

Alluvial* gold potential in buried palaeochannels in the Wyalong district, Lachlan Fold Belt, New South Wales

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Recent advances in understanding palaeodrainage in regolith terrains have led to the development of new conceptual models for landscape evolution in the Lachlan Fold Belt. At the same time, new high-resolution airborne geophysical datasets (magnetic, γ -ray spectrometric, and electromagnetic, AEM) have helped delineate many regolith features with no surface expression — notably buried, alluviated palaeoriver channels. Such palaeochannels, mainly in areas adjacent to high ground, were identified in the 19th century in several of the goldfields in the Lachlan River catchment, where some were mined for alluvial gold and tin until the early 20th century. We have delineated previously unrecognised palaeochannels on high-resolution magnetic images near the Wyalong Goldfield, an historic source of primary gold in quartz veins. Some of these newly

discovered palaeochannels may be prospective for alluvial gold sourced by erosion of the vein deposits.

Geomorphic and palaeogeographic setting

The Wyalong Goldfield is adjacent to the western margin of the north–south-trending Bland Creek palaeovalley (130 × 60 km; Fig. 1), which controlled the northward flow of Tertiary palaeorivers discharging into the main westward-flowing palaeo-Lachlan River system. The palaeovalley drainage first incised (probably in the Paleocene) an already weathered terrain in which saprolite profiles in bedrock locally extended 50 m or more deep. Time-transgressive incision proceeded by nickpoint retreat in response to the combined effects of differential uplift associated with continental break-up, downwarping of the Murray Basin,

and likely climate control related to eustatic sea-level changes (Gibson & Chan 1999: 'Proceedings of Regolith 98 Conference, Kalgoorlie, May 1998', CRC LEME, Perth, 23–37).

Drilling and seismic refraction profiling show that the Bland Creek palaeovalley has a crudely asymmetric cross-section owing to more pronounced incision on its eastern side (Anderson et al. 1993: NSW Department of Water Resources, Technical Services Report 93.045). North-northwest-trending ridges in the palaeovalley apparently owe their expression to bedrock composition, including alteration/mineralisation overprints. On the western palaeovalley margin, numerous magnetically delineated ENE- to NNE-trending palaeochannels appear to cut through these ridges. Steep-sided palaeochannels (gorges?) underlying the Temora Goldfield are as deep as 140 m (Lishmund 1972: Records of the Geological Survey of NSW, 14(2), 133–157).

Alluviation of the palaeo-Lachlan River system during the late Tertiary (Williamson 1986: Water Resources Commission, NSW, Hydrogeological Report 1986/12) buried the Bland Creek palaeovalley, whose alluvial fill comprises two formations. The Late Miocene to Pliocene Lachlan Formation — quartz-dominant, poorly sorted sand and gravel to cobble size — was deposited in a swampy, moderately reducing environment. After a brief erosional hiatus, the Pleistocene Cowra Formation, brown gravel and clay, accumulated in a more oxidising environment in which gravel distribution across the palaeovalley indicates constant reworking by braided stream channels (Williamson 1986: *op. cit.*).

