Host rock composition and hydrothermal alteration as tools for exploration in the Nanortalik gold district

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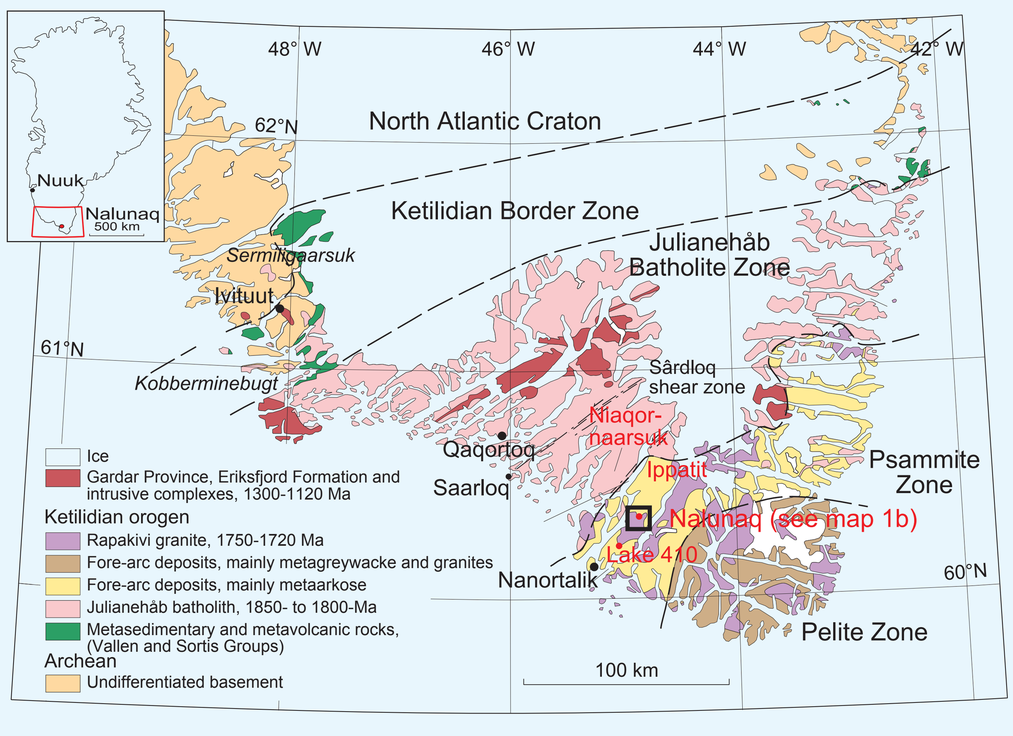
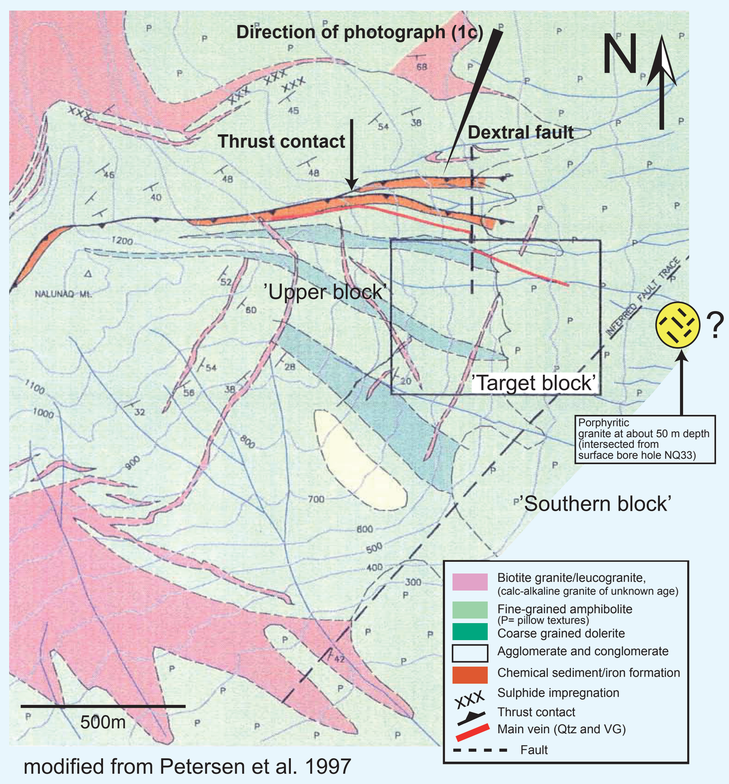
1a. Geology of South Greenland

