NAALAKKERSUISUT
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Ministry of Mineral Resources

Data methodologies applied in the Greenland Diamond Exploration Package

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by

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Nuuk 2019

REFERENCE

The recommended reference for this publication is:

Hutchison, MT 2019, Data methods applied in the Greenland diamond exploration package. Ministry of Mineral Resources Report, Government of Greenland.

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Published 2019 by the Ministry of Mineral Resources, Government of Greenland
This Report is published in digital format (PDF) and is available online at www.govmin.gl.

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Frontispiece: Garnet lherzolite xenolith identified on the day of discovery of the Garnet Lake diamondiferous aillikite / kimberlite sheet, July 17th, 2004. The xenolith exhibits distinctive, deep red-purple G9 and G10-composition garnets with kelyphite rims amongst recrystalised and partially serpentinised olivines. Also evident is the sandpaper-textured thin weathering crust which is typical of Greenlandic kimberlites and related rocks. The hand lens is approximately 2 cm in diameter. Photograph credit MT Hutchison

Back cover: Two Air Greenland A/S AS-350 helicopters employed in the services of Hudson Resources Ltd's exploration at Sarfartoq, April 2006. The machine in flight was conducting Fugro Airborne Surveys' 4952 line-km high resolution stinger mounted magnetometer survey over blocks south of the Sarfartoq valley. The helicopter on ground was supporting Frontier Geosciences Inc's seismic reflection surveying of the Garnet Lake aillikite / kimberlite sheet. Photograph credit: MT Hutchison

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Abstract

The Government of Greenland's Diamond exploration data package compiles over 50 years of diamond exploration data. In addition to samples derived from Greenland's established areas of diamondiferous rocks in central West Greenland, a wide coverage of regional exploration data extending throughout the country is included. The database follows a similar methodology of attribution and has a compatible structure to the Diamond exploration databases of the Northern Territory of Australia and Western Australia, and so meets international standards applied in areas of diamond mining. The Diamond exploration data package is the first of its kind to collate diamond exploration data country-wide in a publicly accessible fashion. It incorporates the locations of 25 000 diamond exploration samples. Associated with these samples are over 109 000 good-quality chemical analyses of mineral separate grains integrated into a standardised framework.

In total, 100 discrete, named in-situ bodies, which in principle have diamond potential (kimberlites, lamproites, ultramafic lamprophyres, and carbonatites) have also been compiled in the diamond exploration data package. These occur among over 3 000 compiled in situ occurrences of dykes, pipes, sills and blows. With considerable data generated from bulk sampling of diamondiferous bodies, notably Garnet Lake, Qeqertaa and Majuagaa, this part of the database considerably expands upon previous compilations of relevant Greenland rocks, including the Geological Survey of Denmark and Greenland's Report 2004-117. As a companion, 56 emplacement age determinations from 36 bodies are reported, encompassing most of the geographic extent of Greenland's known rocks with diamond potential.

Analyses of the exploration data allow for an understanding of exploration history in areas of known occurrences and identification of considerable gaps in the exploration coverage within areas of diamond potential. The Diamond exploration data package stands as a means to support and encourage future diamond exploration in Greenland in addition to further establishing a rigorous framework suitable for development of diamond exploration databases elsewhere.

KEYWORDS: Greenland, database, diamonds, diamond exploration, mineral deposits, kimberlite, aillikite, lamprophyre, lamproite, carbonatite, indicator minerals, chromite, chrome diopside, garnet, picroilmenite, microdiamonds

Introduction

Greenland covers an area of 2 167 450 km^2 but most of that is under ice, being the inland ice cap and other areas of permanent ice cover. Around the coastline there remain 435 019 km^2 of exposed rocks, not accounting for small areas of thick glacial cover, which by nature of the climate are also very sparsely vegetated. Archean rocks, Archean rocks subsequently deformed in the Paleoproterozoic, and Paleoproterozoic rocks comprise 187 522 km^2. Thus, away from thick cover, pre-1.6 Ga rocks comprise around 43% of Greenland. Most notable are the North Atlantic Craton, which extends to Scandinavia and the United Kingdom (where aillikites are known in the Craton margins; Hutchison et al., 2018), and the Rae Craton, which extends to Canada (also known for diamondiferous kimberlite and aillikites; Pell et al., 2013). Even among Greenland's orogenic belts and sedimentary basins, some are also underlain by thick, Archean lithospheric mantle (Nutman et al., 2019). Hence, much of Greenland comprises the conditions conducive for diamond formation; old, cold, thick lithospheric mantle blocks (Haggerty, 1994).

For primary diamond exploitation it is also important that host eruptives are not inaccessible due to overlying younger rocks. No diamondiferous rocks in Greenland can be considered to be particularly young. The youngest known are Jurassic, at Pyramidefjeld in South-West Greenland (149.8 Ma; Geospec Consultants Limited, 2007). Moreover, most diamondiferous rocks in Greenland lie close to the boundary between the Proterozoic and Paleozoic time periods (e.g. 566 Ma at Garnet Lake; Hutchison and Heaman, 2008). The oldest known diamond-prospective rocks are much older, for example, the Tupertalik carbonatite was emplaced at 3007 Ma (Bizzarro et al., 2002) and the Oqaatsunnguit lamproite dates to 1743 Ma (Larsen and Rex, 1992). Hence, considering the full range of emplacement ages of diamondiferous rocks, most of Greenland exhibits a solid surface geology sufficiently old to allow any diamondiferous intrusive rocks to be near surface. Furthermore, younger sediments are not necessarily an impediment to diamond exploration where sedimentary processes have eroded primary deposits and concentrated the resulting diamonds. Glaciation presents a mechanism whereby Greenland has significant potential for having developed palaeo-placer diamond deposits, onshore and offshore. Greenland has by no means been exhaustively explored. Both theory and precedent support potential future economic diamond discoveries in much of the country.

Diamonds have been known in Greenland since at least the 1970s (Emeleus and Andrews, 1975 and references therein). Exploration and discoveries up to 1990 are well-documented in Larsen (1991) and since this time Greenland has seen considerable exploration activity from a range of international companies, large and small, and work by the Geological Survey of Denmark and Greenland (GEUS). The Greenland diamond exploration database documents the activities of the various explorers but most

notable in recent years have been Hudson Resources Ltd, Avannaa Resources Ltd, Icefire Diamonds A/S and Intex Resources ASA, Metalex Ventures Ltd, and Nuna Minerals A/S.

There have never been producing diamond mines in Greenland, however, diamond exploration is relatively new to Greenland and the mining industry in general in Greenland is just developing. Despite this, diamond exploration in Greenland has met with notable successes. The Garnet Lake kimberlite produced the largest diamond (2.392 metric carats; 0.478 g; Hutchison and Frei, 2009) from an early exploration project sharing North American geology. The stone was recovered from the first mini bulk sample at the site, weighing 47 tonnes. Garnet Lake lies as the boundary between the undeformed Archean North Atlantic Craton and the Nagssugtoqidian Orogen. It is likely that such a deep-penetrating crustal boundary is important for emplacement but diamondiferous rocks are also known from locations firmly within the cratonic blocks such as Avannaa Resources Ltd's prior project at Qeqertaa in the Rae Craton, which in turn extends into Canada. The geological association with Canada is important. Diamondiferous aillikites at Chidliak in Baffin Island are very similar to the diamondiferous aillikites and kimberlites at Garnet Lake and the Chidliak occurrences have recently been purchased by diamond-industry behemoth De Beers. Greenland's shared history with Canadian geology places it in a position of considerable interest for the diamond explorer and financier. According to Kimberley Process Certification Scheme statistics for 2018, Canada is estimated to have produced approximately 16% of the global rough diamond production by weight, ranking it third in the world by both value and weight after the Russian Federation and Botswana.

The Diamond exploration data package (referred to throughout this project as DED; Hutchison, 2019) aims to collate as much publicly available sampling data, reflecting as much of Greenland's diamond exploration history, as possible. Aside from basic information such as sample locations and diamond and indicator mineral recovery data, a large number of additional data fields have been populated. These include original sample location / datum information, sampling screen sizes and concentrate weights, and information on associated mineral phases, useful for prospecting for other commodities. A detailed breakdown of the mineral phase subtype is included, using mineral chemistry in conjunction with contemporary kimberlite and mantle mineral classification schemes, such as Grütter et al. (2004) and Wyatt et al. (2004). Locations of drill holes, samples taken for bulk chemical analysis, petrology, geochronology, and full diamond descriptions complement the primary indicator mineral data. In total, the database comprises 338 fields for unique types of data, not including record identifiers.

In order to advance towards an industry-standard, the DED closely matches the structure and population rules of government survey diamond exploration databases of Western Australia (Geological Survey of

Western Australia, 2018) and the Northern Territory (NT) of Australia (Hutchison, 2011). In turn, the NT database draws from structural elements in the prior Greenland diamond database of Jensen et al. (2004). Consequently the description of methodologies of the current DED (this document) have close similarities with the explanatory notes (Hutchison, 2011; Hutchison, 2018a) for the two Australian databases. What the current DED does not yet share with the two Australian databases is a comprehensive interpretation and prospectivity model based on exploration results, geochronology and mantle architecture (Hutchison, 2012; Hutchison, 2017).

For the Greenland DED, a small number of Greenland-specific changes have been made, trace element and drill hole structures have been added and an expanded treatment of mineral chemistry has been described in the current document. Thus it is recommended that the Greenland DED is used for those wishing a template to apply to diamond exploration data from elsewhere. With appropriate reference to the data dictionaries, data from each of the three databases can largely be copied and pasted together if a dataset with a wider perspective is required by the user.

With similarities in structure and overlapping scope, much of the data in Jensen et al. (2004) are incorporated into the DED, as described in the following. However, decisions have been made to not include some data. Specifically, Jensen et al. (2004) include outcrop photographs and plots of mineral chemical data. Exploration companies do not submit outcrop photographs as part of their filing procedures, neither in Greenland nor routinely elsewhere. Furthermore the variety of resolutions and qualities of photographs taken in the field are such that their usefulness is very variable, making time spent on a further archiving unproductive. Explorers are directed to original company and government reports, academic publications such as Hutchison and Frei, (2009) and Jensen et al. (2004) for records of the largely pristine diamond-prospective rocks which Greenland presents. Regarding mineral chemical plots (such as in Jensen et al., 2004), the DED readily allows the user to plot mineral chemical data in whichever way is required, including integration of further data. It is considered more likely that this is how mineral chemical data will be used by the explorer than inspection of standard plots of pre-existing data.

Terminologies

Mineral phases used in the course of diamond exploration are interchangeably called 'diamond indicators', 'kimberlite indicators', and sometimes 'mantle indicators'. Hence, databases incorporating corresponding data are consequently often referred to by similar names. The chemistry of some phases, such as some garnets, can be directly attributed to a likely syngenetic association with diamond. However,

some other phases, such as ilmenites, provide information on a likely association with kimberlite, but no direct information on its diamond potential. Yet, other phases, such as olivine with particular compositions, are evidence of a mantle origin, but reveal little of the likely association with the types of magmatism usually associated with diamond deposits. However, all relevant phases with the various pieces of information they provide, usefully contribute to a picture of the diamond potential of a particular area.

The enviable position which Greenland finds itself in by hosting near-pristine diamond-bearing rocks, free from the effects of significant weathering, means that much diamond exploration has proceeded by field identification of in-situ and transported kimberlites and related rocks. Even when partially weathered, diamond-prospective rocks show a distinct surface texture and colour which readily distinguishes them from country rocks (Hutchison and Frei, 2009). The abundance of fresh rock samples contrasts strongly with the setting of diamond exploration in many diamond producing countries, such as Australia (Hutchison, 2013, 2018a). Aside from diamond-prospective rocks, much of Greenland's diamond exploration has focused on indicator minerals, as it has done elsewhere (Fipke et al., 1995; Grütter et al., 2004). However, other geochemical data such as bulk rock (Larsen et al., 2009) and sediment chemistry (Singh and Cornelius, 2006) are useful in contributing to a picture of diamond potential. Where relevant, such samples are also referred to in the current study. Hence, given the range of types of information presented, the all-encompassing term DED is adopted.

Primary magmatic sources of diamonds were for some time thought to be restricted to true kimberlites. However, diamonds exist as xenocrysts, sometimes in economic concentrations, in ultramafic lamprophyres such as aillikites (which show very subtle mineralogical distinctions from kimberlites; Tappe et al., 2005; Hutchison and Frei, 2009) and also genetically distinct lamproites (e.g. the AK1 pipe at Argyle, Western Australia; Jaques et al., 1986). Furthermore, diamondiferous rocks have been shown to be closely associated temporally and spatially with carbonatites (Larsen and Rex, 1992). Greenland provides examples of all of kimberlite, aillikite, lamproite and carbonatite (associated with kimberlites), many shown to be diamondiferous, and hence all these rocks types are considered diamond-prospective and incorporated in the DED.

The distinctions between aillikite and some kimberlites are very subtle and can only be discerned by detailed petrology of fresh samples (Tappe et al., 2005). Furthermore, the term 'kimberlite' can be subdivided into 'Type-I' and 'Type-II' kimberlite, the latter term being typically regarded as equivalent to the rock type 'orangeite' (Mitchell, 1995). Due to the complexity and often subtlety required to correctly identify diamond host rocks, in the absence of a true petrological classification a practical field term is

useful. With the exception of lamproites, which, when not strongly weathered, can be separately identified, it is common to refer to primary igneous diamond host rocks as 'kimberlites' or 'kimberlitic rocks'. Although using the same word as both a field term and a precise petrological term can cause confusion, particularly when rigorous classification is important, this is the accepted practice within the industry. Other terms have been used, for example, the De Beers Group of companies, including Charter Consolidated Ltd, Monopros Limited and Stockdale Prospecting Ltd, often use the term ‘para-kimberlite’ to refer to rocks which have no formal petrological classification, but may be kimberlites. Depending on the familiarity of the field geologist with kimberlites, some examples of “kimberlitic rocks” which would correctly be termed lamproites may occur. Therefore, where it arises in the DED, the terms 'kimberlite', ‘lamprophyre’ and ‘UML’, or ‘ultramafic lamprophyre’, are used without prejudice and as originally reported. Users of the database should be aware that in many, but not all cases, these terms are used as field terms and as such, should often be considered interchangeable.

Furthermore, regarding terminology, diamond itself is one in the range of minerals indicative of the diamond potential of a prospect. Hence, diamond is often implied where the term 'indicator mineral' is used. However, in some cases it is useful to distinguish between diamond and nondiamond indicator minerals. An example of this is the database field <TOTIND_PKG> where diamond is specifically excluded. In this and similar cases, the exclusion of diamond is made clear in the field definitions.

Understanding the USB product

Files constituting the database and accompanying this Report have been assigned to the four principal folders described in Table 1. The product comprises copies of pre-existing documents and spatial layers of relevance to diamond exploration, such as geological and geophysical maps, government and company reports and GIS layers. Concerning the files unique to the database itself, the core DED data reside in nine MS Excel (.xlsx) files, which have associated data dictionaries and GIS layer files derived from these.

