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THE HODGES HILL GRANITE BETWEEN GRAND FALLS-WINDSOR AND BADGER (NTS 2D/13 AND 2E/4): GEOLOGY, PETROLOGY AND DIMENSION-STONE POTENTIAL

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ABSTRACT

Field work in 1994 provided a geological framework for dimension-stone exploration in the Hodges Hill granite, assessed previously defined potential quarry sites, and resulted in the discovery of three new potential sites. The area contains two distinct granitoid units; a grey, buff or red, coarse-grained (hypersolvus), alkali-feldspar, granite having similarities to those of the Topsails Plateau, and a pink to red, fine- to medium-grained, variably porphyritic, two-feldspar (subsolvus) granite. The latter appears to be younger, and forms a continuous belt located between the coarser grained unit and the country rocks; it is interpreted to be a partial ring-dyke or annular intrusion related to caldera development. Field and petrographic studies suggest that the more intensely coloured orange and red varieties were developed by post-magmatic hydrothermal alteration of a 'primary' granite, as in the Topsails Plateau area. This process caused mineralogical and chemical changes in the granites, and either introduced hematite to K-feldspar, or promoted its exsolution from the feldspar structure.

Twelve potential quarry sites have been assessed in detail. The largest sites, two of which contain from 250 000 m³ to 500 000 m³ of stone, are in the paler coloured, buff varieties of the coarse-grained granite. Coarse-grained orange and red granites tend to be more fractured and heterogeneous, but there are at least two sites with potential for this material. Two important sites in the fine- to medium-grained granite contain pink and red material respectively; the latter is of particular interest for monument stone. Excavation, quarry-face development, and extraction of test blocks commenced at some sites in late 1994; others require further sampling. In view of the commercial interest in the fine-grained red granite, further exploration along the projected course of the outer fine- to medium-grained granite may also be warranted.

INTRODUCTION

OVERVIEW

The Hodges Hill granite, located near Grand Falls-Windsor and Badger (Figure 1), is one of several granite plutons in Newfoundland that have attracted recent attention for high-quality dimension stone. The rights to most of the southwestern lobe of the granite are presently held by Mr. Bill Mercer of Badger, who was the first to recognize the dimension-stone potential of the area, and has defined several zones of potential interest. These vary widely in colour, from pale pink and buff to orange, red and brown, and exhibit a range of textures and grain sizes. Some coarse-grained varieties are reminiscent of the granites of the Topsails Plateau area (Kerr, 1994). In view of potential land-use conflicts concerning quarry development on the Topsails Plateau, the Hodges Hill area is of considerable interest, as it is less controversial, and has access from existing logging roads. The area also contains abundant red granites, which command high prices in the dimension- and monument-stone markets, particularly if large blocks can be extracted.

Detailed studies of the Topsails Plateau granites in 1993 provided assessments of individual quarry sites, and information about colour-development processes and the geometric relationships of colour variants (Kerr, 1994). A similar short field project was initiated in the Hodges Hill area during the 1994 field season. The primary objectives were to define and map different textural units within the Hodges Hill granite, and colour variations within them, and to provide geological assessments and site plans of potential quarry sites. In the long term, this technical information should aid in promoting commercial development of some of these sites. In addition to assessing previously defined sites, some new potential quarry sites were outlined.

LOCATION, TOPOGRAPHY AND ACCESS

The study area (Figures 1 and 2) is located north of the Trans-Canada Highway (TCH) between Grand Falls-Windsor and Badger (NTS 1:50 000-scale map sheets 2D/13 Grand Falls and 2E/4 Hodges Hill), and covers approximately 100 to 150 km². The prominent peak of Hodges Hill (569 m) dominates the northern half of the area, and elevation increases steadily from the Middleton Lake, Aspen Brook and Exploits River valleys in the southwest toward the mountain. The northeastern section of the area forms part of an immense swamp, and contains only a few scattered outcrops. Exposure is very poor in the Aspen Brook valley,

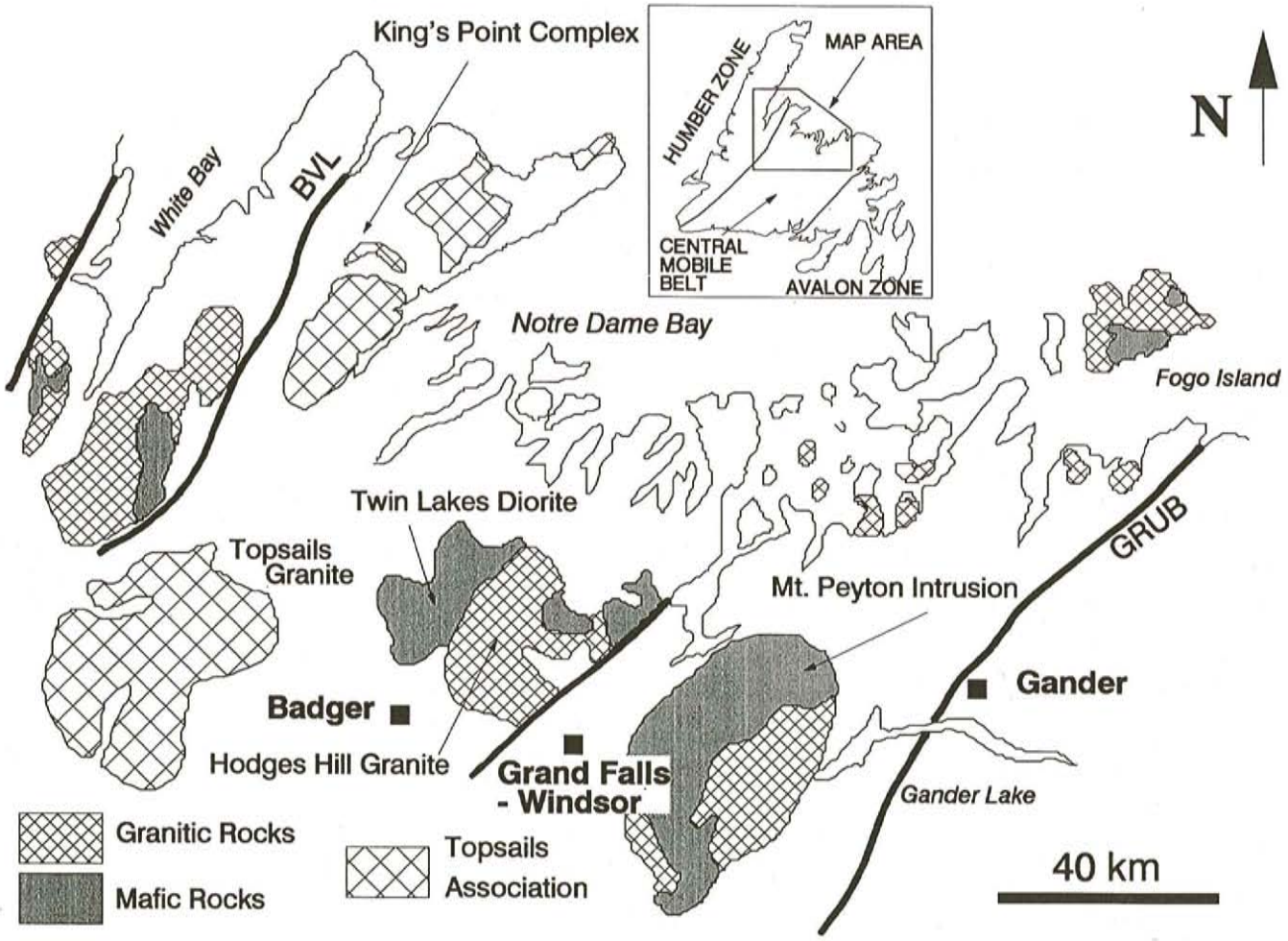


Figure 1. *Location of the Hodges Hill granite and adjacent intrusive complexes in central Newfoundland. BVL = Baie Verte Line; GRUB = Gander River Ultrabasic Belt.*

but is relatively good in the higher country (above 250 m elevation), and extensive on hilltops. The area has been extensively logged, and many logging roads and trails reveal good, glacially polished outcrops. The northern part of the area is accessible by an all-weather road that leaves the TCH at Aspen Brook Provincial Park; disused logging roads branching from this road provide access to most of the potential quarry sites, and an active logging road leaving the TCH about 4 km east of Aspen Brook ('Lew Bushey's Road'), provides access to Sites 8 and 9 (Figure 2). A network of disused roads that leaves the old TCH at the Red Cliff gravel pit provides access to the Leech Pond area, near Grand Falls-Windsor (Figure 2). The condition of these logging roads varies from excellent to virtually impassable, but most major routes are negotiable by high-clearance or 4WD vehicles during summer and autumn.

PREVIOUS WORK

Systematic mapping in the Hodges Hill area was conducted by Hayes (1951) at 1 inch to 1 mile. Subsequent geological maps (e.g., Dean, 1977; Colman-Sadd *et al.*, 1990) are all essentially based on this work. Craig (1949) completed a regional M.Sc. thesis, and Moore (1984) completed a B.Sc. thesis, looking at the geochemistry and Rb–Sr geochronology. The pluton was examined and sampled as part of the Newfoundland granite database project (Kerr *et al.*, 1991), and distinct phases were recognized, but these were not mapped in detail. Regional Nd and oxygen istopic data were reported by Fryer *et al.* (1992). There are no previous published assessments of dimension-stone potential in the area.

GEOLOGY AND PETROLOGY

REGIONAL GEOLOGY

The study area (Figure 1) forms part of the Dunnage Zone of central Newfoundland. The Hodges Hill granite is spatially associated with complex mafic to intermediate plutonic rocks termed the Twin Lakes diorite. Both the Twin Lakes diorite and Hodges Hill granite intrude Ordovician and Silurian volcanic and sedimentary rocks, including parts of the Roberts Arm Group, Frozen Ocean Group and Badger group. Contact relationships between the dioritic and granitoid rocks suggest that the latter are younger, as noted also by Hayes (1951). The

