Sivakkaharju

Occurence type: prospect

Commodity	Rank	Total measure	Total production	Total resource	Importance
gold	1	0,36 t	NA	0,36 t	Occurrence
copper	2	NA	NA	NA	NA
nickel	3	NA	NA	NA	NA
cobalt	3	15 t	NA	15 t	Occurrence
silver	4	NA	NA	NA	NA
zinc	4	NA	NA	NA	NA
uranium	4	NA	NA	NA	NA
lead	4	NA	NA	NA	NA

Easting EUREF: 591979,386
Northing EUREF: 7342706,556
Easting YKJ: 3592189
Northing YKJ: 7345778

Discovery year: 1986
Discovered by: Geological Survey of Finland
Province: Kuusamo-Kuolajärvi (Co, Au)
District: Kuusamo (Co, Au)
Comments: Discovery: a few radioactive boulders were found in 1985 by GTK. This led to a detailed ground radiometric survey and the discovery of the deposit by trenching in the area of the radioactive anomaly
References: 6, 7, 18, 19, 22

Mineral deposit type

Group: Metallogenic deposit
Main type: Orogenic (metamorphic hydrothermal)
Sub type 1: Au-Co-Cu
Comments: The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units.
References: 8, 10, 12, 13, 15, 17, 20, 22

Dimension

Expression: exposed
Form: discordant
Shape: irregular
Length (m): 50
Width (m): 7
Thickness (m): NA
Depth (m): 65
Area (ha): NA
Dip azim: 112
Dip: 80
Plunge azim: NA
Plunge dip: NA
Orientation method: NA
Dimension comments: Two subvertical, wedge-shaped (downwards narrowing) lodes for the known part of the deposit which is more than 50 m long, 5-10 m wide, extends >65 m in depth, and is open along strike and in depth. Also, VLF-R survey suggests a sulphidic zone at >100 m depth, below the extent of drilling, and to the SW and and S there are unchecked IP anomalies in the vicinity.

Holder history

Current holder: Latitude 66 Cobalt Oy
Years: 2018
Holding type: Mining concession (old law)

Previous holders:

Company	Years	Holding type	Comments
Kuusamo Gold Oy	2015-2018	Mining concession (old law)	NA
Dragon Mining Oy	2010-2015	Mining concession (old law)	NA
Polar Mining Oy	2003-2009	Mining concession (old law)	NA
Outokumpu Oy	1995-2002	Mining concession (old law)	NA
Outokumpu Oy	1986-1995	Claim (old law)	NA
Geological Survey of Finland	1984-1988	NA	NA

EXPLORATION ACTIVITY

Dragon Mining Oy

Years	Activity type	Geologist	Exploration result	Ref
2011-2013	ore deposit evaluation	NA	NA	16
	Environmental assessment of mine project			

Outokumpu Oy

Years	Activity type	Geologist	Exploration result	Ref
1992-1994	detailed geochemistry	NA	NA	
	till / weathered bedrock survey			

1992-1992	core drilling	NA	mineral occurrences	
	No report available. Hence no details of drilling is available. According to the database of GTK; 16 diamond drill cores			

Geological Survey of Finland

Years	Activity type	Geologist	Exploration result	Ref
1989-1989	regional geochemistry	NA	geochemical anomaly	
	Country-wide till-geochemical survey			

1986-1989	detailed geochemistry	Erkki Vanhanen	NA	1, 8, 10, 11, 12, 13, 18, 19
	Au, Co, Cu and Mo anomaly in till.			

1985-1986	core drilling	Erkki Vanhanen	mineral resource indicated	18, 19, 21, 22
	Core drilling (reconnaissance drilling): 16 diamond-drill holes, total 2202 m, 9 short, mostly vertical drill holes, total 320 m *Elements enriched in the ore are: Ag, As, Au, B, Ba, Bi, Co, Cu, K, Mo, Pb, Rb, S, Se, Te, U, Th, W ; Y, MREE and HREE (Vanhanen 2001)*			
	Intersections			
	HoleID	R349		
	From-To	NA		
	Length	1,4m		
	gold	56ppm		
	HoleID	R351		
	From-To	NA		
	Length	4,5m		
	gold	6,4ppm		
	HoleID	R353		
	From-To	NA		
	Length	2,2m		

	gold	20,7ppm
	HoleID	NA
	From-To	NA
	Length	4,5m
	gold	5,2ppm
	silver	1,6ppm
	cobalt	145ppm
	copper	1067ppm
	nickel	73ppm
	lead	220ppm
	zinc	23ppm
	HoleID	NA
	From-To	NA
	Length	1m
	gold	5,8ppm

1985-1988	detailed geophysics	Erkki Vanhanen	geophysical anomaly	1, 8, 10, 12, 13, 18, 19

1985-1986	excavation	Erkki Vanhanen	mineralized zone identified	1, 8, 10, 12, 13, 18, 19
	A few radioactive boulders were found in 1985; This led to a detailed ground radiometric survey and the discovery of the deposit by trenching in the area of the radioactive anomaly. 55 trenches or pits, in total 900 m			

1984-1986	detailed geology	Erkki Vanhanen	key geological features	1, 8, 10, 12, 13, 18, 19

1982-1982	regional geophysics	NA	key geological features	1, 8, 10, 12, 13, 18, 19
	Low-altitude airborne magnetic, electromagnetic and radiometric survey			

RESOURCES AND RESERVES

Most recent

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Dragon Mining Oy	2013	NA	JORC code	3, 16
	Comments: In addition to Au and Co, potential commodities include Cu and U (Vanhanen, 2001). Mineral resources remain unchanged as of 1.9.2015.				
	Category:	**Inferred mineral resource**			
	Tonnage:	**50000 t**			
	gold	7,2 ppm			
	cobalt	0,03 %			
	Cutoff:	**gold 0,5 ppm**			
	Comments: Cut-off grade 1 g/t (Dragon Group Mineral Resources Updated, 29.2.2016). Is the difference due to rounding?				

Previous calculations

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Dragon Mining Oy	2011	NA	JORC code	2
	Category:	**Inferred mineral resource**			
	Tonnage:	**0,047 Mt**			
	gold	7,5 ppm			
	cobalt	0,03 %			
	copper	0,12 %			
	uranium	0,03 %			
	Cutoff:	**NA**			

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Polar Mining Oy	2004	NA	NA	4
	Category:	**Inferred mineral resource**			
	Tonnage:	**0,028 Mt**			
	gold	11,32 ppm			
	copper	0,12 %			
	cobalt	0,03 %			
	Cutoff:	**NA**			

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Geological Survey of Finland	2001	NA	NA	22
	Category:	**Inferred mineral resource**			
	Tonnage:	**0,039 Mt**			
	gold	8,5 ppm			
	copper	0,12 %			
	cobalt	0,03 %			
	uranium	0,03 %			
	Cutoff:	**NA**			
	Comments: Open pit cut off at 1 ppm Au, underground part with 3.6 ppm Au cut off				

Type:	Company:	Year:	Date:	Calc Method:	Reference:

Resource	Geological Survey of Finland	1991	NA	NA	9, 13
	Category:	**Inferred mineral resource**			
	Tonnage:	**0,05 Mt**			
	gold	7 ppm			
	Cutoff:	**NA**			

