METAMORPHIC, STRUCTURAL AND ISOTOPIC AGE MAP

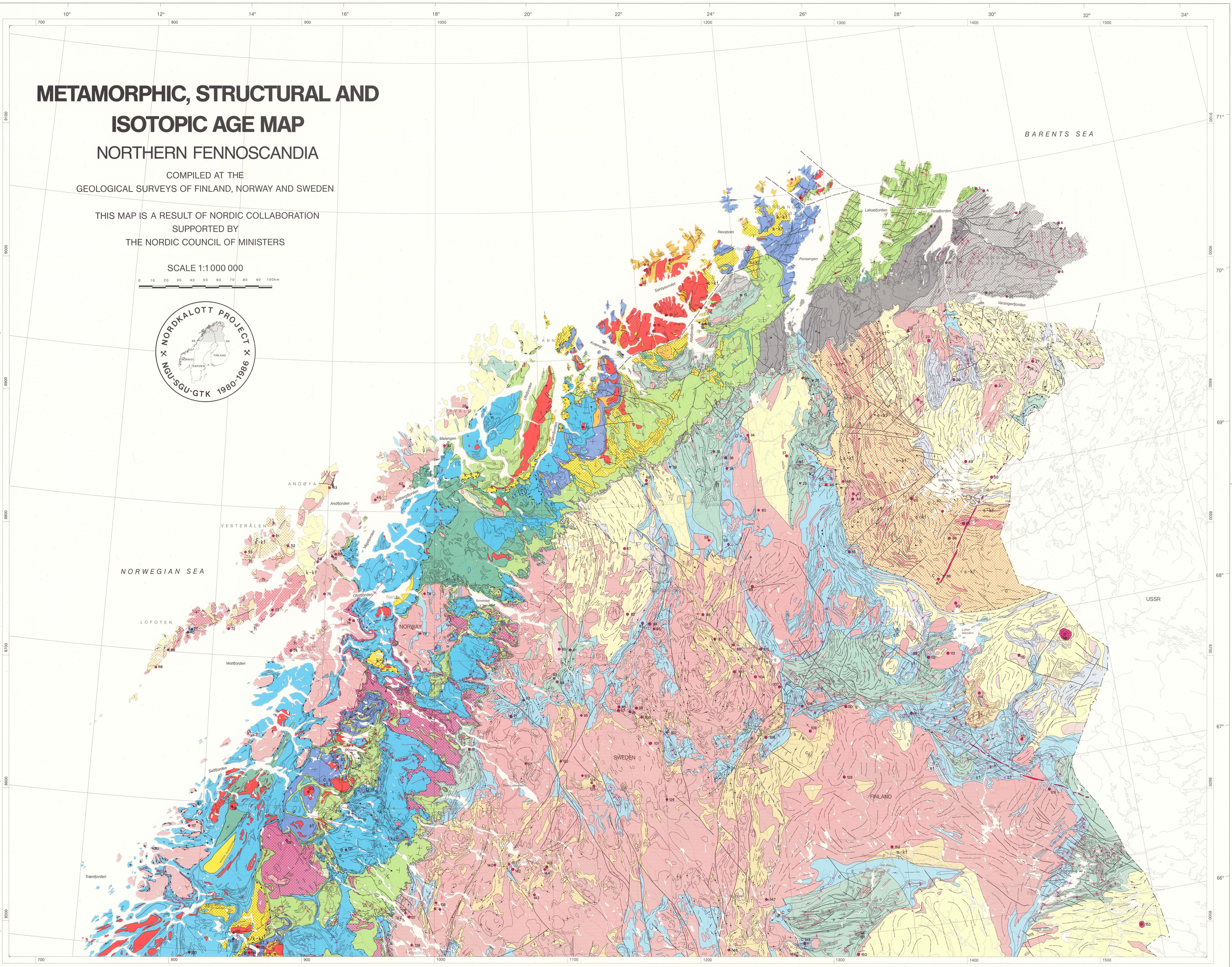
NORTHERN FENNOSCANDIA

COMPILED AT THE
GEOLOGICAL SURVEYS OF FINLAND, NORWAY AND SWEDEN

THIS MAP IS A RESULT OF NORDIC COLLABORATION
SUPPORTED BY
THE NORDIC COUNCIL OF MINISTERS

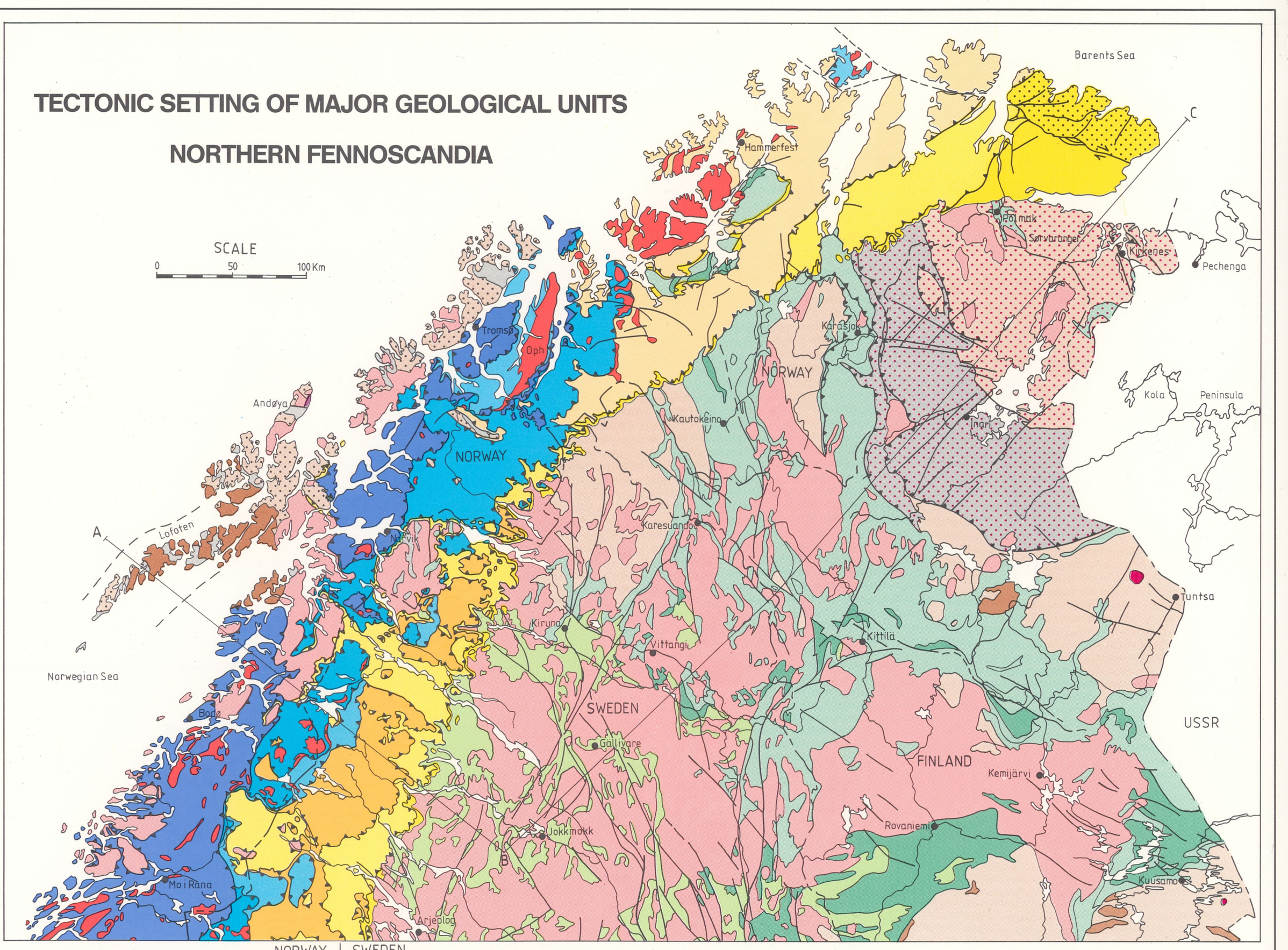
SCALE 1:1 000 000

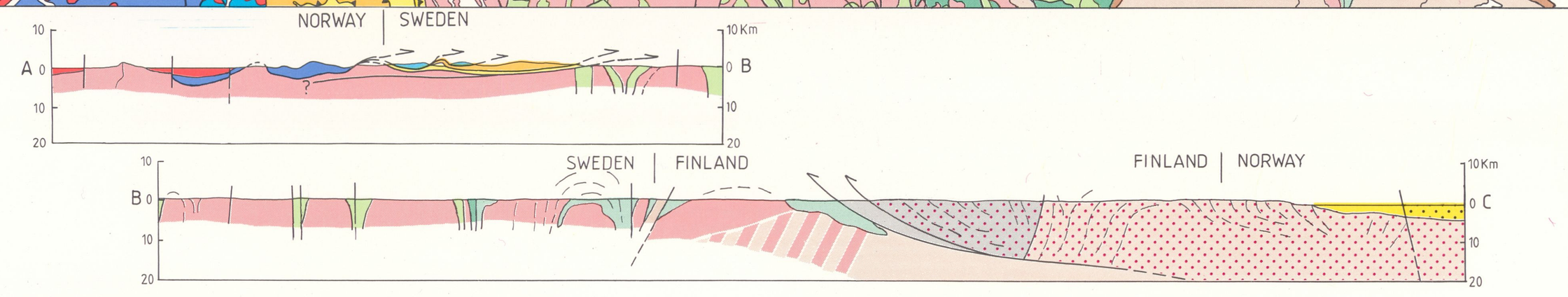
NORDKALOTT PROJECT
NGU-SGU-GTK 1980-1986



TECTONIC SETTING OF MAJOR GEOLOGICAL UNITS

NORTHERN FENNOSCANDIA





LEGEND FOR INSET MAP AND PROFILE

MESOZOIC COVER ROCKS ALONG THE PASSIVE CONTINENTAL MARGIN OF EURASIA

- Sedimentary rocks above a tropical deep-weathering profile, exposed on Andøya; extensive deposits below the Norwegian Sea and Barents Sea not shown

PALAEOZOIC ANOROGENIC INTRUSIONS IN THE FENNOSCANDIAN SHIELD

- Alkaline and carbonatite intrusions

CALEDONIDES
Late Proterozoic-Silurian cover rocks and intrusions, and Archaean-Mid Proterozoic basement complexes, all affected by Caledonian metamorphism, deformation and thrust-nappe transport (c. 380–510 Ma)

- Caledonian pre- and syn-orogenic intrusions. Oph=ophiolite

