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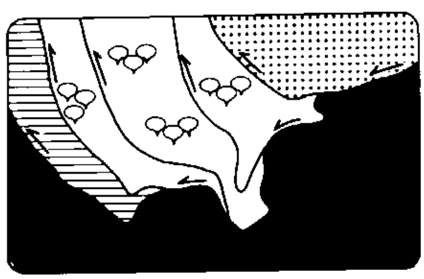

Tectonic setting of Ni-Cu-PGE deposits in the central part of the Cape Smith Belt

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Summary

The Ni-Cu-PGE sulphide deposits in the central and eastern parts of the Cape Smith Belt are best developed near the contact between the Povungnituk and Chukotat Groups. The deposits are associated with differentiated sills and ultramafic intrusions forming part of the feeder system to the lower Chukotat Group which comprises alternating olivine and pyroxene-phyric basalts. The intrusions were emplaced near or at the axis of an oceanic proto-rift. The sulphide deposits are concentrated in two east-west trending horizons: (1) the Raglan horizon, containing deposits associated with sub-volcanic ultramafic intrusions (*e.g.*, Lac Cross, Katinik and Donaldson sulphide deposits) and (2) the Delta horizon which contains deposits associated with differentiated sills (*e.g.*, Delta region) and ultramafic intrusions (Méquillon dyke, Bravo Sills).

Résumé

Les gîtes Ni-Cu-EGP de la partie centrale de la bande du Cap Smith sont abondants près de la limite supérieure du Groupe du Povungnituk, immédiatement sous les premières coulées de basaltes à olivine et pyroxène du Groupe de Chukotat. Ils sont associés aux intrusions différenciées et ultramafiques qui forment une partie du système nourricier des premières séquences de basalte komatiitique du Groupe de Chukotat. Ces intrusions se sont mises en place près de la zone axiale d'un proto-rift en domaine océanique. Les gîtes se concentrent le long de deux horizons est-ouest: (1) l'horizon de Raglan qui comprend des gîtes associés à des conduits sub-volcaniques de composition ultramafique (ex. Lac Cross, Katinik et Donaldson) et (2) l'horizon de Delta, qui comprend des minéralisations associées à des intrusions ultramafiques (ex. dyke de Méquillon) et à des filons-couches ultramafiques à mafiques différenciés (ex. filon-couche Delta).

Introduction

The geotectonic evolution of the southern part of the Cape Smith Belt (Povungnituk and Chukotat Groups, Figure 1) is described by the following sequence of events:

(1) Deposition of mainly shallow water sediments, followed by the extrusion of a volcanic sequence containing continental tholeiitic basalts with interdigitated clastic sediments and local rhyolites, basanites/nephelinites and phonolites (Picard *et al.*, 1989 - this issue, p. 130-134; Gaonac'h *et al.*, 1989 - this issue, p. 137-139). This environment is interpreted as a continental rift zone (Povungnituk Group; Francis *et al.*, 1981, 1983; Picard *et al.*, 1989 - this issue, p. 130-134).

(2) Eruption of komatiitic basalts that mark the beginning of the opening of a oceanic proto-rift (lower Chukotat Group; Picard *et al.*, 1989 - this issue, p. 130-134).

(3) Eruption of a monotonous plagioclase-phyric basalt sequence representing an oceanic floor (upper Chukotant Group: Francis *et al.*, 1983; Picard *et al.*, in press, 1989 - this issue, p. 130-134).

This sequence of events is recognized throughout the Cape Smith Belt, with the various tectonostratigraphic units preserved in east-west trending imbricated thrust-sheets (St-Onge and Lucas, in press).

