REGOLITH–LANDFORM MAPPING AS A VECTOR TO GOLD MINERALISATION UNDERCOVER: INSIGHTS FROM BALLARAT, VICTORIA, AUSTRALIA

Linda Bibby and Andrew Radojkovic

Geological Survey of Victoria, P.O. Box 500, East Melbourne, VIC 3002

Staff from the Geological Survey of Victoria have recently completed a regolith mapping project in the Ballarat–Creswick area. The project was aimed to map and characterise the bedrock geochemistry of the major regolith–landform units and to determine if a major orogenic gold deposit, such as the Ballarat East goldfield, has a distinctive expression in the regolith. The mapping centred on a 10 × 28 km zone extending from the Ballarat East Goldfield in the south, north to Spring Hill, east of Creswick. This area was selected as a representative cross-section of the central Victorian goldfields, as it contains many elements of the landscape, a variety of differing surface and bedrock geological units and a centre of significant gold production.

The results of the project are available as a report (Radojkovic & Bibby 2002), accompanying 1:50,000 scale map (Bibby & Radojkovic 2002) and fully attributed digital data.

BALLARAT EAST GOLDFIELD

About 47,000 kg of primary or orogenic gold was won from the Ballarat East goldfield, which extends from Black Hill south to near Buninyong. It came from a north-striking zone over 10 km long but only about 500 m wide that was worked down to less than 550 m. The goldfield is located along the subvertical eastern limb of the First Chance Anticline (Figure 1). Mineralisation is concentrated along stacked, moderately west-dipping reverse faults, known as *leather jackets* (Taylor *et al.* 1996) and vertical quartz reefs, which cross-cut the anticline. Besanko (1996) reported hydrothermal alteration around the mineralisation extending up to 62 m from a leather jacket lode, intersected in drillcore from 647 m below the surface.

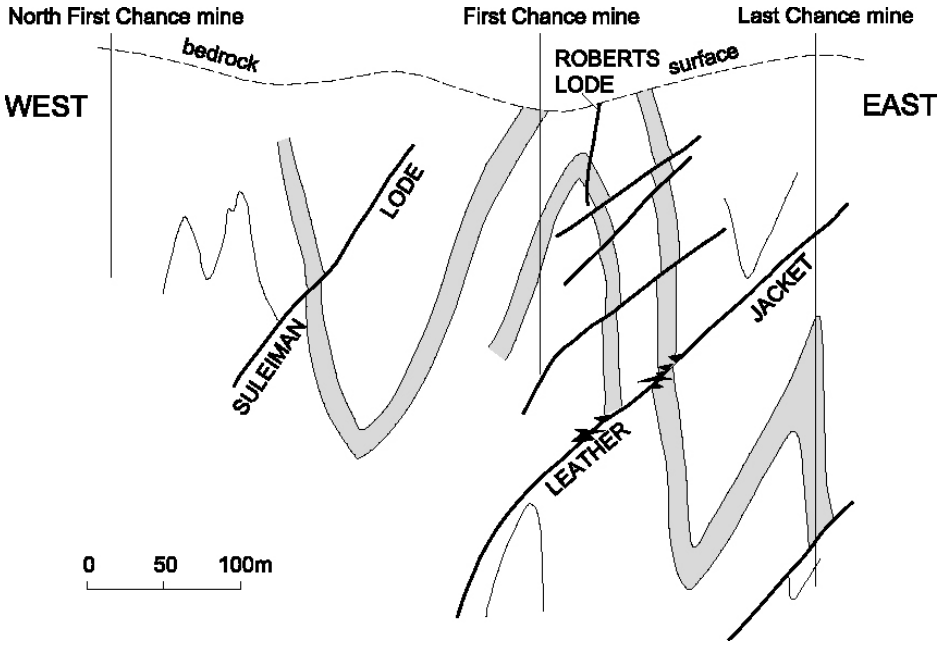

Figure 1: Cross-section of the Ballarat East goldfield showing fold style and position of major mineral-ised quartz reefs (after Taylor *et al*. 1996).

REGOLITH–LANDFORM UNITS

Twenty six regolith–landform units (RLUs) are described based on regolith profiles, landform pattern, landscape position and radiometric response. The units are defined using the RTMAP scheme for regolith mapping devised by Geoscience Australia (see Pain *et al*. in prep.). They fall within two broad categories: saprolite-dominated hills and rises; or transported cover.

Saprolite-dominated units occur over deep marine turbidites of the Ordovician Castlemaine Group, and granitic bedrock of the Late Devonian Mount Egerton Granodiorite. The main landform patterns are

undulating to rolling low hills and rises. A wide range of weathering degrees are present, ranging from slightly weathered saprock with thin lithic soil cover east of Creswick, through to very highly weathered saprolite in several different landscape positions. Soils developed over most of these units are typically acidic or neutral hard pedal mottled-yellow duplex soils (Maher & Martin 1987). Nearly all of the stream channels contain alluvial and colluvial material; some of these have been exploited for gold in the past.

Transported units are differentiated primarily on the process of transport of the materials in the landscape. They are then subdivided on degree of weathering and landscape position.

The Ballarat East goldfield coincides with a zone of pallid, very highly weathered bedrock on the crests and upper slopes of the low hills of the White Horse Range. The landscape position of this unit is unusual—the saprolite is fairly soft, and yet it is preserved along the top of a range. A likely explanation for this is that the extensive quartz veining associated with the alteration and mineralisation, which is armoured by a ferruginous halo on the flanks of the mineralisation, has increased the resistance of the range to erosion.