Folders

\ARCMAP-QGIS folder

The ARCMAP-QGIS folder contains the project file 'DED_GL.mxd'. This is the primary ESRI ArcMap document 'front-end' to the Database in ESRI ArcGIS format. It also contains the QGIS project file DED_GL.qgz, for users of QGIS and which accesses the same ESRI .shp files read by DED_GL.mxd. The

project files open directly from relevant ESRI or QGIS software and reference various files contained in the subfolders of the \ARCMAP-QGIS folder. These provide the geological and geographical context of the data, in addition to aspects of the data presented as thematic and geographically referenced layers. Both DED_GL.mxd and DED_GL.qgz are designed to display the DED in an intuitive way useful to the diamond explorer. However, all spatial layers can be accessed directly as required by the user of the product.

Table 1. Principal subdivision of files provided in this USB product

FOLDER	*Description of contents*
\ARCMAP-QGIS	Contains the database data presented as ESRI ArcGIS and QGIS format projects and feature classes, including thematic maps elucidating key aspects of the data. Also contains background spatial data of use to the diamond explorer such as geographic, geological and geophysical data in various formats.
\DATABASES	Contains MS Excel spreadsheets constituting all of the diamond exploration data in their original, captured form
\DOCUMENTS	Contains data dictionaries defining the format of the data and metadata files, describing the rules and any assumptions applied during the population of records in particular fields
\MAPINFO	Contains the database data presented in MapInfo format (v10), including thematic maps elucidating key aspects of the data

The \ARCMAP-QGIS folder is subdivided into a folder containing background spatial data (\REFERENCE) and a folder (\DED_GL) containing the principle spatial data new to this package. Files are provided as .shp, .lyr, .qlr and .qml formats, with the latter three preserving symbology. In ARCMAP-QGIS\DED_GL, in addition to spatial data and queries deriving from the core MS Excel files of the DED, five further GIS files are included which are unique to the DED and are described in Table 2. Included are buffer zones describing areas within and outside 20 km from known sample locations, outlines and dyke-traces of selected diamond-prospective in situ occurrences, and the surface traces of inferred, but not proven dykes and sills. The purpose of the buffer zone polygons are to discriminate areas which can be considered unexplored, compared to areas which are close enough to a sample site to be considered, at least partially, explored. Buffer zones are clipped to the Greenland coastline at 1:500 000 scale as the majority of samples, which are surface sediment samples, provide no information on what in-situ bodies may lie in nearby areas below sea level. In contrast, exploration buffer zones are not clipped by areas of permanent ice as it is expected that samples may provide some information on in situ rocks under the ice.

The \ARCMAP-QGIS\REFERENCE folder contains a large number of spatial data files covering geography, geology, geophysics, mineral tenure, and map boundaries of relevance to the diamond explorer. Some of the most commonly used data are included in the ArcGIS and QGIS projects (DED_GL.mxd and DED_GL.qgz) such as lakes, rivers and coastline, 1:500 000 and 1:2 500 000 scale geology, regional

magnetism and mineral tenure boundaries. However, many, such as local-scale geophysical surveys are not linked to from these projects and are provided as a resource for users of the DED product to explore and integrate as they see fit.

Table 2. DED-unique spatial layers

Layer	*Description*
DED_GL_Explored_Polygons	Areas within onshore Greenland which lie within a 20 km radius of a sample location identified in file 'DED_GL_BASICS.xlsx'. This file is the inverse selection of DED_WA_Unexplored_Polygons. The significance of 20 km as a cutoff is fairly arbitrary, but it is at the upper limit of the expected indicator mineral survival distance and serves as a visual estimate of the sphere of relevance for individual samples. Note that within areas defined as explored, there are sample locations where the samples have not been processed, particularly in East Greenland amongst the Nordisk Mineselskab A/S datasets. Explored areas are clipped to the Greenland coastline at 1:500 000 scale and the inland ice at 1: xxx scale.
DED_GL_Occurrences_Polygons	Spatial information describing at or near-surface outlines of selected in situ occurrences of diamond-prospective bodies. Further information of samples and localities, where relevant, are included in the file DED_GL_OCCURRENCES.xlsx and associated spatial point layer.
DED_GL_Occurrences_Polylines	Spatial information describing at-surface traces of selected in situ occurrences of diamond-prospective bodies. Further information of samples and localities, where relevant, are included in the file DED_GL_OCCURRENCES.xlsx and associated spatial point layer.
DED_GL_Inferred_Polylines	Spatial information describing inferred traces of selected diamond-prospective bodies. Further information of samples and localities, where relevant, are included in the file DED_GL_FLOAT.xlsx and associated spatial point layer.
DED_GL_Unexplored_Polygons	Areas within onshore Greenland which lie beyond a 20 km radius of a sample location identified in file 'DED_GL_BASICS.xlsx'. This file is the inverse selection of DED_WA_Explored_Polygons. The significance of 20 km as a cutoff is fairly arbitrary, but it is at the upper limit of the expected indicator mineral survival distance and serves as a visual estimate of the sphere of relevance for individual samples.

Data are provided unmodified from their original sources, such as company reports, and company and GEUS archives. In many cases, including for GEUS products, metadata have not been created and keys to symbology are absent. Metadata, raw data and accompanying reports are provided in their relevant folders where available. For geophysical data, these are subdivided between regional and local-scale surveys. Local-scale surveys are further subdivided based on their source report number or the most applicable source report (included in \DOCUMENTS\) in cases of surveys submitted outside of the normal reporting framework. All contextual data are provided in the in their most current forms. While

considerable, the background data provided represent only a portion of the geotechnical, geological, geophysical, and geochemical data, incrementally updated and available online from the Government of Greenland's Interactive GIS-map of Greenland (http://www.greenmin.gl) available on http://maps.greenmin.gl/geusmap/?mapname=greenland_portal, the Greenland Minerals Authority (https://www.govmin.gl/) and the GEUS-hosted data webshop website at https://frisbee.geus.dk/webshop/ (also available through greenmin.gl). Attention is drawn to the full set of archived geophysical data in geophysical_surveys.shp, which is included as feature classes in DED_GL.mxd and DED_GL.qgz.

Table 3. Thematic GIS layers elucidating various aspects of the exploration data

Layer	*Shapefile*	*Notes*
Microdiamonds	DED_GL_thm_BA_ind_micro	Indicates the locations of reported microdiamonds with the symbol size reflecting their abundance in each sample
Macrodiamonds	DED_GL_thm_BA_ind_macro	Indicates the locations of reported macrodiamonds with the symbol size reflecting their abundance in each sample
Indicator minerals	DED_GL_thm_BA_ind_inds	Represents the occurrences of visually identified nondiamond indicator minerals as pie charts subdivided on the basis of phase with the radius proportional to total number of grains reported
Diamond concentration	DED_GL_thm_BA_ind_dia_per_kg	Represents diamond-bearing samples with symbol sizes proportional to total diamonds recovered per kg of sample
Nondiamond concentration	DED_GL_thm_BA_ind_inds_per_kg	Represents samples with nondiamond indicators, identified visually and with symbol sizes proportional to the total indicators recovered per kg of sample
Chemical indicators – clinopyroxene	DED_GL_thm_BA_ind_chemCPX	Represents the occurrences of chemically identified indicator clinopyroxenes as pie charts subdivided on the basis of classification
Chemical indicators – orthopyroxene	DED_GL_thm_BA_ind_chemOPX	Represents the occurrences of chemically identified indicator orthopyroxenes as pie charts subdivided on the basis of classification
Chemical indicators – Ilmenite	DED_GL_thm_BA_ind_chemILM	Represents the occurrences of chemically identified indicator ilmenites as pie charts subdivided on the basis of classification
Chemical indicators – garnet	DED_GL_thm_BA_ind_chemGT	Represents the occurrences of chemically identified indicator garnets as pie charts subdivided on the basis of classification
Chemical indicators – spinel	DED_GL_thm_BA_ind_chemSP	Represents the occurrences of chemically identified indicator spinels as pie charts subdivided on the basis of classification

Queried data

The thematic GIS layers within the ESRI ArcGIS / QGIS projects are designed to be self-explanatory. They query the DED data in a fashion that draws attention to geographic areas exhibiting a variety of properties suggesting diamond potential. The thematic layers included in the project are described in Table 3. Files are provided as .shp, .lyr, .qlr and .qml formats, with the latter three preserving symbology.

Although some basic concepts, such as indicator recovery per kilogram, microdiamond and macrodiamond recovery, and the relative proportions of specific mineral chemical classifications are presented as thematic maps, users of the product are encouraged to use the large quantity and variety of data available to create queries suitable for their own particular requirements. Considerable effort has been applied to ensure data conform strictly to the data dictionaries, for example such that values are quoted with consistent units. Significant scope exists within the data in their current form, therefore, to conduct sophisticated querying, statistical treatments and quality control filtering.

\DATABASES folder

The DATABASES folder provides the core of the newly-compiled DED data. MS Excel files are provided in the MS Excel open spreadsheet XML file format (.xlsx). The MS Excel files constitute the definitive locations for data unique to the DED and from which ESRI ArcMap, QGIS and MapInfo format files have been subsequently derived. The data contained in these files are described in Table 4. The DED MS Excel files are also presented, linked according to their common keys in the MS Access 2007 (.mdb) format file DED_GL.accb.

The DED MS Excel files have been constructed in a fashion to minimise repetition of data fields. Consequently, for example, location coordinates are only provided in root files on which others depend. The DED is split into two groups of files (Fig. 1): those relating to exploration samples where location data are held in the root file DED_GL_BASICS.xlsx and those relating to attributes of in situ diamond-relevant bodies where the root files are DED_GL_OCCURRENCES.xlsx, DED_GL_FLOAT.xlsx and DED_GL_DRILLHOLES.xlsx. All data files incorporate unique reference keys for each record. The <SAMPLEID> field provides a unique numerical identity for each sample and the <INDID> field provides a unique identity for each subsample. For in situ bodies, the <OCCURID> field constitutes the primary key allowing a link to geochronology data. The unique keys allow cross-referencing of data between files. However, the GIS folders (\ARCMAP-QGIS and \MAPINFO) provide various layer files where cross-referencing queries of the data matching some key concepts from the various data files have been already made.

Table 4. Primary data files

Data file	*Description of contents*
DED_GL_BASICS.xlsx	Source of basic location, sample description, and data source information for samples recovered in the course of Greenland's diamond exploration
DED_GL_BULK_ANALYSES_Indicators.xlsx	Sample processing, methods, and recovery results from samples and subsamples tested for indicator minerals, including diamond
DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx	Source of major and minor element mineral chemical data derived from individual mineral grains picked from samples recovered
DED_GL_GRAIN_ANALYSES_Trace_Chem.xlsx	Source of trace element mineral chemical data derived from individual mineral grains picked from samples recovered
DED_GL_GRAIN_ANALYSES_Diamond.xlsx	Source of descriptive information for individual diamonds picked from samples recovered in the course of Greenland's diamond exploration
DED_GL_DRILLHOLES.xlsx	Locations of drillholes and physical characteristics of extracted rocks created during the course of Greenland diamond exploration. Not all holes intersected prospective rocks but where this occurred, they are documented. Excluded are drillhole locations in carbonatites where exploration was carried out for non-diamond commodities such as rare earth elements
DED_GL_OCCURRENCES.xlsx	Locations and physical characteristics of definitively identified in situ occurrences of rocks which in principle may have an affiliation with diamond, viz. kimberlites, lamproites, ultramafic lamprophyres such as aillikites, and carbonatites
DED_GL_OCCURRENCES_AGES.xlsx	Determinations of emplacement age of occurrences
DED_GL_FLOAT.xlsx	Locations and physical characteristics of inferred in-situ bodies and transported rocks which in principle may have an affiliation with diamond, viz. kimberlites, lamproites, ultramafic lamprophyres such as aillikites, and carbonatites

Each data file has corresponding metadata presented in data dictionary files entitled 'Dictionary_*.xlsx', where the star symbol '*' represents the name of the data file to which it refers. Data dictionaries describe the structure of each file, give brief definitions and formatting rules applied to each field, and any rules regarding mandatory population or controlled vocabularies for each field. These rules also apply to the GIS data files. As GIS layers truncate field names at 10 characters, the data dictionaries also provide the abbreviated field name used in GIS files for each full descriptive field name used in the .xlsx files. Many of the key concepts described by metadata files are discussed in this document. Additional metadata files are included for various GIS layers where available and are provided together with their accompanying datasets in subfolders of \ARCMAP-GIS.

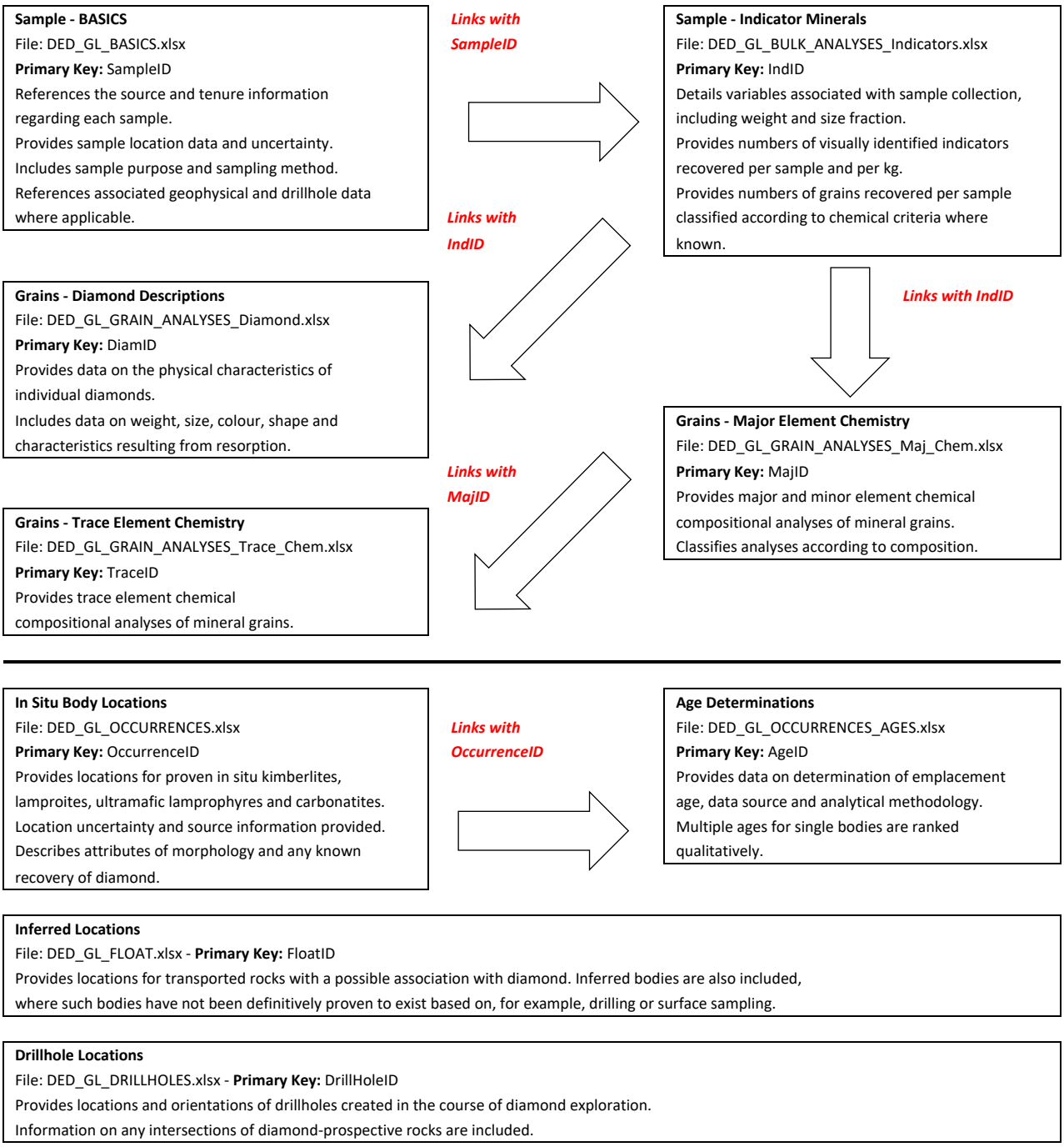

Figure 1. Structure of the Diamond exploration and prospectivity data package. The MS Excel spreadsheets located in the DATABASES\ directory contain the control data and source Excel spreadsheets. They are the definitive locations for diamond exploration data captured into the package. Data dictionary files allow the user to link the MS Excel file field names to the GIS file field names.

