

## **Boliden's Garpenberg Zn-Pb-Ag mine, Sweden - Critical factors behind the discoveries that turned mine closure into a large expansion project**

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The Garpenberg volcanic-, limestone- and skarn-hosted Zn-Pb-Ag-(Cu-Au) deposit in the Bergslagen mineral province, Sweden, had been reporting losses or small profits for decades leading up to the late-1990's. About 20 Mt of Zn-Pb-Ag-(Cu-Au) ores had been produced and ore reserves were low. Mine closure was considered after over 1000 years of mining and milling. However, at the end of the 1990's and start of the 21<sup>st</sup> century, four new satellite deposits were discovered during a period of four years: The Gransjö ore body was discovered 850 m below surface, northeast of the Garpenberg Norra mine, the Kaspersbo and Lappberget ore bodies were discovered south of the Garpenberg Norra mine at 1090 and 1400 m below surface respectively, and the Kvarnberget deposit was discovered 1000 m below surface, southeast of the Garpenberg Norra mine. Today these discoveries stand for the bulk of production and are the basis of an expansion project, where production is increasing from about 1.4 Mt/year to 2.5 Mt/year in 2015. The "new" mine (new underground facilities, new infrastructure and new concentrator) will be completed during 2014. The discoveries also fuelled an optimism and expertise that has led to more discoveries. The Garpenberg operation is now very healthy: the global production, reserves and resources at the end of 2013 were 116 Mt of Zn-Pb-Ag-(Cu-Au) ore, comprising production of 42 Mt, reserves of 36.3 Mt (at 4.6 % Zn, 1.9 % Pb, 132 g/t Ag, 0.3 g/t Au) and resources of 38 Mt.

After a long period of little exploration and little success at the Garpenberg operation, Boliden intersected the first three of the new satellite deposits with three drill holes during a two-year period. This radical change in fortune was the result of several critical factors: (1) innovative study of the stratigraphy and structure showed that the ores are replacement in origin rather than exhalative, have been variably remobilized during deformation, and that the host rocks are folded into dome- and cone-shaped folds, (2) optimism and persistence by the geologist in charge and support by management enabled testing of the new ideas and targets, (3) systematic and rapid compilation of geological cross sections through the area defined the structure and new targets, (4) bold decisions to drill into the hanging-wall rocks, previously considered non-prospective, to test for fold repetitions of the ore zone, (5) successful testing of an in-house, state of the art, down-hole, three component EM method on the Garpenberg ore bodies, which were previously considered poor conductors, but which were now shown to give good off-hole anomalies; routine use of the down-hole EM method allowed 3D interpretation of off-hole EM anomalies and played a major part in three of the discoveries.

A combination of these factors has turned the Garpenberg operation around from a loss maker with a doubtful future to one of Boliden's most profitable and effective operations with a promising long future.