Towards predictive models of landscape geochemistry in deeply weathered terrains using electromagnetics

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INTRODUCTION

Nearly 25% of the Earth's continental surface area is affected by tropical climatic conditions that result in intense chemical weathering. These areas often display lateritic profiles that may reach depths of up to 100m. Understanding the geology of these regions is problematic due to the lack of fresh bedrock outcrop and their complex weathering histories, as many of these areas display weathered profiles, which have been developing for millions of years. Thus, many of these regions correspond to ancient, stable and weathered landscapes, as is the case for several regions in Australia.

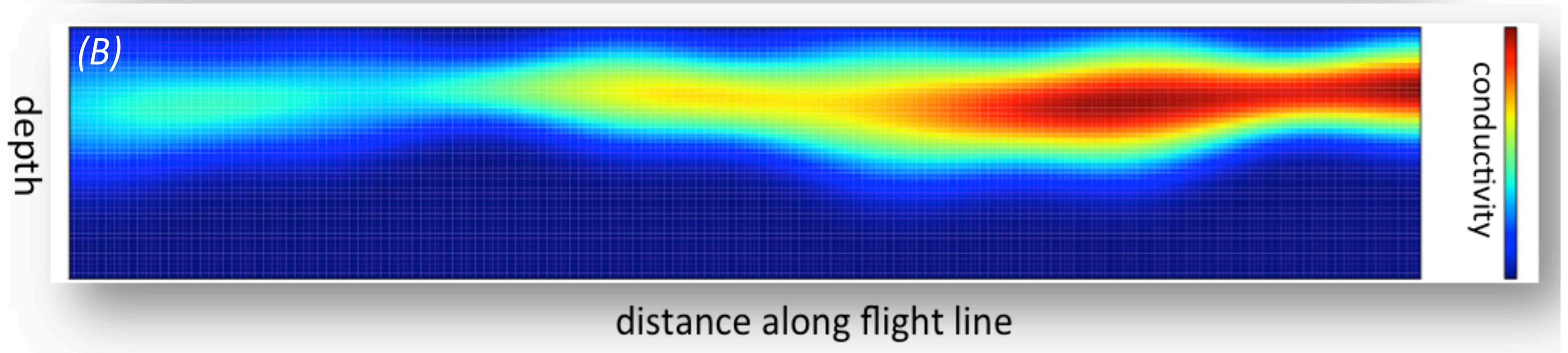
REASONING

The development of links between landscape geochemistry in deeply weathered terrains and geophysical datasets is a key element to understand better the extent and evolution of weathering. Intensely weathered landscapes can be characterized by delineating their stratigraphy, relative age and depth. This allows the generation of 3D models of the cover architecture and, therefore, the delineation of weathering fronts. This combined approach contributes to the generation and evolution of predictive and detective models of the geochemical evolution of a landscape since it has the potential to provide lateral and vertical trace element dispersion.

The data density and the depth of ground penetration (>400 m) of airborne electromagnetics (AEM) is ideally suited for inferring the buried geology between known stratigraphic cover profiles. AEM has the potential to significantly improve weathered cover architecture reconstruction and, therefore, the interpretation of the landscape geochemistry, erosion and deposition. However, inversion of AEM data for conductivity structure of the ground is non-unique: many different models are consistent with the data. Typically, the smoothest model is chosen, out of those that fit the data, so that structure will not be present unless required by the data (e.g. fig 2(B)). However, by including geological constraints in the geophysical inversion, such as knowledge of the number of layers, and the conductivity value ranges for different lithologies, we aim to produce inversion models like fig 2(C), of depths to layer boundaries, rather than conductivities.

In this study we present specific models on the interpretation of AEM for deeply weathered terrains, to understand better the complex weathering processes and their implications for geochemical dispersion in areas of overprinting weathering.