\DOCUMENTS

The DOCUMENTS folder contains publicly-available reports of relevance to Greenland's diamond exploration. Where numerous reports are attributed to particular companies or organisations, these are

assigned to their own folder, otherwise they are placed in the \DOCUMENTS\Various folder. Some exploration work has been carried out by joint ventures between various companies and so it is cautioned that reports attributed to a particular company may reside in a folder named after a partner company. Furthermore, some records in the DED refer to academic papers as data sources. These are generally are not included due to copyright considerations.

\MAPINFO folder

The MAPINFO folder contains spatial data files in MapInfo .tab and associated formats. Specific files equivalent to each of the core MS Excel data files located within the \DATABASES folder are provided. They have been generated following the rules described in the equivalent MS Excel data dictionary files.

In addition to spatial data deriving from the core MS Excel files of the DED, five further GIS files unique to the DED are included and described in Table 2. Included are buffer zones describing areas within and outside 20 km from known sample locations, outlines and dyke-traces of selected diamond-prospective in situ occurrences, and the surface traces of inferred, but not proven dykes and sills. The purpose of the buffer zone polygons are to discriminate areas which can be considered unexplored, compared to areas which are close enough to a sample site to be considered, at least partially, explored. Buffer zones are clipped to the Greenland coastline at 1:500 000 scale as the majority of samples, which are surface sediment samples, provide no information on what in-situ bodies may lie in nearby areas below sea level. In contrast, exploration buffer zones are not clipped by areas of permanent ice as it is expected that samples may provide some information on in situ rocks under the ice.

In addition to spatial data files generated from the core DED data, various background files are provided in .tab format. Users of the USB product are also directed to other file formats such as .grd and georeferenced .tif files in subfolders of \ARCMAP-QGIS\ which may be readable by MapInfo. All contextual data are provided in the USB in their most current forms. However, the background data provided represent a small portion of the geotechnical, geological, geophysical, and geochemical data, incrementally updated and available online from the Government of Greenland's Interactive GIS-map of Greenland (http://www.greenmin.gl) available on http://maps.greenmin.gl/geusmap/?mapname=greenland_portal, the Greenland Minerals Authority (https://www.govmin.gl/) and the GEUS-hosted data webshop website at https://frisbee.geus.dk/webshop/ (also available through greenmin.gl).

Queried data

As for the ESRI ArcGIS and QGIS projects, while not displayed within a MapInfo workspace, subsets of the DED data are provided in such a fashion to readily allow thematic mapping. These files are entitled 'DED_GL_thm_BA_*.tab'. Files appropriate for thematic mapping are the same as for the ESRI ArcMap and QGIS projects and are as described in Table 3.

While some basic concepts, such as indicator recovery per kilogram, microdiamond and macrodiamond recovery, and the relative proportions of specific mineral chemical classifications are presented as files querying the DED data, users of the USB product are encouraged to use the large quantity and variety of data available to create queries suitable for their own particular requirements. Considerable effort has been applied to ensure data conform strictly to the data dictionaries, for example such that values are quoted with consistent units. Considerable scope exists within the data in their current form, therefore, to conduct sophisticated querying, statistical treatments and quality control filtering.

Database structure and contents

Within the context of the two groups of the DED MS Excel files (regarding samples, and diamond-prospective rocks, transported or in situ), the individual files constituting the DED were created in a structured fashion that provides a consistent link between each file. Figure 1 summarises the contents and describes the relative associations of each core file. Each record within each file has its own numerical identifier, unique within each spreadsheet. Furthermore, each sample has an associated and unique numerical key, <SAMPLEID>, which links through each file to entries within the core file DED_GL_BASICS.xlsx and also a subsample ID (<INDID>), which links from MS Excel file DED_GL_BULK_ANALYSES_Indicators.xlsx. As such, the files in the \DATABASES folder can readily be adopted into database software such as MS Access, DataShed, SQL or Oracle according to the structures established by individual users of the data. An MS Access file is provided for convenience.

Rules, assumptions, and identified shortcomings of the data are discussed in the following sections and presented in a comprehensive fashion in data dictionary metadata files located in the the \DATABASES folder of the USB product. Field names referred to hereafter follow the formats of the core MS Excel files as defined in associated data dictionaries. For software compatibility reasons some of these field names have been altered (i.e. capitalised and truncated) for the generation of shapefiles, as documented in the data dictionaries \DATABASES. However, correlations between MS Excel and GIS field names are self-explanatory.

Primary key – <SAMPLEID>

In order to readily discriminate various principal sources of data within the database, primary key <SAMPLEID> values have been assigned in batches, as described in Table 5.

In some cases some <SAMPLEID> numbers appear to be missing. This is because during the compilation of data, particular samples may have been assigned multiple <SAMPLEID> values and later identified as repeats. This arises, for example, when the same sample has been reported in more than one company report. Where obvious repeats have been identified these have been removed from the final database in order to ensure that statistics involved in the numbers of samples are as accurate as possible.

Table 5. Assignment of <SAMPLEID> records

Number range	*Data source*
100 001–113 520	Records integrated from Geological Survey of Denmark and Greenland's (GEUS) Report 2004-117 Diamond exploration data from West Greenland: 2004 update and revision (Jensen et al., 2004)
200 001–200 205	Sample collected by Nuna Minerals A/S and sourced from public records, company datasets and consultants
300 001–301 717	Samples derived from GEUS reports in addition to Report 2004-117 (Jensen et al., 2004). Also included are records from academic papers deriving from GEUS researchers
400 001–400 228	Samples collected by Avannaa Resources Ltd. and associated companies, and sourced from public records, company datasets and consultants
500 001–500 506	Samples collected by Hudson Resources Ltd.and sourced from public records and consulting geologists
700 001–700 277	Samples collected by IceflRe Diamonds A/S and associated companies and sourced from public records and consulting geologists
800 001–808 582	Samples derived manually from submitted company reports and other sources as distinct from those acquired in batch form from specific companies or from existing datasets

Data sources

Table 5 broadly describes the data sources, and field terms throughout the DED give the specifics of these sources. However, some important considerations in the logic behind integrating, or ignoring data is merited.

The Report 2004-117 (Jensen et al., 2004) is a significant source of data for the DED. Consequently a quality assessment of data in GEUS2004-117 has been conducted as a prelude to integration of records into the current database. Due to the quantity of data this has been limited in its scope. Recourse to source documents has generally only been made on occasions where discrepancies in sample locations occur between different spreadsheets within GEUS2004-117. Otherwise records are assumed to be a true and complete reflection of data appearing in referenced reports. This assumption is not necessarily always prudent as examples of values quoted using incorrect units in numerical fields have been identified and corrected. Queries of records with <SampleID> between 100 001 and 113 520 should account for the partly blind integration of these data into the DED.

Jensen et al. (2004) limited their assessment of diamond exploration data to south of 70°N latitude and west of 44°W longitude. Despite the 2004 publication date, aside from 3 samples taken by Dia Met Minerals Ltd in 2001 the most recent company reported data incorporated in Jensen et al. (2004) dates from 1999. Almost all sample locations in Jensen et al. (2004) taken in the 2000s were collected by GEUS (392 samples). Hence in populating the DED, 1999 was taken as the earliest year to conduct a thorough search for further diamond exploration data in South and West Greenland with earlier reports being incorporated when identified as missing. For example, hundreds of missing samples particularly from Charter Consolidated Ltd (affiliated with De Beers) and Platinova pre-dating 2004 were not included in GEUS2004-117 and where these have been identified, they are included in the DED.

The period of approximately 2000 to 2010 saw considerable diamond exploration activity in Greenland with the most active companies being Hudson Resources Ltd, Avannaa Resources Ltd, Icefire Diamonds A/S and Intex Resources ASA, Metalex Ventures Ltd, and Nuna Minerals A/S. A mixture of company reports and data made available from external consultants and laboratories via the companies themselves, has allowed the DED to be populated comprehensively with data from this prolific period. Furthermore, the geographical restriction of Jensen et al. (2004) has been dropped such that the DED incorporates exploration data relevant to diamonds from all geographic extents of Greenland. Included are hundreds of samples from the coast of East Greenland from near Kap Discord (Kangeq) at 60°48’N to Kuhne Ø north of Daneborg at 75°0’N, North Greenland in Inglefield Land and extending to Nares Land at 82°34’N, and West Greenland to a latitude of 72°52’N in Melville Bay east of Savissivik.

During the course of populating the DED, various databases have been encountered which document samples which were not specifically collected for diamond indicator mineral identification, and yet because suitable size fractions are archived, they are appropriate for laboratory-based diamond exploration. Examples include 844 surface sediment samples associated with the SEGMENT project in East

Greenland (GEUS Report 2016-38; Kolb et al., 2016) and the Nordmine database (GEUS Report 2009-71; Thomassen and Tukiainen, 2009 and GEUS Report 2009-72; Thomassen, 2009). Such samples are included in DED_GL_BASICS.xlsx (noted in <SamplePurpose> as 'Bulk_Chemistry_Oversize-Archived') but unlike sporadic samples from other sources which may have been unprocessed, they are not included in DED_GL_BULK_ANALYSES_Indicators.xlsx. This allows the user to readily discriminate between the large number of un-critiqued but useful samples, from genuine diamond exploration program samples.

Field population rules

General population rules

The 338 fields comprising the database provide a large platform to incorporate diamond exploration data. However, because data have been compiled from numerous sources, many may have their own priorities in terms of data acquisition. Hence, for any one record many fields may not be populated. There are various reasons for these omissions. Some are logical omissions, such as diamond descriptions for diamond-absent samples and drillhole depths for surface samples. However, omissions are also present where the data are not reported in the source, in which case 'Not Reported' or similar terminology is used. During the population of the DED some data sources have been deemed to be too time consuming to scrutinise in detail. In this case the term 'Not Assessed' is used. Where there are omissions, users of the database are directed to the original data sources where a more detailed picture of the diamond exploration may be available.

All records have location information attributed and other mandatory fields are described in the accompanying data dictionaries. Useful, but often unreported fields include minimum sieve sizes, dense fraction concentrate weight, occurrences of non-traditional indicator phases, and mineral chemical quality control and classifications. The original sample location coordinates are also provided in separate fields in order to minimise any of the uncertainty occasionally associated with reprojection of sample coordinates or to document errors in sample locations which have been corrected from their source.

Considerable efforts have been made to assess and improve the quality of data obtained from the various sources. Sample locations have been regarded to be of highest importance and have been given particular attention. Examples of quality control include verification against primary sources for samples which plot in unexpected places. There are a small number of genuine offshore samples. However, some land-derived sample coordinates obtained from third party sources corresponded to offshore locations before being corrected. Other samples were identified to have been reported with the incorrect UTM zone or

with typographic errors. Assumptions in making corrections are provided in 'Comment' fields. However, users of the database are referred to primary data sources in cases of uncertainty.

Blank fields exist for the following reasons: either the data has been deliberately omitted (because it was not reported or queried) or the particular field is not of relevance to the record in question. Where a blank field represents unassessed data, such data may or not be available in the original data source referred to. It should not be assumed that blank fields mean that the information does not exist.

In MS Excel, for example, text can be recorded in otherwise numerical fields for ease of presentation and manipulation of the data. However, it should be noted that some MS Excel formulae do not adequately discriminate between text and zero values or blank cells. For fields which largely contain numerical data, particularly if entries are likely to be subjected to statistical testing, these are formatted as numerical fields. Blank entries are not used in fields that are defined as being numerical. This is because some software, such as MapInfo, converts all blank entries of imported data into zeros. This is inappropriate for fields where it is critical to distinguish between blanks and zeros. For example, there is a clear distinction between a sample that was processed and yielded zero diamonds and a sample for which this information is either not available or was not assessed. A series of numerical codes in the form of negative integers have therefore been used to represent various concepts relating to otherwise blank numerical fields. These codes are summarised in Table 6.

Table 6. Numerical codes to represent text in numerical fields

Code	*Definition*
-111	Not applicable. For example, an entry in <GT_G10> (counts of chemically determined G10 grains) where no garnets were recovered from the sample. Note that this code is not consistently used, in place of zeros, but in such cases the applicability of a field is evident from the contents of other fields.
-222	Not possible to calculate. For example, an entry in <Diam_perkg> (total diamonds per kilogram) where the sample weight is unknown.
-333	Not assessed. Such a field has not been populated because the relevant data source has not been searched for the presence or absence of applicable data. In such cases the database user is directed to the referenced data source.
-444	Below detection limit. This code applies to mineral chemical data and the applcable detection limit reported in such cases is described in <Comments> fields.
-555	Analyte not determined. This code applies specifically to mineral chemical fields (e.g. <SiO2>) where a particular analyte has not been measured, as opposed to returning a zero or below detection limit value.
-999	Not reported. This code denotes that. the field cannot be populated because the data source does not mention data applicable to the field. It should therefore not be assumed that any result is zero but it is not likely that recourse to the source will yield more information.

In some cases, it is desirable to specifically note that a particular field is not applicable to a particular record. This is true especially for numerical fields where blanks cannot be used. In text fields, terms like 'Not_Applicable' are used. For numerical fields the number '-111' is used to denote the status of 'Not_Applicable'. Entries in fields that are defined as numerical use the number '-222' to denote 'Not_Calculable'. This code indicates that the data reported do not allow for such a calculation to be made. For example, where sample weight is neither reported nor can be reasonably estimated, recovery of diamonds per kg of sample is not calculable. In numerical fields, which would otherwise be blank, entries are represented by the number '-333' to denote the status of 'Not_Assessed' and '-444' is used in cases of analytes being below detection limit. Distinctly different from blank entries, the term 'Not_Reported' in non-numerical fields indicates that the data has been searched for, but it is not present in the data source. Such entries establish that it is unnecessary to refer to the original source to investigate the presence of these data. Entries in numerical fields use the number '-999' to denote the status of 'Not _Reported'.

While numerical codes are useful, particular care should be taken to remove them from extracts of the data before statistical calculations are made.