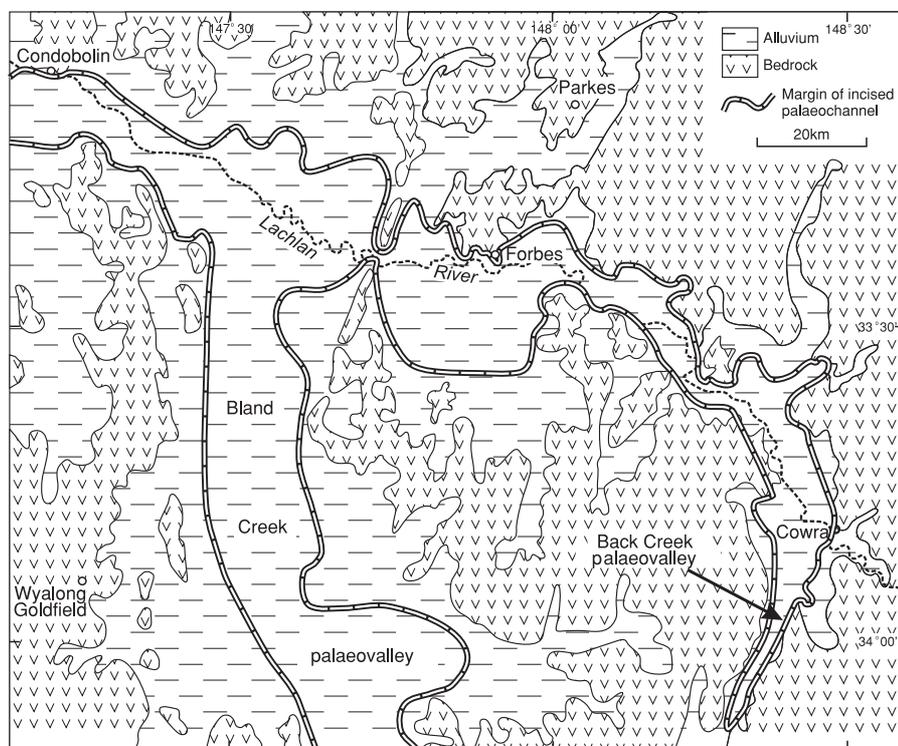


Fig. 1. The Bland Creek palaeovalley in relation to the Lachlan River and Wyalong Goldfield.

* We use the term 'alluvial' synonymously with the terms 'placer', 'palaeoplacer', 'lead' and 'deep-lead'.

Alluvial gold associated with the Lachlan River and Bland Creek palaeovalleys

Gold from alluvial palaeochannels contributed greatly to total gold production from several goldfields in the Lachlan River and tributary Bland Creek palaeovalleys. For example, 3.8 out of 4.2 t Au was mined from the alluvial workings in the Temora Goldfield (Lishmund 1972: *op. cit.*), ~60 km south of Wyalong.

Basal units in the Lachlan Formation are the principal source of alluvial gold in the palaeochannels. The auriferous sediments are typically 0.5–2 m thick and up to 100 m wide (Andrews 1910: NSW Geological Survey Report, Mineral Resources 13; Wilson & McNally 1996: 'Symposium on the geological evolution of eastern Australia', Sydney University Consortium of Geology and Geophysics, 71–73), but appear to be less continuous laterally and downstream than those in palaeochannel deposits in Victoria (Nielsen 1998: Australian Institute of Geoscientists [AIG] Bulletin 24, 121–125). Gold within leads was mined up to 6 km downstream of the channel heads (Mullholland 1935: NSW Geological Survey, Report 1935/002; Lishmund 1972: *op. cit.*). Only in a few examples was it recovered from horizons higher up than 2 m in the palaeochannel fill (e.g., at Golden Gate, Temora; Lishmund 1972: *op. cit.*).

Lateral gold distribution in the palaeochannels is complex. It apparently was controlled by a combination of fluvial processes and local channel geometry. Gold was mined from tributary channels, and at the junction of tributaries and the main channel in the Temora Goldfield (Lishmund 1972: *op. cit.*). Other examples of local controls on gold grades include 'depressions' or scour holes in the courses of channels, and bends in creeks within the main palaeochannel 'gutters' (Andrews 1910: *op. cit.*; Lishmund 1972: *op. cit.*).

Chemical dissolution and reprecipitation of gold in alluvial deposits may have been important for redistributing gold within some deposits in the Bland Creek palaeovalley. For example, high gold grades were associated with limonite-cemented gravels in palaeochannels at Temora (Lishmund 1972: *op. cit.*).

The Wyalong Goldfield — potential source for alluvial Au

The Wyalong (and Hiawatha) Goldfield (Fig. 2) occupies a mainly erosional ter-

rain in which colluvium and alluvium associated with modern drainage form a thin veneer (<3 m) over much of the saprolitic bedrock. Relief in the Wyalong area is subtle, and it is difficult to distinguish between the mostly erosional terrain and the surrounding alluvial areas.

Between 1894 and 1920, the Wyalong goldfield produced ~14 t (450 000 oz) Au (Bowman 1977: 'Forbes 1:250 000 mine data sheets and metallogenic study', NSW Geological Survey, Report) — all of it from several narrow north-northeast-trending subparallel veins (Watt 1899: NSW Geological Survey, Report, Mineral Resources 5; Bowman 1977: *op. cit.*).

