Bedrock Geology of the Wolverine-Doris Corridor, Hope Bay Volcanic Belt, Nunavut
GSC Open File 1553

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This project was undertaken during the summers of 2001 and 2002 in collaboration with Miramar Mining Corporation. Although this represents new mapping and interpretation, by the authors, it builds upon the comprehensive database established by Miramar and precursor companies. Many geologists who have worked in the area since the early 1990's have contributed to an understanding of this area.

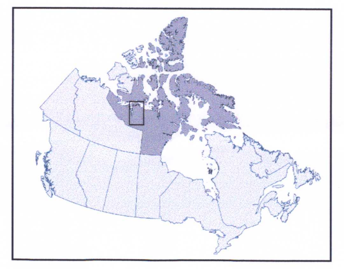

Figure 1. Location of Nunavut and the Hope Bay Volcanic Belt

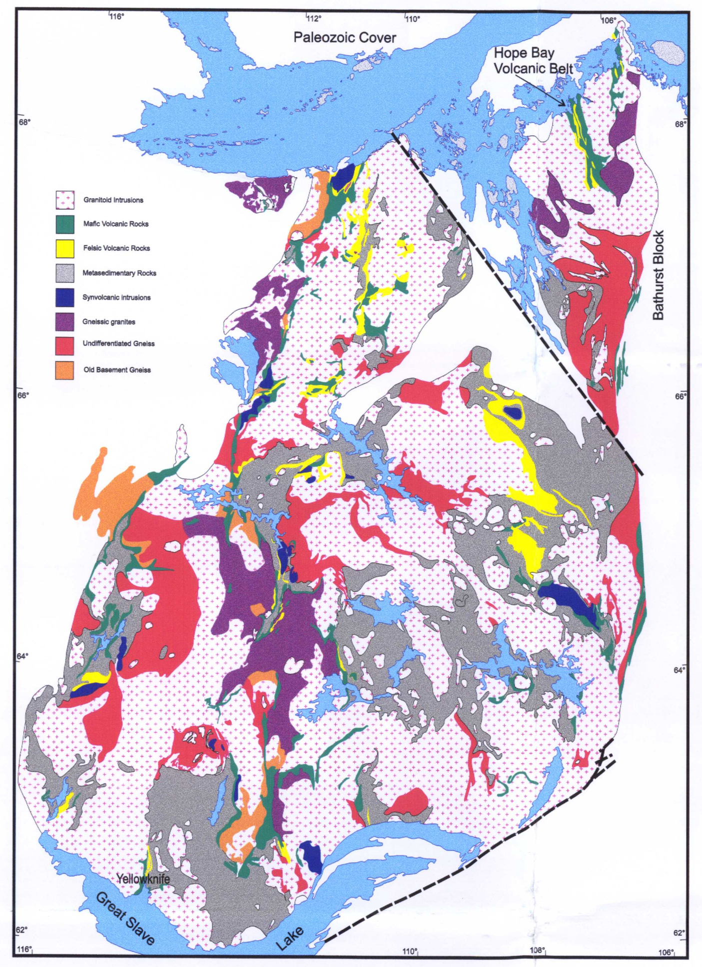

Figure 2. Generalized geology map of the Slave Structural Province after Fyson (1997).

The Hope Bay volcanic belt is located in the northeast portion of the Slave Structural Province. The Slave Province is predominantly an Archean granite-greenstone-metasedimentary terrane that lies between Great Slave Lake and Coronation Gulf, and is bounded to the east by the Thelon Orogen (2020 to 1910 Ma) and to the west by the Wopmay Orogen (1950-1840 Ma; Hoffman, 1988).

About twenty-six granite-greenstone belts are recognized in the Slave Structural Province, which were subdivided into mafic volcanic-dominated (Yellowknife-type) and felsic volcanic-dominated (Hackett River-type) by Padgham (1985). Yellowknife-type belts are typically massive to pillowed tholeiitic flows interbedded with calc-alkaline felsic volcanic and volcaniclastic rocks, clastic sedimentary rocks and rarely synvolcanic conglomerate and carbonate units. Hackett River-type belts are dominated by calc-alkaline felsic and intermediate rocks intercalated with turbidities. U-Pb geochronology brackets volcanism in the Slave to between about 2715 and 2610 Ma (Mortensen et al., 1988; Isachsen et al., 1991). The volcanic belts are typically isoclinally folded and contain belt-parallel shear zones. A late (circa 2.6 Ga) "Timiskaming-type" sedimentary assemblage, consisting of conglomerate and sandstone, may overlie the main greenstone belts (Fyson and Helmstedt, 1988). Villeneuve (1997) subdivided the intrusive rocks into 2.70 to 2.64 Ga pre-deformation tonalite and diorite, 2.62-2.59 Ga K-feldspar megacrystic granite and post-deformation 2.60-2.58 Ga two-mica granites. A regional pan-Slave deformation event is recognized between 2.7 and 2.6 Ga characterized by regional compression, plutonism and late extension (<2.583 Ga).

