Garnet Lu-Hf Geochronology and Geothermobarometry Constrain Pre-Ore Metamorphism in the Au-Sb-W Yellow Pine Mining District

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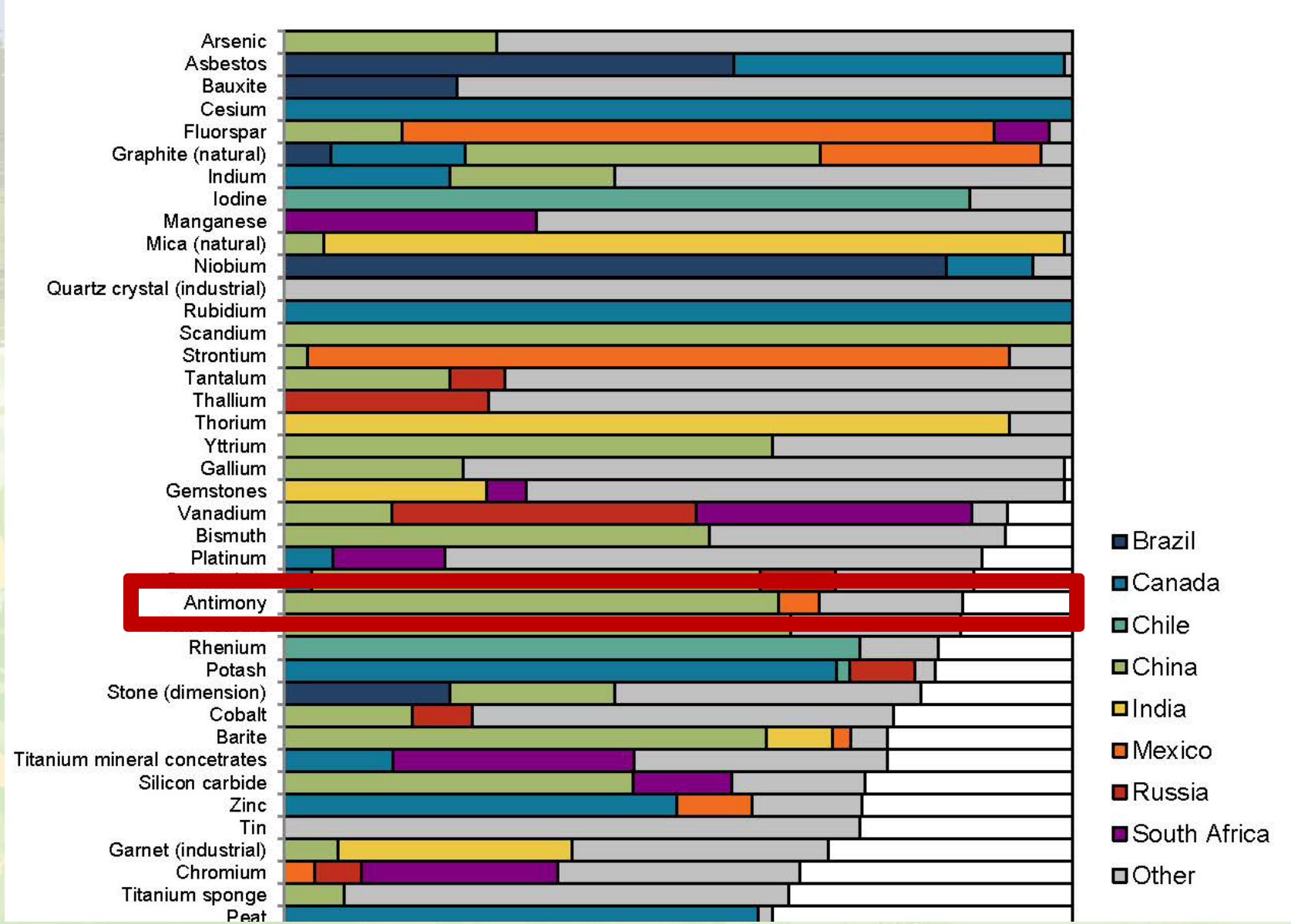
Stibnite is Critical

Stibnite from Wuling Mine in Jiangxi, China

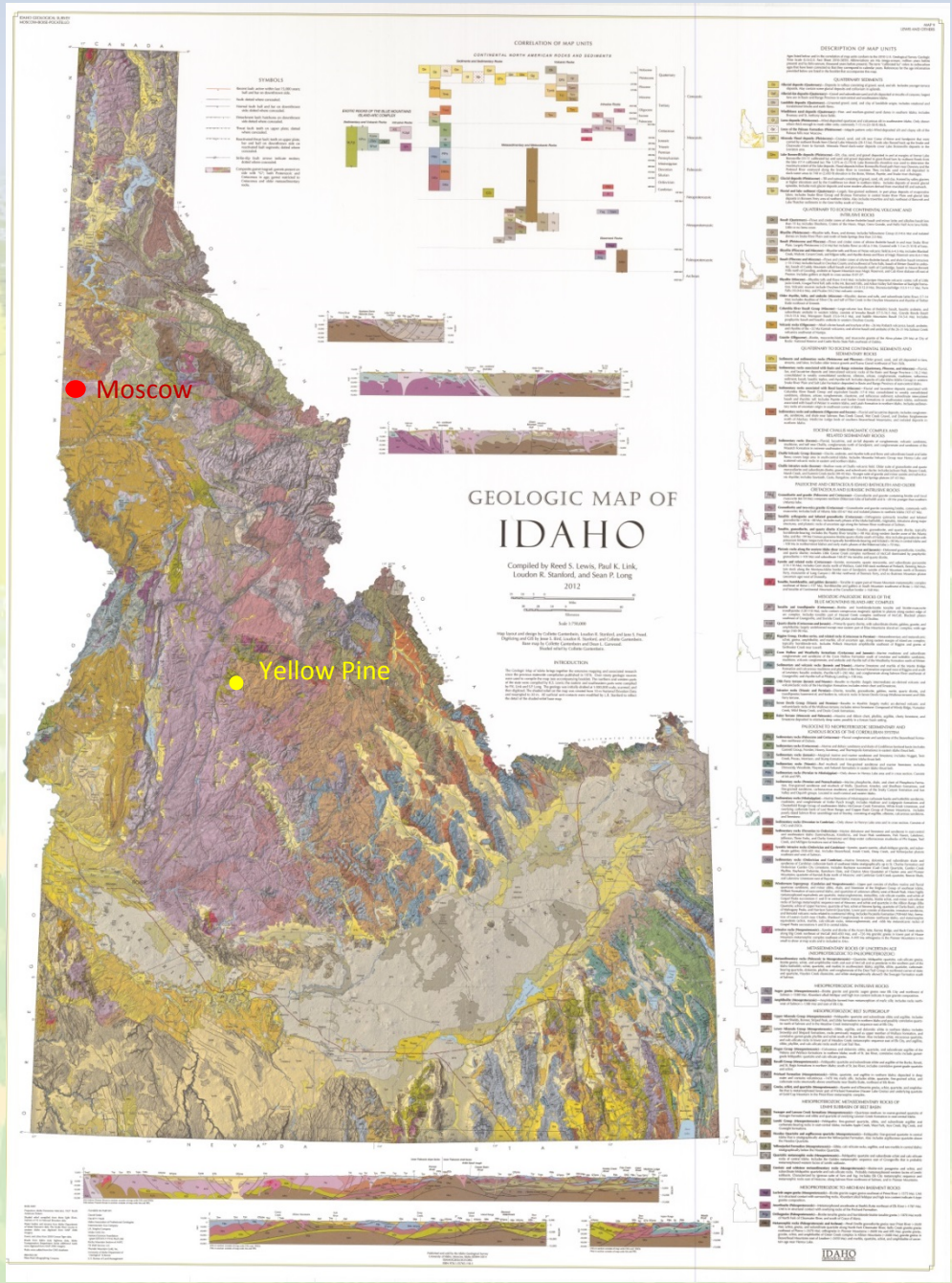
- The Yellow Pine ore deposit contains stibnite.
- Stibnite is the ore mineral for antimony (Sb_2S_3), and is a critical mineral.
- Critical mineral–mineral with a supply chain that is vulnerable to disruption, that serves an essential function in the manufacturing of a product, and the absence of which would cause significant economic or security consequences.

