Proterozoic basement structures and thermogenic sulfate reduction-derived H2S as key controls on economic Laisvall-type Pb-Zn deposits, eastern erosional front of the Scandinavian Caledonides, Sweden*

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Stratabound, non-stratiform, epigenetic galena-sphalerite mineralization in Ediacaran–Cambrian sandstone, including the previously mined deposit at Laisvall (64.3 Mt of ore at 0.6 % Zn, 4.0 % Pb and 9.0 g/t Ag), occurs along the eastern erosional front of the Caledonian orogen in Sweden and Norway. The sandstone is part of a transgressive siliciclastic sedimentary sequence that, at Laisvall, rests unconformably on top of Proterozoic crystalline basement beneath the Caledonian thrust nappes.

At Laisvall, we demonstrated the spatial correlation between linear anomalies in airborne magnetic data and faults in the Proterozoic basement. In addition, some edges along magnetic gradients were shown to be spatially associated with faults at mine scale in the Ediacaran-Cambrian autochthonous rocks suggesting that the reactivation of basement structures triggered tectonic activity in the cover rocks. Several feeders centered on these faults have been identified and are interpreted as conduits for metal-bearing fluids ascending from the crystalline basement.

Pb-Zn grade distribution depicts plume-like features with the highest grades centered on the feeder faults and towards the top of the host sandstone paleoaquifers. Such a spatial distribution is typical of sediment-hosted deposits (e.g., San Vicente deposit in Peru; Topla & Mežica deposits in Slovenia) where metal-bearing fluids from the basement mixed with H2S-bearing fluids in sandstone or dolostone paleoaquifers. An extensive and structurally-orientated sulfur isotope survey identified three sources of reduced sulfur at Laisvall: i) mainly H2S produced during thermogenic sulfate reduction (TSR) by hydrocarbons (the presence of hydrocarbons being illustrated by pyrobitumen intimately intergrown with sphalerite); ii) H2S from the replacement by galena ± sphalerite of early biogenic pyrite and pyrite related to thermal maturation of sulfur-rich organic matter; iii) minor H2S from sulfide leached in the crystalline basement rocks identified in sphalerite in feeder fault areas. TSR-derived reduced sulfur is identified as a key condition for Laisvall-type mineralization at economic level. Consumption of earlier pyrite in Pb-Zn sulfides is indicative of a system starved in reduced sulfur once TSR-derived reduced sulfur is consumed.

A regional exploration strategy for Laisvall-type deposits in autochthonous cover rocks should focus primarily on the mapping of Proterozoic basement structures at the erosional front of the Scandinavian Caledonides, these basement structures being also traceable in magnetic anomalies.
underneath the allochthonous nappes. Early routine petrography and sulfur isotope study, deciphering whether TSR supplied enough reduced sulfur in the paleoaquifer, could help to decide whether more advanced exploration work should be completed.