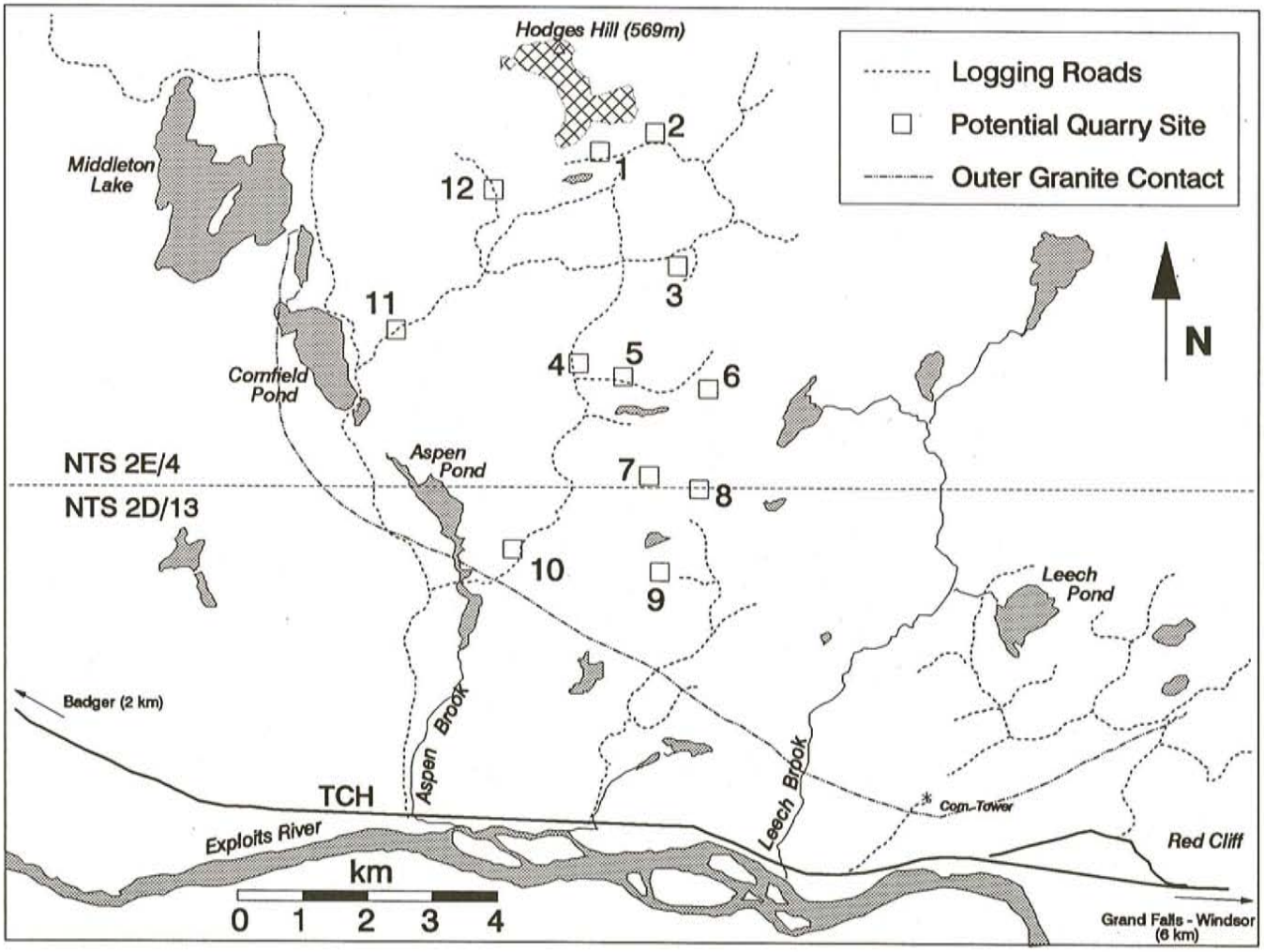


Figure 2. *Location of the main study area, and other areas noted in text, and general locations of Quarry Sites 1 to 12. The map also shows the main access routes.*

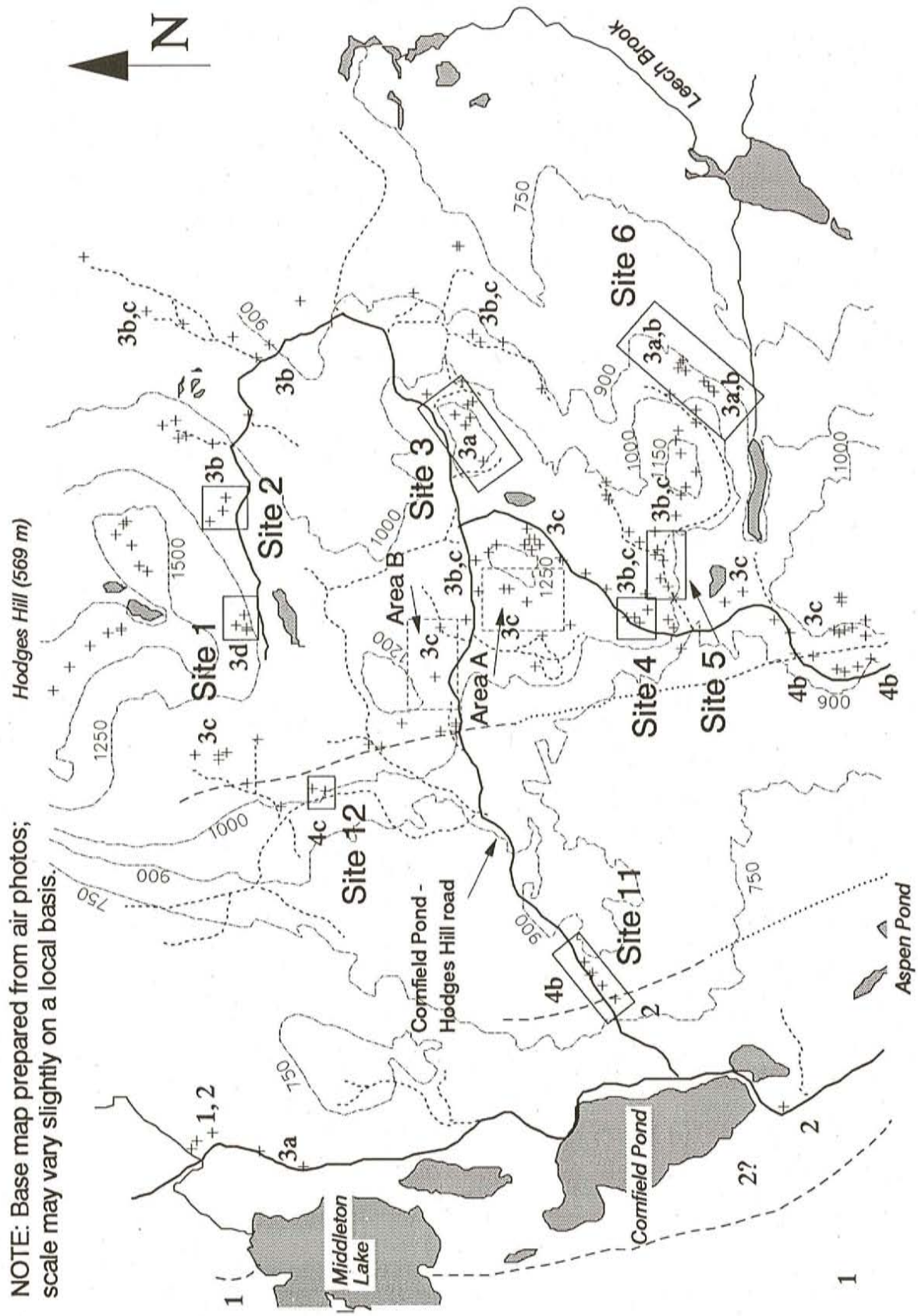
Hodges Hill granite has given a Rb–Sr whole-rock isochron age of 416 ± 5 Ma (initial Sr isotope ratio of 0.7045), indicating that it is of Silurian age (Moore, 1984). Geochemical data from the Hodges Hill granite (Kerr *et al.*, 1990; A. Kerr, unpublished data) show that it is in part peralkaline, and enriched in Zr, Y, Nb and REE, suggesting 'A-type' affinities. In this respect, it resembles Silurian granites of the Topsails intrusive suite (Whalen and Currie, 1988), rather than nearby bimodal complexes such as the Mount Peyton and Fogo Island intrusions (Figure 1).

Sedimentary Rocks (Unit 1)

Poorly exposed sedimentary rocks underly the southwestern part of the study area (Figure 3) and form the country rocks to the diorites and granites. In the Aspen Brook valley, these include sandstones and conglomerates, but in the southeast, around Lew Bushey's road, they are mostly thinly bedded greywackes and slates. The contact between hornfelsed sedimentary rocks and fine-grained diorite is exposed northeast of Middleton Lake, but contacts between granite and country rock have not been observed. According to regional mapping (e.g., Colman-Sadd *et al.*, 1990), these sediments form part of the Ordovician to Silurian Badger group.

Gabbro and Diorite (Unit 2)

Gabbro and diorite are rare in the study area (Figure 3), although they are widespread to the northeast (see below). Medium-grained diorites occur northeast of Middleton Lake, where they are cut by veins of granite, and probably also underly the area south and west of Cornfield Pond, where there are abundant angular diorite float blocks and a few small outcrops. Diorite is also indicated around Aspen Pond in Figure 3, but this is based on float and topography, rather than outcrop data. A medium-grained diorite also occurs near Quarry Site 11 (see below), and may represent a large enclave within the granite. This is an attractive, dark-grey stone, but is too fractured to be of economic interest. In thin section, it consists of calcic plagioclase (50 to 60 percent) and green-brown hornblende (40 to 50 percent), with minor biotite, titanite and magnetite; the amphibole retains an ophitic texture in places, suggesting that it may be after a primary


N
Leech Brook
Hodges Hill (569 m)
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 11
Site 12
Area A
Area B
Cornfield Pond - Hodges Hill road
Middleton Lake
Cornfield Pond
Aspen Pond
NOTE: Base map prepared from air photos; scale may vary slightly on a local basis.

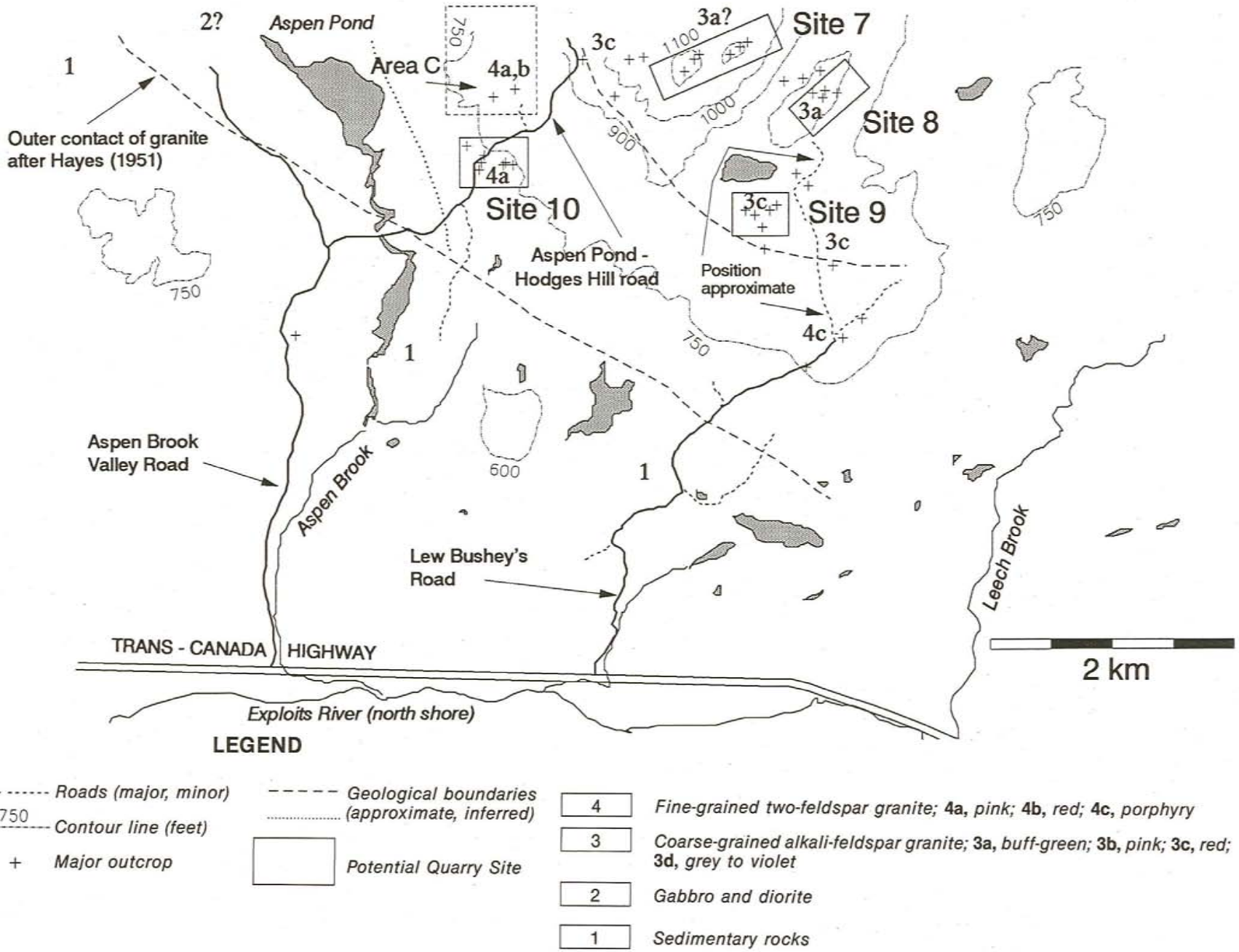


Figure 3. *Geology and site location map of the main study area, south and southeast of Hodges Hill. For detailed maps of some individual quarry sites, see Figures 4 to 11 inclusive.*

clinopyroxene. Secondary alteration and chloritization are widespread in the diorite.