Import Reliance



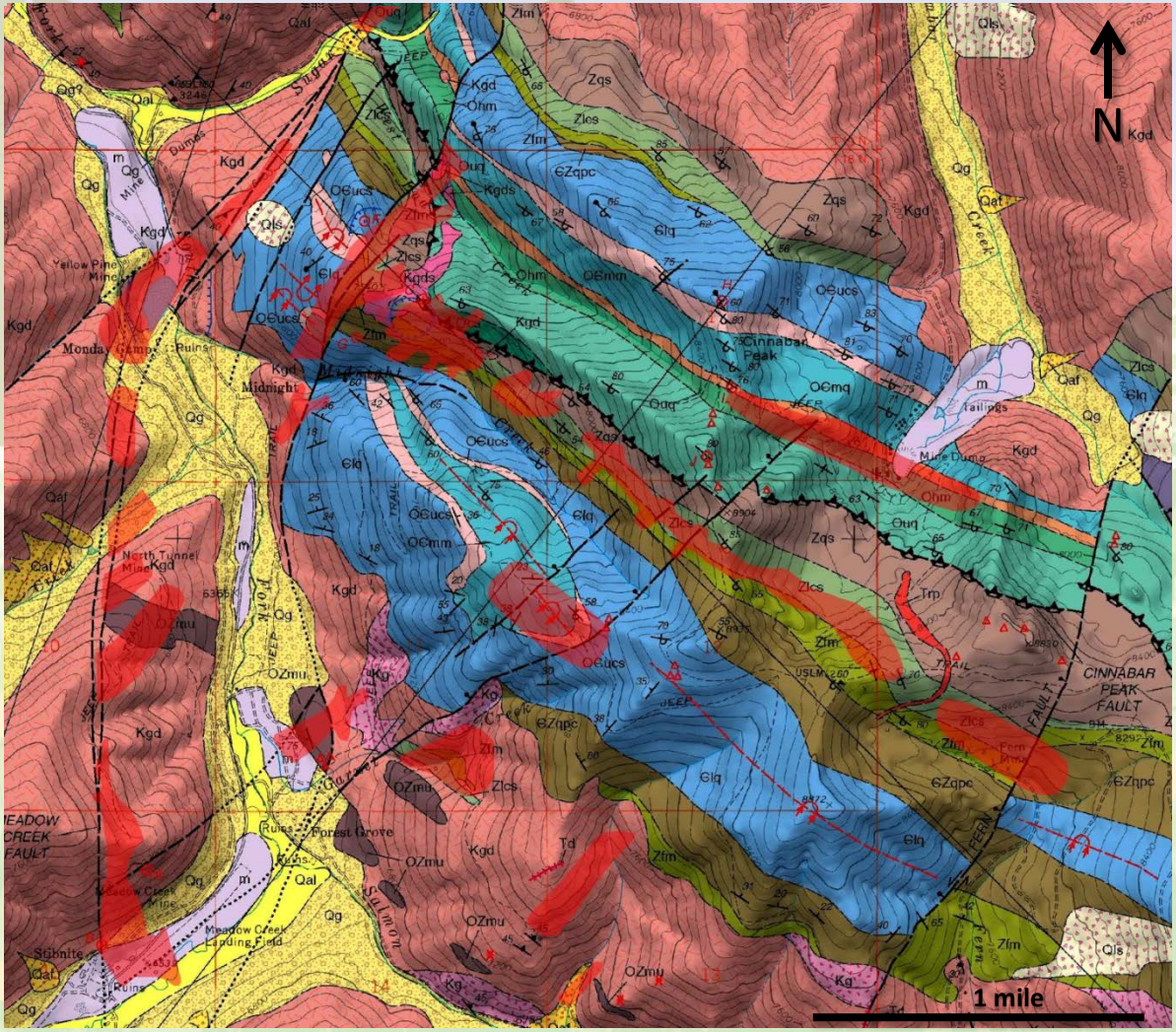
Importance of Yellow Pine Deposit

- Largest antimony-bearing deposit in the United States
- Important to understand our country's resources as much as possible to mitigate any potential supply disruption
- Opportunity to gain a better overall understanding of antimony-bearing deposits

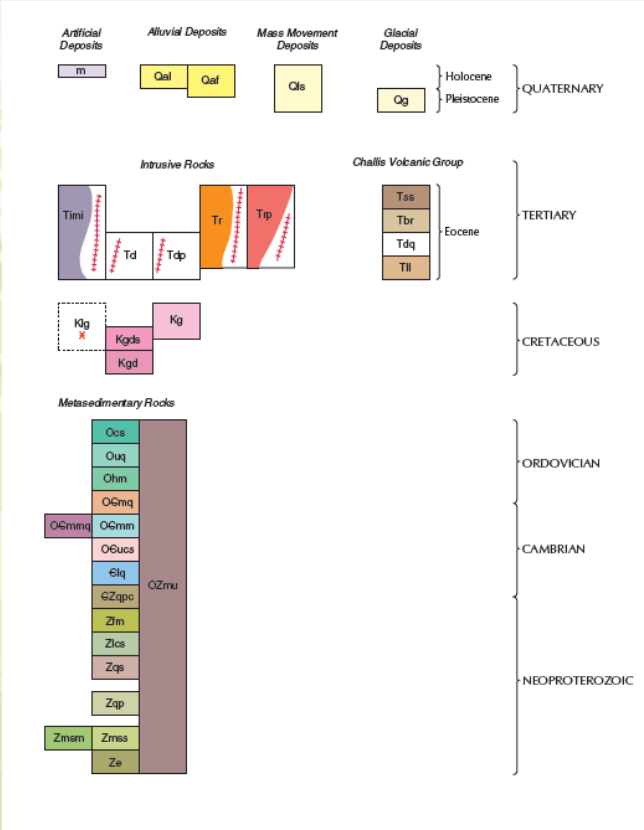


Lewis, R.S., Stanford, L.R., and Long, S.P., 2012, Geologic Map of Idaho: Idaho Geological Survey, geologic map 9, scale 1:750,000.

