Structural geology of the Mount Polley porphyry copper district: reconstruction of post-mineral fault displacement and tilting for the purpose of future exploration

Stephanie Wafforn[1]; John H. Dilles[1]; Andrew Meigs[1]; Patrick McAndless; Chris Rees; Dick Tosdal
[1] College of Earth, Oceanic, and Atmospheric Sciences, Oregon State University, Corvallis, OR

1. Introduction

The Mount Polley Cu-Au mine is located 56km northeast of Williams Lake on the west side of Polley Lake, approximately 8km southeast of Likely, BC. It is developed on multiple breccia-hosted, porphyry Cu-Au ore zones within monzonitic intrusions emplaced into the marine alkalic volcanic rocks of the Nicola Group (Logan et al., 2005).

The Mount Polley Igneous Complex is cut by steeply dipping faults, on which significant displacement is inferred from the geology. The structural block in the Southeast zone has a high temperature alteration assemblage and the highest Au:Cu ratio, implying relatively deep exposure. This is juxtaposed against the Northeast zone structural block, which comprises propylitic alteration and is stratigraphically nearest to a post-mineral unconformity, implying a relatively shallow level of exposure. Evidence of tilting is provided by a post-mineral conglomerate that unconformably overlies mineralized rocks and dips approximately 35° to the northwest. Collectively, the geologic data suggests significant post-mineral modification to the Mount Polley porphyry Cu-Au district.

