

Grønlands mineralske råstoffer

Grønlands mineralske råstoffer –
Nyt materiale til markedsføring;
CD-ROM indlagt

K. Secher, H. Stendal og L. Thorning



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Sammenfatning

Rapporten omfatter aflevering og endelig rapportering om fremstilling af nyt engelsksproget materiale til markedsføring af Grønlands mineralske råstoffer. Materialet følger et nyt koncept med en tre-delt detaljeringsgrad i de udarbejdede produkter, som omfatter fem Power point samlinger (CD-ROM), tre fact sheets (datablade) samt én publikation (populærvidenskabelig fremstilling). Der er endvidere udarbejdet en samlemappe til materialet. Materialet er lanceres under overskriften '**Greenland Mineral Resources**', og hver produkttype karakteriseres med undertitlerne: **Topics on Greenland Mineral Resources** (Power point), **Exploration and Mining in Greenland** (fact sheets), **Geology and Ore** (publikation) og **Greenland Exploration and Mining** (samlemappe).

Materialet er udarbejdet under kontrakt med Greenland Resources A/S.

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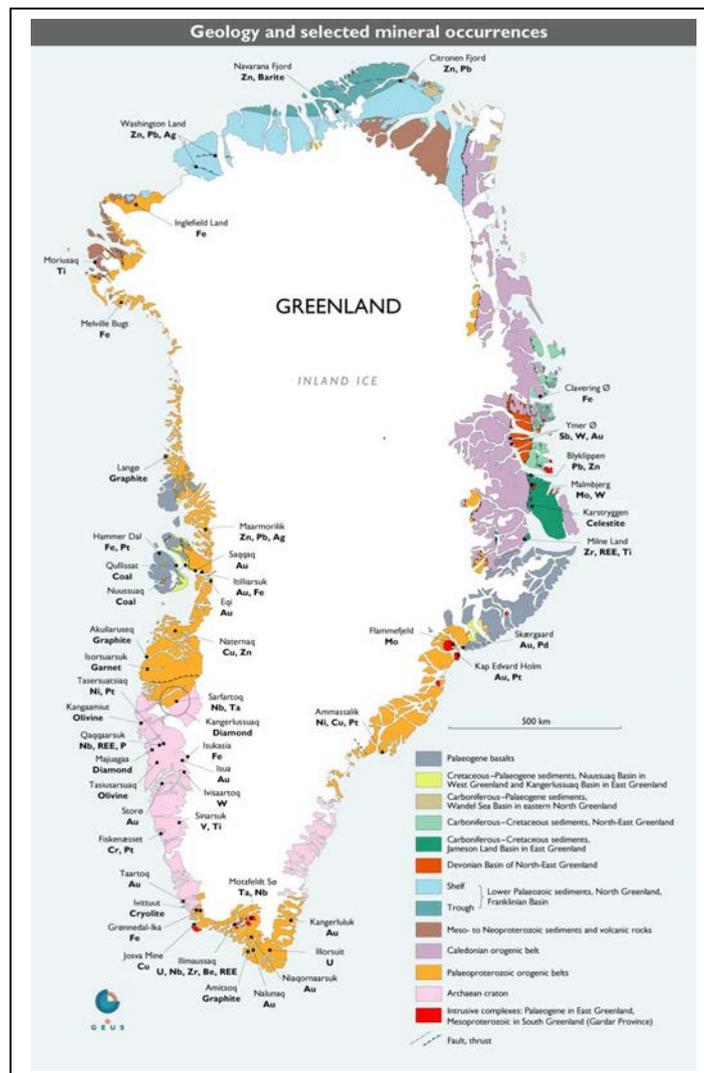
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Indledning

Denne rapport repræsenterer resultaterne af et projekt om udarbejdelse af nyt materiale til markedsføring af de muligheder, der må være til stede, når det gælder udnyttelsen af Grønlands mineralske råstoffer. Projektet er kommet i stand efter anmodning fra Greenland Resources i fortsættelse af forslag fra Danmarks og Grønlands Geologiske Undersøgelse (GEUS). GEUS udarbejdede ovennævnte forslag som en opfølgning på de ideer og principper, der blev fremlagt i Thorning (2001) til diskussion i den af Råstofdirektoratet, Nuuk, nedsatte følgegruppe for PR.

Anmodningen fra GRAS er nedfældet i en aftale mellem GRAS og GEUS dateret 27 september 2001, hvori de nærmere retningslinier for markedsføringsmaterialets indhold er beskrevet og hvor det angives, at materialet ønskes anvendt første gang i forbindelse med råstofmesserne i Nordamerika. Messen i marts 2002, 'Prospectors and developers annual meeting' (PDAC) i Toronto, Canada, blev herefter den aktivitet, som materialet kunne færdiggøres til. Færdiggørelsen var aftalt som en foreløbig version, idet der var enighed om at vurdere materialets egnethed, inden en egentlig trykning og Cd-brænding i større oplag blev iværksat.

Vurderingen af materialet efter denne fremvisning har været positiv og der blev givet grønt lys til nærværende endelige færdiggørelse og forberedelse til trykning. Enkelte ændringer som følge af erfaringer fra Toronto er indarbejdet Rapporten indeholder herefter den færdige version af de enkelte delmaterialer, der hermed afleveres som forudsat i aftalen, således at mangfoldiggørelse kan iværksættes efter Greenland Resources A/S ønske.

Materialets tilblivelse

Baggrund

PR-følgegruppen overgav GEUS opgaven med at udarbejde et oplæg til diskussion af nye markedsførings tiltag, som medio 2001 resulterede i en rapport (Thorning 2001), hvori bl.a. hovedtrækkene af et nyt materiale er skitseret. I GEUS blev der herefter nedsat en projektgruppe under ledelse af forfatteren. Projektgruppen blev ultimo 2001 enig om et indholdsoplæg, som omfattede et i Grønlands råstofhenseende nyt koncept til fremstilling af materiale med konkrete forslag til en række emner, der kunne anvendes.

Markedsføringskoncept

Der har ikke tidligere systematisk været udarbejdet markedsføringsmateriale på engelsk, udover de foldere, som siden 1997 regelmæssigt har præsenteret et koncessionskort og oplysninger om adresser på de engagerede efterforsknings selskaber, og evt. suppleret med enkelt noter om aktuelle nyheder fra råstoffronten. Der har desuden i tre tilfælde været fremstillet særnumre om Grønlands råstoffer, der har været indlagt i tidsskriftet Mining Journal (Country Supplement 1993, 1996, 2000). Herudover har der normalt kun været anvendt materiale fremstillet af GEUS som et led i den almindelige udgivelsespolitik, så som publikationer, kort Cd-rom'er og nyhedsbreve (MINEX News).

Det præsenterede koncept tager udgangspunkt i en mere detaljeret information om specifikke emner i et grafisk delikat design, opdelt i et system med en tredeling af graden af informationsdetalje, således at modtageren kan få netop den type information, som er ønsket. Samtidig opnås den virkning af den grafiske fremtoning, at de præsenterede data alt andet lige skærper nysgerrigheden hos modtageren, også selvom det drejer sig om data, som måske ikke er ukendte for den pågældende. Ikke mindst vil karakteren af det nævnte materiale opfordre til opbevaring, ligesom det vil være en hurtig vej til at fordybe sig yderligere i emnet pga. de anførte henvisninger. Modtageren vil således mere indgående kunne planlægge en evt. henvendelse til råstofmyndighederne, allerede med baggrund i det aktuelle materiale.

Den grafiske udformning er baseret på layout med flere gennemgående fællestræk. Dette signalere det familieskab, der er mellem de forskellige produkter. Der signaleres såvel et seriefællesskab som et fælles udgangspunkt i fremstillingen. Væsentligt for denne effekt er anvendelse af den gennemgående oxid-røde farve for rygbånd og sidemarkeringer samt den ocean-blå baggrund, som ikke mindst ved Power Point billeder er en samlende baggrund. Begge farver er i god harmoni med hinanden og med typiske geologiske naturbilleder og de er i øvrigt inspireret af de hyppigt anvendte bygningsfarver i Grønland.

Emnevalg

I aftalen af 27. september 2001 er der listet en række faglige emner, som forventes at være relevante for den kommende markedsføring, og som er forankret i aktuelle forskningsaktiviteter i GEUS. Blandt disse emner er der udvalgt fem eksempler, der i forskellig grad gennemarbejdes i den tredelte struktur, som det fremgår af nedenstående tabel:

Emne	PP-præsentation	Datablade	Publikation
Gold in South Greenland	Ja	Ja	Ja
Early mining in South Greenland	Ja	Ja	Nej
Speciality metals in South Greenland	Ja	Ja	Nej
The South Greenland CD-ROM	Ja	Nej	Nej
Airborne geophysics in West Greenland	Ja	Nej	Nej
Total	5	3	1

Form og layout

Alle produkter lanceres under hovedoverskriften: **Greenland Mineral Resources**. Af hensyn til identifikation af de enkelte produkter samt for at markere serieeffekten er der herefter foreslået specialtitler samt nummerering, idet det forventes, at antallet af de enkelte produkter efterhånden udvides. Mangfoldiggørelse af produkterne forventes at ske ved trykning i oplag, men print-on-demand produktion kan inddrages i nødstilfælde, selvom det oftest vil betyde en forringelse af kvaliteten.

- Power Point præsentationerne har titlen **Topics on Greenland Mineral Resources**. Tekstindholdet er præget af overskrifter og opremsning, understøttet af billeder og kort. Præsentationen fremlægges i to udgaver, hhv. til manuel fremvisning og til automatisk fremvisning. De fem fremvisninger er samlet i en HTML struktur, således at det er let at skifte mellem to fremvisningsmåder. HTML dokumentet leveres på CD-ROM.
- Datablade (Fact sheets) har titlen **Exploration and Mining in Greenland**, idet funktionen af disse dataark berettiger til en særlig markering om typen af indholdet. Fact sheets består af ét A-4 ark med komprimeret og kortfattet information, i høj grad understøttet af figurer. Disse ark leveres i en trykt (printed) udgave
- Publikationerne har serietitlen **Geology and Ore** og kan sammenlignes med et populærvideenskabeligt tidsskrift, med tema mæssigt indhold. Teksten er en sammenhængende historie, der i høj grad understøttes af illustrationer. Publikationens omfang anbefales at være fra 8–16 sider i A-4 format.
- Samlemappen har titlen **Greenland Exploration and Mining**, idet mappen i lighed med databladene dels skal vække hurtig opmærksomhed og dels for modtageren

være let at genfinde. Mappen er derudover forsynet med alment brugbare informationer trykt på hhv. indersiden af omslaget (kort over Grønland med angivelse af geologi og en række kendte mineralfund og forekomster) samt på bagsiden (de almindelige licensbetingelser for operation i Grønland samt relevante adresser). Mappen er endvidere forsynet med slids til visitkort og er således egnet til at fastholde en lang række af de materialer, der kan tænkes udleveret ved præsentation.

Redaktion

Ved udarbejdelsen af markedsføringsmaterialerne er der lagt vægt på at fremstillingen er klar og let forståelig, ligesom enkelte numre i en serie er gjort ensartede, hvad angår form og stil. Udvalget af referencer/litteraturhenvisninger er søgt gjort så dækkende, aktuelle og relevant som det er muligt. For at en fremtidig produktion skal leve op til disse principper, anbefales en fast overordnet redaktør/redaktion for at sikre kontinuiteten. Redaktion kan om nødvendig foregå eksternt, såfremt ovenstående principper overholdes. De nævnte materialer kan let ajourføres og tilrettes ved genoptryk; en proces der altid skal foregå hos den oprindelige redaktion.

Aftale om anvendelse

I appendiks 1 er vedlagt den aftale om anvendelse af PR-materialet og nogle grundlæggende regler for fremstilling af nyt materiale. Aftalen skal udelukkende sikre en fortsat konsistent og ensartet produktion af nye temaer og beskytte det fremstillede materiale mod misbrug.

Præsentation af samlemappe

Samlemappen har en funktion, der er samlet under titlen **Greenland - Exploration and Mining**, Mappen er forsynet med relevante og nyttige informationer trykt på hhv. indersiden af omslaget (kort over Grønland med angivelse af geologi og en række kendte mineralfund og forekomster) samt på bagsiden (de almindelige licensbetingelser for operation i Grønland samt relevante adresser). Mappen er egnet til at fastholde en lang række af de materialer, der kan tænkes udleveret ved en promotion-aktivitet. Det drejer sig i første omgang om de materialer, der er beskrevet i nærværende rapport, men der udover kan andre tryksager naturligt indgå, fx Minex News, licenskort o.a. Mappen er afbildet nedenfor.



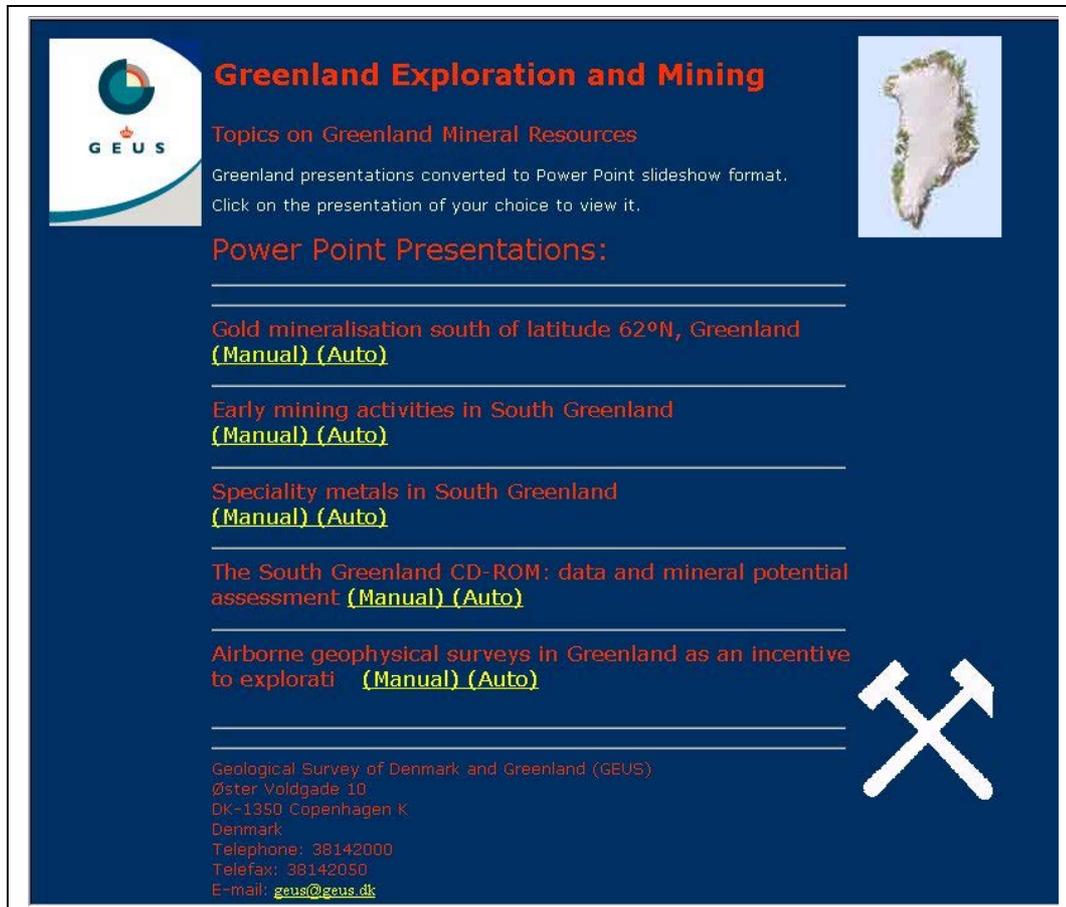
Præsentation af Power Point fremvisning

Baggrund

Power Point præsentationen har titlen **Topics on Greenland Mineral Resources**. Tekstindholdet er præget af overskrifter og opremsning, understøttet af billeder og kort. Der er fremstillet en særlig 'dias-master' til markedsføringsmaterialets Power Point fremvisninger (se figur nedenfor). Fremvisningerne kan anvendes på flere måder, idet indholdet er tilrettelagt således, at budskabet og informationen skulle være umiddelbart tilgængeligt. Eksempler på anvendelser kan være:

- Foredrag med fremvisning (manuel). Noter kan anvendes ved forberedelse og i forbindelse med bevarelse af spørgsmål
- Fremvisning for mindre gruppe (workshops, henvendelser på standen, 'direct marketing' mv.), enten manuelt eller med autofunktion
- Automatisk fremvisning på PC i forbindelse med udstilling som blikfang eller som understøttelse af tema
- Udlevering til udvalgte interesserede personer, som skønnes at have særligt behov

De fem fremvisninger er samlet i en HTML struktur, således at det er let at skifte mellem to fremvisningsmåder manuel og auto. HTML dokumentet leveres på CD-ROM.



The image shows a screenshot of a web page with a dark blue background. In the top left corner is the GEUS logo, which consists of a stylized globe and the letters 'GEUS'. The main title 'Greenland Exploration and Mining' is in orange. Below it, the subtitle 'Topics on Greenland Mineral Resources' is in white. A small map of Greenland is in the top right. The main content is a list of five Power Point presentations, each with a title in orange and two links in yellow: '(Manual)' and '(Auto)'. At the bottom left is contact information for GEUS, and at the bottom right is a white icon of crossed hammers.

Greenland Exploration and Mining

Topics on Greenland Mineral Resources

Greenland presentations converted to Power Point slideshow format.
Click on the presentation of your choice to view it.

Power Point Presentations:

Gold mineralisation south of latitude 62°N, Greenland
(Manual) (Auto)

Early mining activities in South Greenland
(Manual) (Auto)

Speciality metals in South Greenland
(Manual) (Auto)

The South Greenland CD-ROM: data and mineral potential
assessment (Manual) (Auto)

Airborne geophysical surveys in Greenland as an incentive
to explorati (Manual) (Auto)

Geological Survey of Denmark and Greenland (GEUS)
Øster Voldgade 10
DK-1350 Copenhagen K
Denmark
Telephone: 38142000
Telefax: 38142050
E-mail: geus@geus.dk

Topics on Greenland Mineral Resources 1-5

1. Gold mineralisation and gold potential in South Greenland

En oversigt over de bedst kendte guldmineraliseringer i Sydgrønland samt forklaringer af de mineralgenetiske sammenhænge. Potentialet for yderligere fund belyses. Fremvisningen omfatter også en præsentation af den forventede kommende guldmine Nalunaq.

2. Early mining in South Greenland

Gennemgang af tidlig minedrift i Sydgrønland med angivelse af alle relevante informationer om aktiviteten: råstoffer, lødigheder, tonnage, levetid etc. Minedrift i Sydgrønland har stået på siden 1854 og har været gennemført på flere forskellige forekomster.

3. Speciality metals in South Greenland

Oversigt over mulige økonomiske råstoffer inden for gruppen af 'special-metaller' omfattende tantal, niobium, beryllium, lithium, zirkonium, yttrium og sjældne jordarts metaller. Hovedvægten er lagt på at demonstrere områdets potentiale via beskrivelsen af de kendte forekomster.

4. The South Greenland CD-Rom

Præsentation af den CD-ROM, som netop er udsendt af GEUS med præsentation af data til belysning af Sydgrønlands råstofpotentiale. Fremvisningen gennemgår alle datatyper og viser eksempler på de indeholdte geo-refererede kort med tilhørende beskrivelser.

5. Airborne geophysical survey in Greenland as an incentive to exploration

Oversigt over de udførte og tilgængelige luftbårne geofysiske kortlægninger i Grønland udført i perioden 1992-2001. Der omtales undersøgelser med elektromagnetik, magnetik samt hyperspektrale telemålinger.