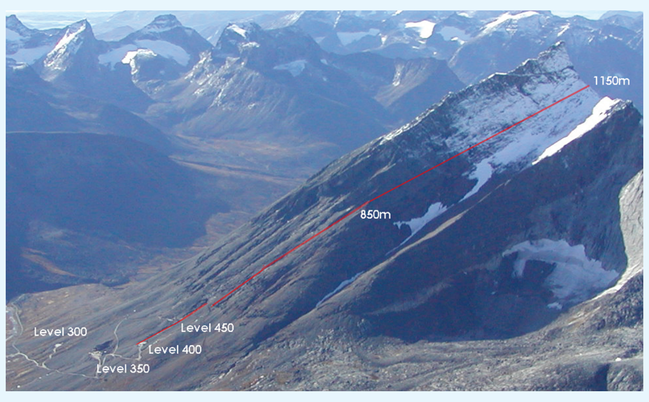


1b. Geology of the Nalunaq area



modified from Petersen et al. 1997

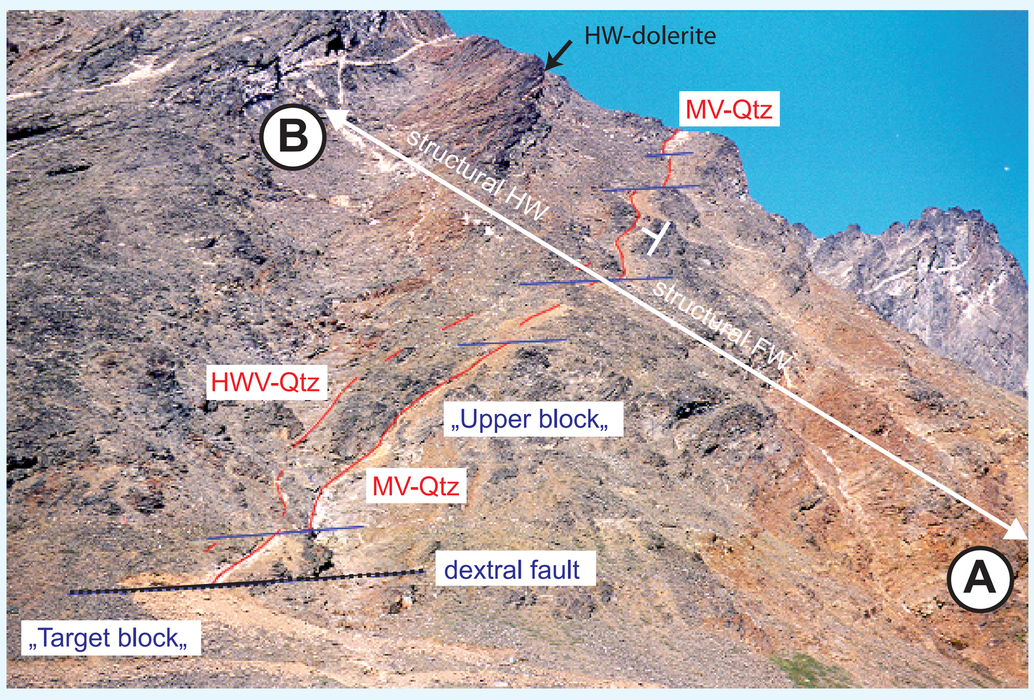
1c. Nalunaq Main Vein (MV)



