GEOLOGY AND ORE

Exploration and Mining in Greenland

# The mineral potential of the East Greenland Palaeogene intrusions

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# The mineral potential of the East Greenland Palaeogene intrusions

***Flood basalts, dyke swarms and intrusive complexes characterise the outer coastal area of East Greenland. They are all part of the Palaeogene volcanic rifted margin that formed prior to, during, and after the onset of seafloor spreading in the North Atlantic. The magmatic province stretches from c. 66°N to c. 75°N, a distance of c. 1,300 km. The magmatism lasted for about 50 million years, from 61 to 13 Ma. More than sixty Palaeogene intrusions are recorded. The plutonic suites range in composition from ultramafic to felsic and from depleted basaltic to highly alkaline, and in form from upper crustal intrusions to subvolcanic centres and breccia pipes with related epithermal vein systems.***

***Due to its remoteness, severe climate and rugged topography, the East Greenland Palaeogene province remains vastly underexplored. In spite of this, two world-class deposits – the Malmbjerg porphyry-molybdenum deposit and the Skaergaard mafic intrusion-hosted stratiform PGE-gold deposit – are known from this region that offers a promising potential for mineral deposits of similar or other types.***

## Flood basalts

Picritic to basaltic lavas erupted locally in the Paleocene (61–57 Ma) and they were followed (57–54 Ma) by regional flood basalts up to 5 km thick. They correlate across the North Atlantic to the Faeroe Islands. The flood basalts are preserved between Kangerlussuaq and Kangertittivaq (Scoresby Sund, 68°–70°N) and are in part overlain by 13 Ma old lavas. With remnants of the flood basalt province present between 66° and 75°N, the East Greenland flood basalt province ranks with provinces like Parana and Deccan as the largest on Earth. The main volume of basalts extruded between 57 and 54 million years ago.

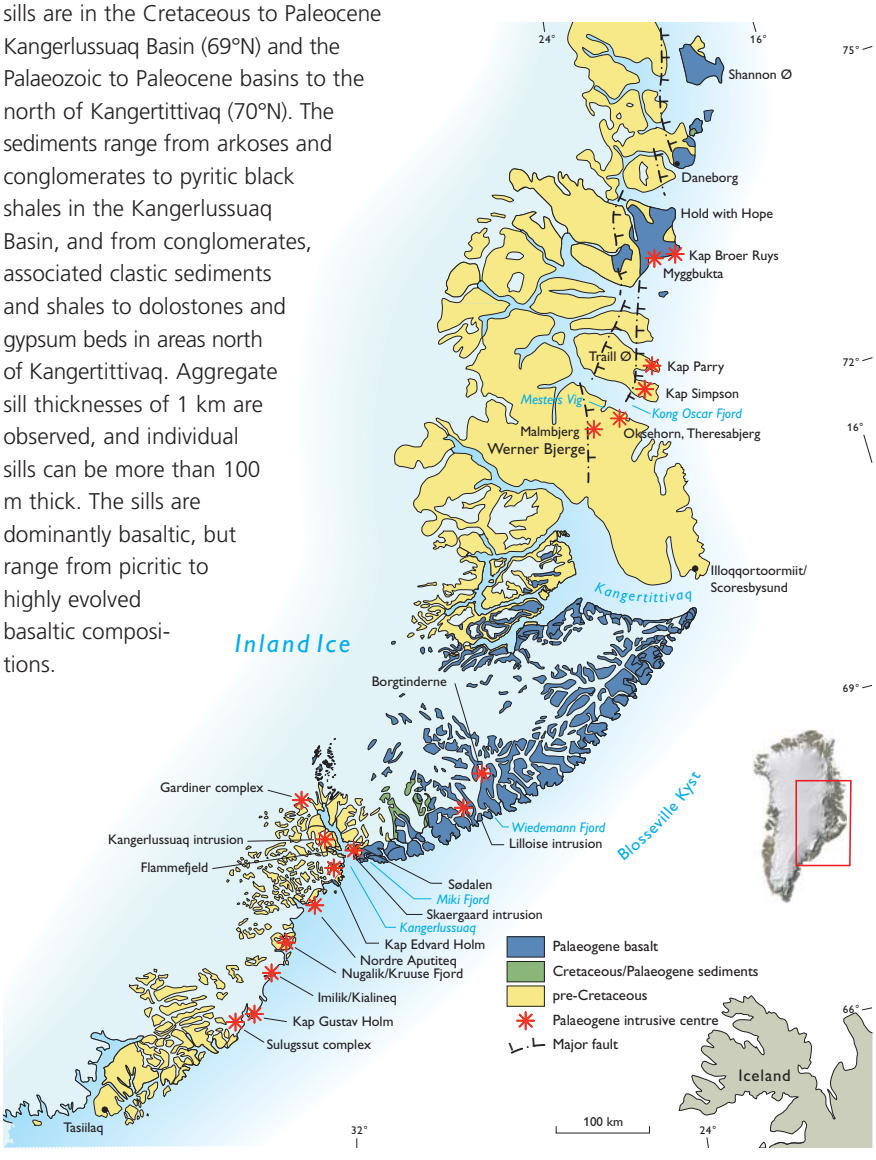
Early picrite lavas show strong similarities to Hawaiian lavas whereas overlying flood basalts show Icelandic affinities. A transition from plume-generated, intraplate products to spreading ridge magmatism is illustrated. A triple junction, plume-type melts and a large domal uplift suggest that the early Iceland plume surfaced in the Kangerlussuaq area (68°N).