Geology of Mining Area

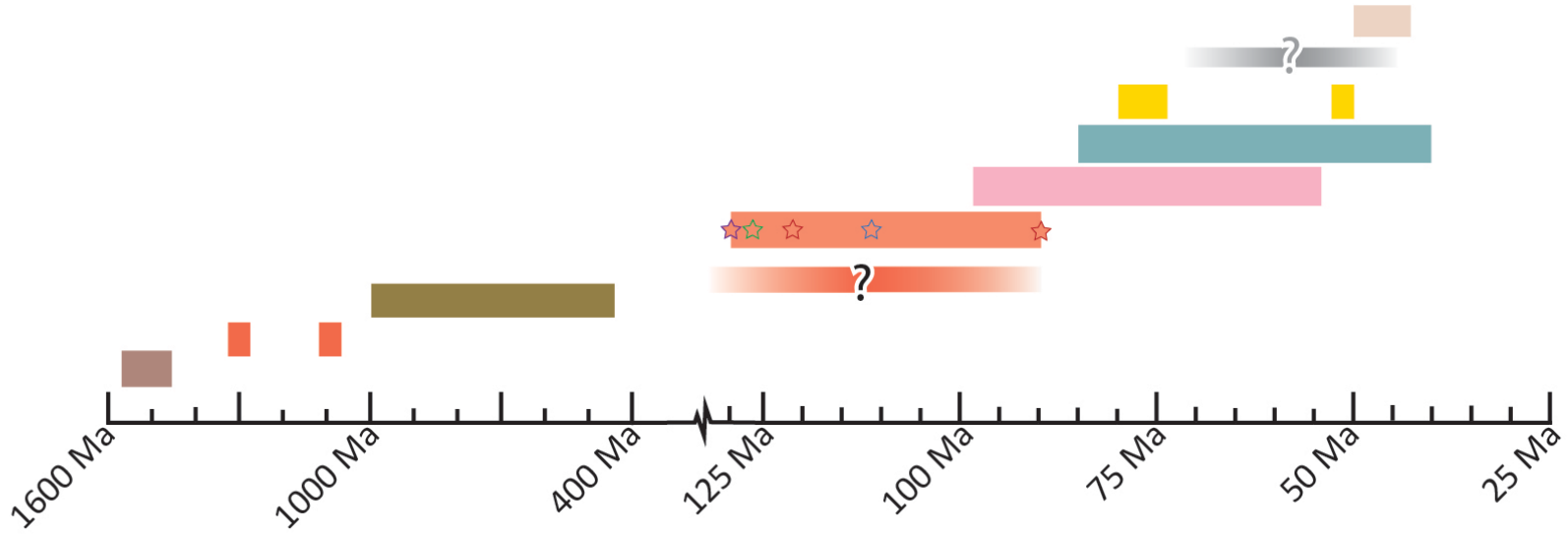


UNITS BY AGE AND TYPE



(Stewart et al., in prep., Geologic map of the Stibnite quadrangle)

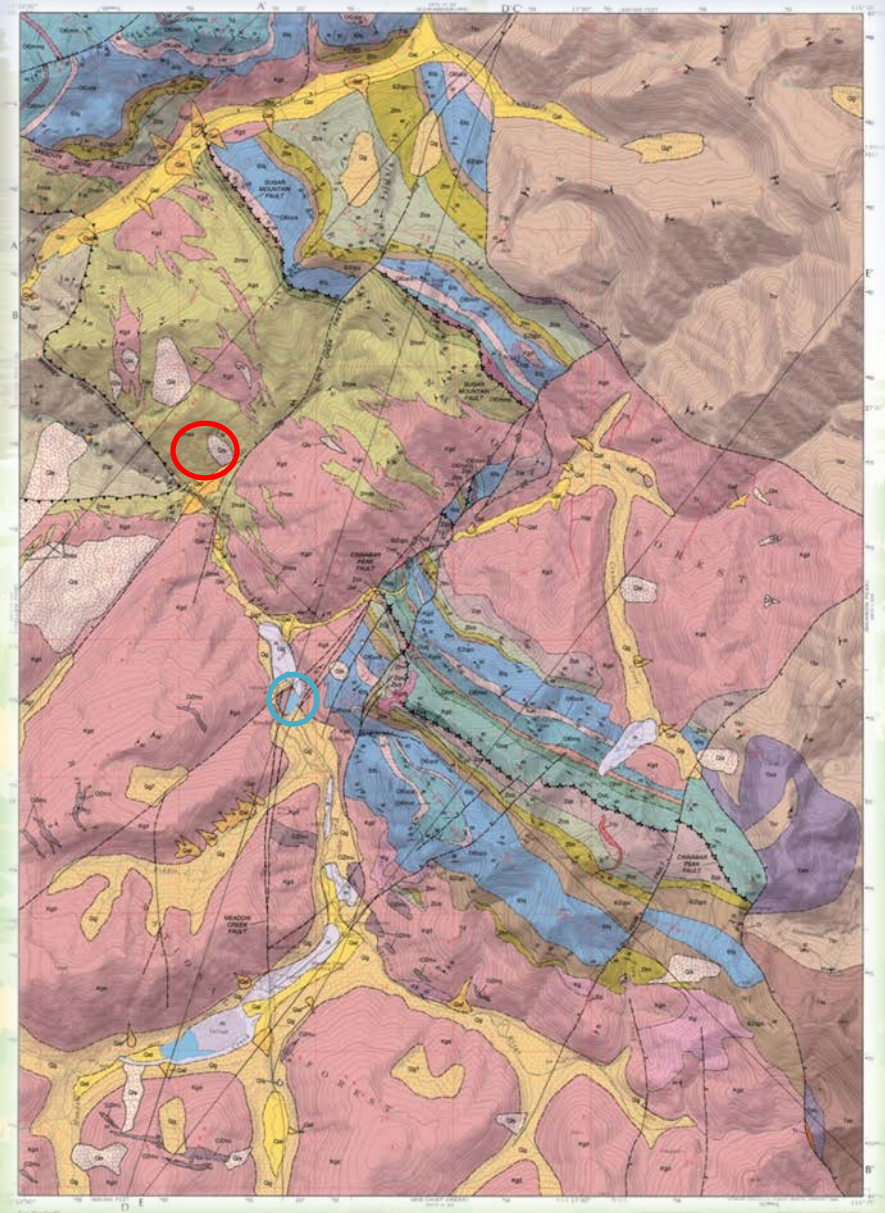
Geologic Timeline Relevant to Yellow Pine Deposit



EXPLANATION

- Belt-Purcell Basin deposition <1576–≤1469 Ma (Meosoproterozoic) Lydon(2007)
- Belt-Purcell Basin metamorphism ~1.3 and ~1.1 Ga (Mesoproterozoic) Zirakparvar and others (2010) & Nesheim and others (2012)
- Windermere deposition local to Stibnite, Idaho 1000–444 Ma (Neoproterozoic to Ordovician) Stewart and others (in prep.)
- Uncertain date of metamorphism local to Stibnite, Idaho
- Salmon River Suture Zone deformation 105–90 Ma (Cretaceous) Giorgis and others (2008)
- Idaho Batholith emplacement 98–54 Ma (Cretaceous) Gaschnig and others (2010)
- Regional uplift 85 to ~40 Ma (Late Cretaceous to Eocene) Giorgis and others (2008)
- Gold mineralization local to Stibnite, Idaho 77.9±0.3 Ma (Cretaceous) Gammons (1988) and/or 51 Ma (Eocene) (Gillerman, 2014)
- Uncertain date of scheelite and stibnite mineralization local to Stibnite, Idaho
- Thunder Mountain caldera complex volcanic suite 50–43 Ma (Eocene) Leonard and Marvin (1982)
- 130 Ma Start of metamorphism in Salmon River Suture Zone from Ar-Ar biotite, hornblende, and muscovite Lund and Snee (1993)
- 128 Ma Peak metamorphism in Salmon River Suture Zone from Sm-Nd garnet Getty and others (1993)
- 122-90 Ma Age range for compression, crustal thickening, transpression, and end of thermal tectonism within Salmon River Suture Zone from Lu-Hf garnet Wilford (2012)
- 112.5 Ma Metamorphism of Rapid River Plate within Salmon River Suture Zone from Sm-Nd garnet McKay (2012)