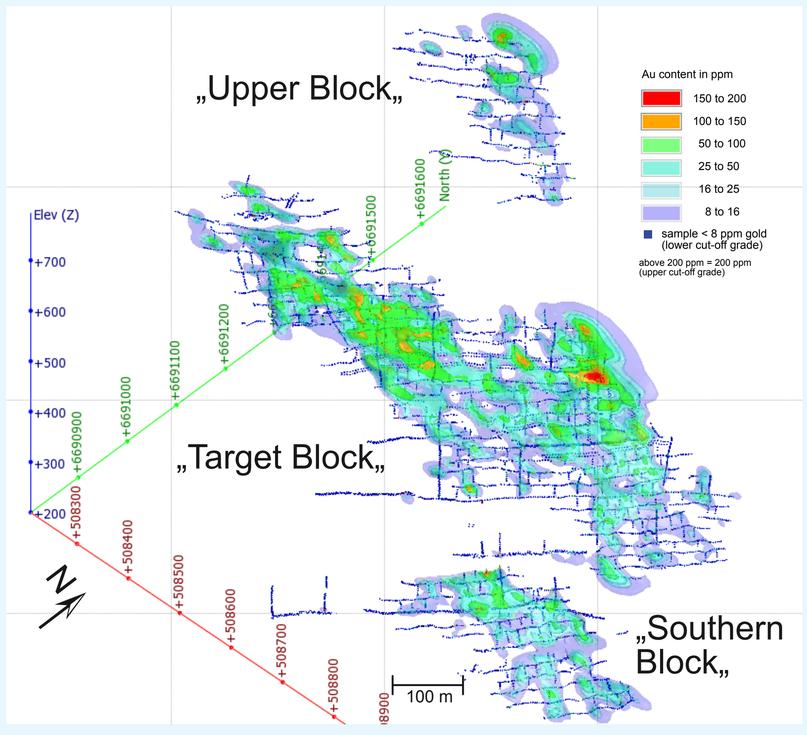
The ca. 1800 to 1770 Ma Nalunaq gold mineralization (Stendal and Frei 2000), is hosted in a thrust sheet of the Ketilidian Nanortalik nappe and formed during the Ketilidian orogeny. The MV-Qtz can be traced at surface for about one km on the east and north facing slopes of the Nalunaq mountain and crosscuts the foliation at a low angle, whereas the foliation is parallel to the bedding.

Nalunaq, Greenland's first gold mine, was officially opened in August, 2004 and is located on the Nanortalik peninsula in South Greenland. The high-grade gold mineralization is hosted in an up to 2 m wide quartz vein in hydrothermally altered amphibolite of Paleoproterozoic age. The amphibolite unit is thrust over the metaarkose. The Ketilidian orogen evolved between 1850 Ma and 1725 Ma during northward subduction of an oceanic plate under the Ketilidian orogen. The exposed rocks represent back arc (Vallen and Sortis Groups), arc (Julianehåb-Batholith) and accretionary wedge (fore arc rocks = flysch).

1d. Structural blocks of the Nalunaq gold deposit



2. Distribution of gold in the Main Vein

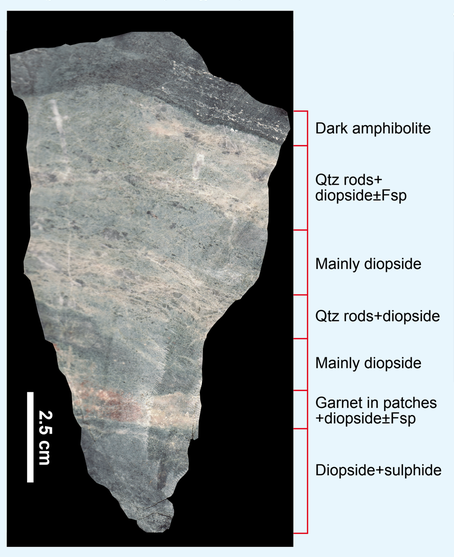


To date >300,000 troy ounces of gold have been produced and the average grade is 18 g/t. Gold distribution on the main vein plan shows that areas with high gold contents are roughly W-E oriented panels.

