

Virtasalmi

Alternative Names: Hällinmäki, Karsikumpu

Occurrence type: deposit

Commodity	Rank	Total measure	Total production	Total resource	Importance
copper	1	31717,5 t	31717,5 t	NA	Small deposit
gold	3	NA	NA	NA	NA
sulphur	5	NA	NA	NA	NA

Easting EUREF: 528867,615

Northing EUREF: 6880714,878

Easting YKJ: 3529050

Northing YKJ: 6883600

Discovery year: 1964

Discovered by: Geological Survey of Finland

Province: Virtasalmi (Cu)

Comments: In 1949 a few magnetite-rich samples were sent to GtK by a local farmer. These findings led to exploration, which lasted up to 1954. Only a few Cu-bearing garnet skarn occurrences were found close to Lake Virmasjärvi. Later in the 1950s and in the early 1960s, more Cu- and Fe-bearing skarn samples were sent to GTK. Mineralogical investigations of these boulders caused intense exploration in the area and discovery of the deposit in outcrop.

References: 1, 2, 4, 7, 9, 11, 13, 15, 16, 18, 19, 20

Mineral deposit type

Group: Metallogenic deposit

Main type: VMS (mixed hydrothermal)

Sub type 1: Mafic-ultramafic

Comments: Enrichment in incompatible elements demonstrates that the Virtasalmi metatholeites are not related to supra-subduction zone magmatism but are WPBs or enriched MORBs. The interlayering of metabasalts with marbles and voluminous clastic metasediments more likely indicates an intracratonic rift geotectonic setting. Stockwork zone below the main ore-rich layers.

References: 7, 8

Dimension

Expression: exposed

Form: concordant

Shape: NA

Length (m): 500

Width (m): 16

Thickness (m): NA

Depth (m): 350

Area (ha): NA

Dip azimuth: NA

Dip: 85

Plunge azimuth: NA

Plunge dip: NA

Orientation method: Calculated average orientation

Dimension comments: The deposit consists of five ore bodies, is 2-30 m wide, and extends to the depth of about 350 m

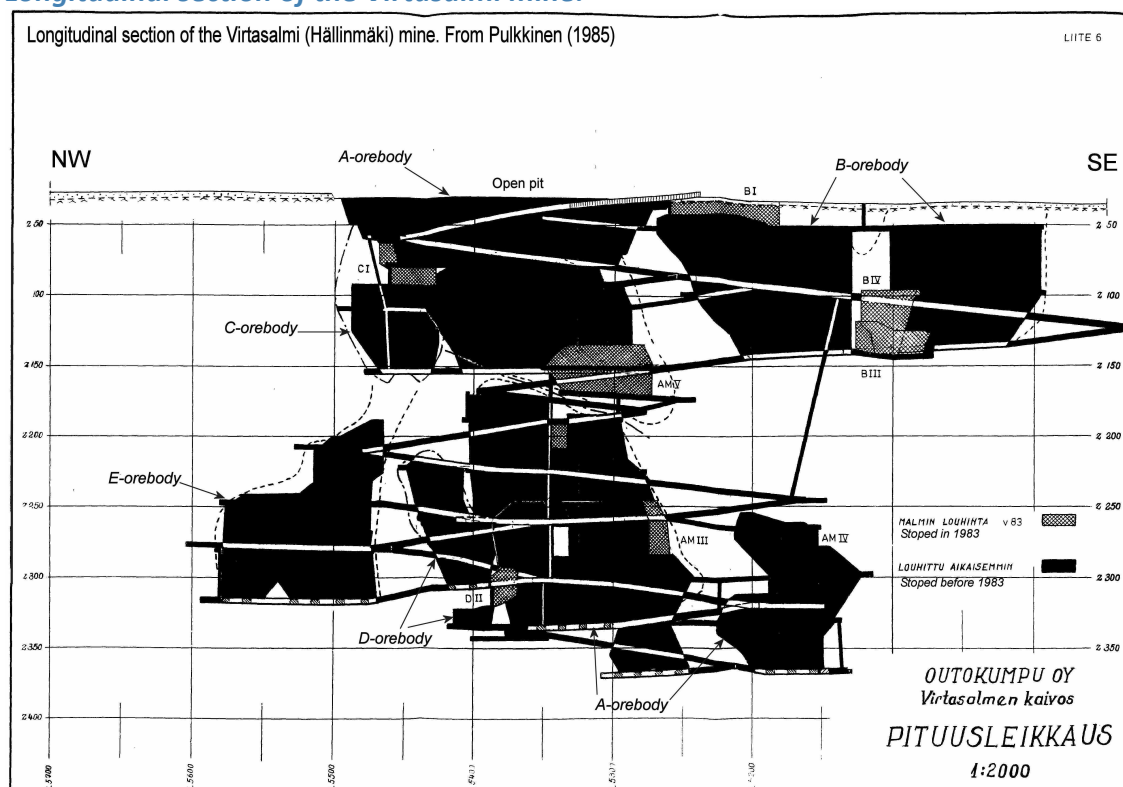
Holder history

Previous holders:

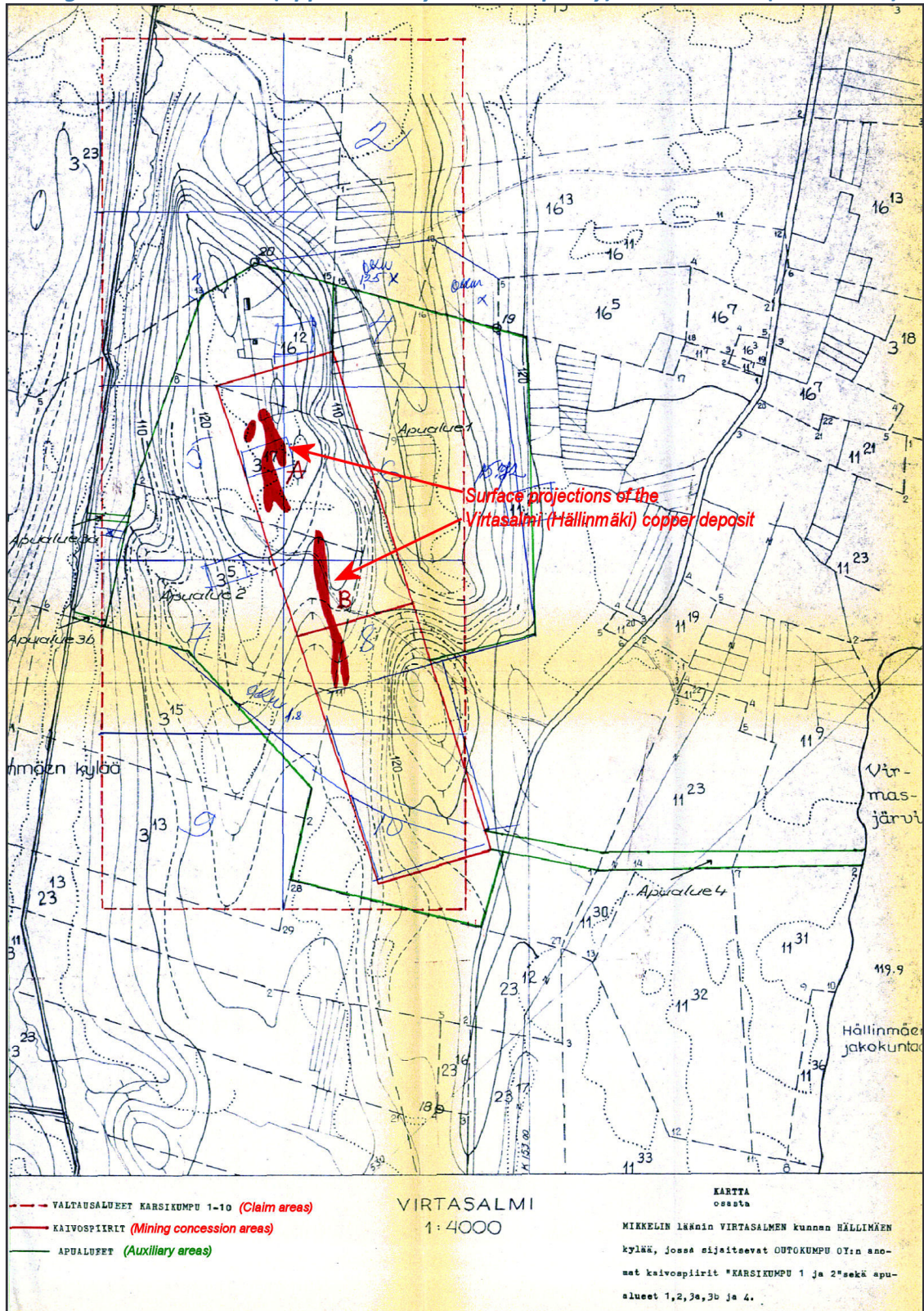
Company	Years	Holding type	Comments
Boliden AB	2018	Reservation	Formally held by Boliden FinnEx Oy
FinnAust Mining Oy	2012-2014	Reservation	NA
Outokumpu Oy	1965-1984	Mining concession (old law)	NA

Figures

Longitudinal section of the Virtasalmi mine:

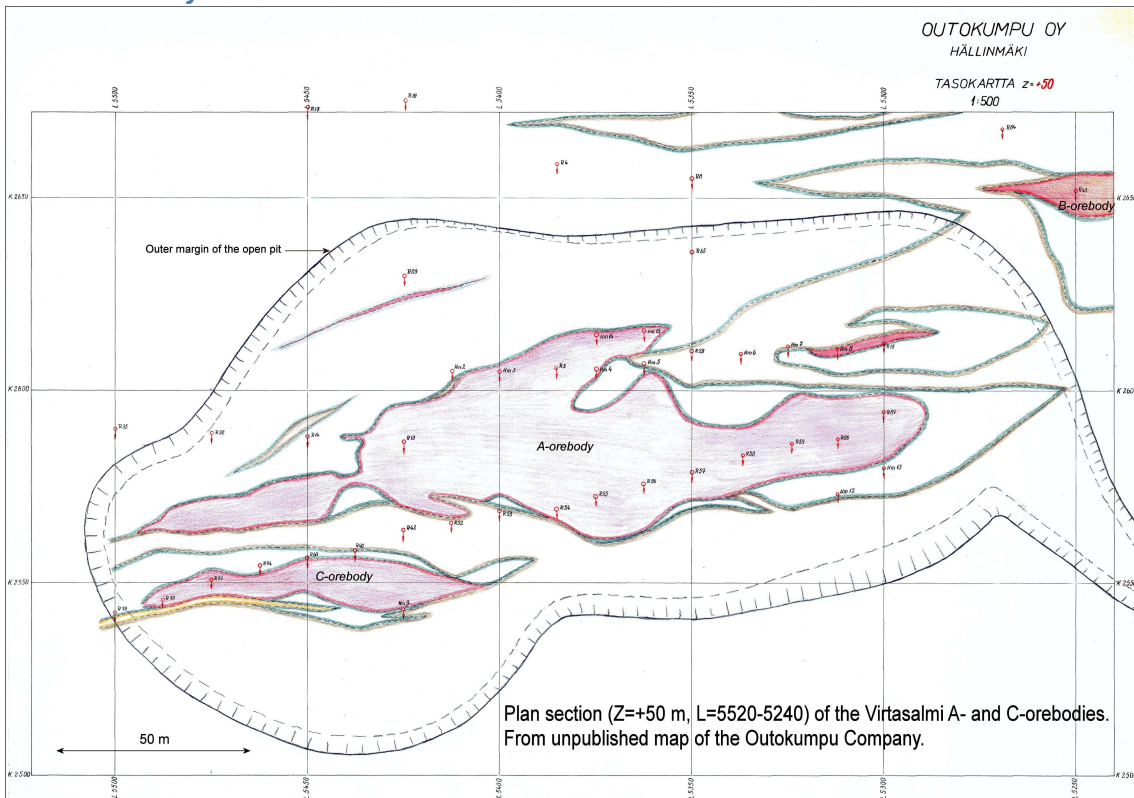


Mining concession areas (application by Outokumpu Oy) at Virtasalmi (Hällinmäki):

