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Authors' addresses

R.L. Sherlock *(sherlock@nrcan.gc.ca)*
Canada-Nunavut Geoscience Office, Iqaluit
Canada-Nunavut Geoscience Office
626 Tumiit Building
P.O. Box 2319
Iqaluit, Nunavut X0A 0H0

R.L. Carpenter *(carpenterr@inac.gc.ca)*
Department of Indian and Northern Affairs
Nunavut District Office
P.O. Box 100
Iqaluit, Nunavut X0A 0H0

M. Bardoux
E. Flood
Peter Kleespies
Hope Bay Joint Venture
311 West First Street
North Vancouver, British Columbia V7M 1B5

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R.L. Sherlock, R.L. Carpenter, M. Bardoux, E. Flood, and Peter Kleespies

Canada-Nunavut Geoscience Office, Iqaluit

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Abstract: Mapping in the Wolverine–Madrid corridor has outlined a well defined volcanic sequence. This stratigraphy includes a lower variolitic pillowed basalt with interflow sedimentary rocks and an upper suite of nonvariolitic pillowed basalt. Both packages display textures typical of submarine mafic volcanism. Felsic volcanic rocks are interbedded with the nonvariolitic suite, providing excellent stratigraphic markers. Associated felsic porphyry bodies also intrude the nonvariolitic suite. Gold occurs along the corridor and is concentrated in the Madrid area, where the Naartok deposit consists of a complex quartz-vein stockwork developed in strongly altered volcano-sedimentary rocks and synvolcanic gabbro. Naartok is localized in the hanging wall of the deformation zone, a complex structure that juxtaposes different volcanic strata. A second style of mineralization occurs in iron-carbonate-altered high-strain zones that host auriferous quartz-carbonate veins with septa of tourmaline and sheet silicates. These zones are commonly localized at or near lithological contacts.

Résumé : La cartographie géologique menée dans le corridor Wolverine-Madrid a permis de délimiter une séquence volcanique bien définie. Cette stratigraphie se compose d'une suite inférieure de coulées en coussins de basalte variolaire entre lesquelles sont présentes des roches sédimentaires et d'une suite supérieure de coulées en coussins de basalte non variolaire. Les deux ensembles présentent des textures typiques d'un volcanisme mafique en milieu sous-marin. Des roches volcaniques de composition felsique sont interstratifiées dans la suite non variolaire et fournissant d'excellents repères stratigraphiques. Des massifs associés de porphyre felsique pénètrent en outre la suite non variolaire. Des minéralisations aurifères sont présentes le long du corridor et sont concentrées dans la région de Madrid, là où le gîte de Naartok se compose d'un stockwerk complexe de filons de quartz qui s'est formé dans des roches volcanosédimentaires très altérées et des gabbros synvolcaniques. Le gîte de Naartok se trouve dans le toit de la zone de déformation, une structure complexe juxtaposant différentes strates volcaniques. Un deuxième style de minéralisation est associé à des zones d'intense déformation à altération de carbonates de fer qui contiennent des filons de quartz-carbonates aurifères renfermant des septa de tourmaline et des phyllosilicates. Ces zones se trouvent généralement à des contacts lithologiques, ou à proximité de ceux-ci.

INTRODUCTION

Gold deposits in the Hope Bay volcanic belt are among Nunavut's most advanced exploration projects and represent potential for near-term production. Several different deposits have been outlined in the belt since the inception of sustained precious-metal exploration by BHP in the early 1990s. These include the Boston, Doris, and Madrid group of deposits (Naartok, Perrin, and Suluk). All these deposits are different in terms of their geological setting, alteration characteristics, and local controls on gold distribution. This diversity in gold mineralization along with abundant outcrops and drill cores, low metamorphic grades, and overall low strain make the Hope Bay belt an ideal location to characterize the mineralizing events and place them in the context of the geological evolution of the host terrane.

This paper reports the results of a detailed (1:5000 scale) mapping program over the Wolverine–Madrid corridor done in conjunction with a detailed core-logging and alteration study of the Naartok deposit.

REGIONAL GEOLOGY

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

About 26 granite–greenstone belts are recognized in the Slave Province. They were subdivided into mafic volcanic-dominated (Yellowknife type) and felsic volcanic-dominated (Hackett River type) types 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 turbidite. Uranium-lead geochronology brackets volcanism in the Slave Province 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 commonly overlies the main greenstone belts (Fyson and Helmsteadt, 1988). Villeneuve et al. (1997) subdivided the intrusive rocks into 2.70 to 2.64 Ga predeformation tonalite and diorite, 2.62 to 2.59 Ga K-feldspar-megacrystic granite, and 2.60 to 2.58 Ga postdeformation two-mica granite. In general, 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).

HOPE BAY VOLCANIC BELT

The Bathurst block is the portion of the Slave 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 lies within the northern portion of the Bathurst block (Fig. 1). It was first mapped at a reconnaissance scale by Fraser (1964) and later in more detail by Gibbons (1987) and Gebert (1990, 1993) who considered it to be an Archean volcanic terrane belonging to the Yellowknife Supergroup. The Hope Bay belt is dominated by mafic volcanic rocks with felsic volcanic and volcaniclastic material and subordinate ultramafic bodies and metasedimentary rocks. Existing U-Pb geochronology indicates that felsic volcanism spanned a period of at least 53 Ma (2716–2663 Ma; Hebel, 1999; M.U. Hebel and J.K. Mortensen, unpub. data, 2001).

To the east, the Hope Bay belt is bordered by felsic intrusions that separate it from the Elu Inlet belt (Fig. 1). A granodiorite northeast of the Hope Bay belt gave an U-Pb zircon age of 2672 +4/-1 Ma, suggesting a synvolcanic 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; M.U. Hebel and J.K. Mortensen, unpub. data, 2001). The Hope Bay belt is bordered to the west by plutonic rocks that contain foliated mafic fragments at 2608 ± 5 Ma, placing a lower limit on deformation and metamorphism (Bevier and Gebert, 1991). Metamorphism is lower greenschist grade in the interior of the belt and amphiolite grade near the belt margins.