EXOTIC TERRANES ACCRETED TO THE CONTINENT BALTICA DURING THE CALEDONIAN OROGENY

- Continental lithosphere (Laurentia–Greenland?) with an active continental margin evolution during the Ordovician-Silurian (Uppermost Allochthon)
- Terranes containing oceanic sequences (Uppermost and Upper Allochthons)
- Metamorphic complexes of uncertain affinity (Upper Allochthon)

SUSPECT TERRANES, PROBABLY COMPRISING THE TECTONICALLY SHORTENED MARGIN OF THE CONTINENT BALTICA

- Outer rifted continental margin (Seve Nappes, Upper Allochthon)
- Continental margin with major pre-orogenic intrusions (Kalak Nappe Complex, Middle Allochthon)

TECTONICALLY SHORTENED MARGIN OF THE CONTINENT BALTICA

- Miogeocline and platform (Middle and Lower Allochthons)

LATE PROTEROZOIC – CAMBRIAN COVER ROCKS

- Platformal margin of the continent Baltica
- Miogeocline in suspect terrane displaced by Vendian-Cambrian dextral strike-slip faulting

FENNOSCANDIAN SHIELD
Archaean-Early Proterozoic rocks affected by Svecokarelian and Gothian intrusions, metamorphism and deformation (1750–1900 Ma and 1500–1800 Ma, resp.)

- Svecokarelian intrusions, including granitoids in the Lofoten and Kola provinces.

WESTERN (LOFOTEN) PROVINCE

- Mangerite, gabbro, anorthosite and charnockite intrusions (Lofoten–Vesterålen Plutonic Complex, 1700–1800 Ma)
- Migmatite, granulite and other Early Proterozoic continental volcanic and sedimentary rocks
- Archaean basement (migmatites and granitoids dated to c. 2700 Ma) affected by Early Proterozoic (c. 1840 Ma) granulite-facies metamorphism

SVECOKARELIAN PROVINCE

- Early Proterozoic marine greywackes with intercalations of mafic volcanic rocks overlain by terrestrial, felsic-intermediate volcanic rocks (Svecofennian Assemblage)
- Early Proterozoic, continental-epicontinental, rift-related sedimentary and volcanic rocks (Karelia Supergroup)
- Pre-orogenic layered gabbro (c. 2450 Ma)
- Early Proterozoic or Archaean, intracratonic, rift-related sedimentary and volcanic rocks (Lapponia Supergroup)
- Archaean basement, including the Granite-gneiss Complex and Late Archaean supracrustal rocks and intrusions (Tuntsa Supergroup) generally reworked by the Svecokarelian orogeny