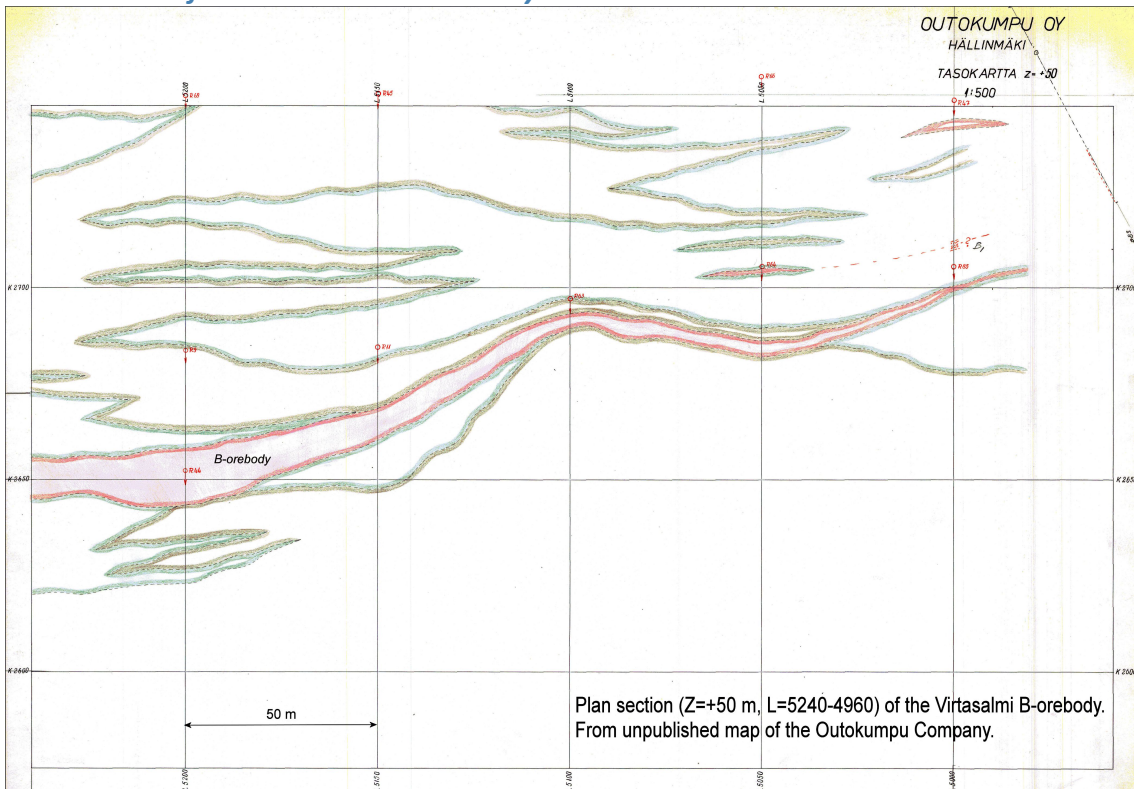


Mining concession areas at Hällinmäki, Virtasalmi. Modified from Vähätalo (1966) by K. Västi

Plan section of the Virtasalmi A- and C-orebodies:



Plan section of the Virtasalmi B-orebody:



EXPLORATION ACTIVITY

Outokumpu Oy

Years	Activity type	Geologist	Exploration result	Ref
1966-1976	detailed geochemistry	L. Grundström, H. Saarnio	geochemical anomaly	2, 7, 8, 10
	<i>In the Virtasalmi area Cu-anomalies in till samples are closely related to the amphibolite horizons and magnetic anomalies. Cu-anomalies close to the Hällinmäki mine are not conspicuous.</i>			
1966-1984	detailed geology	L. Grundström, H. Saarnio	key geological features	
1966-1984	mining pilot	L. Grundström, H. Saarnio	NA	
1966-1984	core drilling	L. Grundström, H. Saarnio	mineral reserve defined	
	<i>15 diamond-rill holes from the surface and (at least) 46 underground, from the mine.</i>			

Geological Survey of Finland

Years	Activity type	Geologist	Exploration result	Ref
1949-1966	detailed geophysics	L. Hyvärinen, T. Siikarla	geophysical anomaly	2, 15, 16
	<i>Outcropping A orebody and the NW end of the B orebody show distinct magnetic anomalies. The C orebody and NW part of the B orebody show negative slingram anomalies. A prominent positive gravity anomaly caused by the diopside and garnet rich rocks. The three separate gravity maxima indicate that mineralised skarn does not occur as a single body along the whole length of the deposit but is broken by intrusives.</i>			
1949-1966	regional geochemistry	L. Hyvärinen, J. Pekkarinen, E. Lyytikäinen	geochemical anomaly	2, 3
1949-1966	detailed geology	L. Hyvärinen, J. Pekkarinen, E. Lyytikäinen	key geological features	2, 3
	<i>Bouder tracing, outcrop mapping</i>			
1949-1966	regional geophysics	L. Hyvärinen, J. Pekkarinen, E. Lyytikäinen	geophysical anomaly	2, 3
	<i>Airborne magnetic and electromagnetic survey</i>			
1949-1966	core drilling	L. Hyvärinen, J. Pekkarinen, E. Lyytikäinen	mineral resource defined	2, 3
	<i>Core drilling (reconnaissance drilling): 87 drill holes totaling ca 17.3 km.</i>			

MINING

Virtasalmi

Easting EUREF: 528867,615

Northing EUREF: 6880714,878

Status: Closed

Operating years: 1966-1983

Years in production: 18

Total ore mined: 4244983 t

Total production:

Product	Product measure
copper	31717,5 t

Other materials:

Material type	Material measure
Waste rock	1087150 t

Mining activity:

Year	Ore mined	Ore processed	Activity type	Production	Other material
1983	310000 t	299886 t	underground mining	copper 2219,15 t	Waste rock 10000 t
1982	354269 t	304269 t	underground mining	copper 2403,72 t	Waste rock 12600 t
1981	295548 t	295548 t	underground mining	copper 2364,38 t	Waste rock 9747 t
1980	298715 t	298715 t	underground mining	copper 2240,36 t	Waste rock 12701 t
1979	302730 t	302730 t	underground mining	copper 2058,56 t sulphur 0 t	Waste rock 16283 t
1978	294493 t	294493 t	underground mining	copper 2061,45 t sulphur 0 t	Waste rock 19934 t
1977	277853 t	277853 t	underground mining	copper 2000,54 t sulphur 0 t	Waste rock 31968 t
1976	267030 t	267030 t	underground mining	copper 2109,53 t sulphur 0 t	Waste rock 31267 t
1975	263990 t	263990 t	underground mining	copper 1900,72 t sulphur 0 t	Waste rock 39648 t
1974	263740 t	263740 t	underground mining	copper 2584,65 t sulphur 0 t	Waste rock 28043 t
1973	263093 t	263093 t	underground mining	copper 1999,5 t sulphur 0 t	Waste rock 39648 t
1972	251710 t	251710 t	underground mining	copper 2139,53 t sulphur 0 t	Waste rock 19250 t
1971	213188 t	213188 t	open-pit mining		

				copper 1385,72 t sulphur 0 t	Waste rock 51950 t
1970	20872 t	44703 t	open-pit mining		
				copper 286,09 t sulphur 0 t	Waste rock 13250 t
1969	139566 t	116566 t	open-pit mining		
				copper 955,84 t sulphur 0 t	Waste rock 27693 t
1968	221515 t	216945 t	open-pit mining		
				copper 1540,3 t sulphur 0 t	Waste rock 258816 t
1967	202104 t	202104 t	open-pit mining		
				copper 1455,14 t sulphur 0 t	Waste rock 318525 t
1966	4567 t	2567 t	open-pit mining		
				copper 12,32 t sulphur 0 t	Waste rock 145827 t

Figures

Aerial view of the Virtasalmi open pit:



The open pit at Virtasalmi 27.09.2007:



Photo by Kaj Västi

The open pit at Virtasalmi (2007.09.27)

GEOLOGY

Host rock: Skarn, Amphibolite

Wall rock: Pegmatite, Tonalite, Gabbro, Dioritic rock

Skarn (Host rock)

Rock type: Host rock

Proportion: major

Grain size: NA

Color: NA

References: 2, 7, 8, 12

Comments: Andradite skarn occurs as irregular lenses or inter-layers commonly showing boudinage structures. This is altered, then metamorphosed basalt. Brecciated ore: Occurs chiefly in garnet skarns or next to them. Sulfides are present in mesh-like structures 5 to 10 cm across or as lenses 1 to 3 cm thick.

Ore minerals:

Mineral	Proportion	Mineral texture
Chalcopyrite	major	
Cubanite	major	
Magnetite	minor	
Pyrite	minor	
Pyrrhotite	major	

Other minerals:

Mineral	Proportion	Mineral texture
Andradite	major	
Apatite	trace	
Calcite	trace	
Epidote	minor	
Hedenbergite	major	
Hornblende	trace	
Plagioclase	minor	
Quartz	trace	
Scapolite	minor	
Titanite	trace	

Structures

Folded

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	Min T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	2-5,5	450-800
<p><i>Comments: Upper-amphibolite facies metamorphic grade. Garnet skarns: 1) Andradite/grossular-diopside-scapolite-calcite, 2) andradite/grossular-calcite, 3) hedenbergite-andradite-scapolite-andesine, 4) magnetite-andradite-quartz, 5) andradite-hedenbergite-magnetite, 6) andradite-bytownite, 7) andradite-scapolite-diopside-calcite-quartz.</i></p>					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1880-1910	1900	Y

Amphibolite (Host rock)

Rock type: Host rock

Proportion: present

Grain size: NA

Color: Green

References: 2, 3, 7, 8, 12

Comments: The ore itself is hosted by garnet skarns and diopside amphibolites and it is located on the eastern limb of a large northerly plunging F2 antiform. Diopside amphibolites are usually banded in structure. Light green bands are diopside (+plagioclase) rich while dark green bands contain more hornblende (+plagioclase). Disseminated ore: Occurs mainly in diopside amphibolite, where it is either evenly distributed or arranged in layers or bands.

Ore minerals:

Mineral	Proportion	Mineral texture
Bornite	minor	
		<i>Occurs only occasionally as microscopic grains. In drill holes R30 and R31 greatest grains may be 1-2 cm in diameter.</i>
Bravoite	minor	
		<i>See pentlandite.</i>
Chalcopyrite	major	Dissemination
		<i>Occurs in disseminated ore as separated grains 0.1-0.4 mm in diameter. In brecciated ore chalcopyrite is more coarse-grained the largest grains being 3-4 cm in diameter. In brecciated ore chalcopyrite contains more inclusions and exsolutions of which cubanite is most important. Small pyrrhotite, sphalerite and mackinawite inclusions are relatively common, too.</i>
Cubanite	minor	Dissemination, Breccia
		<i>Occurs as exsolution lamelle in chalcopyrite the greatest ones being 3-4 cm long and 0.5-1.0 cm broad. In places it looks like chalcopyrite occurs as exsolution in cubanite.</i>
Gersdorffite	minor	
		<i>A few small euhedral inclusions in chalcopyrite.</i>
Ilmenite	minor	
		<i>Usually as exsolutions in magnetite. Sometimes as grains.</i>
Linnaeite	minor	
		<i>Occurs occasionally as graphic compound with chalcopyrite or between pyrite grains.</i>
Ludwigite	minor	
		<i>A rare mineral, which occurs as very small euhedral grains in chlorite-quartz veins crosscutting other ore minerals.</i>
Mackinawite	minor	
		<i>Occurs as flame-like inclusions or exsolutions in chalcopyrite. Mackinawite may contain pyrrhotite and pentlandite inclusions.</i>
Magnetite	major	Dissemination, Breccia
		<i>Occurs usually as euhedral grains 0.04-0.07 mm in diameter. Locally, however, the crystals may be over 1 cm. Generally speaking magnetite is unevenly distributed in the ore. Ilmenite lamelle are common in magnetite.</i>
Millerite	minor	

