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Critical metal deportment of Caledonian-Appalachian volcanogenic massive sulphide (VMS) deposits and implications for deposit- and orogen-scale ore-forming processes

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Volcanogenic massive sulphide (VMS) deposits are hydrothermal (and magmatic) submarine deposits preserved on land during orogens. They are major sources of base and precious metals and have been mined for over a thousand years. While historical production from VMS deposits has focused on zinc, copper, lead, gold and silver, VMS can contain significant amounts of critical metals as potential by-products. Despite this, metals such as tin and cobalt have only been mined from a few deposits [1,2], and critical metal endowment of the majority of VMS deposits is unknown. With the drive to increase critical metal resources during the energy transition, the potential of polymetallic VMS deposits as a viable economic resource for many critical metal by-products is considerable.

The Caledonian-Appalachian orogenic belt extends from Norway, through Ireland and the northwestern United Kingdom, and to northeastern Canada and the USA. It formed from the progressive closure of the Iapetus Ocean during Late Cambrian to Devonian and hosts countless VMS deposits. In Canada, these include some of the world's largest VMS deposits, and those with the highest percentage metal globally. Despite its comparable geology, in the British and Irish Caledonides only a handful of VMS deposits have been discovered and only two deposits mined at Avoca (Ireland) and Parys Mountain (Wales). This disparity in regional metal endowment across the orogenic belt is striking and unexplained. Furthermore, fundamental processes controlling critical metal enrichment and fertility in these systems is poorly understood.

We present first-stage results of detailed LA-ICP-MS and geochemical maps of the critical metal endowment of sample suites from multiple Newfoundland and United Kingdom VMS deposits. Initial deposit-scale comparison of both world-class and smaller, sub-economic systems hosted in varying host rocks will be presented alongside potential implications for deposit-scale and regional-scale magmatic-hydrothermal fertility and metal budget controls across the orogenic system. This project funded through a UK-Canada sustainable critical minerals research partnership aims to enhance exploration techniques through evidence-based targeting methods and facilitate more efficient mining through a greater understanding of critical metal deportment within VMS deposits.

[1] Marcoux et al. (1996). DOI: https://doi.org/10.1007/BF00225392
[2] Hannington et al. (1999). DOI: https://doi.org/10.5382/Mono.10