Eocene Deformation at Tubbs Hill of Coeur d'Alene, Idaho, Southeast Priest River Complex

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Abstract

Sensitive High-Resolution Ion Microprobe analyses of igneous rims on zircons from deformed (mylonitic) granite dike rocks of Tubbs Hill, in downtown Coeur d'Alene, yielded U-Pb dates of 50.1±3.5 Ma and 49.5±1.1 Ma. The dike strikes northwest and is comprised of porphyritic biotite granodiorite with feldspar phenocrysts 0.5-0.75 cm in length. These robust dates provide a constraint on mylonitic deformation within the southeastern part of the Priest River metamorphic complex (PRC). An Eocene igneous age from this Tubbs Hill dike indicates coeval emplacement with Eocene plutonic suites elsewhere in the PRC, such as the locally deformed Silver Point pluton quartz monzonite dated at 50.13±0.02 Ma (Stevens, 2015). The northern most mylonitic deformation within the PRC, 66 kilometers north of Tubbs Hill is constrained by a recent suite of monazite and zircon U-Pb dates of a leucocratic dike indicating crystallization was circa 49.8 Ma (Stevens, 2015). Mylonitic deformation in the PRC appears to be a similar age in both the north and south.

Geologic Setting

The Priest River Complex (PRC) is one of many core complexes along western North America (Fig. 1) comprised of mid-crustal metamorphic rocks that were uplifted and exposed at Earth's surface giving geologists access to otherwise unreachable rocks. Metamorphosed igneous and sedimentary rocks of the Hauser Lake Gneiss, Selkirk igneous complex of the Kaniksu Batholith, the Spokane Granite, Silver Point Pluton, Wrencoe Pluton, and the Tubbs Hill rocks (Fig. 2) make up most of the PRC. Eastward displacement occurred along the Purcell Trench Detachment Fault in conjunction with regional uplift. Overlying Belt-Purcell Supergroup supracrustal rocks were eroded including some Hauser Lake Gneiss, which is an amphibolite-facies metamorphosed lower Belt-Purcell sedimentary unit (Fig. 3). The Spokane Dome Mylonite Zone is defined by mylonitic fabrics that are collectively bowed up into an elongate dome that trends NNE and plunges to the north, which projects partially below the Newport Fault (Fig. 2; Rhodes and others, 1989). Ubiquitous lineations throughout the entire Spokane Dome Mylonite Zone trend generally ENE, plunge moderately, and are defined by elongate mineral grains (Rhodes and Hyndman, 1984; Rhodes and others, 1989). Lineations are interpreted to represent the eastward movement along the Purcell Trench Fault, which predates the doming of the mylonite zone (Rhodes and Hyndman, 1984).

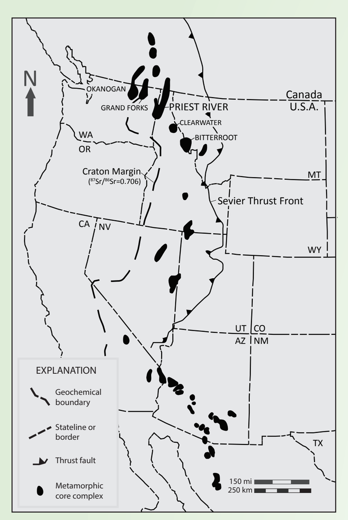


Figure 1. Map of the western United States showing distribution of metamorphic core complexes (modified from Stevens, 2015).

Research about the PRC has been published for over 30 years (e.g.: Rhodes and Hyndman, 1984; Armstrong and others, 1987; Doughty and Price, 1999), and a recent study of the PRC (Stevens, 2015) using advanced geochronologic techniques revealed discrete ages (Cretaceous and Eocene) and magma sources for many of the plutonic bodies within the PRC, but the study did not include the southeastern most portion of the PRC—Tubbs Hill. Comprised chiefly of protomylonitic meta-igneous and meta-sedimentary rocks (Fig. 4; Reid and others, 1993), Tubbs Hill also includes a late dike that crosscuts the entire hill and is variably deformed.