Præsentation af publikationen 'Geology and Ore'

Beskrivelse og ide

Publikationer om Grønlands mineralske råstoffer, rettet især mod den internationale mine- og efterforskningsindustri, er en mangelvare, hvor der her præsenteres et forslag til en ny serie om emnet. Produktet er det mest omfattende af markedsføringsmaterialet og informationsmængden skønnes at tilfredsstille interesserede selskaber som igangsætning for et videre forløb. Serien er temaopdelt og hvert nummer udgør en samlet historie. Der er indtil videre kun udarbejdet et nummer i serien.

Geology and Ore No 1:

Gold mineralisation and gold potential in South Greenland

En oversigt over de bedst kendte guldmineraliseringer i Sydgrønland samt forklaringer af de mineralgenetiske sammenhænge. Potentialet for yderligere fund belyses. Fremvisningen omfatter også en præsentation af den forventede kommende guldmine Nalunaq.

Præsentation af datablade

Baggrund

Datablade (Fact sheets) har titlen **Exploration and Mining in Greenland**, idet funktionen af disse dataark berettiger til en særlig markering om typen af indholdet. Dette skyldes ønsket om at kunne udlevere komprimerede oplysninger, fx i forbindelse med forespørgsler. En række af dataark skønnes endvidere at have nogen reklameeffekt på standen.

Exploration and Mining in Greenland Fact Sheet No 1-3

1. Gold mineralisation and gold potential in South Greenland

En oversigt over de bedst kendte guldmineraliseringer i Sydgrønland samt forklaringer af de mineralgenetiske sammenhænge. Potentialet for yderligere fund belyses. Fremvisningen omfatter også en præsentation af den forventede kommende guldmine Nalunaq.

2. Early mining in South Greenland

Gennemgang af tidlig minedrift i Sydgrønland med angivelse af alle relevante informationer om aktiviteten: råstoffer, lødigheder, tonnage, levetid etc. Minedrift i Sydgrønland har stået på siden 1854 og har været gennemført på flere forskellige forekomster.

3. Deposits of speciality metals in South Greenland

Oversigt over mulige økonomiske råstoffer inden for gruppen af 'special-metaller' omfattende tantal, niobium, beryllium, lithium, zirkonium, yttrium og sjældne jordarts metaller. Hovedvægten er lagt på at demonstrere områdets potentiale via beskrivelsen af de kendte forekomster.

Forslag til anvendelse af materialet

Baggrund

Markedsføringsmaterialets anvendelse er nævnt under de enkelte produkter. Den nuværende promotion-indsats gennemføres hovedsagelig på et antal mineralmesser, hvor de involverede parter typisk præsenterer en udstilling af postere og publikationer mv. med basis i en stand på messen. Deltagelse i messen kan være ledsaget af foredrag i tilknytning til messen eller for særligt interesserede grupper. Alle de nævnte materialer skønnes at kunne indgå i denne aktivitet direkte, og de vil antagelig forbedre mulighederne for at viderebringe information, som er målrettet til deltagerne.

PDAC Toronto, marts 2002

Materialet har været planlagt til at blive præsenteret for første gang ved PDAC – Prospectors and developers annual meeting, 10.–13. marts 2002 i Toronto, Canada.

Power Point præsentationerne var planlagt til orientering af en indbudt kreds af interesserede i forbindelse med en særlig reception afholdt af Grønlands Hjemmestyre. Af forskellige grunde måtte præsentationen udskydes og blev alternativt vist på standen. Der blev efter aftale ikke udleveret Cd-rom'er med power point serierne.

Geology and Ore -publikationen var fremstillet i 25 eksemplarer, som alle blev udleveret til interesserede. Samlingen af datablade var fremstillet i 50 eksemplarer af hvert nummer, og så godt som alle blev udleveret.

Samlemappen fungerede som holder af det komplette materiale, ligesom den også i nogen grad fungerede som blikfang på standen.

Figuren viser en situation fra standen, hvor materialet er fremlagt på bordene.



Foto: Bo Møller Nielsen, GEUS.

Forslag til videre handling

Produkter

I fortsættelse af konceptgrundlaget nævnt ovenfor foreslås det, at det tredelte produktforløb fortsættes og udbygges med henblik på den følgende sæson. Den ideelle plan med emnedækning for geofaglige emner på alle tre niveauer: 'Power point – publikation – datablad' følges, idet der fremstilles tre til fem nye Power point serier, en til to publikationer samt to til tre datablade. Ved sæsonstart ultimo 2002/primo 2003 kan der således være tilgængeligt materiale op til:

- 10 Power point serier (*Topics on Greenland Mineral Resources*)
- 3 Publikationer (*Geology and Ore*)
- 6 Datablade (*Exploration and Mining in Greenland*)

Her udover kan der være tale om udarbejdelse af produkter om generelle emner, så som licensforhold, naturforhold, logistik etc.

Emner

Ved udvælgelsen af geofaglige emner kan der inddrages flere retningslinier i henhold til idégrundlaget. Især kan der opstilles det mål at alle emner er omtalt i alle produkter, eller at inddrage så mange aktuelle emner som muligt i markedsføringsmaterialet. Det foreslåede antal nye produkter repræsenterer en slags kompromis mellem disse to mål, hvor nye emner fx kan vælges fra følgende forslag:

- Kimberlites and the diamond potential in West Greenland
- Geochemical signature of the mineral potential in South Greenland
- Satellite image map of South Greenland
- Map of selected mineral resources in Greenland
- Early mining activities in southern and central West Greenland
- PGE indications within the Archaean of West Greenland
- The Skærgaard intrusion and its mineral potential, southern East Greenland
- Indications of massive sulphides with the Nagssugtoqidian mobile belt of southern and central West Greenland
- Deposits of industrial minerals in Greenland

Afslutning

Igangsætningen af et nyt koncept til fremstilling af markedsføringsmateriale om råstofmulighederne i Grønland er således igangsat med præsentationen af produkter om aktuelle og relevante geofaglige emner. Idéen indebærer at emnet er behandlet i tre forskellige detaljeringsgrader og der er hermed leveret i alt ni enheder, repræsenterende fem forskellige emner, fordelt over fem Power point samlinger, tre datablade (Fact sheets) og én publikation.

Henvisningsliste

Produkter

- Rasmussen, T.M. and Thorning, L. (Editor: Rasmussen, T.M.) 2002: Airborne geophysical survey in Greenland as an incentive to exploration, Power Point Præsentation No 5.
- Secher, K. (Editor: Secher, K.) 2002: Early mining in South Greenland, Fact Sheet No 2, 2 pp.
- Secher, K. (Editor: Secher, K.) 2002: Deposits of speciality metals in South Greenland, Fact Sheet No 3, 2 pp.
- Stendal, H. (Editor: Secher, K.) 2002: Gold mineralisation and gold potential in South Greenland, Power Point Præsentation No 1.
- Secher, K. (Editor: Secher, K.) 2002: Early mining in South Greenland, Power Point Præsentation No 2.
- Secher, K. (Editor: Secher, K.) 2002: Speciality metals in South Greenland, Power Point Præsentation No 3.
- Stendal, H. & Secher K (Editor: Secher, K.) 2002: Gold mineralisation and gold potential in South Greenland, Geology and Ore No 1 (March 2002), 12 pp.
- Stendal, H. & Secher K (Editor: Secher, K.) 2002: Gold mineralisation and gold potential in South Greenland, Fact Sheet No 1, 2 pp.
- Thorning, L. (Editor: Thorning, L.) 2002: The South Greenland CD-Rom. data and mineral assessment, Power Point Præsentation No 4.

Baggrundsinformation og korrespondance

- Thorning, L. 2001: Præsentationsmateriale til markedsføring af Grønlands mineralske råstoffer, Danmarks og Grønlands Geologiske Undersøgelse Rapport 2001/81, 40 p.
- MINEX News 1992-2002, No. 1-22
- Mining Journal (Country Supplement) 1993, 1996, 2000
- Aftaleudkast af 27. september 2001/LTH (oplæg vedr. tilbud og aftale)
- Brev af 3. oktober 2001/LTH (specifikation af aftalens indhold)
- Brev af 21. december 2001/KSE (specifikation af materialets udformning)
- Brev af 2. januar 2001/LTH (udkast til aftale om retningslinier og brug)
- Brev af 26. marts 2002/KSE (status for materialets aflevering og rapportering)
- Brev pr 31. maj 2002/KSE (endelig rapportering)

Appendiks 1: Aftale om anvendelse

Aftale om retningslinier for fremstilling og brug af fælles PR præsentationsmateriale vedrørende Grønlands mineralske råstoffer

1 Aftalens formål og parter

- 1.1 Imellem de institutioner og firmaer som har underskrevet denne aftale, er der enighed om et koordineret samarbejde omkring fremstilling og brug af PR materiale vedrørende mineralske råstoffer i Grønland. Nærværende aftale fastlægger de principper som er gældende for samarbejdet.
- 1.2 Nye parter kan tiltræde aftalen; ved en underskrift tilføjet denne aftale tilkendegives det at nye parter også forpligter sig til at følge de i aftalen beskrevne retningslinier.
- 1.3 Denne aftale ændrer intet i forhold til de forskellige eksisterende aftaler om samarbejde eller andre typer af kontrakter mellem to eller flere af de forskellige parter, men er principielt underlagt sådanne eksisterende forhold.
- 1.4 De faktiske parter til aftalen fremgår af aftalens afsnit 9 med underskrifter.

2 Aftalen omfatter

- 2.1 Aftalen omfatter alt materiale som:
 - 2.1.1 anvender det fælles design beskrevet i Appendiks I,
 - 2.1.2 er fremstillet som anvist i denne aftale,
 - 2.1.3 ved fælles overenskomst er accepteret som en del af det fælles præsentationsmateriale.
- 2.2 Dette gælder uanset hvilken af de følgende typer det drejer sig om:
 - 2.2.1 Foldere til indlæg af materiale
 - 2.2.2 Specialhæfter
 - 2.2.3 Hand-outs og datablade
 - 2.2.4 PowerPoint præsentationer, elektronisk eller på print
 - 2.2.5 Indlæg på WEB steder
 - 2.2.6 Plancher og lignende til udstillinger i den udstrækning de ønskes at disse skal harmonere med det øvrige præsentationsmateriale

- 2.3 Aftalen omfatter også de redskaber og designelementer som er den del af fundamentet for samarbejdet.
- 2.4 Tvivlstilfælde vedrørende et givet materiales indlemmelse i denne aftale afgøres af Råstofdirektoratet efter høring af alle parter.

3 Produktion af præsentationsmateriale

- 3.1 Præsentationsmaterialet udarbejdes som hovedregel af de institutioner som har de pågældende emneområder som deres naturlige arbejds- og ekspertiseområde. Der skal udvises samme omhu og akkuratelse som ved alt andet materiale den pågældende part fremstiller. I nødvendige tilfælde indgås eksplicitte aftaler mellem parterne.
- 3.2 Parter til denne aftale vil have adgang til design redskaber i form af Power-Point skabeloner, Word-skabeloner eller Adobe Illustrator, og skal ved anvendelse følge de retningslinier som ledsager skabelonerne. Appendiks I indeholder en oversigt over de hjælpemidler som er fremstillet til fælles anvendelse i overensstemmelse med denne aftale.
- 3.3 Parter der har underskrevet denne aftale, har ret til at anvende de udarbejdede design redskaber til fremstilling af præsentationsmateriale, såfremt emnet for præsentationsmaterialet af Råstofdirektoratet anses for relevant.
- 3.4 Kun parter der har underskrevet denne aftale må anvende det fælles design af præsentationsmaterialet.
- 3.5 Den part som producerer materialet, har ansvaret for korrekt indhold og kvalitet og skal selv gennemføre en kvalitetskontrol. Ansvar for kvalitet og indhold vises klart ved placering af den pågældende parts logo i overensstemmelse med de givne anvisninger.
- 3.6 Andre parter kan inddrages i kvalitetskontrollen.
- 3.7 Det skal af præsentationsmaterialet fremgå hvem der er forfatter og hvilken institution (part) der har fremstillet materialet. Materialet skal ligeledes forsynes med en produktionsdato. Vejledningerne til de enkelte typer af produkter angiver hvordan det gøres i praksis.
- 3.8 I visse situationer kan det være nødvendigt hurtigt at fremstille f.eks. Power-Point præsentationer eller datablade til et bestemt formål uden at det er praktisk muligt at orientere alle parter om det. Sådant *ad hoc* brug af skabeloner er tilladt hvis den pågældende part mener det tjener det overordnede formål, markedsføring af Grønlands mineralske råstoffer. Efterfølgende kan det således fremstillede materiale indgå i den fælles mængde af præsentationsmateriale under iagttagelse af de retningslinier nærværende aftale definerer.
- 3.9 Hvis én af parterne anvender en ekstern part til fremstilling af markedsføringsmateriale og i den forbindelse giver vedkommende adgang til design-

skabeloner og lignende henhørende under denne aftale, skal den eksterne part også forpligtes til at overholde nærværende aftale.

- 3.10 En part til denne aftale har ret til at anvende indholdet af egne præsentationsprodukter i andre sammenhænge og i andre design. Det at information, viden og lignende indgår som elementer i det fælles markedsføringsmateriale, forhindrer altså ikke anvendelse heraf i andre sammenhænge.

4 Ændringer og opdateringer af præsentationsmateriale

- 4.1 Ændringer af præsentationsmateriale må som hovedregel kun gennemføres af den part som oprindeligt har fremstillet materialet. Denne part er til gengæld forpligtiget til at rette konstaterede fejl eller lignende.
- 4.2 Som hovedregel må der ikke ændres i indholdet af andre parter materiale. Hvis en part finder det nødvendigt, bør det gøres efter fælles drøftelse med den oprindelige producent af materialet.
- 4.3 I visse situationer kan det være nødvendigt at rette fejl i andre parter elektronisk baserede materiale. Det må gøres hvis det er nødvendigt, men den part der oprindeligt har fremstillet materialet skal underrettes herom og har så pligt til at korrigere fejlen i det originale materiale.
- 4.4 De elektroniske medier gør det muligt på meget enkel vis at ændre indholdet af f.eks. filen med en PowerPoint præsentation. Ikke desto mindre gælder de samme regler for denne form for ændringer.
- 4.5 Udviklingen kan gøre det nødvendigt at opdatere indholdet af præsentationsmateriale. Som hovedregel vil det være den part som har fremstillet det oprindelige materiale der også skal fremstille det opdaterede materiale, medmindre der indgås anden aftale mellem involverede parter.
- 4.6 Opdateret materiale skal så hurtigt som muligt gøres tilgængeligt for de øvrige parter.

5 Brug af præsentationsmateriale

- 5.1 Materiale til markedsføring fremstillet efter denne aftales retningslinier kan anvendes af alle parterne, uanset hvilken part der har fremstillet materialet.
- 5.2 Materialet kan anvendes ved alle lejligheder som må antages at have en gavnlig effekt i forbindelse med markedsføringen af Grønlands mineralske råstoffer.
- 5.3 De elektroniske versioner af markedsføringsmateriale kan anvendes i deres helhed (serier) eller i uddrag, dog altid under iagttagelse af denne aftales retningslinier.

- 5.4 Elektroniske versioner kan uanset format og form kun anbringes på en Hjemmeside (Web-site) efter specifik aftale med den part der har produceret det pågældende materiale.
- 5.5 Brug og udvikling af materialer kan drøftes i Følgegruppen for PR, under ledelse af Råstofdirektoratet.

6 Registrering, distribuering og opbevaring af præsentationsmateriale

- 6.1 De enkelte parter er forpligtiget til at registrere elektronisk hvilke markedsføringsmaterialer den pågældende part har fremstillet i overensstemmelse med denne aftale. For hver enkelt tilfælde skal registreres forhold som titel, indhold, forfatter, type, produktionsdato, sidste opdateringsdato, etc., efter nærmere aftale.
- 6.2 Råstofdirektoratet ønsker at have et totalt overblik over tilgængeligt materiale, og derfor skal alle andre parter efter nærmere aftale fremsende kopier af sådanne egne oversigter (6.1) til Råstofdirektoratet, så der kan fremstilles en central oversigt over alt materiale. Kopier af denne oversigt skal i givet fald tilgå alle parter.
- 6.3 Parterne indgår, under hensyntagen til praktiske og principielle forhold vedrørende de specifikke produkter, nærmere aftale om hvordan produkter fremstillet til markedsføring i overensstemmelse med denne aftale skal fordeles til alle parter. Som udgangspunkt vil følgende generelt gælde:
 - 6.3.1 Originalt trykt materiale såsom datablade og specialhæfter opbevares i aftalt oplag hos producenten. Kopier eller deloplag af trykt materiale kan også opbevares af de øvrige parter efter behov, eller centralt hos Råstofdirektoratet. Sådant materiale kan udleveres frit som nærmere aftalt for de enkelte produkter.
 - 6.3.2 Elektroniske oplæg til de i 6.3.1 nævnte produkter, heri også inkluderet sådanne beregnet til print-on-demand reproduktion, opbevares på CD-ROM hos producenten samt hos de andre parter til aftalen. Alle parter har ret til at reproducere det antal print som der er behov for, med mindre der eksplicit er truffet aftale om andet. Disse print kan frit udleveres, mens selve den elektroniske udgave kun må udleveres til eksterne parter hvis producenten forud har givet tilladelse hertil.
 - 6.3.3 Egentlige elektroniske udgaver af markedsføringsmateriale, såsom Power-Point præsentationer eller indlæg på web-sider, placeres på CD-ROM og leveres til alle parter til aftalen. For hvert enkelt sådant produkt skal der desuden gøres opmærksom på, om der er særlige forhold at iagttage omkring elektronisk distribution af produktet. De pågældende filer kan kopieres til en server eller PC'er hvis det er nødvendig for deres anvendelse, men må kun

udleveres til eksterne parter, hvis der generelt eller eksplicit er givet tilladelse hertil af producenten.

7 Ejendomsret, brugsret og copyright

- 7.3 En part til denne aftale fastholder ejendomsret og copyright til de produkter som den pågældende part har fremstillet og har ansvaret for, medmindre disse rettigheder skriftligt overgives til en af de andre parter.
- 7.4 Alle parter har brugsret til alle produkter fremstillet under denne aftale såfremt retningslinierne i denne aftale overholdes. Brugsretten defineres som retten til at anvende produkterne til markedsføringsformål, men indebærer ikke retten til salg, bytte eller anden udveksling med eksterne parter.
- 7.5 Design udviklet til dette formål samt de tilhørende redskaber (skabeloner) må kun anvendes til de i denne aftale definerede formål. Inden for den ramme tilhører alle rettigheder til design og værktøjer Råstofdirektoratet.

8 Ændringer i og ophør af aftalen

- 8.3 Ændringer og tilføjelser til denne aftale kan indgås efter drøftelse og fælles beslutning som addendum til aftalen. Processer i den forbindelse kan igangsættes af alle parter og organiseres af Råstofdirektoratet.
- 8.4 Aftalen er gældende indtil videre og mindst så længe der er mindst to parter til aftalen, hvoraf Råstofdirektoratet skal være den ene.
- 8.5 Aftalen kan opsiges skriftligt af en part med tre måneders varsel. Den skriftlige opsigelse skal rettes til Råstofdirektoratet med kopi til de øvrige parter.
- 8.6 Uanset hvordan en parts deltagelse i aftalen ophører, gælder følgende:
- 8.6.2 Den pågældende part er forpligtiget til fortsat at overholde denne aftale hvad angår andre parter på det pågældende tidspunkt eksisterende produkter fremstillet under denne aftale.
- 8.6.3 Den pågældende part kan fortsat anvende eksisterende egne produkter i det fælles design, men må ikke fremstille nye. Skabeloner m.v. skal afleveres til Råstofdirektoratet.
- 8.6.4 Den pågældende parts produkter fremstillet under aftalen vil fortsat nyde samme beskyttelse som angivet i denne aftale.

