Gold-copper mineralization in alkaline rocks - Preface

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PREFACE

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Gold-copper mineralization in alkaline rocks

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As part of the "Drosophila of igneous petrology" (Barker 1983), alkaline rocks have gained much attention among petrologists worldwide, mainly due to their distinct geochemistry, and many geoscientists still consider them as petrological curiosities with an obscure petrogenesis. In the past, a plethora of genetic hypotheses and a large number of local names for alkaline rocks from different localities have been created (see reviews by Sørensen 1974; Peccerillo 1992).

More recently, alkaline rocks such as shoshonites have been established as being closely related to certain types of gold and base metal deposits (Müller and Groves 1993; Mutschler and Mooney 1993; Sillitoe 1997; Jensen and Barton 2000; Müller and Groves 2000). Some may even be intrinsically enriched in gold and platinum-group elements (Wyborn 1988). Some of the world's largest volcanic- and intrusion-hosted gold and copper-gold deposits are intimately related to potassic calc-alkaline and shoshonitic rocks. For instance, the world-class epithermal gold deposits Cripple Creek, USA (Kelley and Ludington 2001, this volume), Emperor, Fiji (Setterfield et al. 1991), and Ladolam and Porgera, Papua New Guinea (Müller et al. 2001, and Ronacher et al. 2001, both this volume) are all hosted by potassic calc-alkaline or alkaline rocks. Similarly, there are equivalent host plutons associated with the porphyry gold-copper deposits at Bajo de la Alumbrera, Argentina (Müller and Groves 2000), Bingham, USA (Maughan et al. 2001, this volume), Cadia, Australia (Holliday et al. 2001, this volume), Grasberg, Indonesia (Pollard and Taylor 2001, this volume), Skouries, Greece (Kroll et al. 2001, this volume) and Ok Tedi, Papua New Guinea (Rush and Seegers 1990).

In this Thematic Issue, the term "alkaline rocks" is used as an umbrella term to describe those igneous rocks plotting on the fields for alkali basalts, tephrites, phonolites, trachybasalts, trachyandesites, trachydacites, and trachytes, i.e., on the shaded field in the $Na_2O + K_2O$ versus SiO_2 plot (see Fig. 1). The term includes subduction-related potassic calc-alkaline rocks and shoshonites, alkaline rocks from within-plate settings, and shoshonitic and alkaline lamprophyres.

In a review of world-class gold-rich porphyry and epithermal deposits in the circum-Pacific region, Sillitoe (1997) emphasizes the association of many of these giant deposits with alkaline rocks. Sillitoe (1997) points out that about 20% of the large gold deposits are associated with shoshonitic and alkaline rocks, which are unlikely to exceed 3% by volume of circum-Pacific igneous rocks. Importantly, Sillitoe (1997) listed this association as one of only four criteria favorable for both world-class porphyry and epithermal gold-rich deposits in the circum-Pacific region, and attributed this association to the partial melting of stalled lithospheric slabs in the mantle, immediately following collision or arc migration, as a preferred mechanism to promote oxidation of mantle sulfides and the release of gold.

This Thematic Issue aims to provide new data on major gold and gold-copper deposits which are hosted by alkaline rocks in an attempt to document their increasing importance in the global mineral exploration.

Sillitoe (2001, this volume), in the first paper of this Thematic Issue, provides an overview of the increasing role of alkaline rocks in mineral exploration. Alkaline igneous centers apparently include a disproportionately large number of unusual, arguably unique gold and copper deposits. These aberrant deposits are considered important and worthy of special emphasis not only because of the exceptionally large metal contents of several of them, but because of the potential difficulties which they may represent at the exploration stage.

This volume is dedicated to the memory of the late Prof. Peter Beuge, Freiberg.

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Maughan et al. (2001, this volume) discuss the role of mafic alkaline magma in contributing substantial amounts of sulfur and metals to an otherwise unremarkable calc-alkaline porphyry system at Bingham, Utah, USA. Bingham is hosted by quartz-monzonite intrusions which have several chemical and mineralogical indications of magma mixing. These "mixed" lithologies include the hybrid quartz-monzonite porphyry, biotite porphyry, and minette dykes. Until 1998 Bingham has produced about 1,550 Mt @ 0.77% copper and 0.5 g/t gold, but it still contains reserves of about 1,100 Mt @ 0.6% copper and 0.38 g/t gold.

Kelley and Ludington (2001, this volume) provide an overview of a group of gold deposits which share a consistent spatial and temporal association with alkaline rocks found in a north-south belt along the eastern edge of the North American Cordillera and extending from Canada to eastern Mexico. The Cripple Creek district, which has yet produced > 700 metric tons of gold, forms part of this belt.

Müller et al. (2001, this volume) discuss the evolution of the Ladolam gold deposit at Lihir Island, Papua New Guinea, which is hosted by volatile-rich alkaline rocks with distinctly high oxygen fugacities. Ladolam is a unique gold deposit, not only due to its large resource (> 1,300 metric tons gold), but also due to its genesis ranging from a porphyry- to an epithermal gold system.