	<i>Very rare mineral. Occurs together with chalcopyrite, probably as exsolution in linnaeite.</i>	
Molybdenite	minor	
	<i>Unevenly distributed. Occurs only in the ore, which contains Cu less than 0,9 %.</i>	
Pentlandite	minor	
	<i>Occurs as small exsolutions in pyrrhotite and chalcopyrite. Chemical composition is that of cobalt-pentlandite. Alters to bravoite, which contains less cobalt.</i>	
Pyrite	major	Dissemination, Breccia
	<i>Occurs as major ore mineral only in disseminated ore. Pyrite occurs as euhedral crystals in chalcopyrite.</i>	
Pyrrhotite	major	Dissemination, Breccia
	<i>Pyrrhotite is often replaced by chalcopyrite while magnetite is rarely replaced by pyrrhotite. Pyrrhotite occurs both in disseminated and brecciated ore types as major mineral.</i>	
Sphalerite	minor	
	<i>Occurs as small exsolutions in chalcopyrite, pyrrhotite and cubanite.</i>	

Other minerals:

Mineral	Proportion	Mineral texture
Actinolite	present	
Andradite	present	
Apatite	minor	
Biotite	minor	
Diopside	present	
Epidote	minor	
Hedenbergite	present	
Hornblende	present	
Plagioclase	present	
Quartz	present	
Scapolite	present	
Titanite	present	

Structures

Folded

Breccia

Textures

Banded

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	2-5,5	450-800
<i>Comments: Upper-amphibolite facies metamorphic peak</i>					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1880-1910	1900	Y

Pegmatite (Wall rock)

Rock type: Wall rock

Proportion: present

Comments: A few late-kinematic pegmatites in the area

Tonalite (Wall rock)

Rock type: Wall rock

Proportion: major

References: 2, 3, 7, 8

Comments: Diorites to tonalites are the most abundant intrusives in the area

Gabbro (Wall rock)

Rock type: Wall rock

Proportion: minor

Comments: Leucogabros and syn-kinematic basic dykes. Intrusives commonly crosscut ore-bearing lithologies at a high angle

Dioritic rock (Wall rock)

Rock type: Wall rock

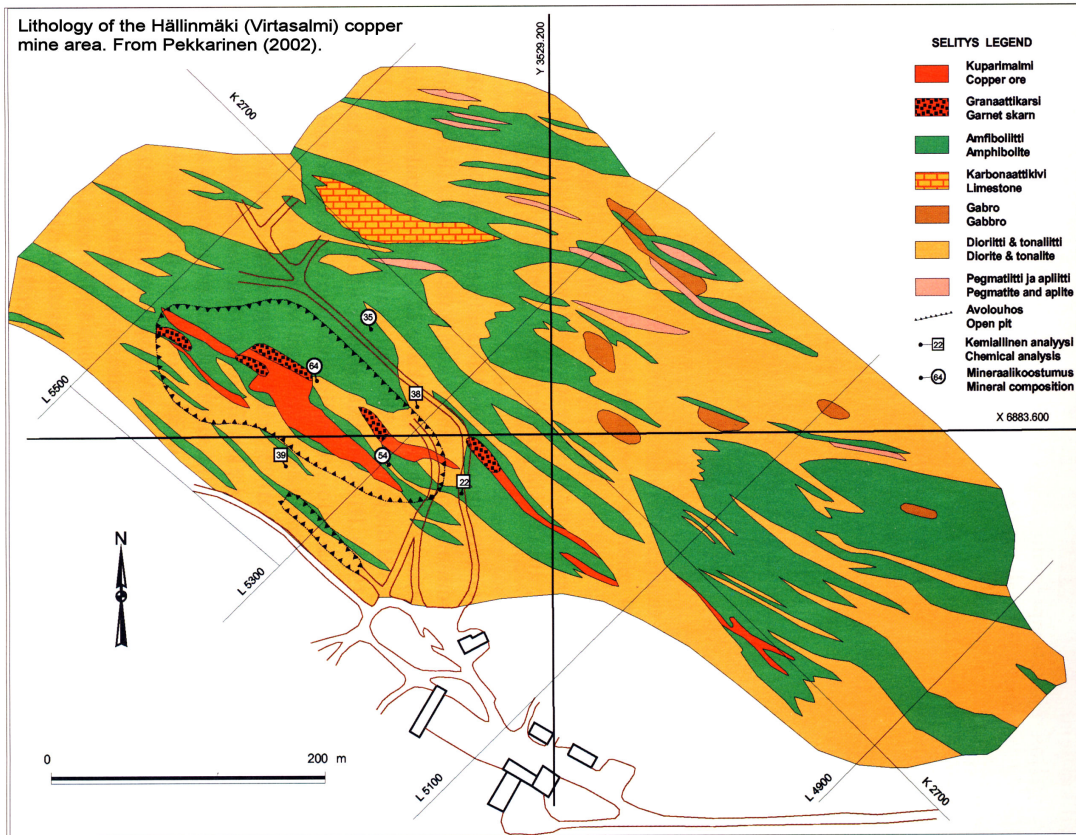
Proportion: major

References: 2, 7, 8

Comments: Diorites to tonalites are the most abundant intrusives in the area

Figures

Geological map of the closed Virtasalmi mine area:



Andradite skarn from the A-orebody:

Andradite skarn from the Hällinmäki mine. The brownish red mineral is andradite, the green minerals are hedenbergite and diopside and the light veins and patches are carbonate and/or scapolite.



