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DIMENSION-STONE POTENTIAL IN THE NAIN ANORTHOSITE

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ABSTRACT

The Department of Mines and Energy is presently investigating the dimension-stone potential of the Nain anorthosite complex. These rocks are known to host occurrences of labradorite, a semiprecious gemstone known for its beautiful play of colors (chatoyance). Test blocks that contain 5 to 18 percent chatoyant labradorite were extracted from three prospects south of Nain. These have been slabbed and polished for further evaluation.

Second-grade labradorite stockpiled around the Grenfell quarry on Tabor Island is also being evaluated as a potential source of aggregate for use in terrazzo tiles, precast concrete and epoxy-backed wall panels.

INTRODUCTION

The Nain anorthosite complex consists of approximately 10,000 km^2 of anorthosite and related basic rocks, which are well exposed along the coast of Northern Labrador (Figure 1) (Emslie *et al.*, 1972). These rocks have been known for centuries to host deposits of gem-quality labradorite. The chatoyant nature (i.e., the play of colors or labradorescence) of this semiprecious feldspar has been utilized mostly in the making of jewelry and other polished, handcrafted products. In the early sixties, Brinex Limited (now Brinco Limited) attempted larger scale commercial exploitation of labradorite, including use 'as building stone and in polished precast concrete for facings on buildings' (Brummer, 1984). After six years of work, which included market studies, Brinex decided that the demand at that time did not warrant further production.

In recent years, there has been a dramatic increase in the markets for dimension stone. In the period from 1980 to 1985, the demand in the United States for granite, much of which is imported, has increased 1735 percent (Marble Institute of America, 1986). The dimension-stone industries' remarkable growth rate has, in part, resulted from new technology that makes it easier and faster to quarry and cut stone. This has allowed natural stone to compete with other building materials. It is now used not only for exterior cladding and walkways, but also on interior walls and floors, and in home and office furnishings, such as countertops for kitchens and bathrooms, table and desk tops, stairways, window sills, and fireplaces.

In 1985, three dimension-stone prospects south of Nain were briefly visited (Figure 2), and were considered to have sufficient potential to warrant more detailed evaluation (Meyer and Dean, 1986). Unlike the gemstone localities that consist of extremely coarse grained pegmatitic pods of labradorite, these three prospects consist of massive, more homogeneous, medium to coarsely crystalline anorthosite containing 5 to

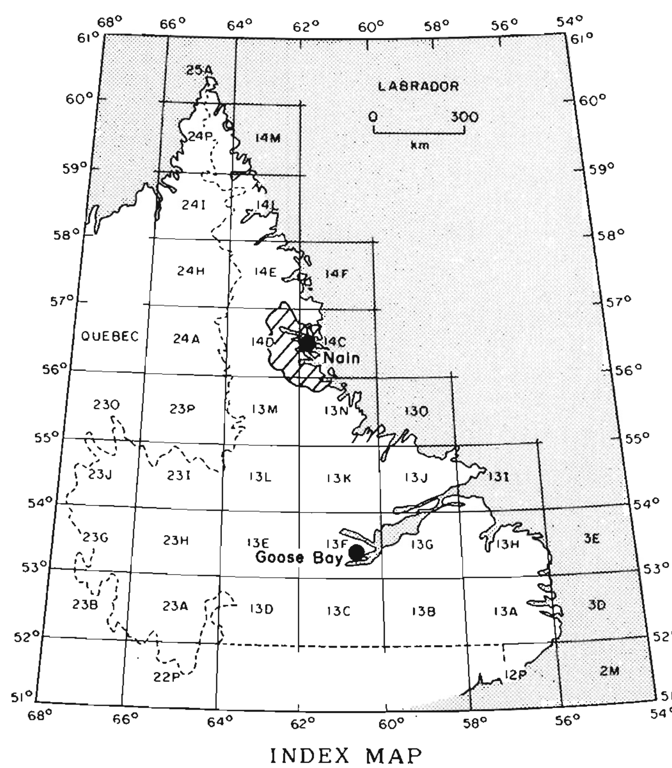

Figure 1: *Location map of Nain anorthosite*

18 percent chatoyant labradorite crystals. There is relatively little fracturing and veining present and all three prospects appear to have good potential for the quarrying of large blocks of stone.