The paper by Pollard and Taylor (2001, this volume) describes the nature and controls of porphyry copper-gold mineralization hosted by potassic calc-alkaline intrusions at Grasberg, Indonesia. The data, which are mainly based on detailed logging of diamond drill holes, supplemented by observations and sampling of pit exposures, suggest that both magmas and fluids were derived from an evolving, deeper level magma chamber. Grasberg is the largest porphyry deposit in terms of gold, with proven reserves in excess of 2,000 metric tons, and 19.69 million tons of copper.

Ronacher et al. (2001, this volume) summarize the geology of the large alkaline rock-hosted Porgera gold deposit, Papua New Guinea, which has to date produced > 280 metric tons of gold. They present new laser $^{40}Ar/^{39}Ar$ dates on hydrothermal mineral phases, elucidating the relatively short life span of the epithermal gold mineralization.

Blevin (2001, this volume) provides an overview of potassic calc-alkaline and shoshonitic intrusions from the Lachlan Fold Belt, eastern Australia, hosting several economic epithermal gold deposits as well as the two world-class porphyry copper-gold deposits Cadia and Northparkes (Goonumbla). His data suggest that economic size and significance of the associated deposits increase with the degree of K-enrichment (but not total alkali contents) observed in the associated igneous complexes, hence supporting conceptual models which link mineralization potential and fertility with processes related to the production of K-enriched protoliths.

Holliday et al. (2001, this volume) describe the Cadia porphyry gold-copper district in the Lachlan Fold Belt, eastern Australia. Porphyry gold-copper mineralization at Cadia is directly associated with alkaline rocks of the shoshonite association. Although Cadia is the largest gold deposit in eastern Australia, with pre-mine resources of 470 metric tons of gold and 2.0 million tons of copper, no detailed description has been published before.

In the last paper of this Thematic Issue, Kroll et al. (2001, this volume) document the geochemistry and petrology of the shoshonitic monzonite intrusions hosting the Skouries porphyry copper-gold deposit,

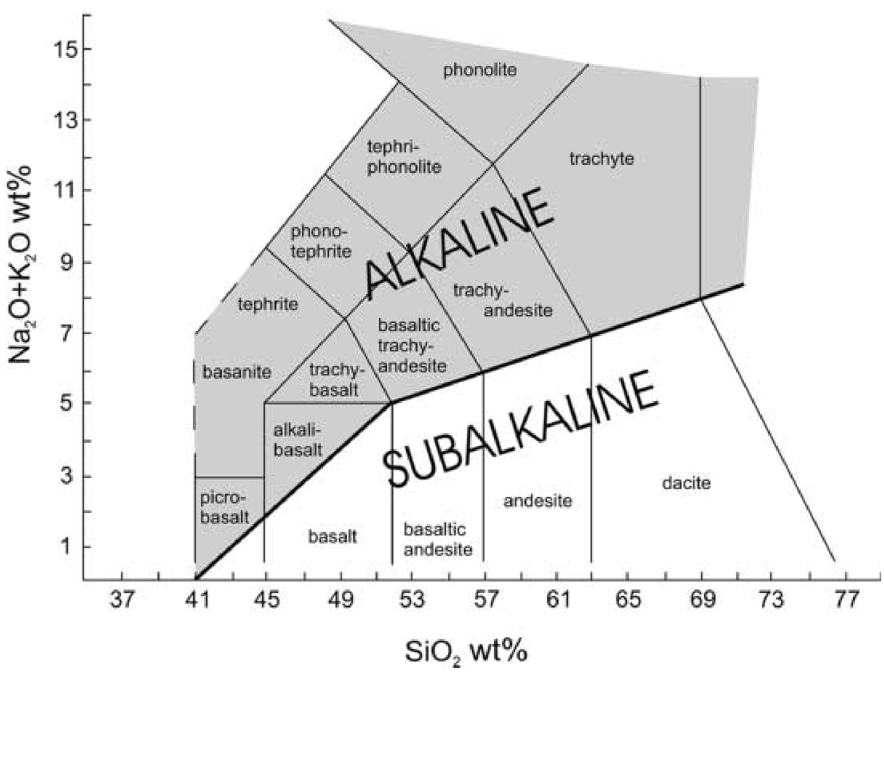

Fig. 1 $Na_2O + K_2O$ versus SiO_2 plot (modified after Le Maitre 1989). Those samples plotting on the fields for alkali basalts, tephrites, phonolites, trachybasalts, trachyandesites, trachydacites, and trachytes, i.e., on the *shaded* field, are considered as "alkaline rocks"

Chalkidiki peninsula, Greece. Skouries contains an indicated reserve of 206 Mt @ 0.54% Cu and 0.80 g/t Au.

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