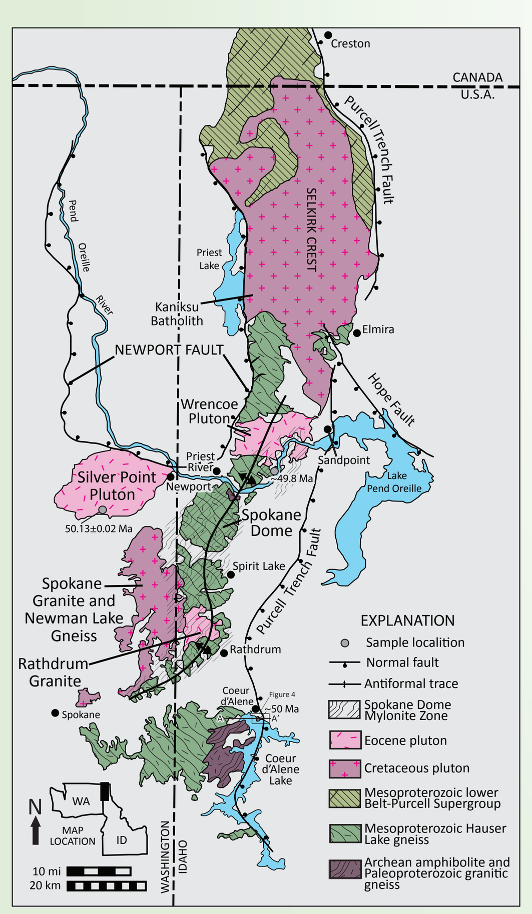
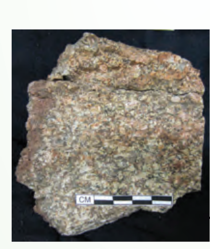


Figure 2. Geologic map of the Priest River Complex showing mylonite zone extent and relevant rock ages (modified from Stevens, 2015).



14DW09

15NW1THD
(Foliation orientation is 307,28)

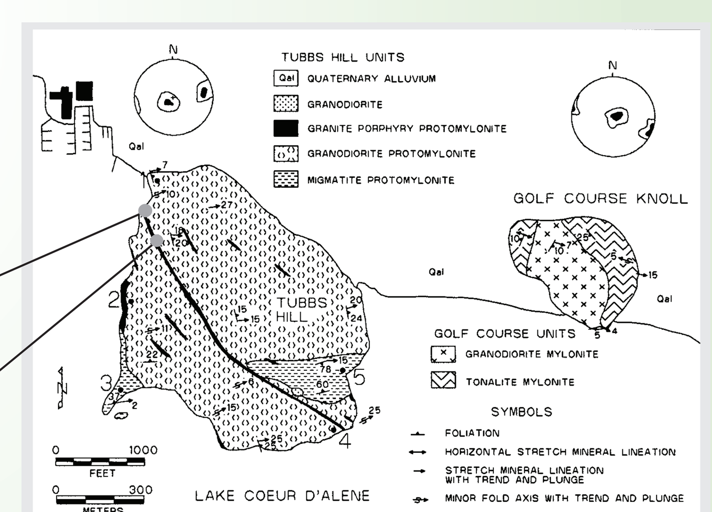


Figure 4. Geologic map of Tubbs Hills in Coeur d'Alene, Idaho showing rock sample locations (Reid and others, 1993).

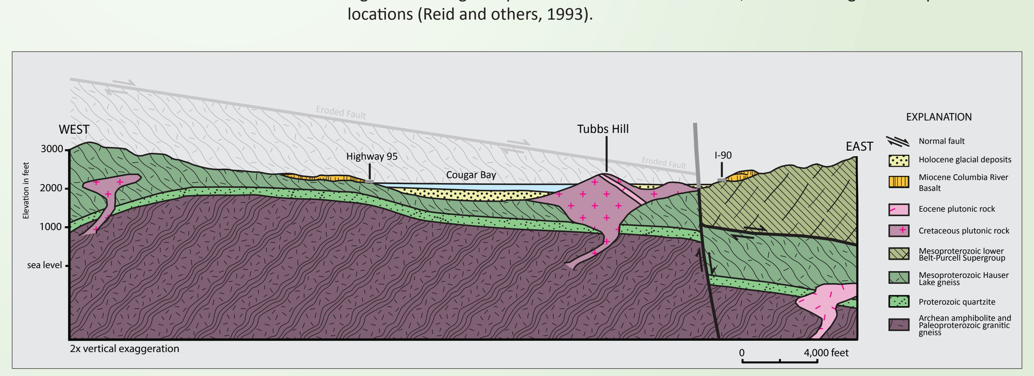


Figure 3. Cross section through Tubbs Hill region showing eroded fault surface, extensive basement, and offset along the sub-horizontal Purcell Trench Detachment Fault.

