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GEOLOGY AND MAGNETIC ANOMALIES OF THE EXPLOITS–MEELPAEG BOUNDARY ZONE IN THE VICTORIA LAKE AREA (CENTRAL NEWFOUNDLAND): REGIONAL IMPLICATIONS

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ABSTRACT

The results of new fieldwork in the eastern half of Victoria Lake, in combination with a new aeromagnetic map of this zone, allow a further interpretation of the local geology. The Victoria Lake shear zone is the most significant structure in the area. This syn-metamorphic shear zone separates low-grade rocks of the Exploits Subzone (Victoria Lake Group, Rogerson Lake Conglomerate, and Victoria Dam belt) to the north, from high-grade metamorphic tectonites to the south. The exposed portion of the Victoria Lake shear zone coincides with the boundary between the two areas with different geophysical response; this geophysical boundary allows to trace the underwater portion of the shear zone with confidence. The shear zone cuts across the contacts between the low-grade units of the Exploits Subzone and is stitched by a late gabbro and associated granite of presumed Devonian age. New data on the Victoria Lake Group suggests the possible presence of Neoproterozoic sediments in the Tally Pond assemblage. The Rogerson Lake Conglomerate contains pre-D_2 mafic dykes and gabbros; such rocks also occur in the Tally Pond assemblage and the Victoria Dam belt. The Victoria Dam belt contains a mélange unit sandwiched between pillow basalt adjacent to silicic volcaniclastic rocks and black shales associated with greywacke, limestone and pillow lava. The metamorphic tectonites on the southern side of the shear zone include coticule-bearing rocks equivalent to the Exploits Subzone (the Howley Waters belt) and Gander Zone-like Meelpaeg Subzone metasediments. Middle Ordovician granite stitches the contact between the Howley Waters belt and the Meelpaeg Subzone. This demonstrates that part of the Exploits Subzone and Gander Zone were together by at least Middle Ordovician times, whereas final juxtaposition of the Gander Zone and the rest of the Exploits Subzone took place in Devonian times along the Victoria Lake shear zone.

INTRODUCTION

The Noel Paul's Line defines the tectonic boundary between the Exploits and Meelpaeg subzones in central Newfoundland (Figure 1; Williams *et al.*, 1988). The nature of the Exploits–Meelpaeg boundary at Victoria Lake is far more complex than at the type locality of the line along Noel Paul's Brook (Figure 1), where a shear zone separates low-grade Exploits Subzone rocks from Meelpaeg Subzone metamorphic tectonites (Snowshoe Pond map sheet; Colman-Sadd, 1987). Around Victoria Lake a major shear zone has been identified, the Victoria Lake shear zone (Valverde-Vaquero and van Staal, 2001). This is analogous to the shear zone at Noel Paul's Brook, in that it separates metamorphic tectonites from low-grade Exploits Subzone rocks. However, the metamorphic tectonites include a rock assemblage having affinities to the Exploits Subzone, here termed the Howley Waters belt. The contact between the Howley Waters belt and the Meelpaeg metasediments is stitched by pre-metamorphic granites that are locally overprinted by the Victoria Lake shear zone (Valverde-Vaquero and van Staal, 2001).

The Victoria Lake shear zone is exposed onshore south of Victoria Lake and was mapped in the summer of 2000 (Valverde-Vaquero and van Staal, 2001). The continuation of the shear zone along the central and eastern parts of the lake was defined after fieldwork in 2001. A good match between lithological units and aeromagnetic anomalies (Oneschuk *et al.*, 2001) permits a confident delineation of the shear zone in poorly exposed areas and beneath the lake. The aeromagnetic data also provide a good image of the distribution of the different low-grade Exploits Subzone rock assemblages beneath the lake. The new data allow preliminary assessment of the relationships among units, lithological correlation of the units with neighbouring areas, and discussion of the geological significance of the different lithotectonic boundaries, including the Meelpaeg–Exploits boundary. The area of study covers the eastern half of the Victoria Lake map (NTS 12 A/6), previously mapped by Kean (1982). This includes the shorelines of the Stanley Waters, the northern Howley Waters, the eastern arm of Victoria Lake and the ground up to Red Cross Lake (Figure 2). The area discussed includes the southern end of the Tally Pond assemblage and its contact with the Tulks Hill assem-