KOLA PROVINCE
Lapland Granulite Belt (incl. Tanaelv Complex)

- Early Proterozoic or possibly Archaean supracrustal rocks and intrusions thrust to the southwest during the Svecokarelian orogeny

Petsamo–Polmak Greenstone Belt

- Early Proterozoic, rift-related volcanic rocks, unconformably overlying the Inari–Sørvaranger Complex.

Inari–Sørvaranger Complex

- Archaean basement, including the Granite-gneiss Complex and Late Archaean supracrustal rocks and intrusions

LEGEND FOR MAIN MAP

METAMORPHISM

The designation of metamorphic grade is based mainly on the classification of Winkler (1976).
The grade of the peak of metamorphism is indicated by colour on the map.
The age of the main metamorphic event is also shown, as more intensive colours represent younger events.
Intrusions with distinct magmatic character have not been classified according to metamorphism.

Charnockitic rocks and granulite high grade indicate the occurrence of hypersthene in intermediate and felsic rocks, or the assemblage clinopyroxene + almandine + quartz. The rocks may or may not be migmatitic. Metamorphic temperatures may have been similar to high grade, but $P_{H_2O} << P_{total}$.

High grade generally includes migmatitic rocks with some degree of partial melting. Areas beyond the stability limit of muscovite, which may contain the assemblage kyanite/sillimanite + K-feldspar + quartz are also included.

Medium grade includes areas that are not migmatitic, but that are of high enough grade to produce staurolite or cordierite in pelitic rocks. Fe-rich chlorite is not stable with muscovite.

Low grade includes rocks which may contain the assemblage chlorite + zoisite/clinozoisite.

Very low grade rocks may contain lawsonite or pumpellyite + prehnite. They do not contain zoisite/clinozoisite.

Reference: Winkler, H.G.F. 1976: Petrogenesis of Metamorphic Rocks. Springer-Verlag, New York

Some minerals and mineral assemblages are also included to help to characterize the metamorphic conditions.

h – hypersthene
c – cordierite
s – sillimanite
k – kyanite
a – andalusite
st – staurolite
g – glaucophane

s-Kf – sillimanite + K-feldspar
k-Kf – kyanite + K-feldspar
e – eclogite (omphacite + garnet)

MESOZOIC COVER ROCKS

- Unmetamorphosed

ANOROGENIC INTRUSIONS IN THE FENNOSCANDIAN SHIELD

- Alkaline and carbonatite intrusions (c. 400 Ma)
- Diabase dykes (c. 1000 Ma)

CALEDONIDES
Late Proterozoic and Early Palaeozoic rocks; Caledonian metamorphism (c. 380–510 Ma)

- Intrusions/charnockitic rocks
- High grade
- Medium grade
- Low grade
- Very low grade and unmetamorphosed

Archaean-Mid Proterozoic rocks and rocks of unknown age; Caledonian metamorphism, in part possibly pre-Caledonian

- Intrusions, locally felsic volcanites (unknown age/Precambrian)
- High grade (unknown age/Precambrian)
- Medium grade
- Low grade

LATE PROTEROZOIC – CAMBRIAN COVER ROCKS

- Low grade
- Very low grade and unmetamorphosed

FENNOSCANDIAN SHIELD
Early Proterozoic rocks; Svecokarelian metamorphism (c. 1750–1900 Ma)

- Intrusions/charnockitic rocks
- Granulite high grade
- High grade
- Medium grade
- Low grade
- Very low grade

Archaean rocks: Svecokarelian or Archaean metamorphism

- Late Archaean intrusions
- Granulite high grade
- High grade ortho- and paragneisses
- Medium or low grade

STRUCTURE

Ages of the structures are not indicated, but most structures are coeval with the metamorphic events shown.

