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### Alkalic-type epithermal gold deposits: Porgera as an example

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If there is a unifying feature of alkalic-type epithermal gold deposits, apart from their association with hydrous alkalic intrusive rocks, it is that they are not coincident with main volcanic arcs. In some cases, such as the Montana alkalic district and Cripple Creek, Colorado, any kind of relationship to subduction activity is tenuous, although continental lithospheric rifting dynamically related to plate-margin processes is likely. In other cases, such as in the SW Pacific, deposits and their source magmas are related to distal (back-arc) or post-subduction processes (arc collision, subduction polarity reversal, arc isolation).

Many other distinctive features are variously but not universally shared by deposits in this class. They include high Au/Cu ratios in epithermal ores, occurrence of telluride minerals, low-sulphidation alteration styles, and the presence of roscoelite (V-rich mica), fluorite, and barite, with relatively minor quartz, as gangue minerals. Some of these characteristics might be attributed to the association with mafic alkalic magmas (e.g., V, F, Ba, Te), but the anomalously high Au/Cu ratio (when compared with other magmatic-hydrothermal ore deposits such as porphyry Cu deposits) is problematic.

It is suggested that the high Au/Cu character of the ores is directly related to the petrogenesis of the source alkalic magmas. In main volcanic arc environments, the influx of sulphur from the subducting slab is likely sufficient to stabilize sulphide mineral phases or melts in the mantle wedge, which will retain highly chalcophile elements such as Au. High volume partial melts from the wedge will be saturated in sulphide, and will thus carry significant dissolved concentrations of base metals, but low concentrations of precious metals. In the absence of a supply of new sulphur, e.g., after the cessation of subduction, melting in the asthenosphere or base of the lithosphere may result in breakdown of residual sulphide minerals, and the release of highly chalcophile elements to the melt. This process may be optimized under conditions of low degrees of partial melting in previously subduction-modified mantle, where (1) highly chalcophile elements have been enriched during earlier arc processes, (2) residual sulphide concentrations are low due to prior extraction of arc magmas, (3) oxidation state is relatively high due to water fluxing, which marginalizes the stability of sulphides, and (4) solidus temperatures are low due to alkali metasomatism and hydration.

Small degrees of partial melting of this previously subduction-modified mantle, yielding highly chalcophile element-rich, hydrous, alkalic magmas, may be triggered by a variety of tectonic processes, as noted above. Localized rifting or shear-fracturing of the lithosphere is likely to be a common factor in all of these settings, however. Such deep-seated fractures pro-

vide high-permeability conduits for the ascent of small-volume, mantle-derived magmas to shallow crustal levels. Compared with highly undersaturated rift-related alkalic magmas, which are often water-poor (e.g., carbonatite), these distal-subduction-related magmas are water-rich, and evolve to a magmatic hydrothermal stage during crystallization. In contrast to calc-alkaline porphyries and related epithermal deposits, however, gas contents (such as CO<sub>2</sub>) are nevertheless relatively high, and this may explain the much greater depth range (to > 2 km) of alkalic-type epithermal systems controlled by phase separation in relatively gassy hydrothermal fluids.