite unit. This suggests development of an erosion surface on and reworking of the underlying unit. The upper contact of the conglomerate unit is not exposed in the area of the transect. Elsewhere in the study area, the conglomerate unit is in fault contact with the felsic volcaniclastic unit, interbedded mudstone and sandstone unit, and coherent rhyolite and associated monomictic breccia unit, or it is in conformable, interfingering contact with the interbedded mudstone and sandstone unit. Farther south it overlies a lower basalt unit (Alldrick et al., in press a).

Felsic volcaniclastic and subordinate polymictic breccia and mudstone unit

Exposure of this unit along the transect was sparse but several facies were mapped.

Black-matrix felsic breccia facies

This facies consists of white, felsic, blocky, splintery clasts (1 mm–2 cm) in a fine-grained black matrix. The breccia is monomictic and jigsaw fit to clast rotated. The monomictic composition and the jigsaw-fit texture suggest a syneruptive origin. This facies is interpreted to be the autoclastic facies of a lava dome, flow, or shallow-level intrusion.

Polymictic sulphide-rich breccia facies

This facies is a clast-supported, poorly sorted, massive polymictic breccia. Clasts range from 1 mm to 10 cm and are angular, blocky, and splintery. Clast types include sulphide-rich clasts, white aphyric felsic or mudstone clasts, white and pink siliceous clasts, and rare fine-grained green clasts. The matrix is black and fine grained with fine disseminated pyrite throughout. The polymictic composition suggests significant reworking and incorporation of clasts from different sources and the breccia was likely transported and deposited by water-supported sediment gravity flows.

Pumice breccia facies

This facies consists of green, randomly oriented, wispy pumice clasts in a fine-grained, cream-coloured matrix. The breccia appears to be monomicitic and varies from poorly to moderately sorted. The wispy pumice clasts are 1 to 6 mm long and have been altered to chlorite. Pumice clast shapes appear to be unmodified and the uniform composition suggests a syneruptive origin. There is no evidence that this facies is a primary pyroclastic deposit and it was more likely transported and deposited by cold, water-supported sediment gravity flows. It is interpreted as a syneruptive, resedimented, volcaniclastic deposit.

Mudstone facies

This facies is similar to the mudstone in the interbedded sandstone and mudstone unit, but contains finely disseminated pyrite throughout (Fig. 4e).

No contacts between the felsic volcaniclastic unit and surrounding units are exposed in the vicinity of the transect. Elsewhere in the study area, the felsic volcaniclastic unit is intimately associated with and surrounds small bodies of coherent to brecciated rhyolite (Fig. 2). Similarly, it is interpreted to be interbedded and interfingered with the mudstone and sandstone unit and likely represents a lateral facies change that reflects input from a coarser grained, mixed volcanic source and/or proximity to a volcanic centre.

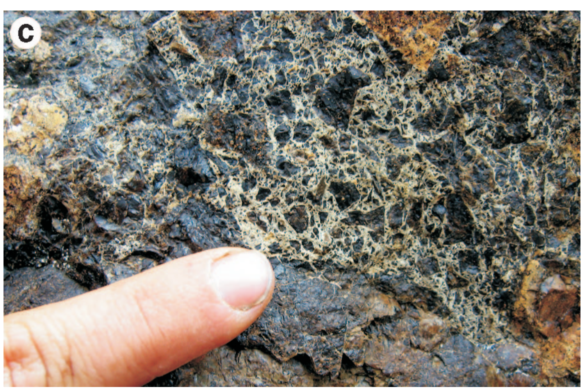
Interbedded mudstone and sandstone unit

This unit consists entirely of interbedded mudstone and sandstone (Fig. 5a). Mudstone beds are dark grey and finely laminated to thinly bedded. Sandstone beds are dominantly fine to medium grained, massive to normally graded, and 0.5 to 10 cm thick. Minor coarse sandstone beds contain angular clasts and crystal fragments. These coarse sandstone intervals are arkosic and contain abundant cream-coloured, fine-grained felsic clasts, possibly equivalent to the felsic clasts in the coarse sandstone to conglomerate unit. The unit is dominantly planar bedded, but locally crossbedded.

This facies is interpreted to have been transported and deposited by turbidity currents or sediment gravity-flow deposits into a below-wave-base environment.

Upper basalt unit

The upper basalt unit conformably overlies interbedded mudstone and sandstone. Its upper limit is not exposed in the map area. Minor rhyolite and dacite dykes crosscut the unit and minor volcaniclastic facies are interbedded with it. It consists of three main facies.



