

are calculated for different datasets

one for pixels with 'occurrences' and one for pixels with 'no occurrences'

A search for





The Nuuk region, West Greenland, forms the central part of the Archean North Atlantic craton; the Canadian counterpart is the Nain craton in Labrador.

The region represents an assemblage of several early to late Archean crustal terranes amalgamated during thrusting at c. 2.7–2.6 Ga. Several amphibolite and granulite facies metamorphic events and associated deformation have affected the region from the Palaeoarchean to the Neoarchean, however, also greenschist facies conditions are present in some areas.

Several distinct supracrustal belts are located in the region; the oldest being, the Isua Greenstone Belt with an age of 3.8–3.7 Ga and the youngest being the Storø Greenstone Belt with an age of 2.8 Ga. Metavolcanic rocks that are intercalated with tonalitic to granodioritic gneisses dominate the belts. The metaandesite to metadacite. The supracrustal primary environments are variable, including magmatic environments, oceanic crust environments, and island arc/supra-subduction environments.

Several gold mineralized sites within the supracrustal belts are known in the region. All show evidence of hydrothermal alteration such as silicification, sericitization, garnetization and carbonatization. The genesis of the gold is still debated but it seems that both epithermal high-sulphidation gold, volcanogenic stratabound gold and mesothermal lode gold systems are present. The most promising gold occurrences occur at Storø, Qussuk and Isua. The former two are currently targets for commercial exploration.



Geological and Statistical Validation of a Gold Prediction Model based on low-density surface geochemistry and other geoscientific data, Nuuk region, West Greenland

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Gold Prediction Model

A prediction model for the favourability for gold is constructed by statistical analysis.

All data are pixelated. Characteristic data signatures of pixels with known gold occurrences are identified and extracted from various datasets. The 'gold signatures' are different from the signatures of pixels without any known occurrences - the 'back-

A search is performed for pixels with similar signature as the established 'gold signature'. The degree of similarities between the signature of a pixel and the 'gold signa-

Three groups of occurrences are established based on a requirement of mutual prediction capability of occurrences within each group. The groups, named after their key





The Qingaaq gold prospect at Storø, Nuuk region, West Greenland. The prospect is currently being drilled and evaluated by the exploration company NunaMinerals A/S. Gold bearing zones are marked by red.

Signatures of Gold Occurrences

Data signatures of gold occurrences and the background are established for each group. Some of the most characteristic data signatures identified are given in the table below.

The stream sediment geochemistry identified as characteristic for the gold occurrences:

The three groups have all high Ni/Mg ratios and high Cs as common features, but they are different in their remaining signatures. Medium to high Rb, La, U and Th characterize the Storø and Bjørneøen groups while these elements are low for the Isua group. The Bjørneøen and Isua groups have medium to high MgO, Fe₂O₃, Ni and Cr, whereas the Storø group is characterized by high Al₂O₃. The Isua group has low Na₂O compared to the other groups. Gold in the stream sediment geochemistry is only found to be indicative for the Isua group. Trivial but important observations to keep in mind such as high gold values in low-density stream sediment geochemistry are not often encountered. Arsenic is only found to be indicative for the Storø group.

The stream sediment signatures for the three gold groups do not exhibit significant contrasts from the background for the following components: CaO, K₂O, P₂O₅, Sb, SiO₂, TiO₂, V, Zr, and Zn.

Data signatures indicative for gold occurrence groups against the background signature

st, low, medium, high and highest) refer to characteristic data values relative to the entire range of the specific dataset. A full coloured cell marks a data signature regarded as distinct for the group; a subdued coloured cell refers to a signature, which is moderately distinct blank cells are non-characteristic for the group.