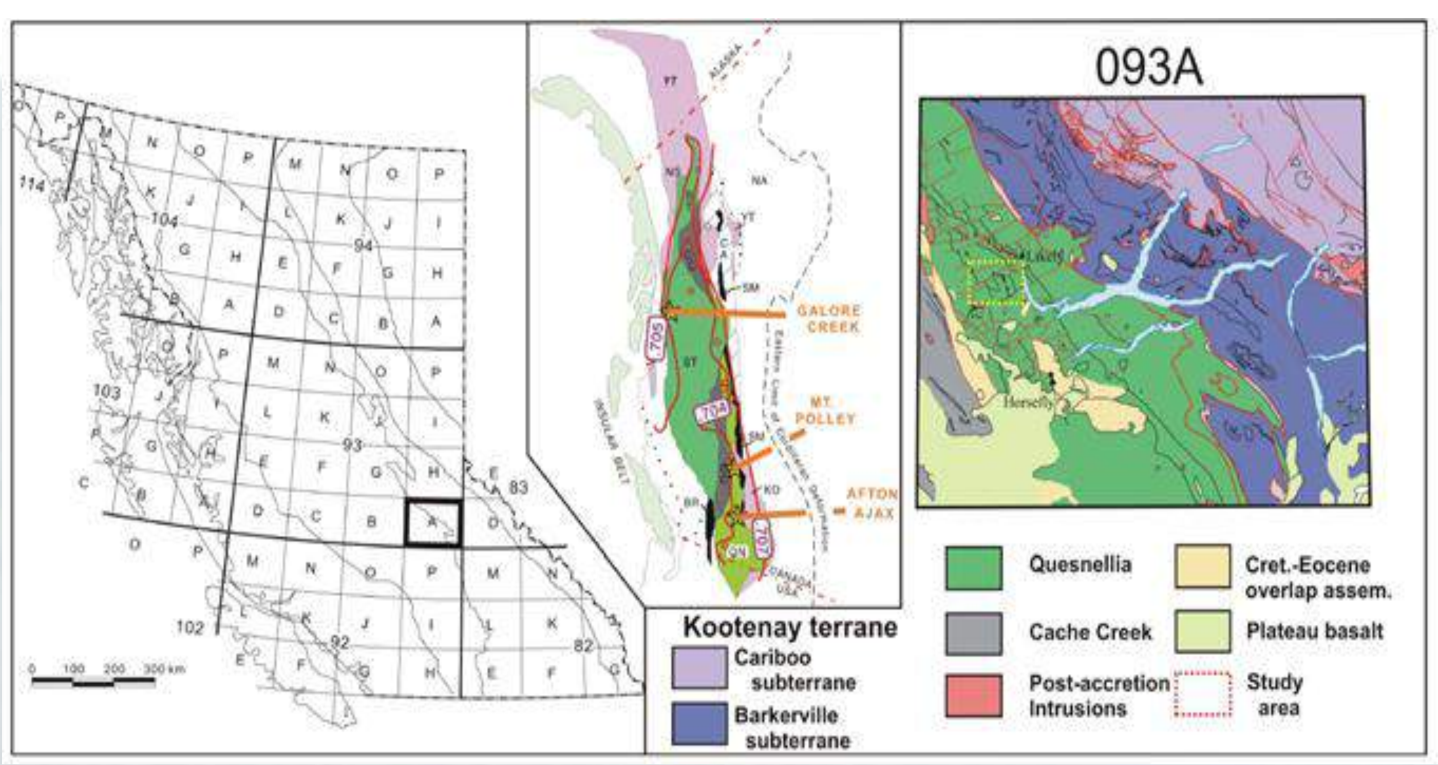

Figure 1: Location of the Mount Polley Cu-Au mine in the south-central British Columbia. Inset is the terrane map of the northern Canadian Cordillera, showing the tectonostratigraphic setting of three large Cu-Au porphyry deposits. Box on the right shows the detailed terrane relationships for the map area NTS 093A, and the Mount Polley area. (Logan et al., 2005)

2. Tectonic Setting

Mount Polley is located on the eastern margin of the Quesnel terrane, in the Intermontane Belt close to its tectonic boundary with the Omineca Belt (Logan et al., 2005) (Fig. 1). The Quesnel terrane is an island arc, fault bounded to the east by the pericratonic Kootenay terrane and the oceanic Slide Mountain terrane, and to the west by the oceanic Cache Creek terrane.

Faunal evidence in the Cache Creek terrane suggests that the island arc formed in an eastward dipping subduction zone in the Paleotheys Ocean (Johnston and Borel, 2007), however it has also been suggested that the island arc formed allochthonous to the western margin of North America (Dostal et al., 2001). The formation of a westward subduction zone, consuming oceanic crust continuous with the North American continent, allowed for the accretion of the exotic terrane onto the continent (Johnston and Borel, 2006).

The Mount Polley igneous complex intruded into the Nicola Group in the latest Triassic, approximately 205Ma. The Nicola Group comprises a lower, dominantly metasedimentary unit and an upper, dominantly volcanic-arc assemblage (Logan et al., 2005). Regionally the structural geology is dominated by thrusting, imbrication, and strike-slip faults that formed during the accretion of the Quesnel terrane onto North America (Struik et al. 2001).