Gabbro and diorite of the Twin Lakes complex are well-exposed on logging roads around Mary Ann Lake and South Twin Lake, 6 to 10 km northeast of the study area. Outcrops are locally massive, and could yield blocks from 4 to 6 m^3, but they tend to be very heterogeneous, with abundant lighter coloured veins, darker inclusions and variable amounts of epidotization. Where homogeneous grey diorites do occur, they are of limited extent, as the adjacent outcrops are highly veined and/or heterogeneous. Several outcrops of intrusive breccia, where diorite is extensively net-veined by white granite, may have potential to produce a spectacular and unusual stone, but the attitudes and characteristics of net-veined zones in these outcrops are unpredictable. Regional observations of the Twin Lakes diorites during previous field work under the granite database project suggest that they are commonly heterogeneous, epidotized and veined, and have less potential for 'black granite' dimension stone than the homogeneous gabbro and diorite of the Mount Peyton intrusion, where such material is already being quarried.

Coarse-Grained, Alkali-Feldspar Granite (Unit 3)

Coarse-grained, alkali-feldspar granite is the most abundant unit in the area, and forms the main massif of Hodges Hill, and virtually all of the high-elevation area south and southeast of the mountain (Figure 3). It is also widespread in the area between Red Cliff and Leech Pond, close to Grand Falls-Windsor (Figure 2). East of Middleton Lake, and at the transmission tower site near Red Cliff, alkali-feldspar granites are present adjacent to the country-rock contact; however, in most areas, Unit 4 (see below) is present between Unit 3 and Unit 1.

The alkali-feldspar granites vary in texture from equigranular to seriate and locally quartz-porphyritic, and vary widely in colour. Four subunits are distinguished on the basis of colour, but these are not discrete 'pigeonholes', and the boundaries between them are gradational. Also, individual outcrops may contain two or three colour variants. Buff to pale-green granites (subunit 3a) are most common in the east, whereas pink (subunit 3b) and orange to red (subunit 3c) granites are most common in the south, around the Hodges Hill–Aspen Pond road. The area between Leech Pond and Red Cliff (Figure 2) is also dominated by red granites. A distinctive pink to grey-violet granite (subunit 3d) is present along the southern flank of Hodges Hill. Outcrop-scale relationships suggest that the most intensely coloured orange and red granites are produced by post-magmatic alteration, as reddened zones are commonly associated with quartz and/or hematite-filled fracture systems, and a higher fracture density. In general, the orange and red granites of subunit 3c are more intensely fractured and jointed than the green, buff or pink varieties, and they are rarely massive enough to be of economic interest. However, there are some important exceptions to this general rule (see below). Like most high-level granites, these rocks contain sporadically distributed miarolitic cavities of interstitial shape, up to 1 to 2 mm in size. The presence and abundance of these is difficult to assess in natural outcrops with roughened, slightly weathered surfaces.

In thin section, the alkali-feldspar granites consist mostly of quartz (25 to 40 percent) perthitic K-feldspar (55 to 75 percent), and mafic minerals, mostly amphibole (up to 5 percent). Zircon, titanite, allanite and magnetite are present as accessory phases. The K-feldspar is commonly microcline, but euhedral crystal outlines and simple twinning, combined with the hypersolvus nature of the granite, suggest that it was originally orthoclase. In orange and red varieties, the feldspar is extremely 'dusty', indicating intense hematization, and contains hematite-filled microfractures. The texture of the granite varies from equigranular to seriate or porphyritic, with typical grain sizes in the latter from 1 to 6 mm. Many samples display spectacular, interstitial, graphic, quartz–feldspar intergrowths, suggesting that the magmas were quenched, probably by loss of a volatile phase. Rounded quartz masses show embayed and irregular outlines, suggesting that they are partly resorbed phenocrysts, and some samples retain a quartz-porphyritic texture. Green, buff and pink granites (subunits 3a, 3b) commonly contain a primary mafic assemblage dominated by green-brown amphibole (hornblende) and lesser amounts of pale-green (Fe-rich) clinopyroxene, which forms relict cores in the amphibole crystals. Blue-black amphibole, of sodic composition, is less common, but locally forms rims on hornblende crystals. Orange and red granites (subunit 3c) rarely retain primary pyroxene, and commonly contain blue-brown sodic amphibole, which appears to have replaced the hornblende. In these granites, red-brown biotite is also common, forming fine-grained aggregates after the amphibole; in extreme cases, amphibole is completely replaced by biotite-iron oxide pseudomorphs. The grey-violet granites (subunit 3d) resemble pink granites in that they contain mostly hornblende, but they rarely preserve primary pyroxene.

The field relationships between colour variants in the alkali-feldspar granite unit resemble those observed in the granites of the Topsails Plateau, which suggest an important role for post-magmatic hydrothermal alteration in colour development (Kerr, 1994). The mineralogical variations in Unit 3 are similar, but not identical to, those described from the Topsails granites, where orange and red colours are associated with development of sodic amphibole and oxidation, attributed to the influence of a fluid phase. However, the linear zones of pervasively-coloured granites defined on the Topsails Plateau (Kerr, 1994) are not as easily recognized around Hodges Hill, where the pattern of colour variation is more diffuse. This may, in part, be due to the obscuring effects of poorer exposure and greater forest cover, but it may also reflect more widespread alteration in the upper part of a large pluton. The finer grain size of the Hodges Hill granite compared to those of the Topsails, and the textural evidence for quenching, suggest a higher emplacement level, and post-magmatic fluids may have been ponded toward the roof of the body. However, the overall similarity of the granites, and the presence of characteristic sodic amphiboles, support a general correlation between the Hodges Hill granite

and the Topsails intrusive suite, as suggested by their geochemistry (Kerr *et al.*, 1990; see above).

Fine to Medium-Grained Granite and Feldspar Porphyry (Unit 4)

The region between Unit 3 and the outer contact of the granite is mostly underlain by Unit 4, a two-feldspar (subsolvus) granite that is completely different from the hypersolvus alkali-feldspar granites. Unit 4 is present on the southwest flank of Hodges Hill, along both the Cornfield Pond–Hodges Hill and Aspen Pond–Hodges Hill logging roads, and also near Lew Bushey's Road (Figure 3). It appears to have topographic expression, as it consistently marks the edge of the higher, well-exposed ground at an elevation of about 250 m (Figure 3). The presence of identical granites in these widely separated areas suggests that Unit 4 forms a continous body parallel to the outer contact of the Hodges Hill pluton. However, coarse-grained alkali-feldspar granite is present between Unit 4 and the country rocks in at least two locations (see above), indicating that Unit 4 cannot simply be a marginal phase. Good intrusive contacts between Units 3 and 4 have not been observed, but there is a notable increase in the abundance of fine-grained granite and aplite veins that cut Unit 3 toward its contact with Unit 4, particularly along the Aspen Pond–Hodges Hill road (Figure 3). Also, the coarse-grained, alkali-feldspar granite of Unit 3 has never been observed to cut Unit 4 granite. For these reasons, it is inferred that the subsolvus granites of Unit 4 postdate the coarse-grained hypersolvus granites of Unit 3. The geometry of Unit 4 is uncertain, but it may represent a partial ring-dyke or annular intrusion related to caldera development. This interpretation is consistent with its continuity and field relationships, and with the presence of ring-complex structures in compositionally similar Silurian intrusive complexes such as the Topsails intrusive suite and King's Point complex (Whalen and Currie, 1988; Coyle and Strong, 1987; Miller and Abdel-Rahman, *this volume*). An alternative interpretation is that Unit 4 represents a flat-lying, sill-like body whose outcrop pattern roughly follows the 250 m contour.

Three subunits of Unit 4 are recognized. Subunits 4a and 4b are essentially pink and red colour variants of a medium-grained, generally equigranular, homogeneous granite with scattered, small, white feldspar (plagioclase) phenocrysts. The best exposures of these subunits are at Quarry sites 10 and 11 respectively, but the pink and red variants commonly occur together. At Quarry Site 10, the red variants are clearly related to crosscutting fracture systems, and they are believed to be developed from the pink variant by post-magmatic alteration. Subunit 4c is a distinctive brown to red porphyry, with 20 to 30 percent evenly distributed, equant, white feldspar phenocrysts. It occurs on the west side of Hodges Hill and near Lew Bushey's Road, but the local presence of similar porphyritic textures elsewhere in Unit 4 indicates that it is a textural variant, rather than a discrete unit.

In thin section, subunits 4a and 4b consist of quartz (25 to 35 percent), K-feldspar (30 to 40 percent), plagioclase (albite to oligoclase; 30 to 40 percent), and biotite and chlorite (2 percent in total). Zircon, titanite and magnetite are present as accessory phases. Locally, rounded quartz phenocrysts are present, but most of the quartz forms graphic groundmass intergrowths with K-feldspar. Plagioclase phenocrysts range up to 4 mm in diameter, and are variably saussuritized, with local diffuse rims of K-feldspar. Chlorite is the dominant mafic mineral, and forms euhedral aggregates that include relict brown biotite; where biotite is more abundant, it is replaced by chlorite along cleavage traces. The pink and red variants are petrographically similar, but the K-feldspar is more turbid and 'dusty' in the red variants; also, biotite appears to be more common in the pink variants. Subunit 4c is texturally similar to subunits 4a and 4b, but contains green hornblende, in addition to biotite and chlorite. Also, the feldspar phenocrysts in subunit 4c do not show well-developed albite twinning, but instead retain simple twinning more suggestive of K-feldspar; however, these phenocrysts are optically positive with a high 2V angle, which indicates that they are sodic plagioclase, as in subunits 4a and 4b.

Diabase Dykes (Unit 5)

Crosscutting diabase dykes are rare within the granites of Units 3 and 4, which is fortunate from a dimension-stone perspective, but a few small-scale examples were observed. They are not indicated in Figure 3, and have not been examined in thin section. Hayes (1951) mapped several northeast–southwest-trending diabase dykes within the Hodges Hill granite, mostly outside the present study area.