Photo by Kaj Västil

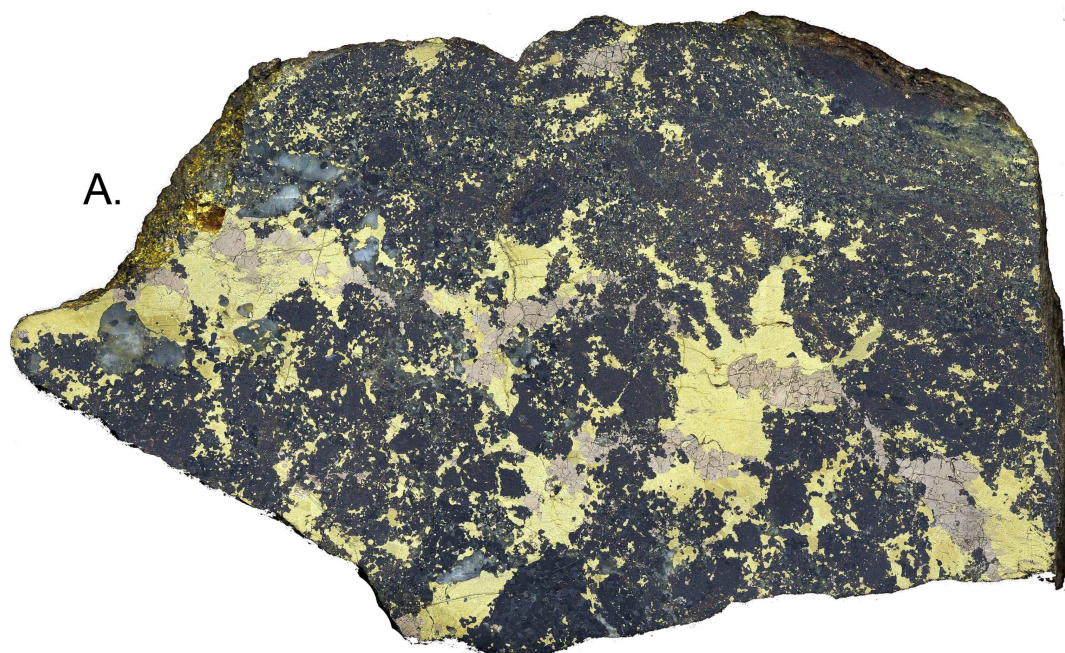
Diopside amphibolite + diorite dyke on the NE-margin of the open pit:

Photo by Kaj Väänänen



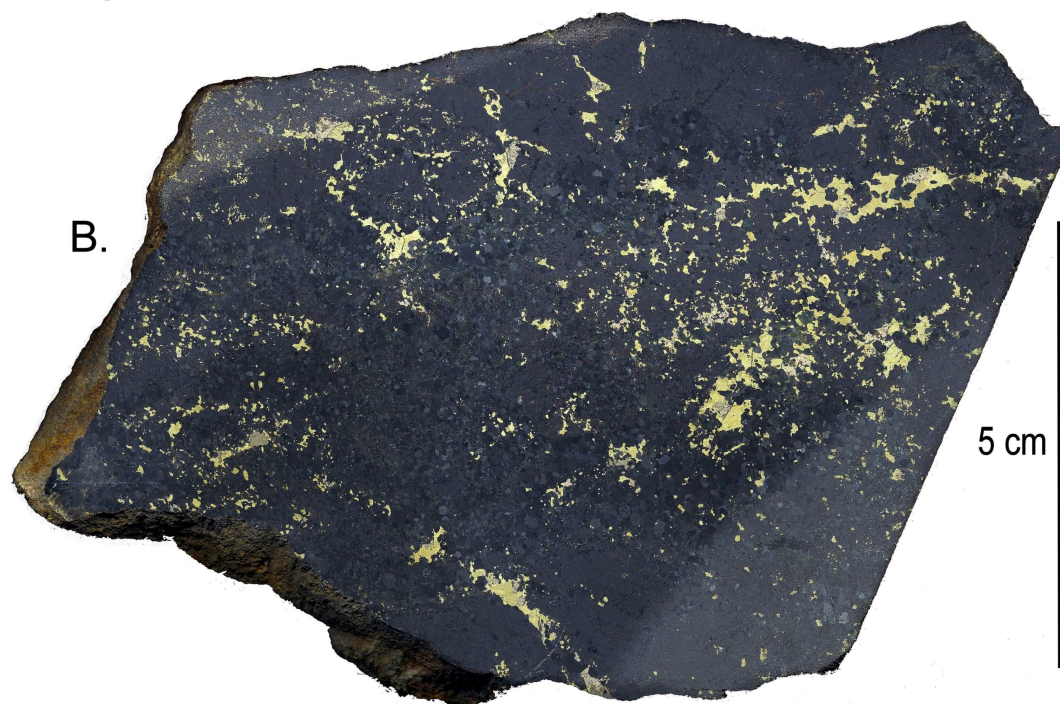
Diopside amphibolite with a diorite dyke in the middle.

Brecciated and disseminated ore:

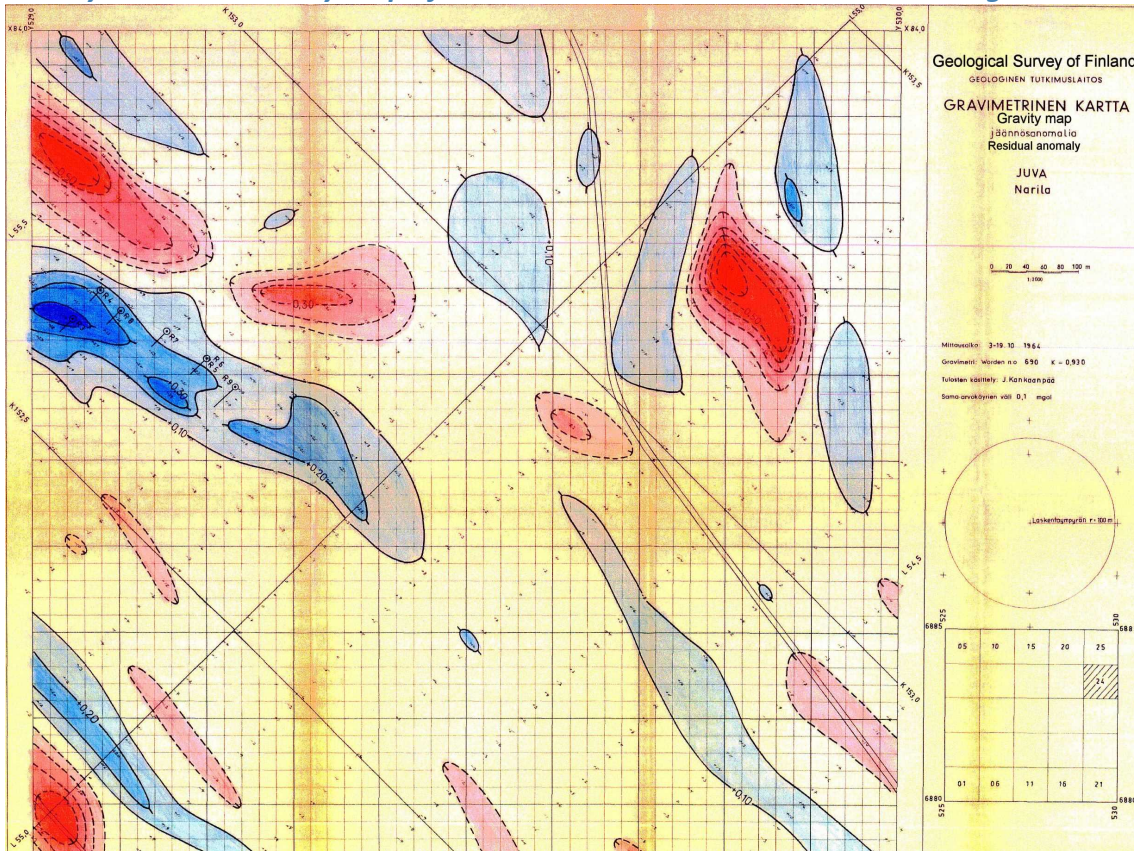


A. Brecciated chalcopyrite (yellow) ore with brownish pyrrhotite in andradite skarn.

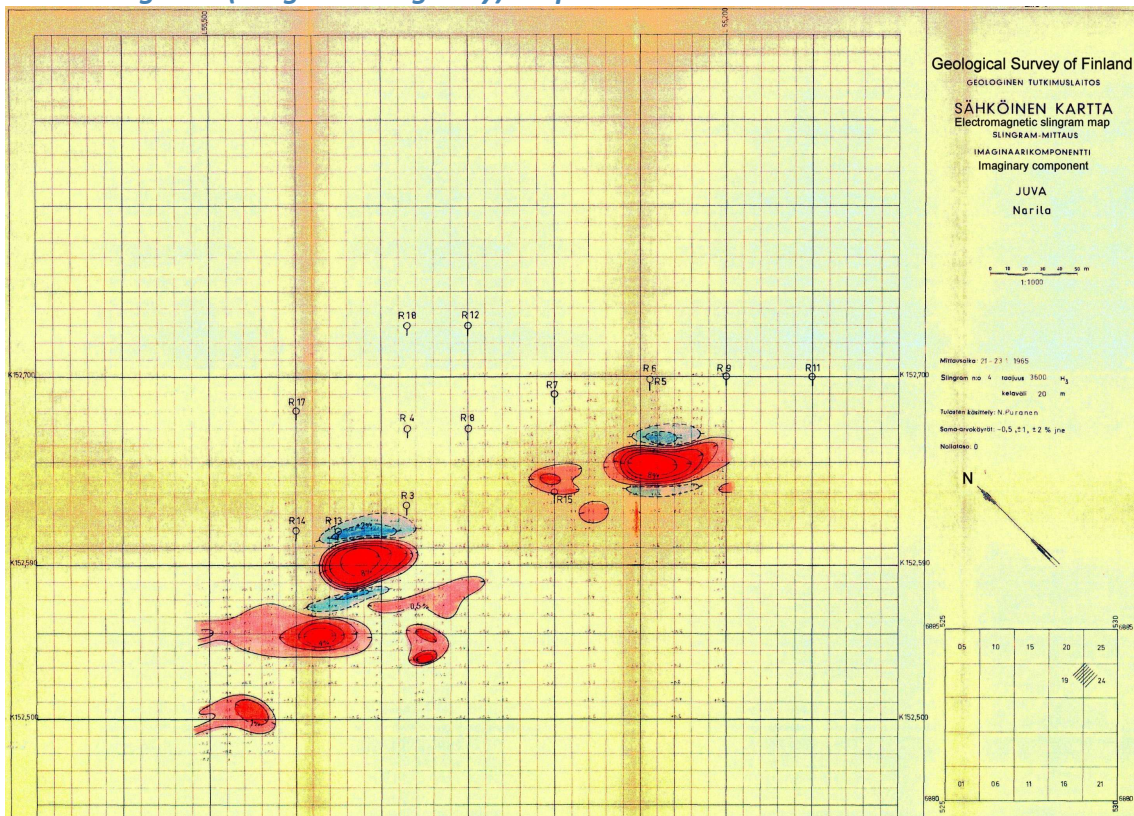
B. Disseminated chalcopyrite ore with minor pyrrhotite grains in diopside amphibolite.