Methods

Rock samples were collected at two separate Tubbs Hill dike localities on the northwest side of Tubbs Hill (Fig. 3 & satellite image above). Mineral grains were separated with a crusher, mill, and water table at the University of Idaho rock preparation laboratory. Zircon separation was completed at Washington State University using a 350 µm sieve, a magnetic separator, and methylene iodide (MeI). Near pure zircon fractions (Fig. 5) were dried and placed in folded weigh paper and then in small plastic bags to protect against grain loss.

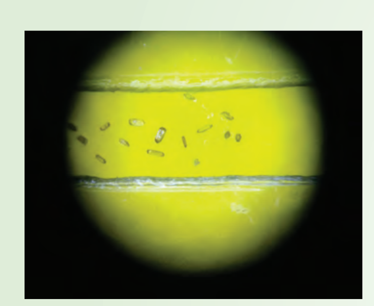


Figure 5. Photograph of zircon grains from sample 15NW1THD taken through the ocular of a microscrope.

Remaining grain preparation and analyses were conduced at the Stanford-USGS Sensitive High-Resolution Ion Microprobe (SHRIMP) Laboratory. Zircon grains were handpicked (Fig. 5), mounted in epoxy, allowed to dry overnight, cut, sanded to expose grain interiors, polished, and rinsed. Cathodluminescent (CL) images were taken of the grain mount and used as a guide for analysis spot selection (Figs. 6 & 7). The grain mount (Fig. 8) was loaded into the SHRIMP (Fig. 9) and exact analysis spots were selected.

The two samples analyzed showed similar but distinct zircon zoning. For sample 14DW09, at least 15 rim spots with oscillatory zoning were selected; only a couple grains showed distinct cores (Fig. 6), so no cores were analyzed (a minimum of 5 cores are needed to produce a robust data set). For 15NW1THD, 15 rim spots with oscillatory zoning were selected as well as distinctly zoned cores (Fig. 7). Many of these cores appeared brighter in CL images, which is due to higher lead (Pb) content.

Figure 6. CL image of a representative zircon grain from 14DW09 showing continuous oscillatory zoning from core to rim.

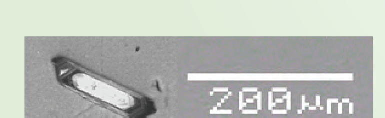


Figure 7. CL image of a representative zircon grain from 15NW1THD showing a bright core and an oscillatory zoned rim.

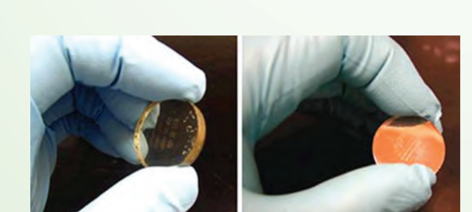


Figure 8. Two grain mounts. Left is an epoxy mount like prepared for this study, and right is an irridium mount. Image from https://shrimprg.stanford.edu/sample-types-and-sample-preparation.

Figure 9. USGS-Stanford Sensitive High-Resolution Ion Microprobe (SHRIMP) located on the Stanford University campus in Palo Alto, California. Image from https://shrimprg.stanford.edu/.

Results

14DW09

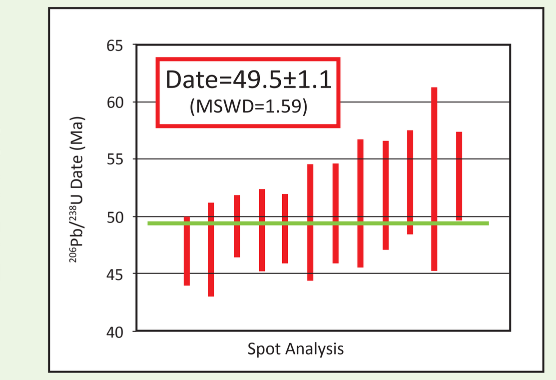


Figure 10. $^{206}Pb/^{238}U$ dates with weighted mean date for less deformed sample of the Tubbs Hill dike, 14DW09.

