Using gold to explore for gold: Trace element content of native gold across Ontario

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I. INTRODUCTION

Gold is one of the most important resources for Ontario's economy, but few investigations have directly studied native gold to explain gold systems. The Gold Fingerprinting project is a collaborative effort between the Ontario Geological Survey (OGS), Metal Earth (Mineral Exploration Research Centre (MERC), Laurentian University) and the Royal Ontario Museum (ROM). It aims to better understand the geochemical signature of native gold, employing in-situ techniques such as EPMA and LA-ICP-MS using 299 samples from 70 gold deposits across Ontario (Fig.1). A robust methodology were developed (Fig 2.) since little work has been done on this subject. The geochemistry of gold has the potential to define the unique elemental attributes that vary depending on its genesis, source, depositional processes and time, thereby providing a new perspective on gold ore systems and new tools to aid in exploration.

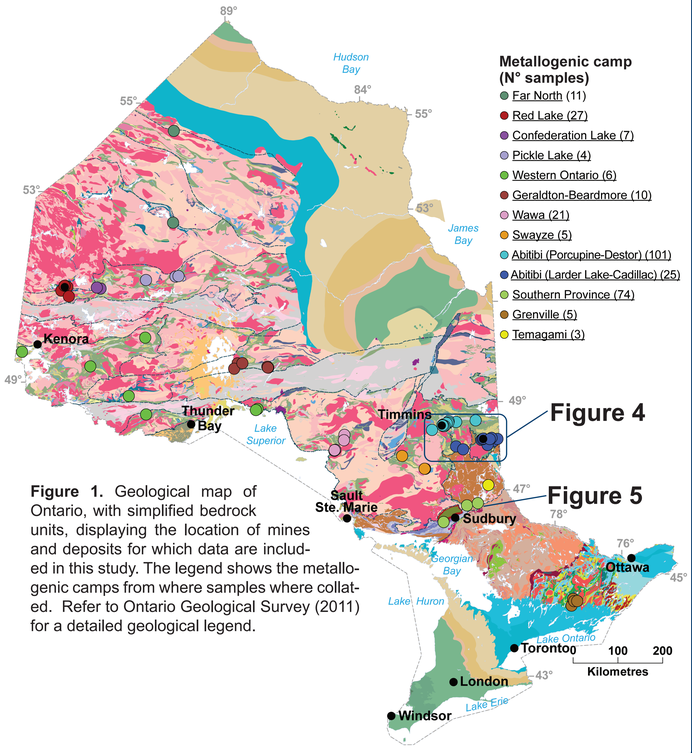


Figure 1. Geological map of Ontario, with simplified bedrock units, displaying the location of mines and deposits for which data are included in this study. The legend shows the metallogenic camps from where samples where collated. Refer to Ontario Geological Survey (2011) for a detailed geological legend.

II. METHODOLOGY

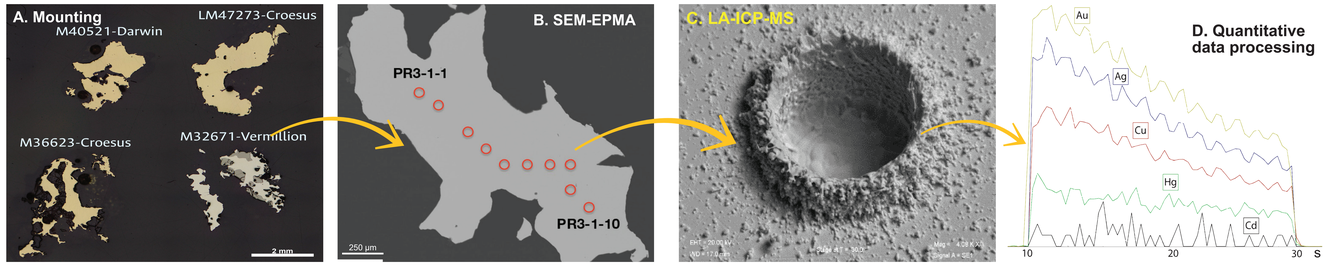
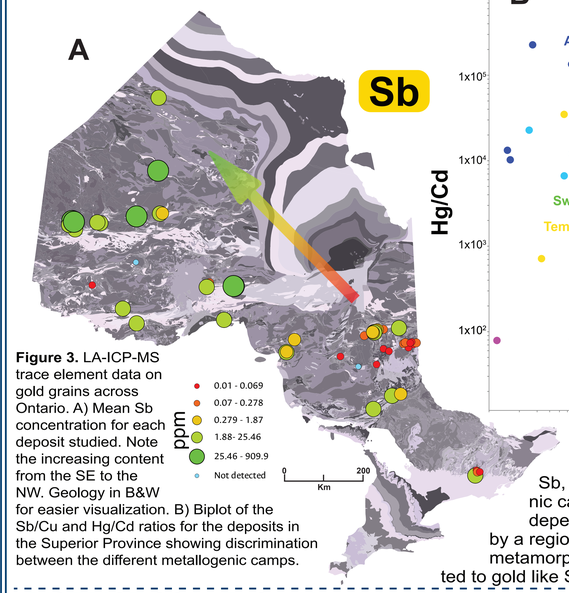