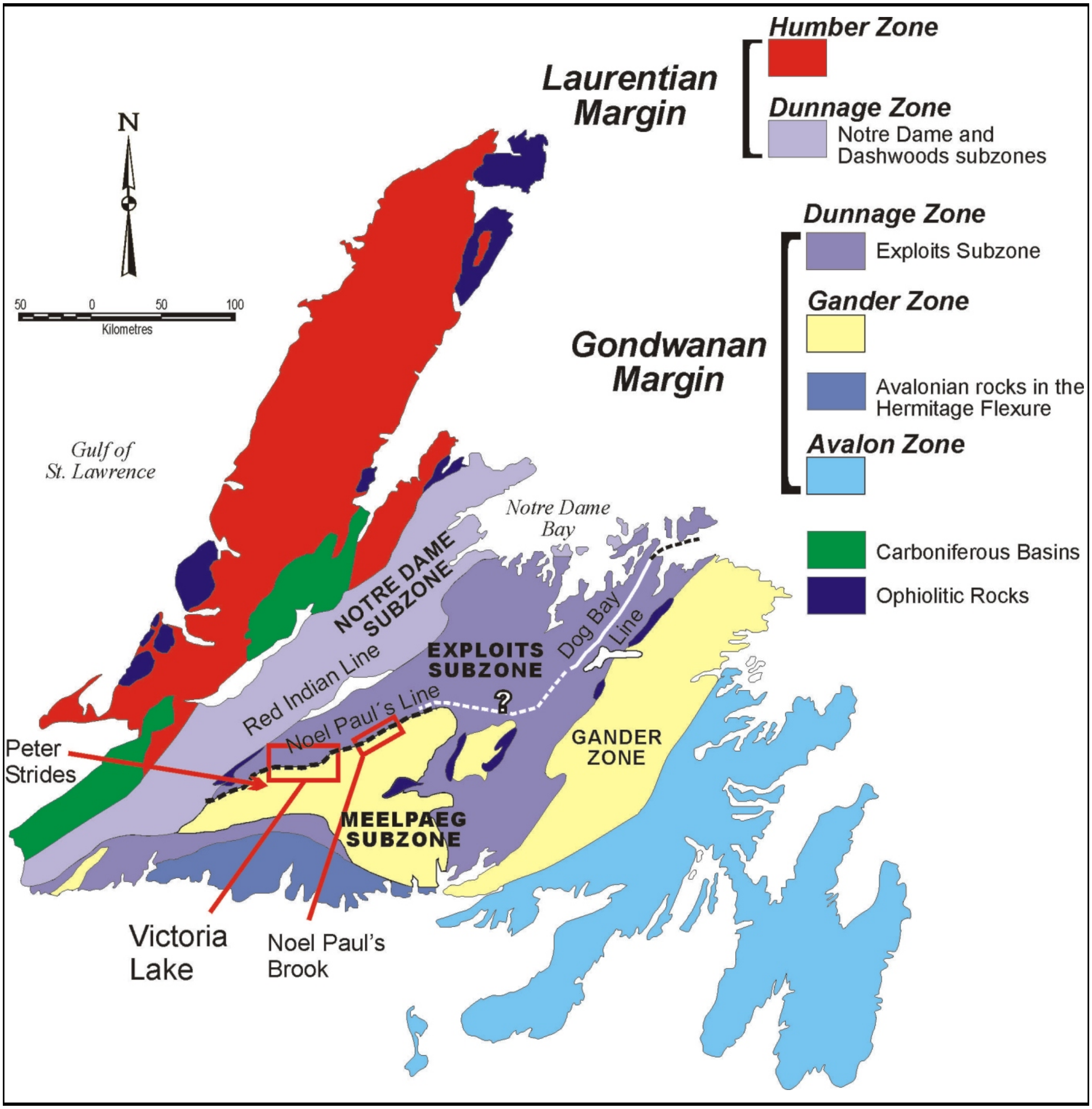

Figure 1. *Lithotectonic zones of the Newfoundland Appalachians (modified after Williams* et al.*, 1988).*

blages of the Victoria Lake Group (*see* Rogers and van Staal, *this volume*). It also covers the greenschist-facies Victoria Dam belt, the amphibolite-facies Howley Waters belt, and adjacent rocks of the Meelpaeg Subzone (*see* Valverde-Vaquero and van Staal, 2001).

GEOLOGICAL SETTING

Major lithotectonic boundaries within the Dunnage and Gander zones converge in the centre of Newfoundland. The Dunnage Zone contains early Paleozoic volcanosedimenta-

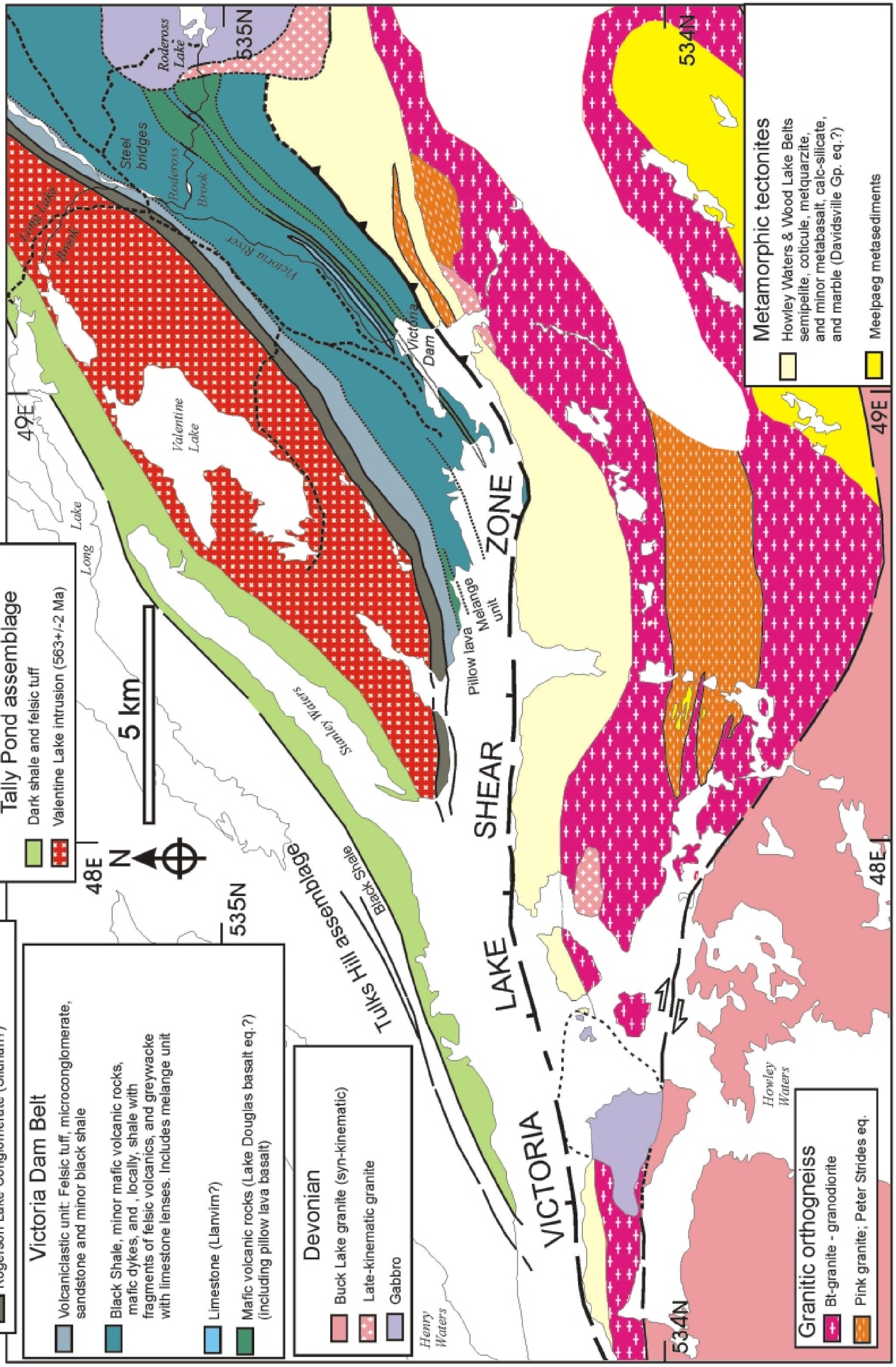

Figure 2. *Geological map of the eastern side of Victoria Lake. HIG, Howley Islands gabbro; RLG, Red Cross Lake gabbro.*