Field-specific population rules

Basic data – DED_GL_BASICS

The DED_GL_BASICS.xlsx file provides the basic location data for each sample and references its source. Selected fields within this file that warrant detailed explanations further to those provided in the data dictionaries are as follows.

Sample names (<SOUSAMPNA>)

Reported sample names are exactly as reported in the data source except in very rare cases where prohibited characters are used. In such cases characters have been replaced with suitable alternatives. Where Jensen et al. (2004) has acted as the source of data <SOUSAMPNA> reflects the source name provided therein. However, it should be noted that Jensen et al.'s (2004) convention was to add the report name or number as a prefix to the original source name joined with an underscore. In populating the DED with Jensen et al. (2004) data this convention has been retained but users of the DED are advised that in order to cross-reference <SOUSAMPNA> entries to original sources, prefixes should be ignored. It is also notable that in some cases, punctuation in sample names has been changed or ignored between

various source reports and so caution is advised when looking for sample names in source material. For example, a sample termed '61.V2 01' may appear as '61V201' or '61.V2-01' in various documents.

Location data (<LONGITUDE>, <LATITUDE>, <PUBYEAR>, <ORIG_LONG>, <ORIG_LAT>, <ORIG_X>, <ORIG_Y>, <ORIGZONE>, <ORIGDATUM>, <LOCMETHOD>, and <LOC_ACC>)

Sample location information that can correctly direct an explorer to a sample site, either in person or through a GIS package, is a core component of the DED. A number of factors influence the accuracy of location data. Many older company reports provide location data only as graphical representations on maps plotted at various scales. In such cases, sample locations have been captured by means of georeferencing and in some cases also by rectifying maps. Notes are made in the <LOCMETHOD> field to this effect. Hence, in addition to the often unknown accuracy of the reported data themselves, the process of estimating locations from maps introduces further uncertainty. Estimation of location data in this way is particularly relevant to samples from Charter Consolidated Ltd reports and Nordmine data (Thomassen and Tukiainen, 2009). Considerable work has been applied (Thomassen and Tukiainen, 2009) to reproject Nordmine maps in order to estimate correct sample locations according to WGS84, but significant uncertainties should be expected. Irrespective of the format in which the data was presented, pre-GPS location information was almost always achieved by cross-referencing topographic features with their representations on published government maps. Although GPS determinations were made in the early 1980s the technology does not appear to have been in common use until at least 1990. While the DED provides an estimate of the uncertainty of location data through the <LOCMETHOD> and <LOC_ACC> fields, where this information is not reported, data users should consider the age of the sample (<PUBYEAR>) and any other relevant information to assess the usefulness of positional data to their specific needs. Except in cases where accurately described and identifiable geographic features can be established, as a general rule of thumb, pre-1990 location data should not be expected to have a precision better than 100 m.

Further uncertainties have been introduced due to changes in mapping protocols. As the name suggests, the World Geodetic System 1984 (WGS 84) was implemented in 1984, replacing prior spheroids. The WGS84 system was current during the large majority of sampling compiled in the DED. However, the NAD83 system was used in some cases, most notably for conversion of Nordmine data (Thomassen and Tukiainen, 2009). While latitudes and longitudes are based directly on the appropriate datum, often the UTM (Universal Transverse Mercator) metric map projection system has been used for geological work in Greenland. Greenland lies within UTM zones 18 to 28. Zone 22 (48°W to 54°W) is most commonly used in west Greenland and zone 24 is used for whole-Greenland map projections.

Although the DED captures location data as originally reported (referencing the particular datum and projection), all locations are also presented in their equivalent decimal latitude and longitude coordinates in WGS94. The WGS94 coordinates (presented in fields <LATITUDE> and <LONGITUDE>) are the definitive locations, which have been used for all spatial queries and layers in the DED. Using a consistent projection system for the database is important for presenting an internally consistent picture of exploration. The fifth decimal place in latitude and longitude at the equator represents approximately 1 metre and hence no more than five decimal places are relevant for location data in the database (and in the case of longitude at extreme northernly latitudes, fewer are justifiable). Many sources have reported location data up to 13 decimal places. The convention for populating <Longitude> and <Latitude> is that all coordinates reported at more than six decimal places numbers are rounded to the sixth decimal place. Otherwise, values are quoted as in the original source.

Composite sample locations (<LONGITUDE>, <LATITUDE>, <LOCAT_TYPE>, <ORIG_LONG>, <ORIG_LAT>, <ORIG_X>, <ORIG_Y>, <ORIGZONE>, <ORIGDATUM>, <LOCMETHOD>, and <LOC_ACC>)

It is common for companies to process composite samples over considerable lengths of drillcore. However, some companies have created composite samples incorporating material from a sometimes wide range of geographical locations. Treatment of the data resulting from such a sampling methodology presents particular problems. A consistent approach for treating composite samples has been applied to reduce the degree of uncertainty to a minimum. In terms of locations, problems arise in connection with assigning location data and even more seriously with mineral recovery data. Composite samples are identified by an entry in the <LOCAT_TYPE> field in the form of 'Composite_xx', where 'xx' denotes an integer representing the number of samples in the composite. Where individual sample names are known, they are itemised in the 'Comment' fields. In some cases, a central coordinate is reported and this is the information given in the database. For example, sometimes five-fold composite samples may have been reported to have been taken in a four-pointed star shape with a portion of the composite taken at a central location. In other cases, the coordinate quoted is an estimate of the most representative geographical location of the components of the composite sample. Extensive use of the 'Comment' fields has been made to describe the assumptions used in generating the reported coordinates.

Sample material (<SAMP_MATRL>)

The controlled vocabulary of <SAMP_MATRL>, provided in the file 'Dictionary_DED_GL_BASICS.xlsx' provides a self-explanatory description of the content of this field. It is notable that wherever possible, discrimination between current and paleodrainages has been made when populating the DED. In cases where this has not been possible or practical, such samples are simply referred to as 'alluvial'. Furthermore, Talus, Glacial - Moraine and Glacial - Erratic, Subcrop, Cover - Rock, and Rock <SAMP_MATRL> designations are rock samples typically collected for mineralogy, bulk chemistry, geochronology petrology or reference purposes as distinct from unconsolidated polymineralic samples collected for loose indicator mineral identification, and in some cases element tracer studies through bulk chemistry.

Trap quality (<TRAP_QUAL>)

Trap quality is a subjective term. Classification schemes exist in the academic literature (Muggeridge, 1989, 1995) and some companies have also attempted to standardise their terminologies. However, there is likely to be a large variability in what constitutes various trap site qualities in different areas and between and within companies. Due to the importance of trap site quality the field has been assigned a controlled vocabulary and where necessary reported terms have been modified to the closest apparent fit to the controlled vocabulary.

Sample purpose (<SAMPURPOSE>)

The majority of diamond exploration samples were collected for the purpose of physical separation and identification of indicator minerals, often also including diamond itself. Nevertheless, a significant number of samples were collected for other reasons, such as bulk chemical analyses, geochronology or determination of indicator mineral compositions through preparation of thin sections. The <SAMPURPOSE> field describes the intent for processing the sample. Geochronology data are reported in DED_GL_OCCURRENCES_AGES.xlsx and thin section mineral data in DED_GL_BULK_ANALYSES_Indicators.xlsx and DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx. The DED does not capture the results of the chemical analyses of sediment or bulk rock samples. However, most data reported as 'Bulk_Chemistry' and its derivatives are the results of chemical testing provided in the referenced data source.

<SAMPURPOSE> entry 'DIM-Indirectly' refers to samples taken for heavy mineral identification where the purpose was not specifically to look for diamond-prospective sources, rather more focused on base metals

exploration. The principle contributor of data attributed in this way are entries from the Nordisk Mineselskab A/S work in East Greenland. These samples are included in the database because some mineral picking results are of use for diamond exploration, the samples are archived at GEUS and available for further work and diamond-prospective rocks have been reported in the general area.

Drillhole samples (<COLMETHOD>, <COMPHOLEID>, <DRILHOLEID>, <DEPTHFROM>, and <DEPTHTO>)

The database refers to numerous samples taken from drillholes, as identified in the field <COLMETHOD>. Basic data regarding samples and indicator mineral recovery data are provided in DED_GL_BASICS.xlsx in the same fashion as samples acquired by other means. However, a separate drillhole dataset, providing more detailed technical and lithological information for some drillholes is provided in DED_GL_DRILLHOLES.xlsx. Drillholes present in both files may be cross-referenced using the <DRILHOLEID> field.

Associated local geology (<GEOLASSOC>)

Each record in the DED is attributed with a corresponding associated geology at 1:500k scale using the digital 1:500k map published in www.greenmin.gl (Pedersen et al., 2013). It should be noted, however, that this map is not a solid geology map and consequently some records are attributed with lake, ice, river, land and undifferentiated Quaternary cover. The attribution has been carried out as a spatial query of the 1:500k data without prejudice to the result. However, hundreds of polygons in the 1:500k map have invalid geometries (not closed) for the purposes of attributing the DED records. Hence some 5,000 records were attributed manually. In cases where some of the manually-attributed records were assigned to the sea or lakes, on the assumption that at 1:500k scale the coastline and lake positions are subject to uncertainty, the nearest geological unit (solid or bedrock) was attributed. It should also be noted that many records in the DED represent surface sediment samples and it should not therefore be assumed that <GEOLASSOC> reflects the material which was sampled. Rather, the field serves to provide the geological context within which the sample was taken. Users of the database should refer to <SAMP_MATRL> and <LITH_DESCN> for what was sampled.

Regional geological context (<GEOL_REG>)

The 1:2500k geological map of Henriksen et al. (2009) provides a suitable basis to subdivide records amongst the principle geological regions of Greenland. The <GEOL_REG> field attributes the gu_name field of Henriksen et al. (2009) with some modifications. While there is no established geological criteria

for subdividing the Rae and North Atlantic Cratons between east and west Greenland, their distinct geographical separation (at least 250 km) makes their discrimination useful in the context of diamond exploration. Hence this distinction has been applied in populating <GEOL_REG>. Furthermore, at the time of writing, the digital map arising from Henriksen et al. (2009) is incomplete to the extent that in east Greenland, Carboniferous-Permian and Devonian sediments, Paleoproterozoic and Tertiary intrusives are not assigned to geological regions. This is reflected to date in the 1:2500k digital geological map in www.greenmin.gl being blank in these areas. In order to avoid records in the DED being left, blank attribution has been made as follows: Carboniferous-Permian sediments are assigned to the East-Greenland rift basin, Devonian sediments are assigned to the Devonian basin in central East Greenland, Paleoproterozoic intrusives are assigned to the North Atlantic Craton (East Greenland), and Tertiary intrusives are assigned to the North Atlantic Igneous Province.

Indicator recovery data – DED_GL_BULK_ANALYSES_Indicators

The DED_GL_BULK_ANALYSES_Indicators file provides information on the methods applied and the results of sample processing. Selected fields within this file that warrant detailed explanation further to that provided in the data dictionaries are as follows.

Subsample fields (<INDID>, <SAMPLEID>, <SOUSAMPNA>, and <SOUSUBSAMP>)

During the course of exploration most companies have chosen to assign separate sample numbers to samples destined for different testing methods, but which derived from the same location. These are treated as subsamples, which accounts for the occurrences of multiple records in the DED_GL_BULK_ANALYSES_Indicators.xlsx data file referencing the same <SAMPLEID> entry. Hence, <SAMPLEID> is not a unique key in DED_GL_BULK_ANALYSES.xlsx. Instead, <INDID> is used for uniquely identifying records. For example, two separately labelled samples have sometimes been taken from the same site, one for diamond testing and the other for non-diamond indicator mineral separation. There are other cases where samples have been subdivided after collection, either by simple manual splitting or designating different size fractions for different types of analyses. Some companies have sent the under 0.25 mm size fraction for caustic fusion separation of diamond and the larger size fraction to non-diamond indicator mineral separation. So-called ‘slimes’, typically also sub-0.1 mm in size, are sometimes assigned to bulk chemical analysis. To tackle these subdivisions of samples, in addition to the <SOUSAMPNA> field, DED_GL_BULK_ANALYSES_Indicators.xlsx introduces the subsample identification field <SOUSUBSAMP>. Occasionally the subsample name has been assigned by the submitting company. However, more commonly, the <SOUSUBSAMP> field has been adapted on the basis of a description of the subsample

processing method and, if known, a processing batch number assigned by the processing laboratory. For consistency, all subsample labels are retained in identical forms throughout all daughter data files as described in Figure 1. However, the <INDID> unique field provides the simplest method to link to daughter files regarding subsamples, rather than having to link both the <SAMPLEID> and <SOUSUBSAMP> fields together.

Sample weights (<SAMPLEWT>, <SAMPLEVOL>, and <NUMBAGS>)

Although the number of indicator minerals recovered is a key component of the database, arguably of greater importance is an understanding of the number of indicators recovered per kg of sample. Such a variable removes the bias introduced by sample size and provides a better reflection of proximity to source. Hence, of critical concern is a comprehensive population of the <SAMPLEWT> field. Sample weights are sporadically reported, there are cases when volume (<SAMPLEVOL>) or numbers of bags collected (<NUMBAGS>) instead have been reported. Due to the importance of populating the <SAMPLEWT> field, in such cases, an estimate of sample weight is made based on assumptions of standard sample density or bag weight.

Very few samples report sample weight and volume or bag weight. Sample BG-4-73 from a current beach, reported in Charter Consolidated Limited (1976) records 900 kg for a 400 l sample (SampleID 113080) and despite the fact that various sources report sample volumes this is the only record from Greenland which reports both sample volume and weight. As a marine sample, which likely expresses a different level of sorting compared to an alluvial or glacial till sample it should be treated with caution as a proxy for estimating the weight of other types of samples. At 2.25 kgl^{-1}, this value is higher than the value of 1.65 kgl^{-1} obtained from alluvial samples in Western Australia (Duncan, 1995; Hutchison, 2018b). A total of 3,848 samples from various sources report sample volume but not weight and due to the importance of calculating numbers of indicators per kg of sample, sample weights have been estimated for all of these samples with appropriate notes made regarding uncertainty in the comments fields. McClenaghan (2005) suggests that a 5-10 litre sample of sediment should be expected to weigh 10-20 kg, i.e. with a density of 2 kgl^{-1} and, as her case studies are almost exclusively for alluvial and till samples in glaciated environments similar to Greenland, a value of 2 kgl^{-1} is applied to records herein where sample volume is known and weight is not reported.

Regarding samples collected in bags, Hudson Resources Ltd report 45 rock samples collected in 20 litre rice bags, which average 11.7 kg per bag. In contrast, Hutchison (2011) reports an average of 22.5 kg per bag for samples from the Northern Territory of Australia, closely matching the value of 22.2 kg per bag reported for Western Australia (Hutchison, 2018b). Jensen (2012) reports two bulk kimberlite rock

samples collected in 'big bags' averaging 1,800 kg per bag. Navigator Exploration Corp. (Hopkins, 2006) collected 39 rock samples at Fossilik in 2006 for diamond processing. The type of bags used were not reported but average 0.67 kg per bag so they are clearly not rice bags. Unless the type of bag used is known, a reasonable estimate of sample weight from number of bags reported cannot be made.

