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Volcanic Sequence and Alteration at the Parys Mountain Volcanic-Hosted Massive Sulfide Deposit, Wales, United Kingdom: Applications of Immobile Element Lithogeochemistry

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Abstract

Lenses of massive Zn-Pb-Cu sulfides at the Parys Mountain deposit in Anglesey, northwestern Wales, occur at and near the contact between Ordovician shales and overlying rhyolites. The rhyolites, which have been dated as Lower Silurian (Parrish, 1999), have a thickness of a few hundred meters and are overlain by Lower Silurian shales. The rhyolites and shales strike northeasterly for 2 to 3 km and dip to the north. Minor basalts are present but there are no intermediate rocks. Cu-bearing stockwork veins occur in the upper portion of the Ordovician shales, and Cu-bearing mineralization was mined from the Lower Silurian shales in the 18th century. Precambrian basement rocks are present to the south and north of Parys Mountain.

Application of immobile element lithogeochemical techniques to >1,000 drill core and outcrop samples allows division of the rhyolites into five main chemical types (A, B, C, D1, and D2), the shales into three main types, and the mafic rocks into two types. The distribution of these units has been mapped across the property. Where individual volcanic chemical units have lateral continuity, they are considered to represent singular geologic events and thus are time markers. Correlations based on volcanic facies alone are of limited use, because a chemical unit can pass laterally through different volcanic facies, whereas in strongly altered zones the original volcanic facies cannot be recognized at all. The chemostratigraphic units, on the other hand, can be traced through even the most altered zones. Consequently they provide an improved means of correlating volcanic units on local to property scales.

The first volcanic rocks to accumulate above the Ordovician shales were thin flows and volcaniclastic beds of rhyolite B and a laterally adjacent lens of largely massive rhyolite C. The main massive sulfide lenses in the western part of the property are associated with these volcanic events. These units were covered by thick flows of rhyolite A in the western part of the property. Rhyolites D and A are the main chemical types in the eastern part. Rhyolite D has two subtypes: D1 is generally massive and flow banded, whereas D2 is pyroclastic. It is suggested that rhyolite D1 was erupted first, followed by less fractionated rhyolite D2, which was the last volcanic event prior to the accumulation of the Silurian shales. The main vents for rhyolite A in the west and D in the east were separated by about 1 km.

The alteration minerals at Parys Mountain are sericite, chlorite, quartz, pyrite, and Fe-bearing carbonates. Mass changes calculated for the rhyolites and the shales show a general property-scale increase in alteration in the downdip direction. FeO and MgO additions of up to 10 and 20 wt percent, respectively, are present in footwall shales up to 50 m below the massive sulfide lenses (in areas where stockwork veins are present). Similar FeO and MgO gains occur in rhyolites up to 50 m above the ore lenses. In rhyolites with Fe + Mg gains, Si and K have generally been lost. In areas lateral to the massive sulfides, shales and rhyolite B have gained large amounts of silica.

Most Parys Mountain rhyolites have moderately high Nb contents and slightly inclined rare earth element (REE) patterns, whereas the basalts are enriched in the high field strength elements (HFSE) including the light REE. The primary geochemical features of the volcanic rocks, together with regional geologic relationships in northwestern Wales, suggest that volcanism occurred during intraplate rifting of a small marine basin, which was underlain by Precambrian continental crust. The small volumes of all rhyolite types (and basalt) at Parys Mountain suggest that they were derived from small, discrete pods of magma, which were tapped by basement faults. Most of the massive sulfides accumulated immediately before, and during, the first outpourings of rhyolitic lava.