DIMENSION-STONE POTENTIAL

Prospecting efforts by Mr. Bill Mercer, and mapping during the 1994 field season, have defined 12 potential quarry sites. In addition, there are other areas that may have potential for coarse-grained red granites, but require further investigation. Individual potential quarry sites are briefly summarized below, with reference to site plans for the larger examples. The sites are divided into two groups, corresponding to their host geological units. In the following descriptions, the term 'outcrop panel' refers to areas of massive granite between major high-angle (subvertical) joints; these are commonly 2-dimensional in natural outcrops.

POTENTIAL QUARRY SITES IN COARSE-GRAINED GRANITE (UNIT 3)

Sites 1 to 9 inclusive are all hosted by alkali-feldspar granites of Unit 3, and include the four largest potential quarry sites, having resources greater than 100 000 m^3, and possibly as much as 500 000 m^3 in one case.

Site 1

Site 1 is the best location for the attractive grey-violet granite of subunit 3d. It is located on the south side of Hodges Hill (Figure 3), and is exposed in a steep skidder trail leading up the hillside, about 100 m from a logging road. Massive

outcrop of pinkish-weathering granite is continuously exposed for 40 m, over an elevation change of about 15 m. The site displays a superb glacial polish, which provides a good indication of the quality of the stone. The granite has an attractive seriate to slightly quartz-porphyritic texture on polished surfaces, and is extremely homogeneous; however, there are rare, rounded pods of fine-grained material in one area. The outcrop is massive, with individual joint-free outcrop panels up to 5 x 3 m (Plate 1), separated by subvertical joints trending at 165 to 190°. A second, less prominent, joint set trends at 080 to 090°.

Plate 1. *Massive, polished outcrop surfaces of coarse-grained, grey-violet granite at Site 1.*

Although the exposed area of Site 1 is relatively small, there are indications of significant quantities of material. A natural outcrop bluff located about 40 m north and uphill from the site contains a similar granite, which forms large 'natural' blocks, and identical grey-violet granites occur some 100 m to the east. There is thus potential to expand the site laterally to the east, as well as northward into the hillside.

Site 2

Site 2 is located about 1 km east of Site 1, on the logging road along the south side of Hodges Hill (Figures 2 and 3). It covers an extensive area of about 200 x 150 m, and includes both natural hillside outcrops and exposures created during road construction (Figure 4).

The largest single outcrop at the site is a triangular zone about 25 m on each side, which consists of a pinkish to locally red, coarse-grained, seriate-textured granite that locally resembles material from Site 1 (see above), but has a darker pink colour. However, some of this difference may reflect greater surficial weathering. Also, a reddened zone, associated with more intense fracturing, crosses the outcrop at about 060°. The surface of the main outcrop dips gently (10 to 15°) to the southwest, as do the upper surfaces of smaller outcrops on the west side of the road; this probably represents the orientation of subhorizontal to low-angle jointing. The main roadside outcrop is extremely massive, with individual joint-free panels up to 10 x 3 m, defined by a prominent joint set trending at about 120°; subordinate high-angle jointing is at 330 to 340°, giving rhomb-shaped outcrop panels. The spacing of low-angle joints is more difficult to assess, but is estimated to be >1 m at the surface. Similarly massive granite is exposed intermittently in a skidder trail, which leads uphill for about 100 m, leading to a natural outcrop bluff, 15 to 20 m above the road, which trends southwest, and continues for at least 150 m. This natural outcrop has been disturbed extensively by frost-heaving and tree roots, but it contains blocks that are at least 2 x 1 x 1 m, and possibly larger, if downslope erratics came from this location. Low-angle jointing is spaced at around 1 m in the upper part of the outcrop, and it appears to increase with depth. The western limit of Site 2 is established by some small roadside outcrops 50 to 100 m west of the main outcrop, but these are more fractured.

The most massive portion of Site 2, including the natural outcrops, covers an area of 150 x 50 m, with an elevation difference of 15 to 20 m, suggesting potential resources (total volume) of up to 50 000 m^3. The site is open to the east. The granite here is texturally similar to Site 1, but seems to show more colour variation, in particular a reddening associated with the cross-cutting fracture zone (Figure 4). Site 2 thus requires systematic sampling of fresh material to assess potential colour-variation problems.

Site 3

Site 3 is arguably the most impressive of the easily accessible coarse-grained granite quarry sites in the Hodges Hill area. It is located south of the main Cornfield Pond–Hodges Hill logging road, opposite Hodges Hill, and comprises an entire hill, with a summit elevation of about 350 m (1125'). The site is accessible at its southwest extremity, which is about 250 m along a skidder trail from a branch road (Figure 3), and covers an area of about 150 x 100 m (Figure 5).

The most impressive feature of Site 3 is a spectacular cliff line on its southeast side, which is about 130 m long and about 25 m high (Plate 2). This natural outcrop shows strong subhorizontal jointing, with a progressive increase in joint spacing with depth, from 1 to 2 m at the top of the face to 4 m or more at the base (Plates 2 and 3). Examination of the base of the cliff face shows that the material is extremely homogeneous buff to orange coarse-grained granite. It appears

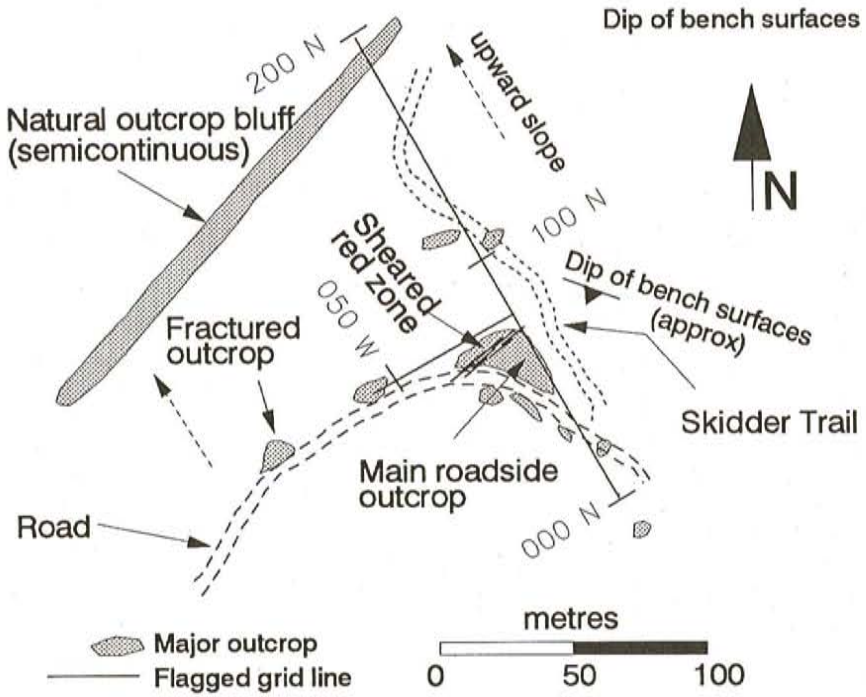


Figure 4. *Detailed sketch map of Site 2. See text for details.*

to be xenolith-free, but does contain a flat-lying aplitic vein at one spot. The granite at the top of the cliff is texturally similar, and extremely fresh, and has a buff to slightly yellow-green colour that is reminiscent of some of the Topsails granites. However, there is little sign of extensive surficial weathering. The hilltop is relatively flat, and mostly covered by caribou moss and thin forest cover, but massive outcrop benches are locally exposed. At the northern end of the hill, there are extensive natural outcrops, where individual outcrop panels exceed 3 x 3 m, and subhorizontal joints are spaced at 1 m or more. The material is identical buff to greenish alkali-feldspar granite, and is extremely homogeneous.

Site 3 is in many respects a 'natural' quarry site, where several step-like benches of material could be worked at the same time. The hilltop, and its bounding cliff lines, are defined by a northeast–southwest-trending joint set, and orthogonal cross joints are less obvious; thus, individual benches could be worked parallel to the cliff line. The potential quantity of high-quality stone in this site is enormous; a rough calculation based on the entire hill suggests resources of at least 250 000 m³ (total volume). Sampling on the hilltop provided fresh material of consistent buff to greenish colour, although some reddening was observed adjacent to the southeastern cliff face, which may be fault-controlled; however, there is no evidence of fracturing or shearing along the cliff (Plate 3), and it may be a largely glacial feature.

Sites 4 and 5

Sites 4 and 5 are about 500 m apart, on the Aspen Pond–Hodges Hill logging road, and are best discussed jointly as they show common features. Both represent a combination of natural outcrops and exposures created by road construction and logging.

Site 4 is located on the main road, about 1.5 km south of the junction with the Cornfield Pond–Hodges Hill road. The main part is a rounded outcrop of white-weathering granite some 30 x 20 m, exposed on both sides of the road (Figure 6a). The outcrop has a well-developed orthogonal high-angle joint pattern, trending at 070 to 090° and 160 to 180°; individual outcrop panels range in size from 0.5 x 0.5 m to 3 x 3 m (Plate 4), and become larger to the north. The outcrop contains narrow quartz veins associated with the 080° direction, which are clearly associated with hematization and reddening around their margins; however, these only affect one part of the outcrop. Small outcrops of similar granite persist for about 50 m to the north. Most of the material in the outcrop is pink to orange in colour, but there are suggestions of colour variations, with some parts showing redder hues. A small, glacially polished outcrop about 20 m south of the main outcrop has a more intense red colour.

Site 5 is located on a nearby branch road, and the main part consists of low, roadside outcrops of pink granite covering an area of about 50 x 25 m (Figure 6b). The high-angle jointing pattern is more complex than at Site 4, but the same prominent 080° and 170° directions are present; individual, joint-free outcrop panels range up to 4 x 2 m, and 'natural' blocks produced by glacial action approach 2 x 2 x 1 m in size. As at Site 4, there appear to be variations in colour at this site, as outcrops some 50 m southwest (Figure 6b) display an intense red colour. It is difficult to assess the character of the red material, as the outcrops are small, but some polished, joint-free surfaces are about 2 m wide. However, red granites slightly farther to the southwest are intensely

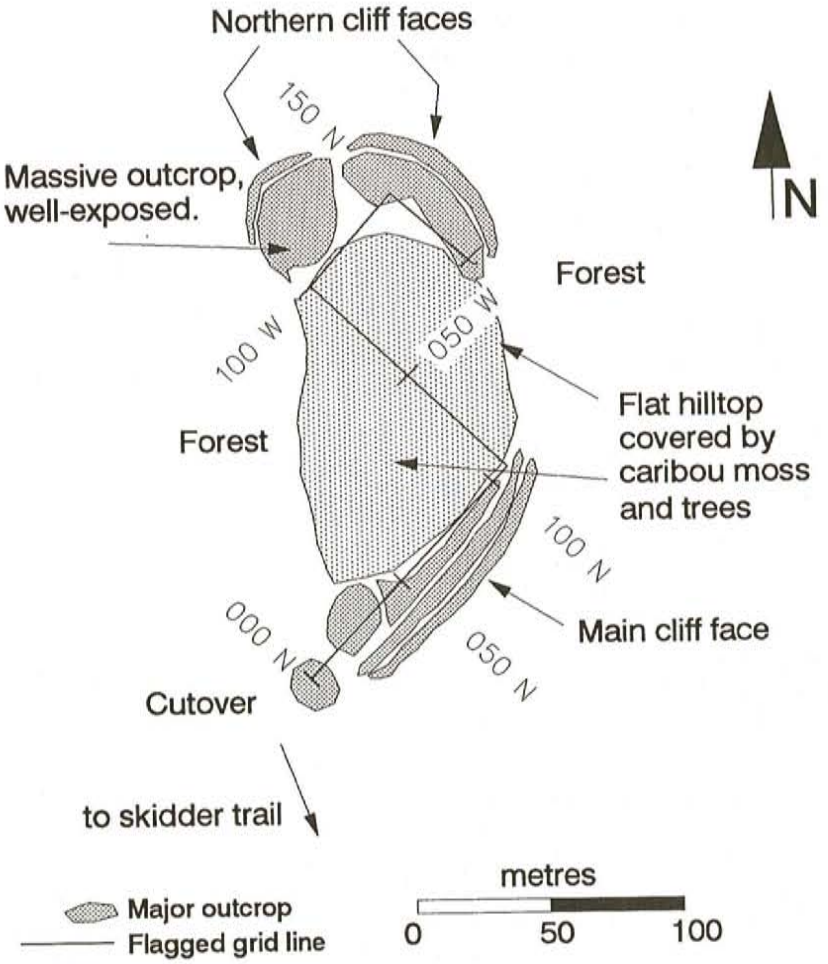


Figure 5. *Detailed sketch map of Site 3. See text for discussion.*

Plate 2. *The impressive cliff exposure at Site 3. Note the increasing spacing of subhorizontal jointing with depth. Cliff face is estimated to be about 25 m high.*

fractured. In the other direction, similarly massive pink granites, also becoming red to the south, outcrop on the road some 250 m to the east. Here, red granites are locally quite massive and unfractured.