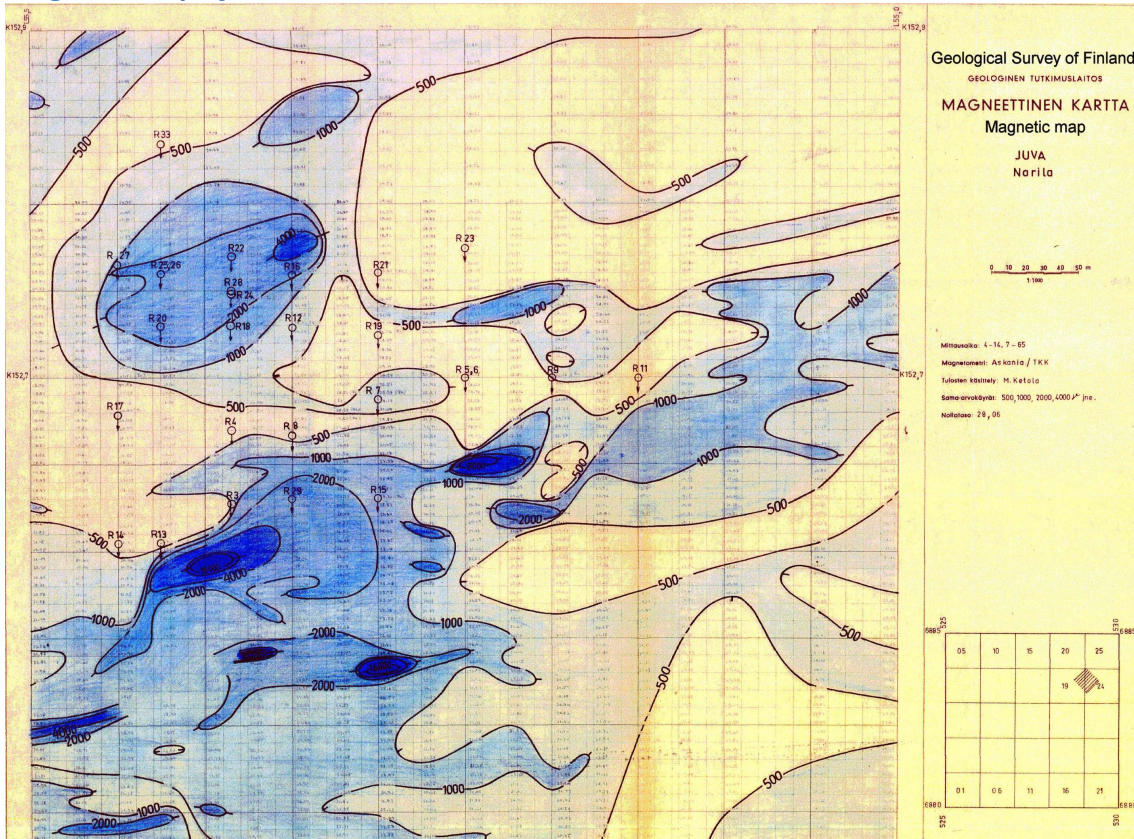
Gravity residual anomaly map of the Virtasalmi mine area and surroundings:



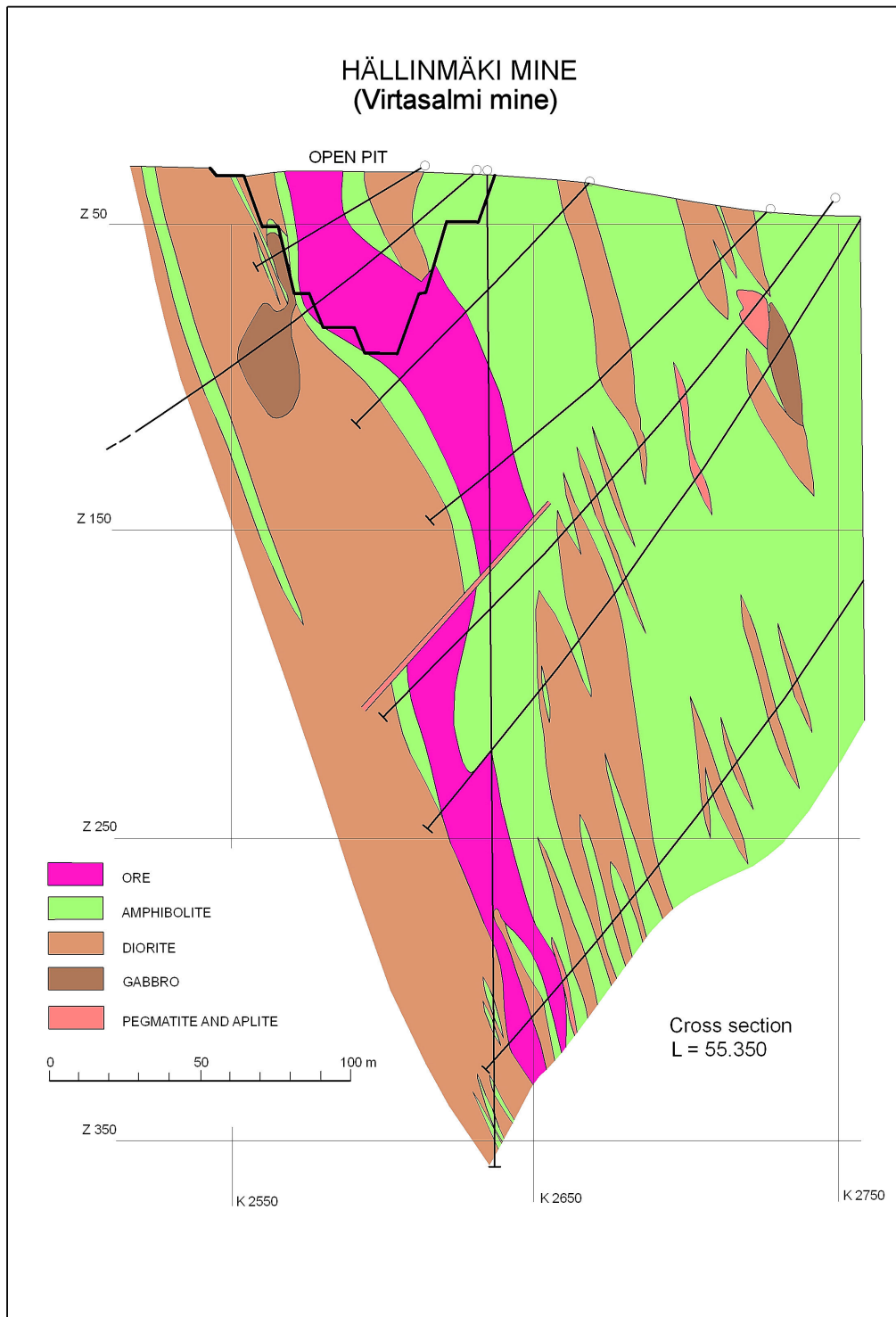
Electromagnetic (slingram imaginary) map:



Magnetic map of the Virtasalmi mine area:



Cross section through the A-orebody:



Cross section through the A-orebody. Modified from Vaajoensuu et al. (1977) by K. Västi

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