ry sequences and various remnants of the Iapetus Ocean (e.g., Williams *et al.*, 1988). In contrast, Cambro-Ordovician siliciclastic sequences of the Gander Zone represent a miogeocline on the peri-Gondwanan margin of Iapetus. The Red Indian Line (Figure 1) marks the suture between the opposing peri-Laurentian (Notre Dame Subzone) and peri-Gondwanan (Exploits Subzone) elements of the Iapetus Ocean (Williams *et al.*, 1988). Formation of this intra-Dunnage suture is Late Ordovician, but the present structures along this line are mainly the result of superimposed Siluro-Devonian events. The amalgamation of the Exploits Subzone with the Gander Zone mainly took place in the Early Ordovician (Penobscottian Event; Colman-Sadd *et al.*, 1992). Dismembered ophiolite slivers are present along the Gander Zone–Exploits Subzone boundary in central and northern Newfoundland. The Meelpaeg and Mount Cormack subzones represent the Gander Zone in central Newfoundland (Figure 1). The Mount Cormack Subzone–Exploits Subzone boundary is stitched by the Mid Ordovician (474 +6/-3 Ma) Partidgeberry Hills granite that intrudes Gander Zone sediments and ophiolite (Colman-Sadd *et al.*, 1992). The aforementioned Noel Paul's Line marks the Meelpaeg Subzone–Exploits Subzone boundary. Southwest of Victoria Lake, Noel Paul's Line merges with the Red Indian Line (Figure 1). The Dog Bay Line (Williams *et al.*, 1993) forms the boundary between the Silurian marine and continental sequences of the Botwood Belt, which covers the Exploits Subzone. The Dog Bay Line formed during final closure of a remaining Iapetan seaway in Newfoundland; the trace of this suture into central Newfoundland is uncertain (Figure 1).

According to Evans *et al.* (1990), the Rogerson Lake Conglomerate is a correlative of the Silurian Botwood Belt. At Victoria Lake, the conglomerate separates two volcanosedimentary packages within the low-grade rocks of the Exploits Subzone: the Victoria Lake Group (Evans *et al.*, 1990) and the Victoria Dam belt (Valverde-Vaquero and van Staal, 2001; Figure 2). The conglomerate is polymictic, and contains clasts of the Victoria Lake Group, upon which it rests unconformably.

The Victoria Lake Group contains a complex set of volcanosedimentary assemblages. It includes Cambrian (513 ± 2 Ma Tally Pond volcanics; Dunning *et al.*, 1991), Early Ordovician (498 +6/-4 Ma Tulks Hill volcanics; Evans *et al.*, 1990), and Mid Ordovician rocks (e.g., 462 +4/-2 Ma Victoria Mine sequence of Evans *et al.*,1990). Mélange and black shale locally separate these assemblages (*see* Rogers and van Staal, *this volume*). Black shales of Caradocian age form a cover to the Victoria Lake Group rocks (Evans *et al.*, 1990).

In the eastern and central portions of Victoria Lake, only the Tulks Hill and the Tally Pond assemblages are exposed. The Tulks Hills assemblage occurs on the peninsula between Stanley and Henry waters, where a narrow belt of black shale separates it from the Tally Pond assemblage (Figure 2). The Tulks Hills assemblage is intruded by 495 ± 4 Ma quartz monzonite and contains widespread massive sulphide mineralization (Evans *et al.*, 1990). The Tally Pond assemblage contains two large plutonic bodies of late Neoproterozoic age: the 563 ± 2 Ma Valentine Lake and the 565 +4/-2 Ma Crippleback Lake quartz monzonites (Evans *et al.*, 1990). These are basement to the mineralized Cambrian Tally Pond volcanic assemblage (e.g., Pollock and Wilton, 2001). The Tulks Hill and Tally Pond assemblages become increasingly deformed toward their southern boundary with the Victoria Lake shear zone. The Tally Pond assemblage, also, becomes more deformed toward the boundary with the Victoria Dam belt (Figure 2).

The Victoria Dam belt (Valverde-Vaquero and van Staal, 2001) is a volcanosedimentary package sandwiched between the Rogerson Lake Conglomerate and the Victoria Lake shear zone (Figure 2). These rocks lie along strike with the Lake Douglas basalt and the Carter Lake volcanic rocks farther north (e.g., Evans *et al.*, 1990). In contrast to the Tally Pond assemblage, deformation is very intense throughout the Victoria Dam belt. The ages of the rocks in this belt are poorly constrained.

The Victoria Lake shear zone separates the greenschist-facies rocks of the Exploits Subzone from staurolite + sillimanite-bearing metasedimentary rocks to the south, defining a prominent metamorphic-facies break. South of the shear zone, the rocks of the Exploits Subzone are represented by the Howley Waters belt (Valverde-Vaquero and van Staal, 2001), which is exposed along the trace of the shear zone (Figure 2). The Howley Waters belt is stitched to the Gander Group-type metasediments of the Meelpaeg Subzone by pre-metamorphic granites. A preliminary U–Pb age of 470 to 463 Ma (P. Valverde-Vaquero, unpublished data, 2001) for one of these granites near Peter Strides suggests that they are Middle Ordovician. Metamorphic grade in the Meelpaeg Subzone increases away from the shear zone, locally reaching temperatures sufficient for partial melting. The Meelpaeg Subzone also contains widespread syn- and late-D_2 Devonian granitoids (*see* Valverde-Vaquero and van Staal, 2001).