Sample Location and Samples

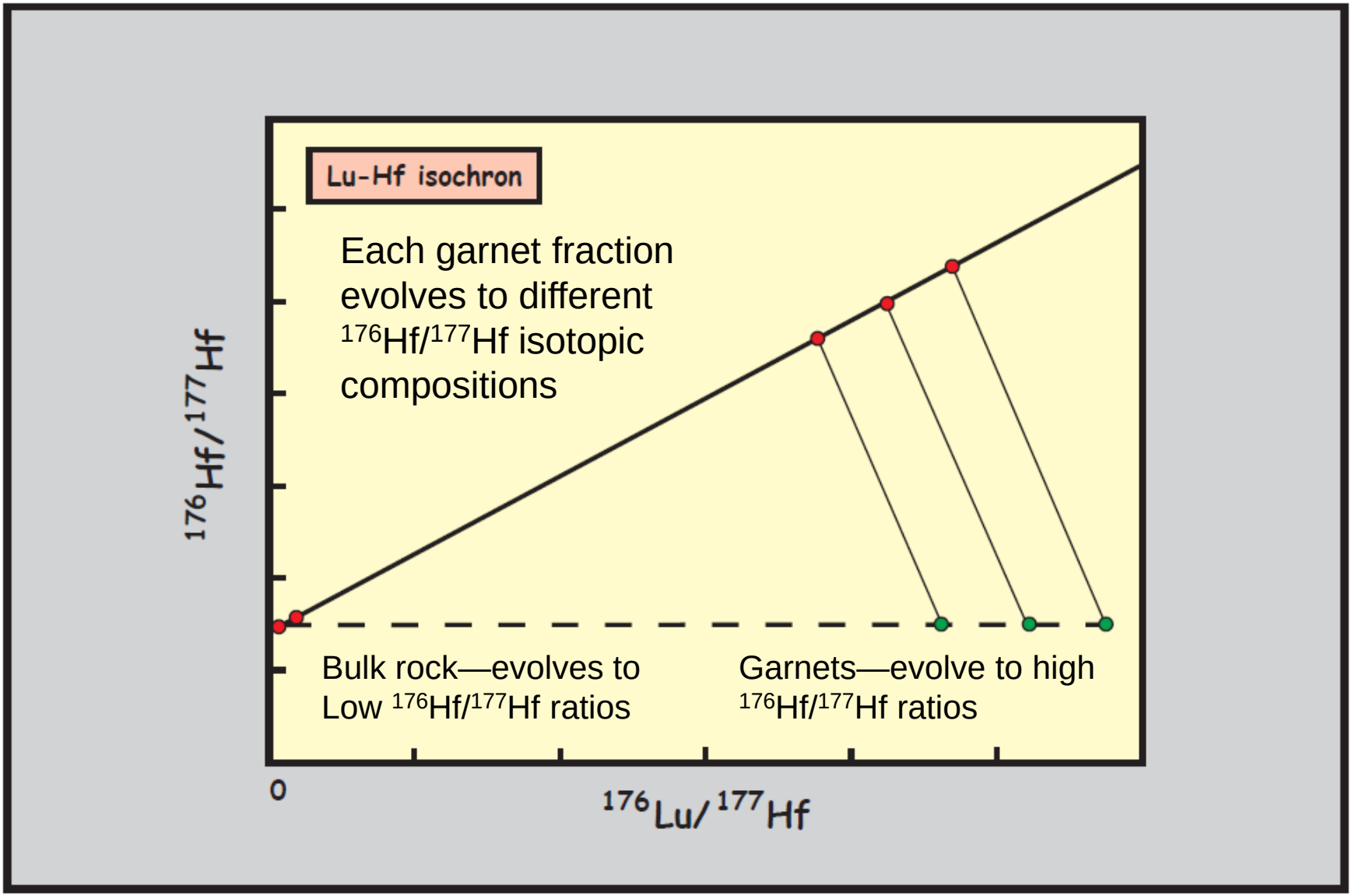


(Stewart et al., in prep.)

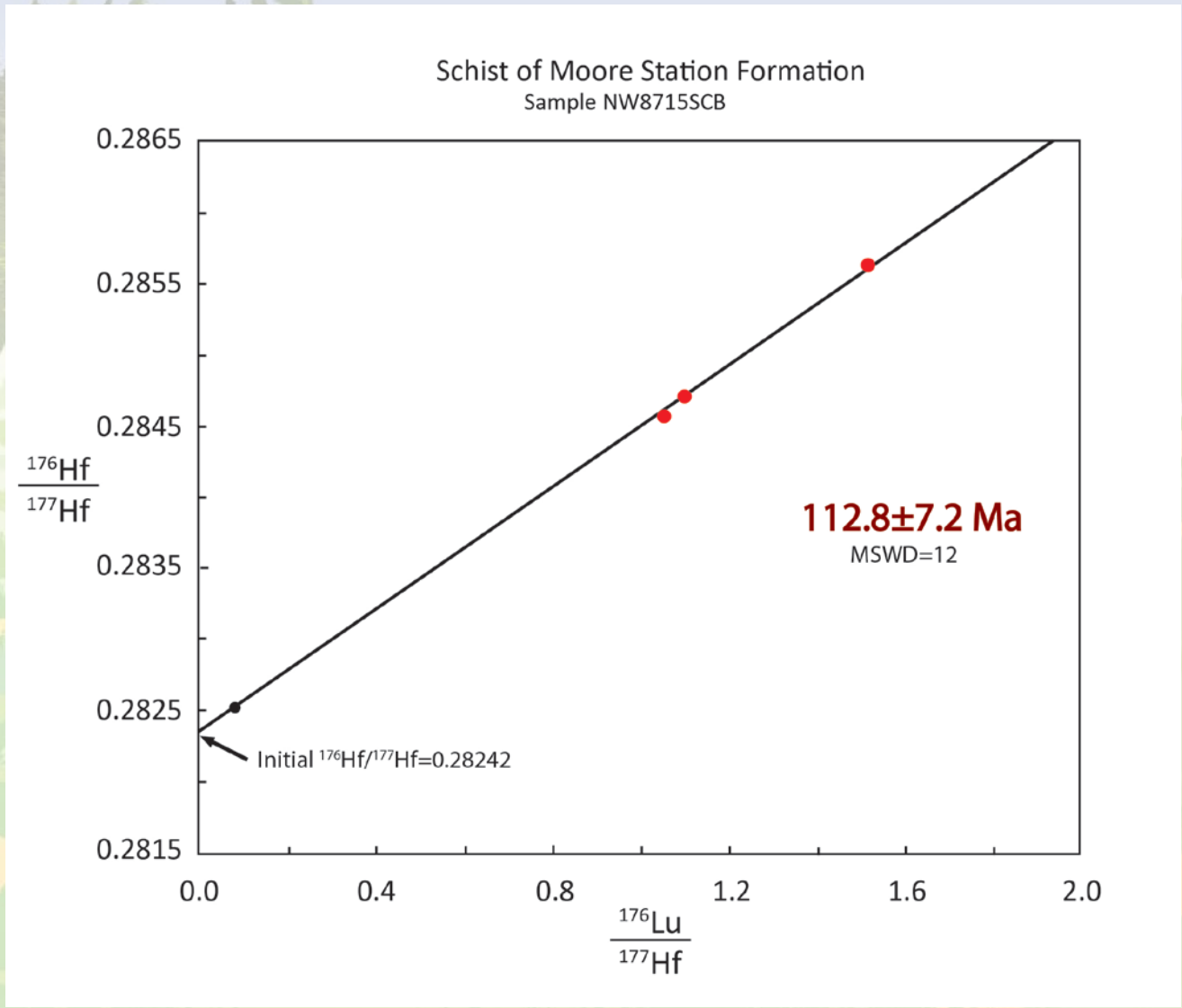
Biotite-garnet schist; foliated and lineated

