Montana – A Sapphire Anomaly

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Montana has produced at least 350 million carats (70 tonnes) of sapphires, but the four surrounding states and three provinces have had no significant production. Why?

Assortment of natural sapphires (unheated) from the Rock Creek sapphire district selected to show the variety of colors. Largest sapphire is 10 mm and most are between 2 and 3 carats. Sapphire provided by Catherine McDonald and photographed by Pete Knudsen.

Typical sapphires from the South Fork of Dry Cottonwood Creek. Average size approximately 5 mm.

Sapphire in Yogo dike.

Sapphire in French Bar sill. Note thin biotite reaction rim.

Sapphire Deposits and Occurrence

Alluvial

Rock Creek sapphire district
- Historic Production – 65 tonnes
- Inferred bedrock source – Rhyolite flows
- Age of bedrock source – 50.20 ± 0.43 Ma (Berg, 2014).

South Fork of Dry Cottonwood Creek and Butte area
- Historic Production – Probably only 0.1-0.2 tonne
- Bedrock source – Lowland Creek Volcanics (Berger and Berg, 2006 and Berg, 2007).
- Age of bedrock source – Eocene

Missouri River deposits
- Historic production – Probably greater than 4 tonnes
- Bedrock source – Unknown, but probably dikes or sills
- Age of bedrock source - Possibly Tertiary

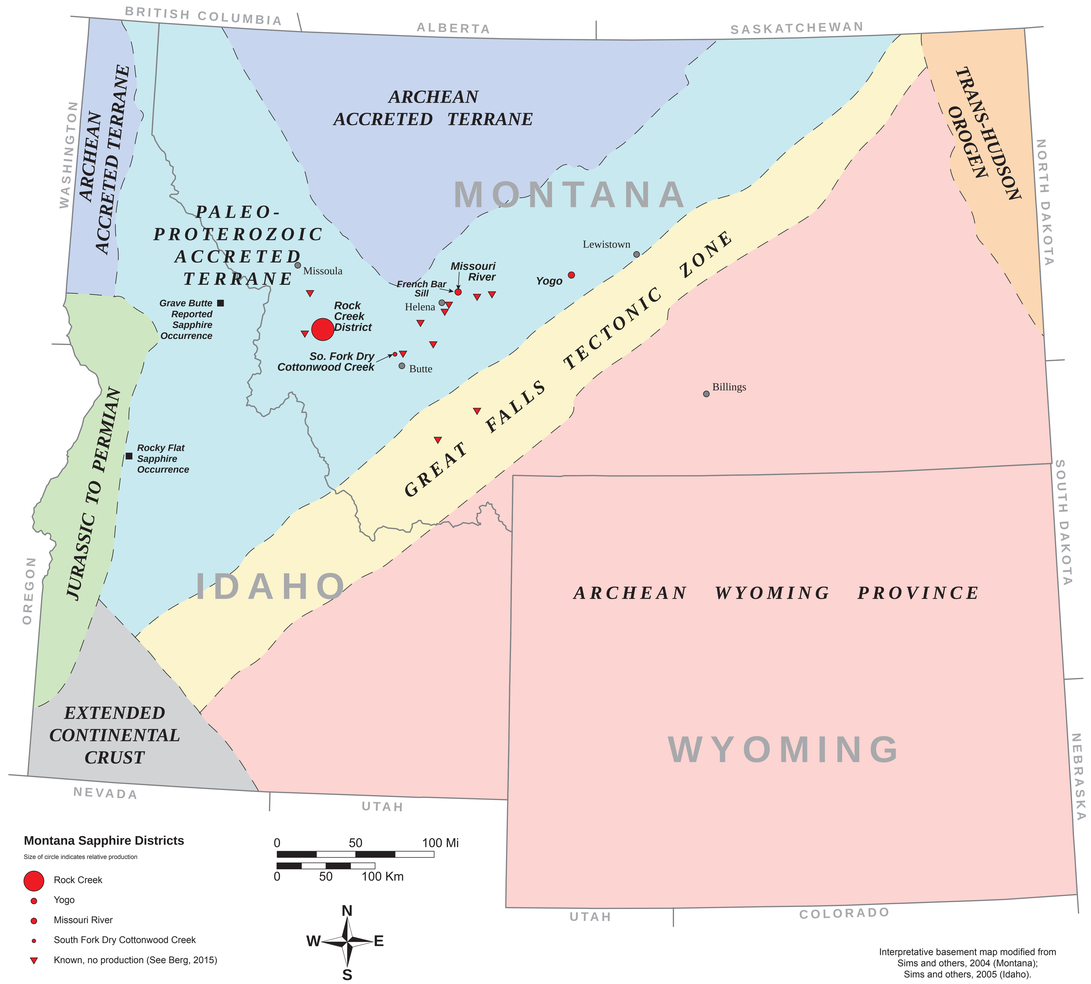
Bedrock

Yogo Dike
- Historic production – 3.6 tonnes (Michaluk, 1995)
- Source – Ouachitite dike
- Age – 48.66 ± 0.06 Ma (Harlan, 1996).

French Bar Sill
- Historic production – Essentially none – Only sparse sapphire xenocrysts
- Source – Basaltic trachyandesite
- Age – 50.8 Ma (Irving and Hearn, 2003)

Origin

Guliani and others (2015) have shown that $\delta^{18}O$ values can be used to differentiate between magmatic and metamorphic sapphires. Sapphires from the Rock Creek district and the South Fork of Dry Cottonwood Creek have $\delta^{18}O$ values less than 7‰, within the range of metamorphic sapphires (Berg and others, 2008). In addition mineral inclusions in sapphires from these districts are indicative of a metamorphic origin (Berg, 2007 and 2014).



Interpretative basement map modified from Sims and others, 2004 (Montana); Sims and others, 2005 (Idaho).

Conclusions

1. Montana sapphires have been brought to the surface by Eocene volcanism.
2. The major Montana sapphire districts are related to the Paleoproterozoic accreted terrane and not the Archean Wyoming Craton. However non-gem corundum deposits occur in the Archean Wyoming Craton in southwestern Montana.

Speculation

Metamorphism in either the lower crust or lithospheric mantle of sediments in the accreted terrane produced corundum of the gem variety.

Problem

If Eocene volcanism and the accreted terrane were the only controls on the formation of sapphire deposits, there should be significant deposits in eastern Idaho. The accreted terrane extends into Idaho and there is abundant Eocene volcanism as evidenced by the Challis Volcanics. Apparently no significant sapphire deposits have been recognized in this area of Idaho. However sapphires occur in Adams and Valley Counties in western Idaho at Rocky Flat (Beckwith, 2003, p. 66-70). Gem-quality corundum reportedly occurs in the Grave Butte area in Idaho County (Eckert, 2000, p. 28).

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