The 1986 field program consisted of mapping the fracture and vein systems at each of the three prospects, and drilling and wedging out of 30- to 60-cm blocks of anorthosite. These blocks were transported to Nain, shipped to St. John's,

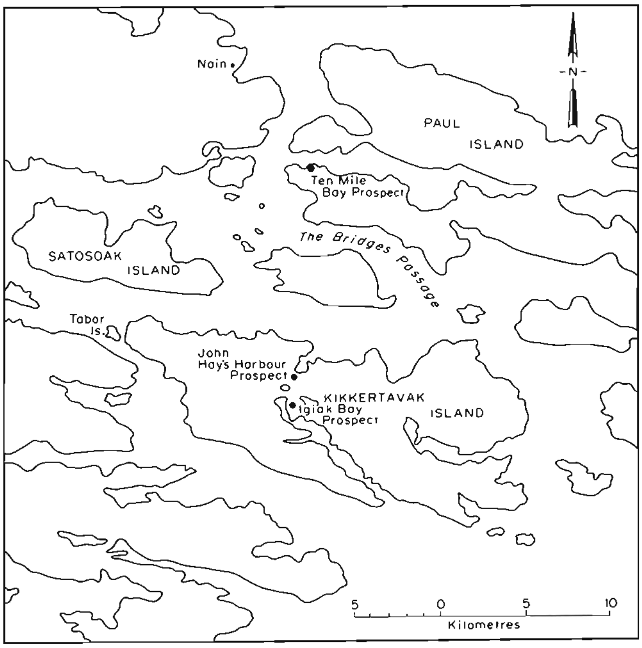

Figure 2: *Location of the three dimension-stone prospects evaluated in 1986.*

and finally trucked to Sussex, New Brunswick, where they were slabbed and polished at Nelson Monuments. The finished slabs will be used for display and reference samples.

General Geology

The Nain anorthosite complex is one of several large anorthosite–adamellite intrusions exposed in central and northern Labrador. They were emplaced ca. 1400 Ma and subsequently uplifted and exposed to approximately their present level by ca. 1150 Ma (Emslie *et al.*, 1972). These intrusions are posttectonic with respect to the Hudsonian Orogeny, and are generally unmetamorphosed. The Nain anorthosite complex is composed of many smaller plutons, and only about one-half of its mass is actually true anorthosite. The anorthosite is well exposed on islands and steep-walled valleys north and south of Nain, which allows for a thorough examination of potential dimension-stone prospects.

PROSPECT DESCRIPTIONS

John Hay's Harbour Prospect

John Hay's Harbour is located 18 km south of Nain on the north side of Kikkertavak Island (Figure 3). The dimension-stone prospect is a 300-m-wide saddle-shaped pass, approximately 500 m south and 80 to 90 m above the harbour. The exposure is excellent having only 20 to 30 percent thin moss cover and a very shallow 30-m-wide bog in the middle of the saddle. There are a small number of quartz and granitic veins cutting the anorthosite, and very little vertical jointing. Subhorizontal jointing runs parallel to the glacially smoothed outcrop surface, and gently sloping joint planes are visible on the east and west sides of the saddle, broken by local 1- to 2-m vertical faces. There are no

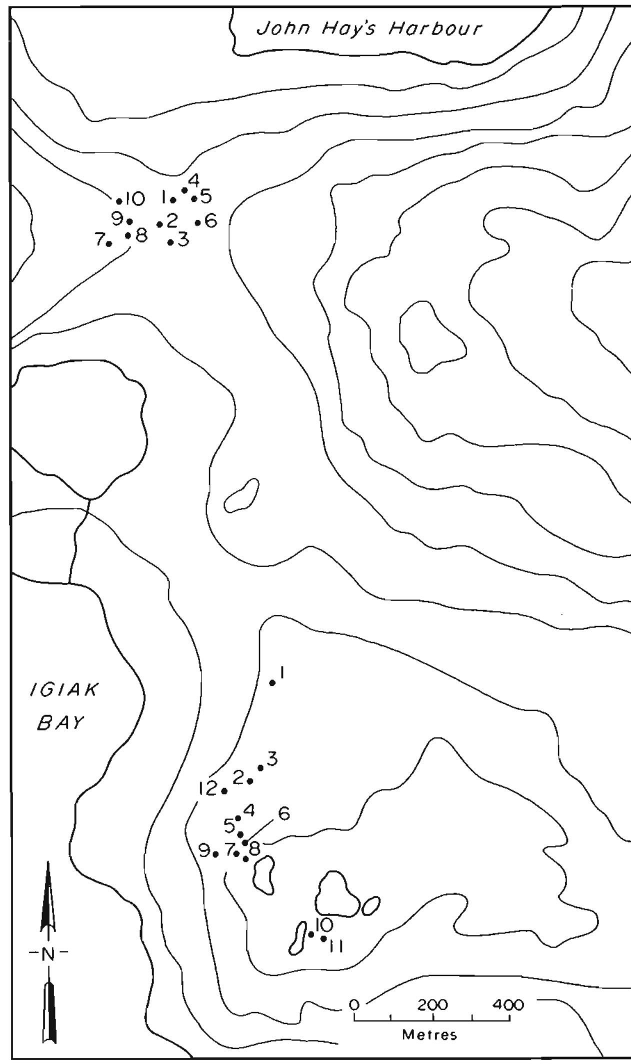

Figure 3: *Location of sites drilled in John Hay's Harbour and Igiak Bay prospects.*

