Royal Norwegian Council
for Scientific and Industrial Research
(NTNF)

NORSAR

NORSAR Scientific Report No. 1-91/92

Semiannual Technical Summary

1 April — 30 September 1991

Kjeller, November 1991

7.7 Contemporary seismicity of the NW part of the USSR

Introduction

The regional seismic network of the Kola Science Centre began to be established in 1982. Today, 7 seismic stations are used to monitor the seismic activity of the Barents Sea and the NW part of the USSR. The station list is shown in Table 7.7.1. All stations are equipped with short-period seismometers with photo sensitive analog recording, and paper speed 60 mm/min. A three-component digitally recording station has recently (June 1991) been installed in Apatity. For better location of seismic events in the Barents Sea platform, data from the seismic station KHE in Franz Josef Land (80.37°N, 58.03°E) are used, even though this station is not part of the network.

Strong earthquakes are known from as far back as the 17th century for the eastern Baltic Shield (T. Ahjos and H. Korhonen, 1984), and before the seismic networks in this region were installed, it was suggested that only large earthquakes could take place here, because the crust of the rigid ancient shield was believed not to be able to produce many small earthquakes (e.g., Panasenko, 1969). Now this opinion has been revised.

The contemporary seismicity in northern Europe is shown in Fig. 7.7.1. Most of the earthquakes shown are for the past 30-year period, but some historical epicenters are also included, dating back as far as the year 1542. The earthquake activity is characterized by small and moderate size earthquakes. The largest earthquake in the Baltic Shield in recent years was the m_L = 5.2 event of 20 May 1967, located at 66.6°N, 33.7°E (Meyer and Ahjos, 1985). It was felt with MSK intensity VII in Karelia, and generated a small tsunami in the White Sea.

The main seismic zones of the Kola Peninsula are seen more clearly when considering only the time interval 1986 to 1991. They comprise the Kola-Finnmark zone and the Khibiny Massif (Fig. 7.7.2).

The Kola-Finnmark zone

Information about the seismicity of the Kola-Finnmark zone was known already from 1772 when an earthquake with maximum intensity VI took place near Murmansk (68.7°, 33.3°E). The largest earthquake known in the Kola-Finnmark zone (Kola Peninsula) during this century occurred on 10 April 1981 (68.8°N, 36.0°E). The magnitude estimated for this event ranges from 4.5 M_L (Upp) to 4.7 m_b (ISC). The 1981 earthquake had two shocks about 10 seconds apart and was felt with intensity V at Murmansk.

During 1986-1990 some tens of events were registered from the Kola-Finnmark zone. One of the larger of these was the earthquake that occurred on 16 June 1990 (69.14°N, 35.15°E) with M_L = 4.0, which was felt with intensity IV at Murmansk.

The seismicity of the Murmansk-Finnmark zone is largely confined to intersections of faults separating the Murmansk Block from the South Barents Sea platform, i.e., the so-called Karpinsky lineament, and to NS-trending faults which are clearly discerned from

Landsat imagery (Fig. 7.7.3). Fig. 7.7.4 presents a fragment of the neotectonic framework for these earthquakes.

The Khibiny Massif

In the last several years there has been a great increase of induced seismicity in the Khibiny Massif. This began to manifest itself after large volumes of rocks had been extracted from a high-stress environment. Fig. 7.7.5 demonstrates the position of the five main mines of the Khibiny Massif (a) and allows a comparison of the quantity of rock removal with the number of Khibiny earthquakes per year (b).

Exploration of the Khibiny apatite deposits was started in 1929. At the present time the production is more than 50 mill. tons per year. The first earthquake on record in the Khibiny area occurred on 23 September 1948 and was felt with intensity IV in populated areas.

The largest earthquake in Khibiny took place on 16 April 1989 ($M_L = 4.2$). This event was felt with intensity VIII in the upper levels of the Kirovsk mine and caused considerable destruction. The maximum measured displacement was 15-20 cm and it occurred along a fault striking at 125-135^o and dipping at 30-35^o NE. This displacement was traced along the surface for 1200 m and observed to a depth of at least 220 m.