The Victoria Lake shear zone postdates D_1 deformation and was developed as a thrust during the D_2 regional deformation (Valverde-Vaquero and van Staal, 2001). The D_2 deformation coincides with peak metamorphism in the staurolite zone in the Howley Waters belt (St+Grt+Sil) and growth of upper greenschist-facies mineral assemblages (Grt+Alb+Bt) in the Victoria Dam belt. Subsequent D_3 deformation of the shear zone also occurred close to peak temperature conditions (*see* Valverde-Vaquero and van Staal, 2001). As a result of the D_3 folding, the central portion of the thrust exposed along the south shore of Victoria Lake dips to the north with an apparent normal sense of shear (Figure 2). Peak metamorphism in the nearby Meelpaeg Subzone rocks is ca. 410 Ma (G. Dunning *in* Owen, 1992), indicating that the shear zone is Devonian.

GEOLOGICAL UNITS

The following is a description of the main rock types in the eastern part of the Victoria Lake area. The only rocks of the Victoria Lake Group discussed are those of the Tally Pond assemblage. The Tulks Hill assemblage is described by Evans *et al*. (1990) and Rogers and van Staal (*this volume*).

THE TALLY POND ASSEMBLAGE

In the Victoria Lake area, the Tally Pond assemblage is separated from the Tulks Hill assemblage by a narrow band of black shale (Unit 6 of Kean, 1982). The age of this unit is uncertain, but it appears that it can be traced farther north along the boundary between the Tally Pond and the Tucks Hill assemblages, and possibly merges with the Caradocian shale cover sequence of the Victoria Lake Group (*see* Rogers and van Staal, *this volume*).

The rocks of the Tally Pond assemblage are exposed along the shores of Stanley Waters (Figure 2), west of the late Neoproterozoic Valentine Lake quartz–monzonite. They consist of grey shale and siltstone interlayered with subordinate light-coloured, fine-grained, felsic tuffaceous siltstone, and minor, cream-coloured, fine- to medium-grained volcanogenic sandstone. Plagioclase crystals are abundant in the silt and sand portions of the sequence. The regional deformation has erased primary sedimentary structures. Locally, they contain metamorphic mineral assemblages along with muscovite, chlorite, biotite, and garnet. Evans *et al*. (1990) state that, the volcanosedimentary rocks are younger than the Valentine Lake intrusion. A decametre-scale screen of garnet–chlorite-bearing schist surrounded by quartz–monzonite was found near the southern shore of Valentine Lake. The schist is interpreted as country rock to the 563 Ma intrusion. According to J. Pollock (personal communication, 2002), the 565-Ma Crippleback quartz–monzonite also intrudes shaly low-grade metasediments. If these metasediments are equivalent to those of the Tally Pond assemblage, these observations suggest the presence of Neoproterozoic sedimentary units within it. However, there is no definitive geochronological evidence. Small mafic dykes and gabbros of uncertain age intrude the volcanosedimentary unit. These are overprinted by the D_2 deformation.

The late Precambrian Valentine Lake intrusion is a composite pluton comprised of monzonite to monzogranite. The intrusion includes two distinctive melanocratic and leucocratic phases, both of which are fine to medium grained and equigranular. The leucocratic phase contains pink feldspar, plagioclase, minor biotite, locally amphibole, and blue quartz. The melanocratic phase may contain up to 50 percent mafic minerals (mainly amphibole, and subordinate biotite), and includes an end member with 70 percent amphibole. The felsic phase generally intrudes the mafic phase forming networks of veins (Plate 1a). A late swarm of pre-D_2 mafic dykes intrudes both mafic and felsic phases, marking the final magmatic pulse in the area (Plate 1b). A striking feature of the Valentine Lake intrusion is that large parts of it are undeformed or weakly deformed. Most deformation is concentrated in discrete, retrograde, greenschist-facies (epidote + chlorite), D_2 high-strain zones. Regional strain associated with the D_2 deformation in the intrusion increases toward the contact with the Rogerson Lake Conglomerate. In the Long Lake brook section, between Long Lake and Victoria River (Figure 2), two separate foliations (S_1 and S_2) can be identified in the Valentine Lake intrusion. Detailed mapping of the structural relationships between S_1 and S_2 suggests that the Valentine Lake intrusion is situated in the core of a large F_2 antiform.

THE ROGERSON LAKE CONGLOMERATE

This unit separates the Tally Pond assemblage from the Victoria Dam belt. The conglomerate forms a continuous band along the eastern border of the Valentine Lake intrusion, and lies unconformably over the Tally Pond assemblage (Figure 2) and is in tectonic contact to the west with the Victoria Dam belt and equivalent units (Evans *et al.*, 1990) . The conglomerate contains rounded clasts of light-purple felsic volcanic rock, rhyolite, chert, siltstone, granite, quartz–monzonite (Valentine Lake intrusion; Plate 1c), red jasper, and locally dark-grey shale and small carbonate lenses (10 cm long); it has a sandy matrix. Locally, there are lenses of sandstone and microconglomerate having graded bedding, indicating bottom toward the Valentine Lake intrusion. The intense deformation has produced flattening and stretching of the conglomerate clasts. Discrete, pre-D_2, mafic dykes and small gabbros intrude the conglomerate in places.

Plate 1. *Tally Pond group. a) Undeformed Valentine Lake intrusion: felsic veins (leucocratic facies) intruding mafic gabbro (melanocratic facies; UTM 488717-5358792); b) Late mafic dykes cross-cutting Valentine Lake monzogranite (leucocratic facies), P.V.V. for scale (UTM 486200-5355800). Similar dykes intrude the Rogerson Lake Conglomerate nearby; c) Rogerson Lake Conglomerate near the contact with the Valentine Lake intrusion, deformed clast of Valentine Lake intrusion (UTM 486800-5356000).*

THE VICTORIA DAM BELT

The Victoria Dam belt is a composite unit of highly deformed rocks sandwiched between the Victoria Lake shear zone and the Rogerson Lake Conglomerate (Figure 2). This belt is well exposed along the shore of Victoria Lake and locally in the Victoria River and Red Cross Brook (Figure 2). Elsewhere, the exposure is poor, and the map is based largely on the distribution of magnetic anomalies. Informal nomenclature is used until sufficient data are available to introduce formal names for the units present.