Where sample weight is calculated rather than reported, a reference is made in the 'Comment' fields. While allowing variables, such as indicators per kilogram to be calculated, numbers derived in this manner should be treated with caution and errors may be as high as a factor of three.

Composite sample constituents (<SAMPLWT>, <SAMPLEVOL>, <NUMBAGS>, <CONCENTWT>, <MICONCWT>, <CONCWTOBS>, and sample results fields)

Close attention has been paid to the treatment of the rare number of composite samples. This is particularly true for fields in DED_GL_BULK_ANALYSES_Indicators.xlsx. Variables relating to the constituent components of composite samples have only rarely been reported. Consequently, the usual assumption is that each composite component has the same weight. Hence, the <SAMPLWT>, <SAMPLEVOL>, <NUMBAGS>, <CONCENTWT>, <MICONCWT>, and <CONCWTOBS> fields are populated by the total quoted values divided either by the number of samples or, if known, in relative proportion based on sample weight. A similar method to the population of weight-related fields has been used to populate sample results fields. To allow for fractional counts for components of composite samples to be accounted for, the database allows for non-integer entries for indicator counts such as <MACRO>, <CHROMITE> and <SP_CID>. For example, a composite sample from which 125 indicator chromites have been recovered with a known central sample weight of 25 kg and a weight of 10 kg for the four satellite sample components would return four records reporting 19.23 spinels and one record reporting 48.08 spinels. It is not satisfactory having to report fractions of an indicator mineral. However, it is considered to be a more useful reflection of the likely constituents of the samples to assign positive recovery to all components of a composite sample rather than arbitrarily to one. Such a method of subdivision is applied both to visually identified indicator grains, in addition to grains identified by means of mineral chemical analyses.

Mesh sizes (<MESHUPPOBS> and <MESHLOWOBS>)

To be consistent with how the original data are usually reported, the <MESHUPPOBS> field usually quotes the largest sieve size with which grains were captured for mineralogical observation. Consequently, the maximum dimension of the largest grain size is unknown, but is likely only to be slightly larger than the largest sieve size used. In contrast, the quoted value for <MESHLOWOBS> is the smallest sieve size with

which grains were captured for mineralogical observation. Hence, this value represents the true smallest size of the grains studied.

Particular care has been applied in populating the sieve size ranges for each sample with the ranges from which indicator grains were picked. For example, it is common for a sample to be sieved at <2 mm in the field (commonly referred to by diamond explorers as '-2 mm'), whereas concentrates and indicators were only generated from the <1 mm fraction. The latter value is the one which would be entered into the <MESHUPPOBS> field.

Concentrate weights (<CONCENTWT>, <MICONCWT>, <CONCWTOBS>, and <PROCMETHOD>)

Among indicator recovery results, laboratories usually report concentrate weights. Sometimes these are subdivided according to the method applied and in some cases fractional quantities of recovered concentrates are observed. In the DED, values are assigned to each concentrate weight field to the extent possible. In the absence of specific reference to methylene iodide (MI) separation, data are assigned to the <CONCENTWT> field. It can generally be assumed that values in the <CONCENTWT> field represent the weight in grams after chemical density separation with tetrabromoethane (TBE) or a similar density separation agent which was used for the recovery of the indicators. However, attention is drawn to the <PROCMETHOD> field to determine further details of the processing methodology. In some cases it has been reported that only a proportion of the recovered concentrate was selected for mineral picking. In these cases the full concentrate weight has been reported with notes included in the 'Comment' fields. The use of such comments provides an important quality control on any calculations related to concentrate weight.

Diamond recovery data (<MACRO>, <MICRO>, <MACRODEFN>, <DIAMWT>, <DIAMRESULT>, and <DIAMDESCYN>)

Some diamond recovery has only been reported in terms of weight, listed in field <DIAMWT> and expressed in metric carats (mct)[1]. Assuming a specific gravity of diamond of 3.51 and a square sieve aperture, a perfect octahedral-shaped diamond passing through a 0.5 mm sieve would weigh 0.00103 mct. On the other hand, a cubic-shaped diamond with the same specific gravity passing through the same sieve aperture would weigh 0.00219 mct. Hence, an average macro–micro cutoff weight of

[1] 1 mct equals 0.2 g

0.0016 mct (0.0003 g) is assumed for assigning such diamonds to a size classification in the <MACRO> or <MICRO> fields in the database.

The <DIAMRESULT> and <DIAMDESCYN> fields are provided in order to rapidly identify diamond-positive samples and those with diamond descriptions documented in the DED without recourse to numerical querying. The diamond results field <DIAMRESULT> is particularly useful because it is possible that counts of diamonds may not be reported in diamond positive samples. Such records would occur where a sample is known to be diamond-bearing, but the data has been provided in a different form. Examples include grade samples where data are reported as carats per tonne and therefore a value for the number of diamonds cannot be obtained. Hence, in filtering the DED for diamond-positive samples, the <DIAMRESULT> field should be used in preference over <TOT_DIAM>.

Microdiamond/macrodiamond definition (<MACRODEFN>, <TOT_DIAM>, and <DIAM_PKG>)

In conjunction with the number of micro- and macrodiamonds recovered, field <MACRODEFN> allows the definition of the microdiamond/macrodiamond subdivision. This field was provided as there is no single international standard for the definition of a macrodiamond. The closest to a standard would perhaps be the requirement that in order to be termed ‘macrodiamond’ all three axial dimensions of a diamond have to be >0.5 mm. Nevertheless, this would require that each stone is physically measured. Despite numerous company reports on microdiamond or macrodiamond recovery, only one (Bizzarro and Plouffe, 1999) has been identified where the term has been defined (a macrodiamond being over 0.5 mm in size). Elsewhere, definitions such as 'one dimension >0.5 mm', 'captured on the 0.5 mm sieve', or simply '0.5 mm' have been used by field explorers (Hutchison, 2018b) whereas De Beers Australia Exploration Ltd (Mitchell, 1999) and Striker Resources NL (Garton, 2003) have used a smaller diameter of 0.4 mm as the cutoff size for macrodiamonds. In the Northern Territory of Australia, Lee et al. (1997) reported microdiamonds within the size range from 0.1 to 0.8 mm. For populations of diamonds that fall far outside the definition boundary, the details of how these boundaries are defined are academic. However, a threshold cutoff diameter of 0.5 mm falls comfortably within the upper size range which may be expected from an exploration sample that was collected within several kilometres of a primary diamond source. Hence, a consistent definition of the terms micro- and macrodiamond is important. Given that such a definition is rarely provided, that there is no rigorous research to support the frequently quoted contention that microdiamonds are easily transported by wind but macrodiamonds are not, and as it avoids the issue of the microdiamond classification, preferential querying of the <TOT_DIAM> or <DIAM_PKG> fields is recommended.

Visually-identified indicator counts – nondiamond (<CHROMITE>, <GARNET>, <PICROILM>, <CHROMEDIOP>, <OPX>, <OLIVINE> and <OTHERINDIC>)

In the database, as a general rule, the fields <CHROMITE>, <GARNET>, <PICROILM>, <CHROMEDIOP>, <OPX>, <OLIVINE> and <OTHERINDIC> are all populated with indicator counts as determined by visual inspection. Chromite can survive sustained transport over considerable distances from its source, even in tropical settings (Towie et al., 1994; Reddicliffe, 1999), and so laboratories exercise considerable care in applying visual criteria to discriminate kimberlite-sourced ('indicator') chromite from other types. The field <CHROMITE> is used in cases when there is a legitimate possibility that the grain may be a genuine indicator. Otherwise the <UNRESCHROM> and <NK_CHROMIT> visual identification fields are available for use. However, in Greenland, the extent of weathering compared to other diamond-prospective areas worldwide is minor. Hence garnets, Cr-diopsides, ilmenites and orthopyroxenes survive away from source much better in Greenland than in many other places. This is evident in the DED by inspecting the distribution of indicator minerals in relation to known in situ occurrences.

The field <OTHERINDIC> is populated for phases which were identified as indicator minerals, but did not fall into any of the other six above-mentioned fields. In such cases the minerals are identified in the 'Comment' fields.

Platinova A/S sampling in North Greenland in 1992 (von Guttenberg and van der Stijl, 1993; <SAMPLEID> 800 512 to 800 568) reported red coloured garnets in the course of indicator mineral sampling for diamondiferous rocks. These garnets were not considered indicators, nor, however, was their mineral chemistry determined. Given the colour, and the paucity of sampling conducted in this remote part of Greenland the garnets have been attributed as possible indicators in the DED. Users should be aware that they may be false positives.

Other visually-identified minerals (<OTHERINDIC>, <OTHERMIN1>, <OTHERMIN2>, and <OTHERMIN3>)

Worldwide the traditional mined sources of diamond are kimberlites, accounting for the very large majority of diamonds produced. Greenland hosts diamondiferous kimberlites (for example Hutchison and Frei, 2009). However ultramafic lamprophyres (aillikites) have been the most prolific producers of diamonds in Greenland (Emeleus and Andrews, 1975; Jensen et al., 2004; Hutchison and Frei, 2009). Both aillikites and kimberlites share very similar mineralogy and hence the indicator mineral field names <CHROMITE>, <GARNET>, <PICROILM>, and <CHROMEDIOP>) represent the minerals which have almost exclusively been targeted during diamond exploration in Greenland. To date, diamond exploration

through mineral processing worldwide has leaned heavily towards a kimberlite model with few modifications from successful methodologies employed in southern Africa and more recently in the Canadian Arctic (Fipke et al., 1995). In kimberlites, less 'traditional' minerals have been identified as indicators, such as zircon (Belousova et al., 2001). Furthermore, lamproites, which also occur in Greenland, have elsewhere been the principle sources of diamond production, such as in India and Western Australia (Hutchison, 2018a) and often contain rather different mineralogies in comparison to kimberlites, such as tourmaline (Fipke, 1994). Hence, allowances have been made in the DED to also deal with these cases. Mineral counts are recorded in the <OTHERINDIC> field when identified as prospective or in <OTHERMIN1>, <OTHERMIN2>, and <OTHERMIN3> when not discriminated. Furthermore, the minerals recorded in fields <OTHERMIN1> to <OTHERMIN3> may be significant to prospectors interested in commodities other than diamond. In this context the most notable commodity is gold, with 59 records in the DED reporting gold recovery.

Indicator mineral statistics (<TOT_DIAM>, <MACRO_PKG>, <MICRO_PKG>, <DIAM_PKG>, <TOTIND_PKG>, and <INDIC_PKG>

Arguably, the calculation of the number of indicators per gram of heavy mineral concentrate may be a better indication of proximity to source than indicators per kg of total sample. However, the significant variability of size fraction, processing methods, and picking protocols introduces too many variables to satisfactorily remove their influence. Hence, the variable which was identified to represent the indicator mineral concentration is the ratio of <TOTIND_EXD> to <SAMPLEWT>, which is represented by the <INDIC_PKG> field. Similar calculations were made for microdiamonds, macrodiamonds, and total diamonds.

Chemically-derived indicator mineral counts (<SP_*> fields, <OPX_*> fields, <GT_*> fields, <ILM_*> fields, and <CPX_*> fields)

Chemically-derived indicator mineral counts fields reflect the number of distinct mineral grains per sample (and subsample), having particular indicator mineral chemistries (i.e. analyses with 'YES' in the <INDICATOR> field in DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx). Indicator mineral counts derive from all applicable parts of composite grains, but exclude repeat analyses. For example, a composite grain of garnet and Cr-diopside with one analysis being classified as 'GT_G9', one as a 'GT_G10' and one as a 'CPX_CGP' composition, would return the numeral '1' in the <GT_G10> field, '0' in the <GT_G9> field (i.e. a repeat count of the same grain) and '1' in the <CPX_CGP> field. This methodology prevents grains being counted more than once and also ensures that all phases of interest are represented. It is evident from

the example that when different parts of a grain result in different mineral classifications of the same mineral phase, the most favourable is represented in the counts of mineral classifications. If it is possible to identify that the core and rim of the same grain has been measured, although noted accordingly in the DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx, such analyses are treated as repeat analyses.

It is notable that only mantle-derived garnets that fall into the G3 and G4 fields are counted in the <GT_G3> and <GT_G4> fields in DED_GL_BULK_ANALYSES_Indicators.xlsx. Hence, crustal-derived garnets, otherwise falling into the G3 and G4 compositional fields (analyses with 'NO' in the <INDICATOR> field), in DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx are not counted in the <GT_G3> and <GT_G4> fields in the DED.

Although the chemically-defined mineral classification fields, such as <SP_CID> and <SP_GT_PER> provide high-value data, the number of grains chosen for chemical analysis is arbitrary and usually does not reflect the abundance of a particular indicator within a sample. Therefore, unlike a field such as <INDIC_PKG>, which is a useful prospectivity variable, a calculation of a number of CID spinels per kg of sample, for example, is largely meaningless. Hence, despite the drawbacks of visual determinations of indicator minerals, fields such as <CHROMITE> give a better indication of the presence of indicators within a sample than, for example <SP_CID>.

When populating mineral chemical fields with data it became clear that the mineral chemistry was reported for some records where no entry of a visual identification of the particular phases was recorded. In some cases this may have been due to a phase appearing as part of a composite grain during the chemical analysis or where mineral chemical data derive from thin sectioned samples which have not been treated by bulk mineral separation methods. In other cases of apparently ‘missing’ visually-derived indicator minerals, this has arisen from shortcomings in the data capture or initial data reporting. In order to ensure that a record with indicator chemistry appears as positive when filtering is performed on the basis of visual indicator picks, all records that returned a higher value in the chemically-derived field had that value included in the equivalent indicator field. For example, a record which reported <CHROMITE> as ‘1’, but mineral chemical analysis which reflected <SP_CID> as ‘1’ and <SP_GT_PER> as ‘2’ would have had the <CHROMITE> field amended to ‘3’. In cases where mineral chemical classifications derive from thin sections, mineral terms, such as <CHROMITE> are populated with ‘1’ to reflect positive identification because the number of grains analysed in a thin section has no relevance as a metric of abundance of a particular phases in a sample.

It is not appropriate to assign the numeral ‘0’ to a mineral class for minerals which have not been observed to exist in the sample. In most such cases the mineral class field is populated with the code ‘-

111'. This convention allows the user to query mineral class fields to ascertain whether or not a particular mineral has been searched for by means of chemical analysis in a sample and therefore discriminate cases where the mineral is actually absent from those samples or where it has not been considered. It is cautioned that population of mineral class fields in this way is not exhaustive.

Major and minor element data – DED_GL_GRAIN_ANALYSES_Maj_Chem

The most involved data quality assurance and data processing in compiling the DED has been applied to the population of DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx. While visual identification of indicator mineral grains is important, it is a highly subjective process, which is very difficult to standardise between sources. Users of the DED are advised that visually-determined indicator data inherently includes false negatives and false positives. This is particularly true for olivines taken as indicator minerals in sediment samples (which may derive from non-diamond prospective mafic rocks). Furthermore, garnet colour is not necessarily a good proxy for garnet composition as minor elements have a strong influence on appearance. It is for this reason that garnets reported from North Greenland (von Guttenberg and van der Stijl, 1993) are assigned as possible indicators in the DED. In contrast, mineral chemical data provide the opportunity to be standardised across all data sources and yield quantifiable information pertinent to diamond-prospectivity. Consequently, while numerically fewer due to their relative cost, compared to visual descriptions, chemical analyses have a high value. It is not uncommon for visually identified phases later to be re-assigned on the basis of mineral chemical data (Hutchison, 2018b). Ilmenites and chromites are also commonly confused with each other. The file DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx provides individual mineral chemical analyses for discrete mineral phases. Each record provides a single analysis, although where averaged analyses are reported, it is noted in the 'Comment' fields to draw attention to this fact.