Sites 4 and 5 are viewed here as part of a single east–west-trending zone, where the granite is pink and massive in the north, but becomes red (and more fractured) to the south. This interpretation is supported by scattered small outcrops of pink and red variants between the two sites. The sites may have potential for coarse-grained red granite, but this is likely to be restricted to a linear zone between the pink and orange material, and the more intensely fractured red material to the south. More work, including removal of thin overburden, is required to assess the extent and fracture characteristics of the red material.

Site 6

Site 6 is the largest single potential quarry site in the area, and was discovered during the 1994 season by a combination of airphoto interpretation and field checking. It is located adjacent to, and topographically below, a logging road connected to the main Aspen Pond–Hodges Hill road, and covers an entire, gently sloping hillside measuring about 400 x 200 m (Figures 3 and 7). The site was initially recognized on aerial photographs, where individual outcrop benches are clearly visible (Plate 5), and confirmed by ground checking.

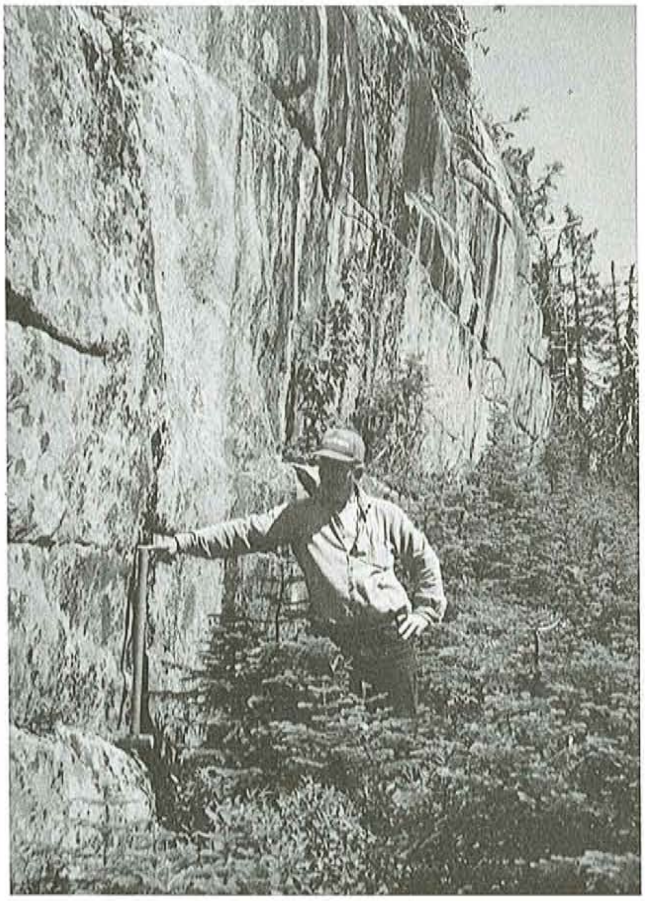


Plate 3. *Massive granite 'benches', over 3 m thick, at the base of the cliff exposure at Site 3.*

Plate 4. *Main roadside outcrop of pink granite at Site 4. Note well-developed orthogonal joint pattern.*

Site 6 is divided into two parts by a north–south trending fractured zone interpreted as a fault (Figure 7). The eastern half of the site is the most impressive. Here, a series of linear outcrop benches run at right angles to the hillside, trending at around 130°. The upper surfaces of the benches are subhorizontal to gently southwest-dipping, and the spacing of low-angle joints at surface is at least 1 m, based on projecting outcrop surfaces, and locally achieves 1.5 m at deeper levels (Plate 6). Close to the vertical bench faces, high-angle jointing is spaced at 1 m or less, presumably reflecting glacial plucking, but the outcrop panels are very large away from the edge, up to 5 x 5 m (Plate 7). Sampling suggests that the material is a very homogeneous, creamy-buff to locally orange, coarse-grained granite throughout the site. A

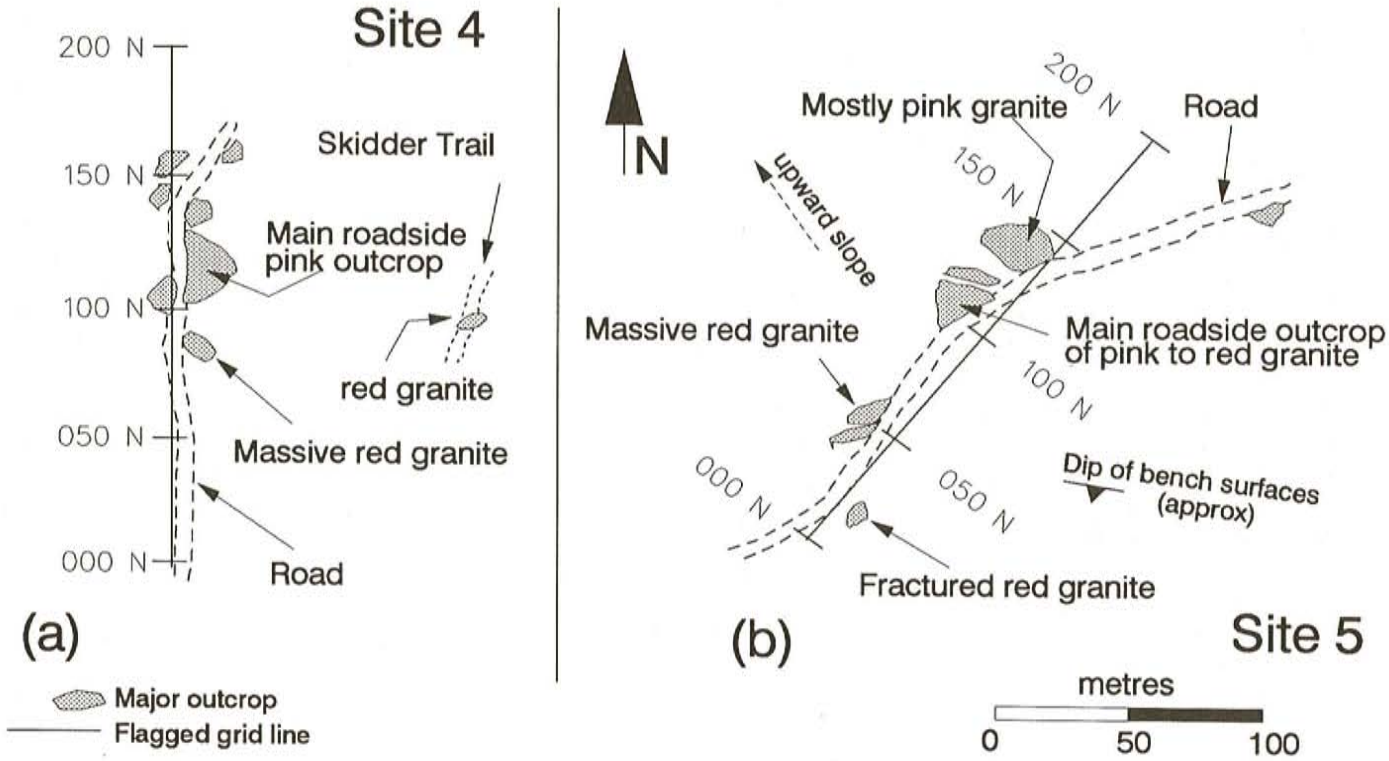


Figure 6. *(a) Detailed sketch map of Site 4. (b) Detailed sketch map of Site 5. See text for details.*