LITHOLOGICAL CONTACT

- Depositional or intrusive contact
- Thrust separating major tectono-stratigraphic units in the Caledonides
- Thrust within major tectonostratigraphic unit
- Svecokarelian thrust in the Fennoscandian Shield
- High angle fault, shear zone
- Strike-slip fault

TRACE OF AXIAL SURFACE OF MEGASCOPIC FOLD

- Antiform (upright)
- Synform (upright)
- Antiform (overturned)
- Synform (overturned)

STRIKE AND DIP OF FOLIATION AND/OR BEDDING

- 0°– 5°
- 5°–30°
- 30°–60°
- 60°–85°
- 85°–90°
- Overturned
- Trend of foliation
- Younging direction

FOLD AXIS OF MESOSCOPIC FOLD

MINERAL AND STRETCHING LINEATIONS

PLUNGE

- 0°– 5°
- 5°–30°
- 30°–60°
- 60°–90°

PUBLISHED ISOTOPIC AGES

Interpretations may vary as to which geological event is indicated by some ages

■ 15 Location of sample on the map and reference to table; numbered principally from north to south ● U–Pb zircon ◆ Rb-Sr whole rock ▼ Sm-Nd ■ Mineral age, K-Ar whole rock

No.	Method	Age (Ma)	Reference	
1.	◆	410±28	NGT 62: 79–85	1982
2.	◆	411±7	NGT 62: 79–85	1982
3.	■	554±17	Scott. J. Geol. 12: 51–65	1975
4.	■	331–363±10	Scott. J. Geol. 12: 51–65	1975
5.	■	571–661±19	Scott. J. Geol. 12: 51–65	1975
6.	◆	520±47	NGU 367: 105–110	1981
7.	■	403±8	NGT 47: 255–273	1967
8.	◆	404±8	NGT 47: 255–273	1967
9.	◆	430±15	J. Geol. Soc. Lond. 135: 597–610	1978
	◆	415±15		
10.	◆	490±27	J. Geol. Soc. Lond. 135: 597–610	1978
	◆	540±17		
11.	■	528±27	J. Geol. Soc. Lond. 135: 597–610	1978
12.	◆	518±50	Geol. Mag. 109: 465–560	1973
13.	■	1840±37	NGT 62: 51–57	1982
14.	■	492±10	NGT 47: 255–273	1967
15.	■	413±8	NGT 47: 255–273	1967
16.	◆	612±17	NGT 53: 11–23	1973
17.	■	436	NGT 53: 11–23	1973
18.	◆	2784±302	NGU 403: 179–181	1985
19.	◆	1533±329	NGU 403: 179–181	1985
20.	◆	653±23	Geol. Mag. 109: 465–560	1973
21.	◆	810±90	Geol. Mag. 109: 465–560	1973
22.	■	1842±37	NGU 403: 37– 54	1985
23.	●	1940	GSF 281:112	1976
24.	◆	2110±105	NGU 403: 37–54	1985
25.	▼	2085±85	NGU 403: 37–54	1985
26.	◆	1706±15	GFF 101: 291–298	1980
27.	●	c. 2500	GSF 281: 111	1976
28.	◆	1673±165	NGU 403: 37–54	1985
29.	●	2480	GSF 281:111	1976
30.	●	1790±22	GSF 337: 20	1986
31.	●	1950	GSF 281:113	1976
32.	◆	453±27	C.R. Acad. Sc. Paris 286: 1653–1656	1978
33.	◆	1300±92	GFF 101: 291–298	1980
34.	■	1554±32	NGU 403: 37–54	1985
35.	◆	1827±323	NGU 403: 37–54	1985
36.	●	1815±24	NGU 403: 37–54	1985
37.	◆	1730±117	NGU 403: 37–54	1985
38.	◆	1789±64	NGU 403: 37–54	1985
39.	▼	2276±300	NGU 403: 37–54	1985
40.	●	1824±90	NGU 403: 37–54	1985
41.	■	1496±30	NGU 403: 37–54	1985
42.	◆	1768±49	NGT 64: 171–172	1984
43.	■	362±4	Geol. Rundschau 68: 523–542	1979
44.	◆	1746±93	NGT 64: 171–172	1984
45.	●	c. 1890	NGU 403: 37–54	1985
46.	◆	c. 1750	NGU 403: 37–54	1985
47.	●	1906±5	Prec. Res. 23: 325–348	1984
48.	●	2115	GSF 281: 109	1976
49.	●	2730	GSF 281: 109	1976
50.	●	2730	GSF 281: 109	1976
51.	◆	1665±80	NGT 51: 85–87	1981
52.	■	c. 450	NGT 49: 257–283	1969