Understanding landscape evolution and quantifying uncertainty



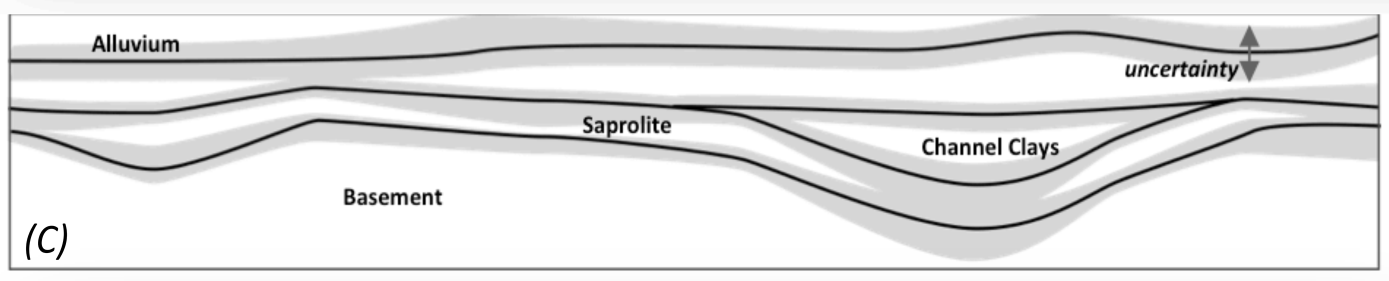
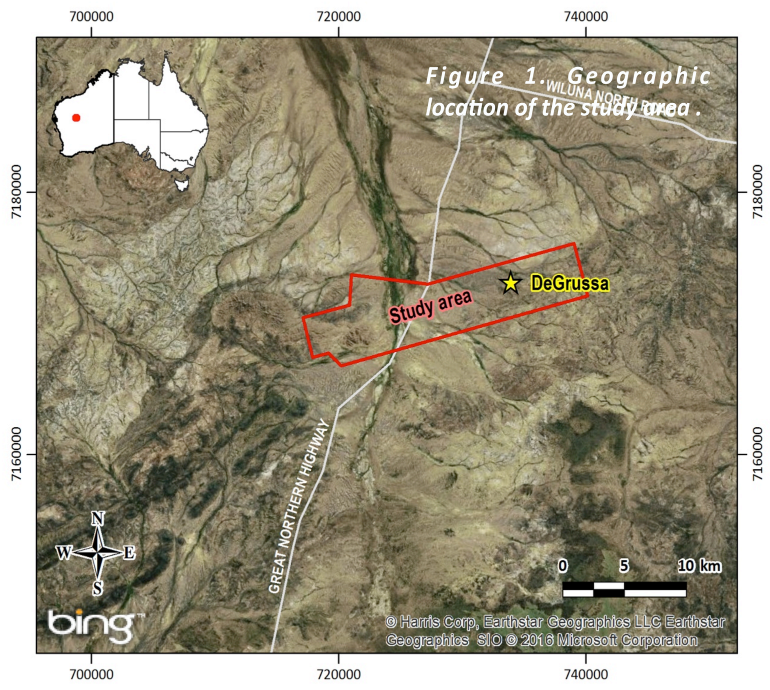


Figure 2. (A) Modern landscape at DeGrussa. (B) Possible inverted AEM model of smooth conductivity, difficult to relate to (C) Example of possible inversion of the AEM obtained by using geological constraints (D) Interpreted ancient landscape at DeGrussa based on (C) and contextual geological data integration.