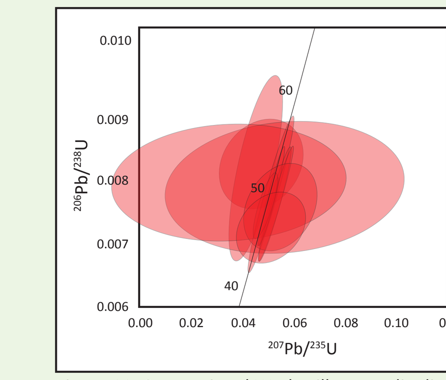


Figure 11. Conventional Wetherill concordia diagram showing U-Pb SHRIMP data distribution of the spot analyses with 2 sigma error ellipses.

15NW1THD

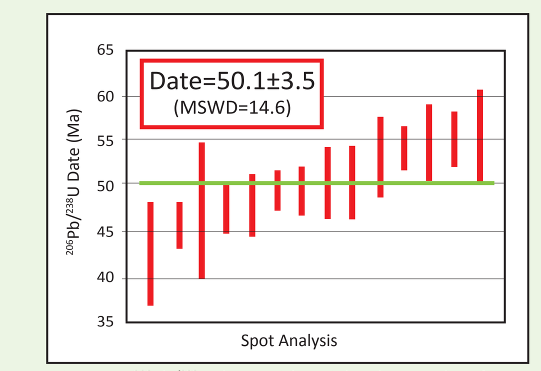


Figure 12. $^{206}Pb/^{238}U$ dates with weighted mean date for the more deformed sample of the Tubbs Hill dike, 15NW1THD.

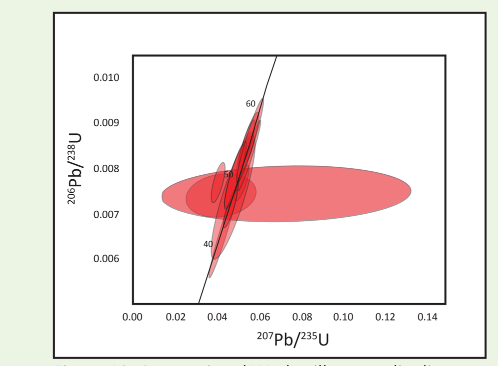


Figure 13. Conventional Wetherill concordia diagram showing U-Pb SHRIMP data distribution of the spot analyses with 2 sigma error ellipses.

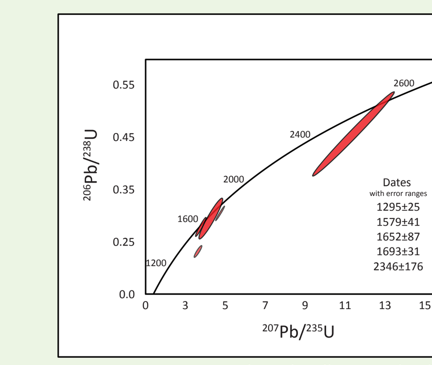


Figure 14. Conventional Wetherill concordia diagram showing various zircon core dates from the U-Pb SHRIMP data distribution of the spot analyses with 2 sigma error ellipses.

Discussion

Two samples from the same dike, although variably deformed, yielded similar dates well within error of each other providing the dike age of circa 50 Ma (Figs. 10 & 12). This age offers the southeastern most constraint on deformation within the PRC. Stevens (2015) determined that Eocene magmatism within the PRC was a response to uplift and exhumation, and that is likely the case with the Tubbs Hill dike. That also means this dike was emplaced synkinematically like the Silver Point pluton, which shows chlorite microbreccia overprinting mylonitic fabrics (Fig. 1; Rhodes and others, 1989) near the en echelon step over in the Newport Fault (Doughty and Price, 1999). Some zircon cores from 15NW1THD yielded significantly older igneous dates than their rims (Fig. 14; 1295±25 to 2346±176) suggesting the cores were scavenged from older rocks below Tubbs Hill. One zircon core yielded a date of 1579±41 (MSWD=0.58) that is within the North American Magmatic Gap (1610-1440 Ma), which is an interval of geologic time not widely represented in the region.

Conclusions

- Tubbs Hill dike was emplaced circa 50 Ma and emplacement was likely initiated by regional uplift and exhumation.
- Some zircon cores found in the Tubbs Hill dike were scavenged from underlying rocks of older and variable age—one of which (1579±41) is within the North American magmatic gap age range.
- The deformed Silver Point pluton (50.13±0.02 Ma) in the northern PRC is the same age as the Tubbs Hill dike (50.1±3.5 and 49.5±1.1 Ma) in the southeastern PRC.
- Deformation continued in the southeastern portion of the PRC until at least 50 Ma.

References

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