A common origin for Thai/Cambodian rubies and blue and violet sapphires from Yogo Gulch, Montana, U.S.A.?

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ABSTRACT

A wide number of genetic models have been proposed for volcanically transported ruby and sapphire deposits around the world. In this contribution we compare the trace element chemistry, mineral and melt inclusions, and oxygen isotope ratios in blue to reddish-violet sapphires from Yogo Gulch, Montana, U.S.A., with rubies from the Chantaburi-Trat region of Thailand and the Pailin region of Cambodia. The similarities between Thai/Cambodian rubies and Yogo sapphires suggest a common origin for gem corundum from both deposits. Specifically, we advance a model whereby sapphires and rubies formed through a peritectic melting reaction when the lamprophyre or basalts that transported the gem corundum to the surface partially melted Al-rich lower crustal rocks. Furthermore, we suggest the protolith of the rubies and sapphires was an anorthosite or, in the case of Thai/Cambodian rubies, an anorthosite subjected to higher pressures and converted into a garnet-clinopyroxenite. In this model the rubies and sapphires are rightfully considered to be xenocrysts in their host basalts or lamprophyre; however, in this scenario they are not “accidental” xenocrysts but their formation is intimately and directly linked to the magmas that transported them to the surface. The similarities in these gem corundum deposits suggests that the partial melting, non-accidental xenocryst model may be more wide-reaching and globally important than previously realized. Importantly, in both cases the gem corundum has an ostensibly “metamorphic” trace element signature, whereas the presence of silicate melt (or magma) inclusions shows they ought to be considered to be “magmatic” rubies and sapphires. This discrepancy suggests that existing trace element discriminant diagrams intended to separate “metamorphic” from “magmatic” gem corundum ought to be used with caution.

Keywords: Sapphire, ruby, Yogo Gulch, melt inclusions, corundum, gemology

INTRODUCTION

Volcanically hosted gem corundum deposits are widespread across the western Pacific margin (eastern Australia, southeast Asia, China, eastern Russia). There are also examples in northeast Russia, France, Slovakia, Africa, Scotland, and North and South America (see references in Giuliani et al. 2014; Hughes 2014; Hughes et al. 2017). They mostly produce sapphires with minor ruby. However, the southeastern Asian nations of Thailand and Cambodia are important major historic producers of rubies [gem-quality corundum (α-Al₂O₃) colored red by Cr³⁺] derived from basalts. While gem production in these areas has declined significantly in recent years, these two countries were major suppliers of gem corundum (especially ruby) during the 20th century. Rubies are found here in alluvial deposits in a region spanning the southern border between Thailand and Cambodia. In Thailand, the gems fields are found in the Chanthaburi-Trat area, while in Cambodia the gem-bearing deposits are in the Pailin region. In both cases, it is generally accepted that the rubies were transported to the surface by young Cenozoic alkali basalt volcanism (<3 Ma, Barr and MacDonald 1981; Surthirat et al. 1994). Yet, it is also accepted that the rubies are xenocrysts within the basalts and were transported from somewhere deep within the Earth. Genetic models for Thai/Cambodian rubies generally suggest they formed through high-pressure metamorphism of (ultra)mafic rocks (Surthirat et al. 2001; Saminpanya and Sutherland 2011). These gemfields have also produced a significant quantity of blue sapphires (gem-quality corundum colored by Fe and Ti), which have distinct inclusion suites and trace element chemistry patterns indicating a different origin than the rubies. The Thai and Cambodian gem fields are generally very similar to other alluvial sapphire deposits associated with alkali basalt fields across the western Pacific margin. The main difference is the generally higher proportion of rubies found in Thailand and Cambodia relative to other major producers of gem corundum like Australia, which produce predominantly blue, green, and yellow sapphires (Graham et al. 2008). This study focuses only on Thai/Cambodian rubies, whereas sapphires from that region are not discussed. While many studies of ruby deposits focus on either the Chanthaburi-Trat area in Thailand or the Pailin region in Cambodia, it is widely recognized that both gem-producing regions are essentially one single deposit straddling the border.

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