9 Underskrifter

- 9.3 Følgende institutioner og firmaer tilkendegiver ved deres underskrift at de tiltræder denne aftale. De navngivne personer er underskriftberettigede i forhold til deres organisation og vil fungere som kontaktpersoner for aftalen. De kan om nødvendigt udnævne andre til at fungere som kontaktpersoner.

Råstofdirektoratet, Grønlands Hjemmestyre

Dato: Navn: Underskrift:

Kontaktperson:

Afdeling for Malmgeologi, Danmarks og Grønlands Geologiske Undersøgelse

Dato: Navn: Underskrift:

Kontaktperson:

Greenland Resources A/S

Dato: Navn: Underskrift:

Kontaktperson:

Afdeling for Arktisk Miljø, Danmarks Miljøundersøgelse

Dato: Navn: Underskrift:

Kontaktperson:

Raw Materials Group

Dato: Navn: Underskrift:

Kontaktperson:

Appendiks 2: Geology and Ore 1

Gold mineralisation and gold potential in South Greenland



No. 1 - March 2002

Gold mineralisation and gold potential in South Greenland



More than 25 years of geological mapping and exploration in South Greenland have demonstrated the existence of geological environments, where gold mineralisations have developed and potentials for viable gold deposits exist. During this period a number of private companies have been engaged in exploration activities, including field investigations and diamond drillings. The Geological Survey has provided systematic geological and geochemical mapping, as well as airborne geophysical surveys including radiometry, magnetometry and EM measurements. A number of geological map sheets in scale 1: 100 000 and 1: 500 000 are issued. Stream sediment geochemistry analyses have been used to compile a comprehensive geochemical atlas, and geophysical maps are available in varying scales depending on locality. The Survey (GEUS) has issued a CD-ROM including much of the available data in geo-referenced formats.

Geological setting

South Greenland is dominated by the Paleoproterozoic Ketilidian Orogen (1900–1750 Ma), which covers the southern tip of Greenland. The middle Proterozoic Gardar province includes pronounced intrusive complexes (1300–1120 Ma) in the central part of the area. The environments for gold deposition can be grouped into several different geological scenarios:

- Archaean foreland composed of high-grade gneisses serving as a basement to Palaeoproterozoic volcano-sedimentary successions
- Archaean border zone affected by Ketilidian orogenesis
- A magmatic arc represented by the 30.000 km², calc-alkaline Julianehåb Batholith and segments of volcano-sedimentary sequences interrelated in
- The Psammite zone south of the batholith composed of metasediments and locally volcanic rocks that are deformed and sometimes migmatized and

- The Pelite zone located most southerly and composed of turbiditic sedimentary rocks, which are highly deformed and migmatized. The supracrustal successions are intruded by a rapakivi suite between 1755-1732 Ma.

Gold and pathfinder elements

The gold potential of South Greenland is indicated in the geochemical mapping by the distribution of high values for gold (Au) and pathfinder elements like arsenic (As) and antimony (Sb) in the fine fractions (<0,1 mm) of stream sediments. Using this information together with gold anomalies in bedrock and in heavy mineral concentrates of stream sediments, the presently recognised potential for gold mineralisations are focussed to specific regions and smaller areas.

The most prospective areas are around the Sermiligaarsuk Fjord, at the southern margin of the Julianehåb Batholith domain, and within large parts of the Psammite Zone.

Gold occurs in various settings and localities:

- **Archaean Tartoq Group greenstone** Sermiligaarsuk
- **Palaeoproterozoic Border Zone** Arsuk and Kobberminebugt
- **Julianehåb Batholith** Qoorormiut, Niaqornaarsuk, Igutsaat
- **At the border between Julianehåb batholith and Psammite Zone** Kangerluluk and Sorte Nunatak
- **Psammite Zone** Nalunaq, Lake 410, Ippatit and Kutseq

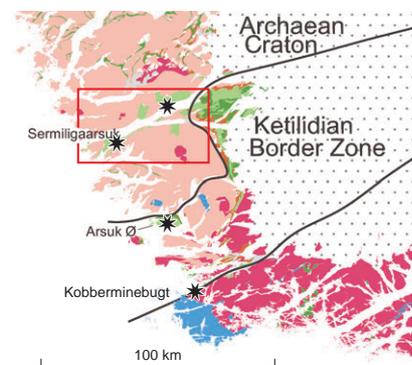
A visit to these localities will reveal a variety of environments and mineral occurrences. They are briefly described here with emphasis on the geological setting and including some important analytical results.

Sermiligaarsuk

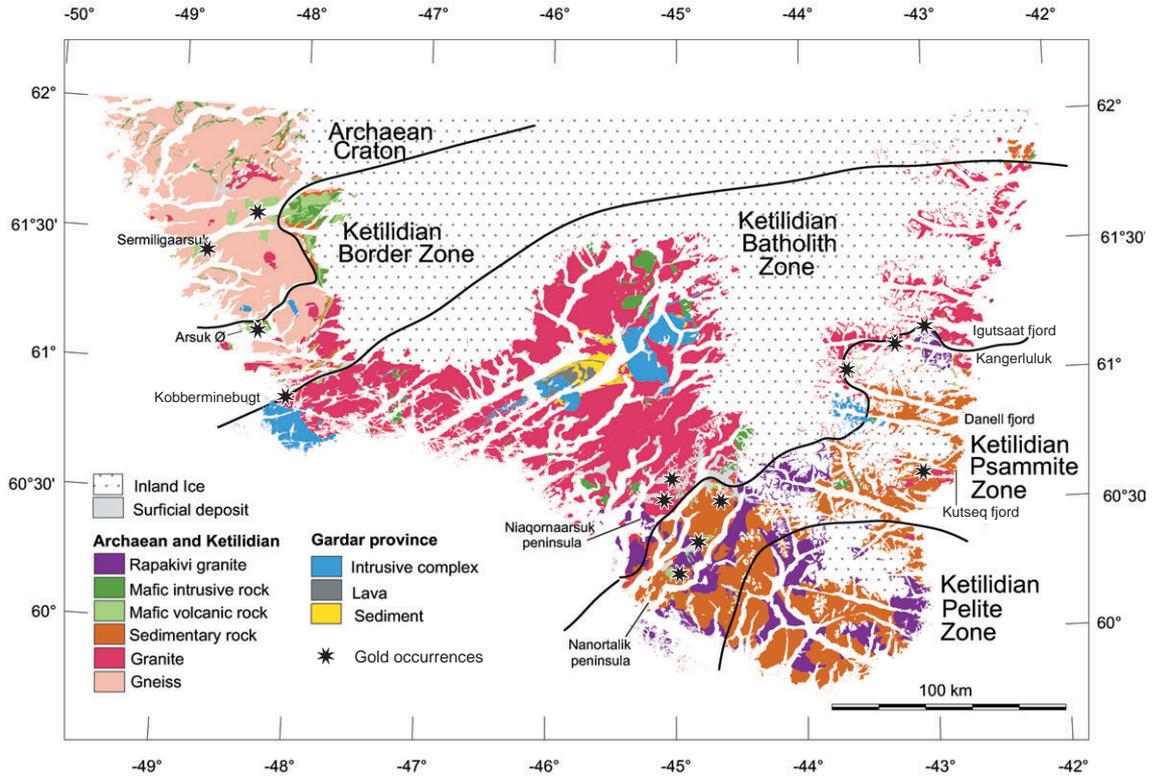
In the Sermiligaarsuk, the Tartoq Group greenstone belt overlies Archaean gneiss. The basement gneiss has ages ranging from 2980-3500 Ma and Tartoq supracrustals are assumed to be late Archaean, deposited between 2500 and 3000 Ma, and older than the unconformably superimposed Palaeoproterozoic Ketilidian sediments and volcanics (several km thick). The Tartoq Group greenstone belt is exposed in several sub-areas along the Sermiligaarsuk Fjord.

Gold formation is confined to linear belts and carbonate rich zones. The carbonate rich zones are composed of several individual, 4-10 m wide units of carbonate schists, where gold occurs in two principal forms within the carbonate succession:

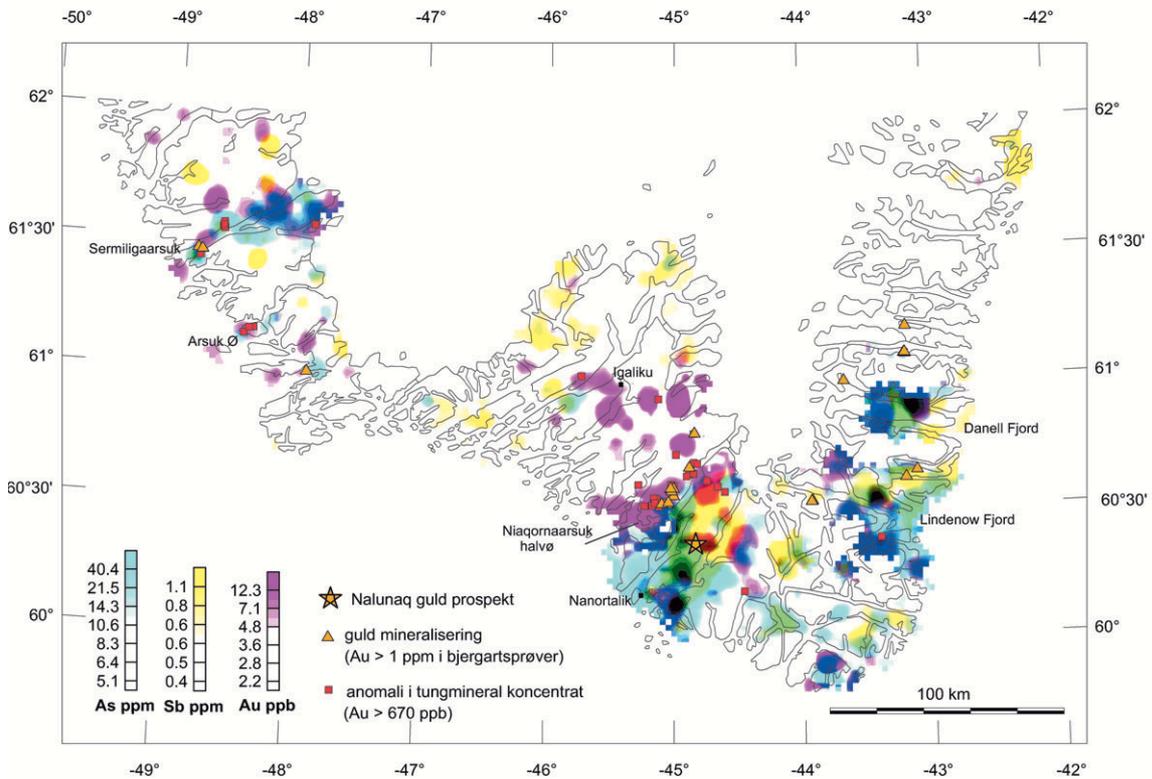
- 1) In disseminated pyrite in quartz-ankerite lenses (up to 2 m by 10 m) and in pyrite accumulations associated with massive arsenopyrite aggregates. In the quartz association gold occurs as discrete inclusions in pyrite. Other sulphides include arsenopyrite, chalcopyrite, tennantite, and chalcocite. The highest grade recorded for gold is 50 g/t, but typical values are 5-8 g/t.
- 2) In association with massive and banded pyrite-arsenopyrite aggregates in meta-chert grading into highly disseminated arsenopyrite – quartz (recrystallised)



Geological map around Sermiligaarsuk in South Greenland.



Geological map of South Greenland.



Gold potential of South Greenland indicated by distribution of gold, arsenic and antimony in stream sediments.

chert) masses, which are up to 1 m by 30 m along strike. The average grade of gold is 8-15 g/t. Gold occurs as tiny inclusions, mainly in pyrite.

Gold is thought to have been introduced into the Taartoq greenstones during the formation of stratiform exhalites with massive-sulphide and chert. Regional metamorphism resulted in recrystallization and segregation of the chert into compact quartz bodies and residual massive-sulphide. Subsequent episodes of shearing and intensive carbonate alteration along the shear zones, lead to the liberation and accumulation of gold.

The gold occurrences in the Taartoq supracrustals are assumed to be deposited between 2500–3000 Ma, and are so far the only Archaean gold mineralisation in South Greenland. An extensive exploration activity has been carried out in the area including several diamond drillings and geophysical surveying.

Arsuk Ø

Arsuk Ø is located within the Border Zone of the Ketilidian mobile belt. On this island there are exposed supracrustal successions of volcanics and metasediments. Bands of mafic metavolcanics, up to 300 m thick, are intercalated within the metasediments. This mixed sequence of volcanics and sediments is overlain by more than 3000 m of pillow lavas, volcanic breccias, agglomerates, tuffs and massive mafic lava flows

A number of small mineralisations are located on Arsuk Ø. Contents of gold, zinc and copper are generally low; two settings are usually recognized:

- 1) rusty chert horizons in the pillow lava sequence and
- 2) quartz veins in the pillow lava sequence.

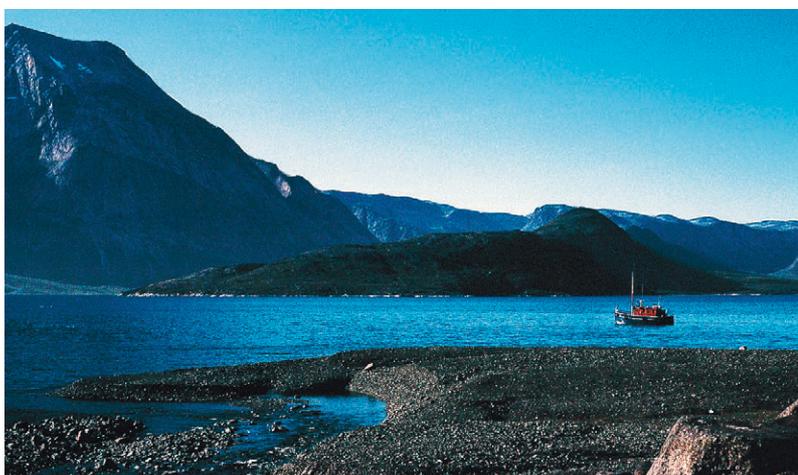
Samples show up to 300 ppb gold. The copper content reaches close to 2000 ppm in rusty metabasic rocks and Zn contents up to nearly 900 ppm are recorded in tuff within disseminated sulphides.



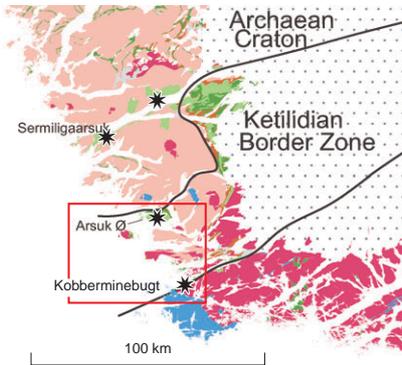
A view at the Taartoq Group greenstones (dark) with intercalations of meta-chert layers (light), hosting gold occurrences, eastern part of Sermiligaarsuk. Persons for scale.



Close-up of solid pyrite-arsenopyrite layer partly malachite stained, eastern Sermiligaarsuk. Hammer head is 10 cm.



View of basic metavolcanics at Blaalershavn, eastern Arsuk Ø.



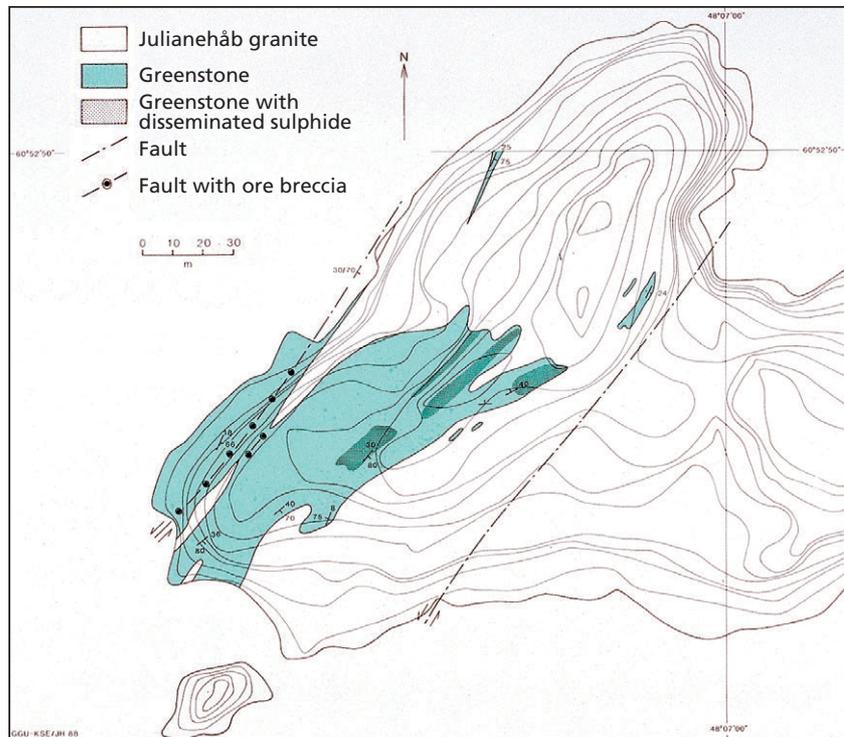
Geological map around Arsuq Ø and Kobberminebugt in South Greenland.

Kobberminebugt

The copper-gold occurrence is hosted by metavolcanic lithologies of the Ilordleq Group, composed of tuffaceous/rhyolitic lithologies and greenschists. Faults and shear zones are locally mineralised with bornite and chalcocite. A major Cu-mineralisation has been located in a fault zone, which is co-planar with the lithological interfaces in the host rocks and separates mylonitic felsitic schist in the footwall from amphibolite schist in the hanging wall. The fault zone is c.130 cm wide, but the sulphide rich layer only makes up some 32 cm of this at places. The bornite-chalcocite lenses have accessory ilmenite, magnetite, chalcopyrite and electrum. The ore is suggested to be of hydrothermal origin. Chalcopyrite and locally bornite is disseminated in the greenstones hosting the ore, in the area from Josva Mine eastwards to Rinks Havn, with up to 5 vol % of sulphides.

The average copper content in the ore vein is 3.5 %, but percentages of c. 5 % are noted in limited parts in upper levels. The ore contains up to 1.5 ppm gold and consistently high silver content up to 250 ppm.

This ore body was actually mined 1904–1915. Total production from the Josva Mine did not exceed 90 tons of copper extracted from 2.200 tons of ore with small additional amounts of gold (0.5 kg)



Detailed geological map around Josva Mine, showing location of the mineralisation.