Prospectors initially discovered the location of individual auriferous veins in this area by tracing gold-bearing quartz float up very low-gradient slopes in dense mallee scrub. The lack of alluvial gold was attributed to the difficulty of prospecting for such deposits in flat country (Pittman 1900: Department of Mines, NSW, Annual Report for 1899, 164). Pittman surmised that the area was denuded in Tertiary times, and that higher rainfall in previous times had conspired with the district's elevation to form drainage channels. Others discounted the formation of alluvial prospects owing to the fine grain size of the gold, which they asserted would have been dispersed by aeolian processes in a moderately arid environment (Watt 1899: *op. cit.*). Lack of relief, low rainfall, and scarcity of groundwater for supporting sluicing operations (Lishmund 1972: *op. cit.*) also dampened enthusiasm for alluvial-gold prospecting in the Wyalong area.

Early mining, nevertheless, revealed the presence of near-surface lumps of gold-bearing quartz, locally known as 'spuds', in the topmost regolith layers, which were clearly the result of denudation of outcropping auriferous quartz reefs. This, and analogies with other bedrock-alluvial gold relationships within the same drainage system would suggest that gold may have accumulated in palaeodrainage channels adjacent to the Wyalong (and Hiawatha) Goldfield. Alluvial gold was mined from small palaeochannels farther north at Billys Lookout (Bowman 1977: *op. cit.*; Fig. 2).

Wyalong Goldfield — primary gold characteristics

The auriferous quartz veins in the Wyalong Goldfield are structurally controlled, and localised in brittle-ductile fault zones 2.5 m wide cross-cutting the

earliest Silurian Ungarie Granite (M. Duggan, AGSO, personal communication 1999). Epidote-quartz-chlorite wall-rock alteration coincides with the fault zones.

Shear-parallel veins in these fault zones are much narrower (typically <1 m) and lenticular. The veins and host fault zones display a variable dip — subvertical or steeply east-dipping near the surface, and some veins flatten out at depth (<17° to the east; Watt 1899: *op. cit.*). Ore shoots plunge to the north in most fault zones, but to the south in the east (Markham 1987: 'Gold deposits of the Lachlan Fold Belt', NSW Geological Survey, unpublished). Steeply plunging ore shoots along strike were selectively mined. Mining extended to depths generally less than 50 m in many veins, but to 100 m in high-grade zones, and below 250 m in the Neelds and True Blue mines, where average grades were 35 and 62 g/t respectively (Aliano & Schwebel 1981: NSW Geological Survey, Report 1981/544).

Primary gold is intimately associated with pyrite. Minor sulphides include arsenopyrite, sphalerite, galena, and chalcopyrite (Watt 1899: *op. cit.*). Coarse gold was recovered from white quartz in veins in the east of the goldfield. Free gold is rare, but good grades were recovered by cyanidation and/or chlorination.