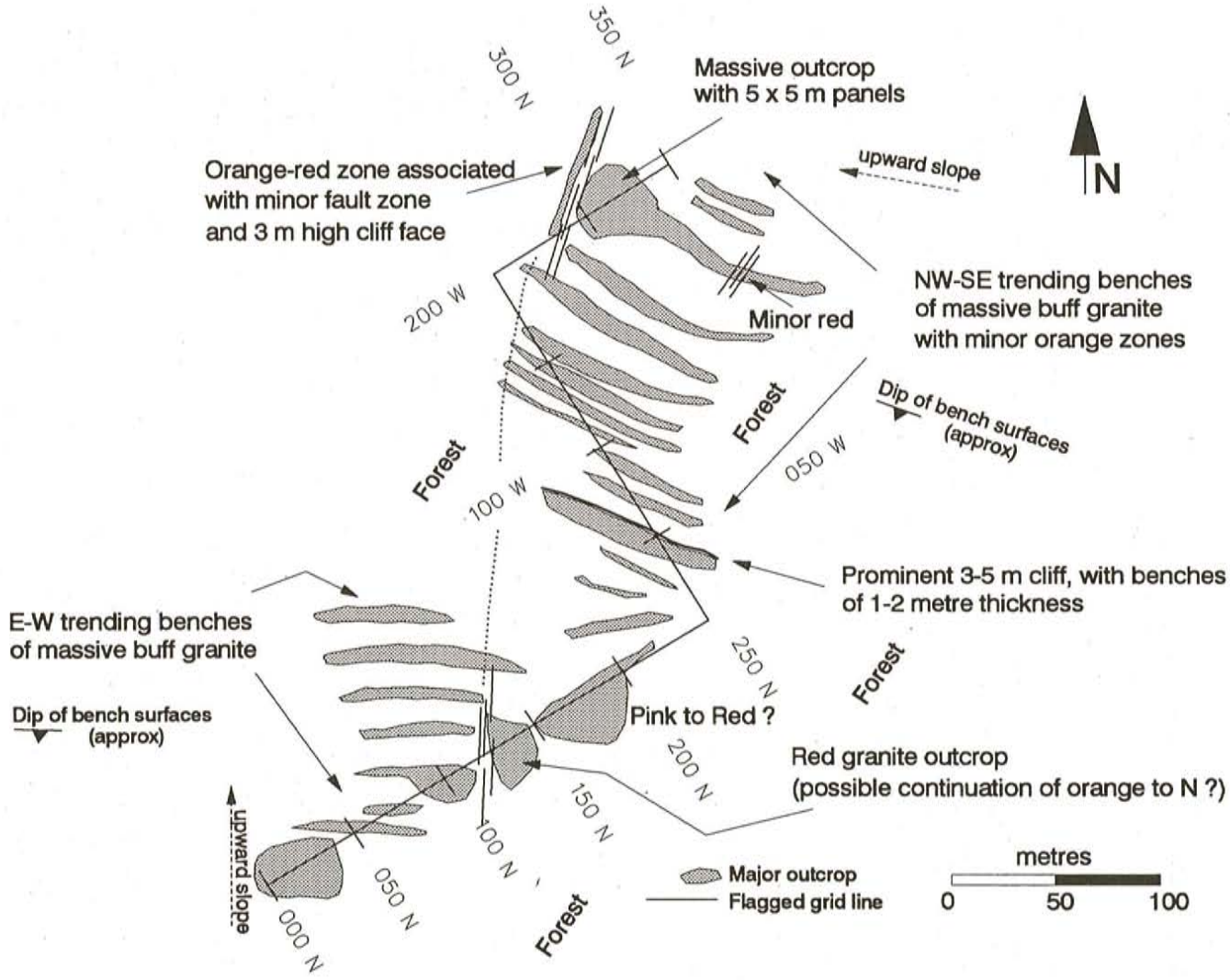


Figure 7. *Detailed sketch map of Site 6. See text for details.*

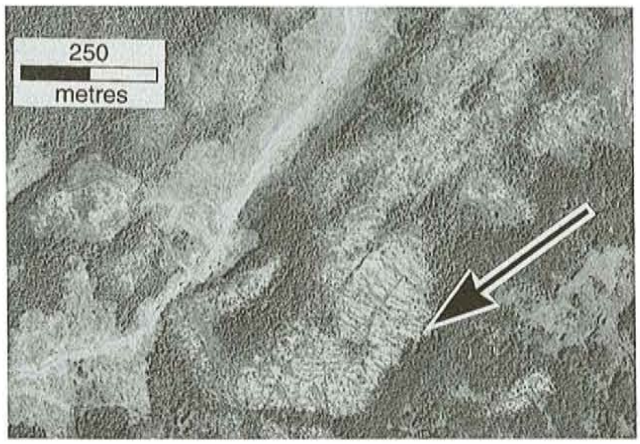


Plate 5. *Aerial photograph of Site 6 (line 83016 / frame 163; 1:12 500 approximate). Note the large area of the site, clearly visible outcrop benches, and proximity of road.*

few narrow, more intensely fractured zones trend at 020 to 040°, at right angles to benching, and host more intensely coloured orange and red granites. The western part of the outcrop contains similarly massive granites, and a well-developed transverse bench pattern, but the hillside here is steeper than in the east, and it also contains a larger, more massive area of orange-red granite, on the baseline at 150 north (Figure 7).

Site 6 is a superb 'natural' quarry site. In the eastern part of the outcrop, the site could be accessed from the bottom of the valley, by extending the logging road and looping back, and several individual granite benches could be worked uphill at the same time. The western part of the site would require more excavation and a higher active face. The potential quantity of high-quality material in Site 6 is enormous. Assuming a surface area of 80 000 m², and and an average excavation depth of 7 m, the site contains in excess of 500 000 m³ of granite (total volume). As parts of the site could be excavated to greater depths, the actual resources are probably much greater than this.

Plate 6. *Granite bench at Site 6. Note increasing spacing of subhorizontal joints with depth.*

Plate 7. *Massive joint-free outcrops of buff granite at Site 6.*

Site 7

Site 7 has not yet been visited in the field and is presently defined on the basis of airphoto interpretation and examination from a distance. It consists of an elongated hilltop, having a maximum elevation of 360 m (1200'), located about 1.3 km east of the Aspen Pond–Hodges Hill road (Figures 2 and 3). It is best viewed from the area around Sites 8 and 9, near Lew Bushey's Road (Figure 2). Airphoto interpretation suggests massive outcrops, and observation from Site 8 suggests subhorizontal benches that are up to 4 m thick. The characteristics of the material are not known, but, on the basis of the massive outcrops, it is suspected to be a buff, coarse-grained granite. At present, the distance from road access precludes serious consideration, but Site 7 represents an important future resource, and should be investigated further.

Site 8

Site 8 is located about 250 m beyond the present termination of Lew Bushey's Road, southeast of and opposite Site 7. It was discovered during 1994 field work by a combination of airphoto interpretation and field checking. The area adjacent to the site is currently being logged, and the site should be closer to road access in years to come.

Site 8 is a natural, elongated hilltop, measuring some 200 x 80 m, with a natural cliff line along its northwestern side (Figure 8). The hilltop is dominated by transverse linear outcrop benches, trending at 090°, with a prominent jointing direction at 035° defining the northwestern escarpment. The two joint directions produce rhomb-shaped outcrop panels, which range up to 3 x 2 m. Subhorizontal joint spacings are harder to assess, and much of the material exposed at surface seems to be fairly thinly-jointed; however, on the cliff face, benches with thicknesses of 1 m or more can be seen. In general, the granite at Site 8 is less impressively massive than at Sites 3 and 6 (see above). The granite is very homogeneous, and has a subtle pale-green colour, with hints of lilac and pink; it is finer grained than sites 3 and 8, and has an attractive quartz-porphyritic texture (Plate 8). It is reminiscent of some of the Topsails granites, but texturally distinct. Although Site 8 is not as spectacular as Sites 3 and 6, the unusual character and stone colour suggests that it is of interest, and worthy of further investigation. Assuming a surface area of 200 x 80 m, and an excavation depth of around 10 m, the site contains resources of at least 160 000 m^3 (total volume).

Site 9

Site 9 is located about 1 km southeast of Site 8, adjacent to Lew Bushey's Road (Figures 2 and 3). The site is partially located on disused logging roads, but these do not connect directly with Lew Bushey's Road in the area of the site. These roads lead southward from the site, and are presumed to connect to Lew Bushey's Road at some point, but they have not yet been traced completely. Site 9 consists of natural and artificial outcrops scattered over an area about 250 x 150 m (Figure 9), and represents one of the few locations in the Hodges Hill area where coarse-grained red granites may be of commercial interest.

Outcrops are scattered over a wide area; low-lying outcrops exposed in the road at the south end of the site contain outcrop panels up to 2 x 2 m in size, which is unusual for red granites. Three prominent linear benches of red to red-brown granite trending at 020° form the main part of the site (Figure 9), and exhibit a variety of fracture characteristics. In places, they are extremely massive, with subhorizontal joints spaced at 2 to 3 m or more (Plate 9); elsewhere, particularly toward the southern part of the site, they are more intensely fractured, and clearly unsuitable for dimension stone. A small outcrop of diabase or fine-grained diorite also occurs in this area. Limited sampling at Site 9 suggests that the colour varies from orange to red-browm but, as always, it is not completely clear how much of the colour variation reflects differential surficial weathering, and how much is 'primary'. Systematic sampling of fresh material is required to assess the material more thoroughly for consistency and quality. Although Site 9 is not uniformly massive, and would have a high proportion of waste, it contains the most massive benches of intensely coloured, coarse-grained, red granite yet noted in the area, and is worthy of further assessment

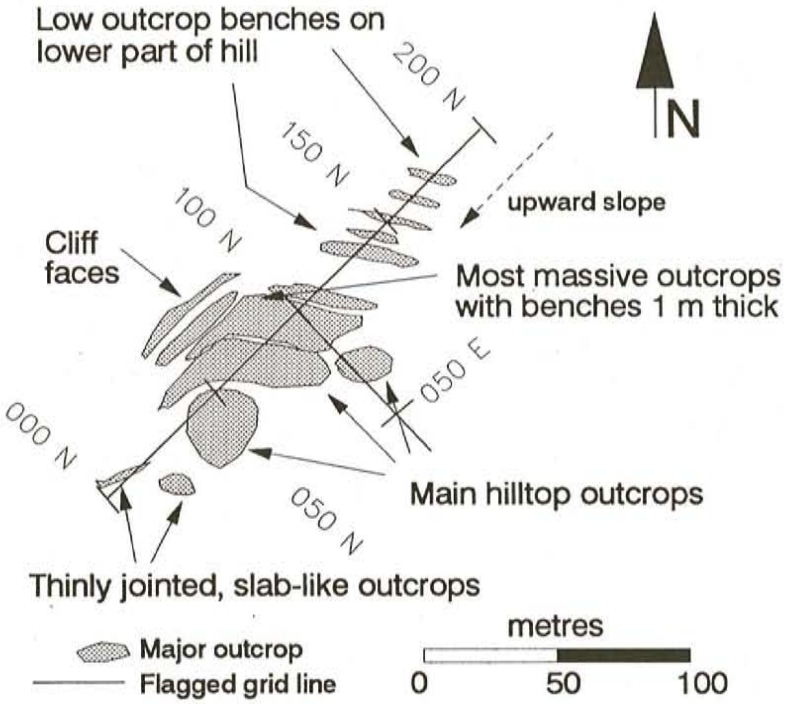


Figure 8. *Detailed sketch map of Site 8. See text for discussion.*

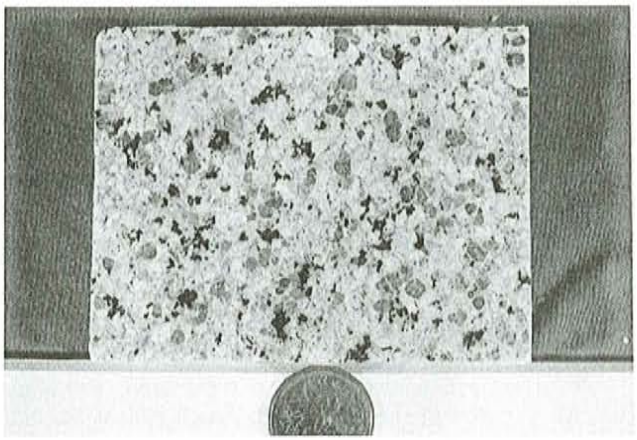


Plate 8. *Quartz-porphyritic variant of coarse-grained alkali-feldspar granite at Site 8.*

on this basis alone. Also, the road network leading southward from the site has yet to be explored, although regional considerations (Figure 3) suggest that the fine- to medium-grained granites of Unit 4 lie in this general area.

POTENTIAL QUARRY SITES IN FINE- TO MEDIUM-GRAINED GRANITE (UNIT 4)

Two major sites occur in the fine- to medium-grained two-feldspar granite of Unit 4, and there may also be potential for the distinctive porphyry of subunit 4c (Figures 2 and 3). Sites 10 and 11 are of particular interest, as they contain material that may be desirable for monument stone, and are also located closest to the main Aspen Brook road (Figure 2).

Site 10

Site 10 is located adjacent to the main Aspen Pond–Hodges Hill logging road, where it climbs the escarpment at about 250 m elevation (Figures 2 and 3). The site consists of an extensive series of outcrops on the west side of the road, and in a skidder trail that cuts off a sharp bend in the road (Figure 10). The southern part of the site is dominated by the pink variant (subunit 4a), and the northern part contains both pink and red (subunit 4b) material.