The Bathurst block (Figure 3) is the part of the Slave Structural Province northeast of Bathurst Inlet. It is isolated from the rest of the Slave by Proterozoic cover of the Kilohigok Basin (Campbell and Cecile, 1976). The Hope Bay volcanic belt is within the northern portion of the Bathurst Block. This belt was first mapped at a reconnaissance scale by Fraser (1964), and later in more detail by Gibbons (1987) and Gebert (1990; 1993) who considered the belt to be analogous to the Yellowknife Supergroup. The Hope Bay belt is dominated by mafic volcanics with felsic volcanic and volcaniclastic products and subordinate ultramafic bodies and metasedimentary rocks. Existing U-Pb geochronology of the belt indicates that felsic volcanism spanned a period of at least 53 Ma (2716-2663 Ma; Hebel, 1999).

To the east, the belt is bordered by felsic intrusions that separate the Hope Bay belt from the Elu Inlet belt (Figure 3). A granodiorite northeast of the Hope Bay belt gave an U-Pb zircon age of 2672 +4/-1 Ma, suggesting a syn- to late volcanic age of emplacement (Bevier and Gebert, 1991). The southeastern contact of the Hope Bay belt is a heterogeneous gneiss terrane that yielded a U-Pb zircon age of 2649.5 +2.9/-2.5 Ma and a titanite age of 2589 Ma, which may represent a metamorphic age (Hebel, 1999). The Hope Bay belt is bordered to the west by plutonic rocks, that contain foliated mafic fragments, dated at 2608 ± 5 Ma which places a lower limit on deformation and metamorphism (Bevier and Gebert, 1991). The metamorphic grade in the interior of the belt is lower greenschist with amphiolite grade near the belt margins.

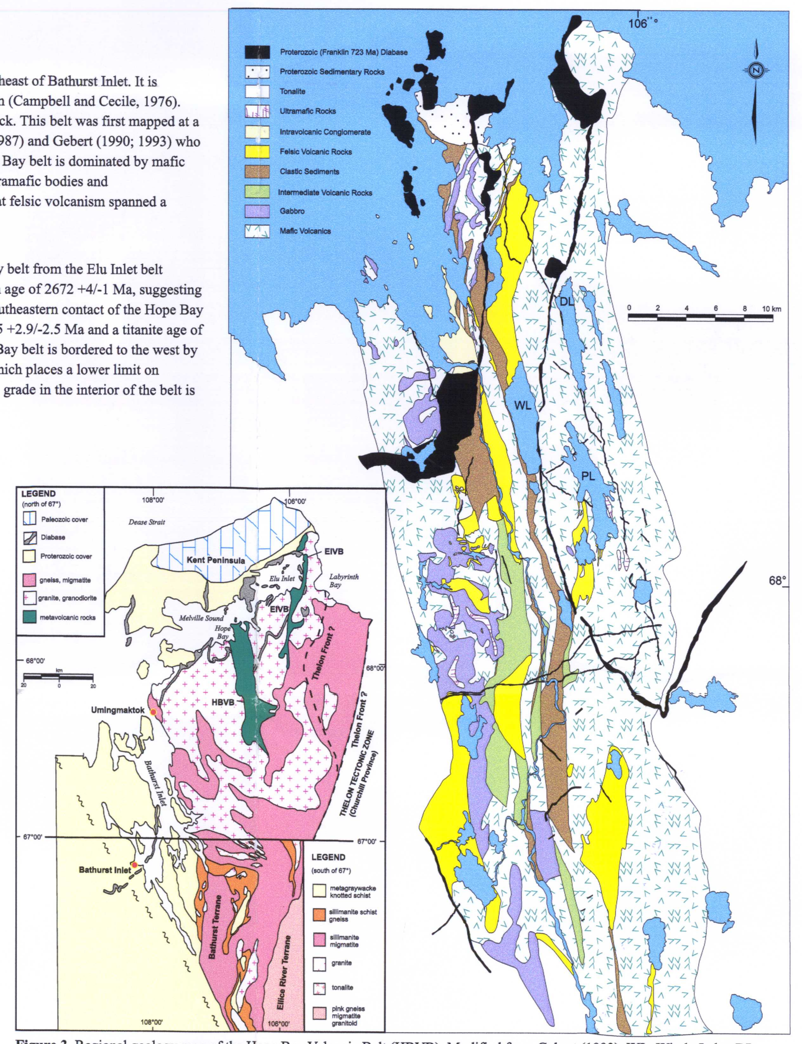

Figure 3. Regional geology map of the Hope Bay Volcanic Belt (HBVB). Modified from Gebert (1993). WL, Windy Lake; DL, Doris Lake, PL Patch Lake. Inset is the generalized geology of the Bathurst Block. North of latitude 67° modified from Fraser (1964), south of latitude 67° modified from Thompson et al. (1986). From Gebert (1993). The Hope Bay (HBVB) and adjacent Elu Inlet volcanic belts (EIVB) are indicated.

