Ore Geology Reviews 79 (2016) 268–287

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Geological setting and fluid inclusion characteristics of a lead-copper-barium occurrence hosted in a Neoproterozoic mafic sill at Kiatak, Northumberland Island, Northwestern Greenland

Yawooz Kettanah [a,b,*], Marcos Zentilli [b], Jacob Hanley [c], Fergus Tweedale [c]

[a] Department of Geology, College of Science, Salahaddin University, Erbil, Iraq
[b] Department of Earth Sciences, Dalhousie University, Halifax, NS, B3H 4J1, Canada
[c] Department of Geology, St. Mary's University, Halifax, NS B3H-3C3, Canada

ARTICLE INFO

Article history:
Received 28 March 2015
Received in revised form 20 May 2016
Accepted 31 May 2016
Available online 3 June 2016

Keywords:
Greenland
Diabase sill
Franklin-Thule dike swarm
LIP
Pb-Cu-Ba
Galena
Fluid inclusions
Methane
Basinal fluids
SEDEX

ABSTRACT

We describe a Pb-Cu-Ba occurrence in Northumberland Island, Northwestern Greenland. Mineralization occupies the brecciated upper contact domain of a Neoproterozoic diabase sill belonging to the Franklin-Thule dike swarm (720–716 Ma), with pyrite-bearing black shales of the Dundas Group, upper Thule Supergroup. The host tholeiitic diabase sill is of different composition (low TiO_2 and P_2O_5) than the locally crosscutting dikes (high TiO_2 and P_2O_5). Chloritization, carbonatization and silicification are intense in proximity to sulfides. Coarse grained, open space-filling galena and minor chalcopyrite are accompanied by 2 generations of calcite and 2 of barite. Galena contains significant amounts of Ag (av. 400 ppm), Sb (av. 700 ppm), Se (av. 20 ppm), traces of Bi, Cd, and Sn. Fluid inclusions in the gangue of the Kiatak occurrence indicate two fluid types. Prior to galena precipitation, a $CaCl_2$-NaCl-rich aqueous brine (~20 wt.% eq NaCl) cooled from temperatures >300 °C and was trapped first in early calcite, and with further cooling, in barite together with solid bitumen inclusions. Following galena crystallization, secondary inclusions containing a similar brine, but of lower salinity, higher Ca:Na ratio, and lower temperature, were trapped in calcite. Corrosion of galena was followed by precipitation of lower temperature (~100 °C) barite from a second fluid, comprising immiscible water and CH_4. Despite its location in the contact between shale and large mafic sill, the low-temperature mineralization postdates the cooling of the sill, and may be related to basinal fluid circulation controlled by regional extensional faults parallel to diabase dikes. Although uneconomic, the Kiatak occurrence may be witness to a larger metallogenic process that could have formed significant SEDEX type metal concentrations in strata within the Thule Supergroup.

1. Introduction

During a foot traverse, sampling for a geochronology study on Northumberland Island, NW Greenland (e.g. Jackson et al., 2002; Grist and Zentilli, 2005; Denyszyn et al., 2006, Denyszyn et al., 2009a, 2009b), an extensive outcrop was unexpectedly encountered that contains Pb and minor Cu sulfides and associated with calcite-barite-quartz gangue, hosted in a large mafic sill belonging to the Neoproterozoic Franklin-Thule Dike Swarm and Large Igneous Province (LIP). In the last few years there has been increased interest in the relationship between LIP and mineral deposits; mafic sills and dikes represent potential sources of energy and metals that can either drive or contribute to a variety of ore-forming systems; alternatively, sills and dikes constitute barriers to fluid flow, or their fractured margins can channel mineralizing fluids (e.g. Lewis, 1955; Ernst and Jowitt, 2013; Ernst, 2014).

Mineral exploration has been active in Greenland in various geological environments (e.g. Nielsen, 1973, 1976; Thomassen and Dawes, 2008; Henriksen et al., 2009). Geochemical anomalies and minor mineralized occurrences with Au, Cu, Zn, Pb and Ba have been identified before in Northumberland Ø, including one spatially associated to a diabase dike (e.g. Dunnells, 1995; Thomassen and Krebs, 2004; Dawes, 2006), but none with a sill and the characteristics of the one here described. The objective of this paper is to describe the Pb (Cu, Ba) occurrence, pose restrictions on the conditions of temperature and pressure during its formation, and ascertain what role, if any, the host mafic sill had in its genesis.

This mineral occurrence, here informally named Kiatak (Figs. 1, 2), is located in Northumberland Island (Danish: *Northumberland Ø*; Greenlander: *Kiatak* and *Kujata*), with coordinates N. 77° 22.087′/W. 71° 30.568′, at ~200 m.a.s.l., on a gently northward-sloping flat surface

* Corresponding author.
E-mail addresses: kettanah@dal.ca (Y. Kettanah), zentilli@dal.ca (M. Zentilli), jacob.hanley@smu.ca (J. Hanley), fergus.tweedale@smu.ca (F. Tweedale).

