# Ultrafine soils — the technique, the advances and the application to GSWA regional map products

by

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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 size fraction (<2 µm) as an improved sample medium for mineral exploration and applied the method to regional orientation studies, including large soil surveys undertaken by the Geological Survey of Western Australia (GSWA).

The M462 Project, which was sponsored by GSWA, the Minerals Research Institute of Western Australia (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 multi-element analysis, along with other, commonly unutilized physico-chemical parameters that should aid exploration. The project delivered the method, workflow and commercialized platform (UltraFine+ certified trademark pending), and demonstrated our success in experiments, orientation field surveys and new regional geochemical map products for Western Australia.

A series of experiments was conducted to demonstrate the value of using <2 µm fractions for exploration geochemistry. Twenty-seven bulk reference soils were collected in the vicinity of known 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 (for Au) and the challenges with detection limits in materials that are dominated by quartz sand. Testing submicron fractions showed that although the <0.2 µm fraction was slightly different from the <2 and <0.75 µm fractions, there was not significant additional value. The <2 µm fraction represents 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, and reprocessed archived regional soil samples from GSWA to test the method’s potential to improve exploration targeting. The orientation program involved approximately 200 samples from the Leonora and Sir Samuel 1:250 000 Geological Series map sheets, an area that hosts known major Au and base metal deposits. We then applied this approach to the Kingston 1:250 000 Geological Series map sheet, analysing a further 300 samples in a largely greenfields region on the Yilgarn Craton margin. There has been little exploration in the region, and the original geochemical survey data was heavily censored due to the dominance of 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; Fig. 1) using historic samples, and re-assaying them enabled us to produce a new geochemistry map of the Kingston 1:250 000 Geological Series map sheet.

The new maps show geochemistry, some example indices for mineral exploration, and lithology indicators through cover (Fig. 2), as well as map products of new interpretations using the additional spectral mineralogy proxies and particle size measurements. Adding spectral mineralogy, particle size and other physico-chemical parameters to this style of mapping is valuable, although not commonly done, and is certainly not currently integrated.

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 (Figs 1, 2). This is an exercise that can be applied to new greenfields surveys and, when exploration budgets are lean, to abundant historically collected samples.

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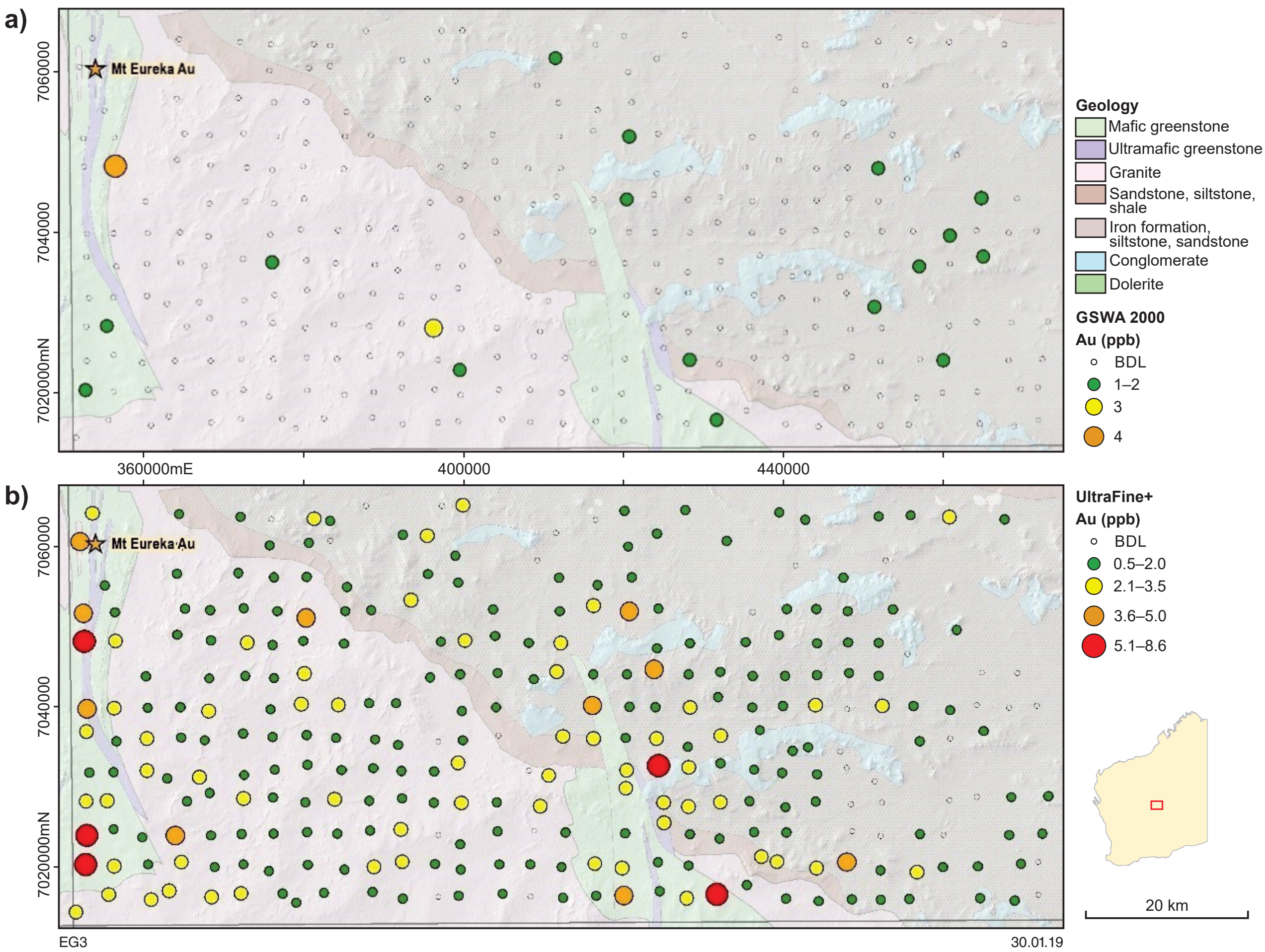