The main part of the site is a continuous outcrop measuring some 100 x 50 m, which continues southward as a series of discontinuous outcrops for a farther 50 m (Figure 10). This area is dominated by extremely massive fine- to medium-grained pink granite, with a speckly texture imparted by small, white plagioclase phenocrysts. The predominant joint direction is at about 110°, and individual, joint-free, outcrop panels range up to 5 x 3 m (Plate 10). Most of the outcrops to the south (downhill) are identical pink granite. The pink section of the outcrop is terminated by a zone of fractures trending at 110°, which are associated with reddening (hematization). North of this zone, outcrop continues for about 75 m, but the colour is more varied, including brighter red zones, and intermediate pink shades; other fractured zones, some with thin quartz veinlets, crosscut the outcrop. In general, this part of the outcrop is less massive, but there are outcrop panels up to 2 x 1 m. To the south, massive pink granite occurs adjacent to a branch road, and the elevation difference between this area and the main part of the site is at least 10 m. Thus, by initiating a quarry face at the southern end of the site, there is potential to extract pink granite, eventually extending the site across the road, parallel to the 100° fracture direction. There are massive outcrops of both

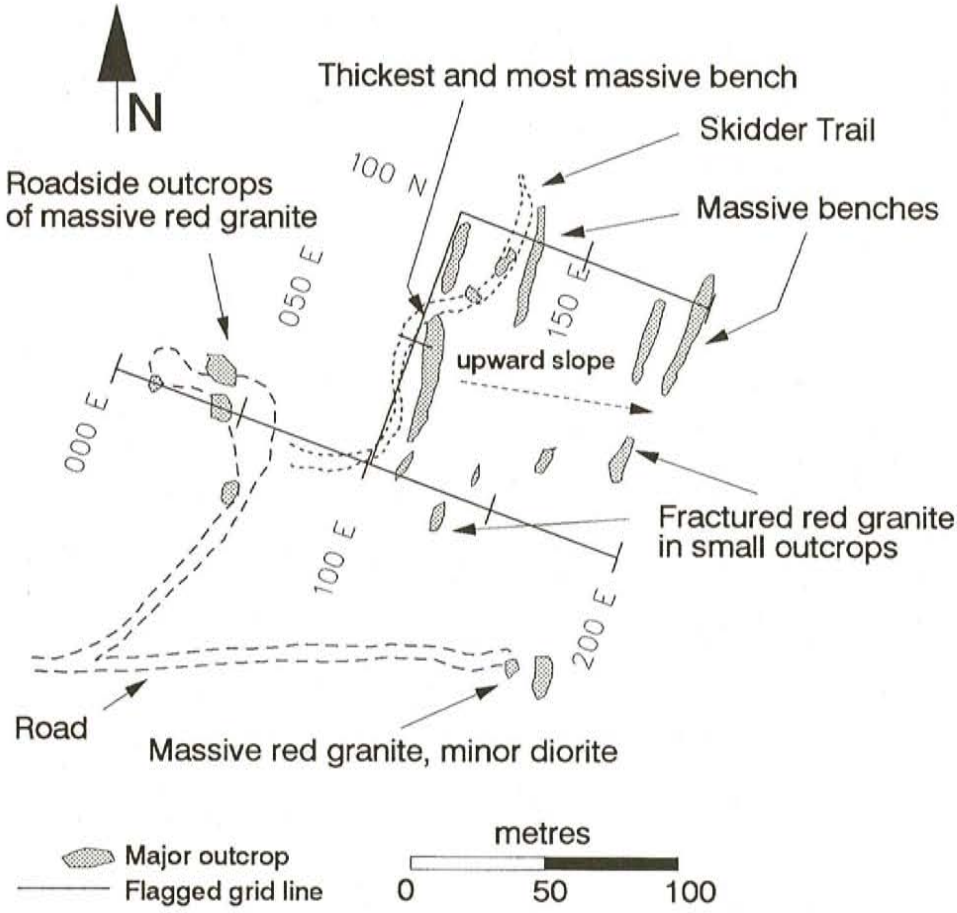


Figure 9. *Detailed sketch map of Site 9. See text for discussion.*

pink and red variants in the woods in this general direction. Although fine-grained red granites are present at Site 10, there is more potential for this material at Site 11 (see below).

Site 11

Site 11 is located on the main Cornfield Pond–Hodges Hill logging road, less than 1 km from Cornfield Pond (Figures 2 and 3). Like Site 10, it is situated close to an escarpment at about 250 m elevation. It consists mostly of fine- to medium-grained, bright red granite.

The site consists of extensive outcrop located on both sides of the road over a distance of about 175 m (Figure 11). A diorite outcrop some 100 m to the southwest delimits the maximum extent of the site (Figure 3). The site is divided into two halves by an arcuate zone of shearing, reddening and quartz veining that crosses the road, swinging in orientation from about 090 to 070°; the most massive and promising part of the site lies to the north of this zone. In this area, high-angle joints are spaced at 2 m or more, and the material seems extremely homogeneous (Plate 11). However, a dioritic xenolith some 25 cm in diameter is present in one area, and there are some hairline fractures of unknown depth extent. The granite is bright red, but is creamy to pink on weathered surfaces. The central part of the site is intensely fractured and riddled with quartz veins, but the material again becomes more massive to the south, with a similar red colour. The axial zone of fracturing and shearing (Plate 12) is interpreted as a hydrothermal conduit, possibly reactivated at a later date as a brittle fault. In view of the postulated links between intense red colour and post-magmatic alteration, it is probable that the red colour diminishes away from this axial zone.

The red granites of Site 11 are unusual, and are in demand as monument stone; some interest has already been shown in this material by a Quebec-based company. However, Site 11 is not as well-suited to quarrying as Site 10, as it is located in a relatively flat area. Thus, development of a face in red granite would entail downward excavation, unless a start was made downslope, near the diorite outcrop; this would require removal of the axial sheared zone before the most massive portion of the outcrop could be accessed. However, given the interest shown in the red granite, further assessment, and possibly exploration for other sites elsewhere in Unit 4, is clearly warranted. Examination of an area to the northwest of Site 11 late in 1994 (J. Meyer, personal communication, 1994) indicates that fine-grained red granites are widespread in the adjacent area.

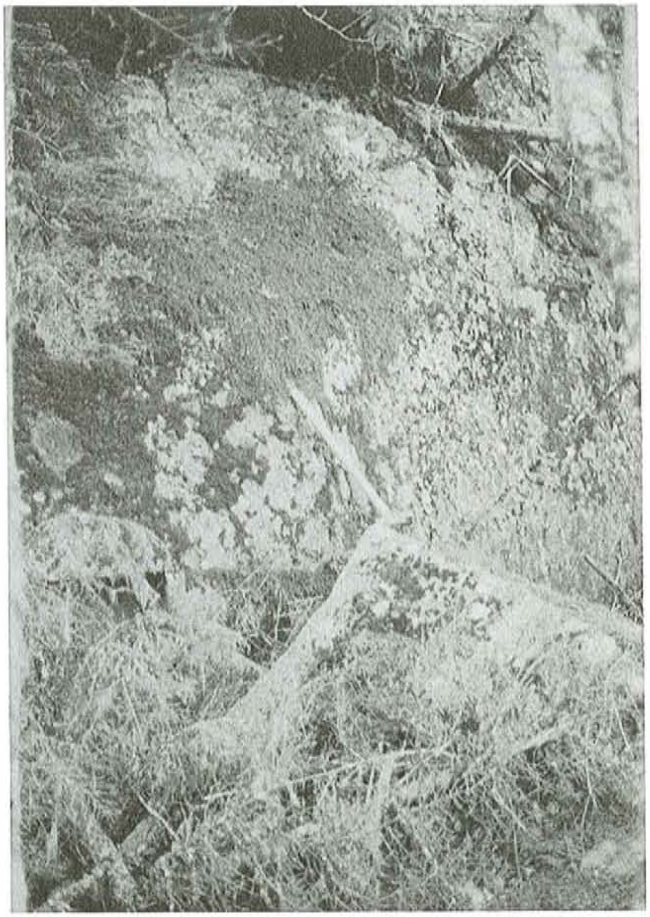


Plate 9. *Massive bench of coarse-grained red granite at Site 9. Material of such massive character is unusual amongst coarse-grained orange and red granites.*

Site 12

Site 12 is located on a branch road, north of Site 11 (Figures 2 and 3). This is the only area where the distinctive and attractive plagioclase-porphyry (subunit 4b) is present over a significant area; there are several outcrops over an area of 400 x 100 m. There is as yet no clearly defined commercial site in this area, and the roadside outcrop of the porphyry is quite small, and in part badly fractured. However, angular blocks topographically below the outcrop are up to 1 m^3 in size, suggesting that there may be a potential site somewhere in the area; given the rarity of subunit 4c, their source must be local. A natural outcrop of porphyry, including some pieces up to 3 x 1 x 1 m, discovered by Bill Mercer about 250 m northeast of the road outcrop, has not yet been fully evaluated. More work is needed in this area, if there is sufficient interest in the feldspar porphyry.

OTHER AREAS WITH POTENTIAL FOR COARSE-GRAINED RED GRANITE

Coarse-grained red granites, of the type commonly labelled 'Indian Red', are a valuable commodity in the dimension-stone industry, and command high prices where available in large blocks. The Hodges Hill area contains many intensely coloured red granites, and small blocks and erratics of 'Indian Red' are a common sight along roads and trails. It is, of course, far more difficult to define areas where red granites are present in commercial quantities and (most importantly) capable of yielding large blocks. At the present time, Sites 4 and 5, and Site 9 are considered to represent the best prospects. However, three other areas that were briefly noted during field work may be worthy of further exploration.

Red granites are abundant in the Red Cliff–Leech Pond area, and are well exposed and fairly massive at the Newfoundland Telephone transmission tower site west of Grand Falls-Windsor (Figure 2). However, it is doubtful that the owners of the site (Newfoundland Telephone) would take kindly to test block extraction (let alone quarrying) so close to their equipment! However, a small outcrop on the other side of the hill, close to an old logging road, consists of white-weathering red granite, and contains large, slab-like joint blocks (Plate 13). Although unsuitable for equant blocks, this outcrop might be amenable to producing large slabs, such as those needed for monuments. Further work is needed to assess the quantity and quality of material. Elsewhere in the Red Cliff–Leech Pond area, the red granites are invariably badly fractured and largely useless, except perhaps at the end of the logging road north of Leech Lake. However, the Leech Lake area is a popular cabin and recreation area, which limits potential development.

In the main part of the area (Figure 3), two areas are also worthy of note. South of the main Cornfield Pond–Hodges Hill road, some outcrops and massive blocks of white-weathering, red granite were adjacent to a small logging road (labelled area A in Figure 3). One of these was a natural bench some 25 m long, with outcrop panels up to 3 x 2 m and a thickness of 1 m. The hill to the east of this area also includes some red granites, which are sporadically massive, but has been incompletely explored. To the northeast (labelled Area B in Figure 3), similar granites outcrop on the main road, and on a side road, and may also merit further exploration if sites 4, 5 and 9 prove not to be viable.