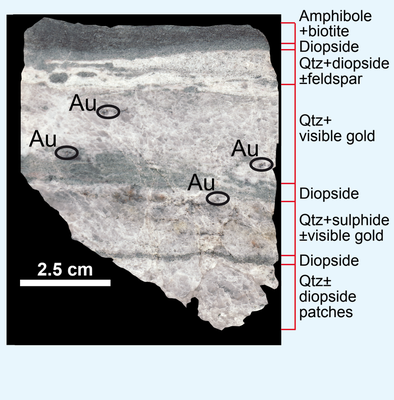
The Nalunaq ore body yields high gold grades with several hundred g/t of gold and underground samples with visible gold (VG) and gold contents of up to 5200 g/t (Kaltoft et al. 2000)

3. Hydrothermal alteration and gold mineralization

Early alteration (stage 1)



Alteration associated with Au mineralization (stage 3)



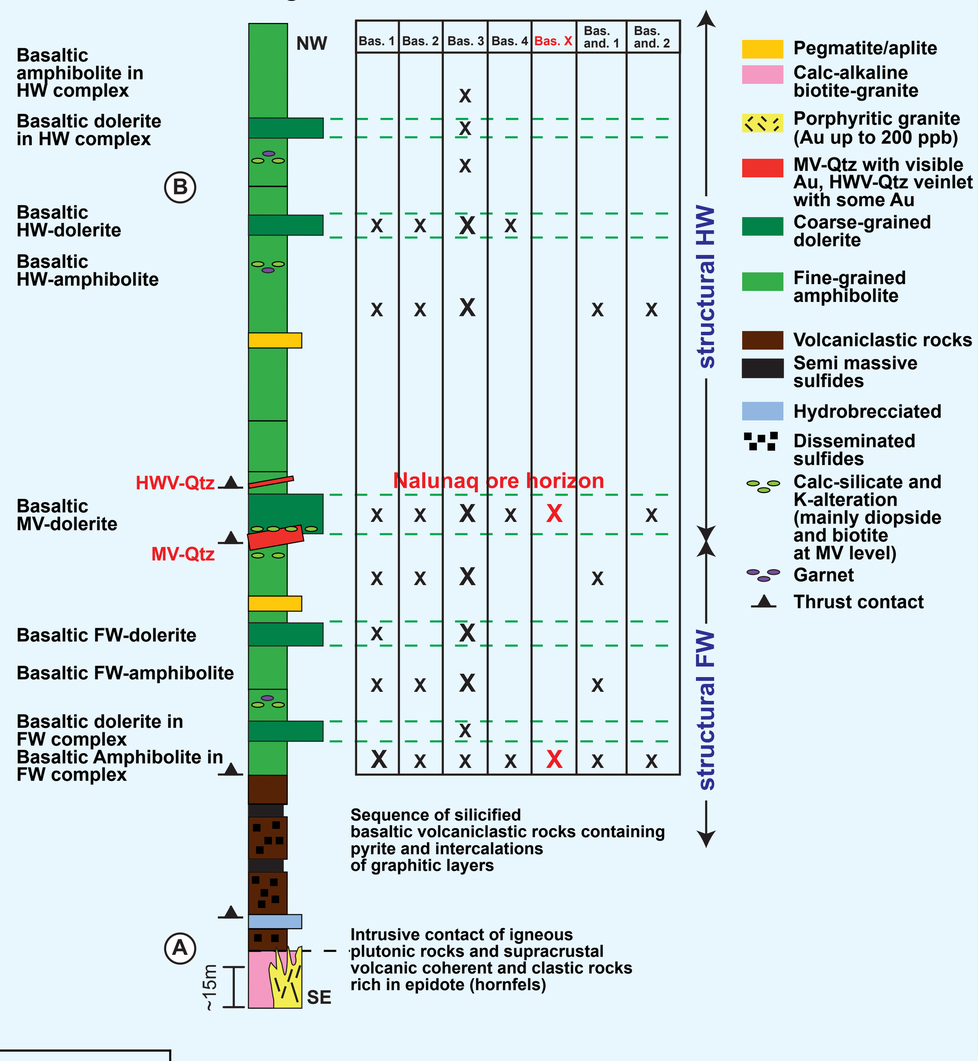
Alteration stage	Minerals
Stage 1 early alteration	garnet, epidote, diopside and plagioclase
Stage 2 contact metamorphism	epidote
Stage 3 Au-alteration	proximal: auriferous quartz vein
	intermediate: bands of biotite + sulphide
	distal: diopside and quartz (silicification)
	As enrichment and uneconomic Au