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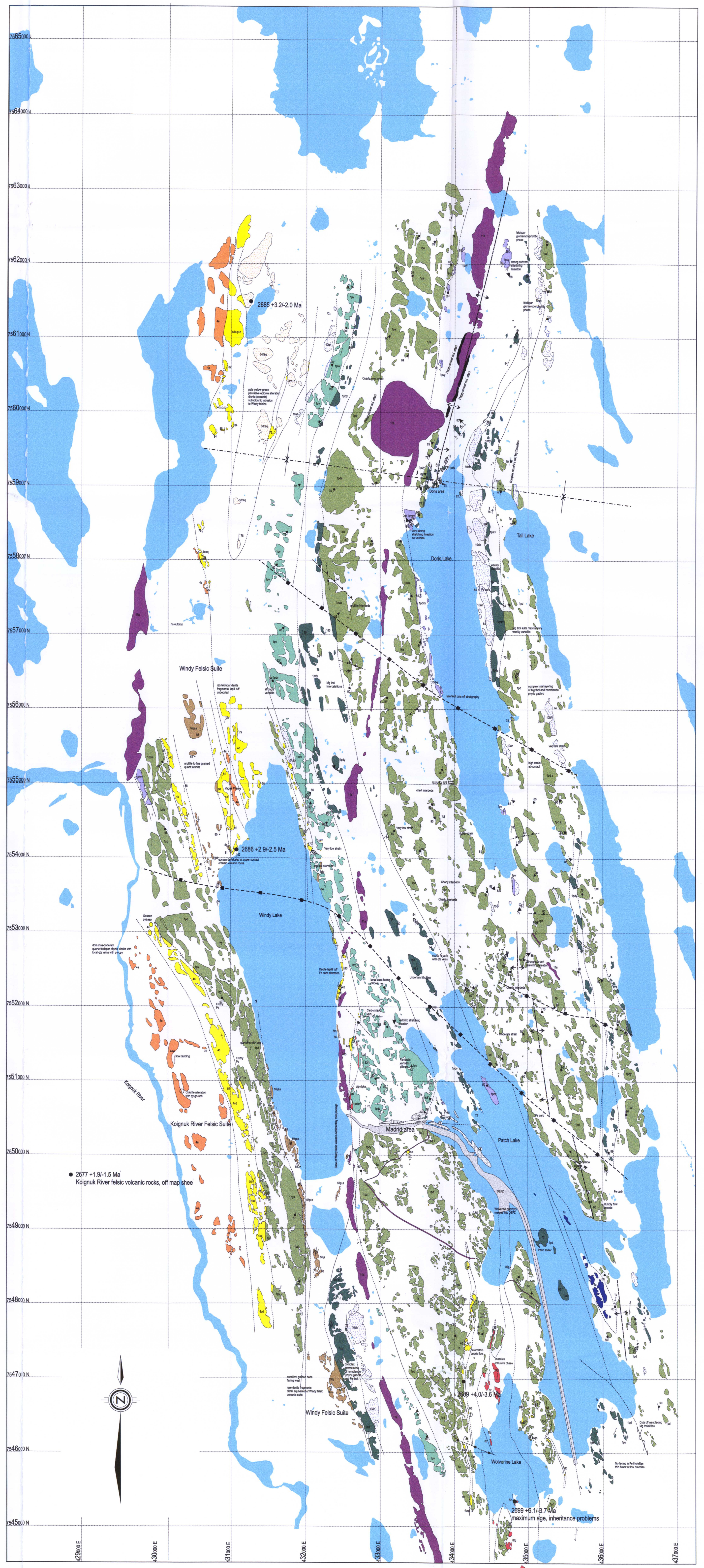

Figure 4. Bedrock geology of the Wolverine-Doris corridor. Scale 1:25,000

UTM Zone 13W, NAD 83

Lithologies

- 11 — Proterozoic diabase: a, inferred Franklin suite (723 Ma)
- 10 — Late, post-volcanic intrusions: a, gabbroic; h, hornblende-phyric
- 8 — Early, syn-volcanic intrusions, subvolcanic intrusion into the Windy felsic volcanic rocks: d, diorite; f, feldspar-phyric; q, quartz-phyric
- 8 — Early, syn-volcanic intrusions, Wolverine porphyry: d, diorite; f, feldspar-phyric; q, quartz-phyric
- 5 — Early, syn-volcanic sedimentary rocks: a, argillite; q, quartzose wacke; f, feldspathic wacke
- 4 — Felsic metavolcanic rocks, coherent facies: a, massive flow; w, flow-banded
- 4 — Felsic metavolcanic rocks, clastic facies: c, lapilli; d, breccia; q, quartz-phyric; o, hetrolithic fragments; s, sericitic
- 1 — Mafic metavolcanic rocks, magnesium tholeiites, non-variolitic: a, massive flows or subvolcanic intrusions d, flow/pillow breccia, hyaloclastite, sediment-lava interaction textures; p, pillowed flow; j, interflow sedimentary rocks y, amygdaloidal, commonly weathered-out
- 1 — Mafic metavolcanic rocks, magnesium tholeiites, variolitic: a, massive flows or subvolcanic intrusions; d, flow/pillow breccia, hyaloclastite, sediment-lava interaction textures; p, pillowed flow; v, variolitic; j, interflow sedimentary rocks; y, amygdaloidal, commonly weathered-out
- 1 — Mafic metavolcanic rocks, iron tholeiites, non-variolitic: a, massive flows or subvolcanic intrusions; d, flow/pillow breccia, hyaloclastite, sediment-lava interaction textures; p, pillowed flow; v, variolitic; j, interflow sedimentary rocks; y, amygdaloidal, commonly weathered-out
- 1 — Mafic metavolcanic rocks, iron tholeiites, variolitic: a, massive flows or subvolcanic intrusions; d, flow/pillow breccia, hyaloclastite, sediment-lava interaction textures; p, pillowed flow; v, variolitic; j, interflow sedimentary rocks; y, amygdaloidal, commonly weathered-out
- 1 — Mafic metavolcanic rock: u, ultramafic phase, likely represents a cumlate phase of the mafic metavolcanic rocks
- Lithologic contacts, observed, interpreted

