Modeling the geometry of Shear Zone hosted gold + bismuth telluride bearing quartz veins at the historic Bunker Hill mine, south of Nelson, B.C. – a covert, mildly folded Tension Vein Array

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With a realistic model vein systems can be drilled effectively. Applying the Tension Vein Array model of Laing (2004) to quartz veins at the historic Bunker Hill mine, south of Salmo B.C., reveals the vein geometry, the state of strain and confirms they formed in a shear zone. At the outcrop scale the veins are not obviously folded; at 10's of meters they are. The veins form a covert, Stage 2 low to moderate strain Tension Vein Array 'TVA' system. Within their formative shear zone they are folded 50-60°.

The BH mine is close to the Waneta-Tillicum Fault accretionary boundary between Quesnellia terrane and ancestral North America; ultramafics occur. The vein-locating shear zone is exposed once (*Figure 3*). Several vuggy veins grade ~0.3 oz / ton (11 g /t) gold. 9 of 13 gold-associated bismuth + bismuth telluride minerals identified in the Liese Zone Pogo gold deposit in Alaska (Rombach et al. 2002) occur, including unnamed Bi_2Te (Howard et al. 2009). First described in Canada are ingodite $Bi_2(TeS)$ and ikunolite Bi_4S_3.

Any or all of these vectors define the TVA axis: intersection lines of crossing veins, vein / parent shear zone intersections, dilational jog axes in the host shear zone, axes of vein bulges, vein tip lines and the linear orientations of any mined ore chutes [shoots] (Laing 2004).

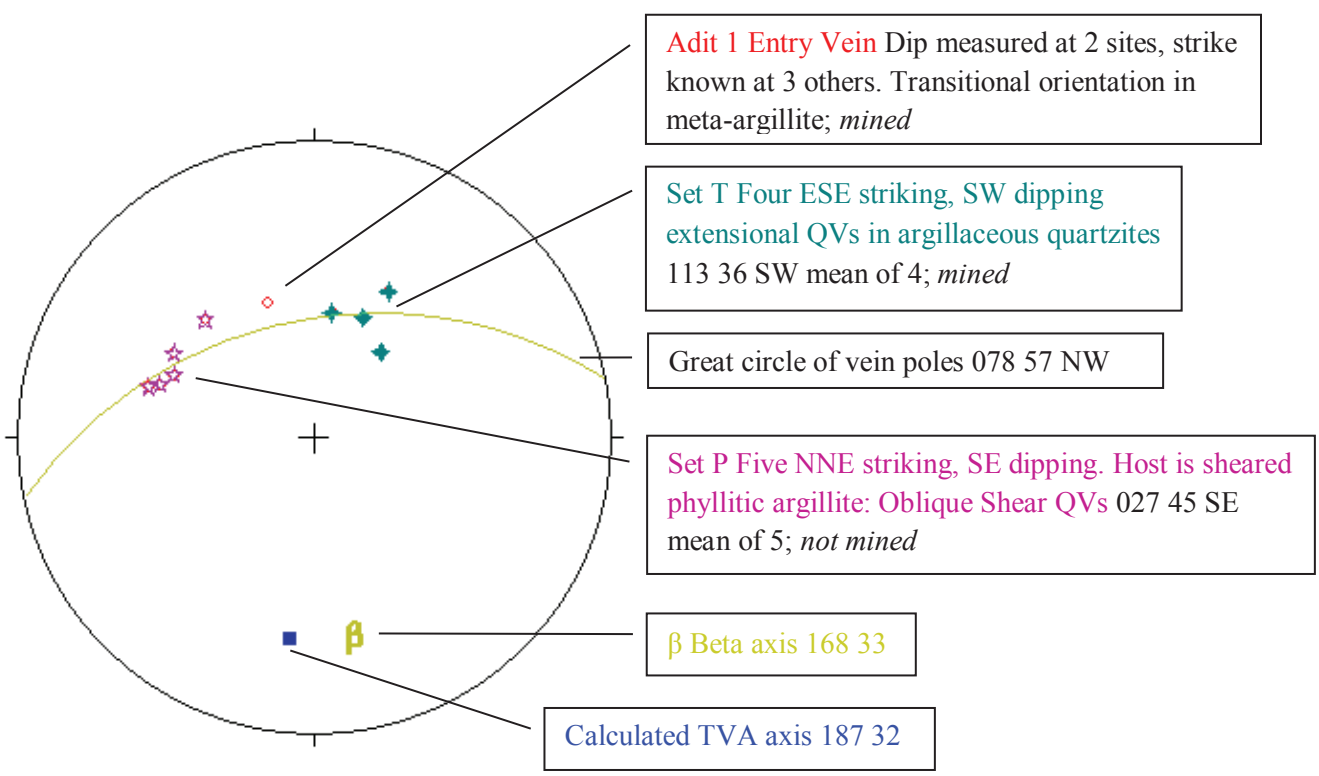

Figure 1 Equal area lower hemisphere plot of poles (normals) to mean principal orientations of 10 individual veins in the Bunker Hill mine area, classed by production or not. Their mean great circle orients 078 57 NW. Its pole, the Beta axis β, is close in orientation to the Calculated TVA axis.

