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Lithogeochemical classification of hydrothermally altered Paleoproterozoic plutonic rocks associated with gold mineralisation: examples from South Greenland and Northern Sweden

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Lithogeochemical techniques using immobile elements are widely described in the literature and such methods have been successfully applied in mineral exploration for the classification of variably (hydrothermally) altered host rocks and for more advanced chemostratigraphy (e.g. Barrett and McLean, 1994). Although lithogeochemical rock classifications are well established for volcanic rocks (including those which have experienced intense alteration), suitable rock classification diagrams for altered plutonic rocks, particularly granitoids, are lacking, with the literature heavily biased to the least altered examples.

Rock classification diagrams based on major oxides (e.g. Debon & Le Fort, 1982; De la Roche *et al*., 1980) are useful for unaltered rocks, however are wholly inappropriate for altered rocks due to the mobility of major elements during alteration. For example, K, Na, Ca, Si, Fe, Mg are recognised to be mobile during alteration and can be added or removed during metasomatism (Barrett and McLean, 1994). The addition of K is observed within highly altered granitoids located in proximal sericite alteration zones at the Vagar gold prospect in South Greenland (Fig. 1a; Schlatter *et al*., 2013). This alteration style is widely reported from other orogenic gold deposits of various ages.

In this contribution we discuss how altered plutonic rocks can be classified based on immobile elements. This has the potential to be used in distinguishing favourable granodiorite compositions associated with gold mineralisation within the study areas thus providing a useful vector for future gold exploration. We present new preliminary classification diagrams from 94 granitoid samples from Vagar gold prospect in the Nanortalik Gold Belt of South Greenland (Schlatter *et al*., 2013) and from the Svartliden (Schlöglova *et al*., 2013) and Fäbodtjärn (Fettweis, 2015) deposits of the Gold Line in Northern Sweden.

The plutonic rocks of both areas host auriferous quartz veins deposited at ca.1.8 Ga (e.g. at Vagar and Fäbodtjärn) or are spatially associated with the gold mineralisation (Schlatter *et al*., 2016; Fettweis, 2015). The preliminary classification diagrams based on the immobile elements Zr and Y discriminate the calc-alkaline Vagar granodiorite samples from the Svartliden and the Fäbodtjärn samples (Fig 1b), and classification based on the immobile element ratios Al/Ti and Zr/Al (Fig. 1c) allow the discrimination of granitoids of different areas and two geochemically discrete granodiorites at Vagar, a feature which is not apparent from major oxides diagrams (Fig. 1a).

It is conceivable that the granodiorites predate the orogenic gold, and thus “fertile” granodiorites reflect the fact they are suitable chemical or structural traps. Perhaps the composition of the Vagar granitoid, hosting significant gold mineralisation (e.g. quartz veins up to 2533 ppm and granodiorite up to 14.4 ppm) and with high Al/Ti ratio (Fig. 1c), is more reactive with an auriferous fluid than other granitoids, and thus represent a more favourable host for gold mineralisation.

High field strength elements bearing phases e.g. synchesite, allanite and monazite identified in SEM-BSE images and EDS analyses of gold bearing samples from Vagar (Schlatter *et al*., 2013), suggests that the hydrothermal fluid introduced REE elements together with the gold, making REE a possible pathfinder for gold exploration.

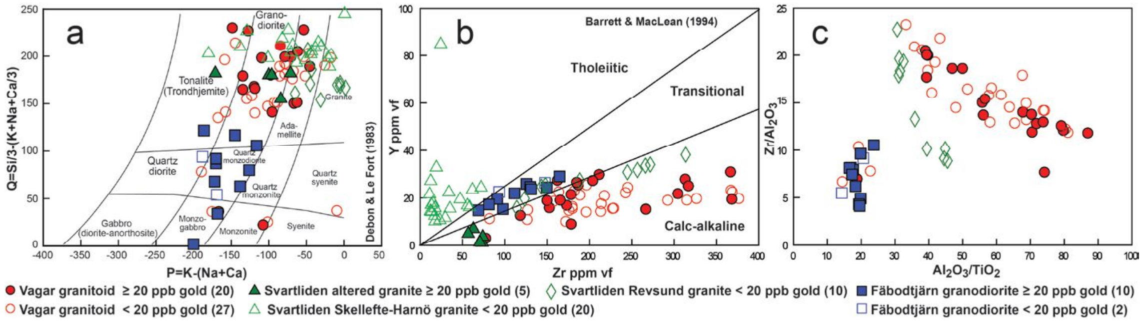

Figure 1. Lithogeochemical plots based on (a) major oxides (b) immobile elements assessing the affinity (c) immobile element ratios fingerprinting different granitoid types. Granitoids carrying gold are discriminated (filled symbols) from those barren (non-filled symbols). vf = volatile free basis.

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