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Diamond Exploration and Regional Prospectivity of Greenland

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Introduction

Greenland is dominated by cratonic blocks that provide conditions for the formation of diamonds. Pre-1.6 Ga rocks are exposed over 43% of ice-free land and many basins in younger areas evidence underlying Archean basement. Studies of mantle xenoliths reveal thick mantle lithosphere to 220 km in the North Atlantic Craton of western Greenland (Sand et al., 2009). While climate and remoteness provide challenges to exploration and mineral development, 50 years of diamond research and exploration have generated abundant data, particularly from western and southern Greenland (Hutchison, 2020). Thus, kimberlites, ultramafic lamprophyres (UML) and lamproites are known to be exposed in almost all regions, and span 1632 Ma of geological time (Larsen and Rex, 1992; Secher et al., 2009; Hutchison et al., this volume). Including carbonatites, 3029 discrete bedrock diamond-prospective occurrences have been identified, mostly occurring as dykes and sills. Known diamondiferous bodies are well represented over 930 km of Greenland's west coast, most notably the Garnet Lake four metre-thick composite aillikite / kimberlite sheet at Sarfartoq (Hutchison and Frei, 2009), and metamorphosed ultramafic lamprophyre sheets at Qeqertaa, Disko Bay (Bernstein et al., 2013). Data from these, and other localities, demonstrate that Greenland is a host for diamondiferous bodies with large, good quality diamonds in potentially economic concentrations, with potential for future discovery. While preserved pipes may still be discovered at higher elevations, the rarity, so far, of known pipes and diatremes evidences extensive glacial erosion. However, this raises the potential, should concentrating mechanisms have operated, for offshore and paleoplacer deposits.

Methodology

Records of 24 996 exploration samples allow an assessment of the methodologies of past exploration and, combined with 120 334 good quality mineral chemical analyses (Hutchison, 2020), allow regional diamond prospectivity analyses of Greenland to be conducted. In this study, critique of exploration methodologies predominantly relied upon industry reports submitted to government (compiled in Hutchison, 2020), and prospectivity modelling followed a two-part approach. A mineral approach inspected diamond concentrations and physical features, and compared and contrasted indicator mineral chemistry among Greenlandic geological regions and with the diamond fields of neighbouring Canada. A quantitative modelling approach followed the methodology described in Hutchison (2018), taking account of mantle lithosphere thickness, the age of surface rocks, and the density of sampling combined with recovery of visually-determined indicators. The most prospective regions overlie thick mantle lithosphere, are dominated by exposed rocks that are relatively old, and have experienced relatively little diamond exploration activities while revealing mantle-derived indicator minerals with diamond tenor. The resulting map (Figure 1) presents a 12 level ranking of attractiveness for future diamond exploration.

Results and Conclusions

Most diamond exploration in Greenland has focussed on diamond indicator minerals, typically from 10 kg alluvial and glaciogenic samples. In a global diamond exploration context these are small samples, and the most common size range for mineral picking of 0.25 to 0.5 mm has a smaller upper limit than is routinely applied in neighbouring Canada. However, Greenland appears to present a weathering environment particularly beneficial to the preservation of Cr-spinels as well as less durable minerals including garnets and Cr-diopsides. While all indicator grains disaggregate, particularly Cr-diopside, data demonstrate that the effect on heavy mineral concentrates is that grains appear in smaller size fractions rather than disappearing altogether. Therefore, it is concluded that sampling strategies in Greenland have usually been adequate, and present a balance between generous sampling and the costs and logistical challenges of exploration.

