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Paragneiss Assimilation in the Genesis of Magmatic Ni-Cu-Co Sulfide Mineralization at Voisey's Bay, Labrador: $\delta^{34}S$, $\delta^{13}C$, and Se/S Evidence

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Abstract

The Voisey's Bay Ni-Cu-Co deposit is located in ca 1.33 Ga troctolitic rocks of the Nain Plutonic Suite, northern Labrador. It is widely regarded as a prime example of sulfide mineralization associated with a magmatic conduit system. Previous geological and geochemical studies have indicated that the Voisey's Bay intrusion was contaminated by interaction with both sulfide-poor Archean gneisses and with Paleoproterozoic sulfide-bearing Tasiuyak metasedimentary gneiss. Limited sulfur isotope data previously indicated that only one of the four ore zones at Voisey's Bay is characterized by $\delta^{34}S$ values outside the range considered normal for uncontaminated, mantle-derived mafic magmas (0 ± 2‰). New S isotope data presented here extends the previously reported range in $\delta^{34}S$ values for the Tasiuyak gneiss from –17.0 to +18.3 per mil, with an average of –1.4 per mil. Assimilation of this sulfur, followed by isotope homogenization in the magmatic system, is consistent with the isotope data from the ore zones, and in line with the wealth of evidence that suggests that interaction with Tasiuyak gneiss was an essential ingredient for ore formation in all the zones. Se/S values of sulfide minerals in the ore zones at Voisey's Bay are also in the same range as those of whole-rock samples from the Tasiuyak gneiss. $\delta^{13}C$ values of both mineralized and nonmineralized parts of the Voisey's Bay intrusion are anomalous (–18.3 to –24.8‰), and similar to values of graphite in the Tasiuyak gneiss. Both S and C contamination of the Voisey's Bay intrusion via diffusive transfer in a fluid phase derived from inclusions and wall rocks are considered unlikely because the area had been subjected to granulite-grade metamorphism prior to emplacement of the Nain Plutonic Suite. Either fractional melting or total fusion of xenoliths is considered a more likely mechanism for S addition to the mafic magma via pyrrhotite melting and for C addition in the form of CO_2 and CH_4 produced by reaction of graphite with O- and H-bearing melt species.