## Sill complexes

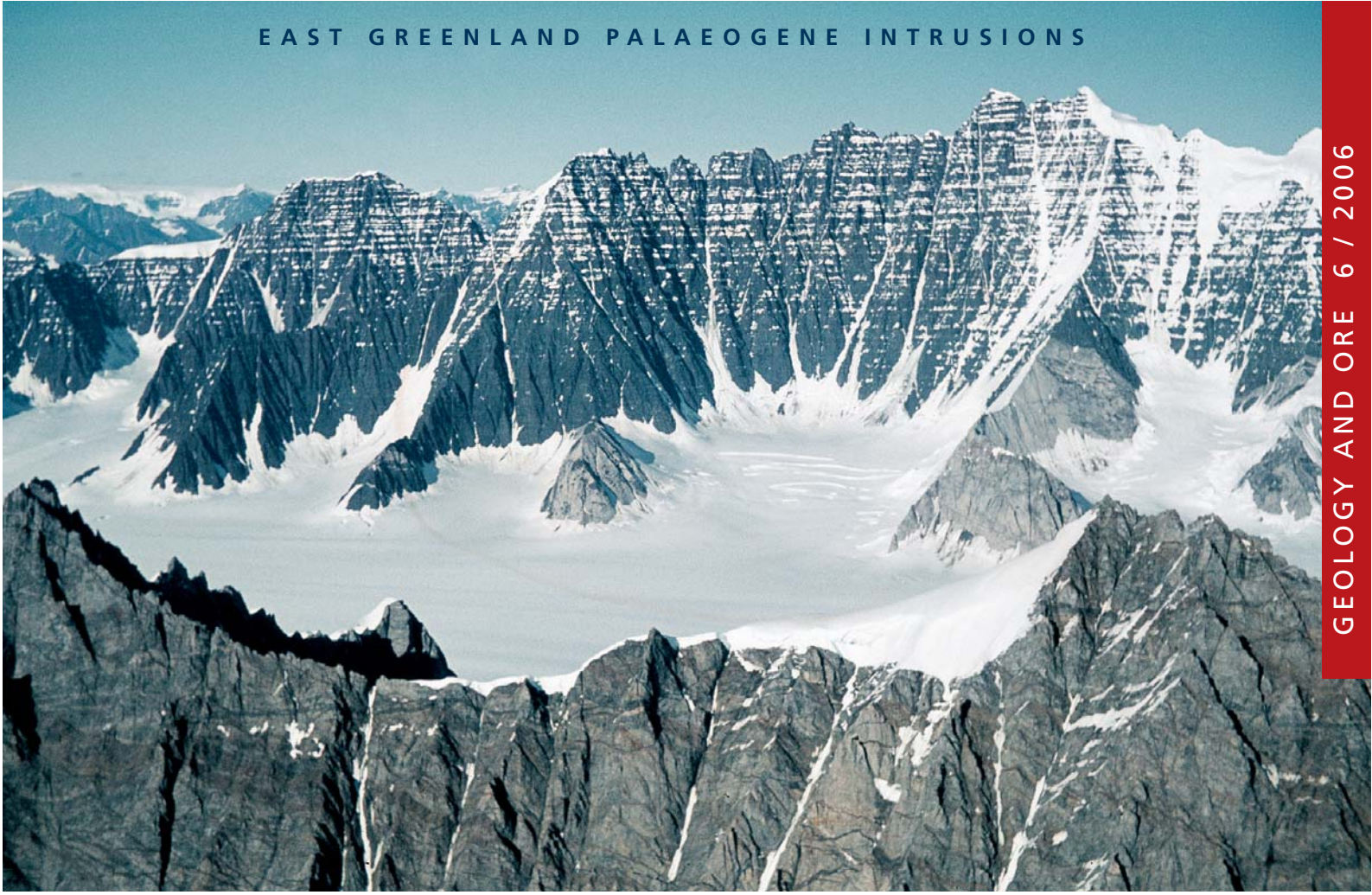
Major sill complexes in sedimentary basins pre-date the lavas. The two main areas of sills are in the Cretaceous to Paleocene Kangerlussuaq Basin (69°N) and the Palaeozoic to Paleocene basins to the north of Kangertittivaq (70°N). The sediments range from arkoses and conglomerates to pyritic black shales in the Kangerlussuaq Basin, and from conglomerates, associated clastic sediments and shales to dolostones and gypsum beds in areas north of Kangertittivaq. Aggregate sill thicknesses of 1 km are observed, and individual sills can be more than 100 m thick. The sills are dominantly basaltic, but range from picritic to highly evolved basaltic compositions.

## Dyke swarms

Large-volume, coast-parallel dyke swarm systems, some resembling sheeted complexes, formed in the flexured continental margin and in relationship to magmatic centres. The dyke swarms strike for hundreds of kilometres and represent intrusion from c. 60 to at least 35 Ma. The dyke swarms are dominated by tholeiitic basalts, but range from picritic tholeiites to highly alkaline nephelinites and carbonatites. All magma types found in flood basalts and central complexes are represented in the dyke swarms.




*Map of the Palaeogene East Greenland igneous province.*



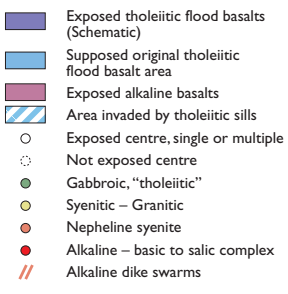
*Aerial view of flood basalts intruded by syenite at Borgtinderne. The peaks are c. 2500 m a.s.l.*

## Intrusions and central complexes

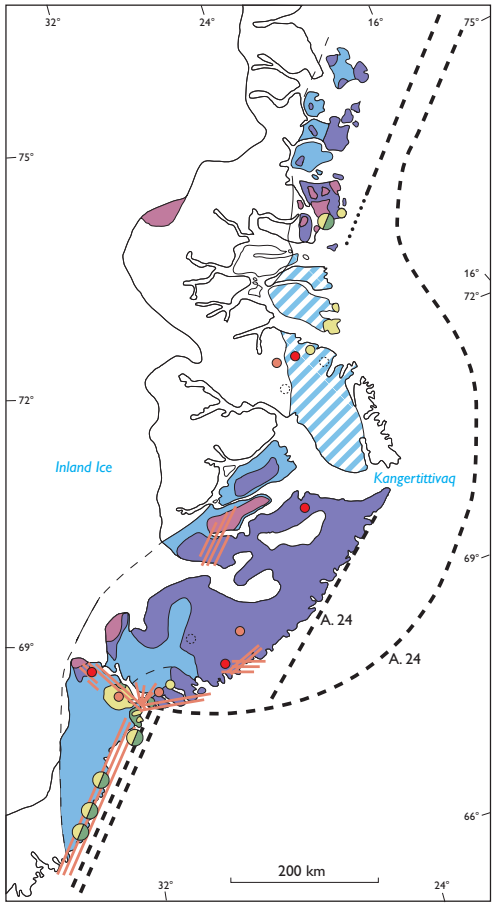
Central complexes are dotted along the East Greenland coast. South of Kangerlussuaq (68°N), uplift followed by deep erosion has exposed a suite of magmatic centres. They comprise early gabbros – some with PGE and gold mineralisation – followed by intermediate to felsic intrusions, including monzonites, syenites and granites. One complex is nephelinitic with carbonatite affinities.

