Driving the paradigm shift of near surface exploration geochemistry using ultrafine soils

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SUMMARY

Soils are widely used as a geochemical sample medium. These samples are sieved to <250 µm or <180 µm to remove larger gravels and coarse sand and later pulverized for analysis, but no other refinement is commonly used. Why is this the case? In transported cover, the soils that host/adsorb the mobile element signature are the smallest size fractions, so we should consider concentrating the clay size fraction (<2 µm) as an improved sample medium. Industry is unlikely to fully adopt these changes without proof of the benefit of refining the size fraction so a series of experiments were conducted to demonstrate the value of using <2 µm fractions for exploration geochemistry. Twenty-seven composite reference soils were collected in the vicinity of known mineral deposits (including background areas) that reflect the common soil types of Western Australia. These soils were used in replicate testing to assess differences in particle size, sample weight, dispersants and how this relates to the geochemistry with intent to optimise the extraction and speed of ultra-fine fraction recovery. Following the refinement of the technique, we commercialised and then applied the new UltraFine+ workflow to numerous orientation site studies, including reprocessed archived regional soil samples from the Geological Survey of Western Australia. Orientation results were promising. Analysing fine fractions (<2 µm) generated reproducible, reliable results, with bigger concentrations. Key benefits were the removal of nugget effects (for Au) and the challenges with detection limits in materials that are dominantly quartz sand. Importantly, the study revealed a marked decrease in censored results for Au (63% to 10% below detection limit) and less variation with sampling depth in soil profiles. The UltraFine+ workflow demonstrates the additional value from (re-) assaying regional soil and sediment samples to generate new targets and improve regional geochemical maps.

Key words: covered terrains, spectral mineralogy, regolith, particle size, clay.

INTRODUCTION

Greenfields exploration in Australia is in decline, and the technical challenge of exploring in deeply weathered and covered regions has not been fully addressed; yet exploration success in these areas is critical to the future economy. Commonly, soil sampling is paired with acid digestion and multi-element measurement. This established approach has not changed significantly over the past 30 years: that is, digest the <250 µm or <180 µm soil fraction and analyse the solution for elemental concentrations. In transported cover, the mobile element signature is contained in the smallest size fractions, so we tested the “ultrafine” clay- and Fe-oxide-rich size fraction (<2 µm) as an improved sample medium for mineral exploration and applied the method to regional orientation studies. The M462 Project sponsored by GSWA, MRIWA and industry recently concluded. This project was conceived to develop and test a new analytical workflow to separate the <2 µm soil and sediment fractions for multielement analysis along with other, commonly not utilised physico-chemical parameters that should aid exploration. The project delivered the method, workflow, and commercialised platform (UltraFine+ certified trademark pending); and demonstrated validity through experiments, orientation field surveys and new regional geochemical map products for Western Australia.

METHOD, RESULTS AND DISCUSSION

Twenty-seven bulk reference soils were collected in the vicinity of known Au and Cu mineral deposits (importantly, including mainly background areas) that reflect the common soil types of Western Australia. By analysing fine fractions (<2 µm) we generated reproducible, reliable results, with higher concentrations than from the <250 µm fraction (average increase of 100-250%). Key benefits were the reduction of nugget effects (in Au) and the challenges with detection limits in materials that are dominated by quartz sand. Testing sub-micron fractions showed that although <0.2 µm fraction was slightly different to the <2 µm and <0.75 µm fractions there was not significant additional value. The <2 µm fraction represent the most effective and cost-efficient sample medium to use. The overall method development showed that ultrasonics were not required, a dispersant was critical for solid recovery and that Na-hexametaphosphate (technical or laboratory grade) was the most effective dispersant. The developed method proved the use of a small weight for analysis was effective (0.2 g) and microwave assisted aqua regia was the best analytical method for Au detection. Our research shows obvious benefits in using fine fractions for Au. Copper and Zn were consistently and abundantly extracted from the fine particle size fraction.

We applied the UltraFine+ workflow to a number of small orientation site studies in Western Australia including DeGrussa, Tooting Bec, Telfer East, Calibre and Area 7 (Figure 1). Reprocessed archived regional soil samples from the

Geological Survey of Western Australia were also used to test the method to improve exploration targeting. The regional orientation program involved ~200 samples from the Leonora and Sir Samuel 1:250k map sheets, an area that hosts known major Au and base metal deposits. We then applied this approach to the Kingston 250k map sheet area, analysing a further 300 samples in a region on the Yilgarn Craton margins that is essentially a greenfields exploration area. There has been limited exploration in the region, and the original geochemical survey data was heavily censored due to the abundant transported regolith dominated by quartz-rich sand. Of most relevance, the study revealed a marked decrease in censored results for Au (~67% to 10% below detection limit; Figure 2) using historic samples, and re-assaying them enabled us to produce a new geochemistry map of the Kingston 1:250,000 map sheet.

Figure 1. The location of the main sites used in this study.

The new maps show geochemistry, some example indices for mineral exploration, and lithology indicators through cover, as well as map products of new interpretations using the additional spectral mineralogy proxies and particle size measurements provided by the Ultrafine+ method. Adding spectral mineralogy, particle size and other physico-chemical parameters to this style of mapping is valuable, but is not commonly done, and is certainly not integrated, currently.