Garnetiferous aplite dike with minor biotite; not foliated or lineated

Ideal Garnet Lu-Hf Isochron



Garnet Lu-Hf Date



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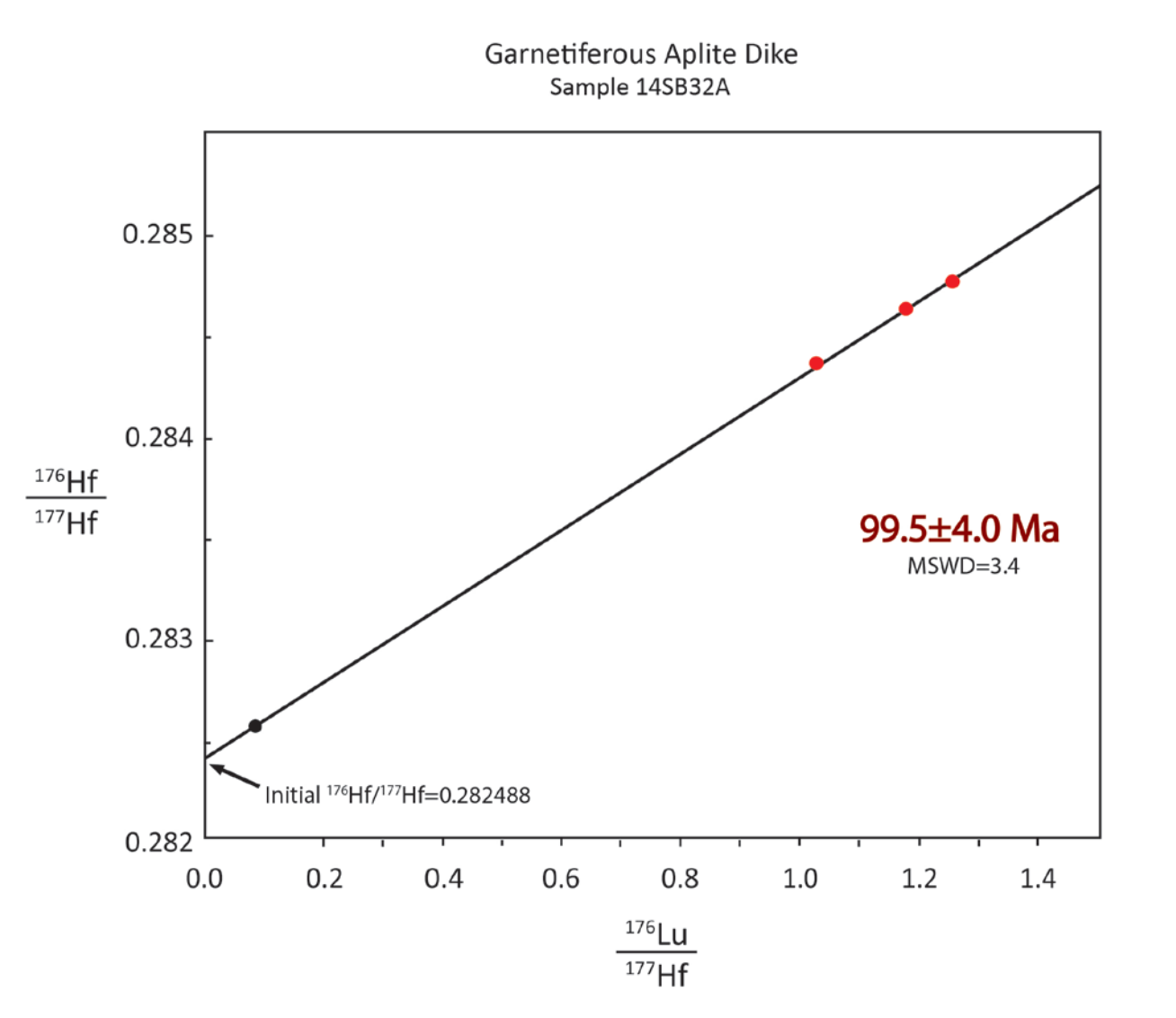
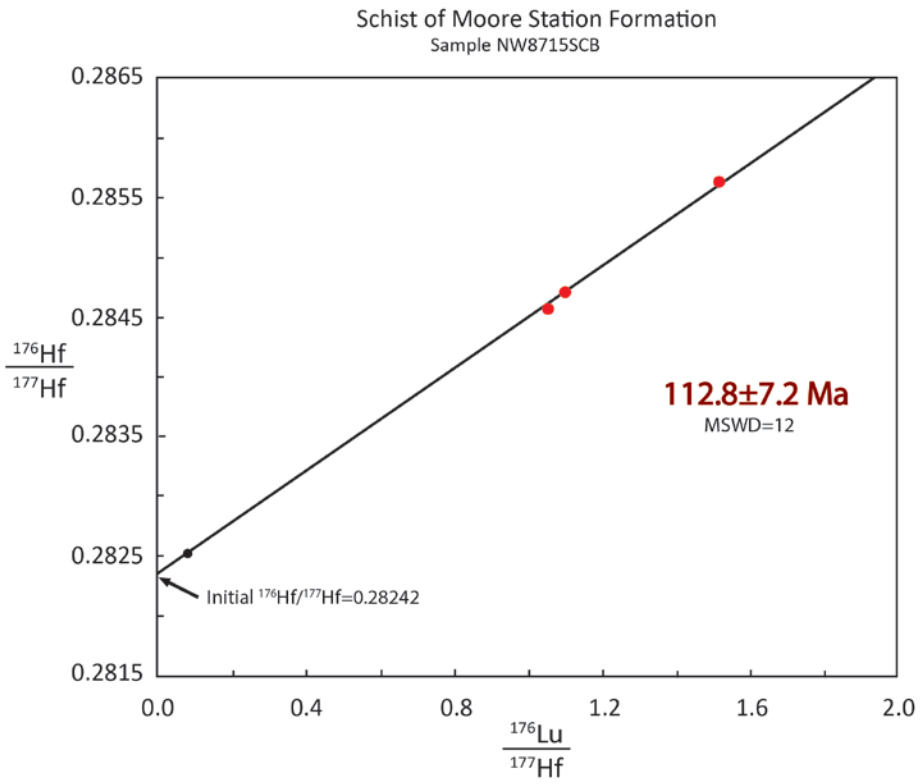
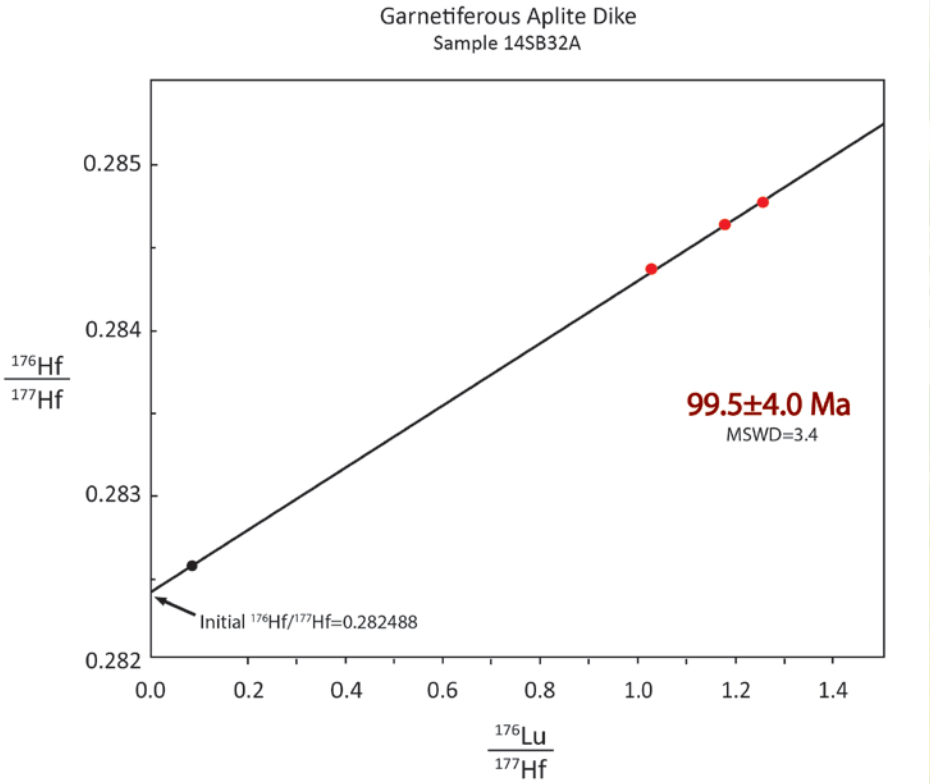
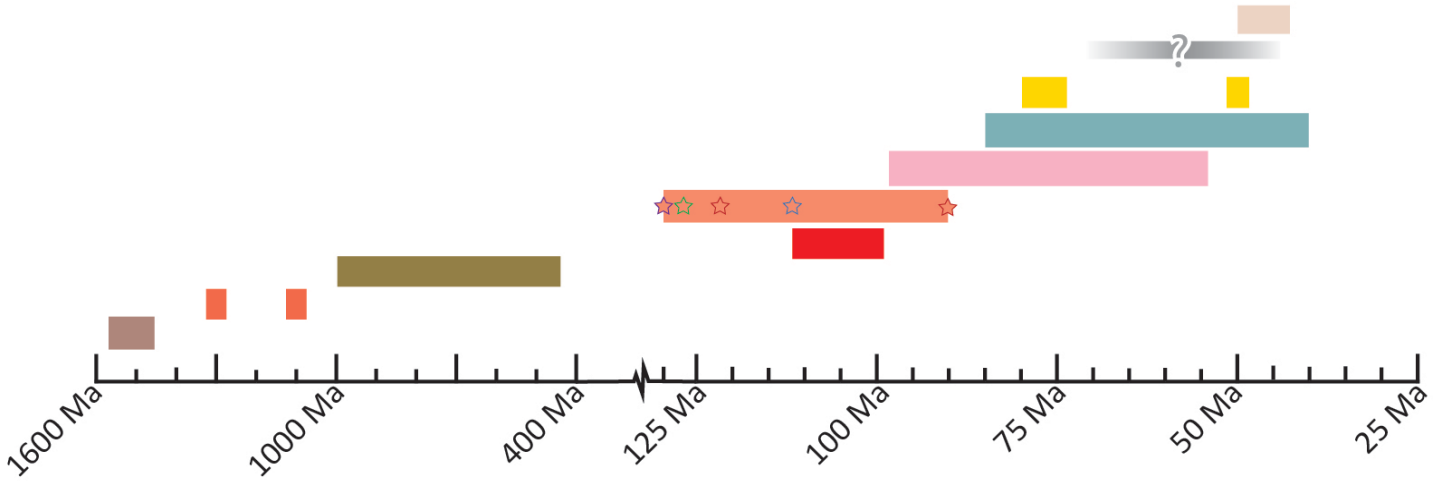