Twenty-eight intrusions and complexes are recorded in the Kangerlussaq area (68°N). They range from ultramafic plugs, replenished ocean floor-type gabbro complexes (Kap Edvard Holm, c. 50 Ma), strongly fractionated closed system gabbros (Skaergaard, c. 54 Ma), dioritic intrusions and undersaturated and oversaturated syenites and granites (Kangerlussuaq, c. 50 Ma), to carbonatite-bearing nephelinitic complexes (Gardiner, c. 54 Ma). The most voluminous intrusions and complexes are the syenitic Kangerlussuaq intrusion (c. 700 km$^2$) and the PGE-bearing Kap Evdard Holm gabbro complex (> 400 km$^2$). To both of these are related suites of smaller and peripheral intrusions, including the subvolcanic Flammefjeld complex with molybdenum mineralisation at the margin of the Kangerlussuaq intrusion. The PGE- and gold-mineralised Skaergaard intrusion (c. 70 km$^2$) is the best-known intrusive complex in East Greenland.

A second large group of intrusive complexes is located in the Kong Oscar Fjord area (72°N). These are large, dominantly felsic intrusions but magnetic anomalies suggest that most are underlain by mafic complexes. The roof zone of a gabbro intrusion is the oldest part of the Werner Bjerge complex which is dominated by




*Thematic map of the Palaeogene East Greenland igneous province. A. 24: magnetic ocean floor anomaly.*



*Palaeogene dyke swarm intruded into Precambrian gneiss, south of Kruuse Fjord. The cliff is c. 80 m high.*

alkali syenites and granites and a large nepheline-syenite body. This complex shows molybdenum mineralisation, best known from the Malmbjerg porphyry-molybdenum deposit hosted by a small granitic stock.

A suite of mainly granitic and syenitic intrusions is exposed north-east of the Werner Bjerge complex. The suite includes the roof sections of two large intrusive centres on the south shore of Kong Oscar Fjord (Oksehorn and Theresabjerg) and two major centres on the eastern headlands of Traill Ø (Kap Simpson and Kap Parry). The most northerly intrusions are found on Hold with Hope (73°30′N), and comprise the roof of a large basaltic complex at Myggbugta and felsic sheets at Kap Broer Ruys.

## Mineral exploration

Commercial mineral exploration in East Greenland was triggered by the 1948 galena-find at Mesters Vig, which led to mining of the Blyklippen Pb-Zn vein deposit between 1956 and 1962. Nordisk Mineselskab A/S was established in 1952 to investigate and mine Blyklippen, but also to explore a large concession area between 70°N and 74° 30′N amounting to 100,000 km$^2$. The company performed mineral exploration in the period 1952–84, and found a large number of mineral occurrences. Most effort was put into the inves-

*Vivid colours of argillic alteration and iron hydroxides in pyroclastic rocks, Kap Simpson complex. The peak is c. 700 m a.s.l.*

tigation of the Malmbjerg molybdenum deposit between1955 and 1981 and partly in joint ventures with AMAX Inc. Other Palaeogene intrusions north of 70°N were, however, also reconnoitred. In 1970–71, the company prospected in the region between 67° and 69°N and detected the first indications of molybdenum and gold in the Kangerlussuaq area. In 1982 detailed surface investigations were accomplished at the Flammefjeld molybdenum prospect.

In the period 1986 to 1996, Platinova A/S operated with various joint venture partners in the region between 67° and 69°N. The main effort was the investigation of the noble metal potential of the Skaergaard intrusion but the Kap Edvard Holm intrusion and other intrusions of this southern region were also investigated to various degrees. A recent player is Galahad Gold Plc, which through its subsidiary Skaergaard Minerals Corp. investigated the Skaergaard deposit in 2003–04, and, through the subsidiary International Molybdenum Plc, the Malmbjerg deposit in 2005.

## Mineral occurrences

Significant mineral occurrences in the Palaeogene East Greenland province are given in table-form below. In order to illustrate the province's mineral potential, some of the best investigated occurrences are described in the following sections.

## Malmbjerg porphyry Mo deposit

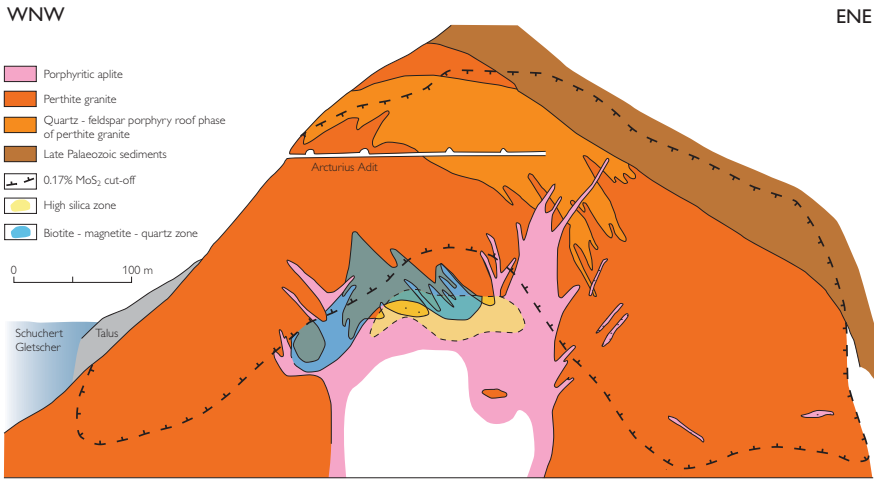
Malmbjerg is located in the Werner Bjerge massif at 72°N. It hosts a porphyry-molybdenum deposit of the Climax-type, discovered in 1954 during systematic mapping by members of the Danish East Greenland Expeditions. Investigations in 1955–61 by Nordisk Mineselskab A/S, and in 1962 by a Nordisk Mineselskab/AMAX Inc. joint venture, involved the excavating of three adits totalling 1,329 m, from where 146 holes were drilled, totalling some 22,000 m. An ore body of 119 Mt grading 0.25% $MoS_2$ at a cut-off of 0.17% $MoS_2$ was defined, but not found profitable with the molybdenum price of the time. In 2004, Galahad Gold Plc acquired the property, spurred by a dramatic rise in the molybdenum price.