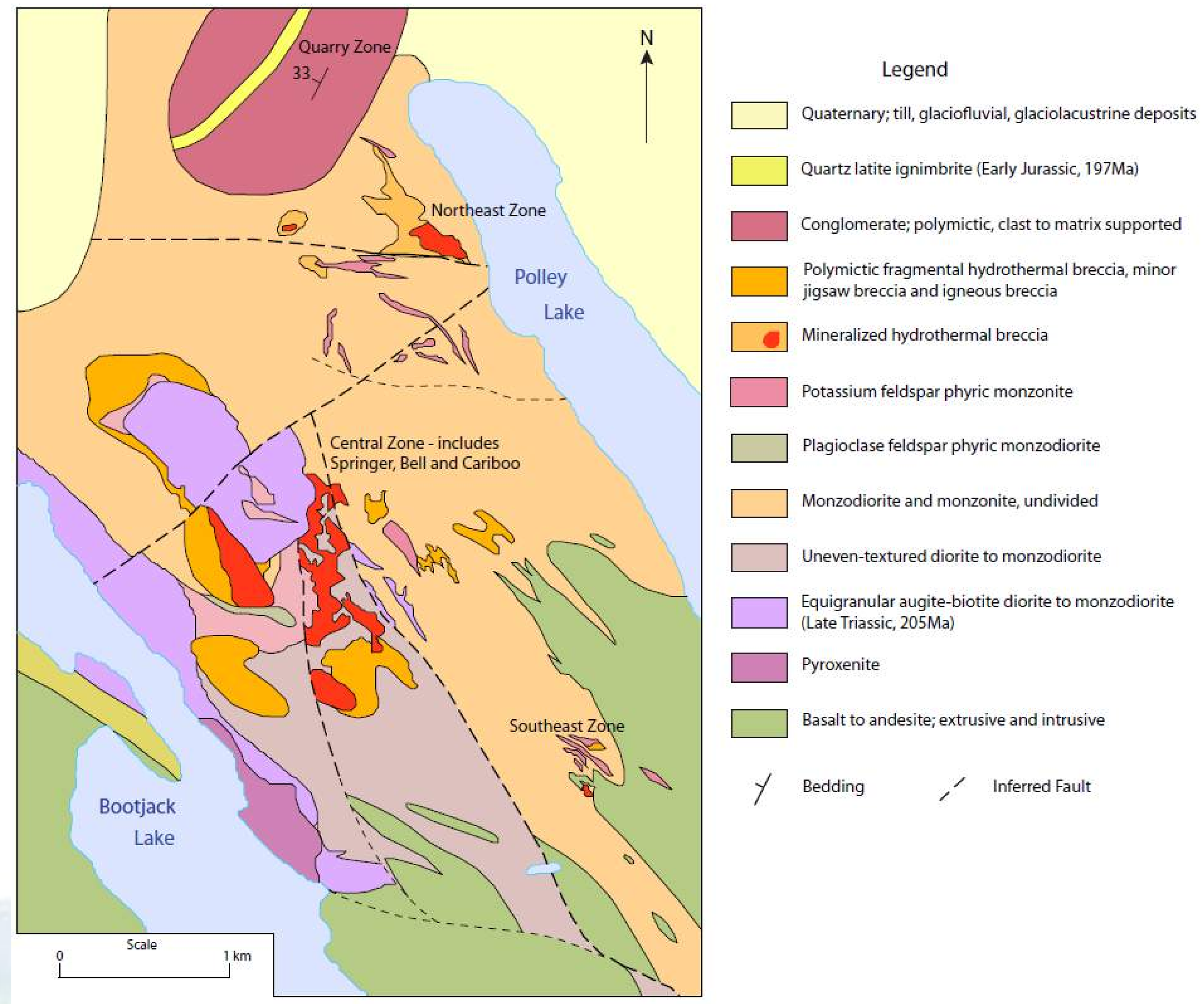

Figure 2: Simplified geologic map of the Mount Polley Property. Mineralized zones within breccia bodies are shown in red. Modified from map provided by Chris Rees, Imperial Metals.

3. Research Objectives

Previous work at Mount Polley has focused on the brecciation, mineralization, and alteration style of the porphyry deposits, particularly in the Northeast zone. The structural geology of the deposit continues to be an enigma, which has strong implications for future exploration at the site. This project will look at the following problems:

(1) What is the nature of the contact between the overlying Jurassic conglomerate and the underlying Mount Polley Igneous Complex? Can the conglomerate provide a constraint on the tilting of the deposit?
(2) What is the nature of the faults and deformation in the Northeast zone? Can these faults be used to understand the distribution of porphyry copper centers in the district?
(3) Are the augite porphyry dykes contemporaneous with the mineralization? Is there a preferential orientation in the dykes that relates to the strain orientation at the time of the porphyry intrusions?

These problems will be addressed by the means of fieldwork and mapping in the Northeast zone and Springer Pit, LIDAR analysis to locate additional outcrop exposure, and thermochronometry to help identify the location, and displacement, of fault blocks along the length of the deposit.