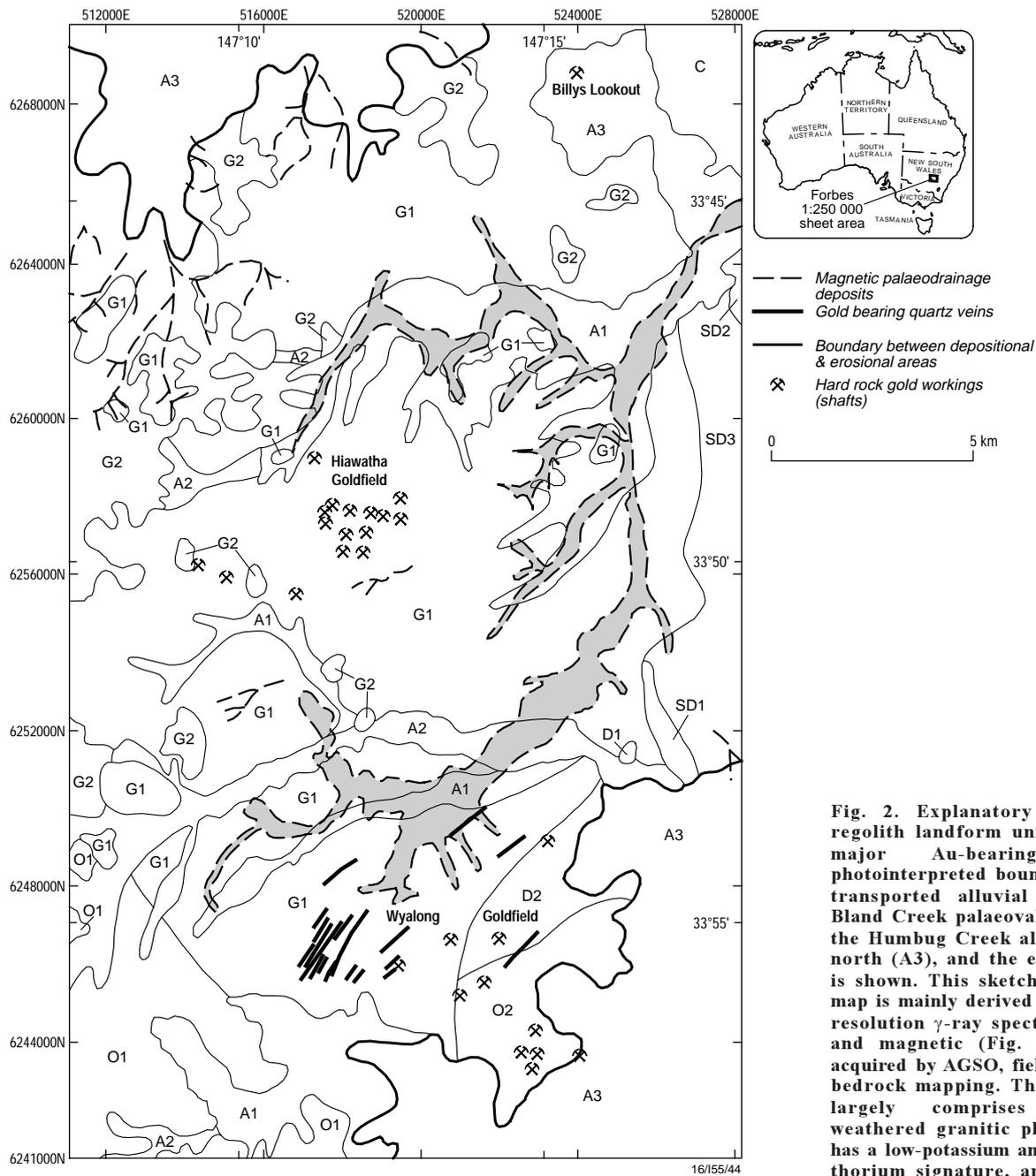
Oxide-zone enrichment

Gold grades of individual veins beneath the base of weathering are not uniform, but commonly <35 g/t. Despite their variability, analysis of gold production figures for individual quartz reefs shows that gold is enriched in the oxide zone (Aliano & Schwebel 1981: *op. cit.*), where they are typically >60 g/t. Many shafts were not deepened below the base of weathering owing to the increased difficulty of digging and diminishing grades (Watt 1899: *op. cit.*).

In the oxide zone, fine gold is intimately associated with iron oxides; coarse gold, with colourless, white, and reddish brown 'opaline' silica (Watt 1899: *op. cit.*). The base of oxidation of the host rock and quartz veins is around 50 m. Above this level, the ore and host rock could be mined with pick and shovel.

Significance of geophysical datasets for palaeochannel identification

As a contribution to the National Geoscience Mapping Accord (NGMA) last year, AGSO and the New South Wales Department of Mineral Resources (DMR)



- A1 Alluvium/colluvium in modern valley floors; sediment derived from low-response weathered granite.
- A2 Alluvium/colluvium in modern valley floors; sediment derived from high-response Ordovician meta-sediments, and high-response weathered granite.
- A3 Thick alluvium in Bland Creek palaeochannel; variable response depending on provenance.
- C Granite-derived colluvium forming distal low-angle colluvial fan; high response.
- G1 Granite, highly weathered to 60 m-100m lag of magnetic pisoliths, veneer of residual/colluvial sediments; low-response. Erosional plains and rises.
- G2 Granite, mostly highly weathered; high-response; erosional plains and rises.
- D1 Diorite, fresh; high response; steep rise.
- D2 Diorite, weathered, masked by residual/colluvial deposits; low-response; erosional plains and rises.
- SD1 Palaeozoic strata, fresh; high total response; steep ridge.
- SD2 Palaeozoic strata, weathered outcrops on rises; high-response.
- SD3 Palaeozoic strata, weathered, veneer of residual/colluvial sediments; low-response; plains and rises.
- O1 Ordovician metasediments, slightly weathered; high-response; low ridges.
- O2 Ordovician volcanics, highly weathered; low-response; erosional plains and rises.