*Traditional transportation: M/S "Ejnar Mikkelsen" off Kap Edvard Holm, 1971.*

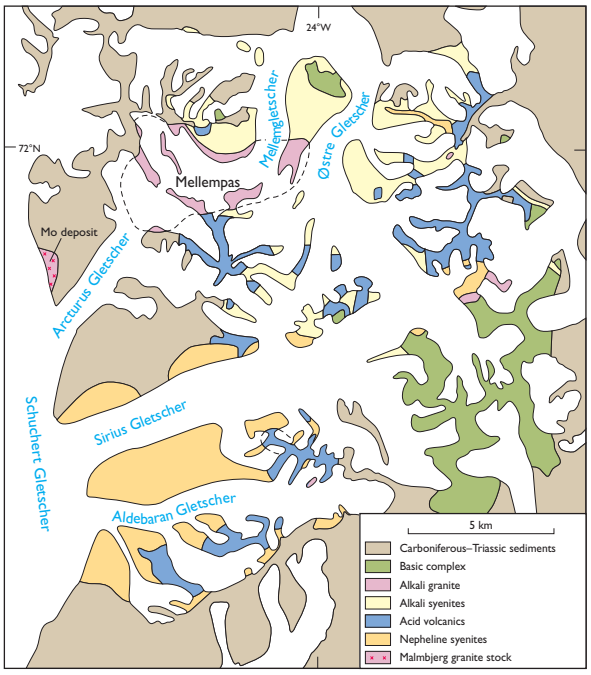

*Modern transportation: unloading of a Twin Otter STOL aircraft at the Sødalen airstrip, 2000.*

**Overview of mineral occurrences in the East Greenland Palaeogene magmatic province**

| Type | Commodities | Deposit/prospect | Showing/indication |
|---|---|---|---|
| Porphyry | Mo, W | Malmbjerg<br>Flammefjeld | Mellempas<br>Kap Simpson |
| Epithermal veins | Au, Ag, Pb, Zn, Cu | Blyklippen<br>Mesters Vig | Amdrup Fjord<br>Coastal dyke swarm<br>Kap Simpson<br>Others |
| Mafic intrusion-hosted, stratiform (Skaergaard type) | Pd, Pt, Au, Ti, Fe, V | Skaergaard intrusion<br>Kap Edvard Holm | Nordre Aputiteq |
| Mafic intrusion-hosted, contact-related (Noril'sk type?) | Pt, Pd, Cu, Ni | | Miki Fjord macrodyke<br>Kruuse Fjord |
| Peralkaline rock-associated | Nb, Ta, Be, Zr, Y, REE | | Werner Bjerge<br>Kap Simpson<br>Kangerlussuaq intrusion |
| Carbonatite-associated | Apatite, Nb, Fe | | Gardiner complex |
| Volcanic redbed | Cu | | Wiedemann Fjord |




*Vertical section through the Malmbjerg ore body. After Harpøth et al. (1986).*




*Geological map of the Werner Bjerge alkaline complex. Simplified after Bearth (1959).*

The Malmbjerg porphyry-molybdenum deposit is associated with a 25.7 Ma, composite, alkali granite stock intruded into Carboniferous sandstones. The stock is part of the intrusive Werner Bjerge alkaline complex and consists of three lithological units: perthite granite with a quartz-feldspar porphyry roof phase, a heterogeneous porphyritic aplite and porphyritic granites. Molybdenite mineralisation occurs in a 700 x 700 x 150 m inverted bowel-shaped body located mainly in the perthite granite and its porphyritic roof phase. Molybdenite occurs in veinlets forming a stockwork of mutually offsetting veins. In addition, Mo-W-bearing greisen mineralisation occurs as flat-lying veins, up to one metre thick; minor base metal veins occur distally. Pronounced alteration is associated with the mineralisation, both inside, below and above the stockwork molybdenum mineralisation.

International Molybdenum Plc (InterMoly) conducted a major field programme in 2005, that included 4,900 m of underground drilling (31 holes) and 1,776 m channel sampling along the existing adits. The programme also comprised geotechnical drilling, bulk-sampling, site studies for processing facilities, environmental studies and a full engineering study to determine the feasibility of moving the Malmbjerg deposit into commercial production. Based on the 2005 results and historical data, a mineral resource estimate was announced by InterMoly in November 2005. It shows meas-

*Malmbjerg drill cores in InterMoly's 2005 camp.*

*Typical stockwork molybdenum mineralisation in the Schuchert adit, Malmbjerg.*

*Malmbjerg, seen from the south, positioned between Schuchert Gletscher (left) and Arcturus Gletscher (right).*

ured and indicated resources of 217 Mt at a grade of 0.20 % $MoS_2$ using a 0.12 % cut-off grade, including a higher-grade zone of 33.8 Mt at a grade of 0.28 % $MoS_2$, above a cut-off of 0.25 %. This resource estimate will form the basis for determination of the mineable reserves in a feasibility study that is under preparation.

## Flammefjeld Mo prospect

Flammefjeld is situated at the margin of the c. 50 Ma old Kangerlussuaq intrusion (68°N). The presumed youngest intrusive rocks comprise the 39.6 Ma subvolcanic Flammefjeld complex that intruded into quartz syenites at the contact between the Kangerlussuaq intrusion and satellite intrusions. The Flammefjeld complex is a 500 x 800 m composite breccia pipe intruded by quartz-feldspar porphyries and it is surrounded by a halo of hydrothermal alteration displaying vivid yellow and red oxidation colours, and distal hydrothermal veins. The name Flammefjeld means 'flame mountain'. The igneous breccias are of various types, of which one is clearly intrusive. The quartz-feldspar porphyries occur as breccia fragments, as a major intrusive body and as late dykes.