4. Preliminary Results

Unconformity and Tilting:
Examination of the contact between the Triassic monzonite and the Jurassic overlying conglomerate shows that it is an unconformity. There are abundant monzonite rip-up clasts in the conglomerate directly overlying the unconformity (Fig. 3), and the majority of clasts are angular to sub-angular. Stratigraphically higher the clast composition becomes more varied, containing pyroxenite, fine grained volcanics, and basalt clasts that are more distally sourced. Bedding is observed in drill core, and field measurements indicate a 207/33 orientation (Fig. 3). Given that the Mount Polley Igneous Complex comprises numerous igneous bodies without foliation, the bedding is the sole constraint on tilting.

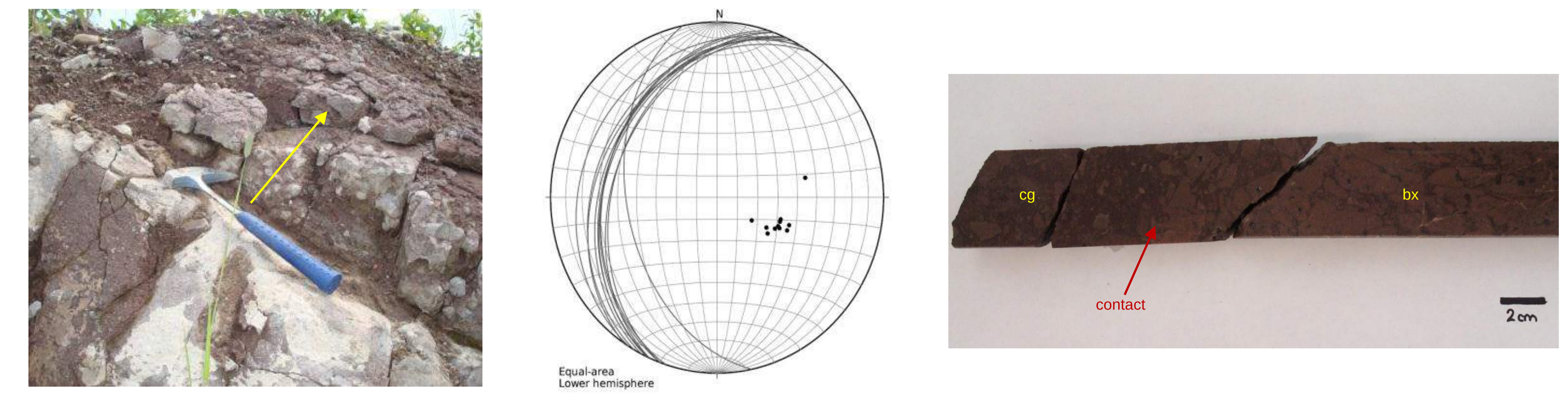

Figure 3: Left: photo shows conglomerate bedding plane in the Quarry Zone,. Arrow indicates up direction. Centre: stereonet plot of conglomerate bedding measurements. The outlier great circle shows a slumped block. Average bedding measurement is 207/33. Right: photo shows the unconformity between the monzonite breccia and the conglomerate (cg=conglomerate, bx=breccia). Drill hole WB-07-240, 91.40m.

Pilot Thermochronometry Study:
Low temperature thermochronometry is a useful tool in orogenic belts for determining the cooling age and exhumation history of the rocks. In a normal fault setting the cooling histories of the hanging wall and footwall are different due to (1) lateral heat flow across the fault due to the juxtaposition of a cool hanging wall with a relatively warmer footwall; (2) uplift and erosion of the footwall and sedimentation and burial of the hanging wall; (3) footwall tilt, and (4) topography (Ehlers and Farley, 2003). These processes can cause significant lateral variations in the apatite He closure age, and can therefore be used to delineate structural blocks (Fig. 4).

A pilot study is in progress. Three samples (one from the Quarry Zone, Northeast zone, and the Southeast zone) have been selected to be analyzed for apatite U-Th/He and fission track ages that may record the timing of low-T uplift. If the ages successfully delineate the fault bounded structural block in the Northeast zone, more detailed sampling will be conducted.