Structure and Alteration

- Brittle faults, major, minor; dipping, vertical
- Trace of F fold axis, inferred
- S fabric, penetrative to spaced planar fabric, verticle, dipping, dip not indicated
- Trace of F anticlinal axis, position indicated by reversals in pillow facing directions
- Small-scale F fold axis, assymetry and plunge indicated, M-folds, Z-folds, S-folds
- Stretching (mainly varioles) or mineral elongation lineation
- Pillow facing directions, younging determined from gas cavities normal and overturned
- S/S composite fabric, vertical, dipping, younging direction indicated, overturned
- DEFZ — Surface trace of the deformation zone. A complex, hydrothermally altered tectonite, that includes various precursor lithologies. Inpart is a reactivation of an early syn-volcanic fault system, partially occupied by the Wolverine porphyry
- Geochronology samples; 1, Hebel (1999), 2, Sherlock and Mortensen, (unplublished data)

Showings

1. Naartok
2. Perrin
3. Matrim
4. Suluk
5. Jeffe
6. Wolverine
7. Light
8. Dinger
9. Spots
10. Doris Hinge

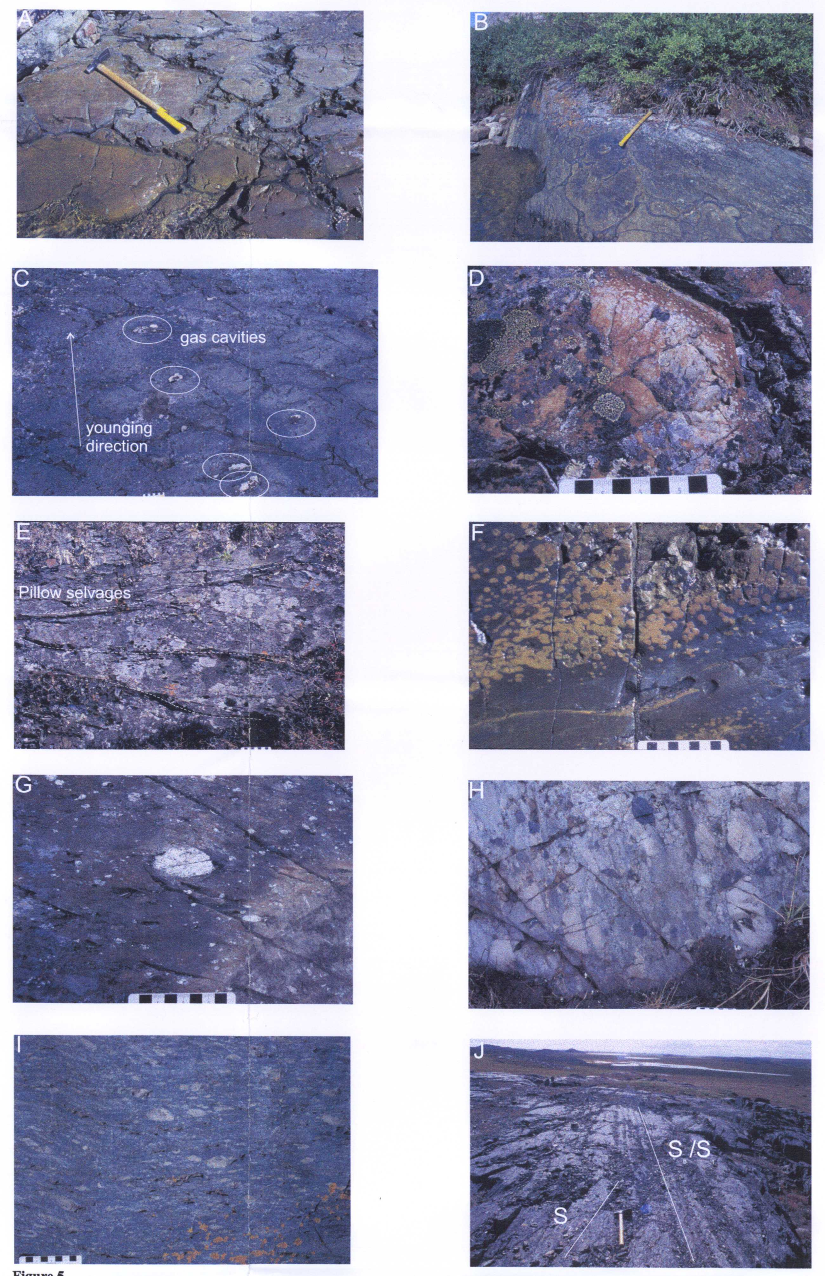

Figure 5

A. Well formed pillows, typical of the Mg tholeiitic basalt suite. East side of Windy Lake (13W 7553603N 432266E).
B. Mg tholeiites pillowed flows, east side of Patch Lake. (13W 7551289N 434513E)
C. Gas cavities in pillowed flows, providing young direction. Southeast end of Patch Lake. (13W 7549261N 435725E)
D. Variolitic Mg tholeiite pillow basalts with coalesced varioles near the pillow selvage. (13W 7551059N 433567E)
E. Fe tholeiite pillowed flows, from the Doris deposit, showing ragged pillow outlines. (13W 7559269N 433845E).
F. Variolitic Fe tholeiite pillow flows, showing coalesced varioles. (13W 7550870N 434457E)
G. Dacite volcanic conglomerate with large fragments of quartz-feldspar porphyritic dacite in a sandy matrix. Poorly sorted and bedded. (13W 7551519N 432601E).
H. Hetrolithic volcanic conglomerate dominated by dacitic fragments but also with variolitic basalt and argillite clasts. (13W 7551852N 432719E).
I. Dacitic lapilli tuff, part of the Windy felsic suite. (13W 7551735N 432422E).
J. Well bedded and graded quartz arenite part of the southern extension of the Windy felsic volcanic suite. locally large dacite fragments are found in these sedimentary rocks. (13W 7546762N 432447E).