Composite samples (<SAMPLEID>, <INDID>)

If not known from which component of the composite sample a particular grain is derived, the grain is assigned to the first sample component which also assigns its SampleID number. The DED_GL_BULK_ANALYSES_Indicators.xlsx file considers mineral counts assigned for each component of the composite, both visually and chemically. The added complexity of reproducing the same chemical analyses numerous times is therefore avoided.

Analysis names (<GRAIN>)

The <GRAIN> field has been populated using the grain identifier used in the source report and has been amended with various suffixes where required. Repeat analyses have been identified where two or more closely similar analyses were reported with identical grain identifications. In such cases, a suffix such as '_repeat1' is applied to the <GRAIN> name to indicate repeat analyses. These repeats are not included in the counts of chemically-defined indicators in DED_GL_BULK_ANALYSES_Indicators.xlsx. Repeat analysis suffixes sometimes also apply to grains where a core and rim have been measured. Attention is drawn to these cases in the 'Comment' field and care should be taken by users of the DED not to calculate mineral chemical averages from such core/rim repeat analyses.

Although indicator minerals are picked visually as discrete grains during the course of mineral chemical analyses, composite grains are occasionally found and the different components are analysed. Such grains are annotated in the <GRAIN> field and include suffixes such as '_phase2' with a further '_repeat' suffix added if necessary. Examples of composite grains are garnet with chromite, phlogopite, ilmenite, calcite and dolomite, ilmenite with olivine or serpentine and phlogopite, perovskite with phlogopite, chromite with Al-orthopyroxene and olivine, Cr-diopside with olivine and serpentine. Rarely, mineral inclusions within other grains (as distinct from composite grains) are reported, such as chromite within garnets. Analyses of different phases comprising composite grains and inclusions are distinct from repeat analyses. Therefore, where composite and inclusion grains are identified, each distinct mineral phase is used to populate the chemically-derived indicator counts reported in DED_GL_BULK_ANALYSES_Indicators.xlsx.

Analysis location (<ANALYS_LOC>)

Some data sources report grain margins, as distinct from rims or cores. It is unclear what this term means but it is retained as an item in the controlled vocabulary for <ANALYS_LOC>.

Analysis quality (<VAL_ANALYS>, <MINERAL>, <MIN_CLASS>, and <TOTANALYTE>)

All records have been subjected to a first pass quality control based on analyte totals. Such quality assessment does not have the same rigour as the inspection of analyte uncertainties and the reproduction of standards as part of the analytical session. However, it is an industry-standard approach. Short of calculation of stoichiometry, it can also be readily applied to mineral chemical data with little context. For each analysis the <VAL_ANALYS> field has a 'YES' or 'NO' entry, and only analyses with analyte totals lying within the ranges specified in Table 7 for each phase are attributed with 'YES'. The default acceptable range is from 96 to 102 wt% inclusive but as Table 7 shows numerous less common minerals are expected

to give analytical totals falling within lower ranges, depending on the analytes measured. Quoted analytical constraints can readily be met with wavelength-dispersive spectrometry (WDS) on well-polished, unweathered grains. The constraints also encompass the majority of analyses that would be considered acceptable performed by energy-dispersive spectrometry (EDS). Furthermore, stoichiometry has not been calculated in all cases but where it has been identified that an analysis has an acceptable analyte total but also poor stoichiometry, it has been rejected.

Table 7. Acceptable analyte totals based on mineral phase

Mineral phase	*Analysis total (wt%)*	*Mineral phase*	*Analysis total (wt%)*
Default	96–102	Ilmenite[e]	94–102
Amphiboles	94–100	Perovskite[f]	90–102
Apatite[a]	51–57	Phlogopite[g]/other micas[c]	90–98
Carbonates[b] (calcite, dolomite, magnesite, siderite)	52–58	Pseudobrookite[h]	93–99
Chlorite[c]	85–92	Serpentine	82–90
Clay minerals	Variable	Spinel[i]	96–102
Hematite[d]	87–90	Magnetite/ulvöspinel[j]	90–93
Iddingsite[c,d]	74–80	Tourmaline[k]	82–91

NOTES:
(a) When P_2O_5 and H_2O are not quoted
(b) When CO_2 is not quoted
(c) When H_2O is not quoted
(d) Where FeO is quoted rather than Fe_2O_3
(e) When Fe_2O_3 is not quoted, otherwise 96–102 wt%. Analyses which resemble ilmenites, have less than 5 wt% MgO and more than 65% FeO_{Total} are not considered to be ilmenites, rather ülvospinels. All analyses resembling ilmenite and with TiO_2 over 70% are considered to be rutiles.
(f) Where REE oxides are not reported. Perovskites can contain as much as 10 wt% REE oxides (and sometimes considerably more for loparite). So a wide range of analysis totals is considered acceptible for perovskites. Whether an analysis is considered acceptible dpends in part on whether it is an outlier or occurs among numerous similar anlayses from neighbouring or associated grains.
(g) After Mitchell (1986)
(h) Pseudobrookite analyses would typically show good stoichiometry or a total of <97 wt% as distinct from ilmenite
(i) Magnetites (MGT, CMGT, MCMGT, MTMGT, TMGT, TCMGT) and ülvospinels (ULV and MULV): when Fe_2O_3 is not quoted, may have analysis total from 90-101 wt% depending on the amount of deviation from end-member compositions, when Fe_2O_3 is quoted, the acceptible range is 92–102 wt%. Non-magnetites: when FeO >20 wt% and Fe_2O_3 is not quoted have an acceptible range of 95–101 wt%, otherwise 96–102 wt% is applied.
(j) Magnetite/ülvospinel analyses without Fe_2O_3 quoted
(k) To account for boron, lithium, and when H_2O is not quoted. Tourmalines are distinguished from micas with low analytical totals (i.e. poor analyses) by having >1 wt% Na_2O.

For some poor analyses where the <VAL_ANALYS> field is populated with 'NO,' there is sufficient chemical data to support a reasonable mineral identification. In such cases a mineral name is provided in the <MINERAL> field, otherwise the mineral is described as 'Unknown'. However, as mineral classification requires high-quality data, mineral classifications are not provided for poor analyses. In this case, the <MIN_CLASS> field is therefore populated with the term 'Poor-Analysis'.

Table 8. Chemical criteria for the subdivision of <MINERAL> field terms

Mineral subdivision	*Criteria*	*Mineral subdivision*	*Criteria*
Diopside-Cr	Cr_2O_3 >1.0 wt%	Orthopyroxene-Al	Al_2O_3 >1.0 wt%
Diopside-Al	Al_2O_3 >10.0 wt%	Phlogopite/biotite[b]	Phlogopite MgO/(MgO + FeO) >0.357
Diopside-Al-Cr	Al_2O_3 >10.0 wt% and Cr_2O_3 >1.0 wt%	Pseudobrookite-Cr	Cr_2O_3 >0.2 wt%
Garnet_Andradite-Cr	Cr_2O_3 >1.0 wt%	Rutile-Fe	FeO_{total} >15.0 wt%
Garnet_Andrarite-Cr-Ti	TiO_2 >1.0 wt% and Cr_2O_3 > 1.0 wt%	Rutile-Nb	Nb_2O_5 >10.0 wt%
Ilmenite-altered	FeO_{total} >53.0 wt%	Tetraferriphlogopite[c]	Al_2O_3 <2.0 wt%
Ilmenite-picro[a]	MgO >5.0 wt%		

Subdivision	*Phase*	*Criteria*
SP-MC[d]	Mg-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 <1.0, ZnO <1.0
SP-ZMC[e]	Zn,Mg-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 <1.0, ZnO ≥1.0
SP-CH[e],[f]	Chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 <1.0, ZnO <1.0
SP-ZCH[e]	Zn-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 <1.0, ZnO ≥1.0
SP-TCH[d]	Ti-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 ≥1.0, ZnO <1.0
SP-ZTCH[e]	Zn,Ti-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 ≥1.0, ZnO ≥1.0
SP-FTCH[e]	Fe,Ti-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# <40.0, TiO_2 ≥1.0
SP-TMC[d]	Ti,Mg-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 ≥1.0
SP-FTMC[e]	Fe,Ti,Mg-chromite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# ≥40.0, TiO_2 ≥1.0
SP-MAC[e]	Mg,Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 <1.0
SP-TMAC[e	Ti,Mg-Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 ≥1.0
SP-AC	Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 <1.0

Subdivision	*Phase*	*Criteria*
SP-TAC[e]	Ti,Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <40.0, TiO_2 ≥1.0
SP-FMAC[e]	Fe,Mg,Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ >0.4, Mg# ≥40.0, TiO_2 <1.0
SP-TFMAC[e]	Ti,Fe,Mg,Al-chromite	Cr# <60.0, Cr# ≥20.0, Cr_2O_3 ≥15.0, $Fe^{3+}/\sum Fe$ >0.4, Mg# ≥40.0, TiO_2 ≥1.0
SP-MCAS[g]	Mg,Cr,Al-spinel	Cr# <20.0, Cr# ≥8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 <1.0
SP-TMCAS[e]	Ti,Mg,Cr,Al-spinel	Cr# <20.0, Cr# ≥8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥40.0, TiO_2 ≥1.0
SP-AS	Al-spinel	Cr# <8.0, Al_2O_3 ≥45.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≥30, TiO_2 <1.0
SP-TMFAS[e]	Ti,Mg,Fe,Al-spinel	Cr# <8.0, Al_2O_3≥40.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# ≥30.0, TiO_2 ≥1.0
SP-HER	Hercynite	Cr# <8.0, Al_2O_3 ≥45.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# <30.0, TiO_2 <1.0, ZnO ≤15.0
SP-GHN[e]	Gahnite	Cr# <8.0, Al_2O_3 ≥45.0, $Fe^{3+}/\sum Fe$<0.4, Mg# <30.0, TiO_2 <1.0, ZnO >15.0
SP-CMGT	Cr-magnetite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ >0.4, Mg# ≤30.0, TiO_2 <1.0
SP-TCMGT	Ti,Cr-magnetite	Cr# ≥60.0, Cr_2O_3 >8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# ≤30.0, TiO_2 ≥1.0
SP-MCMGT	Mg,Cr-magnetite	Cr# ≥60.0, Cr_2O_3 >8.0, Cr_2O_3 <40.0, $Fe^{3+}/\sum Fe$ >0.4, Mg# >30.0, TiO_2 <1.0
SP-FMC[e]	Fe,Mg-chromite	Cr# ≥60.0, Cr_2O_3 ≥40.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# >30.0, TiO_2 <1.0
SP-MGT	Magnetite	Cr_2O_3 <8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# ≤30.0, TiO_2 <5.0
SP-TMGT	Ti-magnetite	Cr_2O_3 <8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# ≤30.0, TiO_2 ≥5.0
SP-MTMGT	Mg,Ti-magnetite	Cr_2O_3 <8.0, $Fe^{3+}/\sum Fe$ ≥0.4, Mg# >30.0, TiO_2 ≥5.0
SP-ULV	Ulvöspinel	Cr_2O_3 <8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# ≤30.0, TiO_2 ≥15.0
SP-MULV	Mg-ulvöspinel	Cr_2O_3 <8.0, $Fe^{3+}/\sum Fe$ <0.4, Mg# >30.0, TiO_2 ≥15.0

NOTES: (a) Referred to as 'picroilmenite' in the text
(b) With all Fe recast as FeO
(c) After Mitchell (1995)

Spinel subdivisions follow the methodology of Taylor,(WR Taylor [Elkedra Diamonds NL] 2010, personal comm.) modified from Ramsay (1992) and as reported in Denny (1998). Spinel subdivision names are abbreviations deriving from 'SP' for 'spinel' and their associated phase names.
(d) High priority indicator mineral
(e) Possible indicator mineral
(f) CH refers to $FeCr_2O_4$ in the strict sense i.e. Cr-spinels with dominant $FeCr_2O_4$ end member composition
(g) Mg,Cr,Al-spinel is usually a crustal phase spinels of this composition are known from kimberlites (EMU-1 kimberlite pipe, Australia; Hutchison, 2011), hence, MCAS grains have been considered for further classification in field <MIN_CLASS>.

All variables are expressed as wt% with the exception of $Fe^{3+}/\sum Fe$, which is based on charge-balanced cation calculations of stoichiometric analyses, where $\sum Fe$ represents (Fe^{2+} + Fe^{3+}); Cr# = 100 × $Cr/(Cr + Al)_{cations}$ and Mg# = 100 × $Mg/(Mg + Fe^{2+})_{cations}$

Mineral identification (<MINERAL>, <MIN_CLASS>)

The mineral phase identity and classifications fields <MINERAL> and <MIN_CLASS> derive from processing of major and minor element analyses according to industry-accepted classification schemes. For consistency, in most cases mineral chemical analyses have been processed from scratch, irrespective of classifications which may have been given in source reports. However, mineral chemical determinations following the methodologies of Grütter et al. (2004) and Ramsay and Tompkins (1994) for SampleIDs 10001-115328 (records from Jensen et al. 2004) have been taken directly from source on the assumption that they were made correctly. Exceptions are for G1 and G11 garnets which were not sufficiently subdivided and G3 and G4 garnets which required further determination of crustal or mantle affinity in order to make a correct assessment of whether to classify them as indicators or not. Further exceptions were made for grains whose analysis totals are determined to be unacceptable following the criteria described in Table 7.

Data presented in field <MIN_CLASS> have been used to populate the chemically-derived mineral counts fields for records in DED_GL_BULK_ANALYSES_Indicators.xlsx.

The <MINERAL> field identifies the mineral phase. Its attribution is based on quantities of various analytes falling within certain ranges and in combinations consistent with accepted norms for minerals. Subdivisions of the <MINERAL> field are similarly based on threshold limits of various elements. Amphibole, feldspar, and mica subdivisions follow established criteria. Definitions of other subdivisions of the field <MINERAL> are provided in Table 8. Poor analyses may be attributed with a <MINERAL> name if sufficient data are available for a confident identification. Note that specific rules are applied to discriminating chemical analyses of ilmenites from rutiles and ülvospinels, as described in Table 7.

The <MIN_CLASS> field provides a further mineral subdivision employing classification schemes commonly used in diamond exploration. Typically, attribution of the <MIN_CLASS> field requires a more sophisticated processing of mineral chemical data, such as stoichiometric calculations, recasting of iron oxidation, and comparison with complex subdivisions of compositional space. Numerous classifications schemes exist for different minerals. However, for the DED, one scheme (as referred to in the data dictionaries) has been chosen for each mineral type because of the scheme's common and contemporary use by diamond explorers and use in other large public databases (Hutchison, 2011; Hutchison, 2018b). In assigning a <MIN_CLASS> term, <MINERAL> subdivisions have been variously either applied or ignored. For instance, all ilmenites regardless of their variety (e.g. picroilmenites, 'Ilmenite-picro') have been considered equal when applying a <MIN_CLASS> term. This is because the classification scheme used takes account of the 'picro-' or 'non-picro-' designation of the data in each case. However, for spinels only

chromites (with the exception of the Al-chromite 'SP_AC') and Mg,Cr,Al-spinel ('SP_MCAS') have been subdivided while other spinels were classified 'SP-Crustal'.

