Status and implications of reserves at carving stone quarries within the Qikiqtaaluk Region of Nunavut

R.A Elgin

1Qikiqtani Inuit Association, Iqaluit, Nunavut, relgin@qia.ca

This work forms part of the Qikiqtani Inuit Association’s Quarry Evaluation Program to address the safety and sustainability of carving stone quarries located on Inuit Owned Lands around the Qikiqtaaluk Region of Nunavut. The program is jointly funded with research partnerships between the Canada-Nunavut Geoscience Office, Government of Nunavut Department of Economic Development and Transportation and Canadian Northern Economic Development Agency. The program aims to carry out bedrock mapping and geochemical analysis of significant sites to better understand how carving stone deposits form, identify unexplored resources and develop known resources to increase carving stone accessibility in the region.


Abstract

The Qikiqtani Inuit Association’s Quarry Evaluation Project was established as a multi-agency approach to address safety concerns around major carving stone sites, while providing a means to better understand the genesis of excellent-quality carving stone and define remaining reserve quantities. While related works have discussed the geology and formation of carving stone deposits, this paper focuses on quantifying reserves remaining at each of the three major carving stone sites in the Qikiqtaaluk Region: Kangiqsukutaak2, Ujararniarvik (also known as Tatsiituk)3 and Qullisajaniavvik. The major site of production for southern Baffin Island, Kangiqsukutaak (Korok Inlet), is nearing the end of its life, with only <3 000 tonnes of artisanal stone remaining. The neighbouring site at Ujararniarvik in Aberdeen Bay may have up to 3 000 tonnes remaining, although this represents an upper-limit estimate and will, therefore, be insufficient to cover the eventual loss and closure of Kangiqsukutaak in the long term. With no viable alternative in reserve, the southern communities of Baffin Island do not have a known source of artisanal stone to enable the envisioned growth of the carving industry. Re-evaluations of deposits on the Belcher Islands and in the Mary River area indicate that, although substantial deposits remain in isolated locations, communities with a more established artistic presence will have to begin transitioning to new, as yet unknown sources of stone in the immediate future.

Résumé

Les responsables d’un projet de la Qikiqtani Inuit Association qui vise à évaluer des carrières de pierre à sculpter ont adopté une approche multipartite non seulement en vue de répondre aux préoccupations en matière de sécurité dans le périmètre d’importants sites de pierre à sculpter, mais aussi afin de mieux comprendre la genèse de la pierre à sculpter d’excellente qualité et de préciser les reserves restantes. Alors que des travaux connexes ont porté sur la géologie et la formation des gisements de pierre à sculpter, la présente étude est axée sur l’évaluation des réserves restantes à chacun des trois plus importants sites de pierre à sculpter de la région de Qikiqtaaluk, soit Kangiqsukutaak4, Ujararniarvik (également connu sous le nom de Tatsiituk)5 et Qullisajaniavvik. La vie utile du site de production principal du sud de l’île de Baffin, c’est-à-dire Kangiqsukutaak (Korok Inlet), tire à sa fin puisqu’il n’y reste plus que moins de 3000 tonnes de pierre artisanale. Le site voisin d’Ujararniarvik à la baie Aberdeen a possiblement accès à quelque 3000 tonnes, bien qu’il s’agisse de la limite supérieure de la meilleure estimation et que ce volume soit d’ailleurs insuffisant pour pallier à long terme à la perte et fermeture éventuelle du site de Kangiqsukutaak. En l’absence d’alternatives viables, les collectivités du sud de l’île de

2This quarry was referred to as ‘Kangiqsukutaaq’ in previous editions of the Canada-Nunavut Geoscience Office Summary of Activities.
3This quarry was referred to as ‘Tatsiituk’ in previous editions of the Canada-Nunavut Geoscience Office Summary of Activities.
4Cette carrière a été identifiée sous le nom de « Kangiqsukutaaq » dans des éditions antérieures de Summary of Activities du Bureau géoscientifique Canada-Nunavut.
5Cette carrière a été identifiée sous le nom de « Tatsiituk » dans des éditions antérieures de Summary of Activities du Bureau géoscientifique Canada-Nunavut.

