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Predictive spatial modelling of surface geochemistry from local to continental scales

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The geochemistry of the Earth's surface reflects the composition of the uppermost continental crust (geosphere) and its interactions with the atmosphere, hydrosphere and biosphere, which change dynamically through time. The concentration and distribution of geochemical elements is important in mineral exploration, agriculture, environmental toxicology and geohealth.

Datasets representing proxies for the factors that control geochemical landscapes include geological maps, geophysics (magnetics, gravity, electromagnetics and gamma-ray spectrometry), digital elevation models and derived terrain attributes (e.g. slope, aspect, relief), climate surfaces (rainfall, temperature, evaporation), and satellite (e.g. Landsat TM, MODIS, SPOT) and airborne imagery. These datasets are available from local to global scales. In the case of satellite imagery, archiving of previous scenes allows time-series analysis and generation of coefficients reflecting temporal changes.

We use several machine learning and rule induction techniques to map and explore the relationships between soil and rock geochemical survey site data in Australia with the data proxies described above. The approach is scalable and allows local to continent-wide predictions. The resultant spatial models are at the resolution of the datasets used in the prediction and not at the (typically much lower) density of the geochemical site attributes. The geochemical site attributes are only used to train and evaluate the model performance.

The methodology couples a quantitative data-driven component that generates predictive models (with associated model uncertainties) with a knowledge-based component where relationships between geochemistry and environmental proxies can be explored and tested against existing process knowledge.

We have used this approach to generate a suite of predictive geochemical landscape models for individual elements, element ratios and geochemical indices over the Australian continent. The predictive models provide inputs, among others, into managing agricultural land and exploring for minerals. The models are also providing insights into weathering processes and the evolution of Australian landscapes.