Review for TAG:

A guide for mineral exploration through the regolith in the Yilgarn Craton, Western Australia

(AJES Vol 57; No. 8)

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A sustained, multi-decadal research program into the development of the Yilgarn Craton’s regolith and related implications for mineral exploration by the CSIRO and collaborating organisations has arguably been one of the most successful in the history of mineral exploration related research, particularly if success is measured by impact on industry practice. The majority of this research was carried by a Co-operative Research Centre, CRC LEME and its successor, colloquially referred to as CRC LEME II, over a fourteen year period during the 1990s and 2000s. A hallmark of this research program was very close interaction with industry and a very strong focus on delivering pragmatic outcomes to help exploration. Therefore, as an industry, we are very fortunate that Ravi Anand and Charles Butt (two of the giants of this field, along with Ray Smith) have written an extremely comprehensive review for us. They have chosen to publish this review in AJES and their paper (published in December 2010) comprises the entirety of Issue 8 in Volume 57 of the journal. This choice no doubt reflects both the standing of AJES as a journal and a desire to ensure that this work is easily and widely accessible for many decades to come, something that might not be achieved with a stand-alone publication.

At 99 pages, this paper is epic in scope covering topics from the long-term weathering history of the landscape through to detailed issues relating to practical sampling strategies. In essence it is a “geochemical exploration manual” for any explorer in the Yilgarn targeting gold, nickel, base-metal or uranium deposits. In most contexts, this paper alone will provide the explorer with a “one-stop shop” with respect to the knowledge required to plan and execute effective geochemical exploration strategies, however the paper has a comprehensive reference list if more detail is sought on a particular topic, or for a particular area. Importantly, in an era where effective visual presentation of geological concepts is critical to maintaining management or investor support for exploration, this paper is beautifully illustrated. These illustrations include high quality photographs of relevant regolith materials, real examples of maps and sections and schematic block diagrams. The latter are superb visual syntheses of much complex research that rapidly communicate optimum sampling strategies and related critical issues in a comprehensive range of likely real-world exploration scenarios. These diagrams are imminently suitable for inclusion in an Exploration Manager’s PowerPoint presentation aimed at explaining a particular project concept to investors.

The paper is very well organised comprising ten sections: Introduction, Regolith (an overview of its character and evolution, together with important contextual issues such as patterns of regional groundwater composition), Exploration Challenges and Strategies, Regional-District Scale Exploration- General Principles, Exploration Strategies for Gold Deposits, Exploration Strategies for VHMS Base-Metal Deposits, Exploration Strategies for Nickel Deposits, Exploration Strategies for Surficial Uranium Deposits, Sample Preparation,
Analysis and Analytical Control, and Conclusions. The Regolith section provides a succinct and accessible summary of a vast body of research on this topic (carried out over many decades) into a coherent synthesis that must underpin any thinking about geochemical exploration in the Yilgarn. However, as the above outline makes clear, the strong focus of this paper is not simply on just providing a conceptual framework for exploration but also on giving us detailed guidance on how to actually sample and explore. The paper includes well-organised flow charts that lay out both the process of regolith mapping and the process of selecting the optimum geochemical sampling strategy for a particular area. I was particularly impressed with the level of practical detail provided about sampling strategies, with guidance provided on topics as diverse as to how to sample ground-water (and importantly how to treat your sample after you have taken it to ensure meaningful results) and the need to store sulphide-rich analytical reference standards in a dessiccator to avoid degradation. Some of the potential pitfalls highlighted when collecting samples were also interesting. We all know we have to be careful about gold wedding rings but how many of us would automatically think about the potential Zn or Cr contamination that might be derived from the red or green paint on our shovel?

The paper also addresses some of the major topics of debate in geochemical sampling strategies in the Yilgarn over the years. They find little evidence for vertical gas-related metal transport and little suggestion that partial leach geochemical methods provide reliably superior results when sampling in covered terranes. They also find little evidence in support of collecting a magnetic lag fraction, as in most cases the non-magnetic goethite fraction tends to be a better concentrator of target metals. Although magnetic concentration might assist when there is significant aeolian dilution of the sample, they suggest that screening out the wind-blown sand fraction might be a better approach.