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Baffin n’ont plus accès à des sources connues de pierre artisanale grâce auxquelles elles seraient en mesure de favoriser la croissance de l’industrie de la sculpture. Une réévaluation des gisements des îles Belcher et de la région de Mary River révèle que, malgré la présence de gisements de très grande taille dans certains endroits isolés, les collectivités reconnues pour leurs communautés artistiques devront bientôt entamer leur transition vers de nouvelles sources encore inconnues de pierre.

Introduction

Carving stone represents a resource of special significance to Inuit communities of Nunavut, providing a significant source of income for indigenous artists and driving part of a multimillion dollar arts and crafts industry (Government of Nunavut Department of Economic Development and Transportation, 2010). Within the Qikiqtaaluk Region, where large deposits are more numerable compared to the rest of the territory (Beauregard et al., 2013; Beauregard and Ell, 2015a, b; Beauregard, 2017), intensive quarrying of artisanal stone since the 1960s has resulted in the depletion of surface reserves at several major sites. This has required Inuit harvesters to undertake subsurface excavations to obtain desirable stone. This practice is driven by a strong community preference for particular qualities in carving stone. Additionally, competition between Inuit harvesters and a lack of any consensual development plan has resulted in many poor quarrying practices having been adopted over the years.

With the majority of carving stone deposits in the Qikiqtaaluk Region located on Inuit Owned Lands (Figure 1), the Qikiqtani Inuit Association (QIA) has jurisdiction over these lands. The QIA carries out periodic inspections to address the potential safety and community concerns that have arisen from any work that has resulted in sustained periods of development. Throughout 2016 and 2017, the QIA conducted inspections at three of the major carving stone quarry sites in the region, Kangiqsukutaak (Korok Inlet, Baffin Island), Ujararniarvik (Aberdeen Bay, Baffin Island) and Quillisijaniavvik (Belcher Islands). This work was done in partnership with the Government of Nunavut Department of Economic Development and Transportation (EDT) and the Canada-Nunavut Geoscience Office (CNGO). This work was undertaken to jointly map the local geology, assess the character and interpret the genesis of carving stone, and complement the outcome of the EDT’s Nunavut Carving Stone Deposit Evaluation Program (NCSDEP; Beauregard et al., 2013; Beauregard, 2014, 2017; Beauregard and Ell, 2015a, b) and associated research (Steenkamp et al., 2014, 2016, 2017; Camacho et al., 2015; Qikiqtani Inuit Association, 2017a–c; Timlick et al., 2017). Revised estimates of remaining carving stone reserves are presented herein, and their immediate implications for the future development of the carving stone industry in the Qikiqtaaluk Region are discussed.

Deposit surveys

Three major carving stone deposits were visited by QIA and CNGO teams during the 2016 fall period, when weather and water conditions permitted access by boat from the nearest neighbouring community. The assistance of a local master carver was employed for all field excursions to ensure community involvement in the project and to provide detailed knowledge of the site and reserves. The field team remained on site for 1–6 days at each location to carry out field mapping, sampling and topological surveys. Mapping and sampling were carried out as described by Steenkamp et al. (2016) and Timlick et al. (2017).

Surveys were carried out using a Nikon reflectorless total station, with several GPS-tagged survey points being set up around each of the quarry locations to provide maximum coverage of the deposit. Triangulation of survey stations was carried out to ensure accurate readings and positioning, with the exception of Ujararniarvik where poor weather necessitated an early departure. Site dimensions were defined through laser surveying of irregular points along the roof and floor of the quarry, providing a series of markers for topological mapping and estimates for pit and reserve volumes. Horizontal and vertical distance conversions were performed in Microsoft® Excel®; and basic digital models were constructed using the freeware program LibreCAD®. Resource estimates were calculated using the assumed conversion ratio of 2.694 tonnes/m³ for direct comparison with existing research (e.g., Beauregard, 2014).