HISTORY

Following the reconnaissance mapping by Fraser (1964), a number of precious-metal- bearing quartz-carbonate veins were staked in the 1960s. In 1972, the Hope Bay Mining Company obtained a four-year lease and in 1973–1974, it initiated small-scale mining activities at the Ida Bay and Roberts Lake silver showings. Less then 100 000 ounces (31 103 000 g) of silver were produced over the two-year period (J.S. Gebert, unpub. rept., 1999).

In 1977, Noranda Ltd. initiated a reconnaissance base-metal exploration program in the belt that continued into the early 1980s with limited success. In 1987 and 1988, Abermin Corporation staked a number of the precious-metal showings. In 1988, BHP Minerals Ltd. conducted a limited reconnaissance program in the belt. Exploration was ramped up to a more comprehensive program following the discovery of the Boston deposit in 1991 and the Doris deposit in 1994. In late 1999, Miramar Mining Corp. and Cambiex Exploration Inc. (Hope Bay Gold) entered into a joint venture to explore and develop deposits in the Hope Bay belt. The current classified resource estimate from several deposits is 2.789 Mt grading 15.7 g/t Au (1.412 million ounces) measured and

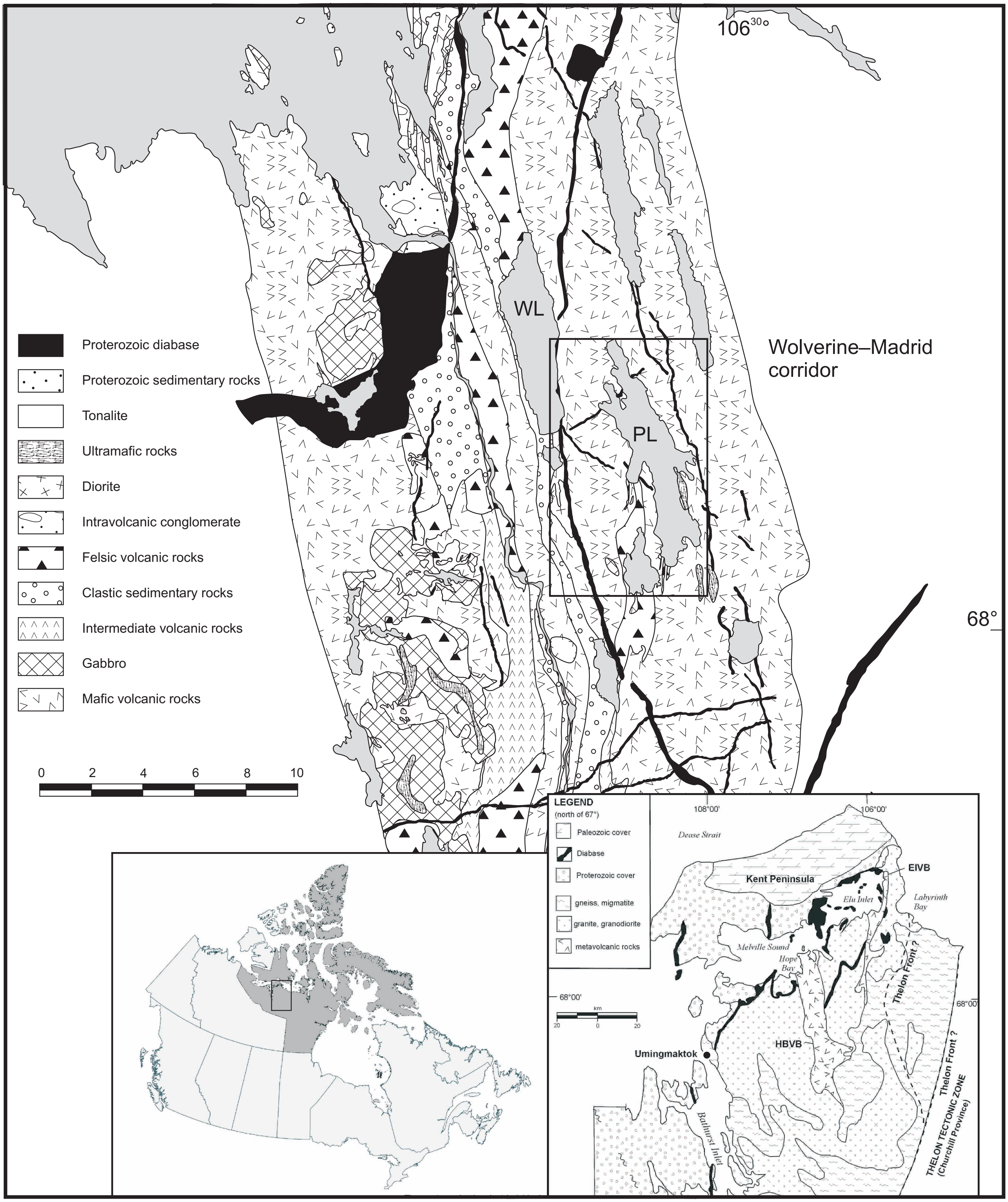

Figure 1. *Location and regional geology map of the Hope Bay volcanic belt (HBVB). Modified from Gebert (1993). Geological inset is modified from Fraser (1964). WL = Windy Lake; PL = Patch Lake.*