**Figure 1.** Gold (ppb) in soils on the KINGSTON 1:250 000 Geological Series map sheet: a) original GSWA data with only a few detectable Au values; b) new results from the Ultrafine+ method developed during this MRIWA project using the same samples, clearly showing the vast improvement in Au information. Mt Eureka is the only known small Au deposit in the region (mined in the 1930s). Geology is generalized and based on data from Martin et al. (2014). BDL, below detection limit

The developed workflow (UltraFine+) has been transferred to a commercial laboratory partner (currently Lab West Pty Ltd) and is 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 that will ensure this process is 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 and building algorithms and machine learning to cloud-process the various data streams. This should be part of the service from commercial laboratories in the future. We envisage a second project of similar size will realize the full potential of the workflow developed in this project over the next few years, and lead to a subsequent improvement to the success rate of greenfields exploration in Western Australia.

The final report (Noble et al., 2018), additional data products and the public data release for the regional maps are hosted in the Department of Mines, Industry Regulation and Safety’s eBookshop at <www.dmp.wa.gov.au/ebookshop> and are accessible in GeoVIEW.WA.

## References


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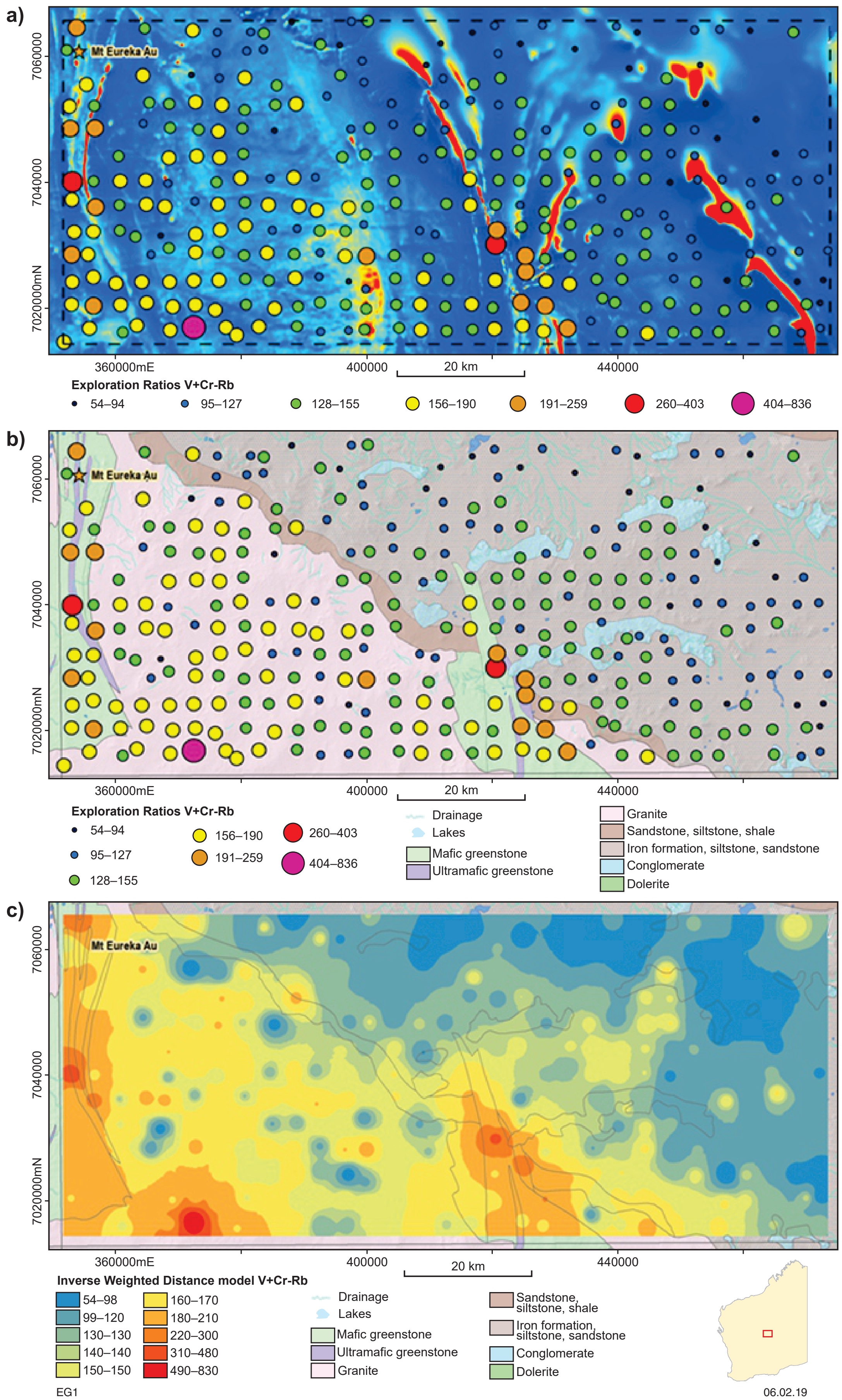


**Figure 2.** a) Lithology ratio using V, Cr and Rb data from the <2 μm fraction analysis with magnetics underlay; b) the ratio with geology underlay; c) the inverse weighted distance interpolation of this data and the outlines of major geological units underneath showing a very close association. Geology is generalized and based on data from Martin et al. (2014)