Deposit descriptions

Estimates of site dimensions and available reserve volumes for each of the three major community quarries are presented in Table 1, with estimates given for accessible, rather than total, reserves. Although each deposit may be significantly larger than presented in Table 1, much of the deposit may only be present at depth or underlie obstacles, and is therefore inaccessible using the hand-mining techniques adopted by Inuit quarry workers.

Kangiqsukutaak

The quarries at Kangiqsukutaak (located in Korok Inlet; Figure 1), approximately 160 km east of Cape Dorset along the southern Baffin Island coast, represent the primary production centre for carving stone in Nunavut (Figure 2a, b). To date, approximately 15 500 tonnes of artisanal serpen-
Figure 1: Location of carving stone deposits in the Qikiqtaaluk Region of Nunavut identified during the NCSDEP in 2010 and 2014 (Beauregard et al., 2013; Beauregard and Ell, 2015a, b). Of the four active quarries in the region, those located near Korok Inlet, Aberdeen Bay and Sanikiluaq (Belcher Islands), were evaluated as part of this work.
tinite stone has been extracted and distributed throughout the southern Baffin Island communities of Iqaluit, Cape Dorset and Kimmirut, as well as to communities in northern Quebec, during the quarry’s heyday in the 1980s. The stone from this site is highly prized due to its dark green/black colour, hardness and ability to hold fine details. Kangiqsukutaak has become the standard against which all other Nunavut deposits are compared when assessing the suitability of their stone for artisanal purposes. A series of quarry workings is located across the inlet to the west of Kangiqsukutaak but these are no longer in production owing to a high concentration of magnetite (K. Tapaungai, pers. comm., 2017).

**Resource dimensions**

The serpentinite body at Kangiqsukutaak (Timlick et al., 2017) is subvertical and likely continues at depth for about 100 m, based on the narrow and well-constrained magnetic anomaly pattern identified by Steenkamp et al. (2014). The serpentinite is laterally discontinuous along a northeast-trending fault, splitting the deposit into northern and southern components. The northern body is <10 m wide and exposed for >37 m along strike, although it may continue for an additional, and maximum distance of 65 m to the south beneath the topsoil. The southern deposit is 10–12 m wide, 76 m long and truncated along its southern extent by an east-trending fault near the shoreline.

**Remaining reserves**

The present-day excavations at Kangiqsukutaak cover most of the known deposits and extend to a visible depth of 8.9 m in the southern pit and 5.7 m in the northern pit. The true depths of the pits are hard to quantify due to the large volume of rubble and debris, but approximately 8 600 m³ of bedrock, equating to 25 000 tonnes, has been extracted to date. This volume is revised from an earlier estimate of 40 000–50 000 tonnes (Steenkamp et al., 2014). In total, approximately 11 000 tonnes and 4 000 tonnes of artisanal stone have been transported from the southern and northern pits, respectively (Qikiqtani Inuit Association, 2017a).

Given the subvertical nature of the deposit, stone can continue to be extracted by deepening the two pits; however, this may lead to issues with drainage and further expose quarry workers to potential slope failures (Qikiqtani Inuit Association, 2017a).

Within the limits of the northern pit, an estimated 2 880 tonnes of stone remains accessible if the workings are deepened by a further 5 m. It is possible that a southern extension may increase this tonnage as the southern limit of the deposit has yet to be found. Recent workings at the northern pit indicate that a depth of at least 2 m must be attained before the stone has sufficient integrity for artisanal use.