Type:	**Company:**	**Year:**	**Date:**	**Calc Method:**	**Reference:**
Resource	Geological Survey of Finland	1989	NA	Non-compliant resource estimate	14
	Category:	**Inferred mineral resource**			
	Tonnage:	**0,03 Mt**			
	gold	5,2 ppm			
	Cutoff:	**NA**			

GEOLOGY

Host rock: Sericite Schist, Quartzite
Wall rock: Mafic volcanic rock

Sericite Schist (Host rock)

Rock type: Host rock
Proportion: major
Grain size: NA
Color: NA
References: 8, 10, 12, 13, 17, 18, 19, 20, 22

Ore minerals:

Mineral	Proportion	Mineral texture
Altaite	minor	
Bornite	minor	
Calaverite	minor	
Chalcopyrite	minor	
Clausthalite	minor	
Cobaltpentlandite	minor	
Covellite	minor	
Galena	minor	
Gold	minor	
	Native gold chiefly between silicates, but also associated with uraninite, and, locally, as inclusions in molybdenite and pyrite, and intergrowths with tellurides, with a grain size of <0.01 mm.Fineness; 96% Au, 1.7% Ag, 1.7% Se, 1.2% Hg, 0.4% Fe	
Marcasite	minor	
Melonite	minor	
Molybdenite	minor	
Pyrite	major	
Pyrrhotite	minor	
Rutile	minor	
Tellurobismuthite	minor	
Uraninite	minor	

Other minerals:

Mineral	Proportion	Mineral texture
Actinolite	present	Alteration product
Albite	present	Alteration product
Allanite	present	Alteration product
Amphibole	present	Alteration product
Ankerite	present	Alteration product
Biotite	present	
Calcite	present	Alteration product
Chlorite	present	
Cobaltite	present	Alteration product
Epidote	present	Alteration product
Hematite	present	Alteration product
Magnetite	present	Alteration product
Phlogopite	present	Alteration product
Quartz	present	
Sericite	present	
Talc	present	Alteration product

Tourmaline	present	
Tremolite	present	Alteration product

Structures
Faulted
Comments: Controlling structure of the occurrence; An antiform structure, local-fault controlled. Located at a crossing of two fault zones within the antiform

Textures
Foliated

Alteration:	Distribution:	Degree:	Relation to mineralization:
silicification	NA	NA	Post
albitic alteration	Pervasive	Strong	Pre
Comments: Intense albitization of clastic sediments and spilitisation of volcanic units when the 2.206 Ga mafic sills and dykes heated the evaporite-bearing sequence and put hot brines into circulation. Proximla alteration: quartz-sericite ± biotite, epidote-allanite, tourmaline, haematite, chlorite, rutile. Distal alteration: Albite-quartz-ferroan dolomite-haematite-ilmenite ± talc, biotite, chlorite			
sulphidation	NA	NA	Syn
biotite alteration	NA	NA	Syn
sericitic alteration	Pervasive	Moderate	Syn
carbonate alteration	Pervasive	Moderate	Syn

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	greenschist metamorphic facies	low metamorphic grade	NA		
Comments: Metamorphic mineral assemblage: biotite-sericite-quartz ± albite, tourmaline, allanite, haematite (Vanhanen 2001)					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1800-2050		Y
Comments: Mineralisation between 2.05-1.8 Ga.			

Quartzite (Host rock)

Rock type: Host rock
Proportion: major
Grain size: NA
Color: NA
References: 8, 10, 12, 13, 17, 18, 19, 20, 22
Comments: The mineralisation is in the contact zone between fine-grained metasedimentary biotite-sericite schist (altered sericite schist?) and quartz-albite-carbonate rock (altered quartzite) in the Sericite Quartzite Formation of the Kuusamo Schist Belt.

Other minerals:

Mineral	Proportion	Mineral texture
Albite	present	
Calcite	present	
Quartz	present	

Textures
Foliated

Alteration:	Distribution:	Degree:	Relation to mineralization:
albitic alteration	Pervasive	Strong	NA

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	greenschist metamorphic facies	low metamorphic grade	NA		
Comments: Metamorphic mineral assemblage; Biotite-sericite-quartz ± albite, tourmaline, allanite, haematite.					

Mafic volcanic rock (Wall rock)

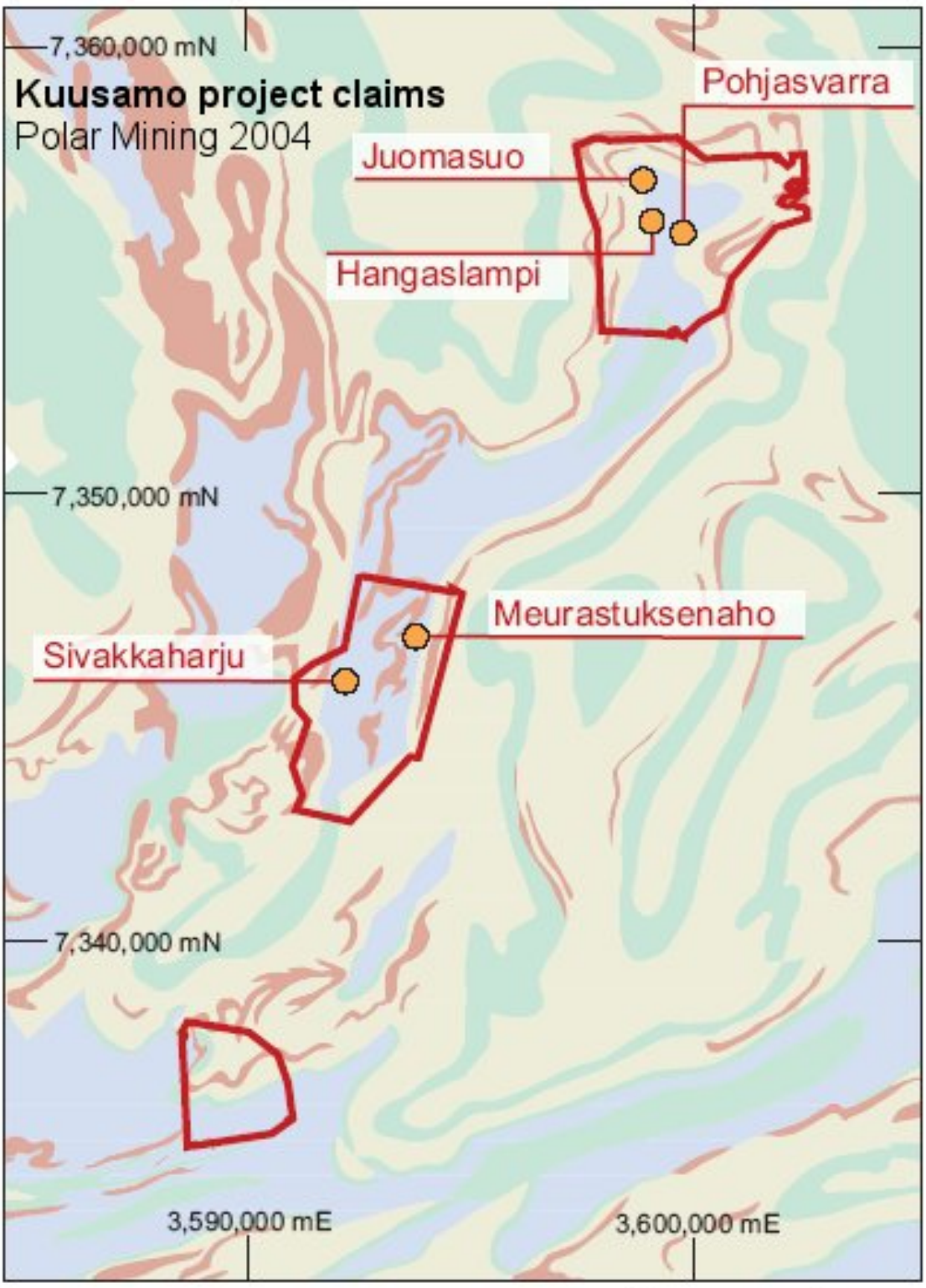
Rock type: Wall rock
Proportion: minor
Grain size: NA
Color: NA
References: 8, 10, 12, 13, 17, 18, 20, 22