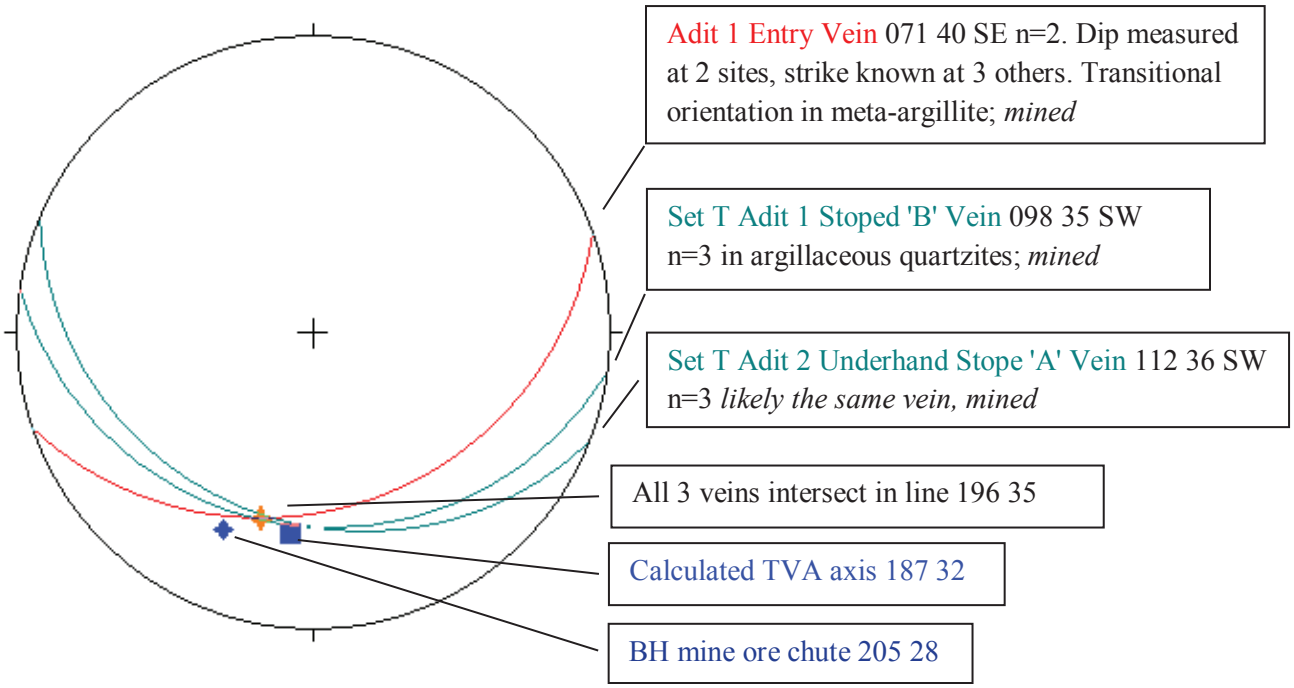

Figure 2 Three individual veins, exposed at surface and in two Bunker Hill mine adits, ***are all approx. co-linear.*** *Within error they contain their mutual intersection, the mined ore chute [ore shoot], and the calculated TVA axis. Equal area plot color-coded same as Fig. 1; veins as great circles.*

Three BH mine veins are approx. co-linear and include the calculated TVA axis 187 32. Set T extensional veins with ~0.3 oz / ton gold were mined; Set P shear veins are sub economic. Poles of 10 vein orients form a great circle with β Beta axis 168 33 (*Figure 1*). The BH mine ore chute [shoot] is a moderately plunging, oblate 'pancake shaped' ore body. Its long axis orients close to the calculated TVA axis 187 32 (*Figure 2*). Crossing veins formed it; in loose pieces "sulfides concentrate at the intersection of the two dominant vein orientations, suggesting highest Au and Ag values in those areas (Barry-Hallee 2016)."