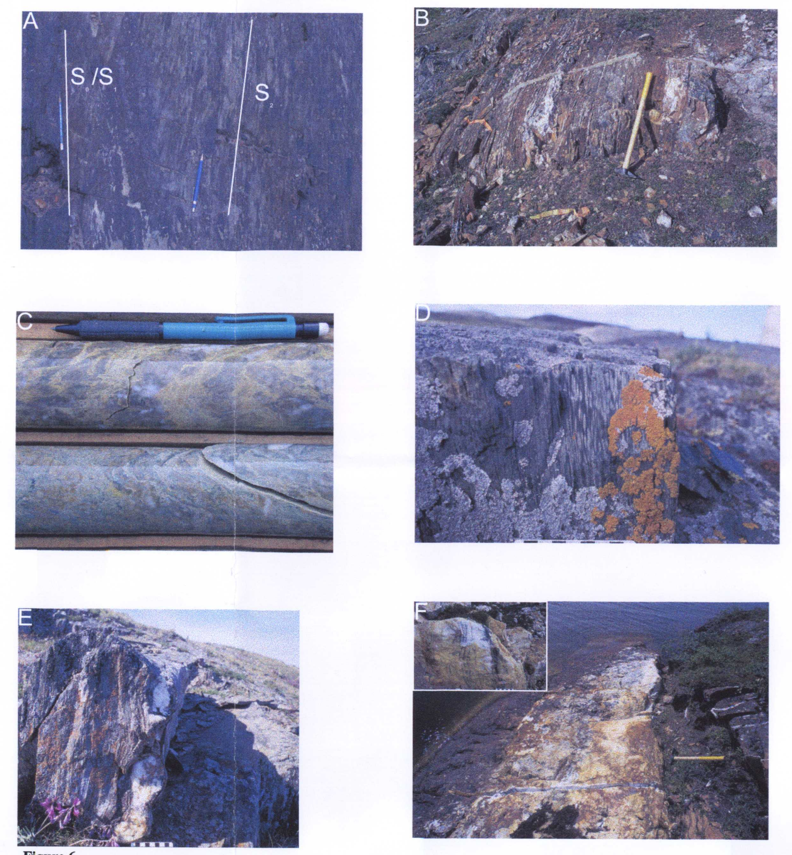

Figure 6

A. Well-developed bedding-cleavage relationships in dacite lapilli tuff, from the Windy felsic volcanic suite. S trends NE, whereas S/S composite fabrics trends N-S. (13W 7552717N 432520E).
B. Iron-carbonate-stained high-strain zone with deformed auriferous quartz carbonate veins from the Wolverine showing. (13W 7546331N 434994E).
C. Deformation zone, showing strong alteration and deformation fabrics (97PMD77, 130.9m).
D. Strongly stretched varioles in Fe tholeiite from the Doris area. (13W 7558435N, 433424E).
E. Boudinaged quartz carbonate veins in an iron-carbonate high-strain zone. Outcrop of the Central vein, Doris deposit. (13W 7559034N 433727E).
F. Lakeshore vein hosted in an iron-carbonate altered high-strain zone, part of the Doris deposit. (13W 7559009N, 433795E).

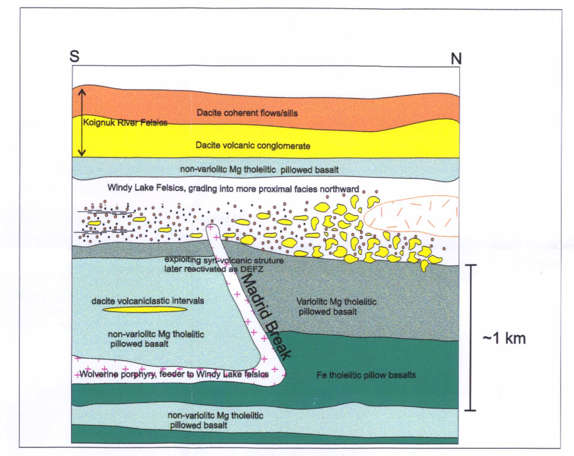

Figure 7. Schematic stratigraphic section through the northern part of the Hope Bay volcanic belt.

Mafic Volcanic rocks

Several distinct suites of mafic volcanic rocks, recognized in the Hope Bay area, are broadly divisible into Mg and Fe tholeiites (Figure 4). Typical outcrops of Mg and Fe tholeiites were identified geochemically and then revisited in order to define a set of field criteria to allow this distinction to be made while mapping.

Mg Tholeiites
The Mg tholeiites are generally characterized by pillowed flows (Figure 5A, B). The pillows tend to be large (~ 1 m across) with thin (<2 cm) brown to green selvages. The flows tend to be light in colour, generally a pale green. These pillows commonly have well-preserved and large gas cavities (Figure 5C) that provide reliable and consistent younging directions. Flow breccias are common, as are massive featureless phases, interpreted as subvolcanic feeders or thicker, non-pillowed portions of flows. Locally, narrow intervals of interflow chert are recognized.

