A new tectonic model for the southern Abitibi Belt: factors contributing to a VHMS-rich metallogenic province

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Regional geology
Volcanism in the Abitibi subprovince corresponds to a period of global crustal growth. Geochronological and geochemical data support the presence of an arc as early as 2750 Ma with volcanism terminating at ~2700 Ma. The subprovince has been subdivided into the Northern Volcanic Zone (NVZ) regarded as a coherent unit, and the Southern Volcanic Zone (SVZ) where there is evidence for autochthonous and allochthonous relationships between supra-arc packages.

Three major periods of volcanic activity have been recognised:
1) an early arc phase characterised by calc-alkaline volcanic sequences at the Hurter Mine and Dalaro groups near the northern boundary of the SVZ (2725-2730 Ma)
2) a 2720 and 2707 Ma phase defined by contiguously packages of tholeiites from Kidd Creek though Munro Township to the Stoughton Raquemore assemblage in the west
3) a post-komatiite younger arc phase between ~2710 and 2698 Ma.

The Kidd Creek Volcanic complex
A detailed study of the 10 by 20 km KVC, host to the Kidd Creek VHMS deposit, has revealed abundant compositional diversity.

The lowest portion of the KVC comprises several hundred metres of spinifex-textured komatites and komatitic basalts. These komatites are widely recognised to have been associated with anomalously thickened oceanic crust in a plume-related setting.

The komatites are overlain by a previously unrecognised suite of low-Ti tholeiites (LOTI). These occur adjacent to and intercalated with rhyolites and andesites that comprise much of the footwall stratigraphy to the ore body. The strongly depleted trace element signature of the LOTI requires a highly depleted mantle source similar to that of boninites. Modern analogues of these rocks are typically found in areas of arc initiation.

This is consistent with much of the stratigraphy above the LOTI, which comprises a sequence of primitive arc tholeiites overlain by evolved arc basalts. The presence of the diverse zone mafic flow complicates this idealised model, as it includes basalts with both MORB-like and arc-like affinities.

The Kidd Creek deposit occurs at a point where the stratigraphy changes from plume-related rocks to arc-related ones. Plume activity, although waning in the KVC did not cease with the onset of LOTI (arc initiation) volcanism. This provides strong evidence that interaction of the plume with the subduction zone resulted in plate reconfiguration and the development of a new arc.

The rhyolites that comprise the footwall stratigraphy to the deposit arc interpreted to be the result of melting of extended buoyant lithosphere on the plateau margin, contemporaneous with melting of ultra-depleted mantle to form LOTI. In the context of this model, the KVC rhyolites are the result of crustal extension and melting in buoyant lithosphere integral to the proto-arc setting. As such the Kidd Creek deposit did not result from a unique metallogenic process and formed in a subduction-related setting. The proximity of a mantle plume may have contributed to the high mantle heat flow in the area and the size of the deposit.

Implications for exploration
The revised plume-arc interaction tectonic model for the Abitibi belt presented above provides a new conceptual framework for exploration for VHMS in Archean terranes. The model highlights a number of extensional terranes (proto-arc and back-arc) that are prospective for VHMS and can be recognised by distinctive geochemical criteria.

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