Until now, only surface investigations have been carried out on Flammefjeld. These include geological mapping and sampling, and geochemical surveys using rock chip samples and stream sediments. The existence of a major stockwork molybdenum mineralisation below Flammefjeld is indicated by the geochemical distribution of molybdenum and tungsten, by the patterns of wall-rock alteration (quartz-sericitic, pyritic and argillic), and by the occurrence of stockwork-type molybdenite mineralisation in breccia fragments. Analyses of ten mineralised breccia fragments range from 651 to 6,847 ppm $MoS_2$ with an average of 2,826 ppm. The proposed conceptual model envisages a blind Climax-type porphyry-molybdenum deposit situated 400–600 m below Flammefjeld. The ore body is inverted-saucer shaped with a diameter of 800 m, a thickness of 200 m and a grade of up to 0.5% $MoS_2$.

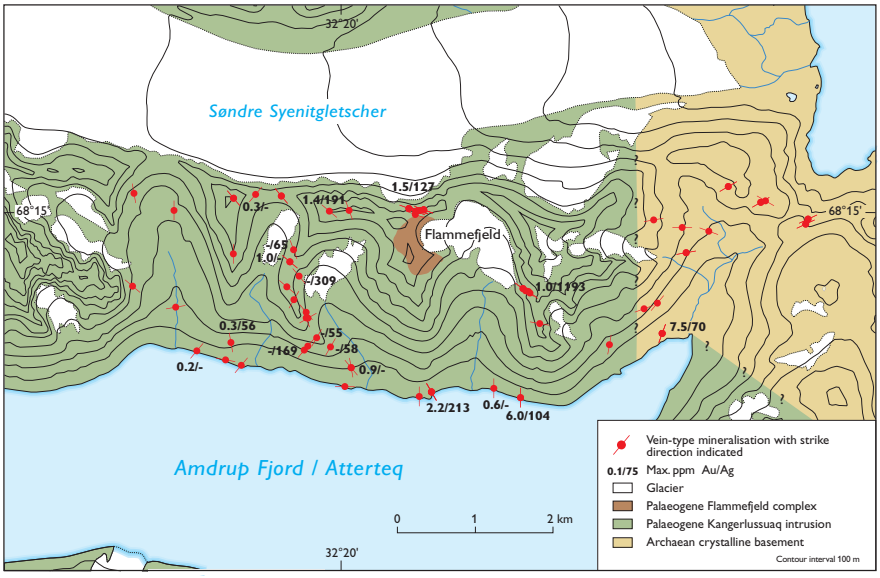
## Mesters Vig Pb-Zn veins

Epithermal lead-zinc veins are abundant over some 300 $km^2$ in the Upper Carboniferous – Lower Permian clastic sediments of the Mesters Vig area (72°N). Two major vein zones are associated with the border faults of a 4 x 12 km graben with a throw of c. 1 km but other veins occur outside the graben. The vein mineralogy is dominated by quartz, baryte, galena and sphalerite with minor calcite, pyrite and chalcopyrite, and traces of tetrahedrite. Galena and sphalerite occur as massive lenses or disseminated; the Pb/Ag ratio varies from 2,000 to 10,000. Wall-rock alteration comprises mainly silicification and kaolinisation of the sandstone host. A vertical zonation involving upwards enrichments from quartz to baryte and from copper through zinc to lead is indicated in some of the veins, but no regional zonational pattern is evident. The mineralisation is assumed to be related to the intrusion of the Werner Bjerge alkaline complex and is thus of Palaeogene age. The richest of the veins, the Blyklippen lead-zinc deposit, was mined between 1956 and 1962 by Nordisk Mineselskab A/S. Total production was 544,600 tons ore grading 9.3% Pb, 9.9% Zn and 15 ppm Ag.

*Flammefjeld seen from south-east with the Kangerlussuaq intrusion in the background.*

## Amdrup Fjord Au-Ag-base metal veins

Epithermal base-metal veins with significant gold-silver concentrations occur in both syenitic and gneissic parts of the area north of Amdrup Fjord within a distance of 5 km from Flammefjeld. Forty veins have been discovered and cursorily investigated. Most have widths in the cm–dm range, but a few vein systems have widths in the metre range (up to 30 m), and can be followed over distances of several hundred metres. The veins are typically located along cross-cutting mafic dykes and developed as breccia fillings and crustifications of epithermal character, often displaying vuggy and colloform structures (cockade structures). Gangue minerals are quartz, Ca-Mg-Mn-Fe-carbonates including rhodochrosite, and occasionally fluorite and baryte. Galena is the most common ore mineral, followed by pyrite and sphalerite. Copper minerals (chalcopyrite and tetrahedrite) are less common, and arsenopyrite occurs sporadically. Gold

