Hydrothermal alteration in metasedimentary rock-hosted orogenic gold deposits, Reefton goldfield, South Island, New Zealand

Abstract Orogenic or mesothermal quartz lodes in lower Palaeozoic Greenland Group metasedimentary rocks of the Reefton area have produced 67 tonnes (t) of gold prior to 1951, and recent exploration has identified new gold resources in several deposits, including the largest past producers, Blackwater and Globe-Progress. The metasedimentary rocks consist of alternating sandstone and mudstone beds that were metamorphosed to lower greenschist facies prior to being hydrothermally altered adjacent to the quartz lodes. The sandstones are feldspathic litharenites averaging Q65–F10–R25, with detrital grains of quartz, rock fragments, muscovite, and plagioclase and biotite that were altered to albite and chlorite, respectively, during metamorphism. Accessory minerals are graphite, apatite, zircon, tourmaline and titanite. Hydrothermal alteration of the sandstones has developed a mineral assemblage of K-mica, carbonate (dolomite, ankerite, ferroan magnesite and magnesian siderite), chlorite, pyrite and arsenopyrite. The abundance of hydrothermal chlorite is greater at Blackwater than at the other prospects studied. Hydrothermal alteration associated with the quartz lodes is marked by bleaching, magnesian siderite spots, disseminated arsenopyrite and pyrite and thin carbonate, quartz and sulphide veins. These trends are accompanied by increasing concentrations of S, As and Sb and decreasing Na, and a decrease of Fe and Mg in K-mica. The alkali alteration indices 3K/Al (representing K-mica) and Na/Al (representing albite) generally show antipathetic trends, with 3K/Al increasing near the lodes and Na/Al decreasing. These trends reflect the replacement of albite by K-mica. Carbonate alteration indices CO2/(Ca + Mg + Fe) and CO2/[Ca + Mg + Fe − 0.5(S + As)] quantify the abundance of hydrothermal carbonates, but they show variable correlation with the lodes. They increase the width of the alteration halo in the hanging wall of the lodes at the Globe-Progress and General Gordon prospects, but the peak values are as far as 150 m from the lodes. By contrast, peak values of the carbonate alteration indices are within 10 and 2 m of the lodes, respectively, at the Merrijigs and Blackwater deposits. Data show that for deposits with wide hydrothermal alteration halos, such as at the Globe-Progress and General Gordon prospects, the use of a suite of geochemical indicators can assist exploration by indicating trends in hydrothermal alteration that provide vectors to mineralisation. They also increase the size of the exploration target. By contrast, the alteration halo of the Blackwater deposit is restricted to within less than 5 m of the quartz lode and, therefore, the geochemical indicators are of more limited assistance to exploration.

Keywords Alteration · New Zealand · Orogenic gold · Reefton

Introduction

The Reefton goldfield includes the largest group of orogenic or mesothermal gold deposits in the Buller terrane of the South Island of New Zealand (Fig. 1). The goldfield produced more than 67 tonnes (t) of gold from 84 mines in the period from 1870 to 1951 (Barry 1993; Brathwaite and Pirajno 1993). Gold exploration was resumed in 1980 by CRA Exploration Pty. Ltd., and from 1990 by GRD Macraes Ltd. (formerly Macraes Mining Company Ltd.). Recently identified resources for the goldfield, mainly at the Globe-Progress deposit, total 14.85 Mt at 2.81 g/t Au, containing 41.67 t or 1.34 Moz Au (GRD Macraes 2000). Development of a new open-pit mine at Globe-Progress commenced in early 2002, with a planned production of 2.2 t or 70,000 oz of gold per year.
Gold occurs in quartz lodes hosted in greywacke and argillite of the lower Palaeozoic Greenland Group (Fig. 2). Based on various mineral deposit classification schemes, the Reefton deposits are turbidite-hosted vein and shear-zone gold (Eckstrand 1984), low-sulphide gold–quartz veins (Berger 1986) or orogenic gold (Groves et al. 1998) deposits. They share many characteristics with lode gold deposits in Victoria, Australia (e.g. Ballarat and Bendigo; Ramsay et al. 1998) and Nova Scotia, Canada (Ryan and Smith 1998). The main differences are an apparent absence of the ‘classic’ saddle reef style of quartz veins and the less common occurrence of bedding parallel veins in the Reefton goldfield (Christie et al. 1999a, 1999b).

Some of the quartz lodes are developed along extensive shear zones and tend to ‘pinch and swell’, forming quartz lenses or ‘shoots’ that may be separated by ‘barren’ shears or displaced by post-lode faulting. The poor continuity makes the deposits notoriously difficult to explore by drilling. Therefore, a technique that could identify proximity to a mineralised quartz shoot, or at least provide a much larger target for exploration than the quartz lens alone, would be most useful. Definition of the mineralogical and geochemical patterns of hydrothermal alteration offers a potentially valuable exploration tool and is the subject of this paper.

Fig. 1 Location and past gold production in tonnes (t) of deposits of the Reefton goldfield and other orogenic (mesothermal) gold deposits hosted in Early Palaeozoic metasedimentary rocks of the Buller terrane, South Island, New Zealand

Historic reports (e.g. Henderson 1917) described the lodes as being surrounded by narrow (less than 1 m) zones of sericite, pyrite and minor carbonate alteration. However, the results of geochemical analyses conducted as part of recent exploration programmes suggest the presence of wider alteration halos. Gold and arsenic geochemical anomalies of as much as 150 m in width, which surround the mineralised shear zones, were defined from bedrock geochemical sampling of the Cumberland and other prospects in the Reefton goldfield by GRD Macraes Ltd. (Magner et al. 1997). Also, recent studies of similar deposits in Victoria have described alteration zones of as wide as several tens of metres surrounding major quartz lodes (Bierlein et al. 1998, 2000). We have examined and sampled core from the GRD Macraes Ltd. diamond drill holes and carried out petrographic, X-ray diffraction (XRD) mineralogy analyses, electron probe microanalyser (EPMA) mineral geochemical analyses and X-ray fluorescence (XRF) whole-rock geochemical analyses. These results are interpreted in concert with drill hole geochemical and