Fig. 2. Explanatory diagram showing regolith landform units and location of major Au-bearing reefs. The photointerpreted boundary between thick transported alluvial sediments of the Bland Creek palaeovalley to the east and the Humbug Creek alluvial plains to the north (A3), and the erosional landforms is shown. This sketch regolith-landform map is mainly derived from imaging high-resolution γ -ray spectrometric (Fig. 3A) and magnetic (Fig. 3B) data recently acquired by AGSO, field observations, and bedrock mapping. The erosional terrain largely comprises in-situ highly weathered granitic plains and rises. G1 has a low-potassium and moderate- to low-thorium signature, and is characterised by ferruginous lag derived from mottled granite. G2 has a high-potassium signature, and appears to be less weathered. Magnetically delineated palaeochannels (grey screen) containing highly magnetic detrital ferruginous pisoliths, sand, and clay cross this area, and exit to the northeast. Colluvial and alluvial deposits associated with modern drainage form a veneer across these units with two distinct provenances (A1 and A2). Variably weathered and covered diorite (D1 and D2) and sedimentary rocks (SD1-3 and O) surround the low-relief granitic landscape. In the northeast, granitic colluvium (C) is associated with steep granite hills in the northeast.

acquired high-resolution magnetic and γ -ray spectrometric datasets along lines 50 m apart 60 m above the ground in the Wyalong area. The resolution of these datasets will be compared with that of others acquired over the area by AGSO and exploration companies at different heights and line-spacings. The new geophysical data trace the outlines of palaeodrainage channels not previously identified (Figs. 2 and 3).

The palaeochannels in the Wyalong Goldfield are magnetically delineated, and therefore apparent in magnetic images. They are also visible on AEM images (T. Munday, Cooperative Research Centre for Airborne Mineral Exploration Technologies, personal communication 1999), but not from the γ -ray data. Other magnetically delineated palaeochannels occur to the south and east. The palaeochannels contain detrital ferruginous (maghemitic) pisoliths concentrated in lenses in sand and clay (Fig. 3A). These pisoliths have high magnetic susceptibilities, which may at least in part explain the magnetic character of the palaeochannels. Palaeoflow was directed to the northeast, as indicated by the dendritic pattern in the magnetics image (Fig. 3A). The palaeochannels are not evident at the present-day land surface, but have been exposed in the West Wyalong rubbish dump. They are incised to unknown depths into weathered bedrock.

The proximity of some of the palaeochannels to the Wyalong (and Hiawatha) Goldfield — combined with the evidence for substantial surficial or near-surface mineralisation, evidence for erosion of these bedrock resources, and the juxtaposition of bedrock and alluvial deposits elsewhere in the same valley catchment — implies that they may be prospective for alluvial gold. Further palaeogeographic reconstructive research will help identify the most prospective ones.

Preliminary comparison of data from the different geophysical datasets suggests that airborne geophysical survey lines flown 50 m apart at ≤ 60 -m elevation can reveal important information about regolith materials, including channel-fill deposits in the Bland Creek palaeovalley (T. Mackey, AGSO, personal communication 1999). However, palaeodrainage can obviously be expressed and mapped at a range of scales, and it is important to match the specifications of each geophysical survey to the scientific objectives of a study.