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	greenschist metamorphic facies	low metamorphic grade	NA		
Comments: Metamorphic mineral assemblage: albite-actinolitic hornblende-epidote-chlorite ± biotite, titanite, quartz (Vanhanen 2001)					

Figures

Regional geology of the Kuusamo area:



Source:www.dragon-mining.com.au/pdf/Annual2004.pdf

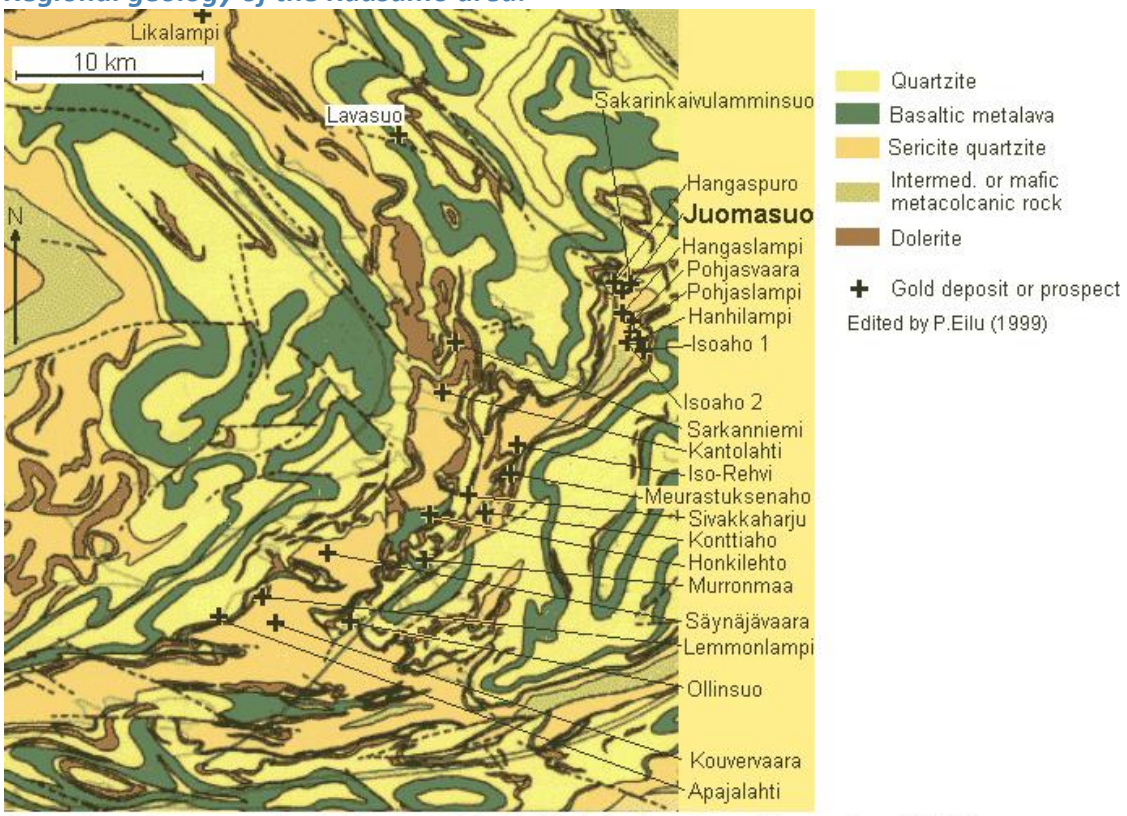
Quartzite, sericite quartzite

Orthoquartzite, phyllite, dolomite, arkose

Mafic volcanics and tuff, basic and intermediate lava

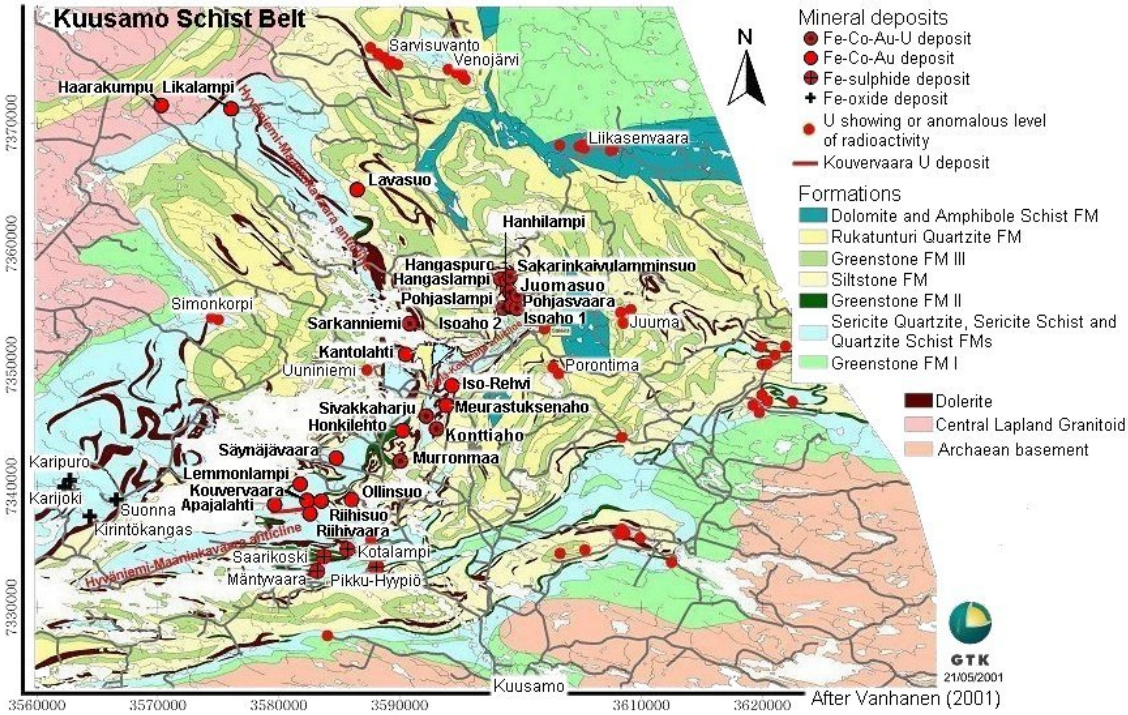
Hornblendite, albite dolerite

Regional geology of the Kuusamo area:

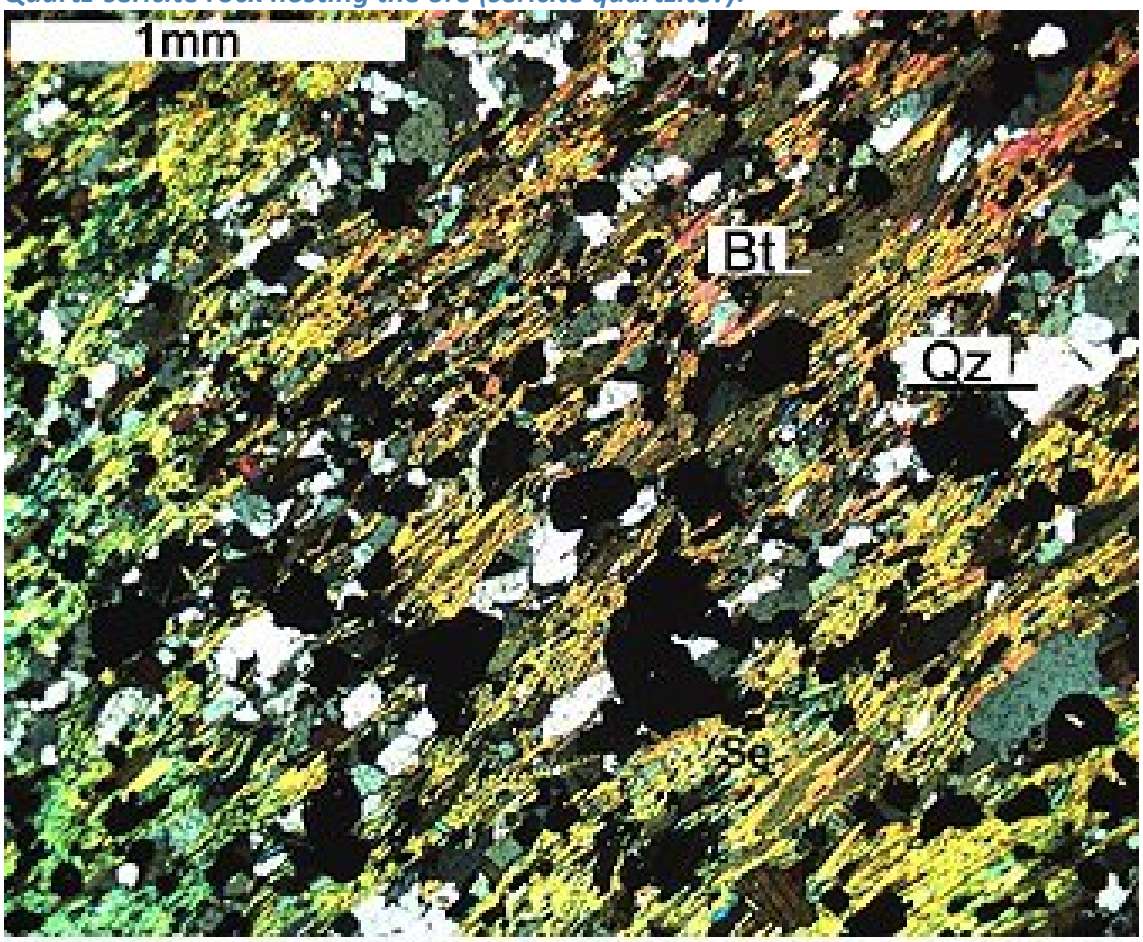


Deposits and prospects in the Kuusamo Schist Belt. Geology from Silvennoinen (1992).
Solid and dashed, curved lines indicate boundaries between lithological units, faults and shear zones

Regional geology and mineral deposits of the Kuusamo area:

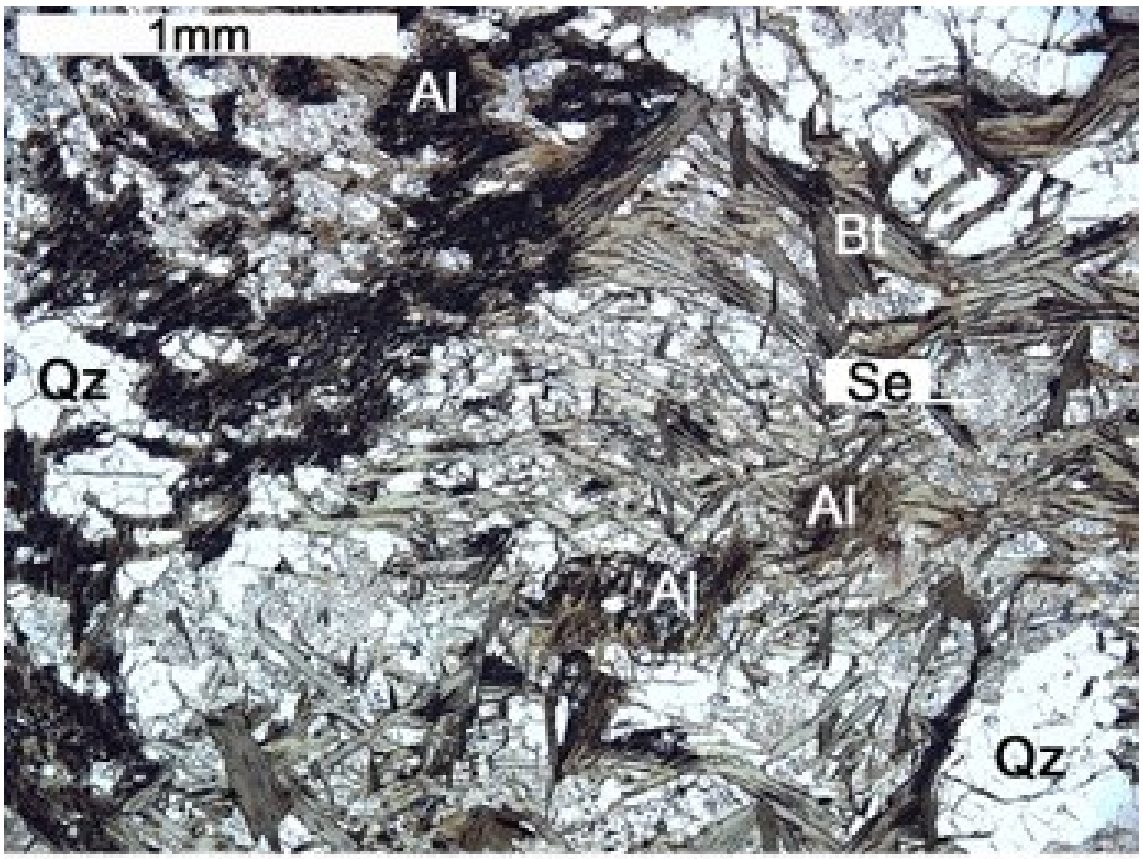


Quartz-sericite rock hosting the ore (sericite quartzite?):