Mineral classifications are provided for guidance and for internal consistency of the DED data. When using the data, users of the DED are advised to consider the assumptions that were applied when populating the data fields and the evolving nature of such classification schemes with regard to diamond exploration.

<MINERAL> field – garnet

Garnets are subdivided into the groups garnet ('Garnet'; pyrope, almandine, and grossular garnets), majoritic garnets ('Garnet_Majoritic'), and andradites ('Garnet_Andradite', 'Garnet_Andradite-Cr', and 'Garnet_Andradite-Cr-Ti'). Members of the garnet and majoritic garnet groups are typically considered as possible indicator minerals.

<MINERAL> field – ilmenite

By definition the mineral picroilmenite contains >5 wt% MgO. This value has commonly been accepted (Mitchell, 1986; Kerr et al., 2000; Wyatt et al., 2004), even though it is empirical and appears to be largely arbitrary (B Wyatt, 2010, personal comm.). Many kimberlites have ilmenite with <5% MgO (including Kirkland Lake and Iron Mountain) (D Schulze [University of Toronto] 2010, personal comm.) and a substantial amount of ferric iron. In the light of these arguments there is discussion to adopt a 3 wt% MgO threshold as the cutoff limit. However, as all ilmenite analyses have an indicator classification applied to them in field <MIN_CLASS>, irrespective of the <MINERAL> subdivision, any statement about the cutoff threshold applied to the picroilmenite subdivision is largely academic.

<MINERAL> field – kirschsteinite

Kirschsteinite is an Fe-analogue of monticellite. It is a very rare mineral that is present in meteorites. It has also been proposed that it exists as a groundmass phase in the Kotakonda kimberlite, India (Chalapathi Rao et al., 1996). However, mineral chemical analyses based on standard analytes fail to discriminate kirschsteinite from andradite garnet. In the absence of crystallographic data, the mineral at Kotakonda that is assumed to be 'larnitic kirschsteinite' is therefore more likely to be andradite. Mineral chemical analyses of the kirschsteinite–andradite type (SiO_2 34 wt%, Fe_2O_3 32 wt% and CaO 34 wt%) appear in the Northern Territory (Hutchison, 2011) where they have been described as monticellite. The term 'kirschsteinite' has been retained in the DED structure for future use. However, if the DED structure is to

be used as a template for diamond exploration elsewhere it should be recognised that potential kirschsteinite analyses are most likely to be correctly reported as 'Garnet_Andradite'.

<MINERAL> field – pseudobrookite

Cr-absent ferropseudobrookite and pseudobrookite (sensu stricto: $Fe^{3+}Ti_2O_5$) are interpreted to be oxidation products of common ilmenite. Further weathering, as is common in the tropical environments but not apparently influential in Greenland, produces leucoxene. However, the Cr-bearing ferropseudobrookite end member $Fe^{2+}Ti_2O_5$ (>0.2 wt% Cr_2O_3 and generally >60 wt% TiO_2) is most likely to be an extreme weathering product of titaniferous Cr-spinel and/or Cr-bearing picroilmenite. While examples are not known from Greenland, the term 'pseudobrookite' is included in the DED structure in order to retain its value as a suitable template for diamond exploration elsewhere.

<MINERAL> field – spinel

The spinel subdivisions (Table 8) follow a modified version by Ramsay (1992), developed by Taylor (WR Taylor, 2010, personal comm.) and reported in Denny (1998), which is based on a large dataset of Australian crustal- and mantle-derived spinels. In his very comprehensive assessment of mantle indicator minerals, Ramsay (1992) concluded that spinel compositions more satisfactorily discriminate diamond potential from non-diamond potential sources than garnet classification. He showed that garnet peridotites almost exclusively contain spinels with <35 wt% Al_2O_3 and >45 wt% Cr_2O_3, and diamond-associated spinels almost always have TiO_2 compositions of <0.5 wt%. However, cation ratios provide the most robust discriminatory criteria with no overlaps between garnet peridotite/diamond-associated spinels: (Cr# [= 100 × Cr/(Cr + Al) cations] >55) and spinel/plagioclase peridotites. Diamond-associated harzburgitic spinels showed Cr# >75.

Taylor (WR Taylor, 2010, personal comm.) modified the Al_2O_3 cutoff to 40 and 45 wt% on the basis that the 35 wt% threshold (Ramsay 1992) that was modelled on specific, well-characterised minerals rather than exploration-style populations. Similarly, Ramsay (1992) used a 1 wt% TiO_2 discriminant, which separates alkali basalts from tholeiitic/arc-related basalts and a $Fe^{3+}/\sum Fe$ ratio of 0.4, which captures FMQ (fayalite–magnetite–quartz) buffer grains in addition to more oxidised phases as would be typical of high-pressure phenocrysts. In contrast, Taylor (WR Taylor, 2010, personal comm.) used a more restrictive minimum Cr# value of 60, as otherwise numerous basaltic and layered-intrusion origin Cr-spinels would overpopulate the dataset.

Among the spinel subdivisions, a number of chromite types are defined on the basis of their Zn content. A Zn overprint can be acquired by hydrothermal activity within kimberlites, probably during serpentinization, but this is rare compared to greenschist-facies Zn overprints. Zn-chromites are not very common in Greenland but 100 such grains have been identified in 10 individual source reports.

<MINERAL> field – element-attributed unknowns

The term 'Unknown' is occasionally used with a suffix, noting a particularly abundant element of interest. As no formal definitions are applied, attention to any unknown phase of interest to specific elements is achieved. Examples for this mineral group include 'Unknown-Ni' analyses with good analysis totals (96 to 102 wt%) and over 10 wt% NiO, 'Unknown-V' analyses with good analysis totals, and about 20 wt% V_2O_3 and 'Unknown-Nb' with poor analysis totals (under 96 wt%; likely to be accounted for by unanalysed elements) with Nb_2O_5 of about 50–80%.

<MIN_CLASS> field – clinopyroxene

Clinopyroxene classification follows the methodologies of Ramsay (1992) and Ramsay and Tompkins (1994) which are based on Cr_2O_3 and Al_2O_3 content.

<MIN_CLASS> field – garnet

Prior to classification, all garnet analyses have been reprocessed to convert any Fe_2O_3 (and combined Fe_2O_3/FeO) to FeO. Garnet classification for pyrope/grossular garnets follows the methodology of Grütter et al. (2004) described in Table 9. With the exception of andradites (<MINERAL> entries 'Garnet_Andradite', 'Garnet_Andradite-Cr' and 'Garnet_Andradite-Cr-Ti') and majoritic garnets, (<MINERAL> entry 'Garnet_Majoritic'), this classification scheme has been applied to all garnets for which mineral chemistry has been acquired. The large majority were identified visually as being indicators. The Grütter et al. (2004) scheme subdivides garnets into 10 number classifications and additionally four of these classes are subdivided using a 'D' suffix. D-classification relies on an accurate measurement of MnO (where MnO is <0.36 wt% for the lower Cr and G10 analyses) and Na_2O (where Na_2O is >0.07 wt% for the G3, G4, and G5 classifications) and as such would typically require measurement by electron probe microanalyzer (EPMA) analysis. The possibility of 'D' designation in the database is not considered for analyses acquired by EDS or scanning electron microscope (SEM) techniques. The analytical method and laboratory facility for each analysis is presented in <PROVIDNAME> and <INSTR_TYPE> fields. Even for good analyses (<VAL_ANALYS> field with 'YES') where a 'D' designation can be made, Grütter and Quadling (1999) concluded that although 0.07 wt% Na_2O in eclogitic garnet is commonly used as a cutoff

limit for potentially diamond-associated eclogites, garnets from graphitic eclogites can range from 0.03 to 0.20 wt% Na_2O with three-quarters of quoted graphite-association analyses having >0.07 wt% Na_2O. Hence, the eclogitic D-classification where applied cannot be used as a fail-safe criteria for diamond association.

Table 9. Description of <MIN_CLASS> names for garnets

Classification	*Petrological association*	*Classification*	*Petrological association*
G0	Unclassified	G5D[(a)]	Pyroxenitic, websteritic, and eclogitic (diamond facies) – with higher Fe than moderate- to low-Cr G9 garnets
G1	Low-Cr megacrysts	G9	Lherzolitic
G3[(b)]	Eclogitic	G10	Harzburgitic
G3D[(c)]	Eclogitic (diamond-facies)	G10D[(b)]	Harzburgitic (diamond facies)
G4[(b)]	Pyroxenitic, websteritic, and eclogitic – with Cr lower than G9 garnets and overlapping with low-Ca eclogitic garnets	G11	High-Ti peridotitic
G4D[(c)]	Pyroxenitic, websteritic, and eclogitic (diamond-facies) – with Cr lower than G9 garnets and overlapping with low-Ca eclogitic garnets	G12	Wehrlitic
G5	Pyroxenitic, websteritic, and eclogitic – with higher Fe than moderate- to low-Cr G9 garnets		

NOTES: (a) Following the classification scheme of Grütter et al. (2004)
(b) Some garnets which are classified as G3 or G4 are crustal-derived and therefore not considered to be indicators. Criteria are as follows: G3 and G4 garnets with MnO >1 wt% or FeO >25 wt% or MgO <4 wt% are crustal-derived and not considered to be indicators. Similarly, margional-composition grains with lower MnO, higher MgO but with FeO > 24 wt% and ≤25 wt% (possibly crustal-derived) are not considered to be indicator minerals either. All other G3 and G4 compositions are classed as indicators.
(c) D-classification relies on precise measurement of MnO and Na_2O. As such they would typically require measurement by EPMA analysis. Irrespective of reported composition, the 'D' designation is not applied to analyses in the DED that were acquired by EDS or SEM techniques.

Garnets classified as G3 or G4 and with concentrations of MnO >1 wt%, FeO >25 wt%, or MgO <4 wt% are regarded as crustal-derived (HS Grütter [BHP Billiton World Exploration Inc.] 2011, personal comm.), and are noted as such in 'Comment' fields. G3 or G4 garnet that have MnO ≤ 1 wt%, MgO ≥ 4 wt% and FeO ≤25 wt% are further subdivided. If FeO is > 24 wt% and ≤25 wt% they are considered to be possibly crustal, > 21.5 wt% and ≤24 wt% possibly mantle-derived and ≤21.5 wt% definitively mantle-derived.

<MIN_CLASS> field – ilmenite

The ilmenite classification follows the methodology of Wyatt et al. (2004), where based on their TiO_2 and MgO compositions ilmenites are subdivided into kimberlitic, non-kimberlitic, and intermediary

associations. The position of Wyatt et al.'s (2004) ILM-Kim/ILM-Inter subdivision is defined by the line of best fit:

TiO_2 wt% = 25.4062 + 6.1433 × MgO wt% – 0.4187 × (MgO wt%)^2 + 0.0106 × (MgO wt%)^3

<MIN_CLASS> field – orthopyroxene

The orthopyroxene classification is based on Al_2O_3, SiO_2, MgO, and FeO contents and follows the methodologies of Ramsay (1992) and Ramsay and Tompkins (1994). Ramsay and Tompkins (1994) do not consider orthopyroxenes with MgO/(MgO + FeO) ratios of under 0.7. Such grains are designated 'OPX-Undefined'.

<MIN_CLASS> field – spinels

All non-chromite spinels, aside from Mg–Cr–Al-spinels and Al-chromite, are considered to be crustal-derived and, hence, are classed as 'SP-Crustal'. Remaining grains are classified according to the methodology of Grütter and Apter (1998). Their modified chromite in the diamond 'SP-CID' boundary is defined as follows:

TiO_2 <0.6 wt%, Cr_2O_3 wt% <68.2 – (3.5 × TiO_2 wt%), Cr_2O_3 >62 wt%, 10.4 wt% <MgO <16.5 wt%, and Fe_2O_3 <6 wt%

As opposed to the spinel peridotite field, the chromite in garnet peridotite field ('SP-Gt-Per') is defined as follows:

TiO_2 <1.0 wt%, then Cr_2O_3 wt% <68.2 – (3.5 × TiO_2 wt%), or where

TiO_2 >1.0 wt%, then Cr_2O_3 wt% <66.0 – (3.5 × TiO_2 wt%).

In order to apply the SP-CID test for analyses in which Fe_2O_3 has not been determined, Fe_2O_3 has been calculated stoichiometrically. Chemical analyses which fail the SP-CID test solely on the basis of calculated or reported Fe_2O_3 are automatically assigned to the 'SP-Gt-Per' field. Grütter and Apter (1998) demonstrated that numerous barren kimberlites contain chromites whose compositional range overlaps the CID field, which is often used by explorers as a proxy for diamond-associated rocks. Hence, caution needs to be exercised when using CID-classified analyses in order to indicate a definitive association with diamond.

Mantle-derived chromites that fail the SP-CID and SP-Gt-Per tests are unclassified ('SP-Unclassified').

Indicator status (<INDICATOR>)

As the principal aim of DED_GL_GRAIN_ANALYSES_Maj_Chem.xlsx is to provide indicator mineral data, the field <INDICATOR> has been included. Conditions where analyses are considered to be from indicators or non-indicators are described in Table 10 and take account of <MINERAL> and <MIN_CLASS> designations.

Table 10. Designation of analyses as indicators and non-indicators

Phase	*Indicator*	*Phase*	*Indicator*
Poor analyses[(a)]	NO	Monticellite and kirschsteinite	YES
Amphibole, apatite, calcite, chlorite, columbite, corundum, dolomite, feldspar, hematite, iddingsite, magnesite, pyroxenoids, quartz, rutile, serpentine, siderite, sphene, staurolite and tourmaline	NO	Olivine[(c)]	YES
Clinopyroxene – CPX-CGP and CPX-CPP	YES	Orthopyroxene – OPX-OGM, OPX-OGP, OPX-ODH, and OPX-ODL	YES
Clinopyroxene – CPX-CLS	NO	Orthopyroxene – OPX-OEC, OPX-OSP, and OPX-Undefined	NO
Garnet – G0 and crustal G3 and G4	NO	Perovskite	YES
Garnet – all other garnet classifications, including Garnet_Majoritic and Garnet_Andradite	YES	Pseudobrookite	NO
Ilmenite – ILM-N-Kim	NO	Pseudobrookite-Cr	YES
Ilmenite – ILM-Inter and ILM-Kim	YES	Spinel – crustal spinels (SP-Crustal), namely: ulvöspinels, magnetites, hercynite, Al-spinel and Al-chromite end-members, and unclassified (Spinel-Unclassified)	NO
Mica – phlogopite and tetraferriphlogopite	YES	Spinel – non-crustal spinels (SP-CID, SP-Gt-Per and SP-Unclassified) deriving from all chromites (aside from SP-AC) and non end-member aluminous spinels (SP-MCAS, SP-TMCAS, SP-TMFAS)	YES
Mica – all other mica classifications	NO		

NOTES: (a) Records where the 'Valid_Analysis' field is 'NO'
(b) Olivines are not typically of high enough analysis quality to discriminate their source. However, because they either derive from known diamond-prospective rocks and they are otherwise not abundant, all olivine grains are designated as indicators.