Garnet Lu-Hf Dates





Geologic Timeline Relevant to Yellow Pine Deposit



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- Metamorphism local to Stibnite, Idaho 112.8±7.2–<99.5±4.0 Ma (Cretaceous) This Study
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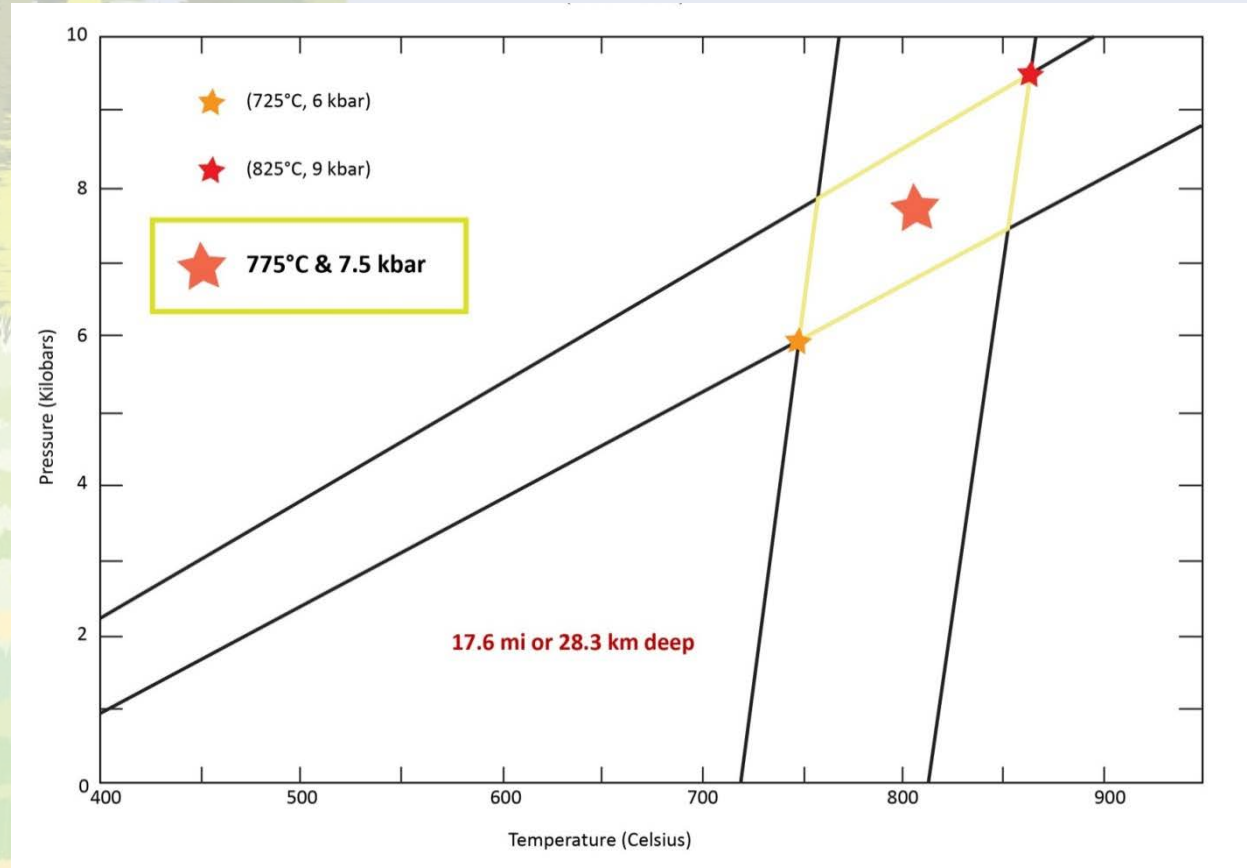
Geothermobarometry