http://dx.doi.org/10.1016/j.oregeorev.2016.05.027
0169-1368/

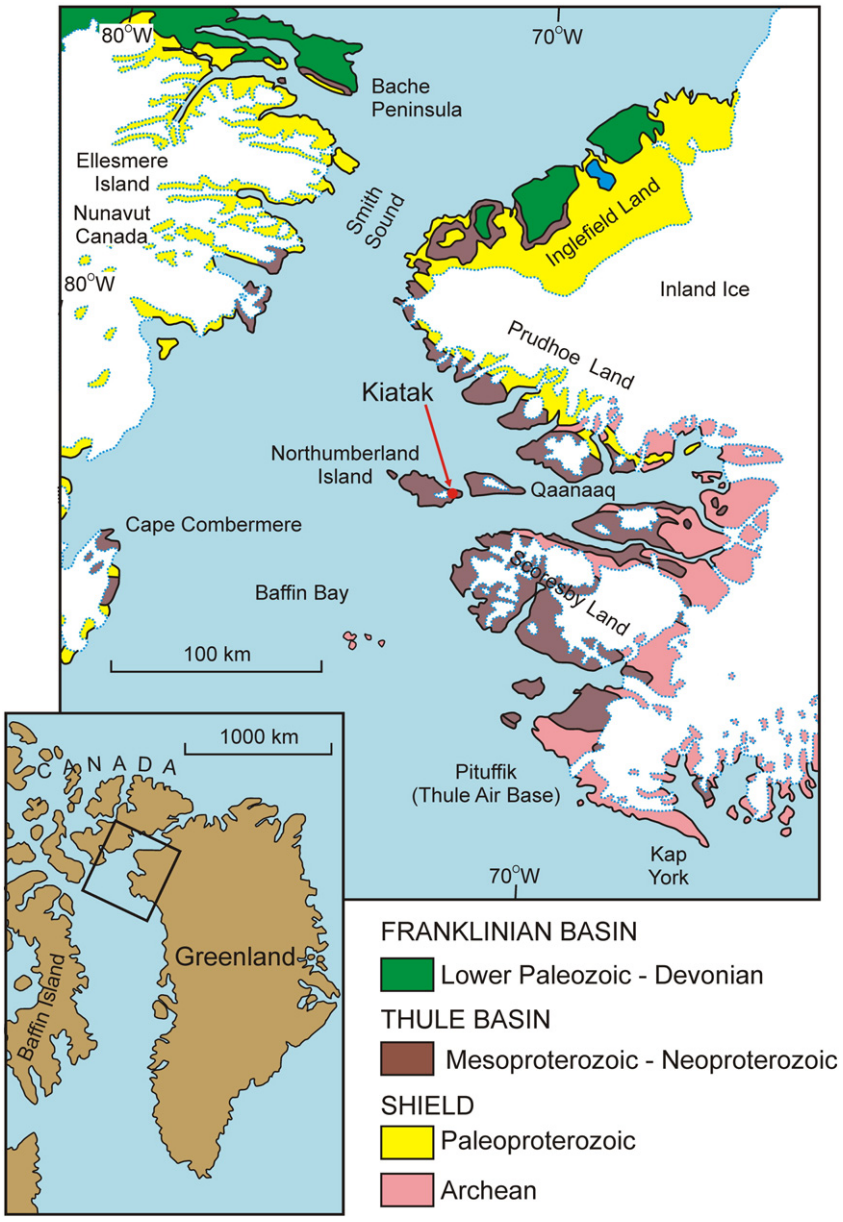

Fig. 1. Location Map of Kiatak, in Northumberland Island, Greenland. Modified from Dawes (2006).

(Fig. 3), 2 km north of a deserted coastal camp on Hvalsund Channel, 5 km southwest of Kap Henson (*Igdlernârssuk*), (Fig. 2), and 54 km west of the town of Qaanaaq (pop.660) on the mainland (Fig. 1).

2. Geology

The Kiatak mineralization is hosted by the exposed uppermost portion of a large diabase sill (Fig. 3) that intrudes dark shales of the Dundas Gp. (Dawes, 1997). The altered and mineralized porphyritic diabase is visible, where not covered by thin glacial detritus, in an area of at least 250 × 50 m, elongated in a SW-NE direction (Fig. 3). In the field, the mineralization is noticeable because of the presence of white tabular calcite and barite, as well as galena crystals, and localized malachite. The mineralization occupies fractures and spaces between angular blocks of diabase in an open-framework breccia, and its domain appears relatively tabular, but it was not possible to ascertain its extent in the vertical direction.

2.1. Stratigraphy

The Dundas Gp. is one of the youngest units of the Mesoproterozoic to Neoproterozoic Thule Supergroup (Dawes, 2006), deposited in the Thule Basin, and widely exposed in NW Greenland and the coastal regions of Ellesmere Island in Canada (Fig. 1). According to Dawes (2006) the Thule Supergroup is 6 to 8 km thick and consists of continental to shallow-marine strata with one main interval of terrestrial basaltic volcanic rocks. The Thule Supergroup unconformably overlies highly metamorphosed Archean to Paleoproterozoic crystalline rocks, which locally contain graphitic schists (e.g. Dawes, 2006; Thomassen and Dawes, 2008). Dawes (2006) concluded that sedimentation in the Thule Basin started in the middle Mesoproterozoic (Ectasian) and continued to the early Neoproterozoic (Tonian).

The Dundas Gp. is 2 to 3 km thick, and is composed of marine sandstone, siltstone and gray and black shale, with lesser amounts of carbonate (dolomite, limestone, arenaceous dolomite), chert and evaporitic strata (Dawes, 1997). It was deposited in an intertidal to subtidal,