Felsic Volcaniclastic Unit

The felsic volcaniclastic unit comprises a package of epiclastic rocks and tuffs that forms a narrow band immediately adjacent to the Rogerson Lake Conglomerate (Figure 2). At the "steel bridges" on Victoria River, between the Red Cross and Long Lake brooks (Figure 2), 5- to 10-cm thick layers of dark-grey shale alternate with light-yellowish grey ash tuff and volcanogenic siltstone. This fine-grained shale–tuff interval grades into coarse tuffaceous sandstones of variable thickness (locally up to 50 cm thick) having fragments of quartz and feldspar-phyric crystal tuff, and minor intercalation of dark and light-green chlorite-rich shale. This sequence coarsens toward the contact with the Rogerson Lake Conglomerate. At the shore of Victoria Lake, a sequence of coarse sandstones and grey shales having discrete intercalation of conglomerate beds is located in a similar structural position, adjacent to the Rogerson Lake Conglomerate (Plate 2a). The sandstones contain abundant volcanogenic material, such as rounded quartz and feldspar fragments. The conglomerate is matrix supported, and superficially resembles the Rogerson Lake Conglomerate, but contains mostly fragments of felsic volcanic rocks and dark shales rather than the polymictic clast population of the latter.

Pillow Basalt Unit

At Victoria Lake, a ca. 200-m-thick unit of pillow basalt is intercalated between the felsic volcaniclastic unit and the mélange unit (*see below*). This unit includes highly deformed pillow basalt with ribbons of limestone (interpillow material?; Plate 2b), intercalations of black shale, and metagabbro (Figure 2). The high strain associated with the D_2-D_3 deformations prevented an assessment of the nature of the contacts with the adjacent units.

Mélange Unit

The mélange unit consists of dark-grey shale containing angular to semi-rounded fragments of felsic volcanic rocks, up to 50 cm in diameter, graphite nodules (2 to 3 cm in diameter), and greywacke (Plate 2c, d). This mélange has not been identified farther north, due to lack of exposure, but it may well correlate with Unit 10 of Colman-Sadd (1987) in the immediately adjacent Snowshoe Pond map area.

Graphitic black shale bounds the mélange unit to the east. Near Victoria Dam, these black shales are intercalated with pillow basalts, greenish shales, greywackes and limestones (Plate 2e). The pillow basalt and the limestone form continuous bands, approximately 50 to 100 m thick, parallel to each other that can be traced at least 4 km north (Figure 2). Discrete pre-D_2 mafic dykes and small gabbroic bodies intrude all these units, and locally a pre-D_2 felsic dyke intrudes the mélange unit (Plate 2f).

North of Victoria Lake, the Red Cross Brook section contains dark shales intruded by mafic dykes, and two packages of mafic volcanic rocks separated by a volcanogenic sedimentary unit containing sandstones and shales (Figure 2). The westernmost mafic volcanic rocks and the volcanogenic sediments correlate with Units 8 and 9 respectively of Colman-Sadd (1987) in the Snowshoe Pond map area. The mafic volcanic rocks have been correlated on the basis of the magnetic anomaly patterns with the basalt exposed on the shore of Victoria Lake. However, this interpretation needs testing by geochemical fingerprinting.

METAMORPHIC TECTONITES

A sequence of middle to upper amphibolite-facies metasedimentary rock, granite orthogneiss, syn-D_2 and late-D_3 granite occurs south of the Victoria Lake shear zone (Figure 2). Two distinctive belts of metasedimentary rocks have been recognized. The Howley Waters belt lies immediately adjacent to the Victoria Lake shear zone, and contains rocks characteristic of the Exploits Subzone (Valverde-Vaquero and van Staal, 2001). South of the Howley Waters belt, quartzose metasedimentary rocks equivalent to the Gander Group occur in the Meelpaeg Subzone. The contact between the two metasedimentary belts is stitched by granitic orthogneiss. Similar stitching relationships have been documented near Peter Strides, where Valverde-Vaquero and van Staal (2001) have referred to the granitic orthogneiss as the "old" granite.

THE HOWLEY WATERS BELT

Along the southern shore of Victoria Lake (Figure 2), the Howley Waters belt consists of a wide variety of rock types. These include light-coloured staurolite-bearing schist and psammite associated with minor calc-silicate, dark metapelitic schist. In addition, locally, there are decametre-scale marble pods, metabasalt, amphibolite, metagabbro and deformed fine-grained felsic porphyry. The widespread occurrence of thin (mm to cm scale) coticule (garnet-rich quartzite) layers is characteristic of this unit (Plate 3a). South of Victoria Lake, the Howley Waters belt is more psammite-rich and includes metaquartzite and garnet–sillimanite schist.

THE MEELPAEG SUBZONE

The metasedimentary rocks of the Meelpaeg Subzone were identified as discrete bands or screens of garnet–sillimanite micaschist and metapsammite (commonly quartzitic), which form the country rock to the granitic orthogneiss (Figure 2). The granitic orthogneiss also intrudes the Howley Waters belt and comprises two main phases: a medium-grained pink granite and a fine- to medium-grained, grey, biotite-bearing granite to granodiorite. The pluton is continuous with the Middle Ordovician Snowshoe Pond granite of Colman-Sadd (1987). The pink phase is equivalent to the Peter Strides granite to the west, which has a lower intercept age of 463 ± 2 Ma (subconcordant zircon; P. Valverde-Vaquero, unpublished data, 2001), within error of the age of the Snowshoe Pond granite (ca. 464 Ma, G. Dunning and S. Colman-Sadd, personal communication,