Schist of Moores Station Formation (112.8±7.2 Ma)



Ten pressures and ten temperatures were calculated and the mean of those pressure and temperature ranges is presented here. The GASP (garnet-aluminosilicate-silica-plagioclase) geothermobarometer was used with fibrous silimanite as the aluminosilicate. Pressures and temperatures were determined using the software GTB (available free at: http://ees2.geo.rpi.edu/metapetaren/software/gtb_prog/gtb.html).

Element Map of Analyzed Garnet

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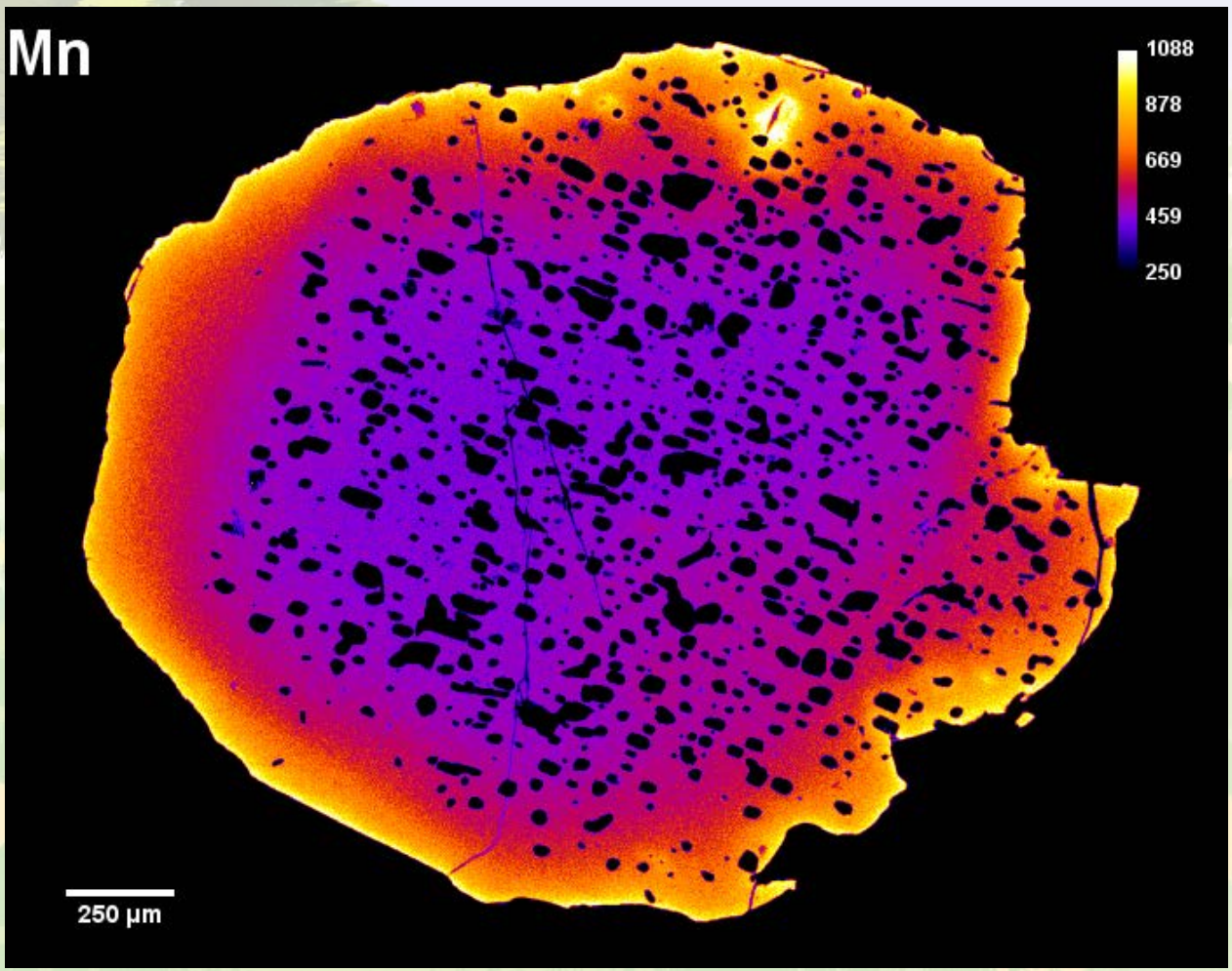
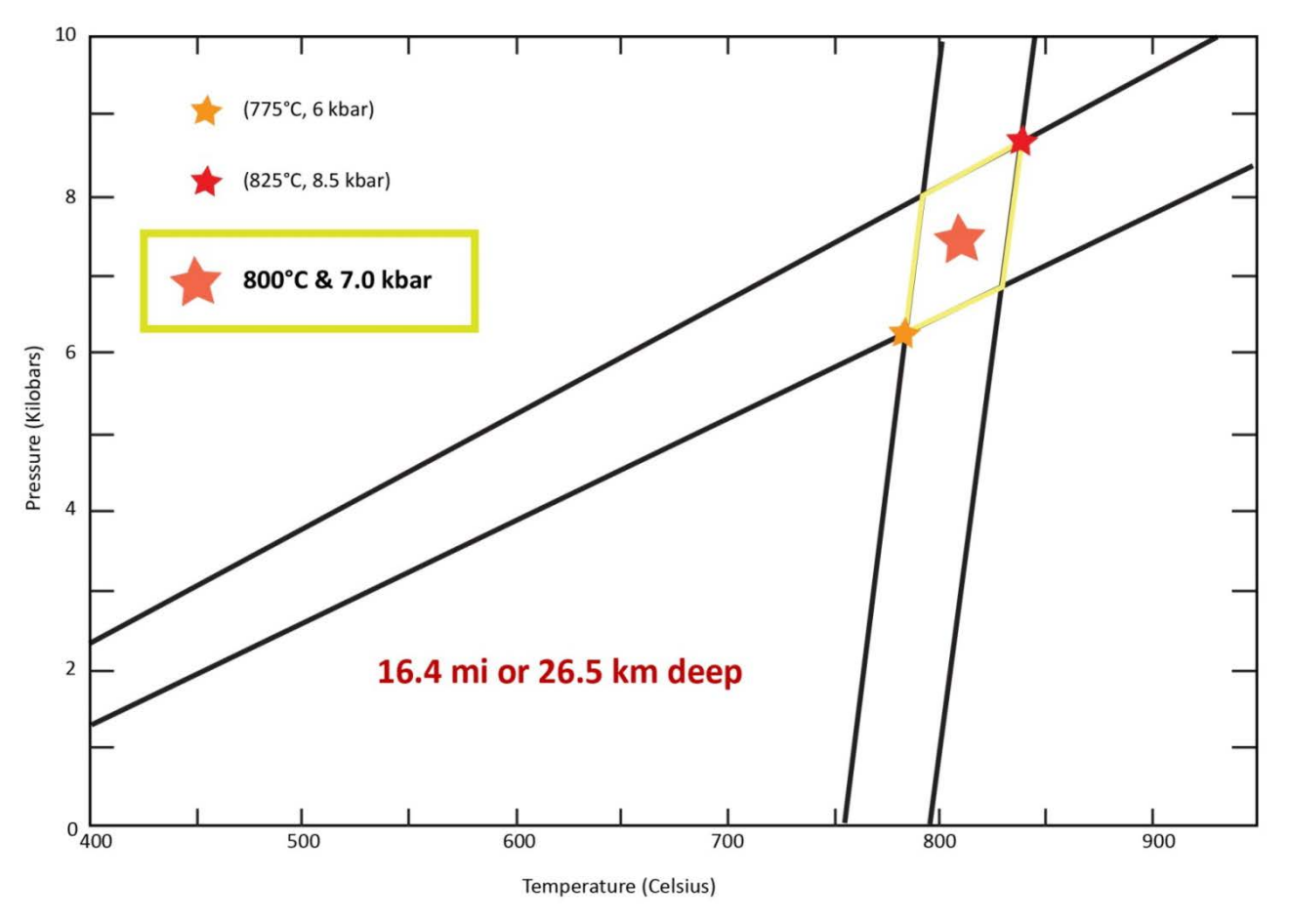