horizontal joints visible on the well exposed, steep north side of the saddle, suggesting that the jointing either disappears at depth or continues to run parallel to the outcrop surface.

Ten sites were sampled in the John Hay's Harbour prospect, mostly along the edges of vertical faces 1- to 2-m high. At these sites, a series of 30- to 40-cm-deep holes were drilled 25 to 35 cm apart, and in a line parallel to and 20 to 40 cm back from the rock face (Plate 1). With the help of several sets of 'plugs and feathers' inserted into the drillholes, large slabs of rock were wedged away from the outcrop and then split into 40- to 100-kg blocks. Unfortunately, the anorthosite at the sites that were easy to drill and wedge tended to be the most intensely weathered, and contains hypersthene crystals that have broken down and caused staining of adjacent labradorite crystals to a yellowish to greenish brown. This weathering problem is common in surface outcrops in dimension-stone quarries in Québec and usually disappears 2 to 5 m below the outcrop surface (Susie Nantel, personal communication, 1986).

Plate 1: *Paul Clarke using 'plug and feather' technique to wedge large slab of rock from outcrop at Site 1, Igiak Bay.*

Much of the anorthosite in the John Hay's Harbour prospect is only slightly weathered and has no joints or fractures, e.g., Site 1 (Plate 2). Drilling and wedging out of large blocks from that prospect was very difficult. Several large flat slabs up to 10 cm thick were obtained from Site 1, but only after two small blasts had created horizontal fractures. The anorthosite at Site 1 is medium to coarse grained (crystalline) and consists of 90 to 95 percent labradorite, 5 to 10 percent hypersthene, and approximately 1 percent ilmenite. The labradorite crystals are 5 mm to 5 cm across, and have a somewhat bimodal size distribution. Large anhedral to euhedral crystals, 1.5 to 5 cm long, constitute 40 to 50 percent of the rock. The crystals are medium to dark brown on a polished surface, and 10 to 20 percent are chatoyant and ubiquitously color zoned. A deep-blue color dominates, usually forming the outer rim of the crystals, and a zonation of green, yellow, and bronze occurs toward the centres. Anhedral to subhedral crystals 2 to 12 mm across constitute 45 to 55 percent of the rock and commonly have a broken or fractured appearance, giving the rock a weak protoclastic texture. The crystals are light brown to semitranslucent on a polished surface, locally exhibiting white rims. Small white patches of very fine grained labradorite impart a lighter brown color to the stone. Hypersthene constitutes 3 to 8 percent of the rock and is

Plate 2: *Massive outcrop of anorthosite at Site 1, John Hay's Harbour.*

typically interstitial to the labradorite crystals. The hypersthene crystals are 1 to 12 mm across, anhedral to euhedral in shape (commonly exhibiting triangular cross-sections), and are shiny black on a polished surface. Metallic-gray to silver ilmenite crystals constitute approximately 1 percent of the rock. Pegmatitic pods of labradorite and hypersthene occur sporadically throughout the prospect.

Although unweathered samples were obtained only at one site in the John Hay's Harbour prospect, the remaining areas show good potential for the quarrying of large blocks of dimension stone because vertical jointing is minimal. There are a small number of veins and thin dikes spaced 5 to 20 m apart, and generally trending from 145 to 160°. These features, combined with the beautiful color zoning in the large chatoyant labradorite crystals, show there is excellent potential here for the production of a unique dimension stone.

Igiak Bay Prospect

The Igiak Bay prospect is 1.5 km south of the John Hay's Harbour prospect, and 60 to 70 m above and to the east of the head of Igiak Bay (Figure 3). The prospect is a flat to gently undulating hilltop, and has a minimum area of 0.5 km^2. It is glacially smoothed and has a very rounded western edge, which drops off sharply down to Igiak Bay. There are two small areas (approximately 75 m by 75 m) of large square blocks that are remnants of a 3- to 4-m-thick sheet of anorthosite, which originally covered the present exposure. The size and shape of these blocks indicate the presence of very widely spaced horizontal and vertical joint systems, an important asset in a quarry.