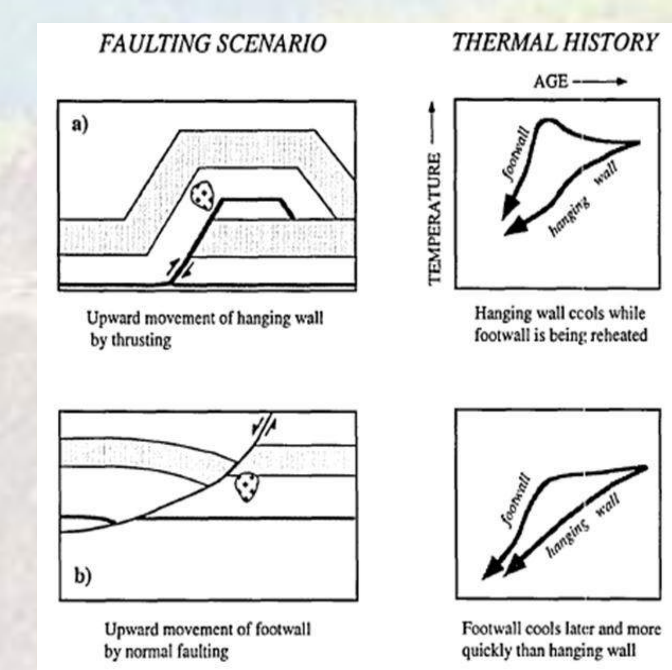

Figure 4: Hypothetical dip-slip faulting scenarios and their expected time-temperature paths (a) thrust fault, (b) normal fault (Fillipone et al., 1995).

Figure 5: Augite porphyry dyke intruding into monzodiorite in the Springer Pit . Dyke oriented 096/87, with some splay near the top.

Dyke Orientation:
Summer field work will be spent mapping and measuring the exposed augite porphyry dykes in both the Northeast zone and in the actively mined Springer pit (Fig. 5). There are two models that could describe dyke emplacement during mineralization (1) the dykes emplace radially from the igneous intrusions, or (2) the dykes are planar and emplace in a conjugate orientation. Analysis of the dyke orientation may provide insight into the strain orientation at the time of dyke emplacement.

References Cited

Dostal, J., Church, B. N. and Hoy, T. (2001): Geological and geochemical evidence for variable magmatism and tectonics in the southern Canadian Cordillera: Paleozoic to Jurassic suites, Greenwood, southern British Columbia; Canadian Journal of Earth Science, 38, 75-90.
Ehlers, T.A. and Farley, K.A. (2003): Apatite (U-Th)/He thermochronometry: methods and applications to problems in tectonic and surface problems; Earth and Planetary Science Letters, 206, 1-14.
Fillipone, J.A., Yin, A., Harrison, T.M., Gehrels, G., Smith, M. and Sample, J.C. (1995): Age and magnitude of dip-slip faulting deduced from differential cooling histories: an example from the Hope fault, Northwest Montana; The Journal of Geology, 103, 199-211.
Johnston, S.T. and Borel, G.D. (2007): The odyssey of the Cache Creek terrane, Canadian Cordillera: Implications for accretionary orogens, tectonic setting of Panthalassa, the Pacific superwell, and the break-up of Pangea; Earth and Planetary Science Letters, 253, 415-428.
Logan, J.M. and Mihalynuk, M.G. (2005): Regional geology and setting of the Cariboo, Bell, Springer, and Northeast porphyry Cu-Au zones at Mount Polley, South-Central British Columbia; Geological Fieldwork 2004, British Columbia Geological Survey, Paper 2005-1, 249-270.
Struik, L.C., Schiarizza, P., Orchard, M.J., Cordey, F., Sano, H., MacIntyre, D.G., Lapierre, H. and Tardy, M. (2001): Imbricate architecture of the upper Paleozoic to Jurrasic oceanic Cache Creek Terrane, central British Columbia; Canadian Journal of Earth Science, 38, 495-514.