Figure 2. Flow of work for the acquirement of trace element data. **A)** Reflected light image of gold samples mounted in an epoxy puck. Note the difference in colour representative of the fineness. B) BSE image of an homogenous gold grain showing the point location of the EMPA and LA-ICP-MS analyses. C) BSE image of the pit produced after an ablation in a gold grain. Modified from Hastie et al. (2020) D) Time-resolved spectra of a LA-ICP-MS spot showing the behaviour of Au, Ag, Cu, Hg and Cd. The Y-axis is arbitrary.

III. RESULTS AND IMPLICATIONS FOR EXPLORATION

REGIONAL-SCALE



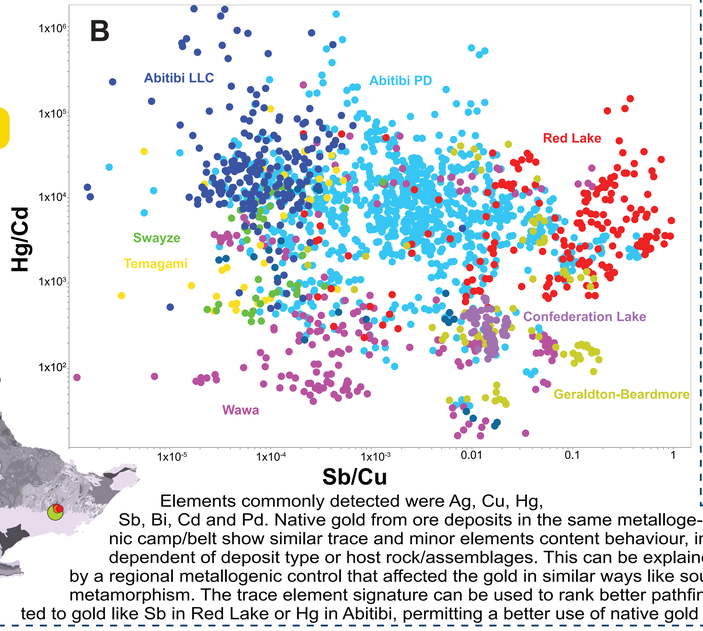
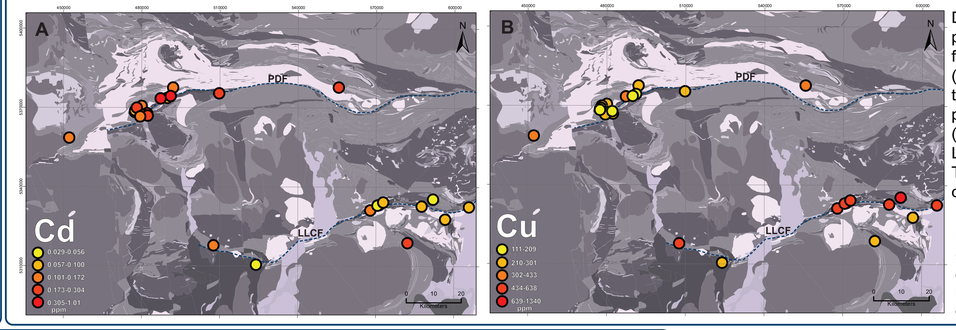


Figure 3. LA-ICP-MS trace element data on gold grains across Ontario. A) Mean Sb concentration for each deposit studied. Note the increasing content from the SE to the NW. Geology in B&W for easier visualization. B) Biplot of the Sb/Cu and Hg/Cd ratios for the deposits in the Superior Province showing discrimination between the different metallogenic camps.