4. Tectonostratigraphic sequence and chemostratigraphic relation of Nalunaq

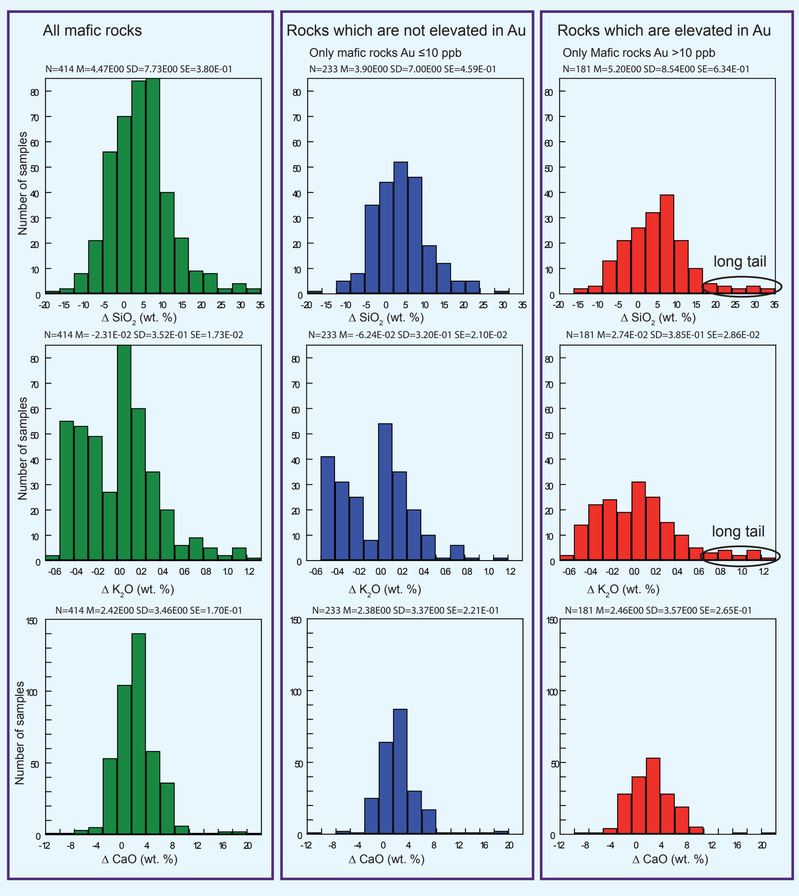
Chemical group (amphibolites)		Immobile element ratios Zr/TiO2	Zr/ Al2O3	Al2O3 /TiO2	Zr/Y
Basalt 1	**mean**	65.7	4.3	15.4	3.2
n=116	average deviation	7.6	0.6	1.2	0.7
Basalt 2	**mean**	53.0	3.5	15.2	2.7
n=87	average deviation	1.3	0.3	1.2	0.4
Basalt 3	**mean**	45.5	3.0	15.1	2.8
n=208	average deviation	2.6	0.3	1.0	0.5
Basalt 4	**mean**	45.8	4.8	9.6	2.6
n=20	average deviation	3.8	0.4	0.3	0.3
Basalt X	**mean**	27.4	1.7	16.4	1.4
n=6	average deviation	4.1	0.3	1.1	0.2
Basaltic andesite 1	**mean**	106.8	6.7	16.1	4.1
n=4	average deviation	3.7	0.7	1.8	0.2
Basaltic andesite 2	**mean**	161.8	9.9	16.3	5.5
n=6	average deviation	12.1	0.5	1.1	1.9