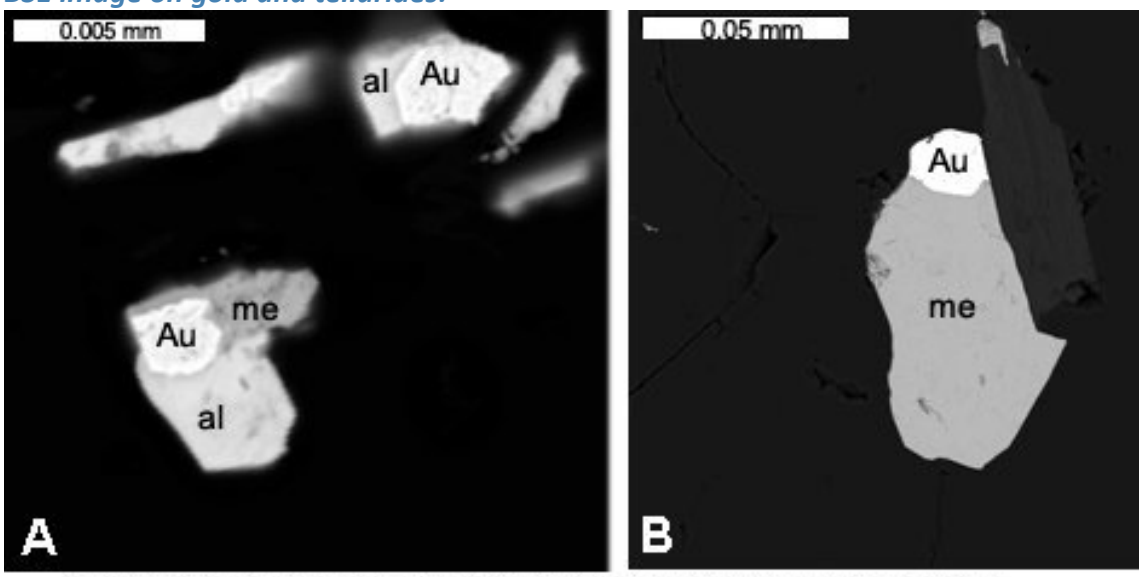
Quartz-sericite rock = ore at Sivakkaharju, Kuusamo Schist Belt. Bt = biotite, Qz = quartz, Se = sericite. Crossed polarisers. Photo Erkki Vanhanen.

Allanite in least-alterd mica schist:



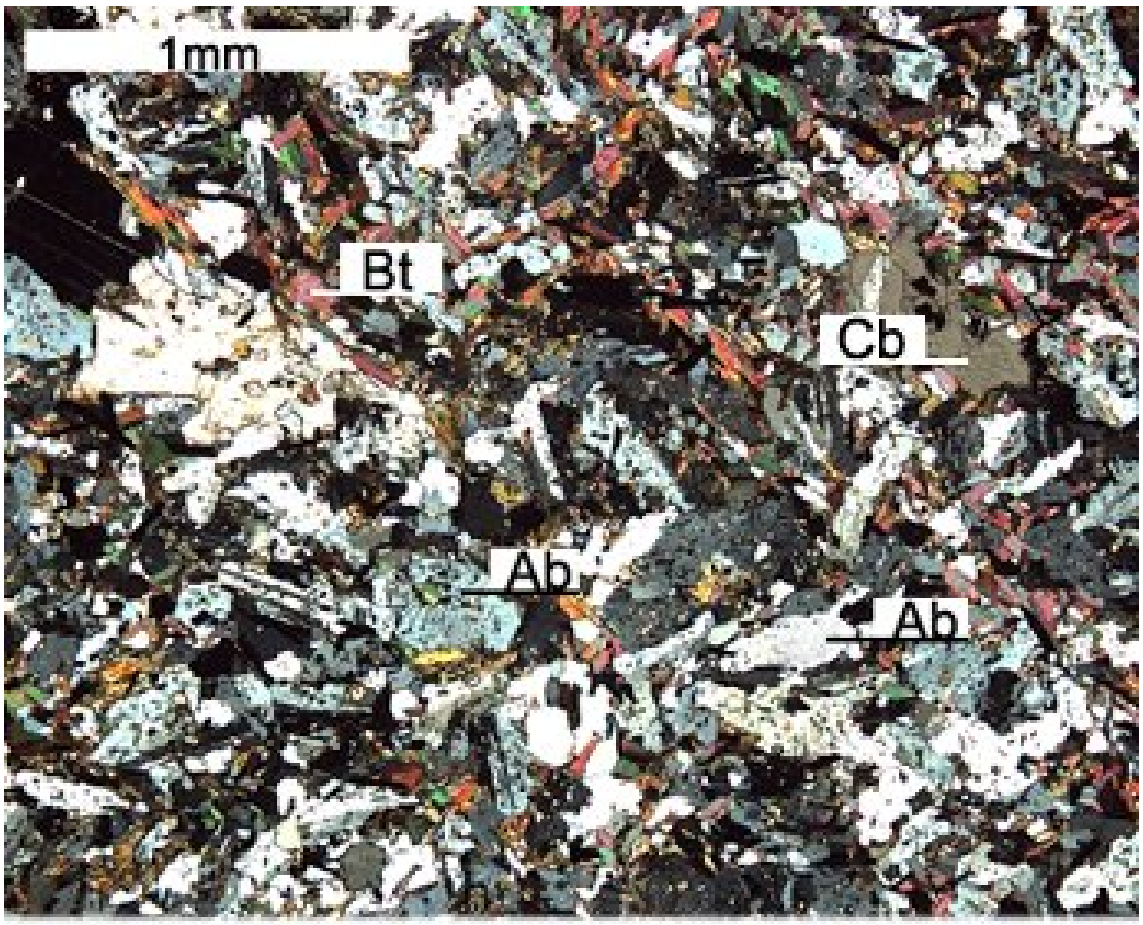
Disintegrated allanite grains in biotite-sericite schist, least altered fine-grained metasedimentary rock at Sivakkaharju, Kuusamo Schist Belt. Al = allanite, Bt = biotite, Qz = quartz, Se = sericite. Parallel polarisers.
Photo Erkki Vanhanen.

BSE image on gold and tellurides:



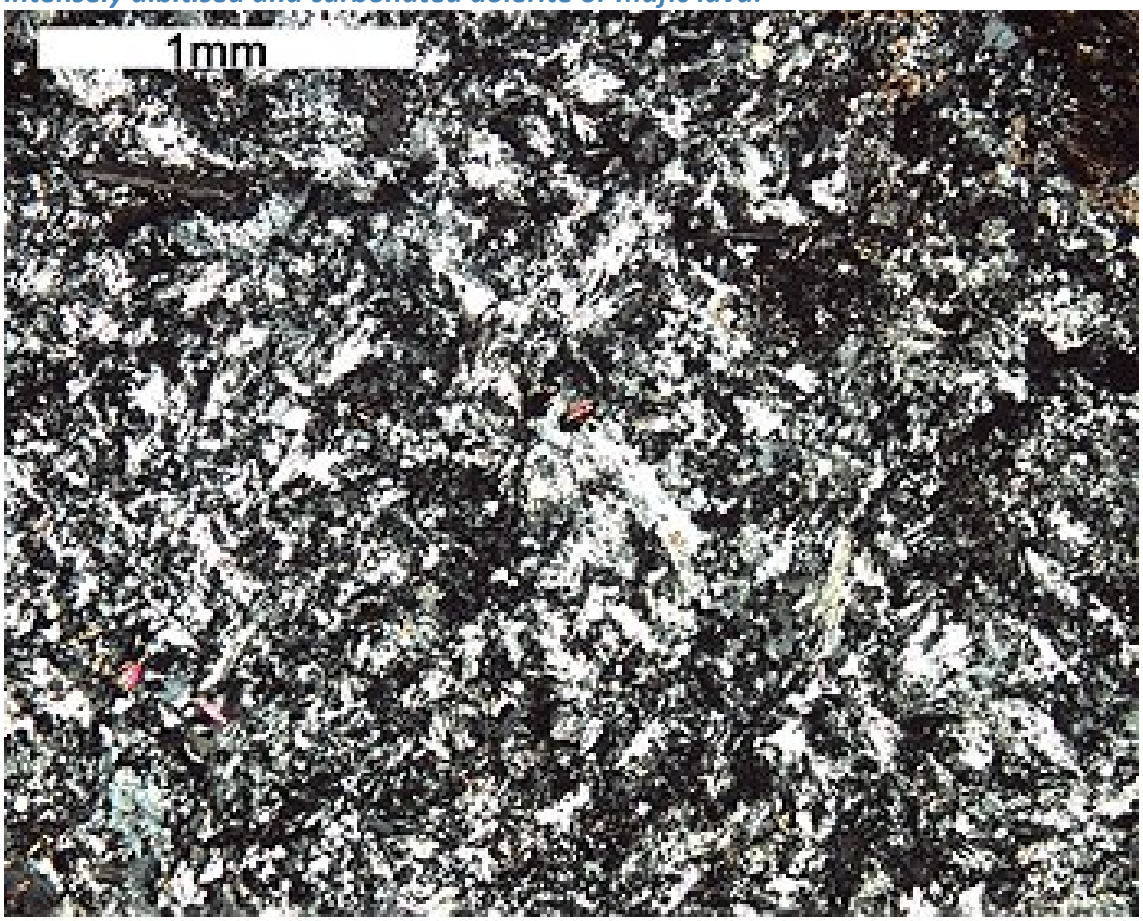
A.Intergrowth of gold (Au) with Pb-rich altaite (al) and melonite (me).
B.Intergrowth of gold (Au) nd melonite (me).
Back-scatter electron images by Erkki Vanhanen. Sivakkaharju

Biotitised and carbonated dolerite:



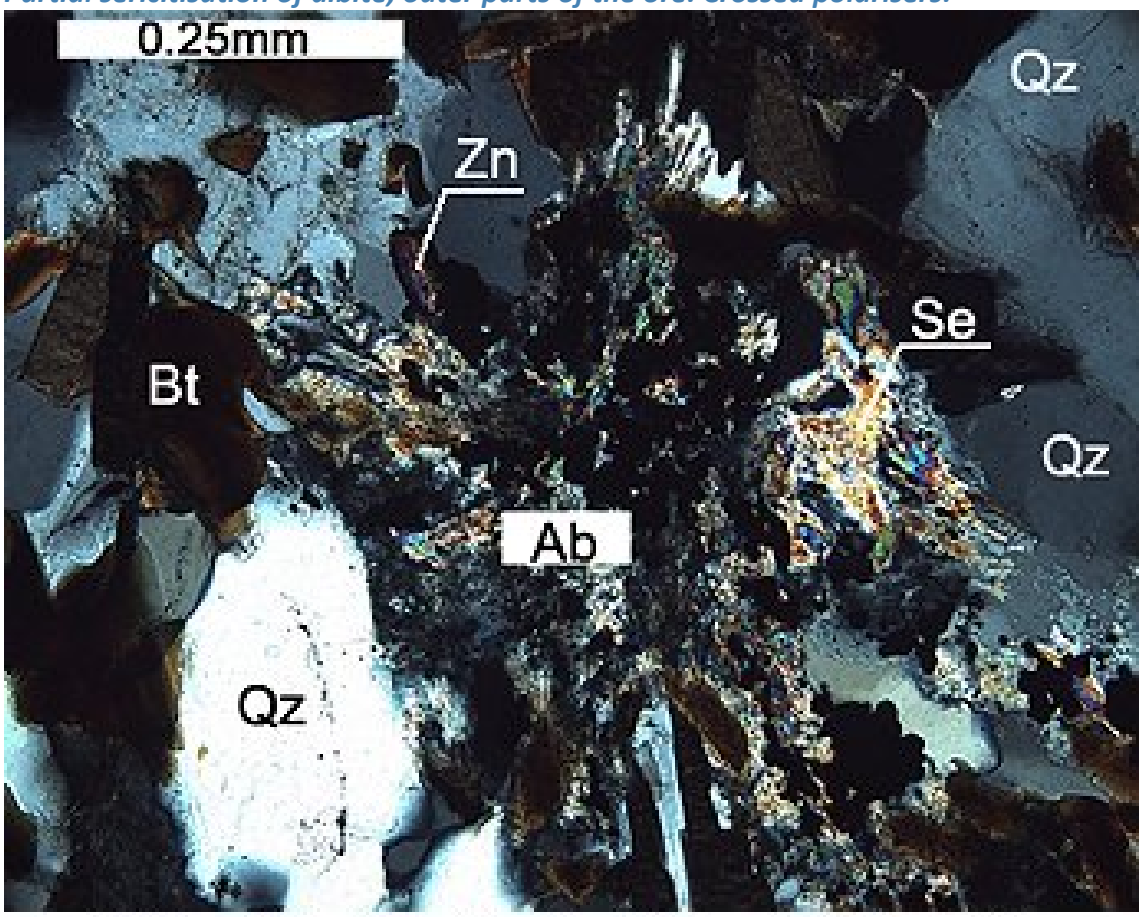
Altered (biotitised + carbonated) dolerite at Sivakkaharju, Kuusamo Schist Belt. Ab = albite, Bt = biotite, Cb = carbonate. Crossed polarisers. Photo Erkki Vanhanen.

Intensely albitised and carbonated dolerite or mafic lava:



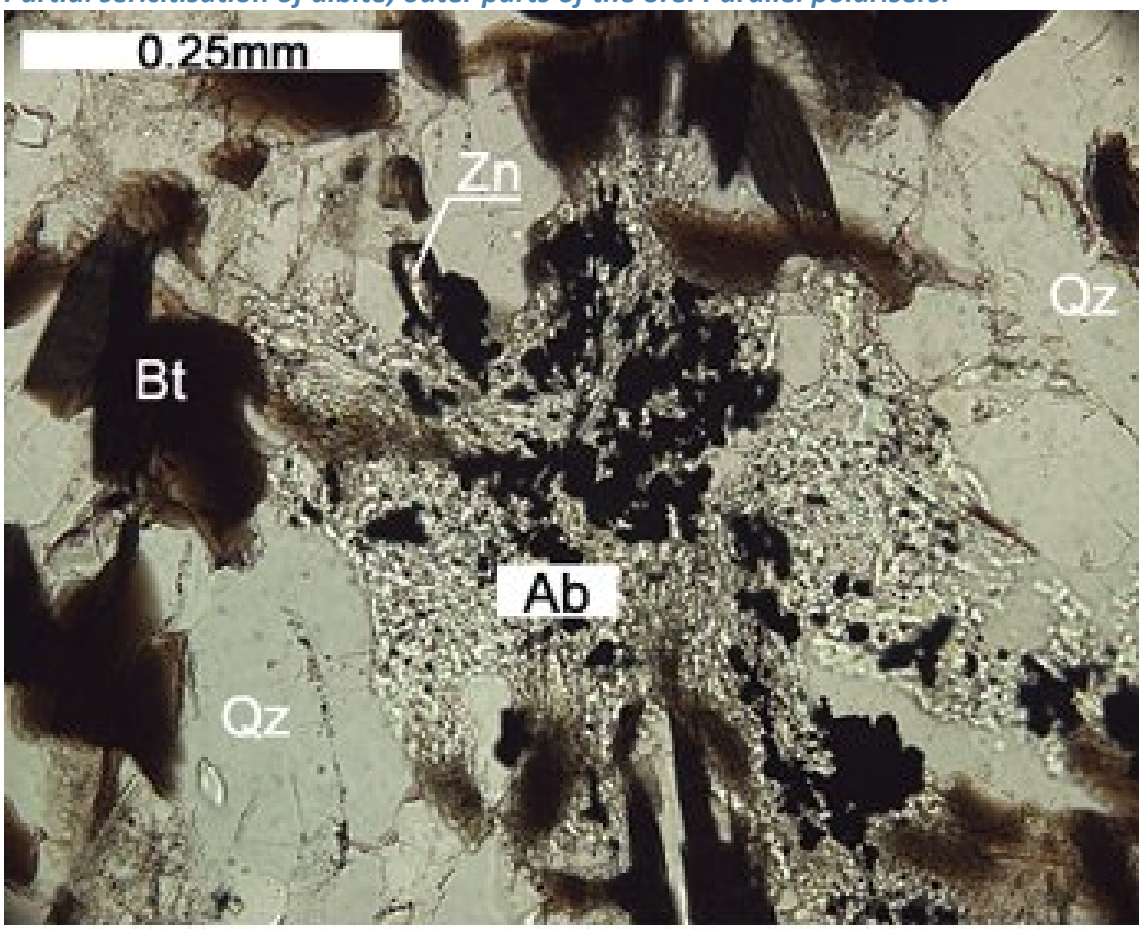
Intensely albitised and carbonated dolerite or mafic lava, presently albite-carbonate rock, at Sivakkaharju, Kuusamo Schist Belt. Crossed polarisers. Photo Erkki Vanhanen.

Partial sericitisation of albite, outer parts of the ore. Crossed polarisers:



Initial sericitisation of albite in the outer parts of the mineralised zone at Sivakkaharju, Kuusamo Schist Belt. Bt = biotite, Qz = quartz, Se = sericite, Zn = zircon. Crossed polarisers. Photo Erkki Vanhanen.

Partial sericitisation of albite, outer parts of the ore. Parallel polarisers:

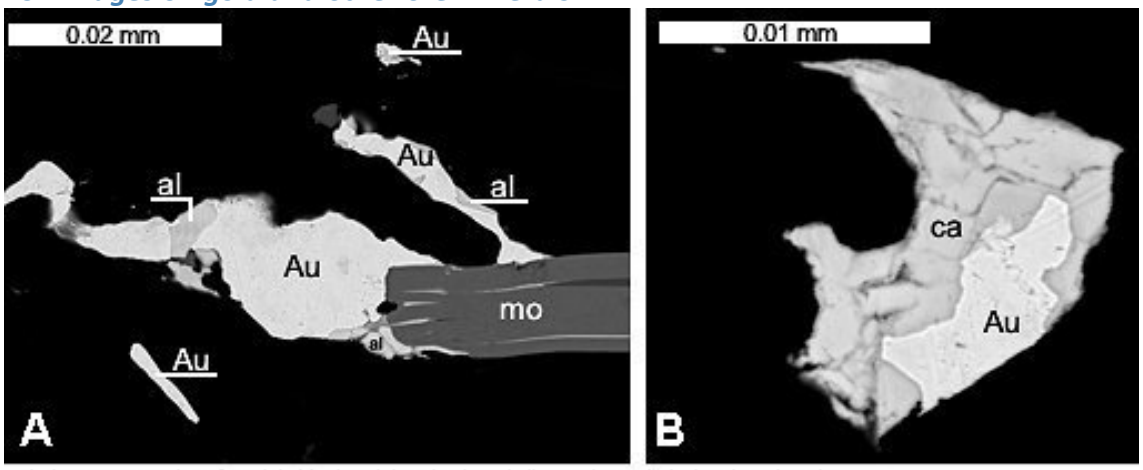


Initial sericitisation of albite in the outer parts of the mineralised zone at Sivakkaharju, Kuusamo Schist Belt. Bt = biotite, Qz = quartz, Se = sericite, Zn = zircon. Parallel polarisers. Photo Erkki Vanhanen.

Albite-talc rock = albitised komatiite??:

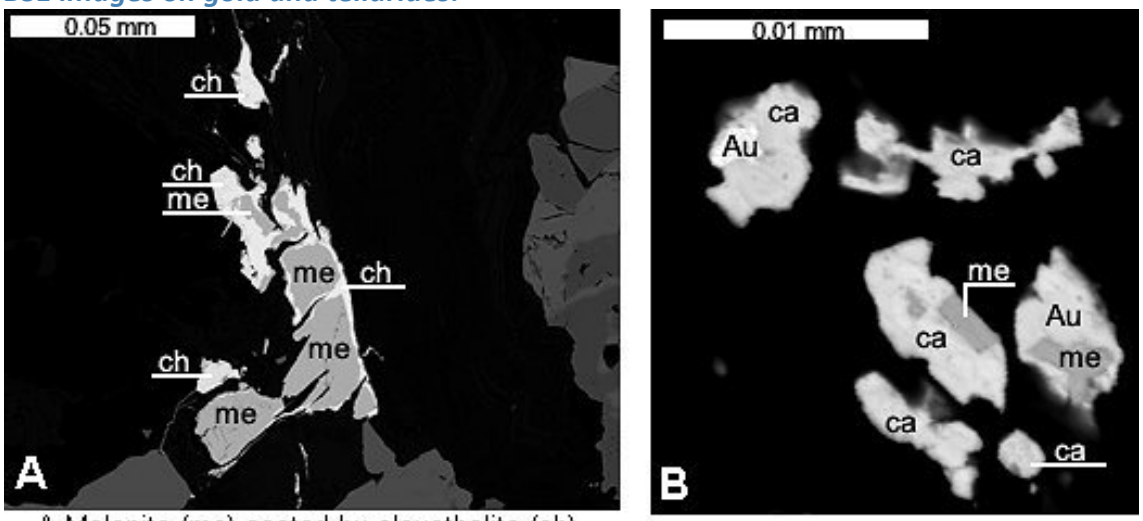
Albite-talc rock (distal or early mineralisation-related alteration). Ab = albite, Tc = talc. Sivakkaharju, Kuusamo Schist Belt. Crossed polarisers. Photo Erkki Vanhanen.