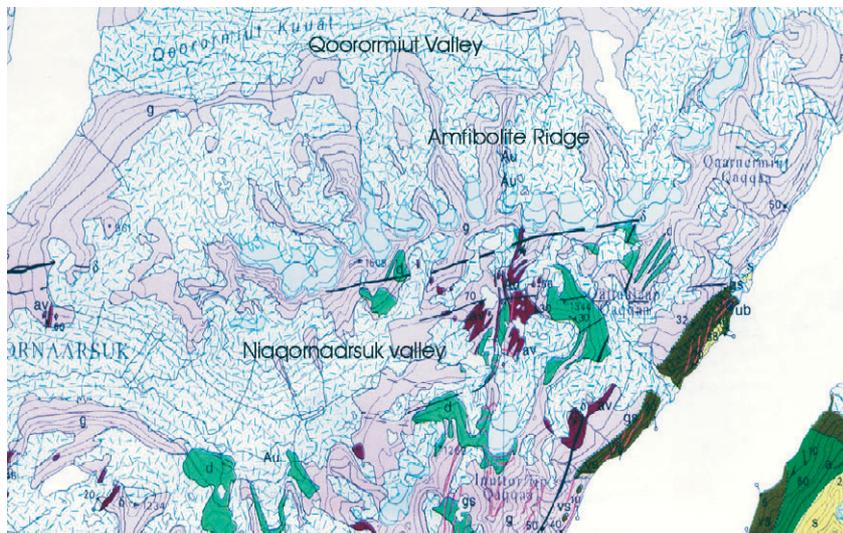


Close-up of the Josva Mine copper vein with solid bornite. Knife for scale.

and silver (50 kg). The size of the remaining ore body at Josva Mine is estimated to be 2000-3000 tons of ore containing 30-40 tons of copper. The potential of the disseminated ore in the vicinity has not been calculated.

Qoorormiut

The gold occurrence in the Qoorormiut Valley is associated with quartz veins in amphibolite dykes hosted in granite of the Julianehåb Batholith. A number of genera-



Geological map of the Qoorormiut-Niaqornaarsuk area.

tions of quartz veins, more or less deformed, can be identified. The quartz veins all strike NE-E with a steep westerly dip. They are 0.5 – 5 m wide, rarely up to 10 m, and discontinuous, but can be followed up to 200 m along strike. The latest un-deformed quartz veins are associated

with a gold-sulphide mineralisation.

Several stages of mineralisation are identified including pyrite, arsenopyrite, gold, electrum, galena-vikingite, chalcopyrite and spahlerite. Fluid inclusion studies show that the gold is precipitated from the CO_2-CH_4 fluids. The temperature for-

mination of the mineralisation is 200-400°C at a pressure between 0.5 and 1.5 kbar.

The gold concentration varies significantly in this type of mesothermal gold mineralisation and reaches 380 ppm in narrow silicified shear zones. Chip samples from preliminary exploration activities resulted in assay results between 114 ppm and 147 ppm gold. Later re-sampling by GEUS, however, could not reproduce higher values than 14 ppm gold.

Niaqornaarsuk

The gold mineralisation in the Niaqornaarsuk valley is related to quartz veins, meta-basic rocks, hydrothermally altered granite and aplite within the Julianehåb Batholith. Two different types of mineralisation are present:

1. gold and sulphide bearing veins
2. molybdenite-quartz veins

The molybdenite-quartz veins (2) do not carry significant gold (<100 ppb). The gold-mineralisation (1) within the hydrothermal alteration halo contains

The smelting plant at the Josva Mine, 1911.





A look along the 'Amphibolite Ridge', hosting mineralised quartz veins. Mountaineers on the slope for scale.

traces of Fe-sulphides (sulphidation) and locally arsenopyrite containing 50-200 ppb gold. Up to 3400 ppb gold has been found in rusty and altered diorite-gabbro in the lower Niaqornaarsuk valley.

The structural fabric is compatible with the regional sinistral shear zone move-

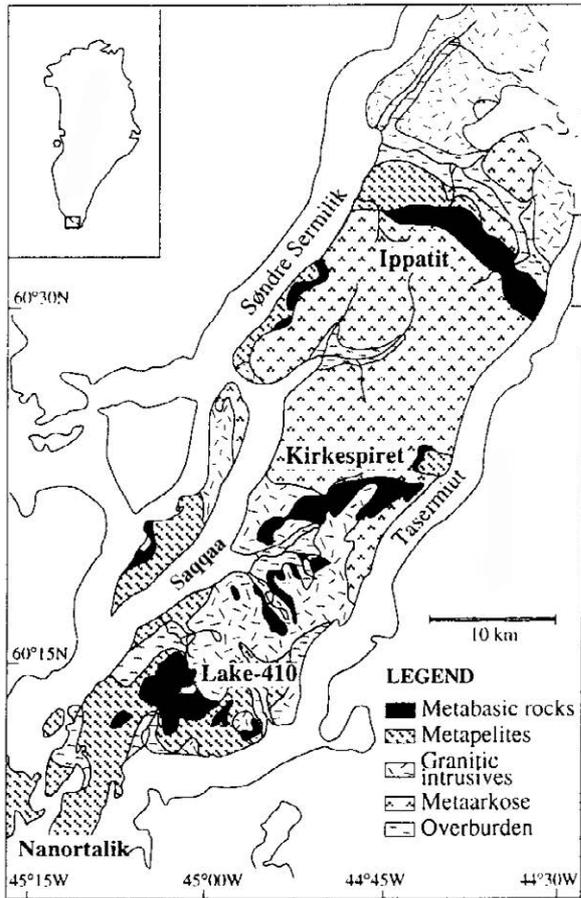
ment with a NNE trend and controls the location of gold mineralisation on Niaqornaarsuk peninsula. The gold mineralisation is located near the roof of the Julianeheb Batholith and is characteristic by the element association Au-Bi-(As-Mo-W).

Ippatit and Lake 410

The Ippatit and Lake 410 occurrences are hosted in Ketilidian amphibolites, which are interpreted to represent a suite of pyroclastic rocks, lavas, pillow lavas, and dolerites. Associated meta-sediments in



Granodiorite, hydrothermally altered, Niaqornaarsuk.



Geological map of the Nanortalik peninsula.

the area include stratiform, rusty sulphide- and graphite-rich horizons. The amphibolites host quartz veins with minor sulphides. The quartz veins are often associated with calc-silicate alterations.

The gold content is low; a rusty section of bedded chert and graphitic schist shows 20-120 ppb Au and 500-2000 ppm As, and quartz veins in meta-pelites return up to 830 ppb Au.

The host rock is considered to be part of the same sheet of meta-volcanic rocks, which also hosts the Nalunaq gold prospect at Kirkespiret (see below). Within the central Nanortalik peninsula, the amphibolite sheet has been disrupted and

partly engulfed by late granite diapirs, dated to app. 1805 Ma. The gold mineralised horizons at both Nalunaq and Lake

410 are located close to the roof of the granite batholith.

The gold is concentrated in quartz-veined amphibolite. The quartz veins are sub-concordant and contain minor sulphides, mainly arsenopyrite and chalcopyrite. At both localities the gold contents are found to be low, ranging from 20–830 ppb associated with As in the range 500–3000 ppm.

Nalunaq

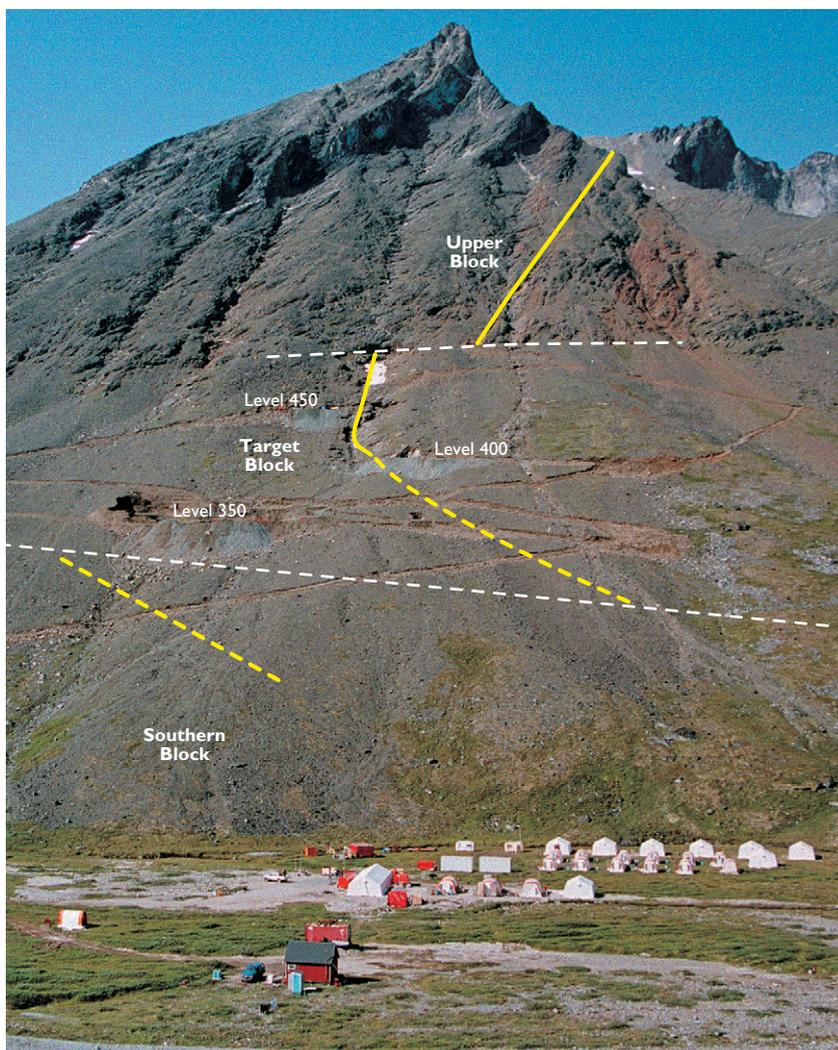
The Nalunaq gold deposit is hosted in meta-pelites and meta-basic rocks of Ketilidian age (1850-1800 Ma). The supracrustal successions are intruded by post-kinematic biotite granites and subsequently by anorogenic rapakivi granites around 1750 Ma. The host rocks represent a thrust sheet overlying molasse-type sediments deposited in a marginal basin in the Ketilidian orogen.

Two major gold-bearing veins occur along a NE striking ductile thrust zone dipping 40° to 55° SE. The gold mineralisation is epigenetic and resides in quartz-veins and in calc-silicate altered shears sub-parallel to the foliation. The 'Main Vein' of Nalunaq has so far been estimated to be 1700 m long and 0.1 to 2 m wide.

The gold is genetically related to metaliferous fluids associated with the emplacement of late intrusive stages of the

Visible gold in Nalunaq quartz veins.





The Nalunaq Mountain with the so-called 'Main Vein' as a yellow line. The mining camp is located at the valley floor.

Julianehåb Batholith granites (1800–1770 Ma) followed by local remobilisation. Preliminary interpretation of the fluid inclusion data suggests precipitation of gold at 525–575 °C and about 2.5 kbar. Measured and indicated resources are 292,000 ounces of gold with an average grade of 25 g/t. As inferred resources 718,000 ounces of gold are considered ore averaging 19 g/t Au. The Nalunaq deposit is expected to go into production during 2003.

Kutseq

In the area around Kutseq fjord on the southeast coast of Greenland, mineralised amphibolite rocks are intercalated within a sequence of psammite and semi-pelitic gneiss. An arsenic-gold association is hosted in shear zones and in dykes in the amphibolites. The mineralised shear zones vary from abundant small horizons 10–20 cm thick and 10–12 m long, to large shear structures up to 12 m across and 500–600 m long.

Gold is found within occurrences of sulpho-arsenides and arsenides. Up to a

few vol.% of disseminated pyrrhotite and arsenopyrite occur within the shear zones. The element contents vary significantly with gold concentrations up to 38.5 ppm and arsenic concentrations up to 6%. Slightly discordant felsic dykes (10–40 cm) carry pyrrhotite and arsenopyrite. As-content reaches 1.7 % and gold is up to 200 ppb.

In the As-Au association, arsenopyrite geothermometry suggests precipitation temperatures for arsenopyrite-löllingite-pyrrhotite and gold at 440–560 °C. Gold is introduced during an early stage of the formation and was partly re-mobilised during cataclastic shear movements. It is suggested that the As-Au association represents an epigenetic mesothermal, lode type of gold mineralisation with genetic relations to the gold mineralisation in the Nanortalik region (see above).

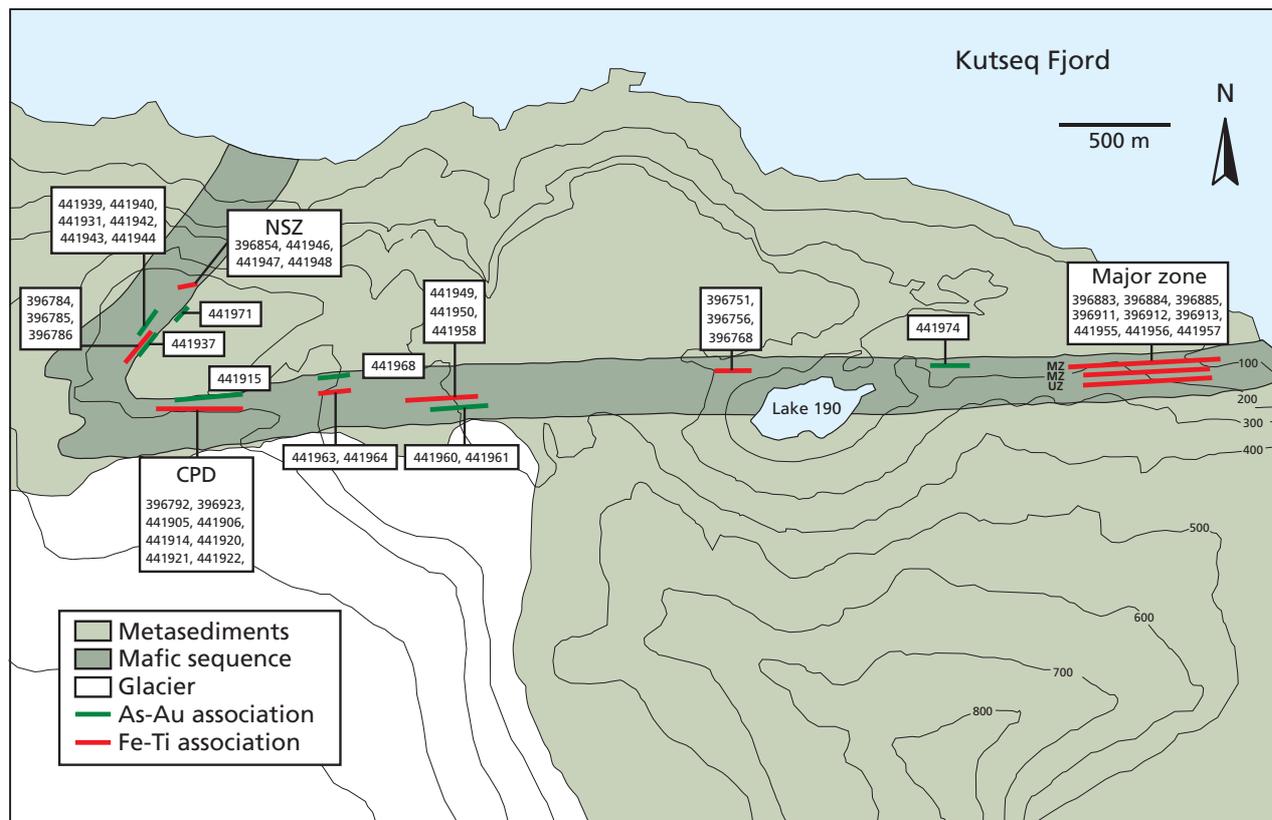
Kangerluluk

A gold-bearing sulphide mineralisation is hosted by a 200–300 m thick mafic volcano-sedimentary supracrustal sequence exposed over an area of app. 4 km². The supracrustals rest unconformably on granites and granodiorites of the Julianehåb Batholith. The following lithofacies: conglomerate-sandstone, pyroclastics, mafic volcanics, and a volumetrically subordinate "peperitic" lithofacies represent the succession. The sequence has been subjected to lower amphibolite facies metamorphism, but sedimentary and volcanic structures are well preserved. At the locality 'Sorte Nunatak' east of Kangerluluk a similar type of mineralisation has been observed.

Alteration and mineralisation

Syn-volcanic alteration: The volcanic rocks were subjected to extensive, pervasive, syn-depositional hydrothermal alteration and seawater interaction. The matrix between pillows is dominated by epidote and is very CaO rich (24–30 wt. %) but shows no significant gold or copper accumulation.

Early, post-volcanic alteration: Early post-volcanic alteration mineral paragenese-



Geological map of the Kutseq area, South-East Greenland.

ses within large faults or shear zones cutting the supracrustal package.

The ore minerals related to a quartz association are dominated by pyrrhotite and pyrite (up to a few vol.%). Locally massive pyrrhotite occurs at the contacts between sediments and more massive quartz veins. Up to 40 cm wide silicified alteration halos with very high gold concentrations are associated with the quartz veins. A grab sample from such a halo contains 118 ppm gold.

Pyrite, chalcopyrite and microscopic visible gold occur in association with faults are typical ore minerals in an epidote association. Chip samples returned up to 3.3 ppm Au and 1.6 % Cu over half metre intervals.

Late, post-volcanic alteration: Late alteration is characterised by bleaching and metamorphic garnet overgrowth as well as vein-related copper-gold mineralisation and brittle deformation with associated carbonate veining and silicification.

Only the copper association returned gold in samples with up to 6.2 ppm Au and 1.8-wt % Cu.

Igutsaat

A major, 5-8 m thick rusty aplite sill striking E-W, is exposed in mafic rocks surrounded by gneiss on the south side of Igusait Fjord. The aplite contains 1-2 vol. % of pyrite in disseminated form and also as veinlets. The aplite yields up to 1.4 ppm Au. The mineralisation is comparable to a similar appearance on the SW coast of Greenland within the Batholith Zone (Niaqornaarsuk).

Pb isotopes and gold emplacement

Pb isotope studies of different mineral occurrences in South Greenland indicate two stages of gold emplacement. The first stage is related to the regional deformation and metamorphism (1792-1785 Ma),

during which sediment-hosted gold was epigenetically concentrated into shear zones and veins.

The second stage seems related to late hydrothermal activity. The source of Pb is possibly a mixture of juvenile Pb from the Julianeåb Batholith with some contributions from the host rocks around 1780 Ma.

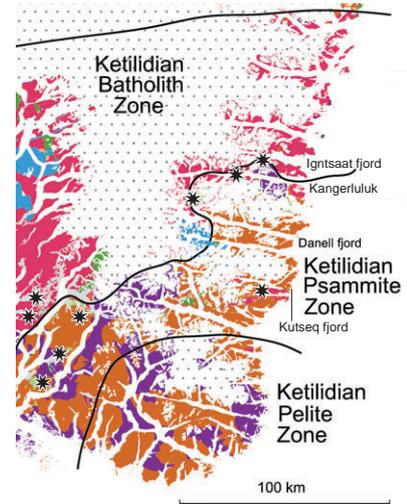
The source indications for Pb in these gold occurrences are a c. 2000 Ma old reservoir, which probably is a mafic source, because of the gold-copper association and the lack of galena. It is concluded that the initial gold mineralisation was genetically related to metalliferous fluids associated with the emplacement of late stages of the Julianeåb Batholith (1800-1770 Ma) followed by local remobilisation.

Gold potential in the Palaeoproterozoic

The gold occurrences in the Ketilidian Orogen are classified as 'Intrusion-related



Basic volcanic rocks with pillow-structures, Kangerluluk.



Geological map of SE Greenland.

Gold Systems'. The gold occurrences are found both within the Julianehåb Batholith and outside as proximal deposits.