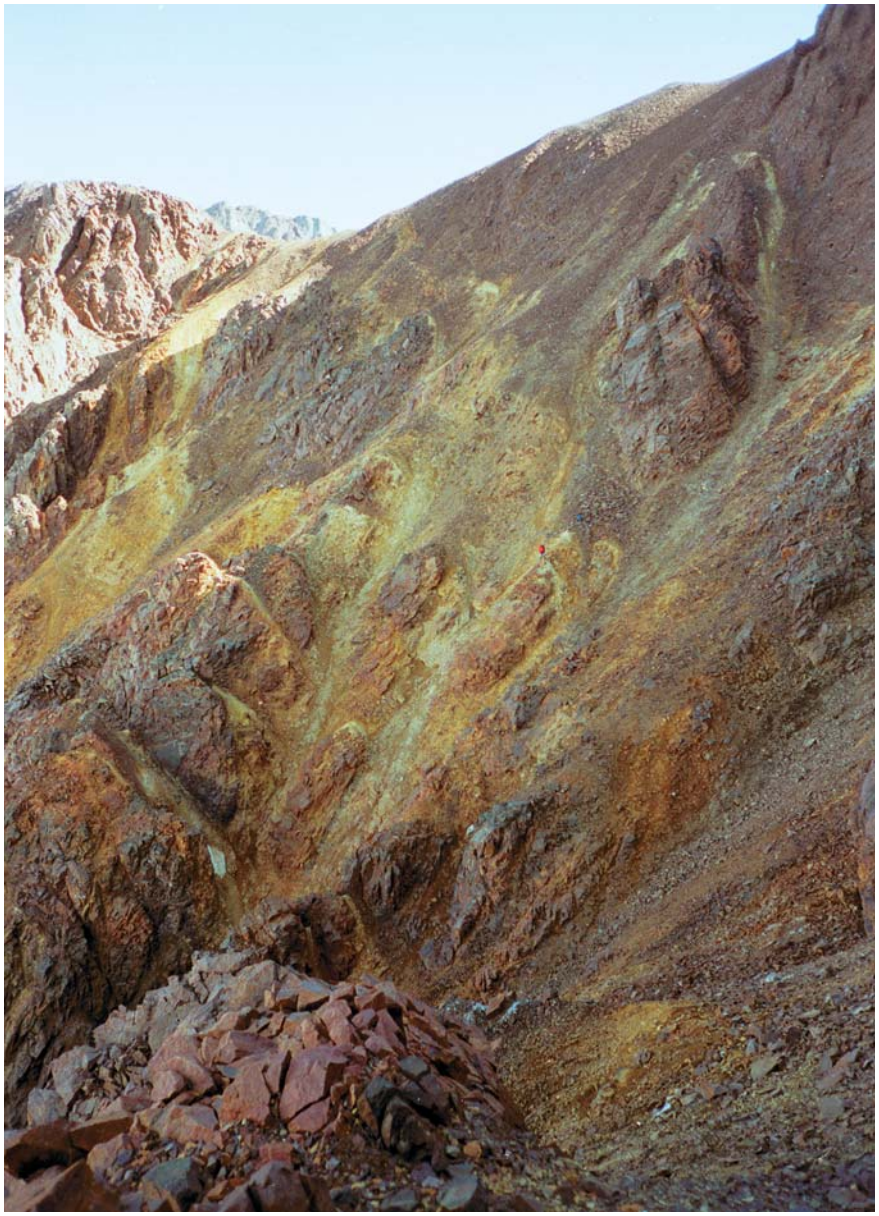



*Simplified geological map of the Amdrup Fjord area. Maximum gold and silver values are indicated where Au > 0.1 ppm and Ag > 50 ppm. From Thomassen & Krebs (2001).*

*Cut surface of igneous breccia from the Flammefjeld complex. The large granitic fragment with stockwork molybdenum mineralisation runs 0.45% $MoS_2$.*

occurs as electrum in association with the sulphide minerals. The sulphides occur as massive lenses and irregular seams of cm-thickness, and disseminated, but total sulphide concentrations rarely exceed 1% over the full width of the veins. Wall-rock alteration comprises silicification, carbonatisation, kaolinisation, sericitisation and propylitisation.

Maximum recorded gold values are 1 ppm Au over 5 m in chip samples and 38.4 ppm Au from float. Maximum silver values are 531 ppm Ag over 2 m in chip samples, and 1,193 ppm Ag in grab samples. The Ag/Au ratio is about 200. The relative concentrations of the base metals are Pb > Zn > Cu, and the mineralisation is also characterised by relative high manganese concentrations, and occasionally elevated arsenic, antimony, molybdenum and bismuth. Although veins are distributed over a vertical distance of 800–900 m, no general hydrothermal zoning centred on Flammefjeld has been observed, apart from proximal copper–distal lead-zinc indicated in some veins. This may be due to insufficient data or to telescoping of ore zones. The mineralisation appears to be epithermal gold-silver veins of low-sulphidation type and a genetic relationship with a porphyry-type molybdenum deposit below Flammefjeld has been proposed.



*Swarm of epithermal veins at the margin of Flammefjeld breccia pipe (upper right). The person clad in red in the centre of the picture is collecting a chip sample, which returned 0.3 ppm Au, 127 ppm Ag, 1.4% Pb, 3.2% Zn and 0.8% Cu over 4 m.*

## Skaergaard mafic intrusion-hosted, stratiform PGE-Au deposit

The 54.5 Ma old Skaergaard intrusion is extensively studied and has for decades been a prime example of fractional crystallisation of basaltic melt in a closed system (68°N). Spectacular layering has made the intrusion famous. The intrusion has recently been suggested to be box-shaped (c. 11 x 7 km and 4 km deep), with a total volume of c. 400 km$^3$. A ferro-basalt magma filled the magma chamber. The Marginal Border Series crystallised along the walls, the Upper Border Series under the roof and the Layered Series accumulated up from the floor leaving a residual trace-element rich melt to crystallise in the Sandwich Horizon c. 600 m below the roof of the intrusion. The distinct layering in the Layered Series is basin-shaped. The c. 3,000 m of gabbros in the Layered Series are on basis of liquidus parageneses divided in the unexposed Hidden Zone (olivine and plagioclase), Lower Zone (olivine, plagioclase, +/- clinopyroxene, ilmenite and magnetite), Middle Zone (plagioclase, clinopyroxene, pigeonite, magnetite and ilmenite) and Upper Zone (Fe-rich olivine, plagioclase, clinopyroxene, magnetite, ilmenite, +/- apatite and ferrobustamite). The cryptic variation in the minerals is significant. Olivine evolves from c. $Fo_{70}$ to $Fo_1$ and plagioclase from $An_{70}$ to $An_{10}$.

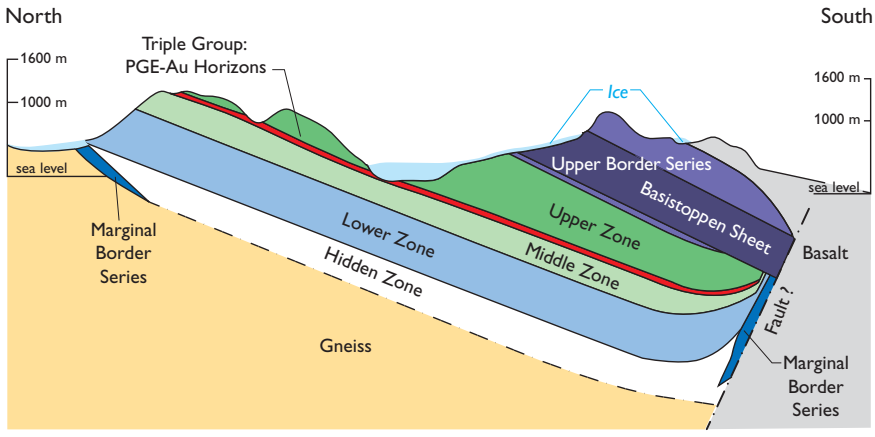

*Cut surface of colloform structures in quartz-carbonate gangue from Amdrup Fjord epithermal vein.*