BSE images on gold and other ore minerals:



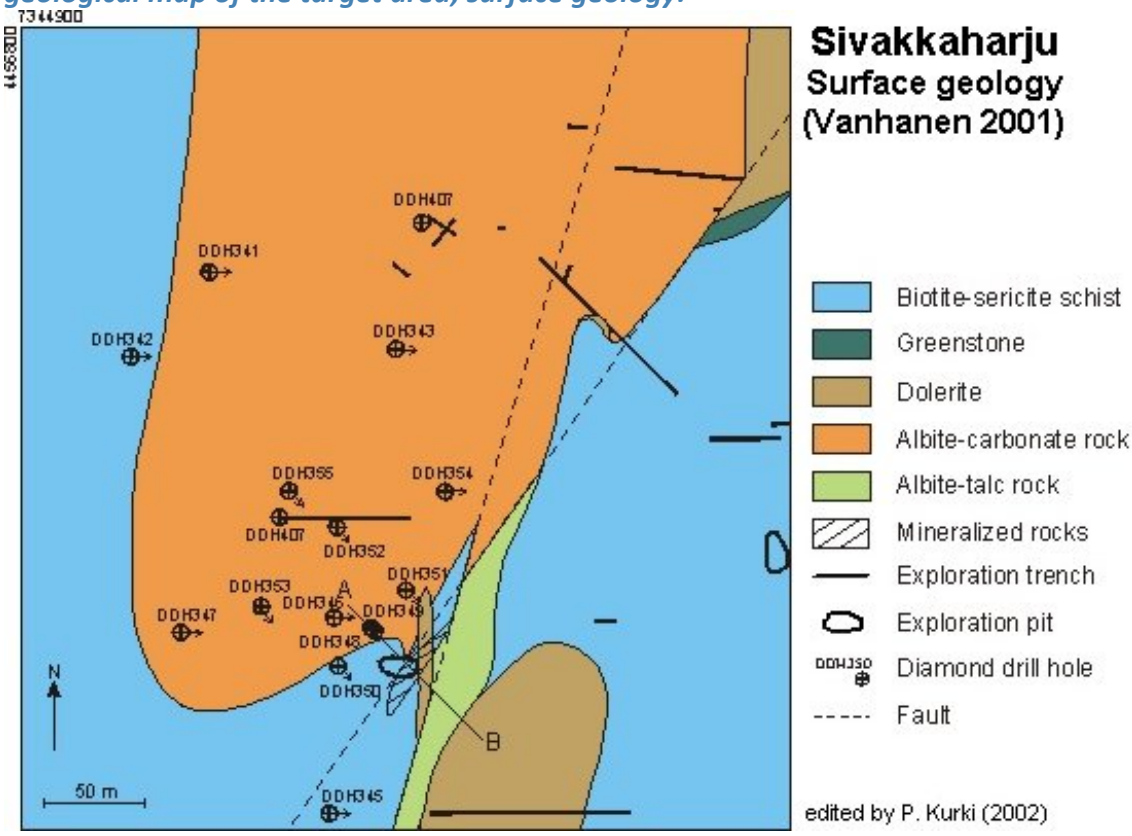
A. Intergrowth of gold (Au) with altaite (al) and molybdenite (mo).
B. Intergrowth of gold (Au) and calaverite (ca).
Back-scatter electron images by Erkki Vanhanen. Sivakkaharju

BSE images on gold and tellurides:

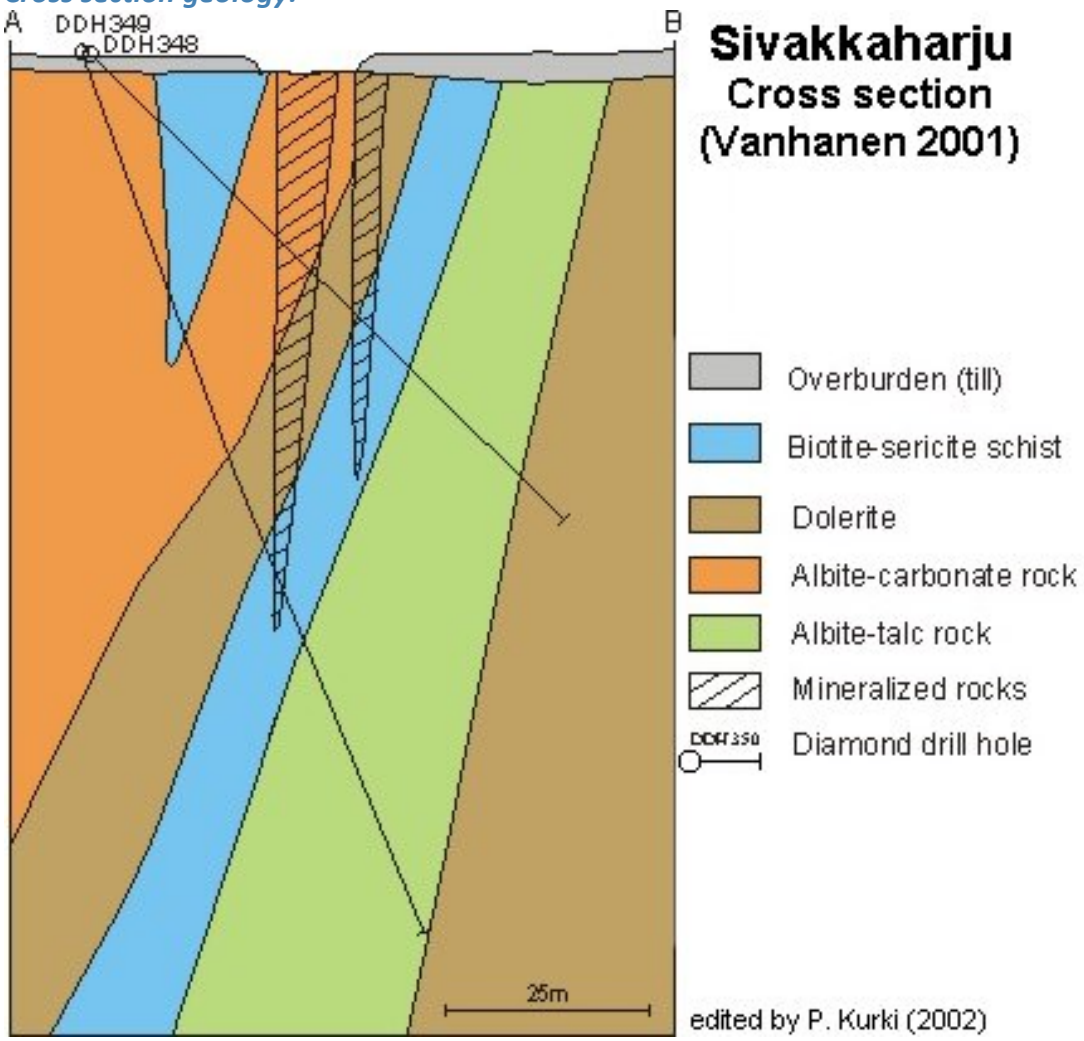


A. Melonite (me) coated by clausthalite (ch).
B. Gold-calaverite (au, ca) and calaverite-melonite intergrowths (ca, me).
Back-scatter electron images by Erkki Vanhanen. Sivakkaharju

geological map of the target area; surface geology:



Cross section geology:



Intensely sulphidised 'sericite schist'. Mineral assemblage probably sericite - quartz - albite

- biotite - pyrite - rutile. Sample length 12 cm. Photo Reijo Lampela, GTK:

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