Plate 2. *Victoria Dam belt. a) Volcaniclastic unit, Victoria Lake shore, grey shales alternating with volcanogenic siltstones and gritstones (top left; UTM 484402-5354417); b) Mafic pillow lavas with interpillow carbonates (white), Victoria Lake shore (UTM 484590-5354286); c) Mélange unit, fragment of felsic fragmental volcanic rock in black shale matrix, Victoria Lake shore (UTM 486903-5354300); d) Mélange unit, mélange of black shale with fragments of volcanic and epiclastic rocks (same location as c); e) Limestone lens, Dan Hagan for scale standing on the limestone, spout of Victoria Dam (UTM 491350-5356000); f) Felsic dyke in mélange unit, Dan Hagan for scale, Victoria Lake shore (UTM 486160-5354275).*

Plate 3. *Metamorphic tectonites and Siluro-Devonian intrusion. a) Howley Waters belt, micaschist with staurolite porphyroblasts and coticule layers (pink; UTM 492551-5355571); b) Buck Lake granite, deformed megacrystic facies, Howley Waters (473500-5349100); c) Howley Islands gabbro, intrusive contact with metasediments of the Howley Waters belt (UTM 475600-5351600).*

2001). The grey phase was locally intruded by pink and white pegmatite, leucogranite, and mafic dykes that are also strongly deformed. Although the intrusive relationships between these two facies are not well-understood at present, the lack of mafic dykes in the pink facies suggests that it is younger. Both orthogneiss facies show good evidence of polyphase deformation and, as a result, contain a well-developed composite penetrative fabric that is folded in places by F_2 and F_3 folds (Valverde-Vaquero and van Staal, 2001).

The syn- to post-D_2 Buck Lake granite (see Kean, 1983; Valverde-Vaquero and van Staal, 2001) occupies the southern portion of the mapped area and intrudes the granitic orthogneiss and Meelpaeg metasediments. Its most distinctive component is the megacrystic phase (Plate 3b). In the Howley Waters, a dextral shear zone overprints the northern boundary of the Buck Lake granite (Figure 2). The relative timing of its intrusion with respect to regional deformation suggests that the Buck Lake granite is Devonian (*see* Valverde-Vaquero and van Staal, 2001). Weakly deformed to undeformed two-mica garnetiferous granite intrudes the granitic orthogneiss and the Howley Waters belt, forming two discrete intrusions at the eastern end of Victoria Lake and the northern end of the Howley Waters (Figure 2). These granites are interpreted to have intruded during the late stages of the D_3 deformation.

Late Intrusions

Kean (1983) described two, kilometre-scale, semicircular bodies of Devonian gabbro in the Victoria Lake map area (Figure 2). A gabbro intrudes the tectonites of the Howley Waters belt and is best exposed on islands in the mouth of the Howley Waters. This gabbro is referred to as the Howley Islands gabbro (HIG, Figure 3). It is coarse-grained

Figure 3. (opposite page). *Map of aeromagnetic anomalies (Oneschuck* et al., *2001). Line 1, Victoria Lake shear zone (VLSZ); line 2 Howley Waters belt–granitic orthogneiss contact; line 3, contact of the Buck Lake granite?; line 4, black shale–Tally Pond assemblage contact; Line 5, contact of the Valentine Lake intrusion; Line 6, trace of the Rogerson Lake Conglomerate; 7, 8, and 9, magnetic anomalies. HIG, Howley Islands gabbro; RLG, Redcross Lake gabbro; VL, Valentine Lake intrusion.*

throughout (Plate 3c) and lacks a chilled margin where it intrudes the metasedimentary rocks. This relationship suggests that the gabbro intruded while the country rock was still hot. This conclusion is consistent with orthopyroxene–garnet assemblages observed in mafic rocks that occur in the immediate envelope of the gabbro on one of the islands of the mouth of Howley Waters, which suggest that the gabbro imposed a contact aureole while the rocks were deeply buried and still hot.

The Red Cross Lake gabbro intrudes the Victoria Dam belt and the Howley Waters belt at the eastern end of the investigated area (Figure 2). The gabbro is spatially associated with a fine-grained, weakly foliated, biotite granite, which also intrudes the metasedimentary country rocks. The Red Cross Lake gabbro and associated granite crosscut the Victoria Lake shear zone (Figure 2). The relationship between the Howley Islands gabbro and the Victoria Lake shear zone is not known, because the latter is mainly situated beneath Victoria Lake.

INTERPRETATION OF THE MAGNETIC ANOMALIES

Figure 3 presents the distribution of the vertical gradient anomalies of the magnetic field. This is a product of the regional geophysical compilation carried out by Oneschuk *et al.* (2001) as part of this Targeted Geoscience Initiative project. Reddish colours mark positive magnetic anomalies, while the blues represent negative anomalies. Shading from the southeast has been added to increase the visual contrast.

Most of the positive magnetic anomalies occur in the area north of the Victoria Lake shear zone (VLSZ; line 1 in Figure 3) and show a distinct northeast trend that corresponds to the regional structural grain. A series of closely spaced positive magnetic anomalies is found in the area underlain by the volcanic rocks of the Tulks Hill assemblage.

Line 1 shows the trace of the Victoria Lake shear zone, as mapped in the field (Valverde-Vaquero and van Staal, 2001; *this study*). This line coincides with the marked contrast between the low-grade rocks of the Exploits Subzone and the high-grade rocks of the Howley Waters belt, and the apparent termination of anomalies 7 and 8 (Figure 3). Furthermore, the anomaly associated with the Red Cross Lake gabbro (RLG anomaly; Figure 3) suggests that the latter cuts the trace of the Victoria Lake shear zone. The relationship between the inferred trace of the Victoria Lake shear zone and the Howley islands gabbro, based on the shape of the anomaly associated with the latter (HIG anomaly; Figure 3), is ambiguous. If the positive anomaly immediately north of line 1 is due to the gabbro, it seems to cut the Victoria Lake shear zone. Alternatively, the latter may continue through the narrow magnetic low that separates the two positive anomalies. In this case, the positive anomaly in the north may be due to the rocks that are also responsible for anomaly 7.