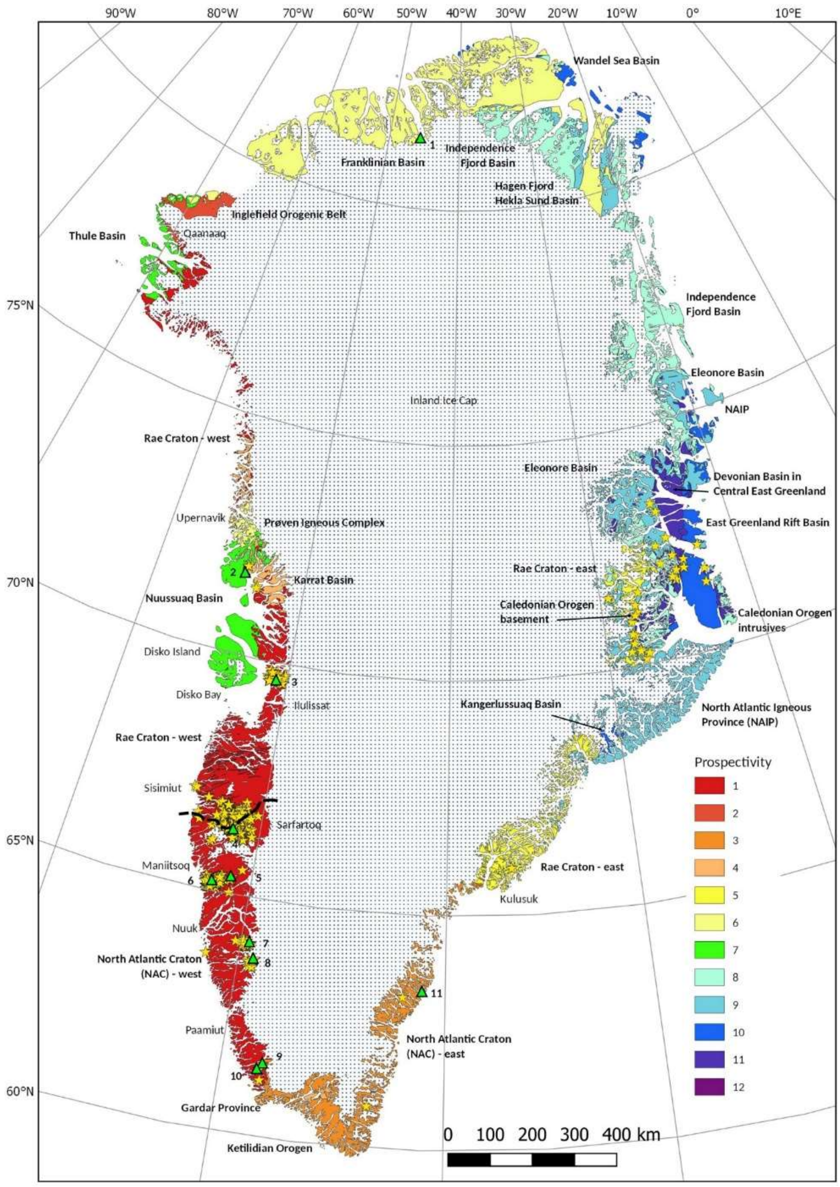

Figure 1: Prospectivity map of Greenland. Geological sub-divisions are colour-coded and ranked for prospectivity, taking account of mantle structure, the age of surface rocks, and the extent of sample coverage and recovery of visually-determined indicators. Prospectivity ranking of 1 identifies the most prospective areas. The extent of permanent ice is identified by stippling. In-situ diamond prospective rocks are shown by yellow stars, with notable localities identified by green triangles: 1 – Inlier of the Rae Craton in north Greenland with visually -identified possible mantle-derived garnets, 2– Svartenhuk Halvø, diamond-bearing UML, 3 – Qeqertaa diamondiferous UML dykes, 4 – Garnet Lake diamond-bearing kimberlite / aillikite sheets, 5 – Qaamasoq, subcrop of diamond-bearing kimberlite float, 6 – Majuagaa diamond-bearing kimberlite dyke, 7– Tikiusaaq Carbonatite and associated diamondiferous aillikite dykes, 8 – Nunatak 1390, abundant kimberlitic float, 9 – Midternæs diamond-bearing aillikite sills, 10 – Pyramidefjeld diamondiferous aillikite sills, 11 – Skjoldungen Carbonatite complex with neighbouring ultramafic rocks with kimberlite affinity.