The earthquake was felt with intensity V-VI in the Kirovsk area, and it was followed by several hundred aftershocks during the next two months. The earthquake on 16 April 1989 occurred simultaneously with a 240 ton explosion in one of the Kirovsk mines. It thus appears that the explosion triggered the earthquake. Supporting this assertion is the observation of analogous events at the Kirovsk mine on 29 August 1982, when an earthquake with maximum intensity VI took place at the same time as a large explosion. A similar pair of events occurred on 28 March 1991.

The location of mines and earthquakes relative to each other is shown in Fig. 7.7.6.

NE Archangelsk and Novaya Zemlya

The seismic station Amderma (AMD) began operation in 1983 (see Fig. 7.7.7). The station was established to study seismic activity of the Barents Sea Platform. The first investigations identified two zones of weak seismic activity in the NE Archangelsk region (Assinovskaya, 1989). The shaded area in Fig. 7.7.7 shows the seismic zone to the southeast of Amderma. No definite information exists about the nature of the events recorded in this region, but neotectonic conditions are consistent with this zone being seismically active.

A seismically active zone has also been found on Novaya Zemlya. Of particular interest is the earthquake on 1 August 1986 with $m_b = 4.6$ near the south coast of the Matochkin Shar strait. The location of this event is shown in Fig. 7.7.8 together with the system of lineaments and faults. There were at least four more earthquakes in this area, information about which has been included in Table 7.7.2.

In conclusion, we find that the seismicity of the NW part of the USSR is characterized by clustering of the most intense earthquakes at sites of intersections of NS and EW trending fault zones.

E.O. Kremenetskaya, Kola Science Centre, USSR

References

Ahjos, T. and H. Korhonen (1984): On a catalogue of historical earthquakes in Fennoscandian area. 24 pp.

Assinovskaya, B.A. and E.R. Acselevich (1989): Results of studies of seismicity in SE Barents Sea. **In:** *Geophysical Research of the Lithosphere of North European Part of the USSR.* Apatity, 41-48.

Meyer, K. and T. Ahjos (1985): Temporal variations of energy release by earthquakes in the Baltic Shield, *Geophysica,* 21, 51-64.