Geothermobarometry

Garnetiferous Aplite Dike (99.5±4.0 Ma)



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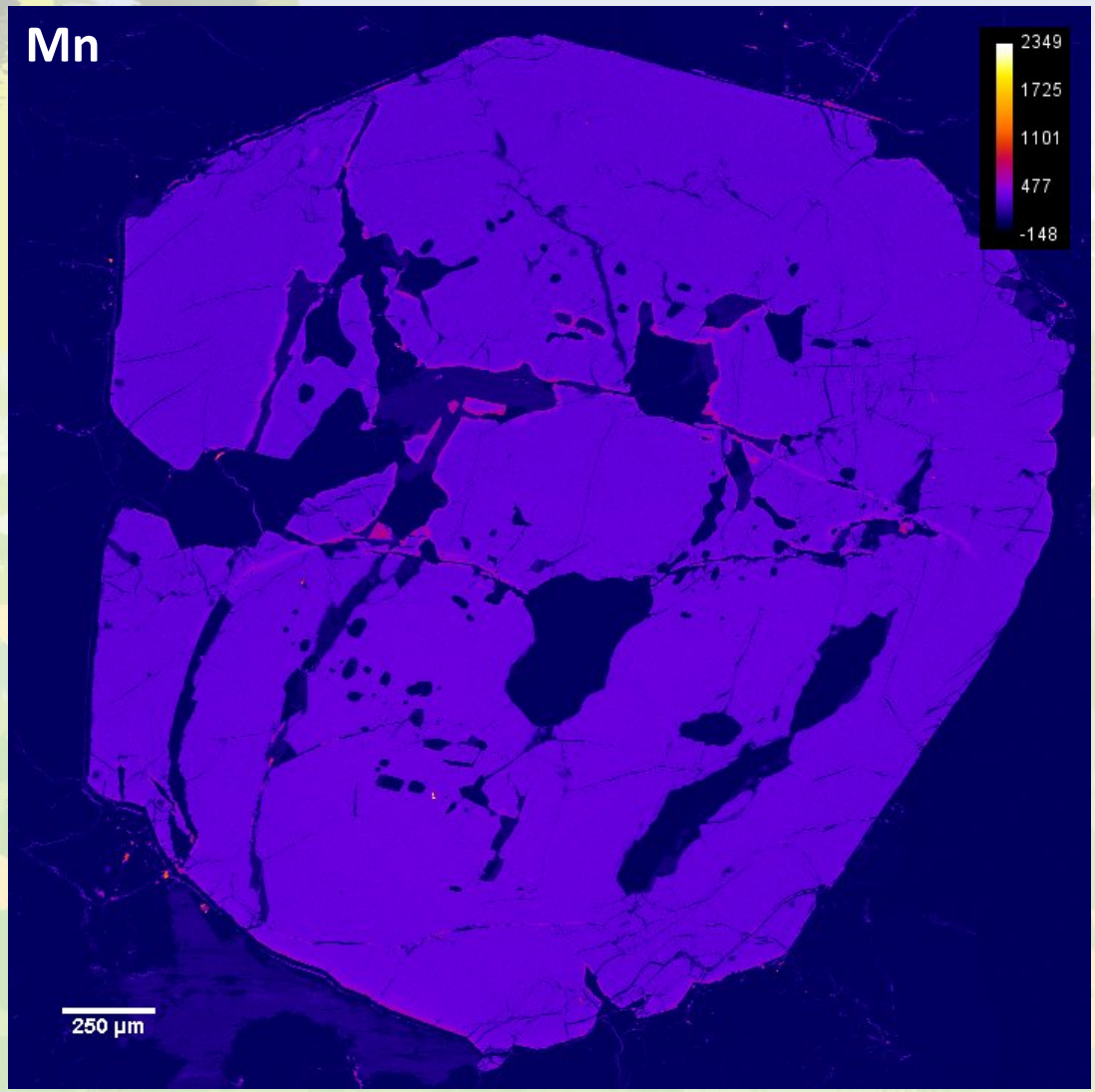

Summary

- New Constraints:
  - Age of pre-ore metamorphism (112.7-99.5 Ma).
  - Pressures of 7.5 to 7.0 kbar indicates depth of formation between 17.6 and 16.4 miles deep (28.3 to 26.5 km).
  - Temperature of 775 °C indicates upper amphibolite-facies metamorphic temperature.

- Regional Context:
  - Timing fits with Salmon River Suture Zone metamorphism and deformation.
  - Timing also fits with the Sevier Orogeny (140-50 Ma).

- **What to Remember:**

  The Cretaceous metamorphic age of the Stibnite roof pendant provides a long-overdue, first-order constraint and regional context for the comprehensive geologic story of the Yellow Pine Au-Sb-W ore deposit.

Questions?

Acknowledgments

I whole-heartedly thank:

- Christopher Dail for his professional collaboration and Samuel Field for his assistance on the mine property.
- Diane Wilford and Charles Knaack for their expert leadership and assistance in the clean lab and with the Neptune.
- Dr. Owen Neill for use of the electron probe microanalyzer at Washington State University.
- Cassandra Hennings for this beautiful and thematically-appropriate background illustration.