53.	◆	2245±50	J. Geol. Soc. Lond. 135: 629–647	1978
54.	◆	2715±120	J. Geol. Soc. Lond. 135: 629–647	1978
55.	◆	1726±97	NGT 61: 237–248	1981
56.	■	361±3	NGT 61: 237–248	1981
		347±4		
57.	●	2800	The Explanation to the General Map of Finland, Sheet B 8, Enontekiö: 15	1969
58.	◆	1821±143	NGU 403: 37–54	1985
59.	◆	1727±40	NGU 403: 131–160	1985
60.	◆	2700±400	NGU 403: 131–160	1985
61.	●	1900±15	GSF 281: 117	1976
62.	●	1910	GSF 281: 118	1976
63.	●	1925	GSF 281: 118	1976
64.	●	1900±15	GSF 281: 117	1976
65.	●	2360	GSF 281: 114	1976
66.	▼	998	17e Nordiska Geologmötet. Abs.: 149	1986
67.	●	2140	GSF 281: 115	1976
68.	■	418±2	J. Geol. Soc. Lond. 135: 629–647	1978
		317±3		
69.	◆	1800±50	J. Geol. Soc. Lond. 135: 629–647	1978
70.	◆	1140±135	J. Geol. Soc. Lond. 135: 629–647	1978
71.	■	364±6	J. Geol. Soc. Lond. 135: 629–647	1978
	■	349±6		
72.	◆	1790±50	J. Geol. Soc. Lond. 135: 629–647	1978
73.	◆	1705±30	J. Geol. Soc. Lond. 135: 629–647	1978
74.	◆	1710±60	J. Geol. Soc. Lond. 135: 629–647	1978
75.	◆	1644±36	NGT 63: 269–279	1983
76.	◆	1742±46	NGT 66: 69–80	1968
77.	■	347±7	NGT 66: 69–80	1968
	■	367±8		
78.	◆	1691±90	NGT 49: 257–283	1969
79.	◆	1780±85	NGT 61: 281–290	1981
80.	●	>2750	SGU C 666	1971
81.	●	2200	Prec. Res. 32: 35–44	1986
82.	●	2834±40	GFF 101: 169–171	1979
83.	●	1874±10	GFF 103: 317–329	1982
84.	●	1847±10	GFF 103: 317–329	1982
	◆	1700±200	GFF 101: 131–137	1979
	■	c. 1550	GFF 101: 131–137	1979
85.	■	1617±107	GFF 101: 131–137	1979
86.	●	1880±28	GFF 101: 131–137	1979
	◆	1915±145	GFF 101: 131–137	1979
	■	1550±40	GFF 101: 131–137	1979
87.	●	<2063	GFF 103: 17–25	1981
88.	●	2700	GFF 103: 17–25	1981
89.	●	1832	The Explanation to the General Map of Finland, Sheet B 8, Enontekiö: 15	1976
90.	●	1772±10	GSF 337:20	1986
91.	●	1909±17	Prec. Res. 26: 1–13	1984
92.	◆	1600±90	SGU C 666	1971
93.	▼	1932±45	Prec. Res. 26: 1–13	1984
94.	●	1570±65	SGU C 666	1971
95.	◆	>1688	GFF 103: 317–329	1982
96.	●	c. 1860	GFF 103: 317–329	1982
97.	●	c. 1860	GFF 103: 317–329	1982
	◆	1777±98	GFF 103: 317–329	1982
98.	●	c. 1860	GFF 103: 317–329	1982
	◆	1725±16	GFF 103: 317–329	1982
99.	●	c. 1860	GFF 103: 317–329	1982
	◆	1707±17	GFF 103: 317–329	1982
100.	◆	1780±50	SGU C 666	1971
101.	●	c. 1795	GFF 103: 317–329	1982
102.	◆	1505±30	GFF 94: 229–244	1972
103.	●	1873±23	GFF 103: 17–25	1981
104.	●	1892±6	Explanation to the maps of Pre-Quaternary rocks, Sheet 2723 Muonio: 59	1984
105.	●	2591±16	Explanation to the maps of Pre-Quaternary rocks, Sheet 2723 Muonio: 59	1984
106.	●	2027±33	GSF 318: 52	1982
107.	●	1780	Jatulian geology in the eastern part of the Baltic Shield: 145–151 ISBN 951–46–4848–X	1980
108.	●	1885	Jatulian geology in the eastern part of the Baltic Shield: 145–151 ISBN 951–46–4848–X	1980
109.	●	1885	Jatulian geology in the eastern part of the Baltic Shield: 145–151 ISBN 951–46–4848–X	1980
110.	●	2136±16	GSF 337:20	1986
111.	●	2132	Explanation to the maps of Pre-Quaternary rocks, Sheets 3713 and 3714 Sodankylä and Sattanen: 48	1983