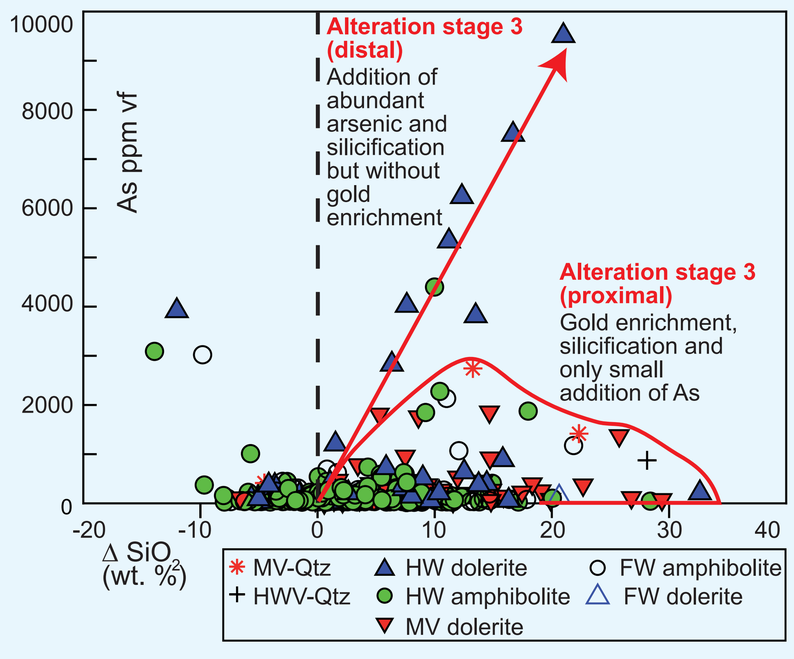
Immobile-element ratios indicate seven different primary amphibolite rock types and identified one single marker horizon namely basalt X. The MV-dolerite comprises geochemically different basalt types and this could represent primary compositional variation indicating different magmatic processes (chilled margins?).

Lithological unit



5. Pathfinder elements for gold and mass change calculations





Lithogeochemical techniques show that the gold-stage is characterized by mass gains of Si and K and that the Au-rich fluids were enriched in Ag, As, Sb, Bi and W which is a typical metal association of hypozonal orogenic gold deposits.

Correlation of Au and trace element	Ag	As	Sb	Bi	W	Mo
r2 (square of the correlation coefficient)	0.820	0.010	0.005	0.060	0.004	0.000
Spearman rank corr. coef.	0.680	0.641	0.449	0.525	0.582	0.097

6. Discussion and Conclusions

- Au mineralization at Nalunaq is located in volcanic rocks at the contact of dolerite dike and amphibolite units (maximal rheological contrast)
- MV-Qtz developed from Au, As, Ag, Sb, Bi and W-enriched fluids
- Basalt X is a good marker horizon and occurs only in the footwall or at the ore horizon of the tectonostratigraphic sequence of Nalunaq
- Close spatial association with calc-alkaline and porphyritic granites and elevated Sb, Bi and W indicate a possible intrusion related gold system

Recommendation for Gold exploration in the Nanortalik gold district or elsewhere in South Greenland:

- Volcanic rocks associated with calc-alkaline and porphyritic granites are good targets for gold exploration
- A shear zone associated with Si-and K-enriched rocks with anomalous levels of Au, As, Ag, Sb, Bi and W represent a particular good target

References:

Kaltoft K, Schlatter DM, Kludt L (2000) Geology and genesis of Nalunaq Palaeoproterozoic shear zone-hosted gold deposit, South Greenland. Applied Earth Science 109 (Section B): B23–B33

Petersen JS, Kaltoft K, Schlatter D (1997) The Nanortalik gold district in South Greenland. In: Papunen, H. (ed.) Mineral deposits: research and exploration. Where do they meet? 4th SGA Meeting, Turku, Balkema, Rotterdam: pp. 285-288

Stendal H, Frei R (2000) Gold occurrences and lead isotopes in Ketilidian Mobile Belt, South Greenland. Applied Earth Science 109 (Section B): B6–B13