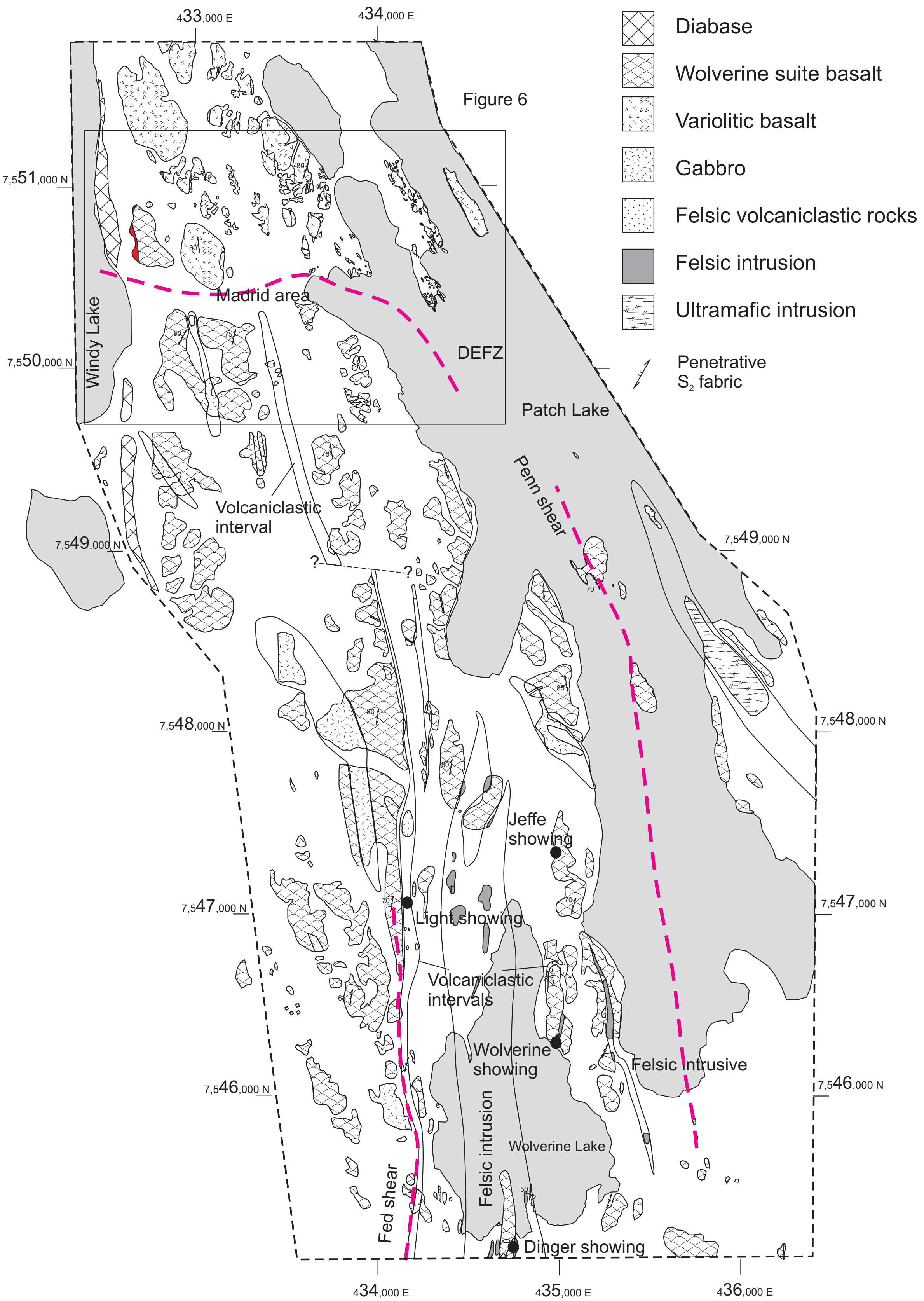

__Figure 2.__ Geology of the Wolverine corridor. The Spot showing is off the figure. Co-ordinates are UTM.

indicated and 4.588 Mt grading 12.5 g/t Au (1.845 million ounces) as an inferred resource (Miramar Mining Corporation press release, November 23, 2000).

From 1987 to 1990, federal and territorial government geological mapping programs were conducted in the belt (Gibbons 1987; Gebert, 1993), leading to the production of a geological map at 1:50 000 scale. This was complemented by more detailed mapping by BHP throughout the 1990s. Hebel (1999) completed a thesis on the geochronology and geochemistry of the belt, which has established the initial geochronological framework. The current program has focused on understanding the detailed volcanic stratigraphy in several key areas of the Hope Bay belt in order to understand the architecture of the belt and the relationship of stratigraphy and deformation to gold mineralization.

WOLVERINE–MADRID CORRIDOR

The Wolverine–Madrid corridor, as defined here, is the belt of rocks extending from the southern end of Wolverine Lake to the northwest end of Patch Lake (Fig. 2). This area was selected for a detailed geology program as it contains a varied volcanic stratigraphy and several different styles of gold deposits.

Mafic volcanic rocks

The stratigraphically lowermost unit recognized (Fig. 2, 3) is a suite of mafic volcanic rocks exposed in the north Patch Lake area, particularly in the north part of the Madrid area. These rocks are dark green to brown with thick dark brown selvages on very large pillows (Fig. 4a). They are strongly variolitic (Fig. 4b) and locally amygdaloidal. Texturally, they include pillowed flows, flow-top breccia, rubbly flow breccia, hyaloclastite, and quench breccia, all typical of submarine mafic volcanic rocks. Fine-grained mudstone to chert interflow sedimentary rocks (Fig. 4c) are commonly interbedded with the variolitic pillows. These sedimentary rocks are a minor component, forming beds a few tens of centimetres thick. Locally, sediment–lava interaction textures are recognized.

Overlying the variolitic suite is a second suite of mafic volcanic rocks that represents the principal rock type in the map area (Fig. 2, 3); it was informally termed the 'Wolverine suite' by the authors. These pale green flows have thin, brown to dark green pillow selvages, no varioles, and are rarely amygdaloidal. The Wolverine suite includes pillowed flows (Fig. 4d) to rubbly pillow breccia (Fig. 4e), to massive flows or gabbro. Included in the pillowed sequences are flow-top breccia and hyaloclastite or quench breccia (Fig. 4f).

Mafic intrusive rocks

A number of gabbroic bodies have been mapped in the Wolverine–Madrid corridor (Fig. 2, 3). They are massive, medium- to coarse-grained, homogenous units that occur within dominantly pillowed flows. They may represent either thicker portions of flows or feeders to the overlying pillowed flows. Initial geochemical work on these rocks supports these suggestions and indicates that the gabbro bodies are synvolcanic.