A significant magnetic low runs along the Stanley Waters (between lines 4 and 5 in Figure 3), separating the Valentine Lake intrusion (VL) from the Tulks Hill assemblage. This magnetic low tapers out toward the southwest, and is at least in part, replaced by a magnetic high situated immediately north of line 1, opposite to the positive anomaly that coincides with the Howley Islands gabbro (HIG anomaly; Figure 3). From field data, line 4 traces the contact between a thin band of black shale (Caradoc?) to the west and a volcanosedimentary unit of the Tally Pond assemblage to the east. Thus, the magnetic low between lines 4 and 5 mainly corresponds with the relatively unmagnetic volcanosedimentary unit of the Tally Pond assemblage. Although the interference by the positive anomaly north of line 1 complicates straightforward interpretations, the magnetic low seems to be terminated against the Victoria Lake shear zone. If correct, the Victoria Lake shear zone must postdate, at least in part, the main deformation and postulated tectonic imbrication of the Tulks Hill and Tally Pond assemblages (Evans *et al.*, 1990).

The Valentine Lake intrusion lies between lines 5 and 6 (Figure 3), and shows discrete positive anomalies that correspond with areas underlain by the melanocratic phase. The trace of the Rogerson Lake Conglomerate coincides with a magnetic low between the Valentine Lake intrusion and the Victoria Dam belt (anomaly 6; Figure 3), but mapping the geometry of the conglomerate where it disappears in the lake is difficult and ambiguous. It has been generally assumed (Kean, 1982, 1983) that this conglomerate is continuous with the conglomerate exposed at the termination of the southwestern arm of Victoria Lake (Valverde-Vaquero

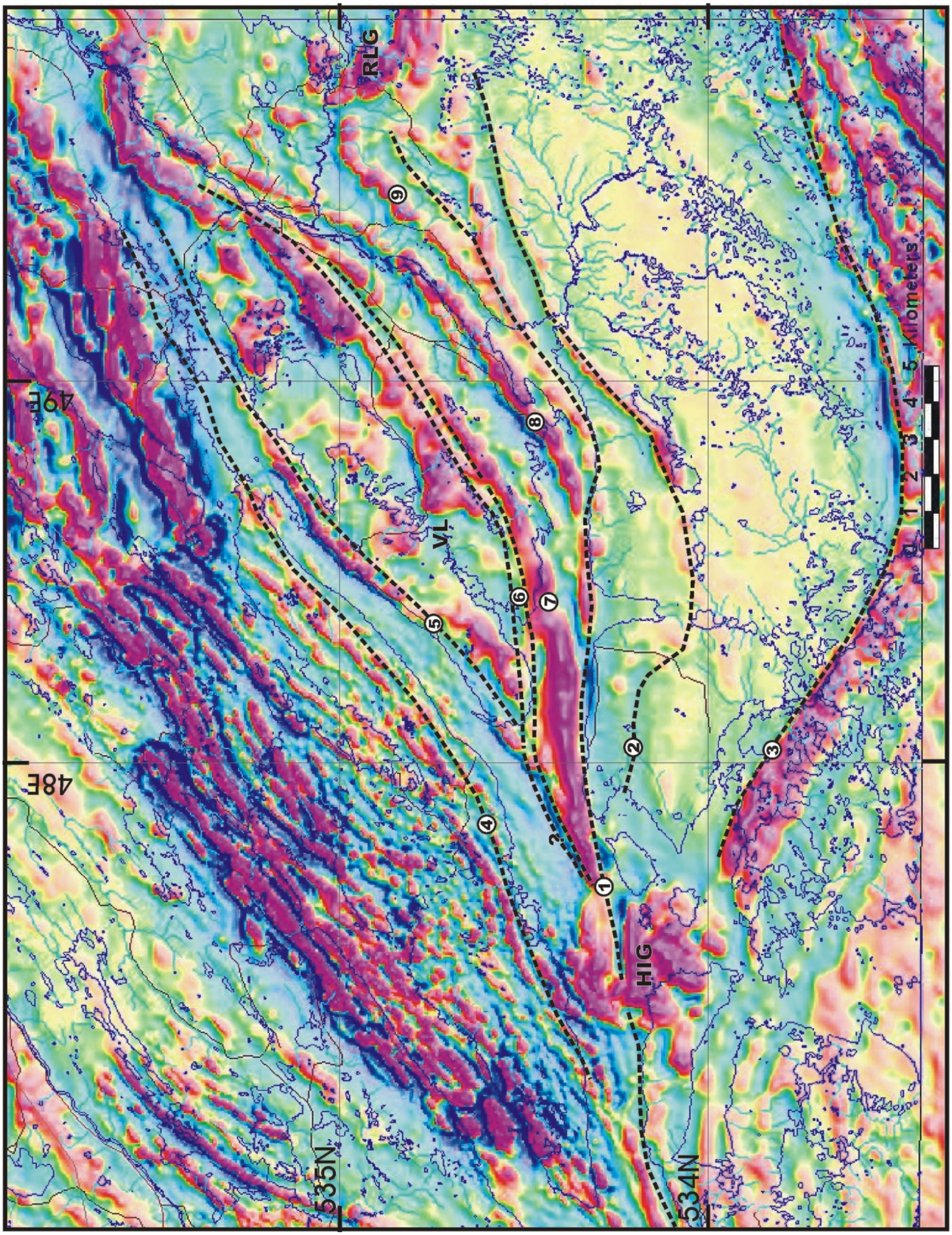

Figure 3. Caption on previous page.

and van Staal, 2001). However, such a correlation has important implications, because if correct, the conglomerate should postdate the main deformation and postulated tectonic imbrication of the Tulks Hill and Tally Pond assemblages, which is not consistent with our structural observations (Valverde-Vaquero and van Staal, 2001). Alternatively, the magnetic anomaly patterns are compatible with excision of the Rogerson Lake Conglomerate by the Victoria Lake shear zone.