Two textural subunits are recognized, which form consistent map units; variolitic and nonvariolitic types. The non-variolitic type is the most abundant, forming the bulk of the map package, but a distinct variolitic phase is recognized and can be correlated over the map area (Figure 5D). In this unit the varioles are mainly developed around pillow selvages, but locally form coalesced varioles that occupy the bulk of a pillow structure.

Fe Tholeiites
Iron tholeiites are distinguished from Mg tholeiites mainly by pillow morphology. The pillows are flattened and commonly highly amygdaloidal (weathered out), with narrow black chloritic pillow selvages and indistinct pillow shapes (Figure 5E). The flows are dark, typically dark green to brown. The pillow forms are small (< 0.5 m across) and lack gas cavities, making them unsuitable as younging indicators.

As with the Mg tholeiites, there are variolitic and non-variolitic units which form consistent map units at 1:10,000 scale. The non-variolitic type is the most abundant, but a distinct variolitic phase (Figure 5F) is recognized forming relatively thin (~50 m thick) units within the non-variolitic Fe tholeiite strata. The variolitic phase is relatively uncommon and makes an excellent marker interval, allowing for high confidence in stratigraphic correlation.

Felsic Volcanic rocks

Several felsic sequences are recognized in the map area (Figure 4): the Wolverine, Windy Lake and Koignuk River felsic volcanic suites. The Wolverine felsic suite is dominated by the Wolverine Porphyry, a quartz-feldspar porphyritic intrusive body, centered over Wolverine Lake. In addition to the large intrusive body, there are several narrow but laterally continuous volcaniclastic intervals. These intervals range from fine-grained lithic tuffs, to dacite lapilli tuffs, to coarse grained mass flow deposits (Sherlock et al., 2002). The Wolverine porphyry wraps into the deformation zone (Figure 4) described below, and is interpreted as a subvolcanic feeder to the Windy Lake felsic suite.

The Windy Lake felsic suite is a diverse suite of rocks. They include sedimentary and reworked volcanic rocks (Figure 5G & H), more proximal volcaniclastic rocks and massive, coherent flows or sills. The basal portion of the succession is dominated by quartz arenite and reworked volcanic rocks. Rock types gradually become more proximal up-section, grading into lapilli tuffs (Figure 5I) and proximal breccias. A second interval of argillite and fine siliciclastic sediments is recognized near the top of the succession. Narrow intervals of massive, fine-grained coherent rhyolite are recognized in the sequence and interpreted as flows or sills. In the north end of the Windy Lake felsic suite is a massive quartz diorite unit, hosted within the coarse-grained volcanic conglomerate. This is interpreted as a subvolcanic intrusive, coeval with the felsic volcanic rocks. The Windy felsic suite grades southward into a succession of fine-grained siliciclastic sedimentary rocks, mainly quartz arenites (Figure 5J). Locally these sedimentary rocks contain clasts of dacite, suggesting that at least some of the sediment was sourced from the more proximal areas of the Windy Lake felsic volanic rocks.

The Koignuk River felsic suite contain a basal conglomerate unit dominated by quartz feldspar porphyritic volcanic clasts in a sandy matrix. Detrital material is poorly sorted and coarse-grained, lacking sedimentary structures. Overlying the conglomerate is a thick, massive, fine-grained quartz feldspar porphyritic coherent flow or sill, which is locally flow-banded.

Mafic Intrusive Rocks

A number of gabbroic bodies have been mapped in the area. These are massive, medium- to coarse-grained, homogeneous units that occur within predominantly pillowed flows. These may represent either thicker portions of flows or feeders to the overlying pillowed flows.

A large ultramafic intrusion crops out on the east side of Patch Lake (Figure 4). This peridotite is enclosed by pillowed flows and is massive with a black knobby texture, presumably the result of olivine weathering. It extends into Patch Lake, forming a small island. Initial geochemical work suggests that it may represent the cumulate phase of a differentiated mafic magma.

A coarse-grained hornblende-bearing leucogabbro forms a late intrusive phase throughout the map area (Figure 4). The intrusive phase consists of plagioclase and hornblende with rare quartz, and locally crosscuts stratigraphy. North of Doris Lake, this unit grades into a coarse-grained plagioclase glomeroporphyritic unit.

Structural Geology

The dominant structure in the map area is a tight to isoclinal anticline (Figure 4). The fold axis strikes ~ north south and is doubly plunging. The antiform plunges shallowly to the north around the Doris deposit, and shallowly to the south at the south end of Doris Lake. The antiform axial plane is slightly inclined with an east vergence. The antiform was mapped based on younging directions from gas cavities in the pillowed Mg tholeiitic basalts. The Fe tholeiites only rarely contain gas cavities and their younging direction is inferred from adjacent Mg tholeiites.

Based on lithologic contacts, interflow sedimentary units and the orientation of gas cavities, stratigraphic units strike to the N-NW in the southern part of the map and to the NE in the northern part of the map, north of Doris Lake. A spaced fabric locally developed parallel to lithologic contacts is interpreted as a composite S/S transposition fabric (Figures 5J & 6A).