*The north-eastern part of the Skaergaard intrusion with Forbindelsesgletscher to the right. The Triple Group in 1200 m peak is arrowed.*

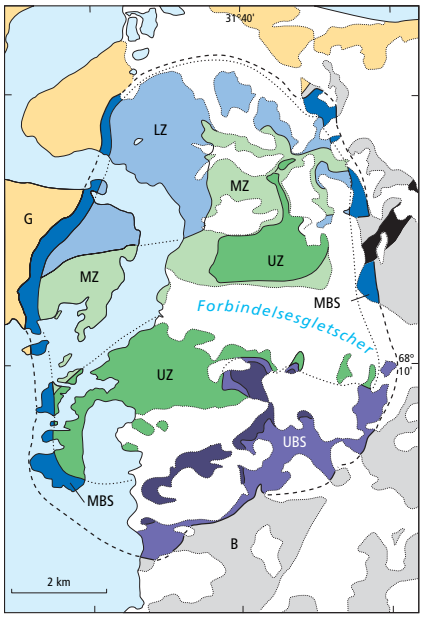
The upper part of Middle Zone (Triple Group) hosts a large tonnage low-grade PGE and gold mineralisation. It is stratiform, and ten levels enriched in PGE, all perfectly concordant with the magmatic layering, are identified in the centre of the intrusion. The number of PGE levels decrease towards the margins of the intrusion, where only one level is developed. The lowest PGE level is the main reservoir of PGE. It is up to 5 m thick at 1 ppm cut-off. All other mineralised levels contain < 1 ppm PGE. Gold is always concentrated in the uppermost PGE level, irrespectively of the number of developed levels. The gold-rich zones are up to 2 m at 1 ppm cut-off.

The dominant precious metal phases are alloys of palladium, gold and copper, varying from Skaergaardite (PdCu) to tetraauricupride (AuCu), with locally significant proportions of sulphides such as vysotskite (PdS). The precious metal minerals are hosted in, or occur near, primary magmatic sulphides dominated by bornite and chalcocite. Primary droplets of copper sulphide with precious metal grains are common. The structure of the mineralisation and its petrography and mineralogy, suggest that the mineralisation has formed at high magmatic temperatures with little post-solidification remobilisation.

To date, a total of 42 drill holes, corresponding to 21,534 m, have been drilled




*Section through the Skaergaard intrusion.*




*Simplified geological map of the Skaergaard intrusion.*

from the surface by Platinova A/S and Skaergaard Minerals Corp. Based on this, Skaergaard Minerals announced an inferred mineral resource estimate in 2005. It operates with a "Combined Zone" of variable thickness, with a "Palladium Zone" at the bottom and a "Gold Zone" at the top, and shows a total tonnage of 1,520 Mt grading 0.21 ppm Au, 0.61 ppm Pd and 0.04 ppm Pt. This includes 107 Mt in the Gold Zone with 1.68 ppm Au, 0.59 ppm Pd and 0.05 ppm Pt, and 104 Mt in the Palladium Zone with 0.11 ppm Au, 1.91 ppm Pd and 0.16 ppm Pt. Titanium, iron and vanadium are important commodities in the Combined Zone, but the available data are insufficient for the resource estimate. However, average bulk concentrations in a single profile across the central part of the Combined Zone are 6.6% $TiO_2$, 19.4% $Fe_2O_3$ and 840 ppm V over 44 m.

## Kap Edvard Holm mafic intrusion-hosted, stratiform PGE prospect

The 50 Ma old Kap Edvard Holm complex is a large replenished basaltic complex analogous to gabbro intrusions of the ocean floor (68°N). Only a smaller proportion of the complex is exposed due to extensive ice cover. The size is difficult to evaluate, and estimates vary between 400 and 800 $km^2$. The complex was originally subdivided into the Lower, Middle and Upper Layered Series. In a more recent consensus, the Middle Layered Series is believed to represent a separate intrusive body, and the Upper Layered Series in the southern part of the complex is believed to be the lateral equivalents of the Lower Layered Series in the northern part of the complex. The complex is intruded by a suite of later syenite and granite intrusions.

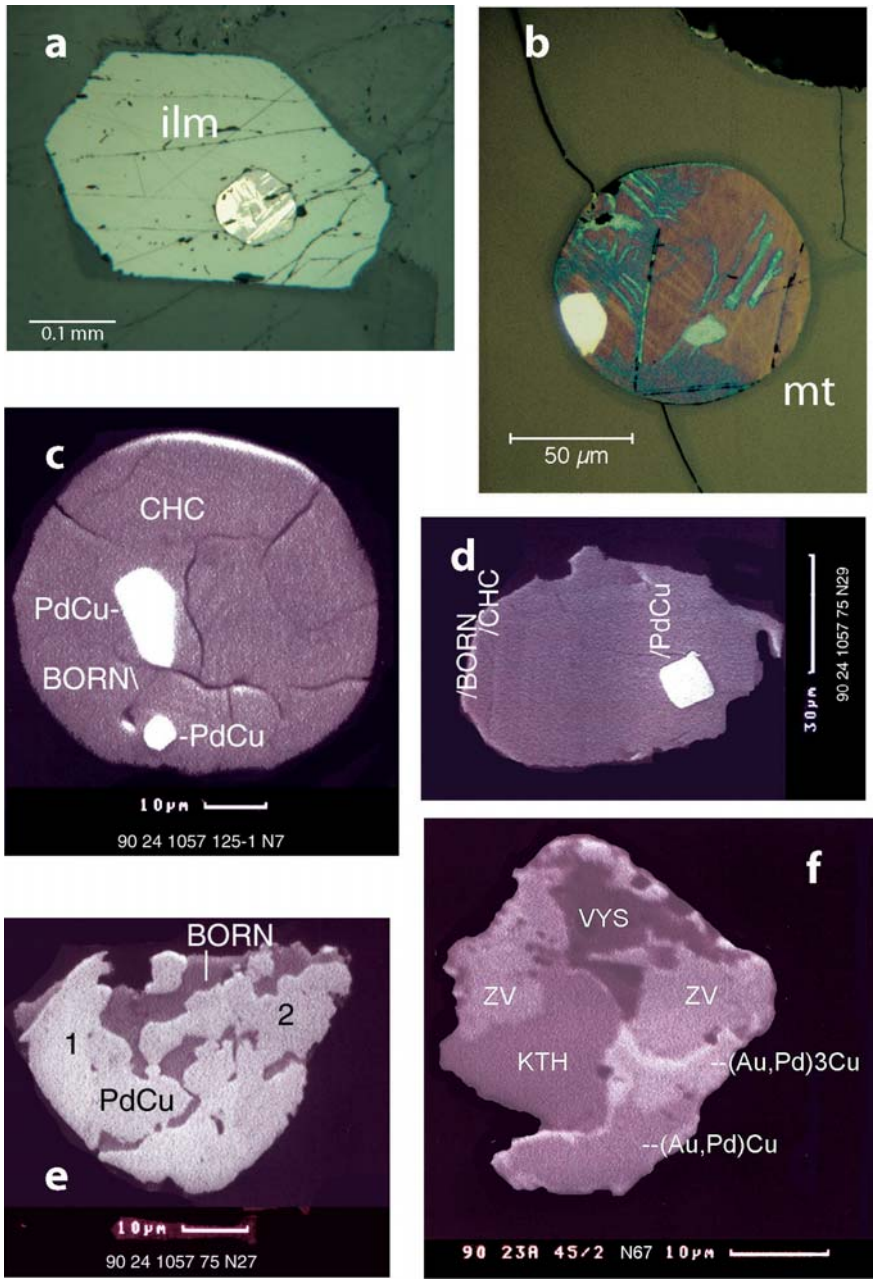
A PGE and gold anomaly has been identified over a distance of c. 30 km. The anomaly, which appears to be stratabound, runs < 1 ppm PGE and Au over a couple of metres. Anomalous high concentrations (up to 3 ppm PGE and 3 ppm Au) were identified in 1990 in one packsack drill core and in chip samples from the contact of a later syenite intrusion. Follow-up drilling the following summer did not confirm the elevated values in the anomalous core.

