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Metallogeny of Greenland

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Greenland, the largest island on Earth, is underlain by rocks ranging from Eoarchean to the most recent ages. The interior is covered by a continental ice sheet, leaving ca. 400 000 km^2 of exposed bedrock. Greenland has a mineral exploration tradition since its colonization in the 18th century, and mining started in 1854. Since the 1960s, the country has been explored systematically, which resulted in the discovery of a few successfully mined deposits.

The geology of central and southern Greenland is dominated by deeply eroded Archean and Paleoproterozoic rocks. The Archean is mainly formed by granite-gneiss terranes and only a few granite-greenstone belts. Significant mineralization includes orthomagmatic Ni-PGE-Au sulfide and Cr- or Fe-Ti-V oxide, and hypozonal orogenic gold systems. The ultramafic units of the orthomagmatic systems locally host gemstone-quality corundum and feldspar mineralization. Mesozonal orogenic gold and iron ore in banded iron formation are restricted to the scattered granite-greenstone belts in western Greenland. Volcano-sedimentary rocks formed during Palaeoproterozoic rifting stages are not well preserved and only a few small VHMS occurrences are known. Three ca. 1.9-1.7 Ga orogens in north, central and south Greenland, respectively, host a variety of deposits including MVT, orthomagmatic Ni-PGE, VHMS, orogenic gold, graphite and IOCG mineralization. There has not been any production from Archean deposits, but significant Paleoproterozoic deposits have been mined, namely the Zn-Pb Black Angel and the Nalunaq Au deposits.

The Palaeoproterozoic assembly of Nuna was followed by rifting and basin development until the Caledonian and Ellesmerian orogens formed. Sedimentary basins host stratiform Cu and P mineralization in north and east Greenland. The Paleozoic Franklinian Basin in north Greenland hosts the Zn-Pb Citronen SEDEX deposit and several similar occurrences. Continental rift-related alkaline magmatism in south Greenland formed the 1.35-1.15 Ga Gardar Province. Large REE-Zr-Nb-Ta-U-Th-Zn-Be and cryolite deposits formed in the most differentiated intrusions in the Kvanefjeld, Kringlerne, Ivigtût and Motzfeldt deposits. Mafic dykes host the large Isortoq Fe-Ti-V deposit. The Sarfartoq rare metal-U deposit is hosted in a Neoproterozoic carbonatite in western Greenland. The Caledonian in East Greenland is represented by the foreland fold-and-thrust belt, where smaller intrusion-related W-Sb±Au±Cu vein-type, skarn, mesozonal orogenic gold and porphyry deposits are known.

Renewed and almost continuous sedimentation occurred from the Devonian until Paleogene in east Greenlandic basins with only small and scattered stratiform sedimentary base metal mineralization. The

Paleogene in east and west Greenland is characterized by widespread mafic-ultramafic magmatism related to opening of the North Atlantic and forming flood basalt and a series of intrusions in east Greenland. Flood basalts are mineralized with Ni-sulfides, whereas the mafic layered intrusions comprise the world-famous Skaergaard intrusion hosting a PGE-Au deposit. Tertiary felsic intrusions host porphyry Mo deposits in Flammefjeld and Malmbjerg with some precious metal veins at Flammefjeld. The review of the Greenlandic metallogeny in this paper clearly shows the enormous potential for finding ores in a wide variety of settings. Geological knowledge is still relatively basic for many parts of Greenland and modern geophysical and geochemical data is often only available at a regional scale, which makes knowledge- and mineral system-driven exploration difficult and costly.