The main fabric observed in outcrop is a locally penetrative cleavage (S). This fabric has a dominantly NNE-SSW orientation and steep dip. To the north of Doris Lake this fabric swings to the northeast. Commonly S is well developed and clearly overprints the weakly developed transposition fabric (S/S). In sedimentary rocks, bedding-cleavage relationships are well preserved (Figure 6A). Locally, the intersection of these planar fabrics forms a steep north- or south-plunging intersection lineation.

High-strain zones are common throughout the map area and possess a strong penetrative planar fabric. These zones range from less then one metre wide and several 10s of metres long to over 10 metres wide and several kilometres long. These zones commonly have a strong Fe-carbonate alteration and may contain auriferous quartz-carbonate veins (Figure 6B). These zones are parallel to the orientation of local S fabrics and are interpreted as higher-strain intervals that developed during D, commonly where strain was partitioned at lithologic contacts.

The "Deformation Zone (DEFZ)" is an enigmatic feature encountered only in drill core, in the Patch Lake area (Figures 4 and 6C). The deformation zone runs NW-SE along the west shore of Patch Lake and cuts east-west through the Madrid area. The deformation zone consists of a contorted quartz-mica-iron-carbonate schist with disseminated pyrite (Figure 6C). Straw-yellow mica forms semi-regular millimeter-scale laminations that define the schistose fabric. The DEFZ encompasses several rock types and can include both Mg and Fe tholeiites and quartz-feldspar porphyritic rocks (Carpenter, unpublished geochemical data). The nature and timing of this structure remains uncertain, but it is spatially related to gold mineralization in the Madrid-South Patch area.

Pronounced stretching lineations are developed mainly in the Fe tholeiitic basalts that host the Doris deposit (Figure 6D). This is one of the unique characteristics of the Doris area, which distinguishes it regionally. Varioles in the Fe tholeiites have aspect ratios of about 50:3:1, indicating intense elongation and minor flattening. Quartz-carbonate veins at the Central Vein, Doris deposit, are strongly boudinaged in an iron-carbonate altered high-strain zone (Figure 6E). This feature has not been recognized outside of the Doris area.

North of Doris Lake, strata and all D structural elements are warped to a northeast orientation. The trace of the Doris antiform also shows a similar deflection to the northeast. Although no evidence for this is found on an outcrop scale, these deflections are interpreted as the result of a superimposed WNW-trending, open F fold.

Late brittle faults are recognized in outcrop as distinct brittle breaks, which have been preferentially weathered. These typically are less then 1 metre across but can be traced for over 1 kilometre (Figure 4). In several cases, stratigraphic offsets are recognized across these structures with a consistent apparent sinistral displacement. These faults do not cross-cut or offset the Franklin diabase. These structures are identical in style to the fault at the Robert's Bay silver mine, about 5 km north of the map area.

Evidence for Synvolcanic Structures

A schematic stratigraphic section is shown in Figure 7, centered around the Madrid break. The Madrid break is an enigmatic feature forming an east-west linear valley, that is almost orthogonal to the general trend of the geology. The south side of the break is dominated by a non-variolitic Mg tholeiite, whereas to the north the dominant lithology is a variolitic Mg tholeiite (Figure 4); these rock types cannot be correlated across the break. Similarly, two felsic intervals on the north and south sides of the break cannot be correlated. The westernmost edge of the break is underlain by variolitic Mg tholeiite, on both the south and north side, which is overlain by quartz arenites and volcanic conglomerates at the base of the Windy felsics.

Stratigraphically overlying the break is a thick succession of quartz arenites in the south that grade northward into into more proximal volcanic conglomerates, breccias and massive, coherent phases. This sedimentary-volcanic package overlies the break without any obvious offset. In the area closest to the break the sedimentary package exceeds 400 metres in thickness.

The DEFZ occupies the Madrid break, which is spatially related to quartz stock work mineralization of the Naartok deposit (Sherlock et al., 2002). As described above it is a deformed and alteration assemblage that overprints several different rock types. Most significantly, this includes altered phases of the Wolverine porphyry (Sherlock unpublished data).

It is likely that the Madrid break represents a synvolcanic structure that juxtaposed variolitic and non-variolitic Mg tholeiites. Overlying the structure is a thin interval of variolitic Mg tholeiites and a thick sequence of siliciclastic sediment that grade northwards into volcanic conglomerates and more proximal volcaniclastic facies. Occupying the synvolcanic structure are dykes of Wolverine porphyry which intruded into the break and likely fed felsic volcanism higher in the stratigraphic package, possibly the Windy Lake felsics. Subsequent deformation (D) resulted in minor reactivation of the Madrid break and mechanical contrasts at lithologic contacts caused dilation, hydrothermal alteration, forming what is now seen as the DEFZ and associated mineralization (Sherlock et al., 2002).