SUMMARY AND RECOMMENDATIONS

Field work during the 1994 season has confirmed and increased the dimension-stone potential of the Hodges Hill area, provided a geological framework for these occurrences, and given basic site maps and technical information for potential quarry sites. In the coarse-grained alkali-feldspar granites of Unit 3, the results of field and petrographic studies confirm conclusions based on the Topsails granites, i.e., that the development of orange and red granites reflects post-magmatic hydrothermal processes, which led to both mineralogical and chemical changes (Kerr, 1994). On this basis, the red and orange varieties will be more difficult to assess and develop than the less altered buff and greenish granites, as they are more subject to colour variation, and tend to have less consistent, but more intense, fracture patterns. Colour variation is a particularly acute problem,

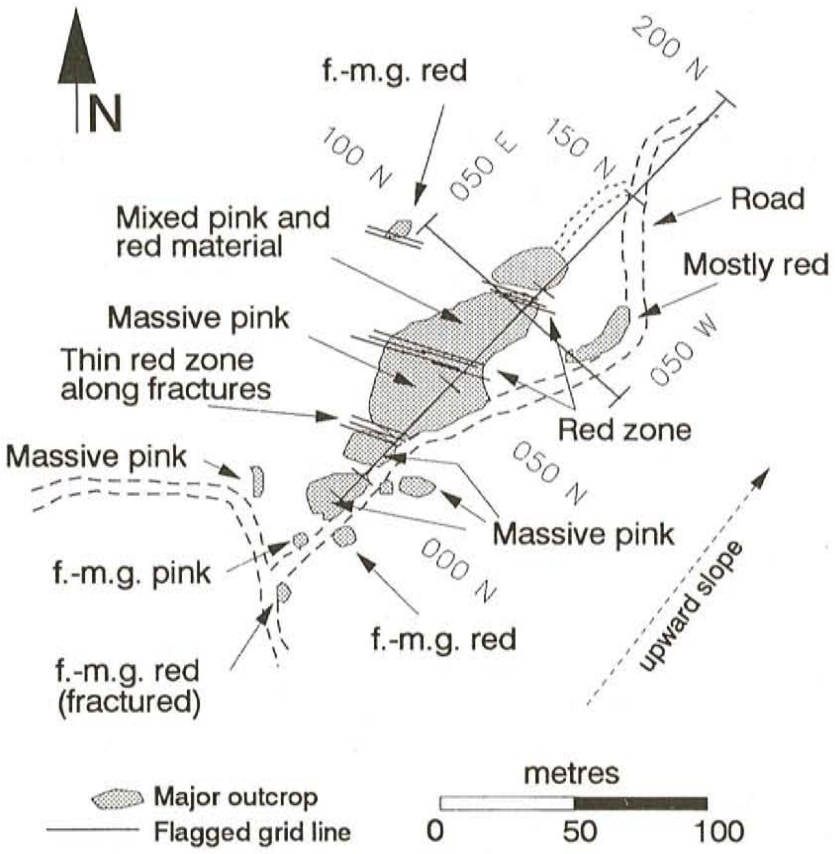


Figure 10. *Detailed sketch map of Site 10. See text for discussion.*

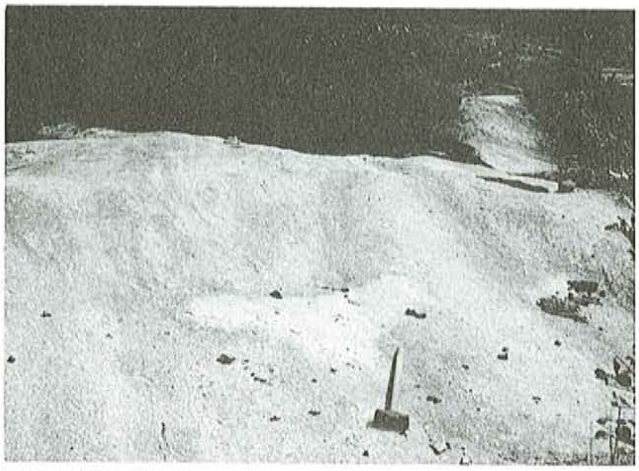


Plate 10. *Massive, weakly jointed outcrops of fine- to medium-grained porphyritic pink granite at Site 10.*

as it is difficult to obtain fresh material with a mere sledgehammer, and therefore difficult to decide how much apparent colour variation is of surficial versus primary origin. The next stage in assessment of Sites 1 to 12 should be the extraction of large test blocks so that the quality and consistency of fresh material can be assessed. In the case of sites containing orange and red granites, detailed systematic sampling to assess colour variation is also required; a short coring device, similar to that used for paleomagnetic sampling, should do this effectively.

Of the coarse-grained granite sites, Sites 1, 3, 5 and 9 are suggested as priorities for further work. The grey-violet granite of Site 1 is unusual and very homogeneous, but large slabs are needed to assess commercial interest. The greenish to buff granites of Site 3 are less unique, but the site clearly has potential for large-volume production. Sites 5 and 9 have the potential for coarse-grained red granites, but this has not yet been proven. The potentially enormous Site 6 is also of considerable interest, but initial access and development costs here are likely to be greater. Of the fine- to medium-grained sites, the red material of Site 11 is probably of most interest, although the porphyritic texture of the pink granite at Site 10 also distinguishes it from more widely available pink granites. However, test blocks should probably be extracted from both sites, as they represent complementary materials. As noted above, Site 11 may not be the most ideal location for quarrying, and other parts of Unit 4 may require further exploration for fine-grained red granites. Airphoto interpretation indicates that there is fairly extensive moss-covered outcrop in an area west of the Aspen Pond–Hodges Hill road, north of Site 10 (labelled Area C on Figure 3). This should be underlain by Unit 4 granites, and, at its southern end, includes some red granites akin to those of Site 11; most of this area is less than 500 m from the road. Other

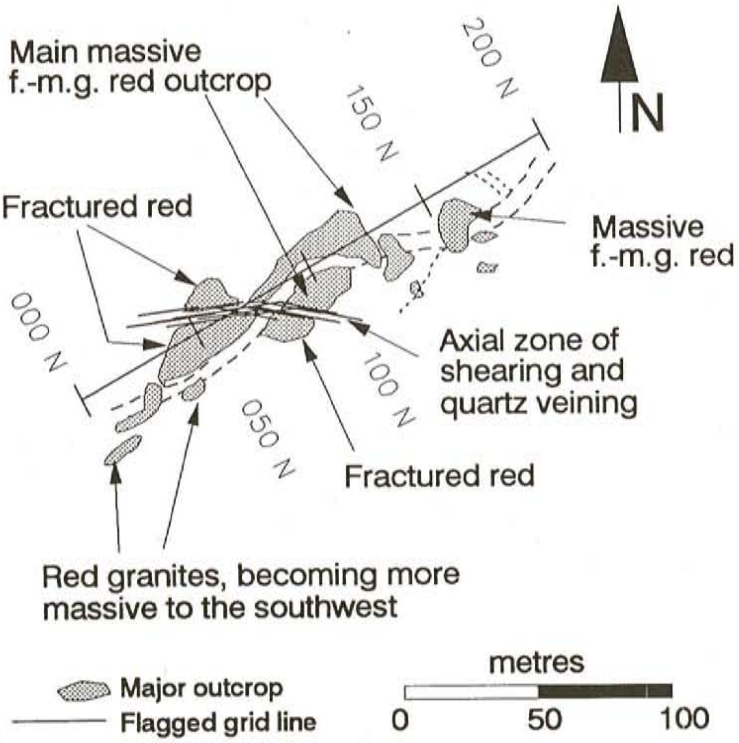


Figure 11. *Detailed sketch map of Site 11. See text for discussion.*

Plate 11. *Massive outcrops of fine- to medium-grained bright red granite, exposed in logging road at Site 11.*

areas along the projected course of Unit 4 between Sites 10 and 11 may also have potential for future exploration.

FURTHER DEVELOPMENTS

Subsequent to the completion of this report in October 1994, Classic Stone Incorporated, and Mr. Bill Mercer finalized an agreement to proceed with test-block extraction and initial site development at several sites located south and east of Hodges Hill. Work commenced in November, 1994, and continued until the onset of winter. The main focus of this work was at Site 3, where excavation has confirmed the massive and homogeneous greenish to bluff coarse-grained granite over significant areas. Miarolitic cavities are present, but these are common features in granites of this type. Interestingly, during preparation of an access route from the main Cornfield Pond–Hodges Hill road, massive red granites were also exposed to the northwest of Site 3. Test blocks will be removed during the winter months. Excavation work in an area between Sites 4 and 5 has confirmed that red granites are extensive, but colour and fracture density variations in this area may present some problems; these were hard to quantify during field work, due to poor exposure. However, as noted in this report, there are other areas worthy of investigation for red granites, notably Site 9. The move toward further assessment and development work provides a good indication of the area's potential, and also the value of geoscientific surveys to locate and assess dimension-stone prospects.

ACKNOWLEDGMENTS

Field work in 1994 was rendered more enjoyable by enthusiastic prospecting efforts and assistance from Bill Mercer, who initially recognized many of the high-potential areas. The staff at Beothuck Provincial Park near Grand Falls-Windsor are thanked for their hospitality and assistance, and for many delectable hot showers. Jamie Meyer is thanked for his encouragement, and for suggesting improvements to manuscript and figures.

Plate 12. *Sheared and veined red granite at Site 11. This forms an axial zone cutting the site, and is interpreted to be the source of the fluids responsible for development of the strong red colour.*

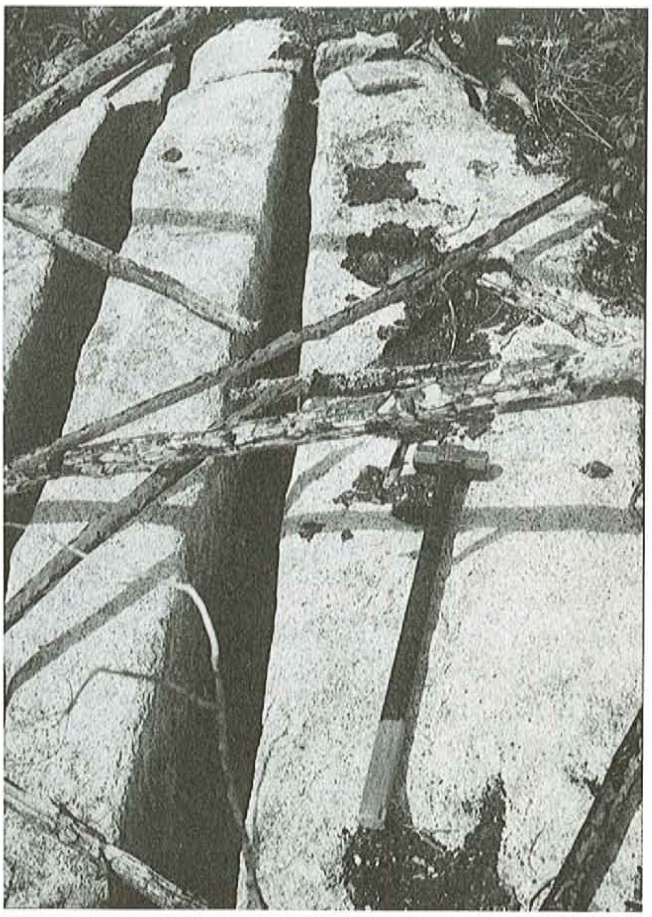


Plate 13. *Slab-like outcrop blocks of coarse-grained red granite at a small outcrop northeast of the Red Cliff transmission tower. Although unsuitable for large tile blocks, these may be of interest for monument slabs.*

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