Within the southern pit, carving stone is accessible only from a 2–3 m high strip along the western wall, which underlies up to 6 m of fractured bedrock. Any further development in the southern pit involves the creation of overhangs that pose significant safety hazards. Assuming that it is logistically feasible to excavate more stone (i.e., another 1 m of stone) from the western wall without significant remediation to remove the fractured overburden and top soil, then up to 430 tonnes of carving stone could be removed in the future from the southern pit.

**Ujararniavik**

Aberdeen Bay, approximately 200 km west of Kimmirut on the southern coast of Baffin Island, contains one active quarry site comprising several small pits and excavations that have been dug into a low-lying beach within 10 m of the high-tide mark (Figure 2c, d). Here, Lake Harbour marble (Sanborn-Barrie et al., 2008) is intersected by several faults and has been hydrothermally altered to a high-quality serpentinite, known for its vibrant, apple-green colour and ability to hold fine detail (Camacho et al., 2015). Several altered ultramafic intrusions within the immediate area remain largely unexplored owing to their small size and position on an intertidal platform.

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**Table 1:** Locations, reserve estimates and pit dimensions of quarries surveyed as part of the Qikiqtani Inuit Association’s Quarry Evaluation Program in 2016 and 2017.

<table>
<thead>
<tr>
<th>Location:</th>
<th>Kangiqsukutaak</th>
<th>Ujararniavik</th>
<th>Quillisajniavvik</th>
</tr>
</thead>
<tbody>
<tr>
<td>South resource</td>
<td>64.396° N</td>
<td>63.758° N</td>
<td>56.177° N</td>
</tr>
<tr>
<td>North resource</td>
<td>73.323° W</td>
<td>72.182° W</td>
<td>78.895° W</td>
</tr>
<tr>
<td>Quarry dimensions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum length</td>
<td>75.69 m</td>
<td>36.35 m</td>
<td>6.82 m</td>
</tr>
<tr>
<td>Maximum width</td>
<td>9.50 m</td>
<td>11.10 m</td>
<td>9.33 m</td>
</tr>
<tr>
<td>Maximum depth</td>
<td>8.89 m</td>
<td>5.71 m</td>
<td>3.83 m</td>
</tr>
<tr>
<td>Resources:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production to date</td>
<td>15 500 tonnes</td>
<td>557 tonnes</td>
<td>1 067–1 127 tonnes</td>
</tr>
<tr>
<td>Remaining resources</td>
<td>&lt;500 tonnes</td>
<td>2 880 tonnes</td>
<td>1 058 tonnes</td>
</tr>
<tr>
<td></td>
<td>2 880 tonnes</td>
<td></td>
<td>15 700–18 540 tonnes</td>
</tr>
</tbody>
</table>
Figure 2: Photographs from major quarries in the Qikiqtaaluk Region: a) southern pit of Kangiqsukutaak, showing the trend of the fault that parallels the deposit; b) carvers examining the western wall in the southern pit of Kangiqsukutaak, which is approximately 9 m tall; c) active pit at Ujararniarvik and adjacent unstable debris slope (carvers for scale); d) infilled pit at Ujararniarvik (carver for scale); e) main pit of Qullisajaniavvik and locations of green and black carving stone, the Haig intrusion diabase (boundary shown by red line) and a minor brittle fault that bisects the outcrop (ATV for scale is 1.2 m tall).
Resource dimensions

The serpentinite deposit lies on the western edge of the flat beach and is separated from an intrusive wall of granite by a north-trending fault. The deposit is 32 m long and up to 16 m wide, beyond which it grades into marble containing a significant amount of serpentine pseudomorphs after olivine, resulting in a rock that is unsuitable as a carving stone. The total surface area of exposed artisanal-grade serpentinite is approximately 520 m², although the maximum depth of the body is unknown.

Remaining reserves

Two excavation sites are visible, although one has been filled in with rubble (Figure 2d) and is presumed to be of equivalent size to that of the active pit. Approximately 130 m³ of rock has been removed from the active pit to a depth of 3.83 m below ground level (Table 1). Applying a wastage rate of 60%, determined by onsite observations of quarrying activities, the total production of both pits is estimated to be 557 tonnes.

