APPENDIX 7

Drilling and sampling the regolith

What to look for in drilled samples

Regolith features observable in drill cuttings may vary significantly depending on the degree of weathering and preservation. Well-developed in situ profiles typically display reddish, orange and yellow-brown colouration in an upper mottled zone, grading to white or cream in leached saprolite, while yellow-brown and orange zones appearing lower in the profile can indicate old redox fronts—generally related to palaeo or perched water tables. Goethite dominance is indicated by yellow and brown colours, while hematite dominance appears as purplish, red and pink shades. Mixtures typically result in different orange hues.

The transition from weathered rock to fresh rock is usually marked by a change from coloured to more neutral hues (e.g. from pale or moderate yellow, brown or orange hues to grey, green grey, dark grey-brown or near black colours): commonly close to, or just below, the active redox front.

In drillcore, it is possible to see most of the detailed regolith components and their vertical distribution, but drillcore only represents its own width laterally. That level of regolith detail presentation is much reduced in drill cuttings:—even for the larger fragments. Regolith zonation may be indicated by colour, but this is not always a reliable identifier. Mineral assemblages, textures, fabrics, competency, intergrain cements and grain morphology are more reliable indicators. Manganese oxides may present as black powdery coatings, fillings or dendrites. Massive goethite/hematite fillings can be dark brown or black, but show a yellow or brownish streak—as distinct from Mn oxides, which have a black streak.

Redox fronts are important chemical transition zones where species in solution may precipitate or be adsorbed, particularly if their solubility is strongly Eh (redox)-dependent. Redox zones generally form above the weathering front and close to the water table, where elements are dispersed laterally by groundwater movement. They are commonly marked by ferruginisation, due to Fe^{2+} in solution oxidising to Fe^{3+} and precipitating ferrihydyrite and insoluble goethite and/or hematite. These minerals adsorb or incorporate many trace elements used in geochemical exploration (particularly As, Ba, Bi, Cu, Pb, Sb and Zn). Where multiple redox or ferruginous zones are preserved, the one closest to the present weathering front will generally relate to the most recent dispersion. Upper and older redox fronts may have formed under quite different climatic regimes: with different dispersion characteristics and element associations.

Although ferruginisation and the location of potential redox boundaries can be estimated visually from colour changes, very small amounts of fine hematite can strongly colour clay-rich regolith. Spectral analysis (e.g. by PIMA or ASD AgriSpec) may give a more reliable estimate of the relative abundance of goethite-hematite. Assessment of the geochemical data can also help. A ferruginisation index based on Fe/Ti ratios (or alternatively Fe/Al) of regolith samples through the weathered profile can help locate redox zones. Aluminium and Ti are the least mobile of the major and minor elements during weathering and provide a basis for comparing total Fe variation. Typically, the least-weathered saprock samples plot at the centre of this range of values, with a trend to lower ratios where significant Fe^{2+} has been leached from saprolite; a trend to higher ratios occurs with ferruginisation (concentration as Fe^{3+}). In a single profile, an abrupt change from a negative (leaching) trend to a positive (ferruginisation) trend will typically mark the redox boundary, being reflected by Fe oxide/oxyhydroxide precipitation.

Calcrete horizons within in situ and transported regolith mark another type of chemical transition (pH >8.6) where evaporative accumulation of dissolved species and complexes has occurred. This is a zone where Au, and other elements, mobilised under acid to neutral pH conditions, may be strongly affected by the pH increase (e.g. Cu, Ni, Pb and Zn), and therefore precipitate. Dispersed carbonate can be difficult to see in powdered drill cuttings but can be detected by testing with acid (1-10% HCl for calcite and 15% for dolomite).

In areas of transported cover the unconformity between transported regolith and underlying in situ saprolith may retain quartz granules, lithic fragments and ferruginous lag derived from the underlying weathering profile. This is a sensible material to sample, because it will retain dispersed elements that may have been leached from the underlying saprolite. Ferruginous sediments from just above the base of the transported regolith may include detritus transported from mineralisation or elements dispersed hydromorphically by groundwater flow (i.e. displaced anomalies).

Zones within in situ regolith with gossanous fragments and ferruginous quartz veins should be sampled, because these may represent the remnants of mineralisation not obvious at the surface owing to soil cover or burial by transported regolith. Shear zones—indicated by brecciated, veined and deformation fabrics in cuttings fragments or core sticks—should also be sampled, because they may contain elements dispersed from related mineralisation.

Logging

As with geological logging, regolith logging should be systematic and consistent. Inconsistent regolith logs have been problematic in the past owing to poorly defined or highly subjective use of terminology use and individualistic logging methods. To improve regolith logging CRC LEME has provided a ‘regolith glossary’ (Eggleton 2001), and has published a field guide on preferred approaches to describing and sampling regolith materials (Pain 2008). The LEME has helped to develop objective regolith logging methods for high throughput sample spectral loggers HyLogger™ and HyChips™, as well as promoted the use of portable logging devices such as PIMA and ASD infrared spectral mineral analysers. Drill cuttings can also be checked with a magnetic susceptibility meter or a radiation scintillometer (these are quick and semi-quantitative ways to detect some non-visual variations in regolith and bedrock). Analysis by portable XRF (e.g. ‘Niton’) is useful for detecting variations in Fe content and high abundances of some target and pathfinder elements.

Digital databases work best with quantitative descriptors (e.g. X% quartz rather than ‘quartz-rich’). It is important to log and describe the regolith separately from the unweathered bedrock. Avoid mixing regolith and fresh rock terms, and the urge to interpret and describe the regolith as the weathering product of a particular parent rock type. Describe it as it is: any interpretation comes afterwards and forms a separate item.

Dry and washed cuttings should be laid out and described on site by the geologist as drilling proceeds. Samples of dry raw cuttings and a few washed chips should be kept as an archival reference (e.g. in plastic chip trays or in labelled plastic bottles). Ultimately, at prospect relinquishment stage or earlier, all, or a representative set of, samples should be offered for archiving with the relevant state Geological Survey Drillcore Storage Facility, where more permanent housing will make sure those samples are available to future explorers and researchers.

It is useful to draw up rough drill sections in the field to help with correlation and recognition of distinctive regolith units. These can be refined later as more specific test and sample data become available. Entry of all this information into a digital database is an essential exploration management process and forward planning tool. Good visual, textural and spectral logs of regolith from all drillholes in a prospect are essential for developing 3D knowledge of the regolith and to identify consistent and appropriate sampling media.

References

Eggleton RA (editor), 2001. *The regolith glossary: surficial geology, soils and landscapes.* CRC LEME, Perth.

Pain CF, 2008. *Field guide to describing regolith materials and landforms.* CRC LEME, Perth.