Elements commonly detected were Ag, Cu, Hg, Sb, Bi, Cd and Pd. Native gold from ore deposits in the same metallogenic camp/belt show similar trace and minor elements content behaviour, independent of deposit type or host rock/assemblages. This can be explained by a regional metallogenic control that affected the gold in similar ways like source, transport or metamorphism. The trace element signature can be used to rank better pathfinders directly related to gold like Sb in Red Lake or Hg in Abitibi, permitting a better use of native gold as indicator mineral.

DISTRICT-SCALE: Southern Abitibi



Differences in the Au/Ag ratio between samples associated to the Larder Lake-Cadillac fault (LLCF) and the Porcupine-Destor fault (PDF; Melo-Gómez et al., 2021) can be identified too in the trace element signature. Samples close to the PDF have different signature (higher Cd, Pd and Sb) than those to the LLCF (higher Cu).
This represents a difference in the ore processes involved in each area.

Figure 4. LA-ICP-MS data for A) Cd and B) Cu. Each spot represents the mean data for each deposit. NAD83, zone 17. (OGS, 2011; Dubé and Mercier-Langevin, 2020). Blue dashed-line represent the fault trace.

DEPOSIT-SCALE: Pardo Project

Analysis of detrital and in-situ grains show that grains, even after fluvial transport, conserve a trace element signature. These sigantures show that there are at least two different populations. One has a similar signature compared to the in-situ ocurrence which is located up to the paleoflow (possible source). The other population (red) has a marked difference indicating a possible distinct source.

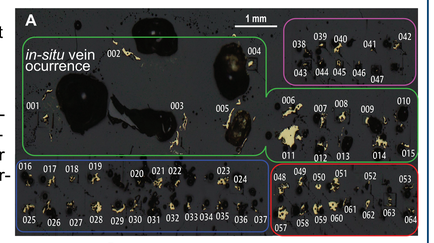


Figure 5. A) Reflected light image showing the studied grains. Red, pink and blue groups are detrital grains from different places. B) Biplot of the Ag/Cu vs Hg/Pd ratios. C) Biplot of U vs Cu concentration.

IV. CONCLUSIONS

1. In-situ techniques with low limits of detection as LA-ICP-MS can quantify the trace elemental content of native gold.
2. The methods developed in the project are robust, reliable, and reproducible
3. Trace element concentrations and ratios proved useful to fingerprint gold at different scales. At a regional and district scale, the most important metallogenic camps in the Superior province show similar signatures within them and different among them. At a deposit scale, the composition is very similar except in more complex deposits like Dome.
4. In paleoplacers the native gold signature can be used to identify different gold sources.
5. Gold geochemical signature varies at the craton scale but is consistent at the camp scale. This suggests that metallogenic districts have undergone similar ore processes that gives this unique fingerprint.
6. Identifying the elements that are truly associated with the gold can be a valuable tool during exploration and definition of pathfinders in an area.

V. ACKNOWLEDGMENTS AND REFERENCES

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References

Dubé, B., and Mercier-Langevin, P., 2020, Gold deposits of the Archean Abitibi greenstone belt, Canada, in Sillitoe, R.H., et al, eds., Geology of the World's Major Gold Deposits and Provinces : Society of Economic Geologists Special Publication 23, p. 669–708.

Hastie, E.C.G., Petrus, J.A., Gibson, H.L. and Tait, K.T. 2020. Gold Fingerprinting: Using major and trace elements associated with native gold to work toward a global gold database; in Summary of Field Work and Other Activities, 2020, Ontario Geological Survey, Open File Report 6370, p.10-1 to 10-10.

Melo-Gómez, J.D., Hastie, E.C.G., Gibson, H.L., Tait, K.T. and Petrus, J.A. 2021. Gold fineness across Ontario: An update on the Gold Fingerprinting Project; in Summary of Field Work and Other Activities, 2021, Ontario Geological Survey, Open File Report 6380, p.13-1 to 13-9.

Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release—Data 126 – Revision 1.

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