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Methods of mineral potential assessment of uranium deposits: A mineral systems approach

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Mineral potential represents the likelihood (probability) that an economic mineral deposit could have formed in an area. Mineral potential assessment and prospectivity analysis use a probabilistic concepts to mineral deposits, where the probability of an event (formation of a mineral deposit) is conditional on two factors : i) geological processes occurring in the area, and ii) the presence of geological features indicative of those process. For instance, one of the geological processes critical for the formation of sandstone-hosted uranium deposits in an area is transport of uranium in groundwaters. Geological features indicative of this process in an area comprise, i) presence of leachable source rocks of uranium; ii) presence of highly permeable sandstone; and iii) suitable hydrogeological gradient driving flow groundwaters.

Mineral deposits can also be conceptualised as mineral systems with more emphasis on mineralising processes. This concept has some clear parallels with the petroleum systems approach which has proven to be a useful in oil and gas exploration. Mineral systems are defined as 'all geological factors that control the generation and preservation of mineral deposits'. Seven important geological factors are outlined to define the characteristics of a hydrothermal mineral system. These factors include: i) source of the mineralising fluids and transporting legends; ii) source of metals and other ore components; iii) migration pathways which may include inflow as well as outflow zones; iv) thermal gradients; v) source of energy to mobilised fluids; vi) mechanical and structural focusing mechanism at the trap site; and vii) chemical and/or physical cause for precipitation of ore minerals at the trap site. This approach, commonly known as the 'source', 'transport'and 'trap'paradigm has been redefined to introduce five questions as a basis to understand spatial and temporal evolution of a mineral system at all scales (regional to deposit). The five questions include: i) what is the architecture and size of the system; ii) what is P-T and geodynamic history of the system; iii) what is the nature of the fluids and fluid reservoirs in the system; iv) what is the nature of fluid pathways; and v) what is the chemistry of metal transport and deposition in space as well as time.

Analysis of fertile mineral systems can provide useful information on geological processes essential to form an economic mineral deposit in an area. Mappable features of these processes in geological datasets can then be used to estimate probabilities visualised in the form of mineral potential, prospectivity and favourability maps. The probabilities (levels of mineral potential, favourability index) can be either shown using non-numerical (high, moderate and low), ordinal (numbers expressing ranking) and cardinal (numbers expressing quantities) scales.

This paper will discuss advantages and disadvantages of various GIS-based methods of qualitative assessment and will also present a number of case studies illustrating mineral potential assessment of uranium deposits carried out in Geoscience Australia.

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