Some of the more recent innovative advances in regolith mapping are also discussed. These include using the spectral response of kaolinite to discriminate transported clay-rich sediments from clay-rich in-situ saprolite (often fiendishly difficult in the field) and the application of scale-specific multi-scale parameters to resample SRTM data in order to reveal very subtle features such as sheetwash fans (where surface sampling is likely to be ineffective) within a basically flat landscape.

Although the focus of the paper is the development of geochemical sampling strategies, I would not want the reader to gain the impression that the role of geophysics has been ignored. There are lucid discussions of the role that various geophysical technologies can play in helping to map the regolith, particularly in the sub-surface. Geophysical methods discussed include gravity, magnetics, EM, SAM, resistivity mapping, radiometrics. The role of remote sensing approaches is also discussed.

It is hard to be critical of such a magnificent piece of work as that represented by this paper, however, there were a few topics where I would have appreciated a little more discussion. One of these is the issue of “false positive” anomalies – these are the bane of the explorer’s life and, although these are discussed at various points in the text, a section that brought this topic together, and perhaps expanded on it, would have been valuable. As an example, it would have been helpful to have included more discussion of the potential role of Mn-rich zones in the regolith in scavenging metals and generating false anomalies, with an emphasis on which environments in which we might need to be particularly cautious. Another issue that is not really addressed is the role of the regolith in obscuring the
geophysical response (particularly in the case of electrical geophysics) of bedrock-hosted mineral deposits.

I would strongly recommend that any explorer working in the Yilgarn reads this paper and then keeps it readily at hand. My generation of geoscientists grew up with the development of these concepts which had a major influence on the way we explored this terrane, particularly in the 1980s and 1990s. However, since the turn of the century, with the exception of the recent calcrete uranium boom, much of the exploration in the Yilgarn has been focused at depth near known deposits. This has resulted in a generation of geologists who in general are probably much less familiar with the complexity of the regolith than the preceding one. Therefore, I suspect that if (or when) exploration in the craton eventually returns to greenfields areas, there will need to be a phase of “rediscovery” of the concepts summarised so succinctly here by Anand and Butt. Any exploration manager responsible for a team operating in the Yilgarn should buy a copy of this issue of AJES for every one of their new geoscientists and make it compulsory reading.

Although there is a widely held perception that the Yilgarn is a mature exploration environment, analysis indicates that Anand and Butt’s “Depositional Regime” remains significantly under-endowed in gold relative to their Relict and Erosional Regimes. This suggests that despite a number of important discoveries in the Depositional Regime such as Bronzewing, Sunrise Dam and Wallaby, we have not yet been as effective in exploring these covered areas as we were in areas of residuum. I wonder, for example, in how many places explorers stopped their drill holes in transported cover but thought they had penetrated the basement? There may be considerable scope for explorers to go back to areas of complex regolith, particularly those with unexplained gold anomalies, and, armed with the synthesis presented in this paper, perhaps finally make a significant discovery. Even in near-mine environments, there may be important clues in the data that require an understanding of regolith dispersion processes.

Perhaps the last point to make about this work is that although all these concepts were developed in the Yilgarn Craton, many of the principles are likely to be broadly applicable to similar deeply weathered environments elsewhere, such as West Africa, where we cannot expect to see a similar comprehensive synthesis for many decades. There will no doubt be many differences in detail, but it would not be wise to be exploring in such weathered terranes without an understanding to the processes first elucidated in the Yilgarn.

In summary, I believe this volume is a landmark paper that will be an invaluable reference for the Australian and global mineral exploration industry for many decades to come. Anand and Butt are to be congratulated for their efforts in making all of these research results so accessible to us industry practitioners. Seldom do we get research results served up to us on a plate as usefully as they have done.

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