Structural & Stratigraphic Relationships

The stratigraphically lowest rocks in the succession are Fe tholeiities that occupy the core of the Doris antiform. These are generally pillowed, often highly amygdaloidal and locally variolitic, and reach a thickness of about 900 metres (Carpenter et al., 2003). Overlying this is a thick unit of non-variolitic Mg tholeiites, reaching a thickness of about 125 metres. Cherty interflow sediment is common in this unit. Overlying these is a thick (~100 m) sequence of Fe tholeiites with highly amygdaloidal pillows, similar to the Doris suite of Fe tholeiites. Stratigraphically overlying this are variolitic to non-variolitic Mg tholeiites juxtaposed along a synvolcanic structure (Figure 7; Sherlock et al., 2003). These units thicken in the southern part of the map sheet, reaching about 220 metres. Intruded into this package is the Wolverine porphyry which likely fed overlying felsic volcanisim. Hebel (1999) obtained a maximum U-Pb age, on zircons, of 2698.7 +6.7/-3.7 for the Wolverine porphyry, on a sample which hadapparent inheritance problems. Further U-Pb work is in progress to better constrain this age. Also present in this unit are narrow (< 20 m) volcaniclastic interbeds suggesting that at this time effusive felsic volcanism was ongoing. U-Pb age, on zircons, from these interbeds are 2689.4 +4.0/-3.6 Ma (Sherlock and Mortensen, unpublished data).

Overlying this dominantly mafic succession is the Windy Lake felsic suite. In the south part of the map sheet the base of the Windy Lake felsic suite is about 70 metres thick interval consisting of quartz arenite and argillite, locally containing large clasts of quartz-feldspar porphyritic dacite. This unit grades northward into a volcanic conglomerate with large dacitic fragments in a sandy matrix, which grades into a dacite lapilli tuff. All evidence suggests that the package becomes both thicker (~170 m) and more proximal to the north. Overlying the basal sedimentary sequence is a thick package of dacite lapilli tuff and narrow intervals of coherent lavas or sills. Near the upper portion of the succession is a second interval of fine-grained siliciclastic sediments and argillite. Hebel (1999) obtained a U-Pb age, on zircons, of 2685 +3.3/-1.9 Ma from a dacite lapilli tuff in the middle of the Windy Lake felsic suite.

Also exposed in the northern part of the area is a unit of quartz diorite. This unit is hosted by a dacitic fragmental unit, is massive and featureless, and is interpreted to be a subvolcanic intrusive. This unit has a distinct yellow-green colour caused by pervasive epidote alteration.

Overlying the Windy Lake felsic suite is a 50 metre-thick interval of pillowed Mg tholeiites. These are indistinguishable from basalts lower down in the stratigraphy with the exception of the upper 20 metres of the section which is highly amygdaloidal, and locally scoriaceous.

Capping the stratigraphic succession mapped during this project are the Koignuk River felsic suite. A 40 metre thick volcanic conglomerate with coarse fragments (to 30 cm) in a fine-grained sandy matrix, forms the base to this unit. The unit is unbedded and unsorted without any recognized sedimentary structures. Overlying the clastic interval is a 100-metre thick interval of coherent feldspar-porphyritic dacite. This interval is fine-grained, massive and locally flow-banded. Hebel (1999) obtained a U-Pb age, on zircons, of 2677 +3/-1 Ma from the upper part of this unit.

The entire stratigraphic succession is intruded by hornblende leucogabbros. These intrusions tend to be concentrated near the fold axis and are most abundant on the eastern side of the antiform. Franklin diabase dykes and sills intrude the area. These intrusions are massive to columnar-jointed and have not been offset by late brittle faults.

Mineralization

Mineralization in the area encompasses several different styles of gold and syngenetic base metal deposits. The main deposit in the area is the Doris deposit (Carpenter et al., 2003), which is an auriferous quartz vein with numerous septa of tourmaline, paragonite and chlorite (Figure 6F). Alteration is quite restricted, only really apparent within several metres of the vein system. Textural relationships suggest that the mineralization was introduced during a progressive D event, possibly analogous to a saddle reef setting (Poulsen et al., 2000). Details of the Doris area can be found in the companion paper (Carpenter et al., 2003).

The Madrid area is described in more detail in Sherlock et al. (2002) and only summarized here. Several gold deposits have been discovered in the Madrid area, including the Naartok, Perrin and Suluk deposits. This zone may be extended to the south Patch area where recent work has intersected similar styles of mineralization. Although quite complex, the Naartok deposit exhibits many of the features typical of these areas. At Naartok, gold occurs within the hangingwall of the deformation zone and may be related to a deflection in the DEFZ. Anomalous gold concentrations at Naartok are related to pervasively altered basaltic, gabbroic and felsic rocks that now contain iron-carbonate, paragonite, sericite and pyrite. Texturally overprinting this alteration is a quartz-carbonate stockwork with associated silica flooding, which locally contains coarse visible gold. Different vein types and textures are present, including, iron-carbonate veinlets, white quartz + iron carbonate veins, quartz ± albite (?) veins, and late fibrous white quartz-carbonate ladder veins. Crosscutting relations between the vein types suggest a progressive mineralizing event during regional D deformation (Sherlock et al., 2002)

The Wolverine area contains a number of high-grade quartz vein prospects located outside of the Madrid area. These are all within iron-carbonate-altered high-strain zones parallel to the local S fabric. Many of these vein systems, and associated high-strain zones, occur at, or near, lithologic boundaries. Within these alteration zones are quartz-carbonate veins, commonly with septa of sheet silicates and/or tourmaline. The septa tend to be parallel to the vein walls, producing a crack and seal texture. Vein geometries are generally planar but are locally deformed with sigmoidal, boudinaged and locally brecciated veins recognized. The range in deformation fabrics seen in the vein geometries suggests that they formed during a progressive D deformation event, with strain localized at lithologic contacts. These geometries and fabrics are typical of fault-fill veins as described by Robert and Poulsen (2001).

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