Estimates of total reserves are impossible to determine given the unknown depth of the serpentinite deposit, but there is no indication from mineralogy at the base of the pit that the lower limit of the body is near. Assuming that the pit can be deepened by a further metre to a depth of 5 m, by which point it must lie close to the high tide level, then a maximum of approximately 2 600 m³ of artisanal stone might yet still be extracted. This figure, however, is likely to be significantly reduced due to natural wastage from quarrying activities and surface weathering of the upper rock, which extends to an observed depth of 2.11 m. It is therefore estimated that 1 058 tonnes of accessible artisanal stone remain on site, with an upper estimate of 2 237 tonnes if much of the surface-weathered layer proves viable (Qikiqtani Inuit Association, 2017b). These estimates are revised from previous values of <500 tonnes (Beauregard, 2017) and 700+ tonnes (Burgoyne and Caine, 1980).

Quillsisajaniavvik

Several carving stone sites have been identified throughout the Belcher Islands; however, stone is currently extracted almost exclusively from Quillsisajaniavvik on Tukarak Island, approximately 40 km southeast from the community of Sanikiluaq. Here, a soft argillite that holds fine detail and can be worked with ease has been created from the contact metamorphism zone of impure dolostones of the Costello Formation (Jackson, 2013) by a Haig diabase sill (Figure 2e; Steenkamp et al., 2016). Although this Haig intrusion lies in contact with many kilometres of carbonates across the Belcher Islands, the metamorphic aureole, where muddy carbonates are converted to argillite, is highly variable in extent and the contact metamorphism within the aureole has not always resulted in a high-quality carving stone (Steenkamp et al., 2016; Timlick et al., 2017).

Resource dimensions

The actively quarried deposit at Quillsisajaniavvik is approximately 100 m long and varies between 9.7 and 24.4 m in width (Steenkamp et al., 2016). While subsurface geometries of the sill, carbonate and artisanal argillite are unconstrained, reserve estimates are made assuming that surface features can be projected at depth and the sill maintains a constant dip of 52° toward the northwest. In total, an estimated 23 000–32 000 tonnes of carving stone is found to make up the deposit, agreeing well with previous estimates of >30 000 tonnes (Beauregard, 2014; Beauregard and Ell, 2015a, b). However, excavation of this amount of rock would require the pit to be sunk to a depth of 25 m below ground level.

Remaining reserves

The active quarry pit is 25.79 m long, <9.32 m wide and <2.14 m deep, indicating that around 290–310 m³ of stone (775–836 tonnes) has been removed (Figure 2e). Taking into account the numerous worksites along the eastern face of the hillside north of the active quarry pit, an estimated total of 1 067–1 127 tonnes of artisanal stone appears to have been removed from Quillsisajaniavvik to date. This figure is less than previous estimates of around 2 000 tonnes (Beauregard, 2014).

Assuming consistent surface and subsurface geometries, the limiting factor for recoverable stone is the depth to which the quarry can be extended, given the steeply dipping strata, the hand-mining approach to quarrying and the hard, overlying Haig sill. Estimates therefore range from 2 500 to 2 900 m³ for a 3 m deep quarry and from 5 800 to 6 900 m³ (15 700–18 540 tonnes) should the pit be sunk 10 m below the current ground level (Qikiqtani Inuit Association, 2017c). Unlike the quarries at Kaniqsukutaak and Ujararniarvik, wastage from quarrying techniques is minimal due to the well-defined bedding of the argillite (Beauregard, 2014).