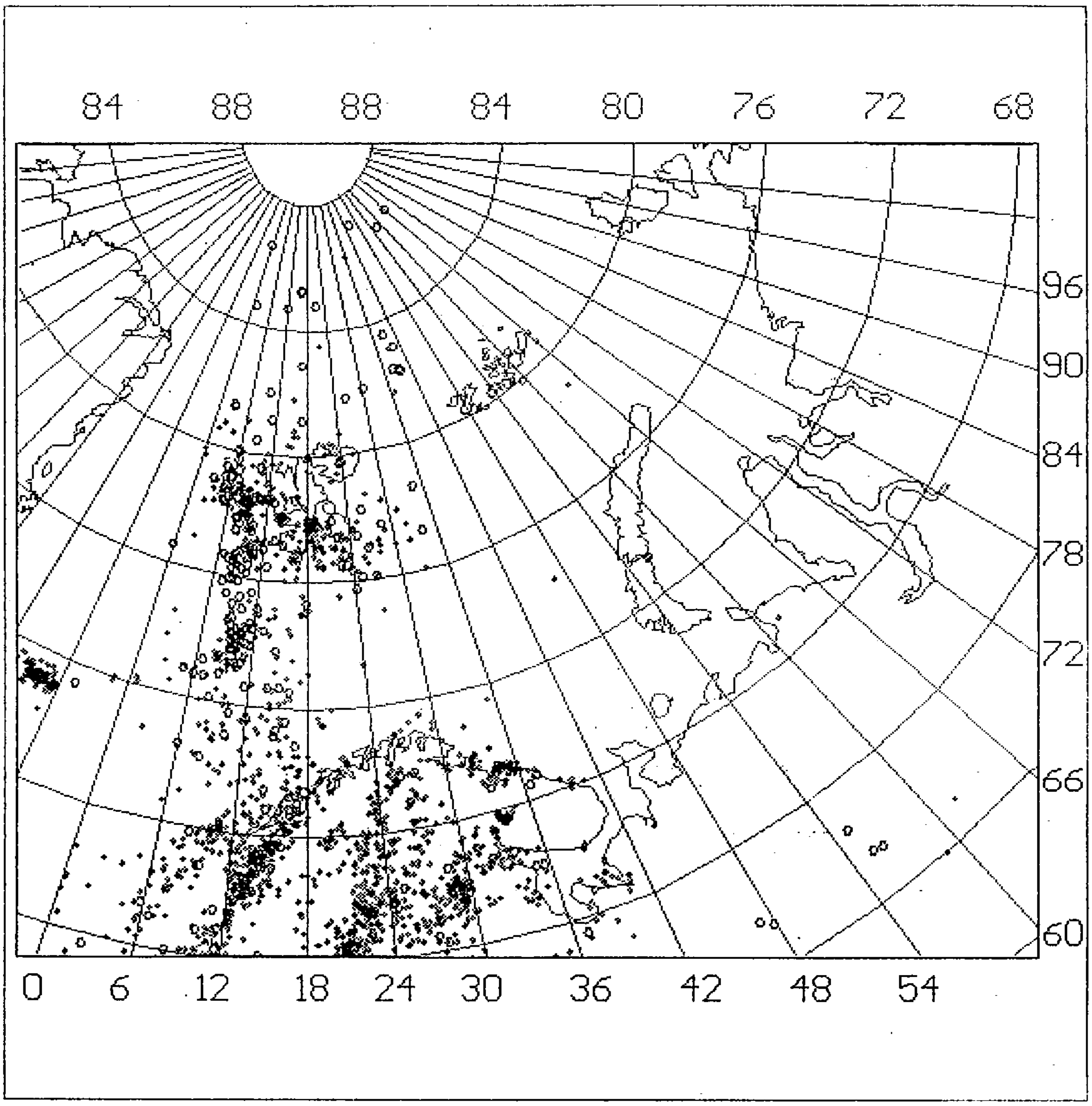
Panasenko, G.D. (1969): Seismic features of the north-east Baltic Shield, Nauka, Leningrad, 184 pp (in Russian).

Name	Coordinates	
APA	67.568N	33.388E
AMD	69.742N	61.655E
BRB	78.073N	14.240E
PLZ	67.400N	32.533E
PLQ	66.410N	32.750E
PLG	62.320N	36.930E
KEM	64.956N	34.635E

Table 7.7.1. List of seismic stations operated by the Kola Science Centre.

Date	Time	Coordinate N	Coordinate E	m_b
20.07.83	015941.7	73.2	56.3	-
31.01.86	110813.0	73.2	56.3	2.1
21.04.86	093753.9	73.2	56.3	3.2
01.08.86	135636.8	73.18	56.32	4.6
29.12.86	034407.4	-	-	3.0

Table 7.7.2. Recent earthquakes in Novaya Zemlya.



· – $m < 4.0$
○ – $m \geq 4.0$

Fig. 7.7.1. Epicentral map of earthquakes in the European Arctic region. Most of the earthquakes shown are from the period 1960-1990, but some earlier events have been included.