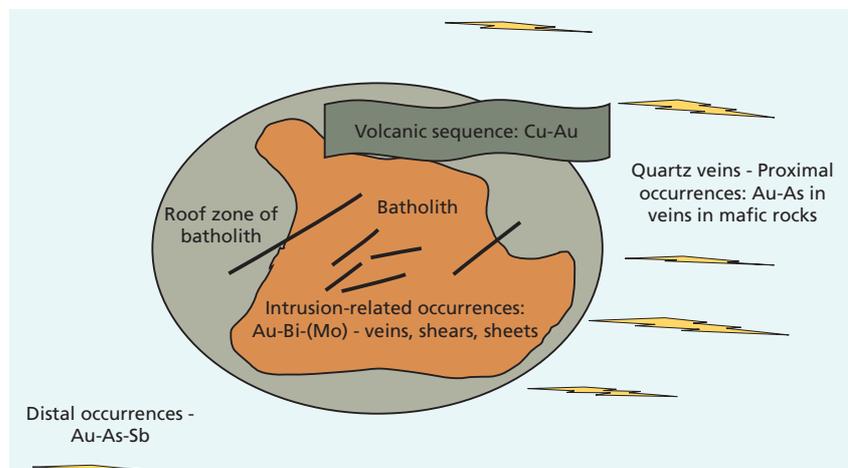
Within the batholith, gold is associated to veins, shears, and sheets in a Au-Bi-W-(Mo) type of mineralisation with disseminated gold. Capping the batholith a Cu-Au association is found in mafic volcanic rocks. Proximal to the batholith quartz veins are carrying Au-As mineralisation in mafic rocks, presently the most promising (e.g. Nalunaq).

Concluding remarks

Gold mineralised occurrences in South Greenland are demonstrated to be located within two major geological environments, the Archaean and the Palaeoproterozoic. During exploration activity in the 1980s and the 1990s the knowledge about gold-mineralisations has been increased and refined and consequently the potential for locating viable gold deposits in the future has improved. As the result of recent exploration and research, the new mine expected to be in operation soon (2003) at the Nalunaq deposit in the southernmost part of Greenland, may signal the opening of a 'golden' period in South Greenland.



Rusty aplite sill, 5 m wide, near Igutsaat.



Schematic presentation of the ore setting in South Greenland.

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Front cover figure:

Gold exploration in Ketilidian rocks, Danell fjord, SE Greenland.



Fig.23: The valley down slope from the Nalunaq deposit. The valley was originally named after the steep mountain (middle-upper part) 'Kirkespiret' ("the church steeple"), 1590 m a.s.l.



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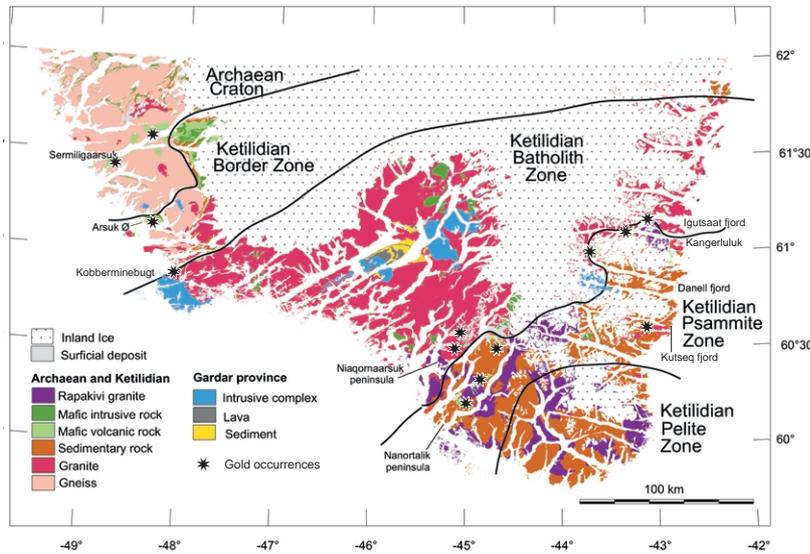
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Appendiks 3: Fact Sheets 1-3

Gold mineralisation and gold potential in South Greenland



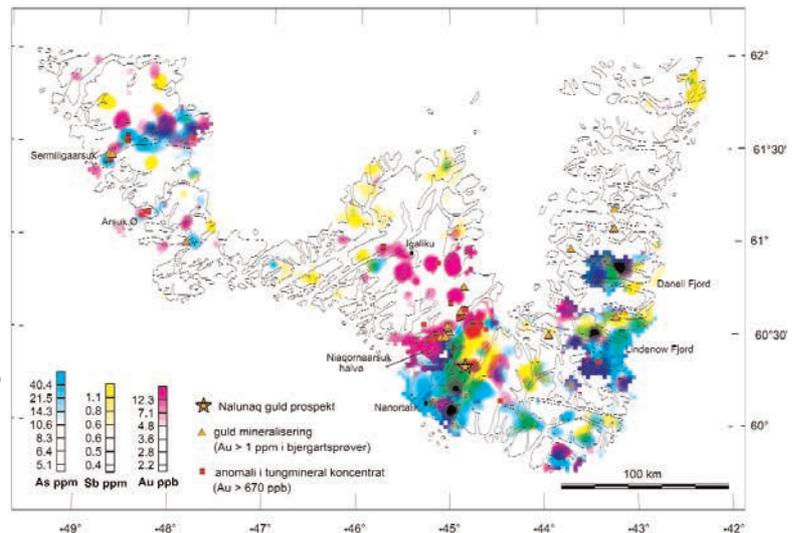
Gold and pathfinder elements

The gold potential of South Greenland is indicated in the geochemical mapping by the distribution of high values for gold (Au) and pathfinder elements like arsenic (As) and antimony (Sb) in the fine fractions (<0,1 mm) of stream sediments. Using this information together with gold anomalies in bedrock and in heavy mineral concentrates of stream sediments, the presently recognised potential

Geological setting

South Greenland is dominated by the Paleoproterozoic Ketilidian Orogen (2000–1750 Ma), which covers the southern tip of Greenland. The middle Proterozoic Gardar province includes pronounced intrusive complexes (1300–1120 Ma) in the central part of the area. The environments for gold deposition can be grouped into several different geological scenarios:

- 1) Archaean foreland composed of highgrade gneisses serving as a basement to Palaeoproterozoic volcanosedimentary successions
- 2) Archaean border zone affected by Ketilidian orogenesis
- 3) A magmatic arc represented by the 30.000-km², calcalkaline Julianeuhåb Batholith and large segments of volcanosedimentary sequences located near the interface to
- 4) The Psammite zone south of the batholith composed of metasediments and locally volcanic rocks that are deformed and sometimes migmatized and
- 5) The Pelite zone located most southerly and composed of turbiditic sedimentary rocks, which are highly deformed and migmatized. The supracrustal successions are intruded by a rapakivi suite between 1755 -1732 Ma.



for gold mineralisations is focussed to specific regions and smaller areas.

The most prospective areas are around the Sermiligaarsuk fjord, at the southern margin of the Julianeuhåb Batholith domain, and within large parts of the Psammite Zone.

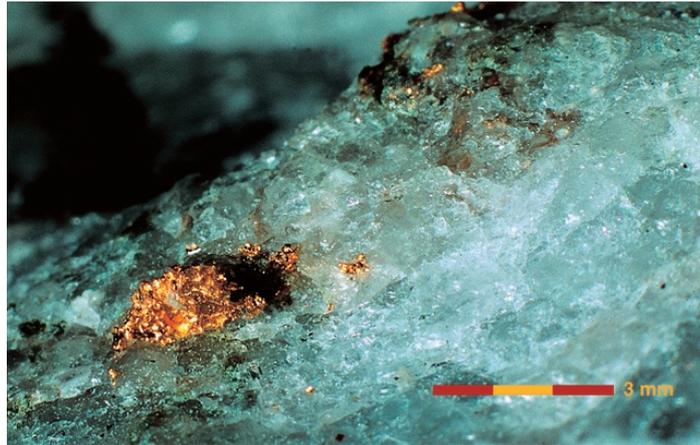
Gold occurs in various settings:

- Archaean Tartoq Group greenstone: Sermiligaarsuk
- Palaeoproterozoic Border Zone: Arsuq and Kobberminebugt
- Julianeuhåb Batholith: Qoorormiut, Niaqornaarsuk, Igutsaat
- Border of Julianeuhåb batholith and Psammite Zone:

Kangerluluk and Sorte Nunatak

- Psammite Zone: Nalunaq, Lake 410, Ippatit and Kutseq

A visit to these localities will reveal a variety of environments and mineral occurrences. They are briefly described here with emphasis on the geological setting and including some important analytical results.



Selected localities with primary gold accumulation

Sermiligaarsuk: The gold occurrences in the Taartoq supracrustals in Sermiligaarsuk are assumed to be deposited between 2500–3000 Ma, and are so far the only Archaean gold mineralisation in South Greenland.

In a quartz association gold occurs as discrete inclusions in pyrite. Other sulphides include arsenopyrite, chalcopyrite, tennantite, and chalcocite. The highest grade recorded for gold is 50 g/t, but typical values are 5–8 g/t.

Qoorormiut: The gold concentration varies significantly in this type of mesothermal gold mineralisation within batholith granite and reaches 380 ppm in narrow silicified shear zones. Chip samples from preliminary exploration activities resulted in assay results up to 114 ppm gold in quartz veins, and up to 14 ppm in zones with carbonated amphibolite.

Nalunaq: The Nalunaq gold deposit is hosted in metapelites and metabasic rocks of Ketilidian age (1850–1800 Ma). The supracrustal successions are intruded by postkinematic biotite granites and subsequently by anorogenic rapakivi granites around 1750 Ma.

The gold mineralisation is epigenetic and resides mainly in quartzveins. The 'Main Vein' of Nalunaq has so far been estimated to be 1700 m long and 0.1 to 2 m wide.

The gold is genetically related to metalliferous fluids associated with the emplacement of late intrusive stages of the Julianehåb Batholith granites (1800–1770 Ma) followed by local remobilisation. Measured and indicated resources are 292,000 ounces of gold with an average grade of 25 g/t. As inferred resources 718,000 ounces of gold are considered in ore averaging 19 g/t Au. The Nalunaq deposit is expected to go into production during 2003.

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The ore minerals related to a 'quartz association' are dominated by pyrrhotite and pyrite. Locally massive pyrrhotite occurs at the contacts between sediments and more massive quartz veins. Narrow silicified alteration halos with very high gold concentrations are associated with the quartz veins. A grab sample from a halo contains 118 ppm gold.

Concluding remarks

Gold mineralised occurrences in South Greenland are located within two major geological environments, the Archaean and the Palaeoproterozoic. During exploration activity in the 1980s and the 1990s the knowledge about goldmineralisations has been increased and refined and consequently the potential for locating viable gold deposits in the future has improved. As the result of recent exploration and research, a new mine is expected to be in operation soon (2003) at the Nalunaq deposit.

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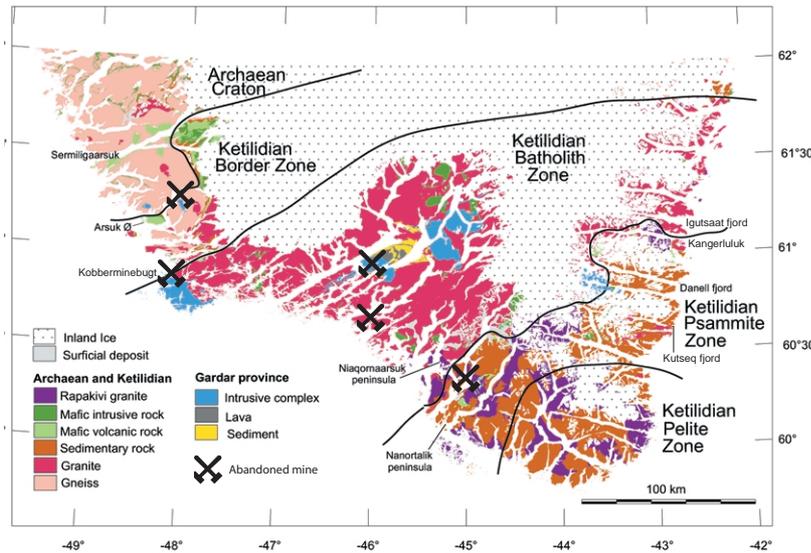
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Early mining activities in South Greenland



This was the situation when a new attempt to mine copper was recommenced at the Josvas copper deposit. From 1904-15 the Josva Mine was in operation, and it was closed because of decreasing ore grade. Shortly thereafter the company dismantled the mine town and plant, and moved the equipment to Amitsoq in the very southern Greenland, for use in a new graphite mine. The Amitsoq mine went on until 1924, and mine activities were abandoned due to the downward tendency for

Locations and history

Mining in Greenland has long been an important element in the exploitation of the country's natural resources, and the mining tradition extends far back in time.

Exploration for minerals was introduced in the 1700s and 1800s, although it was of course on an extremely modest scale in comparison with present standards. Exploitation of the mineral ores increased at the start of the 1900s, when the cryolite mine in Ivittuut was increasingly active in southern Greenland, where there had been mining operations since 1854.

An attempt to mine copper in the area had been made in 1850s, at the so-called Josvas copper mine. Inadequately known quantities of ore, simple technology and a number of ship losses were significant reasons why the copper mine had to be abandoned at that time.

Modern mining

In the period before the First World War the new industrialisation required copper and graphite for the rapid developments occurring in the use of electricity.

commodity prices and the general depression after the war. Only the cryolite mine continued and even steadily increased the profit until the mine closure in 1987.

In the period from 1958 to 1980 the Danish state conducted exploration and test mining for radioactive commodities around the Kvanefjeld deposit in South Greenland.

Mining logistics

Mining in Greenland must be organised from the basic level with the equipment plan and infrastructure, and the entire operation must be based on all necessary materials, supplies and fuel having to be transported to Greenland by sea traditionally, and by air in modern activities.

Mining for cryolite 1854-1987 – Greenland's white gold in Ivittuut

3.7 millions t of ore was mined in the period with an average content of 58 % cryolite in the ore.

Mining began in 1854 with galena as the target. Soon after cryolite became the key commodity. Cryolite was used in the production of soda and iron enamelling

Mine	Commodity	Time	Production	Ore grade
Ivittuut Cryolite Mine	cryolite	1854 –1987	3.7 million t	58 % cryolite
Josva Copper Mine	Cu	1904 –1915	2.200 t	3,5 % Cu
King Frederik VII's Mine	Cu, Ag	1851,1912	18.0 t	5.4 % Cu
Kvanefjeld Uranium Mine	U	1958 / 1980	20.000 t	365 g/t U
Amitsoq Graphite Mine	graphite	1915 –1924	6.000 t	21.5 % graphite



Ivittuut 1898



Ivittuut 1986

until 1887. From 1887-1987 cryolite was used as a flux in the production of metallic aluminium – the use which made cryolite indispensable to modern industry – and the application of aluminium.

Ivittuut was the only cryolite mine in operation world wide so far. After 1987 the operations turned out to be uneconomical and the activity was terminated. Today cryolite is made artificially.

Mining for copper 1904-1915

2200 t of ore was mined in the Josva Mine in this period - with 3.5 % copper in average. Byproducts from the production were 0.5 kg gold and 50 kg silver.



Josva 1911



Amitsoq 1920

The total production went on from underground levels down to 100 m. There were high expectations to the copper mining, and a smelter was installed. Capital and man power were designed as half size of the Ivittuut mine.

Amount and grade were too limited to be economic. Smelting operations failed and the mine was abandoned after 10 years of operation .

Amitsoq graphite mine 1915-1924

During the lifetime of the mine 6000 t of ore with 21 % graphite were mined underground and in open pit. The mine was abandoned after difficulties in separating the graphite flakes.

The deposit has still calculated resources of 250.000 t of ore which averages 20 % graphite.

The company behind the Josva Mine established the mine and the equipment and buildings from Josva were moved to Amitsoq. The graphite mine was partly financed by international capital for the first time in Greenland mining history.



Kvanefjeld 1958

Mining uranium over the period 1958-1980

20.000 t ore with 365 g/t U in average was mined on a pilot scale in several runs. The mining was carried out underground from a 1000 m drift; Calculated reserves are up to 56 million t. Further activity ceased after the early 1980s.

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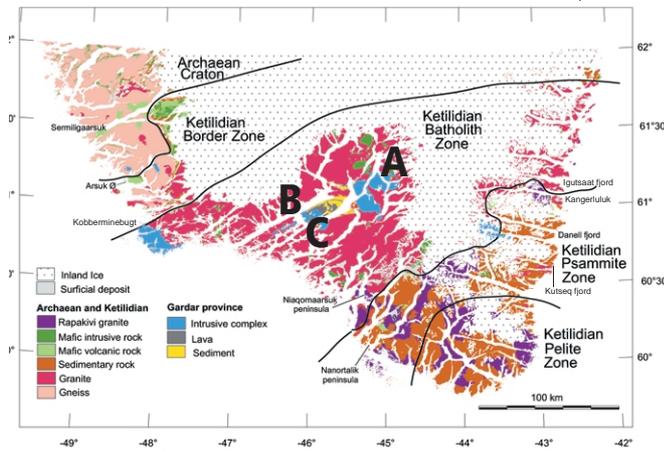
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Deposits of speciality metals in South Greenland

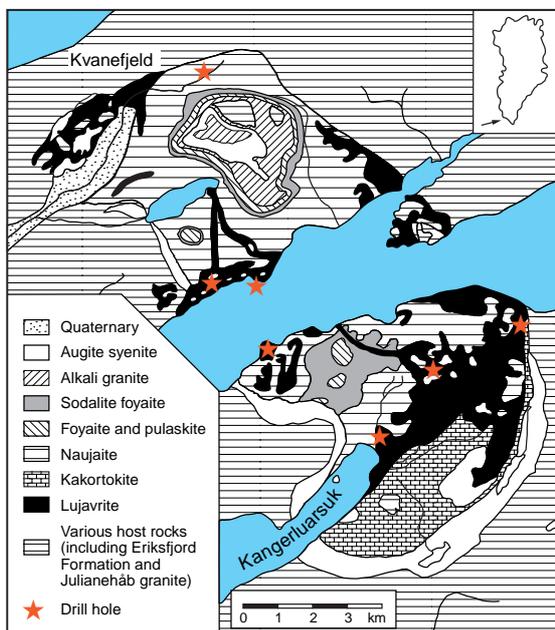


Geological environment and location

Speciality metals in South Greenland are found almost exclusively in peralkaline/alkaline intrusions of the Proterozoic Gardar age, 1300-1120 Ma.

Major commodities include:

- Tantalum, Loc. A
- Niobium, Loc. A, B
- Zirconium, Loc. C
- Yttrium, Loc. C
- Rare Earth Elements, Loc. B, C
- Beryllium, Loc. B
- Speculative commodities, Loc. B



A treasure of speciality metals within the Ilímaussaq Intrusion

The Ilímaussaq intrusion is one of the Gardar intrusions with an age of 1186 Ma. The complex has been known since 1806, but comprehensive descriptions appeared much later – and over a large period of time - in 1912, 1957 and 1964. Since the first discovery the complex has attracted researchers and explorationists worldwide.

The Danish State took over exploration for radioactive elements from 1955-1982. The complex was drilled in 1962 resulting in seven drill holes (* on the map).

A fan of rare metals and elements is recognised within the complex: U, Th, Nb, Ta, Zr, Y, REE, Li, Be.

Tantalum in the Motzfeldt complex

The Motzfeldt Centre is one of the Gardar intrusions (1310 Ma). Pyrochlore accumulations in the Motzfeldt syenite show significant grades of Ta.

The deposit at Motzfeldt is a typical 'Low grade - large tonnage' type of resource. 600 million t of ore with c. grades of 120 ppm Ta are the figure based on major investigations carried out by the Survey (GEUS). High grade zones carries up to 426 ppm Ta. Company exploration has now taken over what is believed to be one of the largest Ta deposits in the World.



