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Potential Field Imaging of the Pembine-Wausau Terrane Wisconsin-Michigan: Implications for Volcanogenic Massive Sulfide Deposit Exploration

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The Pembine-Wausau terrane represents a major Paleoproterozoic belt of metavolcanic and intrusive rocks that hosts several volcanogenic massive sulfide (VMS) deposits including the Back Forty deposit. The island-arc complex accreted to the continental margin of the Superior craton along the Niagara fault zone during the Penokean orogeny and was subsequently intruded by syn- to postorogenic granitoids. Limited outcrop makes bedrock mapping difficult. In addition, Phanerozoic sedimentary rocks cover the eastern extent of the belt. A high-resolution aeromagnetic survey over parts of the Pembine-Wausau terrane was conducted to better understand the geology and potential mineral resources. The data were collected along north-south flight lines spaced 150 m apart at a nominal height of 80 m. These data, along with in-fill gravity stations and targeted new radiometric age dates, help improve our understanding of the VMS potential.

The complete Bouguer gravity anomaly map shows a west-northwest trending linear high that correlates with mapped mafic-ultramafic rocks along the Niagara fault zone delineating the northern extent of the Pembine-Wausau terrane. A moderate-amplitude high continues south for about 15 km where a strong east-west trending gradient is observed. The gradient can be traced more than 150 km to the west, and most known VMS deposits occur north of it. Gravity anomaly lows south of the gradient correlate with felsic volcanic rocks of the Beecher Formation, which hosts the Back Forty deposit. New zircon U-Pb age dates indicate that rhyolite in the Beecher Formation was deposited at 1835.9 ± 4.5 Ma, significantly younger than the ca. 1870 Ma age for VMS deposits in the belt. The Back Forty deposit occurs on the northern edge of a gravity high that continues for more than 25 km to the south. A previously unmapped granitoid at the southern extent of the gravity high has been dated at 1837.3 ± 3.7 Ma.

The reduced-to-pole magnetic anomaly map shows detailed changes in rock magnetization. North-south-trending magnetic lineaments interpreted as dikes are observed near the Back Forty deposit. The dikes appear to be truncated at the strong gravity gradient, indicating a significant change in magmatic setting across the gradient. Several low-amplitude magnetic highs with diameters around 1 to 4 km are observed around the Back Forty deposit. Field observations indicate that the anomalies are sourced in previously unmapped granitoids that may have been the heat source for VMS formation. East-northeast-trending lineaments highlighted with the tilt derivative align with mapped fold axes in the volcanic rocks that presumably overlie the heat source. A high-amplitude magnetic anomaly over the granitoids to the south of the district indicates significantly greater magnetite content than in the granitoids in the district. The granitoids to the south are separated from the granitoids in the district by east-west- to east-northeast-trending tilt derivative lineaments that are interpreted to delineate a shear zone. Taken together, the geophysical data and the new radiometric age dates suggest VMS potential south of the gravity gradient that is younger than the ca. 1870 Ma age of VMS deposits in the Pembine-Wausau terrane.