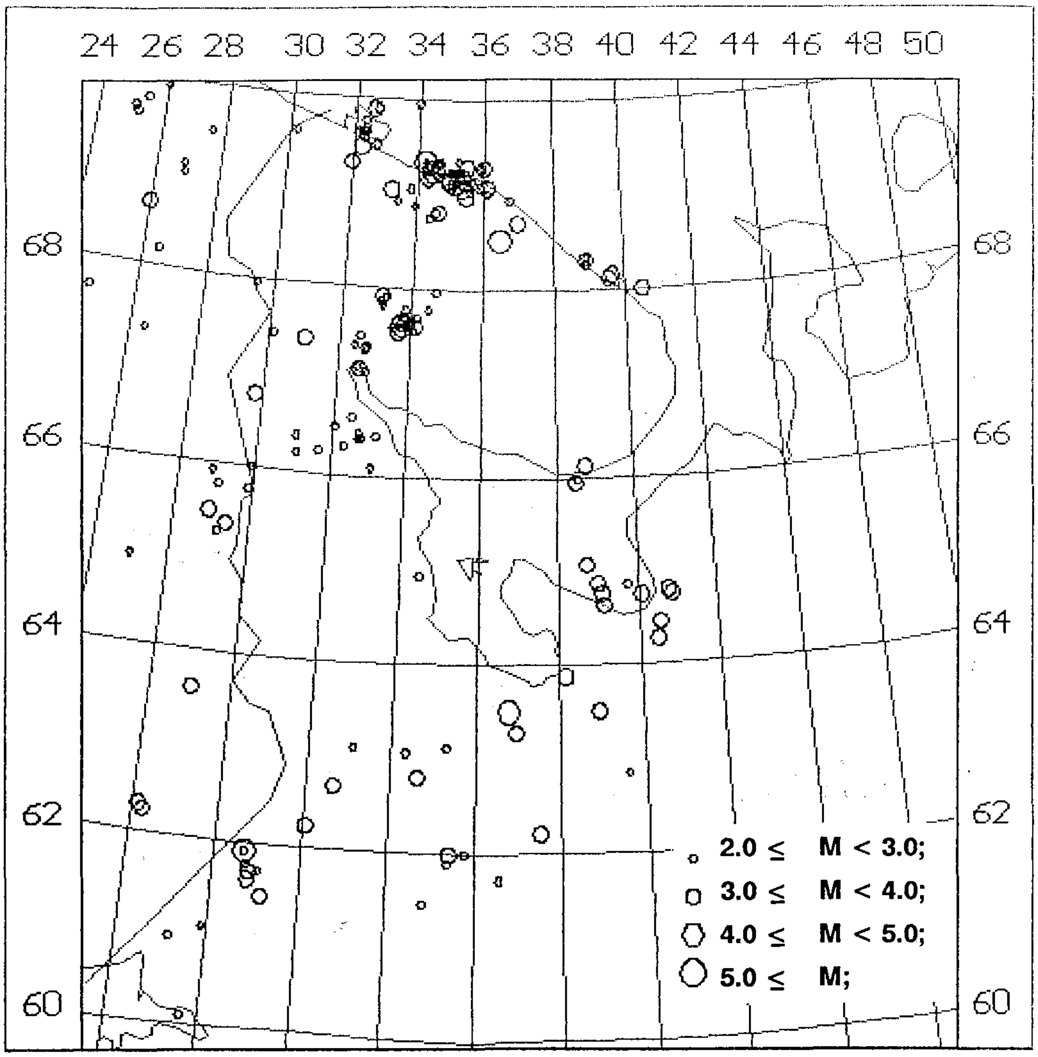


Fig. 7.7.2. Epicentral map of earthquakes of the eastern part of the Baltic Shield 1986-1991.