Twelve sites were excavated in the Igiak Bay prospect, mostly along the western edge where vertical rock faces 30 cm to 2 m high are present. The anorthosite has a large variation in hypersthene content (3 to 15 percent), in the size of the labradorite crystals (1 to 30 cm) and in their degree of chatoyancy. The most promising area is at Site 1, in the northern part of the prospect, where the outcrop surface is quite flat and almost free of jointing. Several blocks were obtained from here by drilling and wedging parallel to a north-trending 1-m face. The anorthosite is medium to coarse grained, and the labradorite crystals locally show a patchy size distribution in the rock. Subhedral labradorite crystals 0.5 to 1.5 cm across constitute 40 to 50 percent of the rock. Approximately 3 to 5 percent are chatoyant, exhibiting a light-blue to blue-green color. The large crystals constitute 30 to 40 percent of the rock, and are 2 to 4 cm long on average (in places, crystals are 6 cm long). They are blocky to rectangular in shape, and 5 to 8 percent are chatoyant and weakly color zoned showing medium-blue rims to blue-green, and less commonly yellow-green, centres. The hypersthene content varies from 5 to 15 percent, thus giving polished slabs a darker appearance than the anorthosite at John Hay's Harbour. Hypersthene crystals, 2 to 20 mm across, are anhedral to euhedral in shape, and are interstitial to the labradorite crystals.

Three of the remaining 11 sites at this prospect contain anorthosite attractive enough and sufficiently free from weathering to warrant slabbing and polishing. Site 5 contains anorthosite similar to Site 1, but has a crude layering of fine and coarse grained crystals. There is a good degree of chatoyancy (4 to 8 percent) and less hypersthene at this site. However, when the anorthosite was cut, the layering appeared more pronounced and revealed planes of structural weakness. At Site 4, the anorthosite is also different, containing less than 5 percent hypersthene unevenly distributed in 2- to 15-mm patches. A unique quality at this site is the rich, deep-blue chatoyancy in 3 to 6 percent of the labradorite crystals. Unfortunately, when the rock was slabbed, the coloration proved to be very inconsistent. The anorthosite in Site 3 is very dark, due to the dark-bluish-gray non-chatoyant feldspar crystals, and it has an extremely homogeneous appearance.

The above descriptions show that there is a great deal of variation in the anorthosite at the Igiak Bay prospect. The variety of anorthosite in some small areas is so great that it severely limits the quarry potential. However, if several medium-sized areas of relatively homogeneous anorthosite could be delineated (100 m by 100 m minimum), each with a unique and a different appearance, several different types of dimension stone could be potentially marketed from this one large prospect.

Quartz veins and fine grained quartz–biotite dikes, ranging from 2 mm to 20 cm in width, are present in the Igiak Bay prospect. They have similar trends to those cutting the John Hay's Harbour prospect (145 to 160° strikes being the most common), and are spaced 10 to 25 m apart. Also, there are many very coarse grained pods of labradorite and hypersthene, occurring both together and separately, widely dispersed throughout this prospect.

Ten Mile Bay Prospect

The Ten Mile Bay prospect is located on the south side of Ten Mile Bay, approximately 10 km southeast of Nain. Brinco attempted to quarry the prospect in the mid-sixties, and many large 5- to 10-tonne blocks still remain on the beach beneath the quarry (Plate 3). This dimension-stone site was

Plate 3: *Large blocks of anorthosite on beach beneath the original quarry at Ten Mile Bay.*

previously thought to have reduced potential for two reasons: 1) the difficulty in quarrying on a steep slope, and 2) the anorthosite contains parallel pyroxene–biotite foliations at irregular-spaced intervals (Meyer and Dean, 1986). However, the anorthosite at this prospect contains the greatest percentage of evenly distributed and regular-sized chatoyant labradorite crystals of any anorthosite seen during the course of this survey. The percentage of chatoyant labradorite crystals is 12 to 18 percent, and cutting and polishing of samples have shown that chatoyancy is not restricted to any one plane within the anorthosite. The color is a soft medium blue, rarely having a purple or turquoise tint. The labradorite crystals average 7.5 mm across, have an angular to rounded shape, and are medium to dark gray, typically exhibiting a thin white outside border. There is also approximately 10 percent light-gray to white, fine grained matrix.