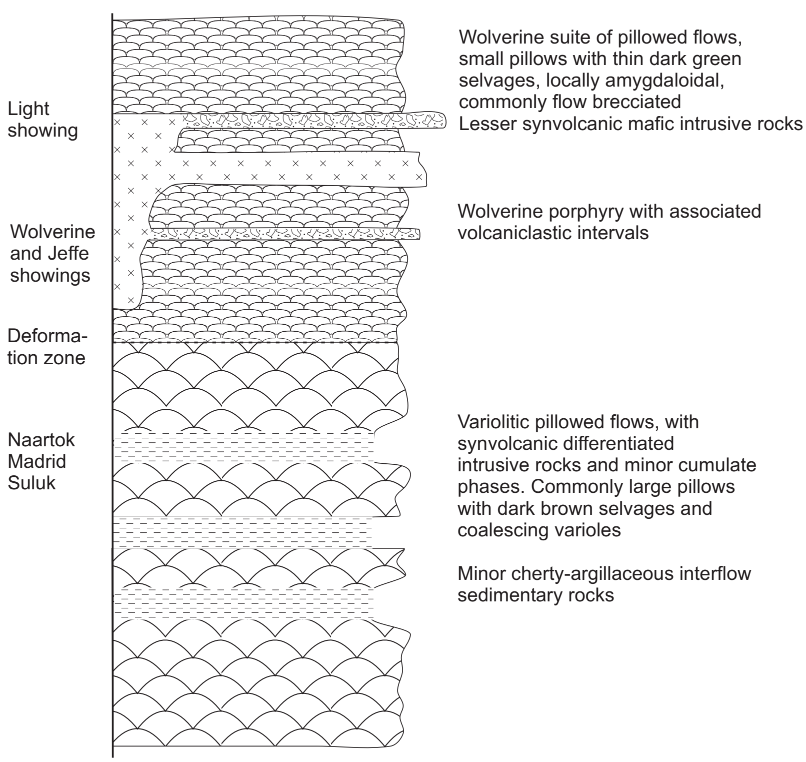

Figure 3.

Simplified stratigraphic column for the Wolverine corridor showing the relative positions of the various showings.

A large ultramafic intrusion outcrops on the east side of Patch Lake (Fig. 2). It is hosted 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 cumulate phases of differentiated mafic magmas.

Felsic volcanic rocks

A suite of dacitic to rhyodacitic rocks previously referred to as the 'Wolverine porphyry' incorporates a number of texturally and compositionally different rock types. The Wolverine porphyry had been interpreted to represent an intrusive body that crosscuts the mafic volcanic suites (J.S. Gebert, unpub.

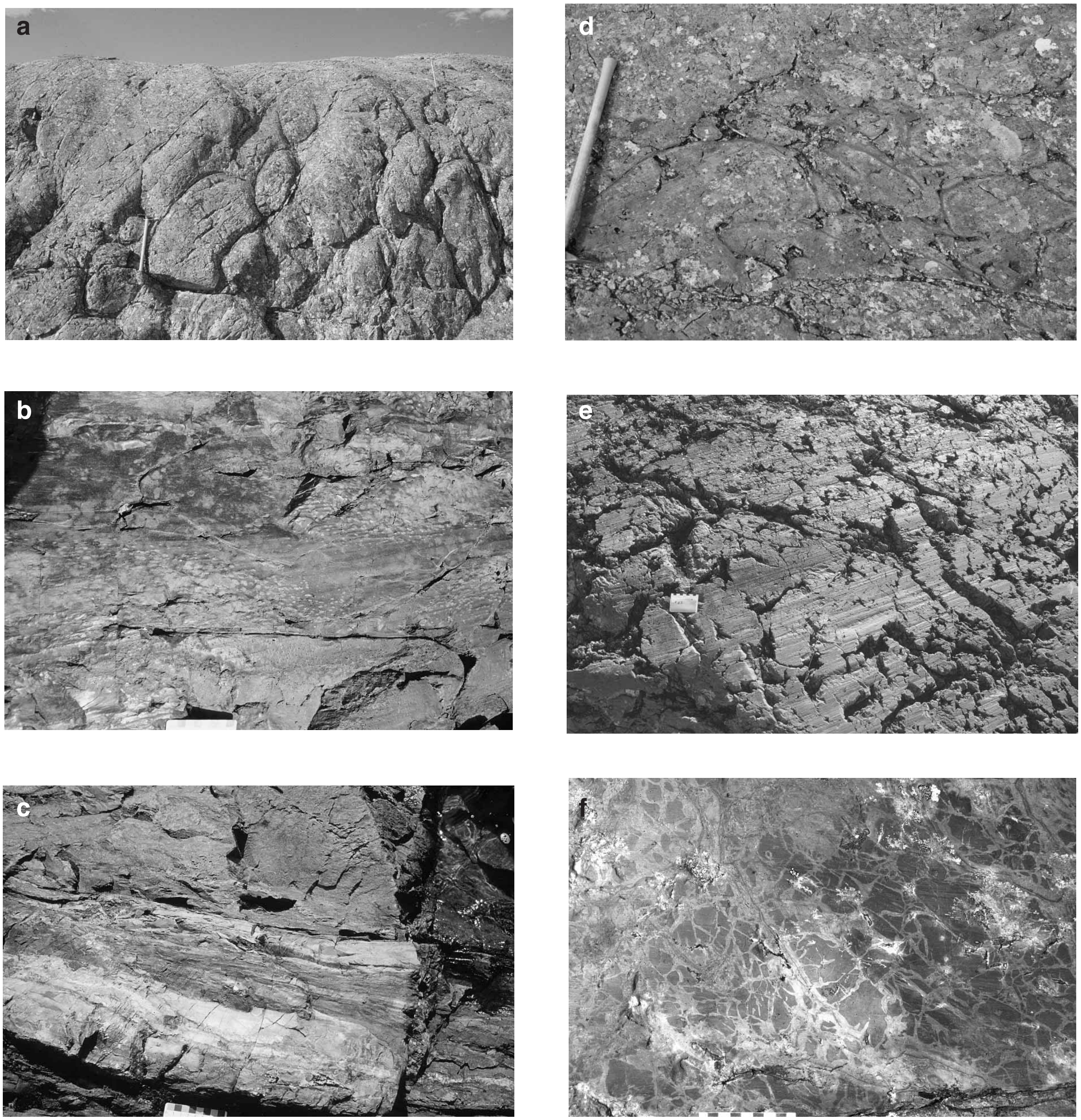

Figure 4. a) *Very large variolitic pillows.* ***b)*** *Coalescing varioles on pillow selvages.* ***c)*** *Interflow chert sedimentary rocks hosted by variolitic flows.* ***d)*** *Pillowed basalt from the Wolverine suit of volcanic rocks.* ***e)*** *Rubbly pillowed breccia.* ***f)*** *Quench breccia/hyaloclastite.*