Implications for the carving stone industry

Development of the carving stone industry requires that communities have a ready supply of stone that is of sufficient, uniform quality and exceeds the estimated 250–750 tonnes of stone consumed annually, given the current rates of production (Government of Nunavut Department of Economic Development and Transportation, 2010). The results presented here indicate that the southern Baffin Island area is poised to lose its primary production centre, Kaniqsukutaak, which has <500 tonnes of stone remaining in the prized lower pit, and <3 000 tonnes of stone in the northern pit. Unfortunately, none of these remaining reserves are currently accessible without implementing either extensive remediation or dangerous quarrying practices, such as the undercutting of high, unstable walls. Although estimates indicate that Ujararniarvik has suffi-
cient reserves to accommodate the eventual closure of Kangiqsukutaak in the short term, the long-term survival of the carving stone industry in the southern Baffin Island communities relies on new sources of carving stone being located, or the development of a structured distribution network to transport stone from larger deposits.

A number of sites containing suitable stone for carving have been evaluated to date, but none currently offer the necessary size and quality that would permit the industry to grow its capacity, as proposed in the Ukkusiksaqtarvik plan (Government of Nunavut Department of Economic Development and Transportation, 2007). While marble remains an abundant alternative, it is an unattractive option for artists used to working with the more distinctive serpentinite that is traditionally associated with Inuit carvings. The establishment of distribution networks to bring stone from sites with abundant reserves to stone-impoverished communities remains a challenge, as the only other major deposits in Nunavut are the Leybourne Islands (Cumberland Sound), Koonark (Mary River) and Kingora (Melville Peninsula) sites, which are either too distant or too difficult to access.

Although an assessment of the quarry at Qullisajaniavvik has reduced the argillite reserve estimate, the volume is nonetheless sufficient to accommodate the needs of carvers in Sanikiluaq and support a regional centre for distribution to the mainland communities if regular shipping routes can be established.

Economic considerations

Carving stone remains a major material for artistic work within northern communities and a valuable commodity that can sell for $5.50–6.60 per kilogram ($2.50–3.00 per pound) in its raw form (Ell, 2015). This provides a seasonal income for numerous quarry workers who sell the stone to local cooperatives, or take a percentage of final sales in partnership with skilled carvers. In addition to the raw value of artisanal stone, the combined net reserves of the three sites presented here have a value of about $110 million; however, carving stone harvesting stimulates the Nunavut economy further through the purchase of fuel, supplies and tools to quarry or transport raw stone. The decreasing output and inevitable loss of stone from Kangiqsukutaak and Ujararniavvik over the coming years will likely have a negative impact on not just carvers, but also those employed on a seasonal basis in its collection and distribution.

Conclusions

A survey of quarry dimensions and available reserves at three of the major quarries in the Qikiqtaaluk Region of Nunavut has led to a revision of the amounts of carving stone reserves available for use by Inuit artists. Kangiqsukutaak is estimated to have <3 000 tonnes of accessible stone, almost all confined to the northern pit. The relatively smaller Ujararniavvik body holds an additional reserve of <3 000 tonnes. The dwindling reserves at known deposits along the southern coast of Baffin Island indicate that an active program of prospecting and quarry development is necessary in the immediate future, before carving stone becomes significantly harder to source and quarry workers resort to unsafe practices of harvesting beneath high and overhanging walls. Numerous locations with potential carving stone deposits, identified through the NCSDEP (Beauregard 2014, 2017; Beauregard et al., 2013; Beauregard and Ell 2015a, b) and by local elders (K. Tapaungai, pers. comm., 2017), still require suitability testing and should therefore be high-priority targets for community prospectors or follow-up studies.

Although accessible stone at Qullisajaniavvik has been downgraded to a maximum of 15 700–18 540 tonnes, the average production of Sanikiluaq stands at only 24.5 tonnes annually (Qikiqtani Inuit Association, 2017c) and will accommodate community needs for the foreseeable future. The option to transport and sell excess stone to neighbouring hamlets, placing the Belcher Islands at the centre of a regional distribution network, remains a viable option if this is found to be consistent with the wishes of the community.

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