The Victoria Dam belt shows three linear positive anomalies (anomalies 7, 8, and 9; Figure 3) that show a gradual change from a northeast–southwest to an east–west trend, and which appear to terminate, at least, in part, against the Victoria Lake shear zone. Anomaly 7 is the most pronounced and largely coincides with the volcaniclastic unit. Disseminated sulphides in the interlayered dark-grey shales may, in part, be responsible for its marked magnetic signature (Plate 2a). Similar mineralization in black shales and associated greywacke could be responsible also for anomalies 8 and 9. Anomaly 8 is immediately adjacent to the narrow limestone band mapped near the Victoria Dam (Figure 2).

South of the Victoria Lake shear zone, there is a wide area with no significant discrete anomalies, except for a series of weak positive anomalies along the boundary of the Howley Waters belt with the Meelpaeg granitic orthogneisses (line 2; Figure 3).The Howley Waters belt and the nearby rocks of the Meelpaeg Subzone do not show any contrasting magnetic signatures. A belt of positive magnetic anomalies occurs immediately south of line 3 (Figure 3), which marks the contact between Meelpaeg metasediments and migmatitic tonalite and granodiorite to the northeast and the Buck Lake granite in the southwest (Kean, 1982).

REGIONAL IMPLICATIONS

1) Metasedimentary screens within the Valentine Lake intrusion raise the possibility that these may be Neoproterozoic sedimentary rocks in the Tally Pond belt. Therefore, Avalonian rocks might be more extensive in the Tally Pond belt than previously thought.

2) All units of the low-grade Exploits Subzone, including the Rogerson Lake Conglomerate, contain a similar suite of pre-D2 mafic dykes and gabbros. Thus, this mafic magmatism is bracketed between the deposition of the conglomerate (Silurian?) and the onset of the D_2 deformation (ca. 417 to 410 Ma; *see* Valverde-Vaquero and van Staal, 2001). This mafic magmatism does not appear to have equivalents in the Meelpaeg Subzone.

3) The Victoria Dam belt remains an enigmatic unit. The presence of mélange, combined with its position southeast of the Rogerson Lake Conglomerate of the Botwood belt, suggest a correlation with the mélanges of the Dog Bay Line in northeast Newfoundland (Figure 1; Williams *et al.*, 1993).

4) The abundance of coticule in the Howley Waters belts provides a strong correlation with other coticule-bearing volcanosedimentary sequences in the Exploits Subzone (Williams, 1992).

5) The Howley Waters belt–Meelpaeg contact is stitched by ca. 463 Ma granite (P. Valverde-Vaquero, unpublished data, 2001), which demonstrates that the Exploits Subzone–Meelpaeg Subzone assembly occurred prior to that time.

6) The Victoria Lake shear zone cuts across the Tulks Hill and Tally Pond assemblages, the Rogerson Lake Conglomerate and the Victoria Dam belt at a low angle. Therefore, the Victoria Lake shear zone postdates the structural amalgamation of the low-grade Exploits Subzone rocks. The shear zone is cut by the Red Cross Lake gabbro, which is probably Middle Devonian or younger. Correlation of the Victoria Lake shear zone with the shear zone that marks Noel Paul's Line at its type locality (Figure 1) suggests that Noel Paul's Line is a Devonian structure and does not everywhere coincide with the boundary between the Meelpaeg and Exploits subzones.

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REFERENCES

Colman-Sadd, S.P.
1987: Snowshoe Pond (12A/7) Newfoundland Department of Mines and Energy, Geological Survey Branch, GSB Map 87-87, scale 1:50 000.

Colman-Sadd, S.P., Hayes, J.P. and Knight, I.
1990: Geology of the Island of Newfoundland. Newfoundland Department of Mines and Energy, Geological Survey Branch, Map 90-01, scale 1:100 000.

Colman-Sadd, S.P., Dunning, G.R. and Dec, T.
1992: Dunnage-Gander relationships and Ordovician orogeny in central Newfoundland: a sedimentary provenance and U/Pb age study. American Journal of Science, Volume 292, pages 317-355.

Dunning, G.R., Swinden, H.S., Kean, B.F., Evans, D.T.W. and Jenner, G.A.
1991: A Cambrian island arc in Iapetus: geochronology and geochemistry of the Lake Ambrose Volcanic Belt, Newfoundland Appalachians. Geological Magazine, Volume 128, pages 1-17.

Evans, D.T.W., Kean, B.F. and Dunning, G.R.
1990: Geological studies, Victoria Lake Group, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 131-144.

Kean, B.F.
1982: Geology of the Victoria Lake map area, southwestern Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, scale 1: 50.000.

1983: Geology of the King George IV Lake map area (12A/4). Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-4, 67 pages.

Oneschuck, D., Tod, J. and Kilfoil, G.
2001: Red Indian Line Airborne Geophysics Compilation (Part I), central Newfoundland. Geological Survey of Canada and Newfoundland Department of Mines and Energy Geological Survey, GSC Open File 3923, Newfoundland Geological Survey Open File 12A/0911, CD-ROM.

Owen, J.V.
1992: Comparative petrology of gneissic rocks in southwestern Newfoundland. Canadian Journal of Earth Sciences, Volume 29, pages 2663-2676.

Pollock, J.C. and Wilton, D.H.C.
2001: Metallogenic studies of the Tally Pond belt, Victoria Lake Group: trace-element geochemistry and lead-isotope data from the Exploits Subzone, Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 01-1, pages 247-266.

Rogers, N. and van Staal, C.R.
This volume: Toward a Victoria Lake Supergroup: A provisional stratigraphic revision of the Red Indian Lake to Victoria Lake area, central Newfoundland.

Valverde-Vaquero, P. and van Staal, C.R.
2001: Relationships between the Dunnage-Gander zones in the Victoria Lake–Peter Strides Pond area. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 01-1, pages 159-167.

Williams, H.
1992, Mélanges and coticule occurrences in the northeast Exploits Subzone, Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 92-1D, pages 121-127.

Williams, H., Colman-Sadd, S.P. and Swinden, H.S.
1988: Tectonic-stratigraphic subdivisions of central Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 88-1B, pages 91-98.

Williams, H., Currie, K.L. and Piasecki, M.A.J.
1993: The Dog Bay Line - a major Silurian tectonic boundary in northeast Newfoundland. Canadian Journal of Earth Sciences, Volume 30, pages 2481-2494.