The Povungnituk Group. The Povungnituk Group contains a lower, mostly sedimentary sequence of quartzites, shales, dolomites and a few iron formations structurally overlain by a volcanosedimentary package containing continental LREE-enriched tholeiitic basaltic sequences (Picard *et al.*, in press) with local alkali volcanic centres (Picard, 1986, in press; Gaonac'h *et al.*, 1989 - this issue, p. 137-139). A sedimentary unit terminates the Povungnituk Group and a local enrichment in LREE is observed (Giovenazzo *et al.*, in press). This transition zone between the Povungnituk and the Chukotat Groups is characterized by graphitic shales and siltstones, sulphidic shales, cherts and a few basaltic flows intruded by dioritic sills, differentiated sills and sub-volcanic ultramafic intrusions.

The Chukotat Group. This Group contains a volcanic sequence, with rare interflow sediments, composed of a basal series of alternating olivine and pyroxene-phyric basalts followed by an upper series composed of monotonous plagioclase-phyric basalts having N-MORB characteristics (Francis *et al.*, 1981, 1983; Picard *et al.*, in press). The alternating basal series indicates that volcanism was characterized by episodic eruption cycles with the olivine basalts being the most primitive or closer to a komatiitic composition. Each sequence of olivine to pyroxene-phyric basalts is controlled by fractionation of olivine and then olivine-pyroxene during the rise of the magma in the conduit system (Francis *et al.*, 1983).

Ni-Cu-PGE Mineralization

Ni-Cu-PGE mineralization is associated with differentiated sills and ultramafic intrusions that are co-magmatic with the lower, more MgO-rich sequences of the Chukotat Group. These intrusions form part of a channelized conduit system within the Povungnituk Group (Francis *et al.*, 1983). They are especially abundant in the central and eastern part of the Cape Smith Belt suggesting that the opening of the rift zone was diachronous, the most komatiitic magmas representing the first phase of the opening of this rift. The mineralization is grouped in two horizons: the Raglan horizon and the Delta horizon (Figures 1 and 2).

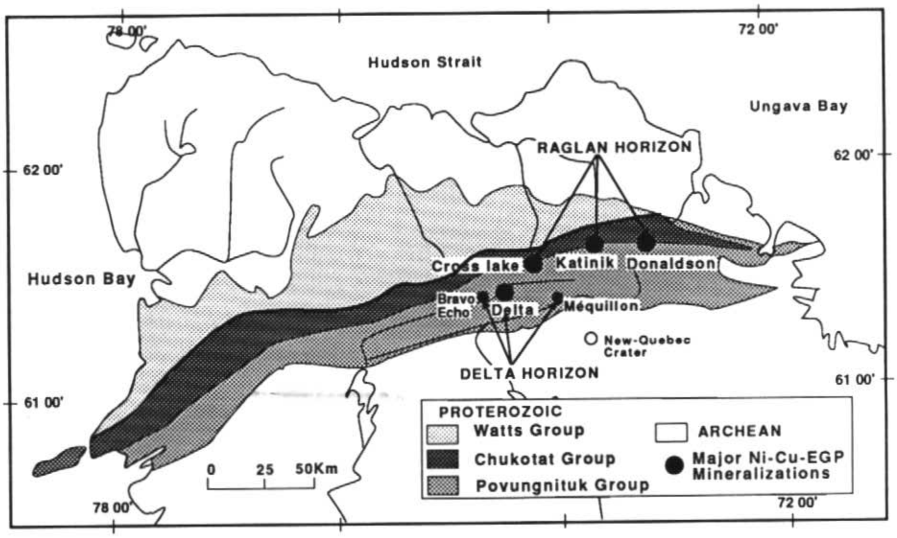

Figure 1 *Simplified geological map of the Cape Smith Belt with localization of the Ni-Cu-PGE deposits discussed in text.*