rept., 1999; Hebel, 1999). We suggest that the felsic rocks are in part volcaniclastic and coeval with the Wolverine basalt suite.

In the immediate Wolverine area, several intervals of felsic rocks are present (Fig. 2, 3). Felsic fragmental rocks are distinguished by their clastic nature, with numerous chloritic fragments as well as coarse-grained feldspar and quartz phenocrysts (Fig. 4g). These intervals are commonly thin (< 2 m) and are difficult to trace because of structural and stratigraphic complexities combined with poor exposure. Also within the Wolverine area are massive quartz-feldspar-phyric bodies that may represent small subvolcanic intrusions or flows.

The main felsic intrusive phase is centred under Wolverine Lake, being thickest in the centre of the lake and fingering out to the north. Individual phases of the porphyry are defined by variations in phenocryst content. Some exposures are quartz- and feldspar-porphyritic whereas others have only feldspar phenocrysts; contact relationships between the various phases have not been observed. Contacts with the wall rocks and the porphyry are sharp and distinct, although chilled margins have not been recognized.

Several intervals of volcaniclastic rocks have been recognized. The best exposure is in a well defined linear unit west of the porphyry. This heterolithic unit is thick (up to 40 m), unbedded, poorly sorted, and interpreted to be a debris flow (Fig. 4h). The fragments are dominantly felsic at the base; mafic fragments become more abundant upward in the section, but the unit never becomes mafic dominated. Rare sedimentary fragments, generally argillaceous or cherty, are recognized. The debris-flow facies has a limited lateral extent (~100 m), suggesting that it may be a localized channel fill reflecting the original basin topography. Laterally the debris flow grades into a well sorted, but unbedded, monolithic lapilli tuff. This interval of felsic volcaniclastic rocks is traceable along strike for about 5 km and provides an excellent stratigraphic marker. This volcaniclastic interval represents the main extrusive phase of felsic volcanism in the Wolverine corridor. On the hanging-wall and footwall side of the felsic volcaniclastic intervals, no textural difference is recognized within the basalt bodies. This suggests that the felsic volcaniclastic rocks were emplaced during a hiatus within a single mafic volcanic cycle (Fig. 3).

STRUCTURAL GEOLOGY

Stratigraphy trends north–north-northwest based on lithological correlations across the mapped area (Fig. 2). Locally, a spaced fabric is developed parallel to lithological contacts; it strikes north–north-northwest and dips steeply, and is inferred to be a composite S_0/S_1 transposition fabric.

The main fabric observed in outcrop and developed in the Wolverine corridor is a locally penetrative cleavage (S_2). It has a dominantly north-northeast orientation and a steep dip. It is commonly well developed and clearly overprints the weakly developed transposition fabric (S_0/S_1). Locally, the intersection between these two planar fabrics forms a steep north- or south-plunging intersection lineation.

Fold patterns are poorly developed, with rare examples of asymmetrical 'Z' folds in the Wolverine area. S_2 is axial planar to these asymmetrical folds. Mapping within the Wolverine–Madrid corridor has consistently revealed west-facing pillows, suggesting that the map area represents a continuous stratigraphic section. The asymmetry of the folds and the discordance between S_0/S_1 and S_2 suggest that the Wolverine–Madrid corridor may be on the west side of a large-scale, north-trending synform. Further detailed mapping at a larger scale is required to define the geometry of these inferred structures.

Locally, fabrics that developed during D_2 are weakly folded into open to closed, east-west folds (F_3) with upright axial surfaces. The effect of this event on the overall map pattern is minor.

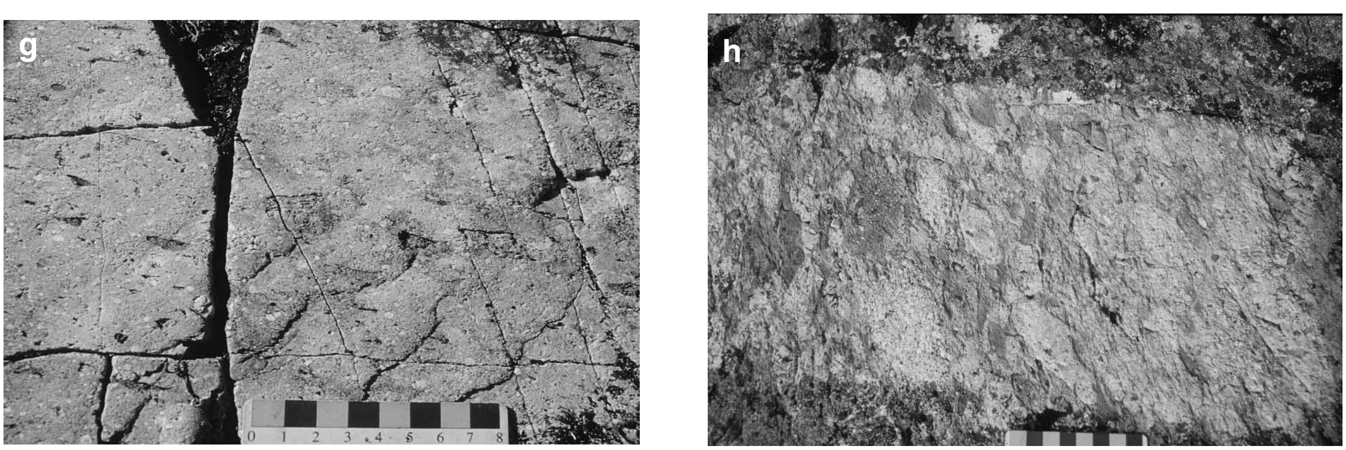

Figure 4. g) *Narrow beds of felsic volcaniclastic rock with chloritic fragments and coarse-grained quartz and feldspar phenocrysts.* ***h)*** *Coarse-grained felsic volcaniclastic rocks, heterolithic, unbedded, and poorly sorted, likely a debris flow.*