Niobium at Motzfeldt and Kvanefjeld

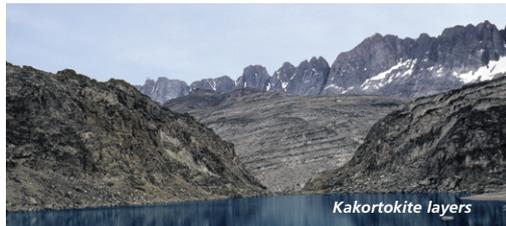
The Motzfeldt Centre Ta deposit is located in minealised syenite. Additionally a Nb resource of at least 130 million t with 0.4-1.0% Nb205 is known.



The Kvanefjeld uranium deposit has an additional potential for Nb, settled in several rare minerals (e.g. pyrochlore and epidote) partly in the ore and in associated veins. Resource estimates are not available.

Zirconium and Yttrium at Kangerluarsuk

Deposit are found in Zr and Y rich apatitic rocks within the Ilímaussaq Intrusion, where Zr, Y and REE are accumulated in the mineral eudialyte. The host rock - kakortokite - is a layered rock, where the eudialyte is enriched in 29 separate layers.



Kakortokite layers

Eudialyte is a complex Zr-silicate. The ZrO₂ content is c. 14 %, and the (Ce,La,Y)₂O₃ content is c. 3 %. Y element can reach 4000 ppm.

Eudialyte accumulations carry a potential for exploitable amounts of Zr, Y, REE and Nb. Estimated resources of +2 million t ore with an average of 3% ZrO₂ are located. Peak values of 6% ZrO₂, 0.2% Y₂O₃, 3% REE₂O₃ and 0.2% Nb₂O₅ are at hand.

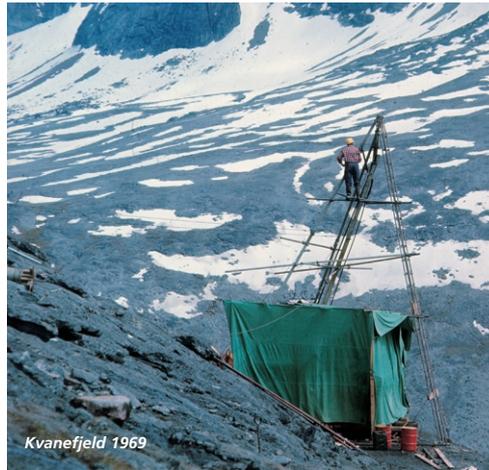
Beryllium at Kvanefjeld

The Ilímaussaq Intrusion rocks have an average Be content of 30 ppm. Be is located in a suite of rare minerals ranging in mineral content from more than 40% BeO (beryllite) to about 5% BeO (tugtupite).



Tugtupite (pink)

In the Kvanefjeld area a rough estimate indicates a resource of 180.000 t rock with 0.1 % Be.



Kvanefjeld 1969

Speculative commodities at Kvanefjeld

Lithium is enriched in the apatitic rocks of the Ilímaussaq Intrusion. Values of Li in the Kvanefjeld deposit are found between 600-1900 ppm. An estimated resource in the Kvanefjeld deposit counts 235.000 t Li.

Summary of potential for speciality metals

South Greenland has an obvious potential for speciality metals. Characteristically both 'large tonnage low grade' as well as 'low tonnage high grade' deposits are outlined.

Tantalum takes the lead in the deposit of the Motzfeldt centre with more than 600 million t of Ta ore grading 120 ppm. Zirconium is found at the exceptional formation at Kangerluarsuk where over 2 million t of Zr ore grading 3% ZrO₂ is located. Additional rare metals are Y, Nb, REE, Be and Li.

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Appendiks 4: Power Point Præsentation 1-5

TOPICS ON GREENLAND MINERAL RESOURCES 1

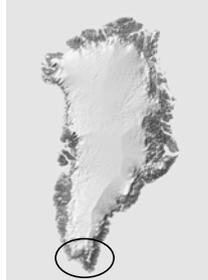
Gold mineralisation south of latitude 62°N, Greenland

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Gold mineralisation south of latitude 62°N, Greenland 1 TOPICS ON GREENLAND MINERAL RESOURCES 1

Gold in South Greenland

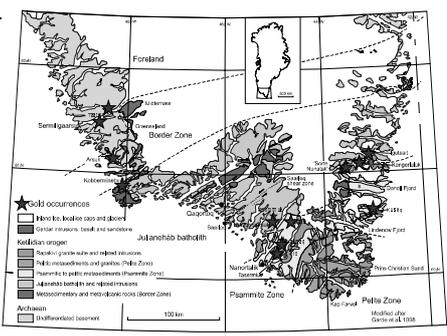


Includes the story of:

- Geological setting
- Geochemical dispersion
- Visit to important localities
- Pb isotopes and the gold formation
- Model for the gold setting
- Conclusions on the gold potential
- The next step

Gold mineralisation south of latitude 62°N, Greenland 2 TOPICS ON GREENLAND MINERAL RESOURCES 1

Geological setting in South Greenland

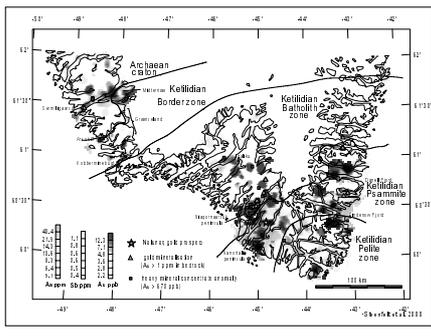


★ Gold occurrences

- Micro-ke.沸石岩 and 沸石
- 花岗岩、流纹岩和玄武岩
- Archean orogen
- 变质花岗岩和杂岩体
- 中元古生代花岗岩和杂岩体 (Pelite Zone)
- 与花岗岩有关的侵入体 (Pammitte Zone)
- 中元古生代花岗岩和杂岩体 (Pammitte Zone)
- 中元古生代花岗岩和杂岩体 (Pammitte Zone)
- 中元古生代花岗岩和杂岩体 (Pammitte Zone)
- Archean
- 中元古生代花岗岩和杂岩体 (Pammitte Zone)

Gold mineralisation south of latitude 62°N, Greenland 3 TOPICS ON GREENLAND MINERAL RESOURCES 1

Geochemical dispersion in South Greenland



Gold mineralisation south of latitude 62°N, Greenland 4 TOPICS ON GREENLAND MINERAL RESOURCES 1

Geochemical information from stream sediments

The geochemical map shows:

- Gold anomalies
- Arsen(As) and antimony(Sb)pathfinder anomalies

The geochemical and geological knowledge points to:

A gold potential within the Archean Craton and the Palaeoproterozoic zones in South Greenland

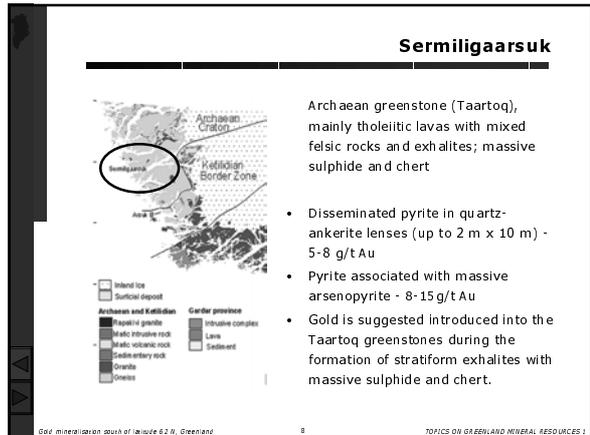
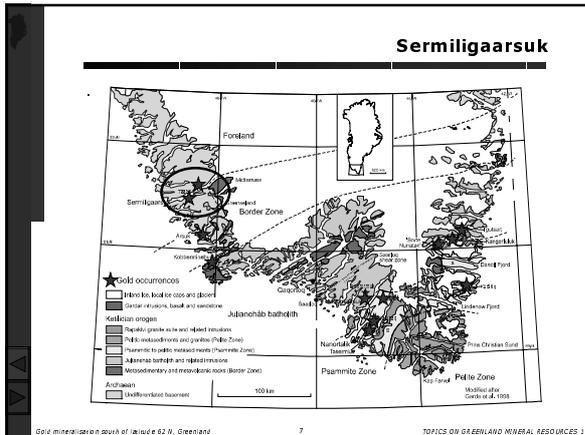
Gold mineralisation south of latitude 62°N, Greenland 5 TOPICS ON GREENLAND MINERAL RESOURCES 1

Gold mineralisation localities

Gold in West Greenland (WG) and East Greenland (EG):

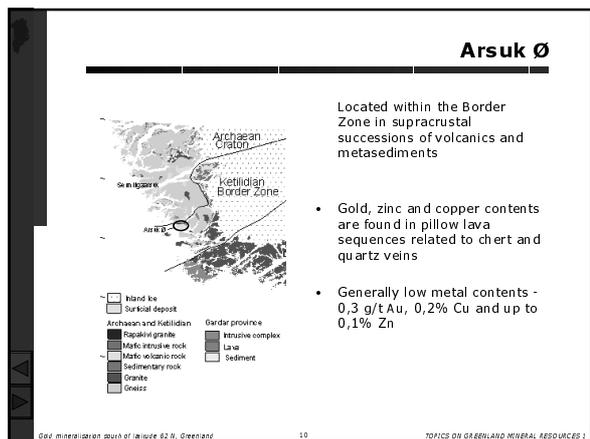
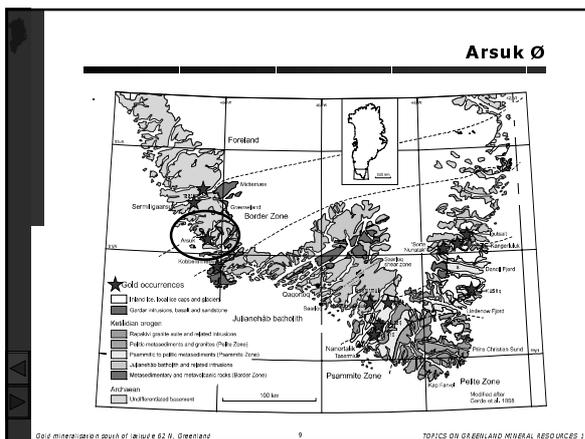
- Archean Taartoq greenstone belt (WG) - Sermiligaarsuk
- Palaeoproterozoic 'Border Zone' (WG) - Arsuq Ø and Kobberminebugt
- 'Julianehåb Batholith Zone' (WG) - Qooromut, Niaqornaarsuk, Igutsaat (EG)
- 'Pammitte Zone' (WG) - Nalunaq, Lake 410, Ipatit and Kutseq (EG)
- Between 'Julianehåb Batholith Zone' and 'Pammitte Zone' (EG) - Kangerluluk-area

Gold mineralisation south of latitude 62°N, Greenland 6 TOPICS ON GREENLAND MINERAL RESOURCES 1



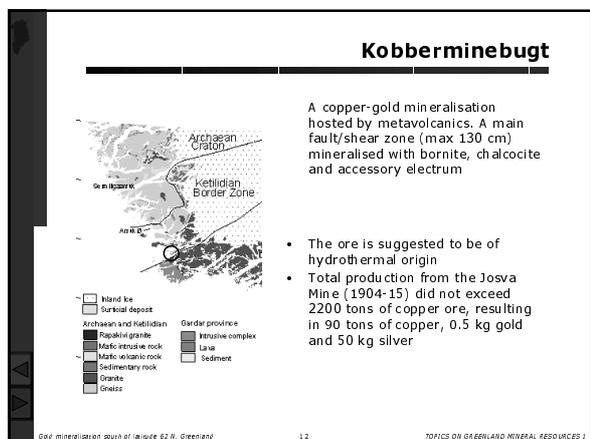
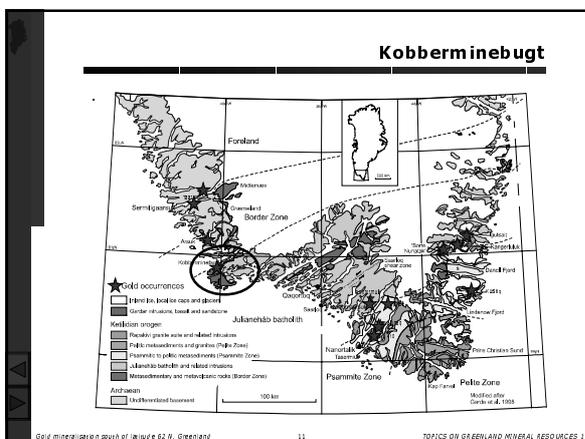
Archaean greenstone (Taartoq), mainly tholeiitic lavas with mixed felsic rocks and exhalites; massive sulphide and chert

- Disseminated pyrite in quartz-ankerite lenses (up to 2 m x 10 m) - 5-8 g/t Au
- Pyrite associated with massive arsenopyrite - 8-15 g/t Au
- Gold is suggested introduced into the Taartoq greenstones during the formation of stratiform exhalites with massive sulphide and chert.



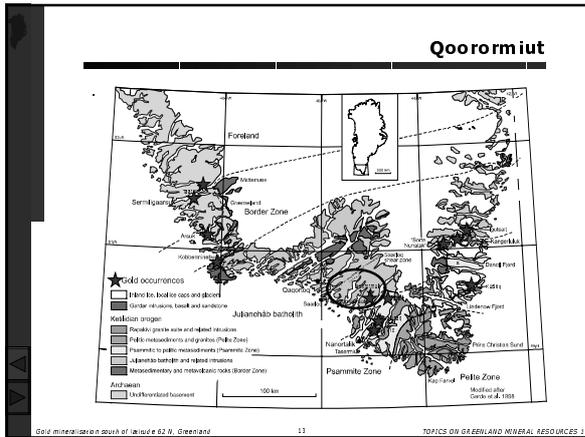
Located within the Border Zone in supracrustal successions of volcanics and metasediments

- Gold, zinc and copper contents are found in pillow lava sequences related to chert and quartz veins
- Generally low metal contents - 0,3 g/t Au, 0,2% Cu and up to 0,1% Zn

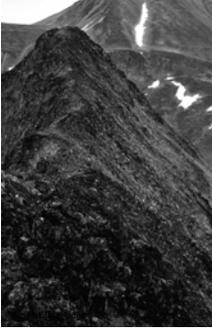


A copper-gold mineralisation hosted by metavolcanics. A main fault/shear zone (max 130 cm) mineralised with bornite, chalcocite and accessory electrum

- The ore is suggested to be of hydrothermal origin
- Total production from the Josva Mine (1904-15) did not exceed 2200 tons of copper ore, resulting in 90 tons of copper, 0,5 kg gold and 50 kg silver



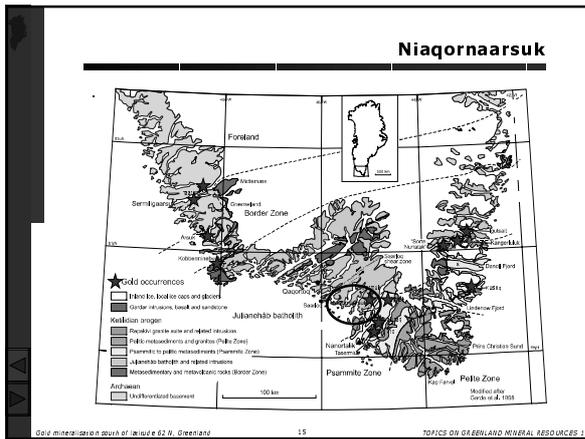
Qoorormiut



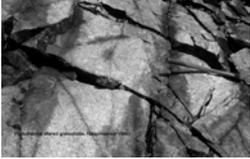

Gold mineralisation in the Qoorormiut valley associated to quartz veins in mafic dykes hosted in batholith granite

Gold is precipitated from the CO₂-CH₄ fluids at 200-400°C and at a pressure between 0.5 and 1.5 kbar, as shown by fluid inclusion studies.

Gold mineralisation study of (slide 62.0), Greenland 14 TOPICS ON GREENLAND MINERAL RESOURCES 1



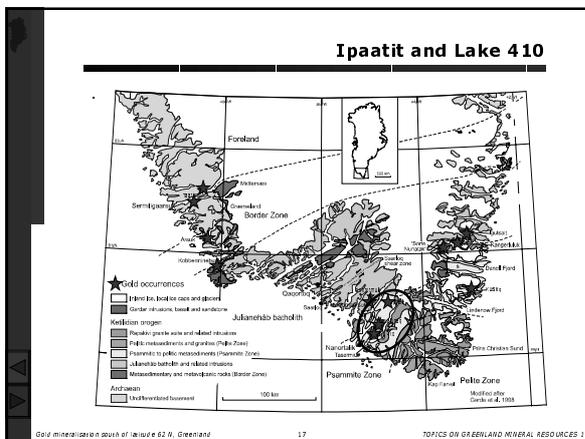
Niaqornaarsuk

Gold mineralisation in the Niaqornaarsuk valley is related to quartz veins, meta-basic rocks, aplites, shear zones and hydrothermal altered batholith rocks

The gold mineralisation is located near the roof of the Julianehåb Batholith and is characterised by the element association Au-Bi-(As-Mo-W).

Gold mineralisation study of (slide 62.0), Greenland 16 TOPICS ON GREENLAND MINERAL RESOURCES 1



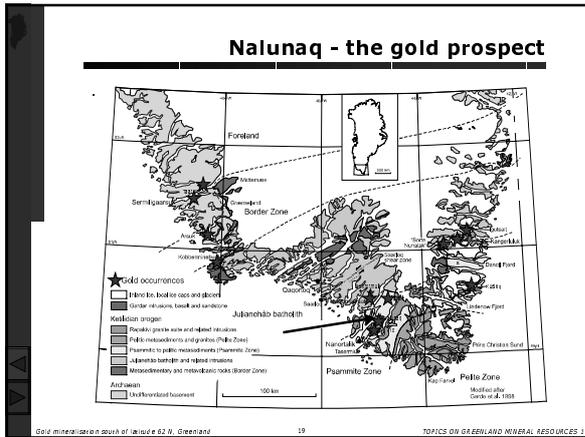
Ippatit and Lake 410



Ippatit (1) and Lake 410 (2) area - dominated by a sheet of meta-volcanic rock with low gold contents

The same rock suite hosts the Nalunaq (Kirkespiret) gold prospect (3) with high gold contents

Gold mineralisation study of (slide 62.0), Greenland 18 TOPICS ON GREENLAND MINERAL RESOURCES 1



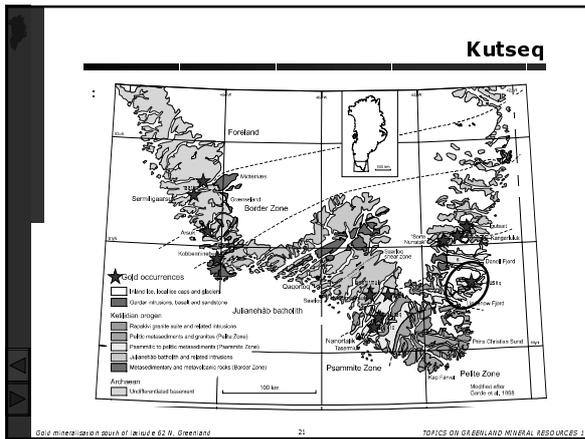
Nalunaq - the gold prospect

Underground test mining face at level 450 m

A major gold occurrence has been discovered within the Sediment Zone

- The gold is genetically related to late intrusive stages of the granite batholith (1800-1770 Ma)
- Measured and indicated resources are 9 t gold (292.000 ounces) - 32 g/t in average
- Inferred resources are >22 t gold (718.000 ounces)

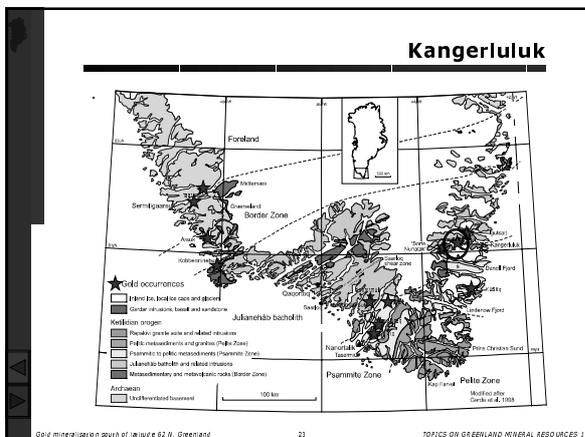
Gold mineralisation sketch of latitude 62 N, Greenland 20 TOPICS ON GREENLAND MINERAL RESOURCES 1



Kutseq

- Gold in sulpho-arsenides and arsenides within a mafic sequence. Shear zones have up to a few vol.% of disseminated pyrrhotite and arsenopyrite
- In the As-Au association, arsenopyrite geothermometry suggests precipitation temperatures for arsenopyrite-löllingite-pyrrhotite and gold of 440-560°C.