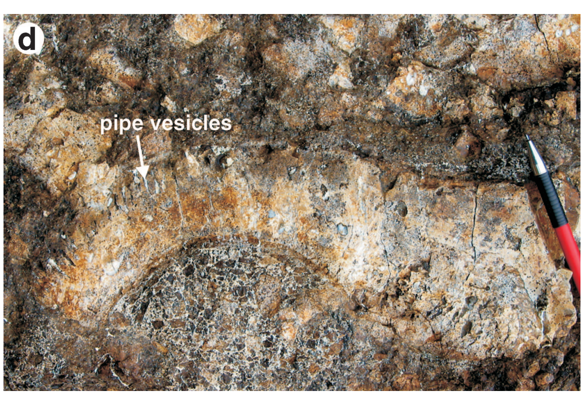


Figure 5. ***a****) Typical exposure of interbedded mudstone and sandstone unit.* ***b****) Fluidal-clast breccia facies in the upper basalt unit. Pale, irregular, fluidally shaped clasts are set in a fine-grained clastic matrix.* ***c****) Close-up of matrix in the fluidal-clast breccia facies. The monomictic, finely fragmented matrix contains blocky, splintery, poorly vesicular clasts generated by quench fragmentation.* ***d****) Close-up of a fluidal clast with pipe vesicles perpendicular to the clast margin.* ***e****) Crude pillow shapes in aphyric, moderately vesicular, coherent basalt. This exposure is spatially associated with the fluidal-clast breccia facies.*

Monomictic, blocky, basalt breccia facies

This facies is dark green and consists of blocky, curviplanar, jigsaw-fit clasts. Clasts range in size from 1 to 6 cm. The breccia is clast supported, moderately sorted, and monomictic. The matrix is cryptocrystalline and siliceous.

The monomictic composition, curviplanar clasts, and jigsaw-fit textures suggest that the breccia formed by in situ quench fragmentation of lava. It is interpreted as a hyaloclastite basalt breccia.

Fluidal-clast breccia facies

This facies is monomictic, poorly sorted, internally massive, clast supported, and contains both blocky, splintery clasts and fluidally shaped clasts (Fig. 5b, c, d). The blocky clasts are dark green and nonvesicular to highly vesicular. They have curviplanar margins and locally show jigsaw-fit textures (Fig. 5c). The curviplanar clast shapes are indicative of quench fragmentation due to the interaction of magma and water. These blocky clasts are the 'matrix' to the highly irregular fluidally shaped clasts. The fluidally shaped clasts are cream coloured, highly vesicular, and have delicate, irregular shapes. Some also contain pipe vesicles (up to 10 cm long) perpendicular to clast margins (Fig. 5d). The fluidally shaped clasts resemble subaerial bombs; however, the evidence for quench fragmentation provided by the blocky clasts, the spatial association with pillow lava, and the overall evidence for a subaqueous setting within the study area indicate that these clasts are subaqueous bombs.

The clast shapes and monomictic composition indicate that this facies is a primary volcanic breccia and it is interpreted to have formed by submarine fire-fountaining. Similar breccia units have been described from the modern seafloor (Smith and Batiza, 1989) and in several other subaqueous volcanic successions worldwide (e.g. Simpson and McPhie, 2001, and references therein). Although these deposits are not good indicators of water depth, they do indicate proximity to a volcanic centre as fire-fountain deposits rarely extend beyond tens of metres from the source vent (Kokelaar and Durant, 1983; Kokelaar, 1986).

Aphyric coherent basalt facies

This facies consists of dark green, massive or pillowed, and nonvesicular to moderately vesicular basalt. Pillows are up to 1 m across (Fig. 5e). This facies is interpreted to be the coherent facies of lava flows or shallow-level intrusions. The presence of pillows indicates that lava is at least locally present and confirms a subaqueous depositional environment.

STRUCTURAL GEOMETRY

The strata dip predominantly to the northeast, but are deformed into open folds with straight limbs and angular hinges (Fig. 3). Outcrop-scale, southwest-vergent folds mimic the large-scale geometry. Vertical faults break the cores of some folds, particularly at the anticline near the centre of the cross-section (Fig. 3).

CONCLUSIONS

Preliminary mapping results from the east part of the Telegraph Creek area have defined five principal mappable units: 1) plagioclase-phyric monomictic dacite–andesite breccia unit; 2) coarse sandstone to conglomerate unit; 3) felsic volcaniclastic and subordinate polymictic breccia and mudstone unit; 4) interbedded mudstone and sandstone unit; and 5) upper basalt unit. The field area is dominated by subaqueous, volcaniclastic, and nonvolcanic clastic rocks that were deposited by sediment gravity flows into an extensional basin setting. Basin subsidence appears to have kept pace with sediment deposition as no shallow-water sedimentary structures or subaerial deposits were mapped. The presence of marine fossils, sediment gravity-flow deposits, and pillow basalt provide evidence for a submarine environment. Coherent volcanic and associated volcaniclastic facies occur in several areas and are considered to indicate proximity to volcanic sources. In particular, the fire-fountain breccia and associated pillow basalt indicate proximity to basaltic centres. Although the specific genetic relationships are currently unknown, the occurrence of subaqueous fire-fountain deposits in several productive VHMS districts (e.g. Bergslagen region, Sweden, Allen et al., 1996a; Skellefte District, Sweden, Allen et al., 1996b; Mount Windsor Volcanics, Australia, Simpson and McPhie, 2001; Ryugazaki, Hokkaido, Japan, Cas et al., 1996) may be indicative of favourable environments for the occurrence of VHMS mineralization.