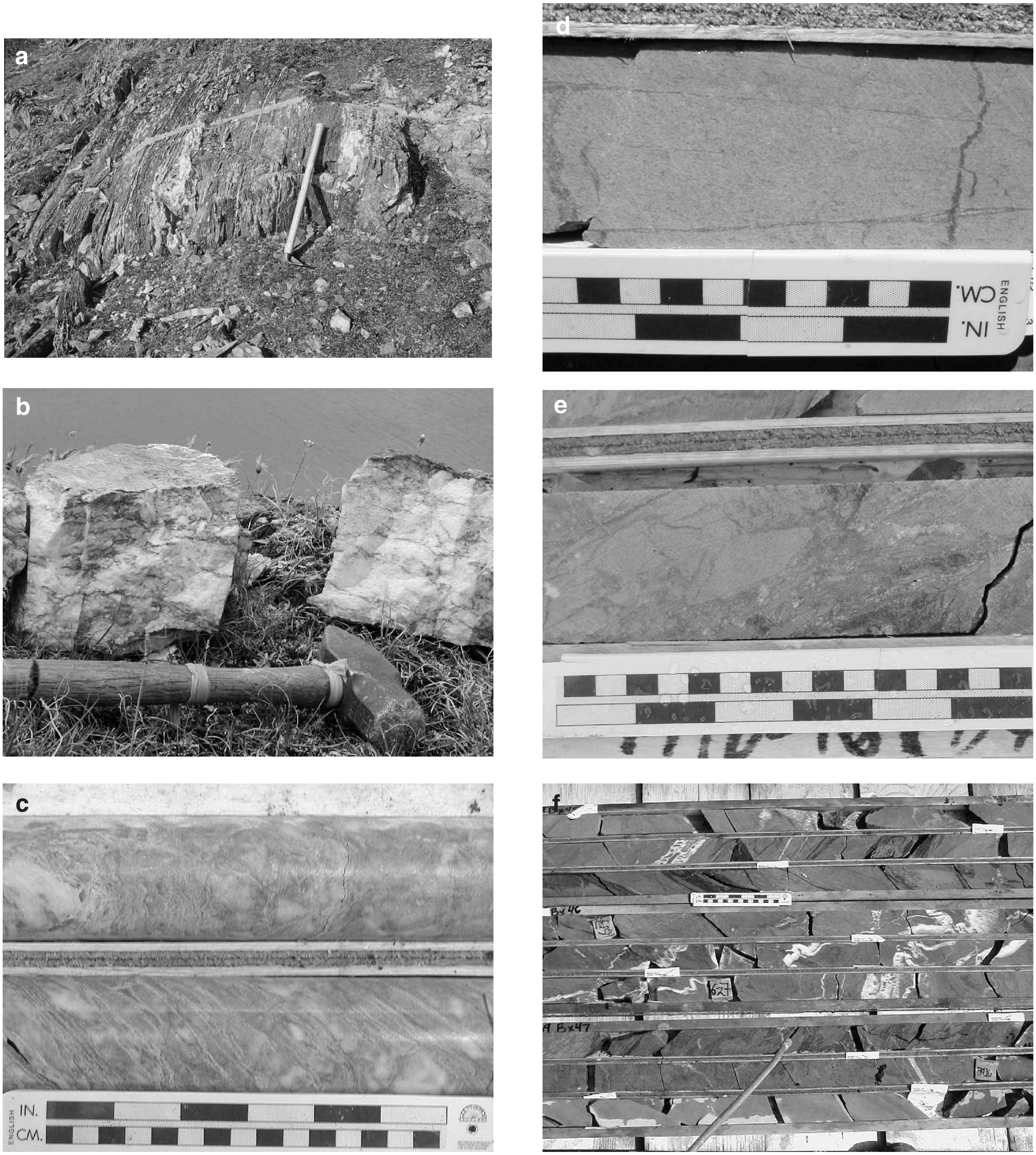

Figure 5. ***a)*** *The Wolverine prospect showing the high-strain zone, marked by well developed penetrative planar fabric (S_2) and strong iron-carbonate alteration. White quartz-carbonate veins with micaceous septa are developed as fault-fill veins generally parallel to the margins of the high-strain zone. Gold is contained within both the quartz vein and the alteration assemblage.* ***b)*** *Laminated quartz veins from the Light showing. This texture is typical of the veins associated with high-strain zones in the Wolverine corridor.* ***c)*** *Deformation zone (PMD-99) showing the strong iron-carbonate alteration and white quartz breccia with foliated straw-yellow mica.* ***d)*** *Typical altered gabbro. Note the even, medium-grained granular texture and diagnostic olive-green colour. Cut by iron-carbonate veins (PMD-93-85m).* ***e)*** *Gabbroic-textured, hydrothermally brecciated rock with iron-carbonate and quartz flooding (PMD-161Bx 28).* ***f)*** *Example of folded and/or buckled quartz veins hosted in altered basalt. Also note argillitic interbeds within basalt (PMD-139).*

High-strain zones are common throughout the map area and possess a strongly developed penetrative planar fabric. They range from less than 1 m wide and several tens of metres long to over 10 m wide and several kilometres long, and may contain auriferous quartz-carbonate veins (Fig. 5a, b). They are parallel to the orientation of local S_2 fabrics and are interpreted to be zones of higher strain developed during D_2. Kinematic indicators are rare in the narrow zones and do not provide any consistent sense of displacement. In the larger zones, kinematic indicators such as S-C fabrics, drag folds, and fault-vein relationships suggest a sinistral sense of shear.