The original quarry site is at the western edge of a moderately dipping glacially smoothed 'toe' of land that juts out 100 to 150 m from the base of a steep cliff. This toe of land stretches approximately 400 m eastward from the cove beneath the original quarry site. The elevation at the base of the cliffs is approximately 30 m above sea level. The original quarry test site was selected at the western edge of the prospect, close to the cliffs, perhaps with the intention of quarrying eastward, thus taking advantage of a moderately spaced north–south joint system. This also allowed the removal of blocks one layer at a time, using the 1- to 3-m-spaced horizontal joint system, which dips moderately northward toward the sea. It has been suggested that this prospect might be better quarried from the north (sea) side in any future attempt (Henry Ehm, personal communication, 1986). The original quarrymen blasted out seven test sites that were close to the sea and spread out along the length of the prospect. This revealed the consistency of the chatoyant labradorite and the less consistent mafic foliations.

The potential for dimension stone at the Ten Mile Bay prospect is excellent. The stone has such an attractive and unique appearance that it could have many other uses in addition to dimension stone for buildings. These include decorative panels for entrance ways, framing of elevator doorways or windows, countertops, floor and wall tiles, desk tops, fireplace mantles, etc. Production of these products would be labour intensive, and would not require the same amount of capital investment needed for large-scale production. Also, the number of large blocks remaining on the beach from the previous quarrying attempt could provide enough stone to begin production of some of the marketable products mentioned above.

LABRADORITE AGGREGATE

Over the past year, the Department of Mines and Energy has been working with the Labrador Inuit Development Corporation (L.I.D.C.) to try and find uses for the second-grade labradorite mined from the Grenfell Quarry on Tabor Island, 30 km south of Nain. Even though most of the labradorite quarried is chatoyant, not all of it is of sufficient quality for jewelery. Over the years, a 20-tonne stockpile has built up and spread out around the mouth of the quarry. In the fall of 1985, the L.I.D.C. shipped three 45-gallon drums of this material to St. John's, Newfoundland, for crushing and testing.

Two of the possible uses for labradorite aggregate are terrazzo tiles and precast concrete slabs, both of which use a mixture of cement and aggregate to make attractive floors and exterior wall panels respectively. Brinex Limited carried out similar tests in the sixties, using labradorite aggregate to make polished precast concrete panels, which were used on a small building in Toronto, but no work has been carried out since then. In the last five years, however, there has been a strong trend toward using concrete panels that have a rough rock-chip finish on the outside of new buildings, examples of which can be seen in St. John's at Hotel Newfoundland, the Bank of Montreal on Water Street, and the Newfoundland Medical Association Building on MacDonald Drive.

In the winter of 1986, the Department of Mines and Energy supplied labradorite aggregate to Del-Tile and Terrazzo Company of St. John's, Newfoundland, to make terrazzo tiles, and to Atlantic Concrete, to make precast concrete panels. Eleven terrazzo tiles were made from four different size fractions using both a white and gray cement. The results were somewhat disappointing because when the tiles were ground to a smooth finish, only 2 to 3 percent of the aggregate was chatoyant. The precast concrete panels, however, have a very rough finish, with the labradorite aggregate (12 to 28 mm size) protruding through a white concrete matrix. This means that the natural cleavage planes of the labradorite are preserved and even the non-chatoyant surfaces reflect light, giving the test panel a slight sparkle in sunlight. Approximately 5 to 10 percent of the labradorite aggregate is chatoyant, especially when viewed from different angles. Thus, a person walking by a building faced with concrete panels made from labradorite aggregate sees many different cleavage faces flashing color. This pleasing effect also occurs on epoxy-backed light-weight panels. Labradorite aggregate, 4 to 8 mm in size, set into a 5-mm-thick bed of fiberglass epoxy resin, produces a light-weight, durable, outside wall panel that requires very little framing for support, especially in comparison to precast concrete panels. Japanese architects have expressed much interest in labradorite aggregates for epoxy-backed panels.

SUMMARY

The Department of Mines and Energy is evaluating three dimension-stone prospects in the Nain anorthosite complex. Two prospects consist of medium to very coarse grained anorthosite that is medium to dark brown on a polished surface, and contains 5 to 15 percent chatoyant labradorite. The third prospect consists of fine to medium grained anorthosite that is light to medium gray on a polished surface, and contains 12 to 18 percent chatoyant labradorite. This prospect (Ten Mile Bay) has excellent potential because it outcrops along the shoreline and has a very homogeneous and colorful appearance. Test blocks from all three prospects have been slabbed and polished and are undergoing further evaluation.

Second-quality material from the Grenfell Quarry on Tabor Island is being evaluated as a source of labradorite aggregate. The aggregate is being used to make terrazzo tiles, precast concrete panels and light-weight, epoxy-backed panels. The chatoyant nature of the aggregate is best utilized in the precast concrete and epoxy-backed panels, and there is much interest in both of these products.

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