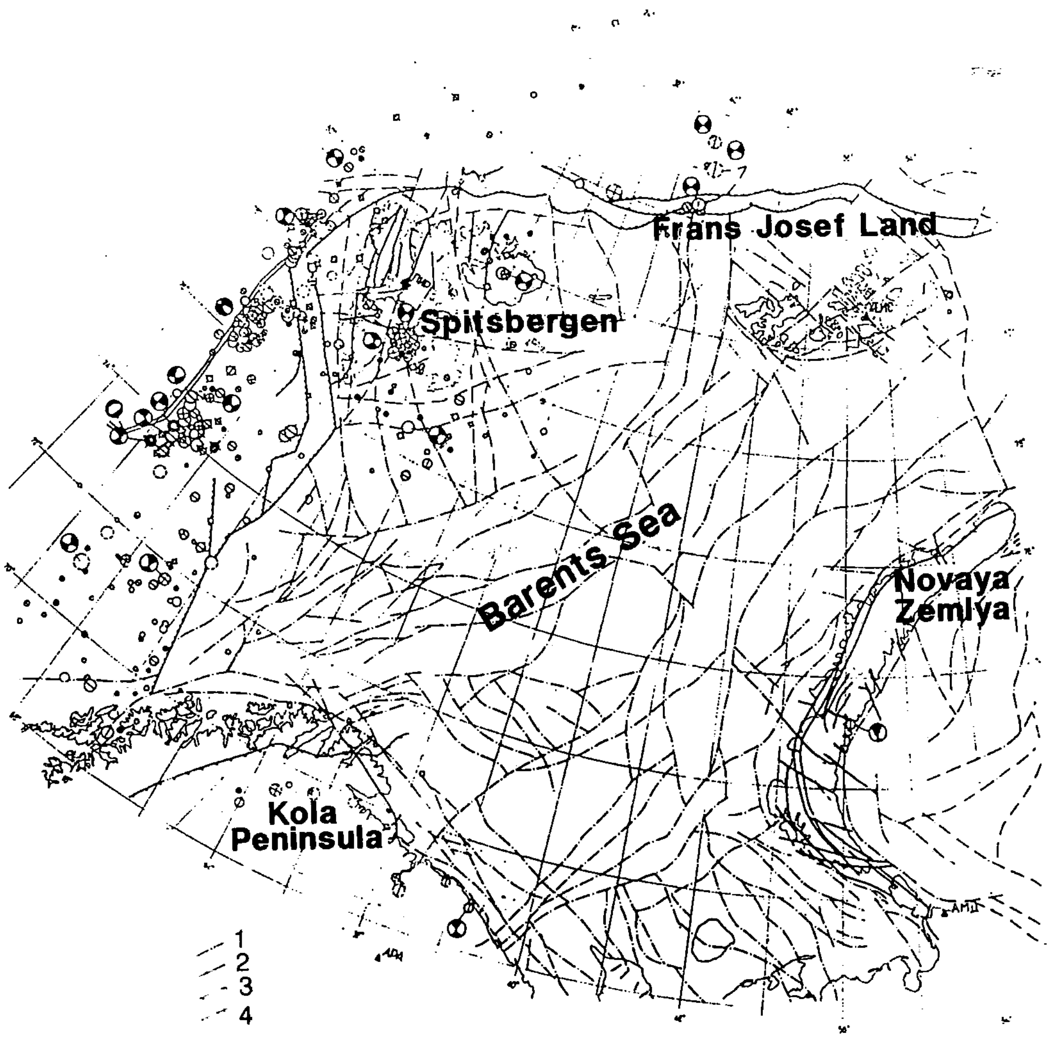


Fig. 7.7.3. Epicentral map of earthquakes of the Barents Sea with tectonic features: 1) faults from geophysical data; 2) faults from geological data; 3) thrusts; 4) dislocations.