The 'deformation zone' is an unusual, but significant, feature encountered only in drill cores in the north Patch Lake area of the Wolverine–Madrid corridor (Fig. 2, 6). It runs northwest-southeast along Patch Lake and cuts east-west through the Madrid area, then may swing north-south again through Windy Lake. When in the northwest-southeast orientation, it is subvertical, but where it swings east-west, it dips ~70° N. It consists of a contorted quartz-mica-iron carbonate schist with disseminated pyrite (Fig. 5c). White quartz ((?)vein) fragments are disrupted and form variably sized angular fragments set in a grey iron-carbonate matrix. Straw-yellow mica forms semiregular millimetre-scale laminations that define the schistose fabric. The deformation zone is commonly cut by late pink-red quartz veins that carry chlorite, but no visible sulphides. The upper contact of the deformation zone with the overlying rocks is distinct and generally marked by a zone of broken core up to several metres wide. The nature and timing of this structure are unclear, but it is spatially related to mineralization in the Madrid area.

STRUCTURAL AND STRATIGRAPHIC RELATIONS

Recognition of the variolitic and nonvariolitic suites of pillowed basalt along with the volcaniclastic nature of the felsic volcanic rocks, allow offsets in stratigraphy to define structures that may otherwise be cryptic. The relationship between the lower variolitic flows and the upper nonvariolitic flows is critical, in that the contact identifies the east-west Madrid area as a structure that juxtaposes different volcanic rocks (Fig. 6). Felsic volcaniclastic rocks, flow geometry, and bedding from interflow sedimentary rocks all trend approximately north-northwest along the corridor. However, the north side of the Madrid area is underlain by variolitic basalt and the south side, by nonvariolitic basalt, indicating that stratigraphy does not continue uninterrupted across the valley. Similarly, a felsic volcaniclastic bed that is traced from the southern portion of Wolverine Lake does not extend across the valley, suggesting a fault offset.

The variolitic and nonvariolitic contact is well exposed only on the north side of the Madrid area, near the shore of Windy Lake (Fig. 6). There the nonvariolitic basalt conformably overlies the variolitic suite. If this relationship holds on the south side of the Madrid area, then variolitic basalt should occur under Patch Lake, giving an apparent sinistral offset by any structure in the Madrid valley. This displacement may be accommodated by movement along the deformation zone described above.

ALTERATION

For the most part, the volcanic rocks in the map area are unaltered. Locally, zones of iron-carbonate alteration are recognized by their rusty red colour. These zones are generally associated with intervals of high strain (Fig. 5a). They contain iron carbonate (ferroan dolomite±siderite), paragonite (±sericite, chlorite and fuchsite), quartz, and minor pyrite. Contacts between unaltered volcanic rocks and iron-carbonate alteration zones are sharp and generally correspond to an increase in strain inferred from the development of a strong penetrative planar fabric. In many cases, such as at the Jeffe and Wolverine showings, the alteration patches are small and difficult to trace along strike. However, in the more extensive high-strain zones, such as the Fed and Penn shears, the alteration is pervasive and traceable along the strike length of the shears. Widespread alteration is recognized mainly from drill cores in the Madrid area. The alteration tends to be texturally destructive, and primary textures are rarely preserved. In some cases, the degree of alteration may be overstated due to the spectacular colour anomalies created by oxidation of the iron carbonates.

MINERALIZATION

Madrid area

Several gold deposits have been discovered in the Madrid area, including the Naartok, Perrin, and Suluk deposits (Fig. 6). The Naartok deposit encompasses many of the features typical of the Suluk and Perrin deposits in the Madrid area. At Naartok, gold mineralization occurs within the hanging wall of the deformation zone and may be related to a deflection in that zone. The deformation zone is generally subvertical, but deflects to a ~70° N dip in the Naartok area. Anomalous gold concentrations at Naartok are related to pervasively altered basaltic and gabbroic rocks that now contain iron carbonate, paragonite, sericite, and pyrite. Texturally overprinting this alteration is a quartz-carbonate stockwork with associated silica flooding, which may contain coarse visible gold.

Distal grey or white quartz veins (±pyrite) progress into stockwork veins and localized breccia as silica abundance increases toward zones of higher gold contents (Fig. 4d, e). Several different vein types and textures can be 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 are ambiguous and complex, suggesting a progressive mineralizing event. Veins are typically narrow (<1–3 cm wide) and likely represent stockworks rather than the fault-fill veins common in the Wolverine area.