## Miki Fjord macrodyke: mafic intrusion-hosted, contact-related PGE-Au-Cu-Ni showing

The Miki Fjord macrodyke is a NE-trending tholeiitic, gabbro dyke which is up to 500 m wide and can be followed for more than 50 km inland (68°N). Field relations and similarities to the Skaergaard intrusion suggest that the dyke is c. 55 Ma old and contemporaneous with the Skaergaard intrusion.

Near Miki Fjord, parts of the roof zone are preserved in the high country, and the gabbros below the roof are strongly layered and very rich in large rafts of hornfelsed lava. The lower parts of the dyke exposed at the coast are unlayered. The upper gabbros show spectacular layering due to anorthositic melt layers formed during anatectic melting of altered basalt inclusions.

Contacts to the Precambrian basement are characterised by rheomorphic melting




*Thin section and back scatter images illustrating petrographic relationships in the Skaergaard mineralisation. a–b: droplets of intergrown bornite (born) and chalcosite (chc) enclosed in ilmenite (ilm) and magnetite (mt); c–d: skaergaardite (PdCu) in sulphide droplets; e–f: free intergrowths of noble metal minerals (VYS, KTH, ZV).*

*Igneous layering in the Upper Zone of the Skaergaard intrusion.*

and formation of pillow contact zones where melts derived from the basement mingled with dyke melts. The contacts host showings of massive and disseminated sulphides with up to 0.1 ppm Pt, 2.2 ppm Pd, 0.3 ppm Au, 2.18% Cu and 0.06% Ni, and the existence of larger bodies of massive sulphides in the deeper parts of the dyke has been indicated by a geophysical survey. The mineralisation is probably caused by contamination of basaltic melt.

## Mineral potential

The mineral potential of the Palaeogene intrusions of East Greenland lies mainly with porphyry-type molybdenum deposits, mafic intrusion-hosted platinum group elements, gold, copper and nickel, and epithermal gold-silver. In view of the limited exploration carried out in this extensive region, the chances of discovering new deposits are believed to be very promising.

## Key references


**Bearth, P. 1959:** On the alkali massif of the Werner Bjerge in East Greenland. Meddelelser om Grønland **153**, 4, 62 pp.

**Brooks, C.K. & Nielsen, T.F.D. 1982:** The Phanerozoic development of the Kangerdlugssuaq area, East Greenland. Meddelelser om Grønland Geoscience **9**, 30 pp.

**Brooks, C.K., Tegner, C., Stein, H. & Thomassen, B. 2004:** Re-Os and $^{40}Ar/^{39}Ar$ ages of porphyry molybdenum deposits in the East Greenland volcanic-rifted margin. Economic Geology **99**, 1215–1222.

**Geyti, A. & Thomassen, B. 1984:** Molybdenum and precious metal mineralization at Flammefjeld, Southeast Greenland. Economic Geology **79**, 1921–1929.

**Harpøth, O., Pedersen, J.L., Schønwandt, H.K. & Thomassen, B. 1986:** The mineral occurrences of central East Greenland. Meddelelser om Grønland Geoscience **17**, 138 pp.

**Nielsen T.F.D 1987:** Tertiary alkaline magmatism in East Greenland: a review. In: Fitton, J.G. & Upton, B.G.J. (eds): Alkaline igneous rocks. Geological Society Special Publication (London) **30**, 489–515.

**Nielsen, T.F.D. 2002:** Palaeogene intrusions and magmatic complexes in East Greenland, 66 to 75°N. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2002/113**, 249 pp.

**Nielsen, T.F.D., Andersen, J.C.Ø. & Brooks, C.K. 2005:** The Platinova Reef of the Skaergaard intrusion. In: Mungall, J.E. (ed.): Exploration for Platinum-Group Element Deposits. MAC Short Course **35**, 431–455. Ottawa: Mineralogical Association of Canada.

**Thomassen, B. 2005:** The Blyklippen lead-zinc mine at Mesters Vig, East Greenland. Geology & Ore **5**, 12 pp.

**Thomassen, B. & Krebs, J.D. 2001:** Palaeogene gold- and silver-bearing epithermal veins at Amdrup Fjord, southern East Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2001/133**, 78 pp.



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**Front cover photograph**
South-west view over Amdrup Fjord with epithermal vein in the foreground. A grab sample returned 1.4 ppm Au, 191 ppm Ag, 1.4% Pb and 5.7% Zn.


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