Gold mineralisation sketch of latitude 62 N, Greenland 22 TOPICS ON GREENLAND MINERAL RESOURCES 1

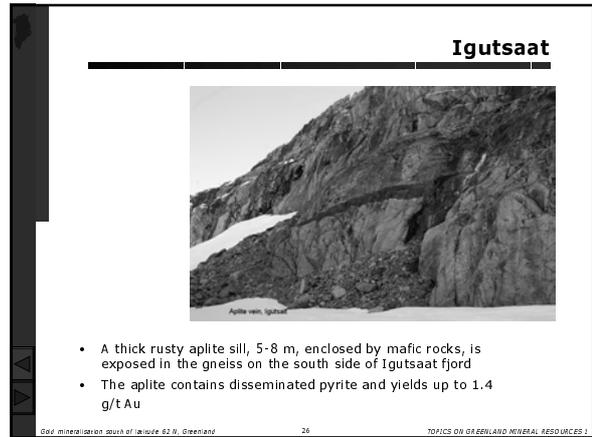
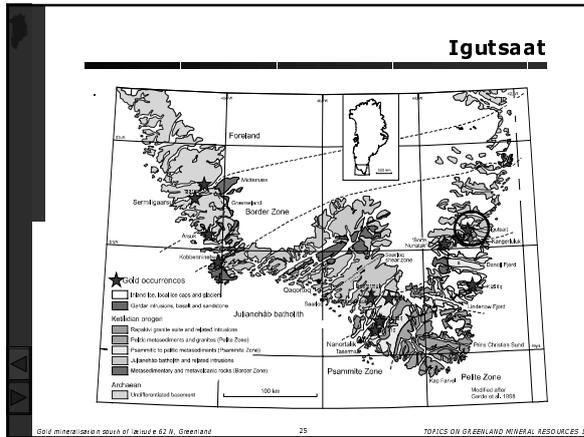


Kangerluluk

- Gold-bearing sulphide mineralisation hosted by a 200-300 m mafic volcano-sedimentary sequence
- Pyrite, chalcopyrite and microscopical gold in association with faults
- Pyrrhotite and pyrite associated to quartz veins are related to silicified alteration halos with very high gold values.

A grab sample from a halo contains 118 ppm gold

Gold mineralisation sketch of latitude 62 N, Greenland 24 TOPICS ON GREENLAND MINERAL RESOURCES 1

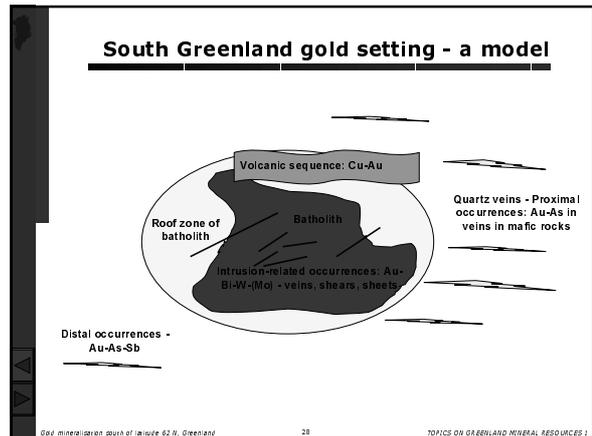


Pb isotopes and gold formation

Pb isotope studies of different mineral occurrences in South Greenland indicate two stages of gold emplacement.

- First stage is related to the Palaeoproterozoic regional deformation and metamorphism (1792-1785 Ma), during which sediment-hosted gold was epigenetically concentrated into shear zones and veins.
- Second stage seems related to late hydrothermal activity. The source of Pb is possibly a mixture of juvenile Pb from the batholith with some contributions from the host rocks around 1780 Ma.
- The source indications for Pb in these gold occurrences is a c. 2000 Ma old reservoir.
- The reservoir is probably a mafic source due to the gold-copper association and lack of galena.

Gold mineralisation south of latitude 62 N, Greenland 27 TOPICS ON GREENLAND MINERAL RESOURCES 1



Conclusions on the gold potential

- 'Intrusion-related gold systems'
- The source is 2000 Ma old rocks, probably of mafic origin
- Main gold emplacement is related to regional metamorphism (1792-1785 Ma) - shear zones and quartz veins
- Remobilisation of gold took place at later stages

All gold occurrences are found during modern exploration activity of the late 20th Century.

A mine will probably open within one or two years at Nalunaq

Gold mineralisation south of latitude 62 N, Greenland 29 TOPICS ON GREENLAND MINERAL RESOURCES 1

The next step - a gold mine ?!

The Nalunaq gold occurs in the so-called Main Vein (MV), which is 0.1 to 2 m wide and at least 1700 m long

The mining camp is conveniently located with easy access to port and town facilities in the regional town of Nanortalik

A mining operation is expected to be initiated soon.....

Gold mineralisation south of latitude 62 N, Greenland 30 TOPICS ON GREENLAND MINERAL RESOURCES 1

TOPICS ON GREENLAND MINERAL RESOURCES 1

Information slide:
Gold mineralisation
south of latitude 62°N, Greenland

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Editor: Karsten Secher

Geological Survey of Denmark and Greenland (GEUS)

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www.geus.dk

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TOPICS ON GREENLAND MINERAL RESOURCES 2

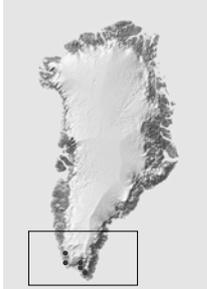
Early mining activities in South Greenland

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South Greenland mining

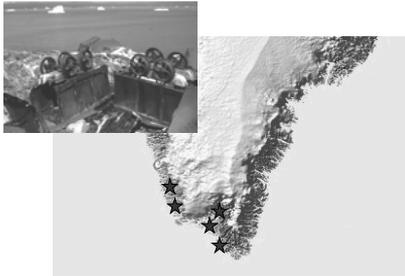


Includes the story of:

- Places with mining and pilot scale operations
- Ivittuut Cryolite mine
- Josva Copper mine
- King Frederik Vilis Copper mine
- Kvanefjeld Uranium mine
- Amitsoq Graphite mine
- Feasibility of South Greenland mining
- From past to present in mining

Early mining activities in South Greenland 2 TOPICS ON GREENLAND MINERAL RESOURCES 2

Mining localities in South Greenland



Early mining activities in South Greenland 3 TOPICS ON GREENLAND MINERAL RESOURCES 2

Early mining, production and grades

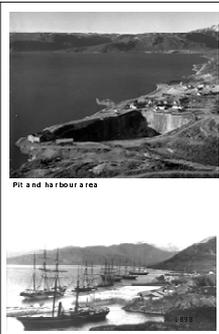


Cryolite ore handling, 1920

Mine	Commodity	Time	Production	Ore grade
Ivittuut Cryolite Mine	Cryolite	1854-1987	3.7 million t	58 % cryolite
Josva Copper Mine	Cu	1904-1915	2200 t	3,5 % Cu
King Frederik Vilis Mine	Cu, Ag	1851, 1912	18 t	5,4 % Cu
Kvanefjeld Uranium Mine	U	1958/1980	20 000 t	365 g/t U
Amitsoq Graphite Mine	Graphite	1915-1924	6000 t	21,5 % graphite

Early mining activities in South Greenland 4 TOPICS ON GREENLAND MINERAL RESOURCES 2

Ivittuut Cryolite mine



Mining for cryolite 1854-1987

- 3.7 millions t of ore mined - with 58 % cryolite in average
- Impurities in the ore are made into by-products as sulphides and siderite
- Total production from one open pit, 70 m deep and c. 200 m wide
- Ore shipments direct from the pit area to destinations in Europe and North America

Early mining activities in South Greenland 5 TOPICS ON GREENLAND MINERAL RESOURCES 2

History of the cryolite



Mining for cryolite 1854-1987 - Greenland's white gold

Mining began 1854 with argentiferous galena as target commodity

- Cryolite was used in the production of soda and iron enamelling until 1887
- From 1887-1987 cryolite was used as a flux in the production of metallic aluminium



Crystals of cryolite

Early mining activities in South Greenland 6 TOPICS ON GREENLAND MINERAL RESOURCES 2

Facts about cryolite mining

- Mining and handling methods were especially developed by the mining company
- After quarrying the cryolite was hand picked - resulting in a product with up to 85 % cryolite




- Cryolite ore was moved directly from the pit to the loading area in tipper wagons. The equipment was used for decades
- Ivittuut was the only cryolite mine in operation world wide so far
- Cryolite is made artificially now

Early mining activities in South Greenland 7 TOPICS ON GREENLAND MINERAL RESOURCES 2

Josva Copper mine



Mining for copper 1851-1855 and 1904-1915

- 2200 t of ore mined - with 3.5 % copper in average
- By-products were 0.5 kg gold and 50 kg silver

- Total production from underground levels down to 100 m
- Ore shipments direct from the mine area to destinations in Denmark

Early mining activities in South Greenland 8 TOPICS ON GREENLAND MINERAL RESOURCES 2

Smelting plant at Josva Mine



High expectations - smelter installed

Modern technology applied

Capital and man power designed as half size of Ivittuut mine



- Amount and grade too limited to be economic
- Smelting operations failed
- Mine abandoned after 10 years

Early mining activities in South Greenland 9 TOPICS ON GREENLAND MINERAL RESOURCES 2

King Frederik VII's Copper mine




Mining in 1851 and 1912 for copper and silver

- Only 18t ore mined from underground; app. 5.4 % Cu and 1000 g/t Ag
- Mine empty and abandoned after 1912
- Properly the first organised underground mine in Greenland

Early mining activities in South Greenland 10 TOPICS ON GREENLAND MINERAL RESOURCES 2

Earliest underground operation - in name of the King




- Mine adit driven in 1851, 4 m long (!)
- Renewed search for ore in 1853, 1854, 1905 and 1912
- Float with string silver created 'rush' like expectations like famous Kongsberg mine, Norway

Early mining activities in South Greenland 11 TOPICS ON GREENLAND MINERAL RESOURCES 2

Kvanefjeld Uranium mine



Mining (pilot scale) uranium 1958-62 and 1979-1980

- 20.000 t ore mined from 1000 m drift; 365 g/t U in average
- Calculated reserves up to 56 million t
- Mining activity ceased after 1982

- The extraction of uranium from the atypical ore needed research
- The ore is located in rocks from a major peralkaline intrusive suite of the Ilimaussaq nepheline syenite complex
- The ore mineral is steenstrupine, a phosphate-silicate with major traces of U, Th and Zr



Early mining activities in South Greenland 12 TOPICS ON GREENLAND MINERAL RESOURCES 2

Ore testing at the Ilímaussaq complex

Zirconium resources within the complex at Kangerluarsuk explored and tested 1888-89, 1946, 1968 and 1986-95

- In 1968 100 t of Zr ore was mined and tested on a pilot scale
- The Zr mineral is eudialyte. Ore grade up to 6 % ZrO₂
- Estimated resources are +2 million t
- The Zr ore also contains commodities as Nb, Y and REE

The Ilímaussaq complex has an additional potential of Be, Li and F



Drilling 1968



Zr ore shipped from Ilímaussaq

Early mining activities in South Greenland 11 TOPICS ON GREENLAND MINERAL RESOURCES 2

Amitsoq Graphite mine

Graphite mining 1915-1924



Open pit graphite mine



Ore load from shaft 1920

6000 t of ore with 21% graphite, mined underground and in open pit

Calculated resources are 250.000 t of ore

Mine abandoned after difficulties in separating the graphite flakes

Early mining activities in South Greenland 14 TOPICS ON GREENLAND MINERAL RESOURCES 2

Amitsoq infrastructure

- Mining town located on a slope. Buildings and equipment moved from Josva mine
- Ore shipments direct from the mine to destinations in Denmark
- First mine in Greenland operated as a joint venture with international capital invested



1920

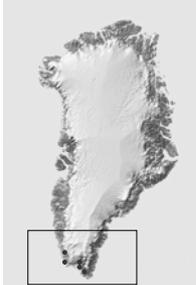


1936 1941

Early mining activities in South Greenland 15 TOPICS ON GREENLAND MINERAL RESOURCES 2

Feasibility of South Greenland mining

- Success and failure can be the lesson
- Underground and open cast operations
- All year operation practical
- Importance of field experience and planning
- Providing ore and mining technology -very profitable operations can be achieved



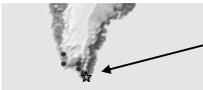

Dansk 1913

Early mining activities in South Greenland 16 TOPICS ON GREENLAND MINERAL RESOURCES 2

From past to present in mining

150 years of mining activity in SouthGreenland has shown operational feasibility in an arctic environment

- Projects based on classical and indigenous knowledge have been tested throughout this period
- Modern exploration has revealed new targets - precious metals, base metals, speciality metals and industrial minerals
- - and the next mine to open in Greenland will probably be a gold mine at Naluuaq - vis a vis the early graphite workings to the very South

Early mining activities in South Greenland 17 TOPICS ON GREENLAND MINERAL RESOURCES 2

TOPICS ON GREENLAND MINERAL RESOURCES 2

Information slide:
Early mining activities in South Greenland

Author: Karsten Secher
Editor: Karsten Secher
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Photo: GEUS, SULUK, RD, DPC
Geological Museum, KØ, Greenland

Department of Economic Geology
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This presentation is the result of a co-production between GEUS and Greenland Resources, financed by the latter and made in order to propagate knowledge about mineral resources in Greenland

Early mining activities in South Greenland 18 TOPICS ON GREENLAND MINERAL RESOURCES 2

TOPICS ON GREENLAND MINERAL RESOURCES 3

Speciality metals in South Greenland

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GEUS
&
GREENLAND RESOURCES

Ta
Nb
Be
Zr
Y
REE

Speciality metals in South Greenland 1 TOPICS ON GREENLAND MINERAL RESOURCES 3

Potential for speciality metals

Major commodities includes

- Tantalum
- Niobium
- Zirconium
- Yttrium
- Rare Earth Elements
- Beryllium
- Speculative commodities

Speciality metals in South Greenland 2 TOPICS ON GREENLAND MINERAL RESOURCES 3

Geological environment

Speciality metals in South Greenland 3 TOPICS ON GREENLAND MINERAL RESOURCES 3

Geology and localities

Localities with a known potential for speciality metals

- Loc. A : Motzfeldt Centre
- Loc. B : Kvanefjeld
- Loc. C : Kangerluarsuk

Speciality metals are found in peralkaline/alkaline intrusions of Palaeoproterozoic Gardar age 1300-1120 Ma

Speciality metals in South Greenland 4 TOPICS ON GREENLAND MINERAL RESOURCES 3

Tantalum in the Motzfeldt complex

Motzfeldt Lake south of the intrusive centre. In the foreground a look at the syenite, locally with Ta-Nb mineralisation

- The Motzfeldt Centre is one of the Gardar intrusions (1310 Ma)
- Pyrochlore accumulations in the Motzfeldt syenite show significant grades of Ta
- Ta is found in mineralised zones within syenite
- Low grade - large tonnage type of deposit

Speciality metals in South Greenland 5 TOPICS ON GREENLAND MINERAL RESOURCES 3

Tantalum deposit

- Major investigations carried out by the Survey (GEUS)
- 600 million t of ore with app. grades of 120 ppm Ta
- High grade zones carry up to 426 ppm Ta
- Motzfeldt Centre among one of the largest known Ta deposits

Drilling at Motzfeldt, 2001

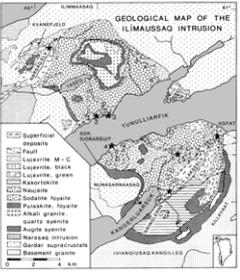
Licence Angus & Ross PLC, UK, has found up to 630 ppm Ta after diamond drilling

Exploration and drilling planned to continue

Speciality metals in South Greenland 6 TOPICS ON GREENLAND MINERAL RESOURCES 3

Ilimaussaq Intrusion - a treasure of speciality metals

- The Ilimaussaq intrusion is one of the Gardar intrusions (1186 Ma)
- The complex known since 1806, but comprehensive descriptions appeared much later - in 1912, 1957 and 1964
- Since the first discovery the complex has attracted researchers and explorationists worldwide
- The Danish state took over exploration for radioactive elements from 1955-1985
- The complex was drilled in 1962 - seven drill holes (* on the map)
- A fan of rare metals and elements is recognised within the complex



Speciality metals in South Greenland 7 TOPICS ON GREENLAND MINERAL RESOURCES

Niobium at Motzfeldt and Kvanefjeld



Kvanefjeld uranium deposit has potential for Nb in several rare minerals (e.g. pyrochlore and epidote), partly in the U-ore and in associated veins

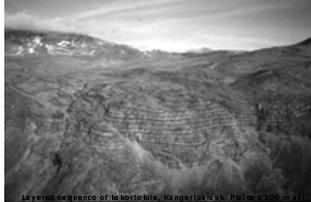
Resource estimates not available



Motzfeldt Se Ta deposit is followed by a Nb resource of at least 130 million t of 0.4-1.0% Nb₂O₅

Speciality metals in South Greenland 8 TOPICS ON GREENLAND MINERAL RESOURCES

Zirconium and Yttrium at Kangerluarsuk



- Deposit of Zr and Y rich apgaitic rocks within the Ilimaussaq Intrusion
- Zr and Y together with REE are accumulated in the mineral eudialyte
- The host rock - kakortokite - is a layered rock, where the eudialyte is enriched in 29 separate layers



Large crystals of eudialyte (red). Scale 1 cm.