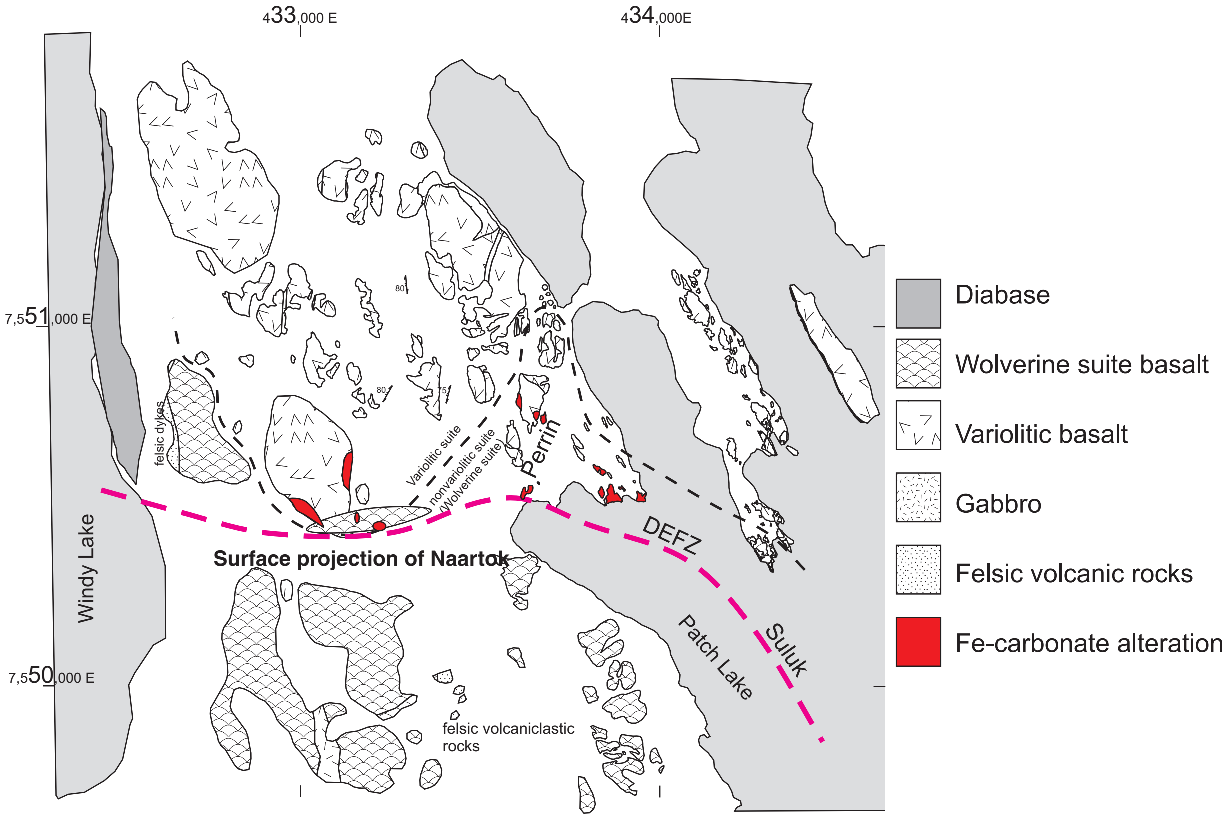

Figure 6. *Detail of the Madrid area, showing the locations of the various deposits and the distribution of rock types. The deformation zone (DEFZ) cuts through the Madrid linear, a till-filled valley without outcrop Co-ordinates are UTM.*

Mineralization, based on the recognition of varioles and interflow sedimentary rocks in the less altered host strata, suggests that the Naartok zone is primarily hosted by the variolitic suite of pillowed flows, in the hanging wall of the deformation zone. Stratigraphy in the Naartok area, based on correlations through level plans, appears to be north-south-striking, similar to the rest of the package of rocks. The Wolverine suite of volcanic rocks outcrops in the footwall of the deformation zone. This demonstrates that the deformation zone represents a bounding structure that juxtaposes two different suites of mafic volcanic rocks.

Determining the relative timing of mineralization with respect to fabric development can help explain vein orientations and related geometries. Quartz veins associated with gold mineralization at Naartok are generally folded and buckled (Fig. 4f). Iron-carbonate and silica-flooded zones are typically less foliated than surrounding alteration and veins within foliated alteration zones are variably transposed into S_2 planes. These observations are consistent with alteration and veining developing as a progressive event during D_2, which culminates in the S_2 fabric. The deformation zone may represent an early feature that acted as a fluid conduit during syn-D_2 fluid flow. Whether it formed during D_2 or predates D_2 and was subsequently reactivated, is uncertain.

Wolverine area

The Wolverine–Madrid corridor is unusual in the number of high-grade quartz-vein showings located outside the Madrid area. These include the Dinger, Light, Jeffe, Jeffe South, Wolverine, and Spot showings (Fig. 2). These showings all occur within iron-carbonate-altered high-strain zones, parallel to the local S_2 fabric (Fig. 4a). Hosted within these alteration zones are quartz-carbonate veins commonly with septa of sheet silicates and/or tourmaline (Fig. 4b). The septa tend to be parallel to the vein walls, producing a crack-and-seal texture. Small angular discordances between S_2 and the vein orientations are common. 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 the fabrics formed during a progressive deformation event. These geometries and fabrics are typical of fault-fill veins as described by Robert and Poulsen (2001).

Sulphides are a minor component of the veins. Pyrite, the most common sulphide, is generally fine grained and concentrated with the septa or at the vein selvages. Chalcopyrite is also seen locally (mainly at the Spot showing). Gold is contained within the quartz-carbonate veins and the iron-carbonate-altered units. Visible gold is common.

Many of these vein systems and associated high-strain zones occur at, or near, lithological boundaries. The Wolverine, Light, and Dinger showings are developed at or near the contact between felsic and mafic volcanic rocks. The rheological contrast between these rock types likely localized strain at these contacts.

SUMMARY

Geological mapping and core logging in the Wolverine–Madrid corridor have demonstrated the presence of a well defined volcanic stratigraphy. The lower stratigraphic sequence is a variolitic pillowed basalt with interflow sedimentary rocks. Overlying the variolitic suite are smaller, nonvariolitic pillows without any recognized interflow sedimentary rocks (Wolverine suite). Both groups of mafic volcanic rocks as well as various pillow forms display rubbly flow breccia, quench breccia, and locally sediment interaction textures. Felsic volcaniclastic and subvolcanic intrusive rocks are interbedded with and intrude into the Wolverine suite of mafic volcanic rocks and provide excellent stratigraphic markers.

Gold mineralization developed in the Madrid area is represented by the Naartok deposit where gold occurs as a complex stockwork system developed in brecciated basalt with lesser altered gabbro and sedimentary rocks. The Naartok area is spatially associated with the hanging wall of the deformation zone, which is a complex structure that juxtaposes different volcanic intervals.

In the Wolverine area, gold occurs in iron-carbonate-altered high-strain zones with crack-seal veins that have septa of tourmaline and/or sheet silicates. The quartz-carbonate veins are generally deformed to some degree within the high-strain zones. Kinematic indicators are rare in all but the largest of these zones, but where observed suggest sinistral offsets. These high-strain zones and the associated alteration and mineralization are commonly localized at lithological contacts. The felsic–mafic volcanic contacts are commonly preferentially mineralized, likely as a result of contrasting mechanical properties.

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