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Magmatic and Metallogenic Evolution of a Greenstone Belt: The Example of the Chibougamau Area, NE Corner of the Abitibi Subprovince, Canada

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Magmatism is a major component of crustal evolution and is paramount to mineralizing processes, as magmas carry metals from the mantle to the upper crust. In addition, magmatic fluids are an important carrier of precious and base metals in many mineralized systems (porphyry deposits, intrusion-related gold systems – IRGS, volcanogenic massive sulphides – VMS). The importance of fluids exsolved from magmas remains a source of much debate for some contexts, such as IRGS and orogenic gold deposits, while the amount of metal transported by magmas, throughout the evolution of greenstone belts, remains to be quantified. Addressing these issues requires (1) regional-scale studies, to evaluate the distribution of magmatic systems with distinct chemical characteristics (including metals and volatiles contents) and to unravel the volume, architecture, and duration of magmatic processes. It also requires (2) deposit-scale investigations to evaluate the processes leading to fluid exsolution and circulation, as well as metal precipitation. To address these issues, we take the example of the Chibougamau area, NE corner of the Neoarchean Abitibi Subprovince (greenstone belt), which is characterized by an abundance of Cu-Au and Au magmatic-hydrothermal mineralizing systems. In the Chibougamau area, metals accumulated during the synvolcanic and syntectonic periods to form porphyry-like and IRGS deposits, respectively. Using geochemical and geophysical methods, the architecture of the crust is addressed, with emphasis on the evolution and duration of magmatic systems. Combining new seismic data (Metal Earth profile) with known stratigraphic, structural, and magmatic records, we propose that the study area originated as normal (i.e., thick) Archean oceanic crust that formed at or before 2.80 Ga and that evolved through terrane imbrication at 2.73-2.70 Ga. Shortening caused rapid burial, devolatilization, and partial melting of hydrated mafic rocks to produce tonalite magmas that may have mixed with mantle-derived melts to produce the tonalite-trondhjemite-diorite (TTD) suite associated with observed Cu-Au magmatic-hydrothermal mineralization. Tonalite-trondhjemite-granodiorite (TTG) suites are most abundant in the Abitibi greenstone belt except in the Chibougamau area, where TTD suites dominate. This and other aspect of the Chibougamau magmatic record (e.g., abundance of sanukitoid plutons) may, in part, explain the fertility of this area for magmatic-hydrothermal mineralizing systems.

Fig. 1. Geologic map of the Abitibi Subprovince showing the distribution of the main lithologies. The map is modified from the Ministère de l’Énergie et des Ressources Naturelles of Québec (MERN), Sigeom data set, and the Ontario Geological Survey (OGS). The projection is UTM NAD83 Zone 17N. Numbers locate the Chibougamau (1) and Chester (2) plutons, as well as the gold-endowed Cadillac-Larder Lake fault zone (3). (From Mathieu et al., 2020, doi: 10.3390/min10030242.)