The developed workflow (UltraFine+) has been transferred to a commercial laboratory (currently LabWest Pty Ltd) and available to all. We anticipate other laboratories will also offer this service in the near future. The technique was designed to be robust for industry and streamlined enough to be economically viable. Over the course of the project, we determined a number of additional developments will ensure that this process will become the world leader for providing better high-quality data in a useable format for future explorers. The next iteration of this workflow should improve the UltraFine+ method, particularly estimating organic C as well as building algorithms and machine learning to cloud-process the various data streams; and this should be part of the service from commercial laboratories in the future. This will drive a paradigm shift for future near surface geochemical exploration. A new project of similar size will realise the full potential of the workflow developed in this project over the next few years, and lead to a subsequent improvement to the WA greenfields exploration success rate.

The final report (Noble et al., 2019), additional data products and the public data release for the regional maps are hosted in GSWA publications repository and accessible in GeoView.

CONCLUSIONS

By analysing fine fractions (<2 µm) soil geochemical results were more reproducible and reliable that standard techniques, with higher concentrations than from the <250 µm fraction with an average concentration increase of 100-250%. Key benefits were the reduction of nugget effects (in Au) and the challenges with detection limits in materials that are dominated by quartz sand. Future integration of the UltraFine+ data with machine learning, exploration algorithms and spatial data is the next phase to achieve the step change in near surface geochemical analysis and interpretation. The application of the <2 µm particle size separation and the UltraFine+ workflow demonstrate the importance of the additional value from (re-) assaying regional soil and sediment samples to generate new targets and improve regional geochemical maps. This is an exercise that can be applied to new greenfields surveys, and when exploration budgets are lean, applied to abundant, historically collected samples.

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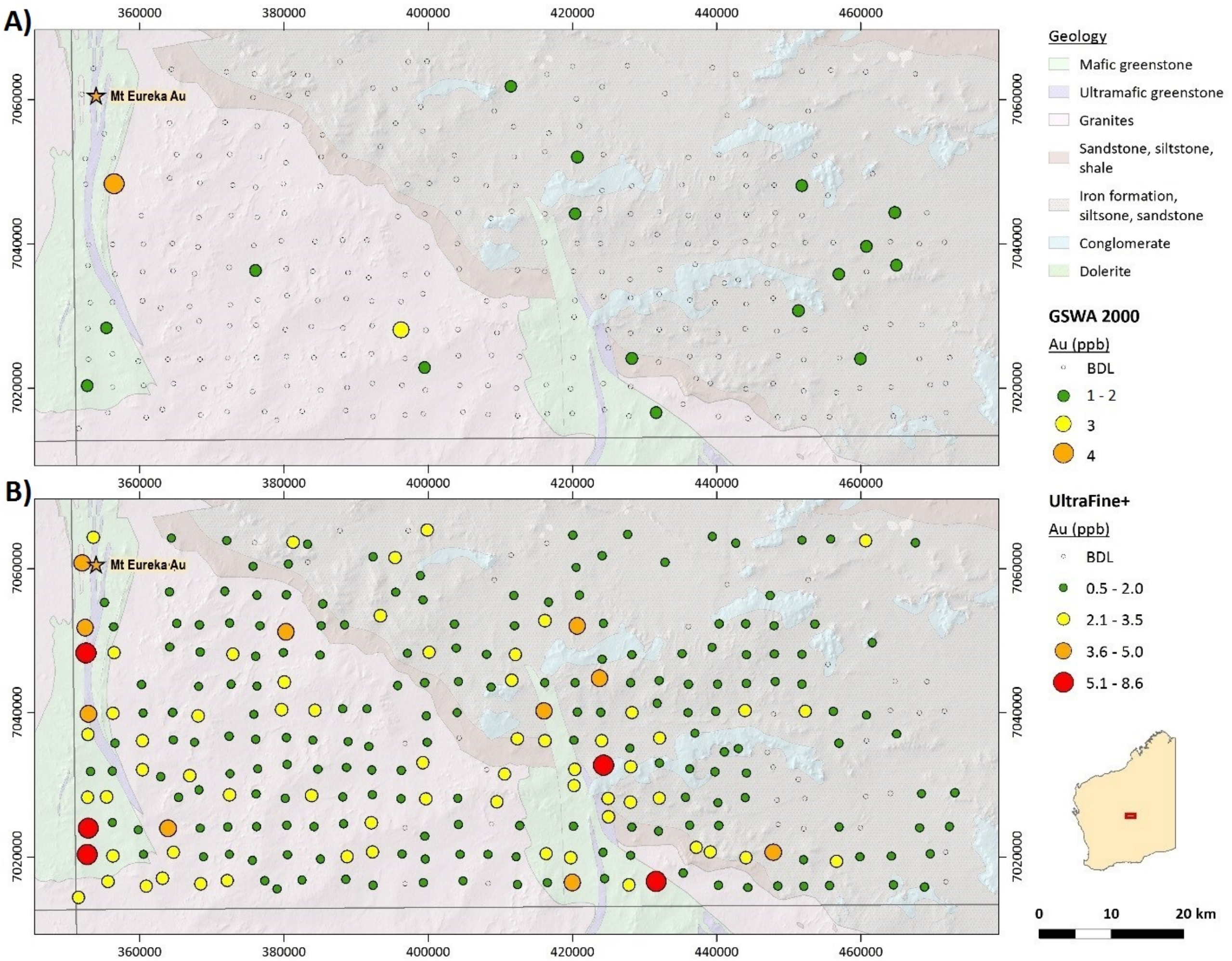

Figure 2. Gold (ppb) in soils in the Kingston 1:250 0000 map sheet. A) Original GSWA data with only a few detectable Au values, B) the new results of the Ultrafine+ method developed in this MRIWA project using the same samples, clearly showing the vast improvement in Au information. Mt Eureka is the only known small Au deposit in the region (mined in the 1930s). Geology is generalised and based on the data from GSWA (2014).