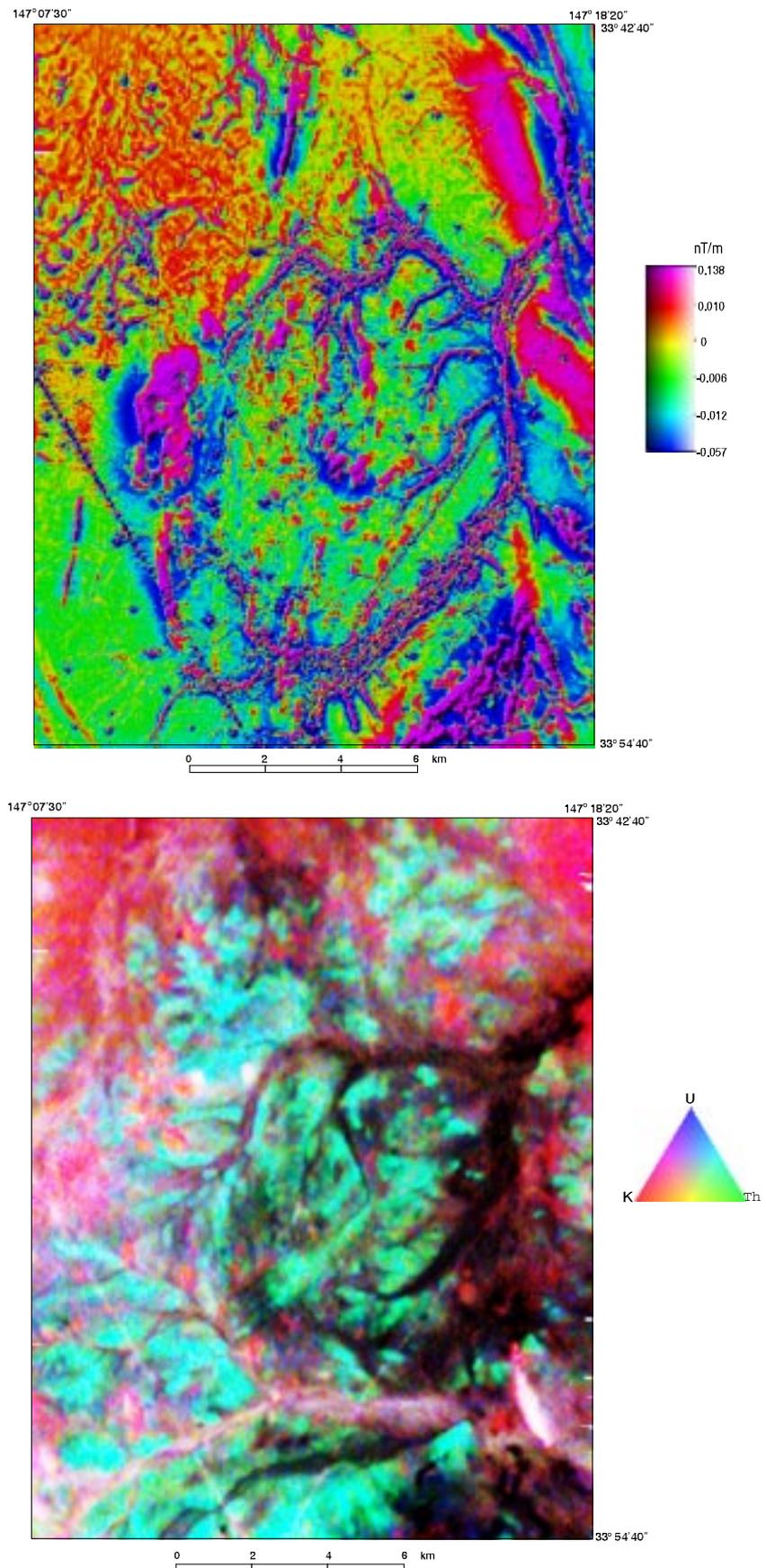


Fig. 3. High-resolution magnetic (top) and γ -ray spectrometric (bottom) images for the Wyalong district.

For our study, survey specifications facilitated the mapping of palaeochannels with a potential economic significance. In addition to their potential for hosting alluvial gold deposits, palaeochannels in the Lachlan River system are commonly reservoirs of saline groundwater (Andrews 1910: *op. cit.*; Wilson & McNally 1996: *op. cit.*). Therefore, mapping their distribution may also contribute to developing hydrogeological models for dryland salinity hazard assessment (W.R. Evans, Bureau of Rural Sciences, personal communication 1999). Three-dimensional mapping of regolith materials, including palaeochannels, should also lead to a better understanding of the hydromorphic dispersion of metals.

Conclusions

Modern airborne geophysical survey lines (magnetic and γ -ray spectrometric)

flowed low (60 m) and closely spaced (50 m apart) help map the distribution of buried channels in the Bland Creek palaeovalley. Owing to their proximity to bedrock gold deposits, these palaeochannels and others to the south and east of Wyalong may be prospective for alluvial gold. Similar buried palaeochannels adjacent to bedrock gold deposits in analogous settings elsewhere in the Lachlan River catchment also may be potential sources of alluvial gold.

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