Modeling the Bunker Hill QVs as a TVA system confirms a shear zone is the controlling structure; estimates the Stage 2 (low) state of rotational strain; differentiates the orientation of higher-grade veins; confirms one ore shoot formed at a triple-vein crossing; and identifies the optimum drill hole orientation (Corbett & Leach 1998). Other ore shoots are fully expected under drift cover; some will be blind.

Barry-Hallee, N., 2016. Implications of Vein Genesis on Ore Mineralization, Bunker Hill, B.C.; Dept. of Earth Sciences Mount Royal University, Calgary AB; Directed readings report April 01 2016; 15 p.

Corbett, G.J., and Leach, T.M., 1998. Southwest Pacific Rim Gold-Copper Systems: Structure, alteration and mineralization. Special Publication No. 6 Society of Economic Geologists; 237 p.

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Laing, W.P., 2004. Tension vein arrays in progressive strain: complex but predictable architecture, and major hosts of ore deposits. Journal of Structural Geology, Vol. 26 p. 1303–1315.

Rombach, C.S., Newberry, R.J., Goldfarb, R., & Smith, M. 2002. Geochronology and Mineralization of the Liese Zones, Pogo Deposit, Alaska. GSA Abstracts with Programs, 2002.

Tapsoba, B., 2015. Observations of Geologic Structures controlling the Locations and Geometry of gold bearing Quartz Veins and Skarn on central CLY gold + tungsten polymetallic prospect, south of Salmo, British Columbia. 70 pp. with photos; Part III of Howard et al. 2016 (this ref. above).

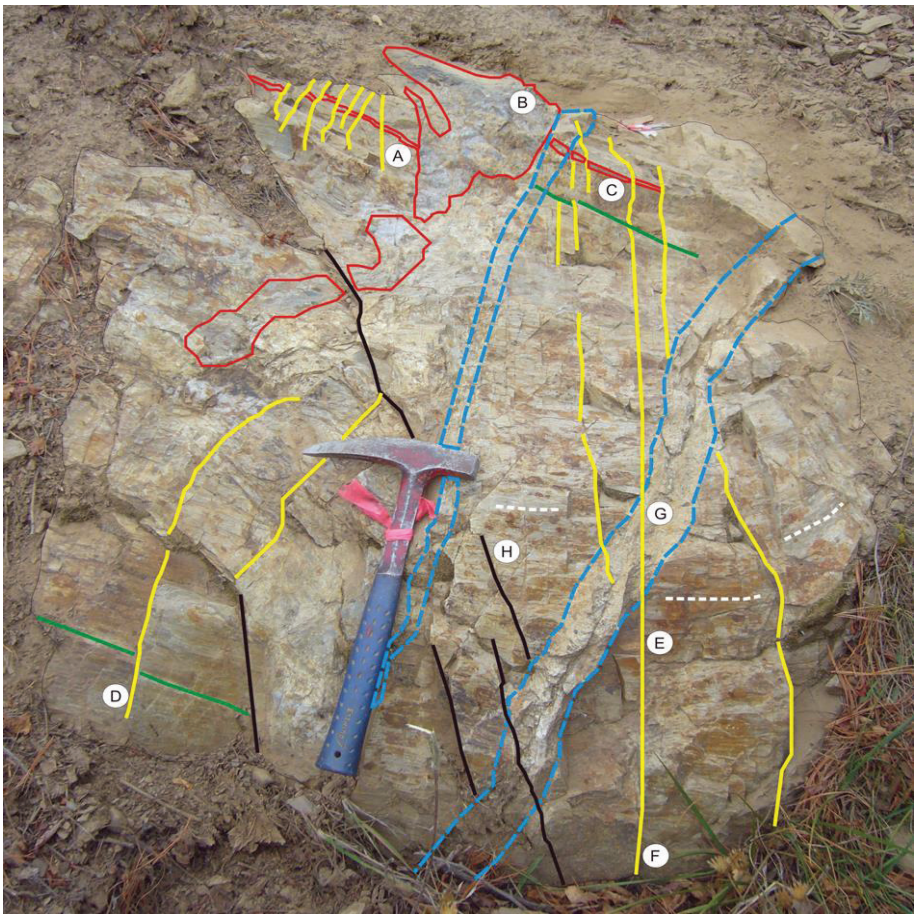

Figure 3 The single 'Curving Sheared Quartzite' exposure tens of meters from the Bunker Hill mine, on the access road. The argillaceous quartzite has shear lineations as green and white lines. Blue outlines two younger aplite dykes, in red greyish irregular quartz veins & veinlets. In yellow a series of fractures post-date all, except ones in black. Letters are orient sites; view is about East 070°. Veinlets at (A) and (C) orient like Set T extensional QVs. UTM Zone 11 471,324mE 5,434,490mN , from Tapsoba (2015).