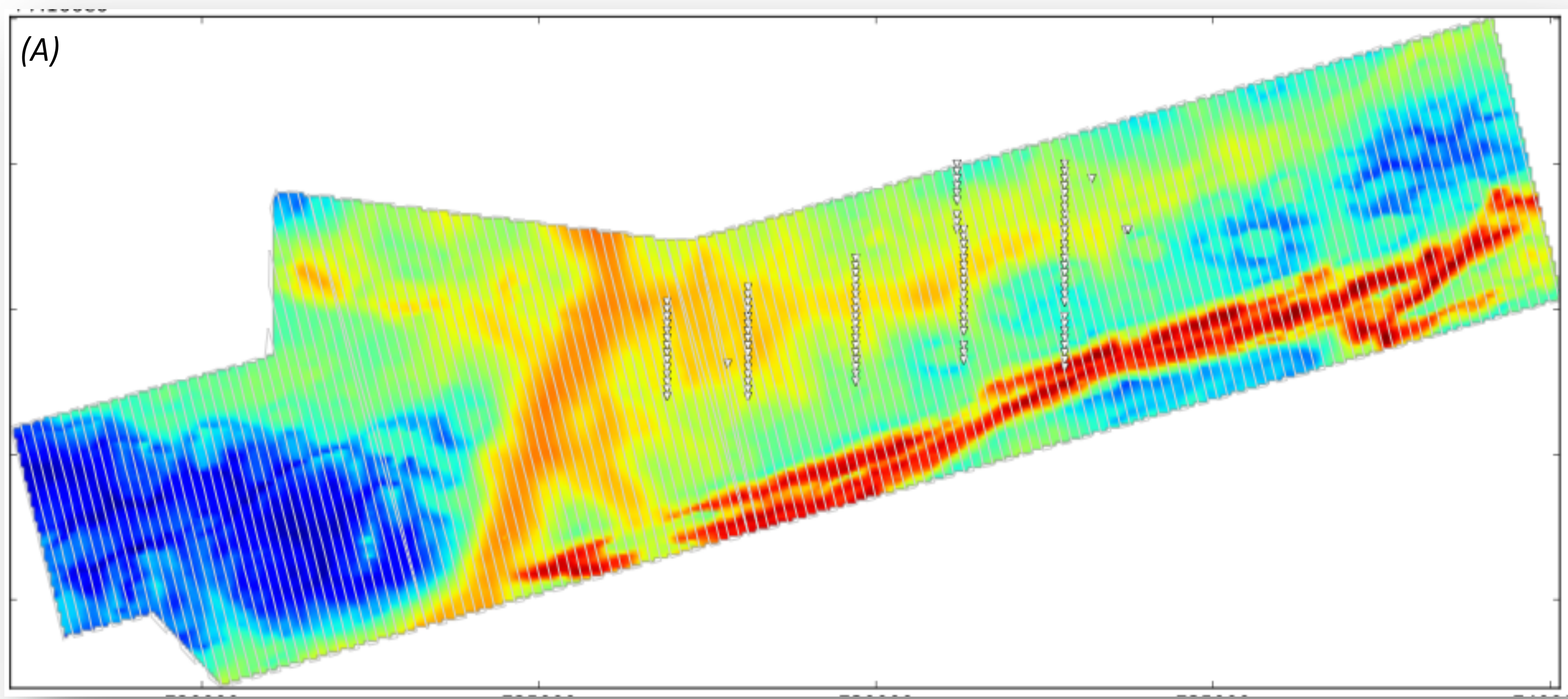
Geological and regolith context

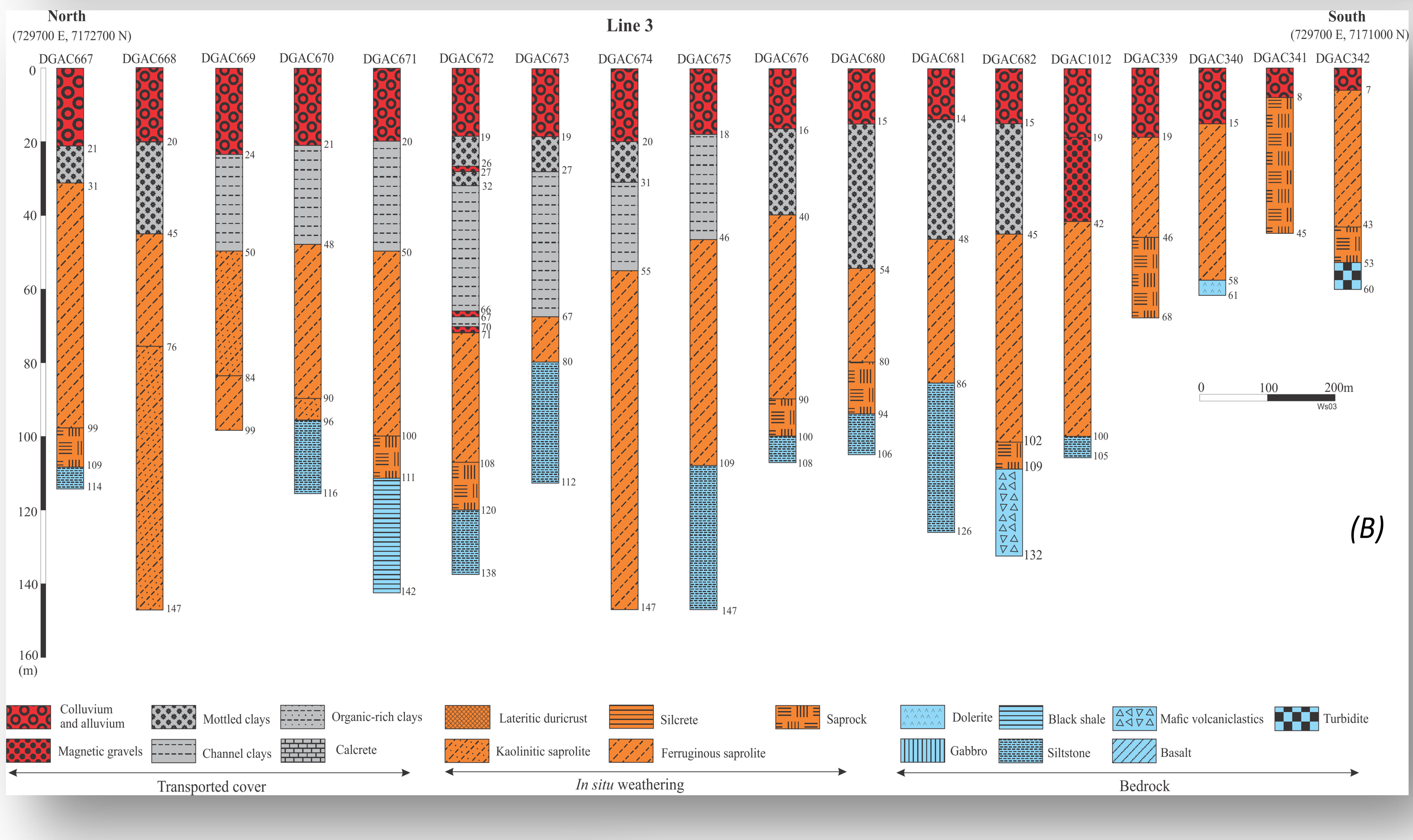


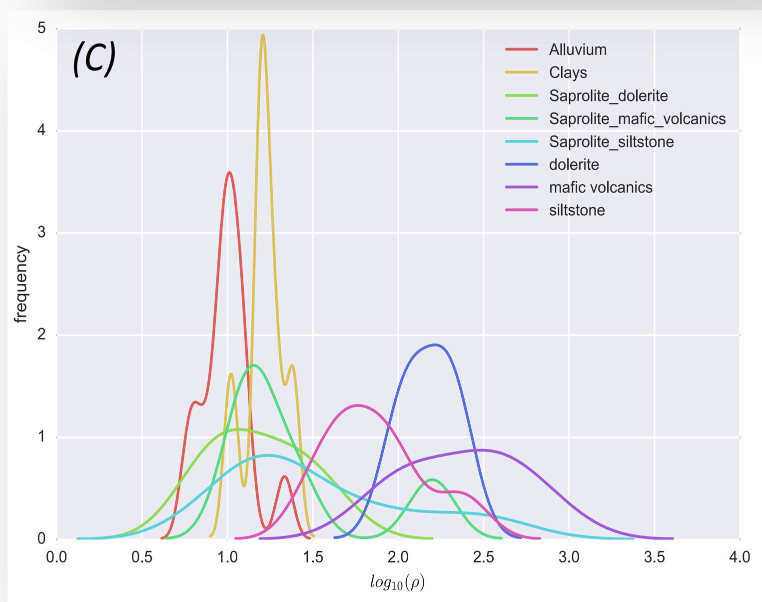
Characterising electrical properties of regolith materials using:

- AEM data
- Lithology, mineralogy and geochemistry from drilling
- Basement geology
- Hydrogeology
- Landscape evolution
- Sedimentary evolution and stratigraphic variability
- Weathering
- Petrophysics

Data fusion







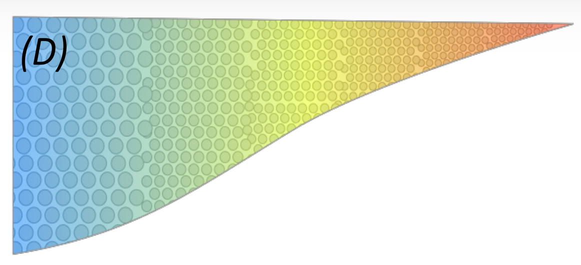


Figure 3. (A) AEM survey and drill hole location at Degrussa area in Western Australia. (B) Stratigraphy described based on drill hole data (González-Álvarez and Salama, 2015). ((C) conductivity variability of the different stratigraphic units. (D) Example of possible lateral variability in a stratigraphic layer due to changes in salinity, moisture, mineralogy, porosity…

Vision for mineral exploration

Based on two main datasets: EM and drilling (coupled with its derivative datasets) such as stratigraphy, mineralogy, geochemistry…), EM data can be processed using the contextual known geological knowledge as the constraints for the mathematical variables to build a model. This model would quantify uncertainty and will be the result of the fusion of the geological knowledge with the EM data, and therefore, tailored to that specific area studied.

FOR FURTHER INFORMATION
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