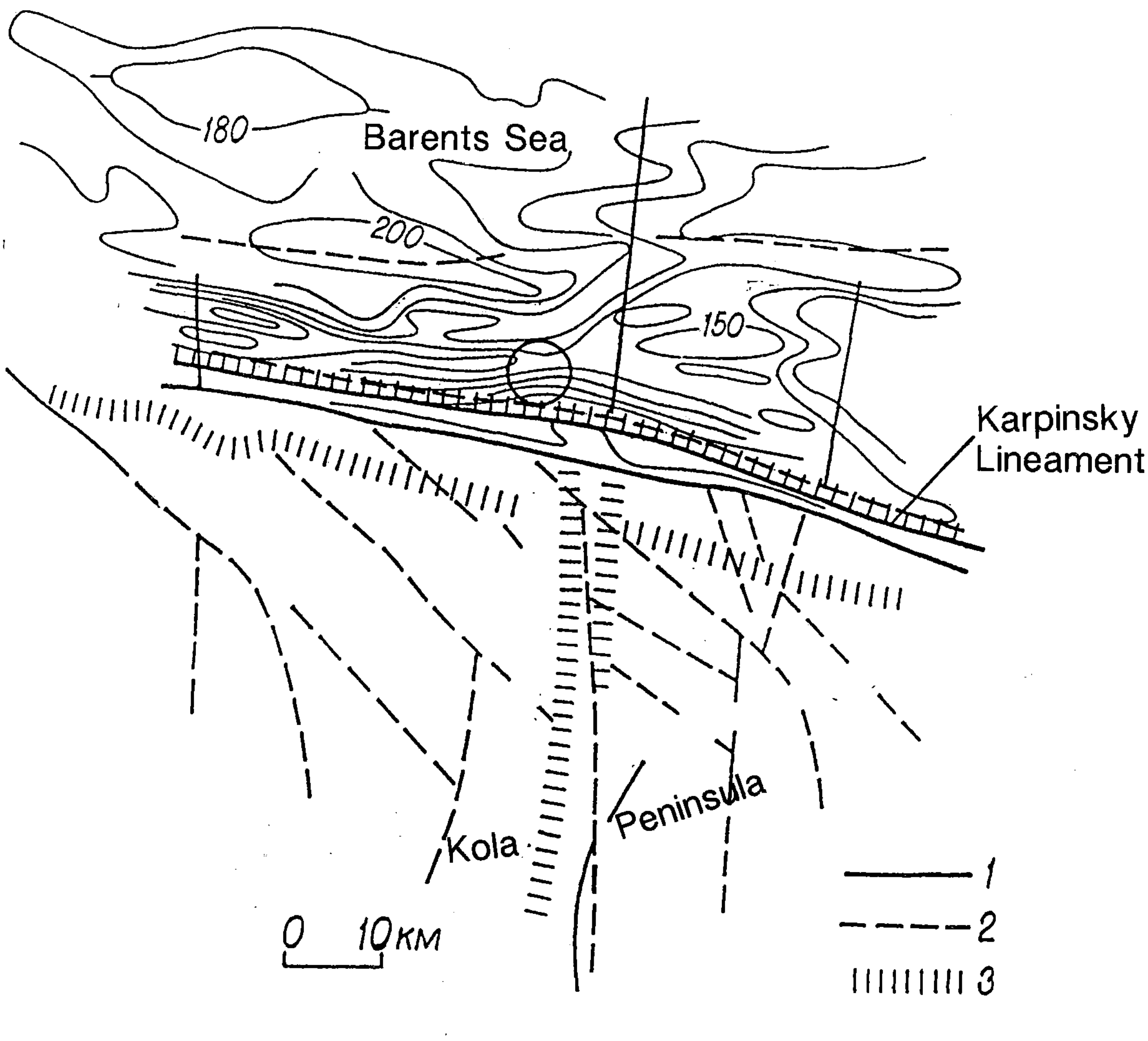
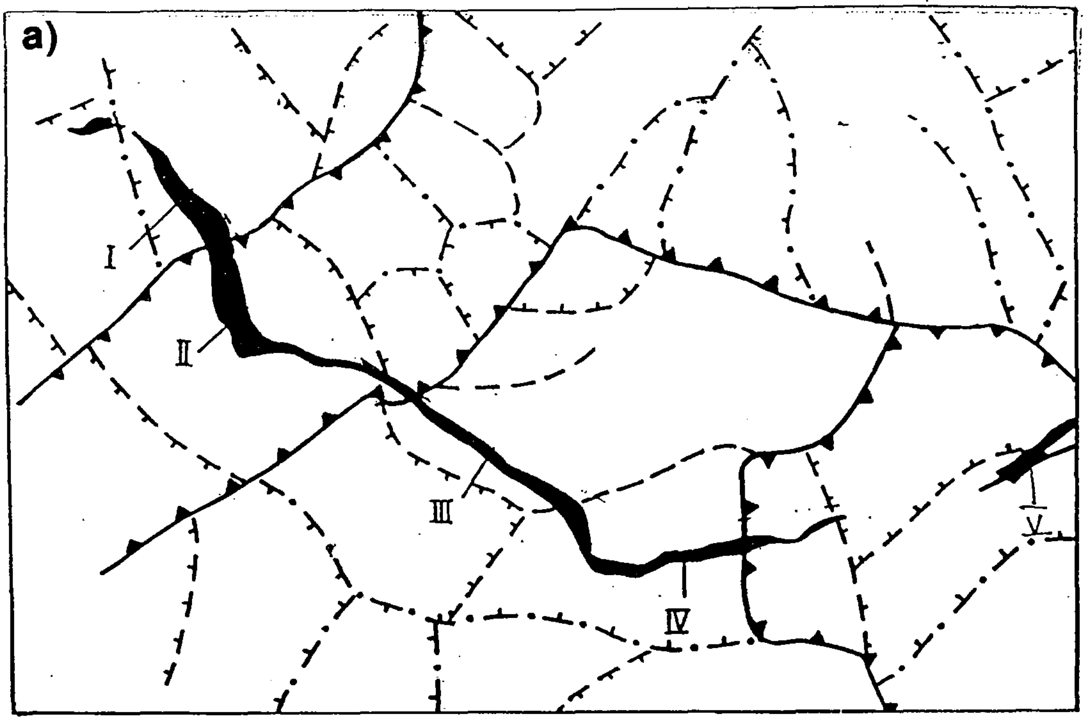