- Eudialyte is a complex Zr-silicate
- ZrO₂ content is app. 14 %
- (Ce,La,Y)₂O₃ content is app. 3 %
- Y element can reach 4000 ppm

Speciality metals in South Greenland 9 TOPICS ON GREENLAND MINERAL RESOURCES

Zirconium and Yttrium at Kangerluarsuk

- Eudialyte accumulations carry a potential for exploitable amounts of Zr, Y, REE and Nb
- Estimated resources of +2 million t ore with an average of 3% ZrO₂
- Peak values of 6% ZrO₂, 0.2% Y₂O₃, 3% REE₂O₃ and 0.2% Nb₂O₅ are at hand

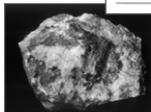


Speciality metals in South Greenland 10 TOPICS ON GREENLAND MINERAL RESOURCES

Beryllium at Kvanefjeld

- The Ilimaussaq Intrusion has an average Be content of 30 ppm
- Be is located in a suite of rare minerals
- In the Kvanefjeld area a rough estimate indicates a resource of 180.000 t rock with 0.1 % Be

Mineral	Wt% BeO	Formula
Bertrandite	40-43	Be ₂ (OH) ₂ (Si ₂ O ₆)
Berylite	40	Be ₂ SiO ₂ (OH) ₂ H ₂ O
Chabowite	11-13	Na ₂ BeSi ₂ O ₆
Epidymite	11	NaBe(OH)Si ₂ O ₆
Eudialyte	11	NaBe(OH)Si ₂ O ₆
Gelbertsundite	c. 34	Be ₂ (Si ₂ O ₆)(OH) ₂ H ₂ O
Grothite	11-14	Zn ₂ (BeSiO ₄)
Leucophane	10-12	NaCaBeSi ₂ O ₆ F
Sarcosite	7-8	Na ₂ (Si ₂ O ₆)(OH) ₂
Sphenohemimorphite	40-43	Be ₂ (Si ₂ O ₆)(OH) ₂
Tugtupite	5	Na ₂ (Cl)(Be-Al)Si ₂ O ₆



Sample (10 x 15 cm) of tugtupite; one of the Be-minerals - also a popular gemstone from Greenland

Speciality metals in South Greenland 11 TOPICS ON GREENLAND MINERAL RESOURCES

Speculative commodities at Kvanefjeld



- Lithium is enriched in the apgaitic rocks of the Ilimaussaq Intrusion
- Values of Li in the Kvanefjeld deposit are found between 600-1900 ppm
- An estimated resource in the Kvanefjeld deposit counts 235.000 t Li

Speciality metals in South Greenland 12 TOPICS ON GREENLAND MINERAL RESOURCES

Summary of South Greenland speciality metals

- South Greenland has an obvious potential for speciality metals
- Characteristically both 'large tonnage-low grade' as well as 'low tonnage-high grade' deposits are outlined
- Tantalum takes the lead in the deposit of the Motzfeldt centre - 600 million t of Ta ore grading 120 ppm
- Zirconium is found at the exceptional formation at Kangerluarsuk - over 2 million t of Zr ore grading 3% ZrO₂
- Additional metals are Y, Nb, REE, Be and Li

Information slide: Speciality metals in South Greenland

Author: Karsten Secher

Editor: Karsten Secher

© GEUS January 2002

Photo: GEUS, RD

Department of Economic Geology
Geological Survey of Denmark and Greenland (GEUS)
Copenhagen, Denmark
www.geus.dk

This presentation is the result of a co-production between GEUS, BMP and Greenland Resources in order to propagate knowledge about mineral resources in Greenland. The production is financed by Greenland Resources.

**The South Greenland CD-ROM:
data and mineral potential assessment**

Presented by
GEUS



A re-assessment
must take into
account:

- Quality
- Relevance
- Meaning
- Formats
- Availability
- Compatibility
- and more



GEUS regional mineral resource assessment

- Searches for old data, reports and literature
- Controls the quality of all old analogue data
- Digitises all data into the GIS domain
- Carries out new field work
- Organises new analysis programmes
- Calibrates analyses from different sources
- Integrates all data types
- Produces many new maps
- Carries out the assessment
- Produces the reports
- Includes all data in GimmeX databases
- Publishes the CD-ROM
- Plans and initiates follow up work
- Involves many people

South Greenland on CD-ROM gives access to

- Topographic Base Map
- Digital Elevation Model
- Mosaic of Landsat TM scenes
- Geological map (scale 1:500 000)
- Airborne magnetics
- Airborne electromagnetics
- Airborne radiometrics
- Gravity maps
- Sample locations



South Greenland on CD-ROM....



- Stream sediments
- Heavy mineral concentrates of stream sediments
- Rock analyses
- Mineral occurrences
- Mineral exploration licenses 1992 - 2000
- List of existing maps from South Greenland
- Bibliographies including company reports and scientific papers

A geological map is a summary



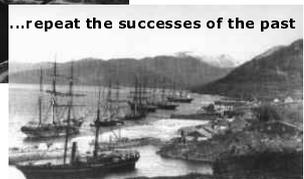
A complete database is needed

- and it must be digital !

For modern exploration to

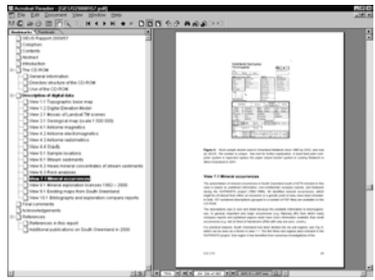


...repeat the successes of the past



The South Greenland CD-ROM 7 TD/PICS ON GREENLAND MINERAL RESOURCES 4

Reports as PDF-files on the CD-ROM



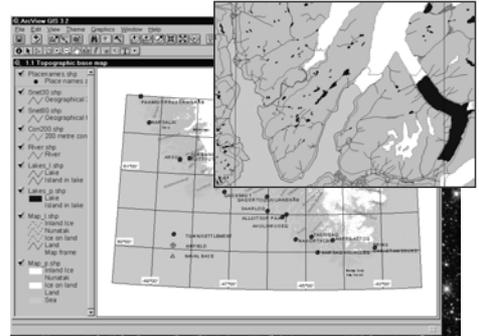
The South Greenland CD-ROM 8 TD/PICS ON GREENLAND MINERAL RESOURCES 4

Data and maps in ArcView project on the CD-ROM



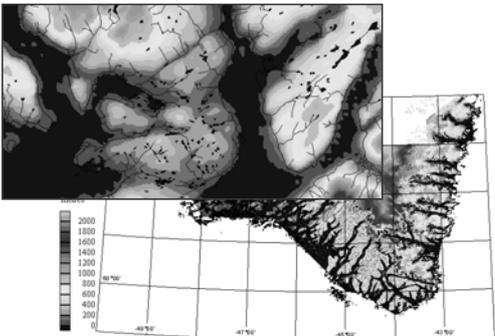
The South Greenland CD-ROM 9 TD/PICS ON GREENLAND MINERAL RESOURCES 4

Digital topographical map



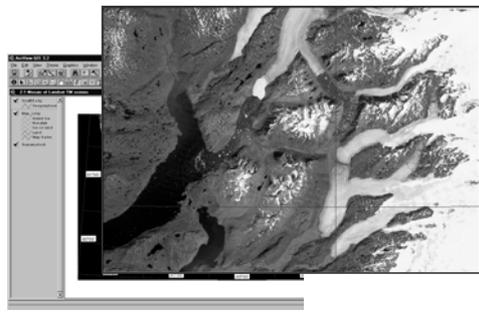
The South Greenland CD-ROM 10 TD/PICS ON GREENLAND MINERAL RESOURCES 4

Digital terrain model from airborne data

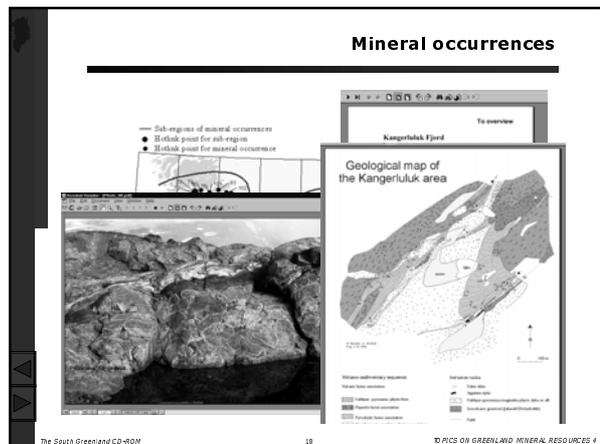
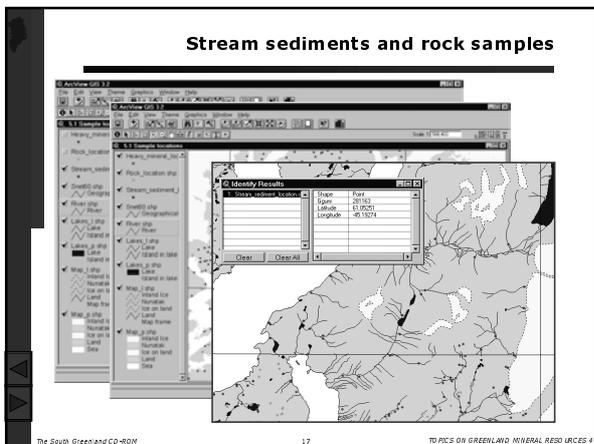
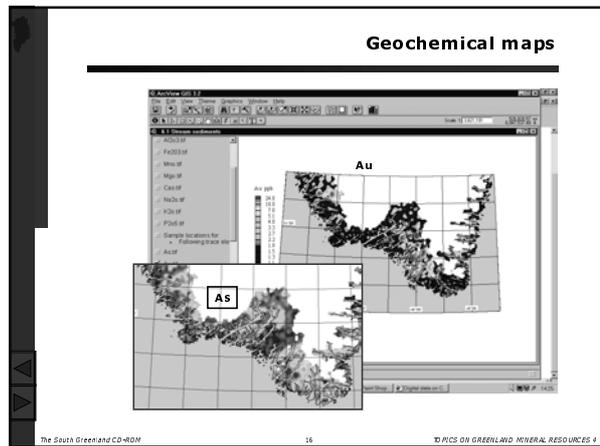
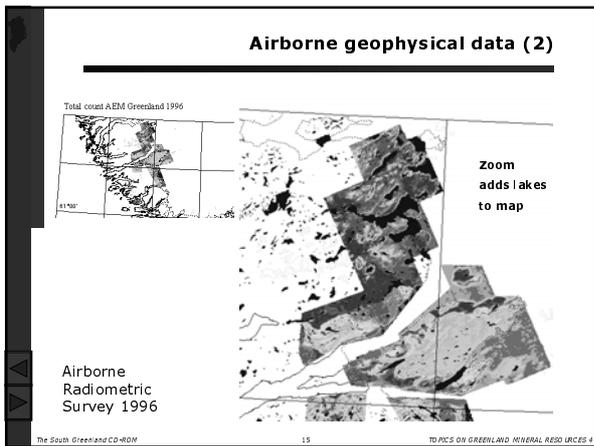
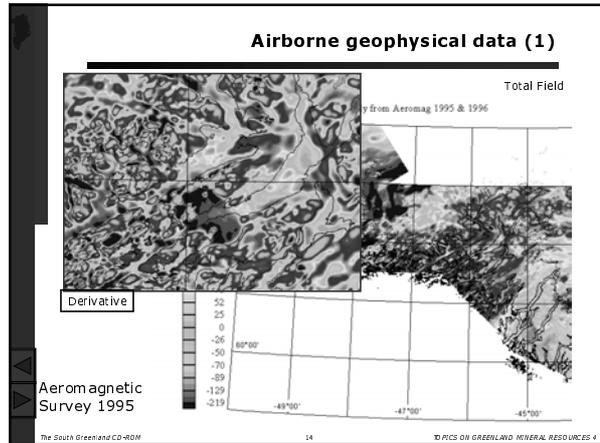
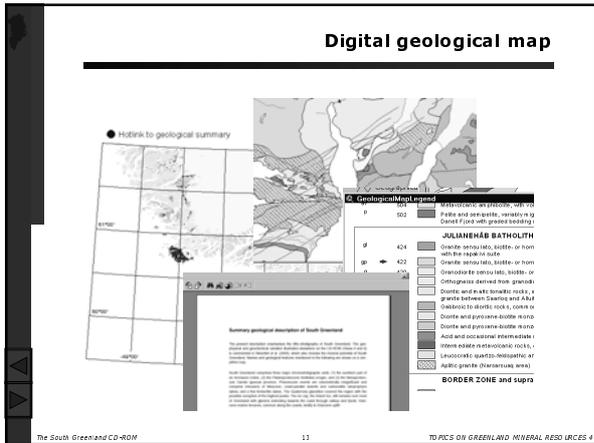


The South Greenland CD-ROM 11 TD/PICS ON GREENLAND MINERAL RESOURCES 4

Landsat data mosaic



The South Greenland CD-ROM 12 TD/PICS ON GREENLAND MINERAL RESOURCES 4



License maps

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TOPICS ON GREENLAND MINERAL RESOURCES 4

Existing maps

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TOPICS ON GREENLAND MINERAL RESOURCES 4

Reports

GEUS no.	Date	Author(s)	Title
20047	1983	King, A. S.	Report on sampling and prospect Green A2, 16 pp., 14 photos.
20049	1988	Williams, B. S.	Stratigraphic column summary, Sump, Neuvundak Mine, A2, 1 pp., 1.
20050	1988	Engelley, J. S.	The property of Neuvundak Mine, Green A2, 1 pp., 1.

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TOPICS ON GREENLAND MINERAL RESOURCES 4

TOPICS ON GREENLAND MINERAL RESOURCES 4

Information slide:
**The South Greenland CD-ROM:
 data and mineral potential assessment**

Author: Leif Thorning Department of Economic Geology
Editor: Leif Thorning Geological Survey of Denmark and Greenland (GEUS)
 © **GEUS February 2002** Copenhagen, Denmark
 www.geus.dk

This presentation is the result of a co-production between GEUS and Greenland Resources, financed by the latter and made in order to propagate knowledge about mineral resources in Greenland

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TOPICS ON GREENLAND MINERAL RESOURCES 4

Airborne geophysical surveys in Greenland as an incentive to exploration

Presented by
GEUS



A clear public strategy to help private-sector mineral exploration

The Government of Greenland actively supports and promotes the search for minerals

- By legal, regulatory and financial incentives
- By creation of a good commercial atmosphere
- By attention to the industry's need for good quality geoscience data
- By financing geoscience projects carried out by GEUS

GEUS and mineral exploration

- Basic and applied geoscience research in many fields
- Projects in Greenland: geological mapping, geophysics, geochemistry, economic geology, remote sensing etc.
- Host for national Geoscience Databases
- Assist BMP with administration and related issues
- Services the mining industry

Airborne Geophysical Projects

AEM Greenland 1994 - 1998

- Electromagnetic
- Detailed - small areas

Aeromag 1992, 1995 - 1999, 2001

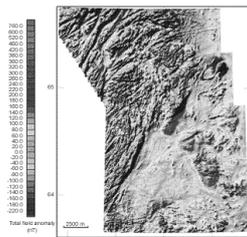
- Magnetic data
- Regional - large areas

HyperGreen & MINEO - 2000, 2001 & 2002

- High quality hyper spectral data
- 0.45 - 2.5 nm (126 bands)

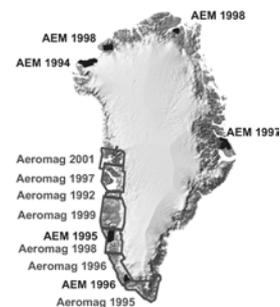
Geophysical maps and digital data

- Thousands of geophysical maps have been produced



- All the data behind maps are available from GEUS databases
- The quality of the data is so good that they will be useful many years into the future

EM and magnetic surveys 1992 - 2001



AEM Greenland 1994 - 1998

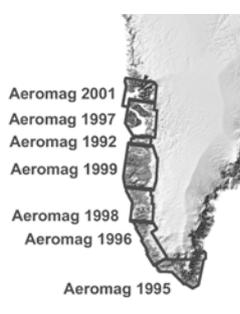
Five years, six survey areas and reconnaissance lines, 73.500 linekm

- Geoterrex Ltd
- Aerodat Inc
- Mostly Transient GEOTEM data



Airborne geophysical surveys 7 TOPICS ON GREENLAND MINERAL RESOURCES 5

Regional aeromagnetic surveys



- Seven surveys
- Sander Geophysics Ltd
- Geoterrex Ltd.
- 515 000 line km
- 250 000 km²



Airborne geophysical surveys 8 TOPICS ON GREENLAND MINERAL RESOURCES 5

Airborne hyperspectral surveys 2000 - 2002



MINEO 2000 HyperGreen 2000

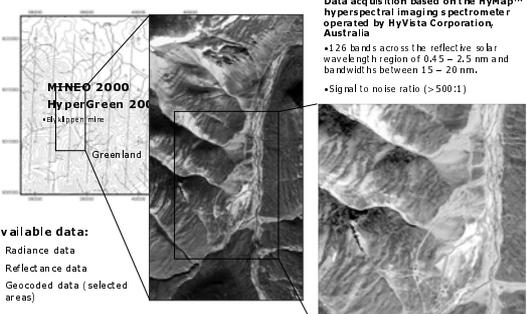
- Eight survey areas
- 1924 line kilometres flown
- IFOV (pixel size) 5 m
- Overlap per line 20 %
- Exploration targets
- Environmental targets

HyperGreen 2002

- Data acquisition scheduled to July 2002
- 16 000 - 20 000 km²
- IFOV 4-5 m
- Overlap per line 20 %
- Exploration targets (kimberlite)

Airborne geophysical surveys 9 TOPICS ON GREENLAND MINERAL RESOURCES 5

High quality hyperspectral data



MINEO 2000 HyperGreen 2000

Data acquisition based on the HyMap™ hyperspectral imaging spectrometer operated by HyVista Corporation, Australia

- 126 bands across the reflective solar wavelength region of 0.45 – 2.5 nm and bandwidths between 15 – 20 nm.
- Signal to noise ratio (> 500:1)

Available data:

- Radiance data
- Reflectance data
- Geocoded data (selected areas)

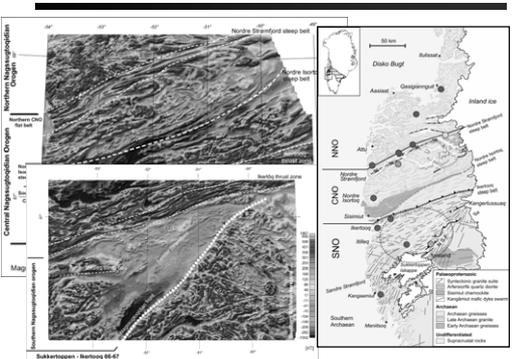
Airborne geophysical surveys 10 TOPICS ON GREENLAND MINERAL RESOURCES 5

Services to the industry

- All data and maps available for inspection in Nuuk and in Copenhagen
- All digital data available in databases for purchase at very modest prices
- Consulting and co-operation
- Metadata access via web site
- Access to geophysical aircraft for additional surveying at own cost but without mobilisation

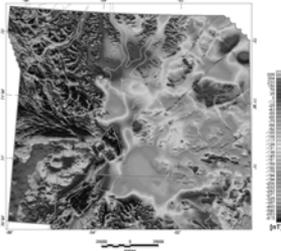
Airborne geophysical surveys 11 TOPICS ON GREENLAND MINERAL RESOURCES 5

Geoscientific research



Airborne geophysical surveys 12 TOPICS ON GREENLAND MINERAL RESOURCES 5

New aeromagnetic data from 2001 released



- Aeromag 2001
- BMP contract with Sander Geophysics Ltd
- ~70 000 linekm
- 500/5000 line spacing
- 300 m drape
- Based out of Qaarsut
- Data and maps released 1 March 2002

Incentive!

- Very significant improvement of geoscience database
- Data purchased by nearly all companies active in Greenland
- Data purchased by majors not active in Greenland
- Some increase in activity and licence grabbing
- Attention

More information?



TOPICS ON GREENLAND MINERAL RESOURCES 5

Information slide:

Airborne geophysical surveys in Greenland as an incentive to exploration

Author: *Thorikild M. Rasmussen & Leif Thorning*

Editor: *Thorikild M. Rasmussen*

© *GEUS January 2002*

Photo: *GEUS, R.D, Sander Geophysics, Geobirrex*

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