112.	●	3110	Contrib. Mineral. Petrol. 76: 33–41	1981
113.	●	2435	Prospecting in areas of glaciated terrains. Instn. Min. Metall. London: 6–13	1977
114.	●	2150	17e Nordiska Geologmötet. Abs.: 166	1986
115.	●	2730	GSF 281: 109	1976
116.	●	378	Geol. Soc. Finland, Bull 46: 81–91	1981
117.	◆	1694±73	J. Geol. Soc. Lond. 129. 365–387	1973
118.	◆	440±30	NGU: 339:27–40	1985
119.	◆	742±43	J. Geol. Soc. Lond. 129: 365–387	1973
120.	◆	424±11	Terra. Cogn. 1: 82	1981
121.	◆	1530±25	GFF 94: 229–244	1972
122.	◆	1530±35	SGU C 666	1971
123.	◆	1530±35	SGU C 666	1971
124.	■	1875	Bull. Geol. Soc. Finland 44: 35–46	1972
125.	●	>1860	Prec. Res. 26: 1–13	1984
126.	◆	1780±50	SGU C 666	1971
127.	●	2400	17e Nordiska Geologmötet Abs.: 166	1986
128.	●	1843±23	GSF 337:22	1986
129.	●	2216	Bull. Geol. Soc. Finland 54: 92	1981
130.	◆	362±50	NGT 62: 219–224	1982
131.	■	491±8, 447±7	Geol. Soc. Am. Bull. 97: 26–34	1986
	◆	436±7		
132.	◆	447±7	GFF 101: 353–356	1979
133.	◆	447±7	GFF 101: 353–356	1979
134.	■	511, 447	Thesis, Univ. Leiden	1979
135.	◆	438±6	Am. J. Sci. 274: 1–9	1974
136.	◆	1590±35	SGU C 731	1977
137.	●	1864±20	Earth Planet. Sci. Lett 72:376–388	1985
	◆	1535±35		
138.	◆	1590±45	SGU C 666	1971
139.	◆	c. 1700	SGU C 731	1977
140.	◆	1780±50	SGU C 666	1971
141.	◆	1875±20	GFF 100: 171–176	1978
142.	●	2010±40	GFF 100: 171–176	1978
	◆	1885±117	GFF 100: 171–176	
143.	◆	1780±50	SGU C 666	1971
144.	◆	1688	GFF 103: 317–329	1982
145.	●	c. 1795	GFF 86: 33–50	1964
146.	◆	1772±20	GFF 99: 76–79	1977
147.	◆	1780±50	SGU C 666	1971
148.	◆	c. 1840	GFF 92: 336–346	1970
149.	●	1891±11	GSF Rept. of inv. 76: 32	1987
150.	●	2440	Contrib. Mineral. Petrol. 78: 285	1981
151.	▼	2090±70	GSF 337: 25	1986
152.	●	1770	Bull. Geol. Soc. Finland 54: 94	1982
153.	●	430	Can. J. Earth Sci. 7:22–28	1970

The topographic base has been compiled by the Publications Division of the National Board of Survey of Finland in cooperation with the National Land Survey of Sweden and the Geographical Survey of Norway. Lambert conformal conical projection. Standard parallels 54° N and 68° N, centre meridian 18° E. Lat=66° N and long=18° E correspond to x=8472.976; y=1000.000.

Det topografiska underlaget har sammanställts av Lantmäteristyrelsens karttryckeri i Finland i samarbete med Lantmäteriverket i Sverige och Norges Geografiske Oppmåling. Lamberts konforma koniska projektion. Standardparalleller 54° N och 68° N, medel meridian 18° E. Lat=66° N och long=18° E motsvarar x=8472,976; y=1000,000.

This map is a result of the Nordkalott Project, a joint venture (1980–1986) between the Geological Surveys of Finland, Norway, Sweden and Greenland (Denmark) to define ore provinces in Fennoscandia north of latitude 66°N by means of regional geological, geophysical, geochemical and remote sensing methods. Project leader: G. Kautsky.

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