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REFERENCES

Alldrick, D.J., Stewart, M.L., Nelson, J.L. and Simpson, K.A.
in press a: Geology and mineral deposits of the More Creek–Kinaskan Lake area, northwestern British Columbia; British Columbia Ministry of Energy and Mines, Geological Fieldwork 2003, Paper 2004-1.
in press b: Geology and mineral deposits of the More Creek–Kinaskan Lake area, northwestern British Columbia; British Columbia Ministry of Energy and Mines, Open File Map 2004-2, scale 1:50 000.

Allen, J.L., Lindstrom, I., Ripa, M., Simeonov, A., and Christofferson, H.
1996a: Facies analysis of a 1.9 Ga, continental margin, back-arc, felsic caldera province with diverse Zn-Pb-Ag-(Cu-Au) sulfide and Fe oxide deposits, Bergslagen Region, Sweden; Economic Geology, v. 91, p. 979–1008.

Allen, J.L., Weihed, P., and Svenson, S.
1996b: Setting of Zn-Cu-Au-Ag massive sulfide deposits in the evolution and facies architecture of a 1.9 Ga marine volcanic arc, Skellefte District, Sweden; Economic Geology, v. 91, p. 1022–1053.

Anderson, R.G.
1993: A Mesozoic stratigraphic and plutonic framework for northwestern Stikinia (Iskut River area), northwestern British Columbia, Canada; *in* Mesozoic Paleogeography of the Western United States – II, (ed.) G. Dunne and K. McDougall; Society of Economic Paleontologists and Mineralogists, Pacific Section, v. 71, p. 477–494.

Anderson, R.G. and Thorkelson, D.J.
1990: Mesozoic stratigraphy and setting for some mineral deposits in Iskut River map area, northwestern British Columbia; *in* Current Research, Part E; Geological Survey of Canada, Paper 90-1E, p. 131–139.

Cas, R., Moore, C., and Scutter, C.
1996: Fragmentation processes and water depth significance of Miocene submarine fire fountain deposits, Ryugazaki, Hokkaido, Japan; EOS Transactions, v. 77, p. 125.

Corbett, K.D.
1989: Stratigraphy, palaeogeography and geochemistry of the Mt. Read Volcanics; Geological Society of Australia, Special Publication, v. 15, p. 88–117.
1992: Stratigraphic-volcanic setting of massive sulfide deposits in the Cambrian Mount Read Volcanics, Tasmania; Economic Geology, v. 87, p. 564–586.

Kokelaar, P.
1986: Magma-water interactions in subaqueous and emergent basaltic volcanism; Bulletin of Volcanology, v. 48, p. 275–289.

Kokelaar, B.P. and Durant, G.P.
1983: The submarine eruption and erosion of Surtla (Surtsey), Iceland; Journal of Volcanology and Geothermal Research, v. 19, p. 239–246.

MacDonald, A.J., Lewis, P.D., Thompson, J.F.H., Nadaraju, G., Bartsch, R.D., Bridge, D.J., Rhys, D.A., Roth, T., Kaip, A., Godwin, C.I., and Sinclair, A.J.
1996: Metallogeny of an Early to Middle Jurassic arc, Iskut River area, northwestern British Columbia; Economic Geology, v. 91, p. 1098–1114.

McPhie, J. and Allen, J.L.
1992: Facies architecture of mineralized submarine volcanic sequences: Cambrian Mount Read Volcanics, Western Tasmania; Economic Geology, v. 87, p. 587–596.

Okulitch, A.V.
2001: Geological time scale; Geological Survey of Canada, Open File 3040.

Simpson, K. and McPhie, J.
2001: Fluidal-clast breccia generated by submarine fire fountaining, Trooper Creek Formation, Queensland, Australia; Journal of Volcanology and Geothermal Research, v. 109, p. 339–355.

Smith, T.L. and Batiza, R.
1989: New field and laboratory evidence for the origin of hyaloclastite flows on seamount summits; Bulletin of Volcanology, v. 51, p. 96–114.

Souther, J.G.
1972: Telegraph Creek map-area, British Columbia; Geological Survey of Canada, Paper 71-44.

Geological Survey of Canada Project J-201-Y01-Eskay-NR4001-00-0