Data	Storø	Bjørneøen	Isua	Background	
Data	occurrences	occurrences	occurrences	Dackyrounu	
Stream sediment geochemistry data					
Au	Low	Low	High	Low	
	(as background)	(as background)	(> 60 ppb)	(0 – 40 ppb)	
As	High	Low	Low	Low	
	(> 20 ppm)	(as background)	(as background)	(< 4 ppm)	
Cs	High (2.5 5 ppm)	High (2.5 5 ppm)	Hignest	LOW	
-	(3.5–5 ppm)	(3.5 – 5 ppm) High	High	(< 2.5 ppm)	
Rb	(40 – 80 ppm)	(40 – 80 ppm)	(30 – 70 ppm)	(10 - 50 ppm)	
	High	Medium	Low	Medium	
La	(50 – 70 ppm)	(35 – 55 ppm)	(30 – 10 ppm)	(15 – 50 ppm)	
U	Highest	Medium	Low	Low	
	(> 80 ppm)	(17 – 35 ppm)	(as background)	(< 15 ppm)	
Th	Highest	High	Low	Low	
	(12.5 – 20 ppm)	(10 – 15 ppm)	(as background)	(< 12.5 ppm)	
Ni/Mg ratio	(30 – 40)	Hign (30 – 37)	Hign (30 – 45)	LOW (10 - 35)	
	Highest				
AI_2O_3	(15.5 – 16.5%)	(as background)	(as background)	(13.5 - 15.5%)	
	Low	Medium	Highest	Low	
Fe ₂ O ₃	(as background)	(as background)	(7.0 – 12.5%)	(3 – 9%)	
Na ₂ O	High	Medium	Low	High	
	(as background)	(2.75 – 3.5%)	(2.5 – 3.5%)	(3.0 – 4.75%)	
Zn	Hign	(55 °5 ppm)	(50 110 ppm)	LOW-IVIEdium	
_		(33 – 83 ppm)		Medium-High	
Zr	(200 – 450 ppm)	(200 – 450 ppm)	(< 300 ppm)	(150 - 900 ppm)	
Aoromagnot	ic data				
			Lowest and		
VG-TMI	Medium		HIGNEST		
	(-0.2 - 0.2 m/m)	(-0.2 – 0.2 n1/m)	(-0.3 - 0.23 m/m)	(-0.3 – 0.4 n1/m)	
			0.4 0.70 11711		
			Highest		
AmpHG-TMI	(0.0-0.1 nT/m)	(0.0-0.1 nT/m)	(0.1 – 1.0 nT/m)	(0.0 - 0.25 nT/m)	
				(0.0 0.20 11711)	
Aeroradiometric data					
	High	Madium	Medium	Madium	
K	нідп (1 75 – 2 5%)	(as background)	(0.5 - 1.25%)	(0.25 - 2.5%)	
Th	High	LOW (as background)	(1 - 8 ppm)	LOW	
	<u>(0 – 14 ppm)</u>				
Total Gamma	High (10 - 12 Ur)	LOW	(as background)		
			Modium		
U	High				
	(2.5 – 5.5ppm)	(0.3 - 1.5%)	$\frac{-(1.0 - 4.0 \text{ ppm})}{\text{Modium}}$	(0 – 3 ppm)	
U/Th ratio	Medium-High	Medium–Low		Low	
	(0.25 - 0.55)	(0.50 - 0.30)	(0.1 - 0.65)	(0.0 - 0.3)	

Geological Validation

A statistical model is not valuable to the exploration geologist without a geological validation that addresses questions like "Are the results verifiable, geologically reasonable and explainable?"

For this purpose, field visits were made to several of the areas with predicted favourability outside the known mineralized sites, and settings, lithology and available lithochemistry were studied in predicted areas.

Given the spacing (5 to 6 km) of the stream sediment data, it is obvious that the prediction is unable to characterize the small target of the gold mineralization itself but it may identify larger features, such as lithology, alteration and other characteristics for the mineralized environment. All known gold occurrences are located within mafic metavolcanic rocks and the fact that all predicted areas are situated within mapped supracrustal rock units can be considered the initial verification of the results.

Statistical Validation

Statistical prediction models are of little use if their reliability or capability to predict is not tested. Users need to know how reliable the prediction is

For this purpose, statistical cross-validation is carried out. One gold occurrence is selected from each group and its location assumed to be unknown. A gold potential map is constructed based on the remaining occurrences of the group. The pixel occupied by the selected occurrence is then assessed in order to evaluate the ability of the remaining occurrences to predict the 'unknown' occurrence. When the process has been carried out for each occurrence in a group, a prediction rate curve is con-

The quality of the prediction can be judged from the slope of the prediction rate curve: the steeper the slope, the more reliable the prediction.



Area assigned for exploration

ion:	
egend:	
-	Random area selection
-	All 52 showings - SSS0, AM0
	Isua group - SSS1
	Isua group - SSS1, AM1
•••••	Isua group - SS1, AM1, AR1
	Storø group - SSS1
	Storø group - SSS2
	Storø group - SSS2, AR1
	Bjørneøen group - SSS1

The Inner Fiskefjord area is predicted as being favourable for Isua gold occurrences The favourable areas lie within greenstone belts and are proximal to the major Fiskefjord fault. No known gold occurrences have previously been reported from the area.