GEOCHEMISTRY

A statistical examination of the geochemistry combined with clay mineralogy of the saprolitic bedrock units highlighted several trends that that may act as a vector to gold mineralisation.

Across the Ballarat East goldfield, gold is associated with K–Rb–Ba–Al in the near surface, bleached, very highly weathered saprolite. This represents illite–sericite and kaolinite alteration of regional metamorphic chlorite within bedrock turbidites. On the margins of the bleached zone, a ferruginous halo defined by goethite and haematite films is associated with Fe–Mn–Cu–Bi–As. In soils similar geochemical trends to the bedrock are observed, complicated by differing soil horizons and the degree of weathering. In general, the most representative soil sample medium was found to be the C-horizon, where the clay composition is predominantly illite/sericite and the geochemistry is the closest approximation of the bedrock. In addition, PIMA analysis of the clays indicates mineralisation can be linked to a more crystalline, muscovitic illite clay composition with lesser kaolinite and chlorite.

IMPLICATIONS FOR GOLD EXPLORATION

The combination of geochemistry and landscape position of the Ballarat East goldfield has implications for exploring for similar deposits both at surface and under cover. The high standing relief of the goldfield is believed to be a reflection of the intense quartz veining associated with mineralisation along the White Horse Range (Figure 2).

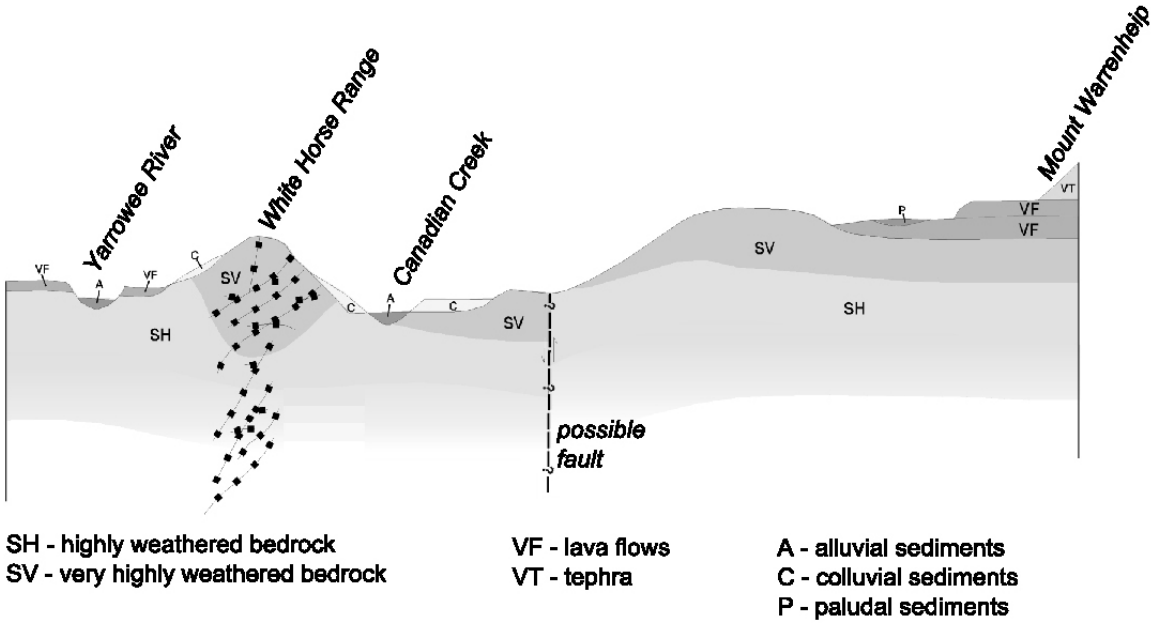

Figure 2: Idealised cross section through the Ballarat area showing regolith–landform relationships. Note the unusual position of very highly weathered and altered bedrock along the White Horse Range coinciding with the Ballarat East goldfield.

Topographic and palaeotopographic highs (the latter beneath cover), coincident with pallid, highly crystalline, muscovitic illite and Fe-carbonate alteration are all indicative of hydrothermal mineralising systems. In contrast, pallid, less crystalline, very highly weathered kaolinitic saprolite in low landscape positions is less prospective and sampling is difficult to interpret, with the potential for gold contamination via current or stripped overlying Cainozoic placer deposits. Therefore, palaeotopographic highs in favourable structural positions may be prospective for gold mineralisation.

REFERENCES

BESANKO J. 1996. B.App.Sci. (Hons) thesis, University of Ballarat, unpublished.

BIBBY L.M. & RADOJKOVIC A. 2002. Ballarat–Creswick special 1:50,000 regolith–landforms. Geological Survey of Victoria.

MAHER J.M. & MARTIN J.J. 1987. Soil and landforms of south-western Victoria. Part 1. Inventory of soils and their associated landscapes. *State Chemistry Laboratory, Department of Agriculture and Rural Affairs Research Report series* **40**, 229 pp.

PAIN C., CHAN R., CRAIG M., GIBSON D., URSEM P. & WILFORD J. in prep. *RTMAP regolith database field book and users guide, 2nd edition*. CRCLEME **Report 138**, 97 pp.

RADOJKOVIC A. & BIBBY L.M. 2002. The regolith of the Ballarat–Creswick area. *Victorian Initiative for Minerals and Petroleum Report* **76**. Department of Natural Resources and Environment.

TAYLOR D.H., WHITEHEAD M.L., OLSHINA A. & LEONARD J.G. 1996. Ballarat 1:100,000 map geological report. *Geological Survey Report* **101**.