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Review

Assessment of undiscovered metal resources in Finland

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ABSTRACT

This paper summarises the results of probabilistic estimates of the amounts of Cu, Zn, Pb, Ni, Co, Pt, Pd, Au, Ag and Mo in undiscovered orogenic Au, volcanogenic massive sulphide (VMS), porphyry Cu, Outokumpu-type Cu-Zn-Co, synorogenic intrusion-related Ni-Cu, komatiite-related Ni, and layered intrusion-hosted contact-type and reef-type PGE deposits in Finland. The assessments were carried out down to the depth of one kilometre using the three-part quantitative assessment method.

Permissive areas (tracts) within which mineral deposits can exist based on their geological properties were delineated separately for each deposit type. Total number of tracts delineated was 188, and excluding overlap, total area covered by the tracts is 190,700 km^2. This means that 57% of the land area of Finland holds potential for the discovery of new mineral deposits of the types included in the assessments. Orogenic Au tracts cover the largest area (110,000 km^2), and the contact-type PGE and Talvivaara-type tracts cover the smallest areas (both 310 km^2). The number of undiscovered deposits was estimated at several levels of confidence for each permissive tract. The total expected number of undiscovered deposits across all permissive tracts is 309 deposits. The largest expected numbers of deposits are associated with the orogenic Au (90), synorogenic intrusion-related Ni-Cu (66) and VMS (45) tracts.

Statistical comparisons indicated differences in tonnage and grade values between Fennoscandian and global data sets for several deposit types, and between global Precambrian and Phanerozoic porphyry Cu deposit data sets. The reason for the differences is inconclusive but probably related to both global variations in exploration maturity and availability of grade and tonnage information. Due to the differences, grade-tonnage models were constructed using data from well-known deposits within the Fennoscandian shield for most of the assessed deposit types. The orogenic Au model was constructed using Fennoscandian and north Australian deposits and the porphyry Cu model using global data on Precambrian deposits.

The sum of median estimates of undiscovered resources across all the assessed deposit types is 9.7 Mt Cu, 5.0 Mt Ni, 1.8 Mt Zn, 0.15 Mt Pb, 0.10 Mt Mo, 86,000 t Co, 12,000 t Pd, 5600 t Pt, 2100 t Ag and 1400 t Au. Layered intrusion-hosted PGE deposits and porphyry Cu deposits are estimated to host the largest undiscovered resources containing the majority of the undiscovered Cu, Ni, Pt, Pd and Mo. Most of the undiscovered Zn is in VMS deposits and more than half of the undiscovered Au is in orogenic Au deposits.

Comparison between discovered and estimated undiscovered resources indicates that practically all Mo, Pt and Pd resources and more than half of the Au and Cu resources in Finland exist in undiscovered or poorly known deposits. Undiscovered resources of Ni, Pb and Ag are smaller than the discovered resources. Most of the total endowment of Zn and Co appears to be in discovered resources.

On a global scale, the Finnish resources are small. The discovered resources and estimated total endowment for most of the metals assessed are <1% of the corresponding global identified resources. Platinum-group elements, Ni, Co and possibly Au might be exceptions to this, at least on a European scale. As a caveat to the results of this work, we stress that a few potentially significant deposit types (e.g., Kevitsa and Talvivaara types, Precambrian

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epithermal Au) were excluded from the assessments, due to the lack of statistically reliable grade and tonnage data.

Contents

1. Introduction

Throughout the history of humankind, the demand for mineral resources has increased with the continuing growth of the world population and the rise in the average material standard of living of an ever-increasing number of individuals. In the modern world, no country can always rely on readily available domestic or imported raw materials for manufacturing and other industries. This also applies to the entire European Union, which is globally a major net importer of nearly all metallic ores and concentrates (Commission of the European Communities, 2008; European Commission, 2011, 2014). In tandem with the growing demand for raw materials, exploration for and the development of new mineral resources all over the world are facing increasing competition from other land uses (Briskey et al., 2007; Cunningham et al., 2007; Rasmussen, 2011). Due to the competing needs, effective land management planning is essential to ensure optimal land use and sustainable resource development. As input for this type of planning, detailed knowledge of our mineral resources is needed. The essential information includes the location of the known resources, the location and amount of the possibly existing, yet undiscovered resources, and the uncertainty related to their existence.

The Geological Survey of Finland (GTK) has carried out assessments of undiscovered mineral resources for Finland, using the three-part quantitative assessment method since 2008 (Rasilainen et al., 2010a,