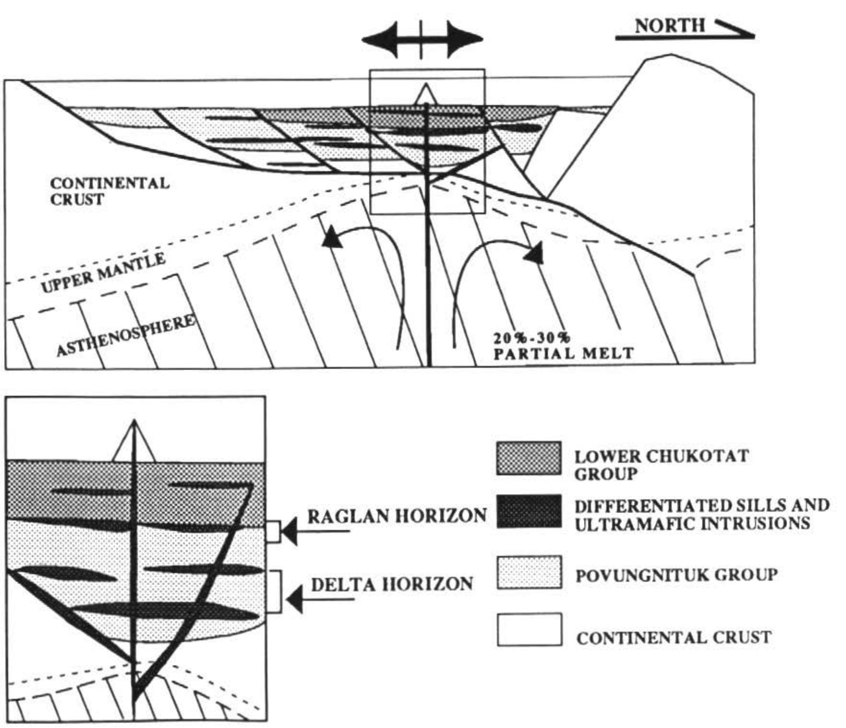

Figure 2 *Schematic illustration of the geotectonic environment of the Cape Smith Belt around 1918 Ma (U/Pb age; Parrish, 1989) with inset figure showing location of the Raglan and Delta horizons discussed in text.*

The Raglan horizon. The east-west trending horizon (Figures 1 and 2) is located within the upper sedimentary sequence of the Povungnituk Group immediately below the first lavas of the Chukotat Group. It is the most important in terms of presence and potential discovery of economic Ni-Cu-PGE deposits. It contains the more important deposits in the belt in the Lac Cross, Katinik and Donaldson areas (with estimated reserves of 10 million tons at 1.6% Ni and 0.8% Cu; 10.2 million tons at 2.4% Ni and 0.7% Cu; and 3.8 million tons at 4.4% Ni and 1.0% Cu, respectively: Coats, 1982; Barnes *et al.*, 1982). The ultramafic sills hosting the Ni-Cu-PGE deposits are generally thinner than 150 metres and can be traced for a few kilometres. They consist mainly of peridotite in the centre bordered by thin pyroxene-rich margins. Olivine mesocumulate dominates, and contains variable amounts of olivine crystals (<0.5 mm) pseudomorphosed to either antigorite, tremolite, talc and carbonate (only in Donaldson-east) in a microblastic matrix of chlorite and antigorite. This assemblage also includes poikilitic diopsidic clinopyroxenes. Sulphides are always present in these intrusions.

Deposits formed by magmatic segregation contain a thin (< 10 cm) basal horizon of massive sulphides surmounted by net-textured and disseminated sulphides. Breccia and foliated massive sulphides occur within shear zones. The sulphides are comprised of pyrrhotite, pentlandite, chalcopyrite, magnetite and ferrochromite with rare pyrite and PGE minerals (sudburyite, merenskyite, kotulskite, testiobiopalladinite and sperrylite: Giovenazzo *et al.*, 1988; Dillon-Leitch *et al.*, 1986). These sulphide accumulations have a magmatic origin. They were formed when an immiscible sulphide liquid separated from a parental komatiitic magma because of sudden sulphur saturation in the magma. They were subsequently modified to variable extents by deformation and metamorphism (Barnes *et al.*, 1982; Dillon-Leitch *et al.*, 1986; Giovenazzo *et al.*, 1988). Relatively high PGE contents in the sulphides indicate either that the sulphide liquid must have equilibrated with a large volume of silicate magma during ascent or that the primary magma was exceptionally rich in PGE (Barnes *et al.*, 1982), with 30-40 ppb of total PGE in chilled margins (Picard and Giovenazzo, in press).