Garnet, ilmenite, spinel, Cr-diopside and orthopyroxene all reveal mineral chemistries consistent with deep mantle sources, often within the diamond stability field (following standard discriminatory criteria, such as Grütter et al., 2004). Ilmenite compositions with low levels of iron oxidation often indicate the potential for very high diamond preservation, as is evidenced for example in the high abundance of unaltered octahedral diamonds from the Qeqertaa UML (90% in the Qeqertarsuaq area as a whole; data compiled in Hutchison, 2020). Furthermore, the most diamondiferous body known in Greenland, at Garnet Lake, contains a diamond population with 72% octahedrons and dodecahedrons and revealed an exceptionally large 2.39 metric carat stone from a small (47 tonne) bulk sample (Hutchison and Frei, 2009). The North Atlantic Craton of West Greenland and most notably the Ketilidian Orogen of southern Greenland show particularly consistent diamond-prospective chemistries among indicator minerals, while the Rae Craton of western Greenland is more variable. However, all of Greenland's geographic subdivisions exhibit indicator mineral chemistries overlapping those from diamond-producing areas of Canada at Chidliak (northern Baffin Island) and in the diamond-mining areas around Diavik and Ekati.

Quantitative prospectivity modelling ranked the North Atlantic and Rae Cratons of western Greenland equally most prospective. This result is reflected in analyses of mineral chemistry, the abundance of recovered diamonds and the focus of historical exploration activities. However, high rankings (prospectivity scores of 2 and 3) highlight considerable diamond potential in the under-explored Inglefield Orogen (North-West Greenland), Ketilidian Orogen (southern Greenland) and North Atlantic Craton of eastern Greenland (Figure 1). Notable also is the small (276 km^2) inlier of the Rae Craton of North Greenland, which despite its size distinguishes itself by reports of pyrope garnet in transported sediment samples which, while not chemically analysed, may indicate a mantle origin. The existence of the Rae Craton as an inlier in this extremely under-explored part of Greenland suggests that, as in Inglefield Land, the overlying Franklinian Basin (prospectivity score of 6) may also have some diamond prospectivity. Exploration attractiveness would depend on diamondiferous magmatism being post early-Paleozoic in age.

In conclusion, historical data, compared with regional prospectivity metrics identify further opportunities for diamond exploration in Greenland particularly in selected areas of the west coast, as well as within less-explored areas such as eastern and northern regions, and off-shore.

References

Bernstein, S, Szilas, K, Kelemen, PB (2013) Highly depleted cratonic mantle in West Greenland extending into diamond stability field in the Proterozoic. Lithos 168-169:160-172

Grütter, HS, Gurney, JJ, Menzies, AH, Winter, F (2004) An updated classification scheme for mantle-derived garnet, for use by diamond explorers. Lithos, 77:841–857

Hutchison, MT (2018) Diamond exploration and regional prospectivity of Western Australia. Mineralogy and Petrology, 112:S737–S753

Hutchison, MT (2020) Greenland diamond exploration data package. USB flash drive with Explanatory Notes (vers. January 2020) Ministry of Mineral Resources Data Package, Government of Greenland https://doi.org/10.22008/FK2/VYJX5D

Hutchison, MT, Frei, D (2009) Kimberlite and related rocks from Garnet Lake, West Greenland, including their mantle constituents, diamond occurrence, age and provenance. Lithos 112:318–333

Larsen, LM, Rex, DC (1992) A review of the 2500 Ma span of alkaline-ultramafic, potassic and carbonatitic magmatism in West Greenland. Lithos, 28:367–402

Sand, KK, Waight, TE, Pearson, DG, Nielsen, TRD, Makovicky, E, Hutchison, MT (2009) The lithospheric mantle below southern West Greenland: a geothermobarometric approach to diamond potential and mantle stratigraphy. Lithos 112S:1155-1166

Secher, K, Heaman, LM, Nielsen, TFD, Jensen, SM, Schjøth, F, Creaser, RA (2009) Timing of kimberlite, carbonatite, and ultramafic lamprophyre emplacement in the alkaline province located 64°–67° N in southern West Greenland. Lithos, 112S:400–406