The user of the database will naturally focus on grains where <INDICATOR> is populated with 'YES'. However, as some mineral classification schemes (such as Grütter et al., 2004) apply an empirical approach to an indicator designation it would be unwise to preclude all non-indicators from further consideration. Furthermore, the chemical criteria discriminating indicators from non-indicators evolve with time and as a consequence non-indicator analyses are retained in the DED. Hence, users of the database are advised to consider the assumptions made for current schemes and the possibility of new or alternative mineral classification methods that may alter the indicator designation of the data.

<INDICATOR> field – clinopyroxene

Clinopyroxene from garnet peridotite (CPX-CGP) and eclogitic, megacrystic, and cognate clinopyroxene (CPX-CPP) are considered to be favourable indicators for a diamond association. Spinel peridotite association (CPX-CLS) composition grains are not considered to be indicators.

<INDICATOR> field – corundum

Corundum is not considered to be an indicator phase because of its ubiquity with many crustal rocks. However, because it is reported from some lamproites (Fipke, 1994) its presence may be of interest.

<INDICATOR> field – garnet

Garnets classified as G0 are not considered indicator minerals. Garnets classified as G3 or G4 and considered to be crustal-derived (with concentrations of MnO >1 wt% or FeO >25 wt% or MgO <4 wt%) are also not considered to be indicators. Similarly, marginal-composition grains with lower MnO, higher MgO but FeO > 24 wt% and ≤25 wt% (possibly crustal-derived) are not considered to be indicator minerals either. All such analyses are assigned a 'NO' in the <INDICATOR> field and are not included in the mineral counts provided in G3 and G4 fields in DED_GL_BULK_ANALYSES_Indicators.xlsx. Otherwise, G3 and G4 garnets are considered to at least be possibly mantle-derived and thus indicators. Text is added in the 'Comment' fields indicating the crustal assignment criteria for G3 and G4 garnets.

Garnets classified as mantle-derived eclogitic G3, G4, harzburgitic G10, and especially those with a 'D' suffix, are regarded as being particularly indicative of an association with diamond. G1, G5, G5D, G9, G11, and G12 garnets are also all classed as indicator minerals (see Table 9). However, much of the classification scheme by Grütter et al. (2004) is empirical, with boundaries between fields based on the capture of 80 to 90% of grains with particular characteristics. Consequently, G9 garnets, for example, should not necessarily be considered to be poorly-prospective for diamonds. In fact, numerous examples

of diamondiferous kimberlites and lamprophyres contain garnet populations dominated by G9 rather than G10 garnets (Hutchison and Frei, 2009). Another example is the diamondiferous Merlin kimberlite in Australia where there are more than 10 times as many G9 garnets compared to G10s (Reddicliffe, 1999). In the DED, of all reported grain analyses, G9s constitute 62% of those falling into either the G9 (4587 grains) or G10 (2807 grains) fields.

Due to their chemical similarity to kirschsteinite, and their occasional association with lamproites, andradite garnets are considered to be potential indicators and are identified in the DED structure as such. It has to be considered that andradite garnets may derive from crustal sources, hence, an association with potentially diamond-bearing rocks is not guaranteed. In any case, no andradite garnets are known to have been noted in the course of diamond exploration in Greenland.

<INDICATOR> field – ilmenite

Wyatt et al. (2004) stressed the point that boundary lines between ilmenite compositional fields may lie at parallel, but slightly offset locations for specific populations of ilmenites. Therefore, for the purposes of populating the DED, both ILM-Kim and ILM-Inter classifications are considered to be indicators. Hence, users of the database are cautioned that the designation of this group as an indicator mineral may therefore lead to a larger data yield. It should also be noted that although the quoted boundaries constrain compositions associated with kimberlites reasonably well, significant proportions of the population of some non-kimberlite sources of ilmenites (e.g. melnoites, alnöites, and basanites) fall into the ILM-Kim field. Hence, the classification scheme captures kimberlitic ilmenites, but does not necessarily preclude ilmenites from some other sources.

<INDICATOR> field – Nb-rutile

Nb-rutile is not identified as an indicator mineral in the DED although its presence should merit attention.

<INDICATOR> field – olivine

Olivines from mineral separates of hand samples or thin sections of kimberlites and related rocks are determined to be indicators. Where they derive from surface sediment samples, their mineral chemistry is usually not determined in a fashion suitable to discriminate diamond-prospective from non-diamond prospective sources. However, such samples are uncommon and, as olivine usually does not survive far from source, they are also classified as indicators. Comments fields are used to draw attention to the uncertainty involved in designating sediment-derived olivine records as indicators.

<INDICATOR> field – orthopyroxene

Grains with compositions falling in the diamond lherzolite (OPX-ODL), diamond harzburgite (OPX-ODH), on-craton diamond peridotite (OPX-OGP), and garnet peridotite and on-craton megacrysts (OPX-OGM) fields are considered to be indicators. Spinel-lherzolite (OPX-OSP) and eclogite/pyroxenite (OPX-OEC) association compositions and 'Undefined' compositions, where MgO wt%/(MgO wt% + FeO wt%) <0.7, are not considered indicators.

<INDICATOR> field – pseudobrookite

Due to the fact that Pseudobrookite-Cr is most likely to be an extreme weathering product of titaniferous Cr-spinel and/or Cr-bearing picroilmenite, it considered to be an indicator mineral. Hence, occurrences of Pseudobrookite-Cr would also counted in the <OTHERINDIC> field of DED_GL_BULK_ANALYSES_Indicators.xlsx. Pseudobrookites have not, however, been reported in Greenland.

<INDICATOR> field – spinel

The Mg–Cr–Al-spinel (SP-MCAS) and all chromites, excluding Al-chromite (SP-AC), are considered to be indicator minerals. Hence, all spinel classifications (SP-CID, SP-Gt-Per, and SP-Unclassified), aside from SP-Crustal, are populated with 'YES' in the <INDICATOR> field.

<INDICATOR> field – tourmaline

Unlike in Australia (Hutchison, 2018b), tourmaline is not classified as an indicator in the Greenland DED due to the absence of tourmaline-bearing lamproites.

Analytes (<SiO_2>, etc.)

Entries are as reported, except for data with over four decimal places, which are truncated. In fact, it is unlikely that there are any cases where analytical precision justifies four decimal places. Users of the database are encouraged to consider similar analytical precision, particularly when using such analyses.

Analyte concentrations are expressed as positive numbers. In some cases, sources have reported negative numbers, which reflect concentrations below a certain detection limit. Detection limit concentrations are handled in the DED with the analyte field populated with '-444' and known detection limits quoted in the 'Comment' fields.

Diamond description data – DED_GL_GRAIN_ANALYSES_Diamond

The diamond description file reflects the range of physical criteria for diamond crysts reported in company submissions. Some companies only report carat weight or diamond size, either by direct measurement of the various axes or by discrimination based on sieve size. Other companies have provided more comprehensive descriptions, incorporating colour, shape, surface, and internal features. Fields have been designed to subdivide descriptions into features, reflecting colour (<DIAMCOLOUR>), shape as a result of growth and resorption (<DIAM_CRYST>), discrete surface features (<DIAM_SURF>), and the effects of brittle deformation (<DIAM_CLEAV>). Reported data have been rearranged where they were appropriate to fit these fields. Hence, data can be reasonably easily filtered to provide an idea of the extent to which diamond crystals have been compromised within their magmatic transport media (<DIAM_CRYST>) or during emplacement (<DIAM_CLEAV>), and the length of time they may have resided in sediments rather than their primary hosts (<DIAMCOLOUR>).

Although attempts have been made to make the descriptive terms for various criteria more consistent, entries largely reflect the actual terms reported. Care should therefore be taken when, for example, comparing crystal shapes between samples, as explorers may not have used internally or externally consistent definitions of descriptive terms.

Size classification (<MACROMICRO>, <MACMICREP>)

In order to establish consistency, a macrodiamond or microdiamond classification (<MACROMICRO>) has been applied on the basis of the physical properties of each diamond reported. This classification is distinct from the one used by the reporting company (<MACMICREP>). The criteria used for defining a macrodiamond is a weight of ≥0.0016 mct or the stone has been captured on a sieve with diameter of ≥0.5 mm, or else the largest dimension reported is ≥0.5 mm. Note that the application of this test could result in the reclassification of some diamonds which had previously been reported to be microdiamonds being reclassified as macrodiamonds and vice versa.

In situ occurrences – DED_GL_OCCURRENCES

All locations of primary occurrences of rocks of interest to diamond prospectors (‘occurrences’) are compiled in DED_GL_OCCURRENCES.xlsx. All associated coordinates have been verified by GPS-based ground-truthing, reference to original company reports, peer-reviewed publications, or geophysical data, such as aeromagnetic surveys or satellite imagery. The DED_GL_OCCURRENCES.xlsx dataset represents a significant advance over prior datasets, including Jensen et al. (2004) which included some of the same

rock bodies, but where occurrences were not so readily distinguished between in situ and transported material.

Naming conventions (<TITLE> and <OTHER_NAME>)

Each contiguous in-situ body is assigned only one record where it is given a unique <TITLE>. This record can be regarded as the principle location for the body and in most cases is either the discovery location, or where the body is most clearly exposed, occurs at its greatest size or where a significant sample such as a bulk sample has been taken. In order to keep <TITLE> unique, where more than one occurrence has been determined to be a part of the same body (such as where it is intersected in drill core at depth or at another notable location along strike), each additional record has the <TITLE> field blank. In such cases the field <OTHER_NAME> is used to indicate its association with the titled-occurrence.

Diamond occurrence (<DIAM_GRADE>)

The DED uses the field <DIAM_GRADE> to provide information on diamond testing. Where an entry is '0', the rock body has been tested and found to be barren. Untested rock bodies are populated with 'Not_Reported'. In most cases <DIAM_GRADE> refers to the diamond grade recorded from the largest sample taken from the occurrence. The field <DIAM_GRADE> should not be considered exhaustive and the user of the DED is directed to the field <DIAMRESULT> in DED_GL_BULK_ANALYSES_Indicators.xlsx to identify all known diamond-positive samples.

Orientation (<DIP> and <DIPDIR>)

Strikes of planar bodies are assumed to have always been made with reference to grid north based on the UTM system but they are almost never quoted as such. Where original locations are reported to have been determined within a particular UTM zone, this will likewise be the zone used as the reference grid for orientation measurements. Where original coordinates are reported in latitude and longitude if a UTM grid is to be assumed then it should be the statutory UTM Zone for the location of relevance. If orientations are made with reference to True North, and this is known, this is elaborated upon in the Comments fields.

Transported rocks and inferred locations of in situ bodies – DED_GL_FLOAT

Where discoveries of diamond-prospective rocks cannot be said to be definitively in-situ or topographic features infer the existence of an in-situ body in the context of known nearby occurrences, records are

assigned to DED_GL_FLOAT.xlsx. It is notable that locations designated in Jensen et al. (2004) as 'subcrop', as distinct from float and in-situ occurrences, do not usefully identify any possibly in-situ bodies not already identified by locations in DED_GL_OCCURRENCES.xlsx. Hence there is no need to treat any Jensen et al. (2004) subcrop location as an occurrence. All such records are assigned to DED_GL_FLOAT.xlsx.

Drillholes – DED_GL_DRILLHOLES

Drillholes aiming to intersect in situ occurrences are documented in DED_GL_DRILLHOLES.xlsx. Drillhole data from Jensen et al. (2004) almost never reference the samples derived from each hole, and vice versa, almost no sample in Jensen et al. (2004) references that it derived from a drillhole. In the DED, cross-references have been established to the extent possible. As for other files, field terms follow the accompanying data dictionary. Of particular note, however, are the following fields.

Hole orientation (<AZIMUTH> and <AZGRID>)

Drill hole azimuths are assumed to have always been made with reference to grid north based on the UTM system. Where original locations are reported to have been determined within a particular UTM zone, this will likewise be the zone used as the reference grid for orientation measurements. Where original coordinates are reported in latitude and longitude if a UTM grid is to be assumed then it should be the statutory UTM Zone for the location of relevance. If orientations are made with reference to True North, and this is known, this is elaborated upon in the Comments fields.

Geological environment (<GEOLASSOC> and <GEOL_REG>)

Fields <GEOLASSOC> and <GEOL_REG> are populated with the same methodology described for DED_GL_BASICS. In the case of drillholes <GEOLASSOC> reflects the host rock lithology to any kimberlitic or diamond-relevant rocks intersected. Due to the small number of records, locations matching lakes and Quaternary deposits are attributed with the closest solid lithology and notes made accordingly in Comments fields.

Acknowledgements

The structure of the DED relies heavily on that designed previously for the Northern Territory of Australia and Western Australia, being the most modern and comprehensive large and publicly available diamond exploration databases. In that regard, Dan Schulze (University of Toronto), Bruce Wyatt (Wyatt Geology Consulting) and Herman Grütter (ex-BHP Billiton World Exploration) are gratefully acknowledged for their invaluable discussions regarding mineral chemistry, and particularly Wayne Taylor (Energy Metals Ltd). Regarding data, the considerable work conducted by Karsten Secher and Sven Monrad Jensen, in particular, in construction of the GEUS Report 2004/117 (what was a ground-breaking public diamond exploration database for its time) is firmly acknowledged. Companies contributing to Greenland's diamond exploration provided assistance, in the form of data, permissions for data use and other assistance and advice. Ken Armstrong and Barb Kupsch (North Arrow Minerals Inc., with reference to Navigator Exploration Corp.) are gratefully acknowledged, as are Stefan Bernstein (GEUS, with reference to Avannaa Resources Ltd data), Guy Della Valle (Major General Resources Ltd), Paul Armitage (previously of Nuna Minerals A/S) and Jamie Tuer and Jim Cambon (Hudson Resources Ltd.). Sven Monrad Jensen is particularly thanked for provision of very well organised data and swiftly-delivered precise information regarding Icefire Diamonds A/S and Intex Resources ASA activities. Chad Ulansky is acknowledged for trying, albeit unsuccessfully, to acquire data from Metalex Ventures Ltd which was unreported from its final years of Greenland exploration. Símun Dalsenni Olsen, Bjørn Thomassen, Bjørn Henning Heincke, Kristine Thrane and particularly Troels Nielsen are thanked for their contributions in conjunction with GEUS and GEUS-hosted data. Brian Upton and John Craven (University of Edinburgh) and Graham Pearson (University of Edmonton) are also thanked for their contributions regarding academically-published data. The author is indebted to the numerous people who have promoted and facilitated his diamond interests in Greenland, notably Kathleen and Neville Cartwright, Brian Upton, Julie Hollis, Lotte Larsen, Troels Nielsen, John Ferguson, Jamie Tuer, Hans Peter Hansen, Karina Sand, Louise Nielsen, Peter Møller, Jennifer Porter, Anders Lie, Stefan Bernstein, Matilde Rink, Guy Della Valle, Ole Christiansen and Urban Burger.

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