Fieldwork: 14 days, 2 person, tent camp. Zodiac used for transport and field traverse by foot. Helicopter lift to northernmost area.







old occurrences are associated with high Ni/Mg signature in stream sediment geochemistry - this is validated by lithogeochemistry Lithogeochemistry of samples collected by GEUS during field seasons in 2003-2005 - and samples taken during the follow up in favourable areas during the 2006 field season by the author. High Ni/Mg ratio is confirmed to be associated with known gold mineralized sites and is present within visited favourable areas. • Hign Ni/Mg - 2003-2005 samples [n 49] ▼ High Ni/Mg - 2006 samples [n 12] Normal' Ni/Mg - 2006 samples [n 80] 'Normal' Ni/Mg - 2003-2005 samples [n 74

Combinations of datasets

All 52 occurrences as one group:			
SSS0	As, Au, Cs, Rb, Th, U, Ni/Mg-ratio in stream		
	sediment geochemistry		
AM0	Vertical gradient of total magnetic field intensity		
	and the amplitude of horizontal gradients		
Isua occurrences:			
SSS1	Au, Cs, La, MgO, Fe ₂ O ₃ , Ni+Cr and Ni/Mg-ratio in stream sediment geochemistry		
AM1	Vertical gradient of total magnetic field intensity		
	and the amplitude of horizontal gradients		
AR1	Radiometric U/Th-ratio		
Storø occurrences:			
SSS1	Al ₂ O ₃ , As, Cs, La, Rb, Th, U, and Ni/Mg-ratio		
	In stream sediment geochemistry		
SSS2	Al ₂ O ₃ , Cs, La, Rb, Th, U, and Ni/Mg-ratio in		
	stream sediment geochemistry		
Bjørneøen occurrences:			
SSS1	Cs, Rb, U, Th, Mg, Ni+Cr and Ni/Mg-ratio in		
	stream sediment geochemistry		



Inner Fiskefjord



- Large hydrothermal alteration stem recognized
- Several new mineralized sites di ed - highest gold in rock nples being 377 ppb Au.
- Rock units in the Fiskefjord are q rally enriched in gold and auferi ous pathfinder elements.
- Gold content well-above back ound values encountered at several localities.
- New sediment samples confirms gold potential - highest being a soil mple with 144 ppb Au.
- by rock and sediment geochemist



An area southwest of the well-known Isua greenstone belt, which host several gold mineralized sites, is predicted as being favourable for both Isua and Bjørneøen gold occurrences. No prior information on mineralization exists fron the area.

The area is situated within two 100-300 m wide slivers of greenstone rocks in isses. It is also notable that the area is located 2–3 km away from the main ex sion of the Ataneq-Ivinnguit fault zone, which may play a role for the gold mi lization at Storø. Outcrops at visited localities comprise mainly migmat isses, amphibolite and ultra-basic rocks. Rocks in the visited area are strong sheared and folded. Garnetization and silicification occurs.

Fieldwork: The ground follow-up in this area was carried out during a 1.5-hour reconnaissance stop.

- Mineralized sites discovered Strong shearing and alteration system observed.
- Data signatures confirmed by rock and sediment geochemistry.
- Most significant for gold content is a soil sediment sample running 15 and 701 ppm As.
- Geochemical results verify the favourability for gold in the area - rock units are generally enriched in Cs, Rb, Sb and



ological map of the gold favourable area



sheared garnet-fuchsite-bearing and altered an



Distribution of high rock



▼2006 High Ni/Mg samples [n 12]

Conclusion

- Distinct data signatures characteristic for gold occurrences have been identified
- Data signatures have been validated by fieldwork and lithogeo-
 - reflections of signatures were encountered to variable degree in all areas
- The predictions are found to be statistically reliable and have been validated by field visits
- Predicted gold favourable areas and associated data signatures reflect to a large extent local geological environments and varia-
- Gold occurrences themselves are too small targets for predictions with the resolution of the present datasets
- Elevated gold where encountered in ca one-third of the favourable areas visited during fieldwork
- Critically evaluated multivariate statistical analysis optimizes the use of data and provides a tool for extracting information, integrating data and targeting geological features