The Delta horizon. This horizon is located in the central part of the Povungnituk Group (Figures 1 and 2). Situated at a lower stratigraphic level than the Raglan horizon, many small sulphide deposits occur within differentiated sills, such as the Delta 3 (Picard and Giovenazzo, in press; Giovenazzo *et al.*, 1988) and ultramafic intrusions, such as the

Bravo sill (Barnes and Giovenazzo, 1989) and the Méquillon dyke (Tremblay, 1989).

The ultramafic- to mafic-differentiated sills typically contain layers of peridotite, pyroxenite, gabbro, and locally layers of ferro-gabbro, quartz ferro-gabbro and anorthosite. They are generally poor in sulphides, but may contain localized Ni-Cu-PGE concentrations in thin (< 1 m) pyroxene-rich pegmatoidal gabbros interpreted as a reef-type PGE mineralization (*e.g.*, Delta 3, Giovenazzo *et al.*, 1988; Picard and Giovenazzo, in press). These reefs may contain up to 15% disseminated sulphides. The Ni-Cu-PGE deposits associated with the ultramafic dykes and sills occur near the base of the intrusions and present features similar to the ones in the Raglan horizon.

Discussion

The lower volcanic sequences of the Chukotat Group consist of alternating horizons of olivine and pyroxene-phyric basalts related to a mantle-equilibrated komatiitic parental magma (Francis *et al.*, 1983). This magma was able to reach the surface because of the absence of a true magmatic chamber. Ultramafic to mafic intrusions within the Povungnituk Group were emplaced near or at the axis of an oceanic proto-rift zone. The evolution of each basalt sequence in the Chukotat Group is controlled by fractionation of olivine and olivine-pyroxene in the conduit systems.

The presence of sulphides in all of these intrusions indicates that sulphur saturation was attained at an early stage in the magmatic history. In some cases, the sulphur is thought to be of totally magmatic derivation (Méquillon dyke, Tremblay, 1989) and in others, partly from the assimilation of sulphidic sediments. The latter case may apply to the Lac Cross, Katinik and Donaldson deposits (Figure 1), but this remains to be verified. Once sulphur saturation is attained, Ni, Cu and the PGE in the liquid will partition easily into the sulphides because of the high distribution coefficients (Naldrett and Barnes, 1986). Magmas segregating an immiscible sulphide liquid during their crystallization in sub-crustal magmatic reservoirs will lose most of their Ni, Cu and PGE before reaching the surface. Thus, any remaining extruded magma will be PGE poor.

This is the reason why Ni-Cu-PGE deposits in the Cape Smith Belt are associated with feeder system intrusions and not with the overlying flows.

Conclusions

In the southern part of the Cape Smith Belt, all Ni-Cu-PGE deposits are associated with intrusions forming part of a plumbing system related to the first ultramafic sequences of the Chukotat Group. The basal part of this group, composed of alternating flows of olivine-phyric and pyroxene-phyric basalts has a mantle-equilibrated source that has fractionated in feeder conduits. This primitive komatiitic magma was sulphur saturated at an early stage and remained so in the course of its crystallization history.

The intrusions in the Raglan horizon are emplaced in the predominantly sedimentary sequence of the Povungnituk Group and the Ni-Cu-PGE deposits are commonly in the proximity of sulphidic shales and siltstone. It is possible that the great dimension of these orebodies and their widespread occurrence in this horizon is related to assimilation of these sedimentary units thus provoking sulphur saturation and rapid deposition of sulphides in these sills. The high contents of PGE in the sulphides tend to confirm that they equilibrated with a great quantity of magma and that the host intrusions acted as open-ended feeder channels to the overlying primitive high-MgO Chukotat flows.

Acknowledgements

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