Fig. 7.7.4. Neotectonic framework for earthquakes of the Murmansk coast: 1) faults from geophysical data; 2) dislocations; 3) deep structures. The epicenter of the earthquake of 10 April 1981 discussed in the text is marked as a circle near the center of the map.



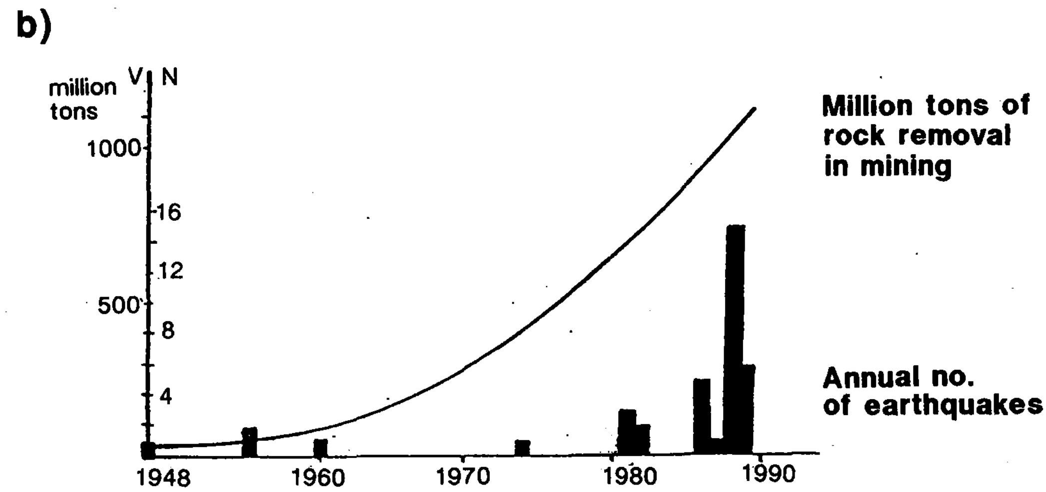


Fig. 7.7.5. a) The position of mines (I-V) in the Khibiny Massif together with fault structures. b) The relation between removed rock per year (1) and the number of earthquakes (2).

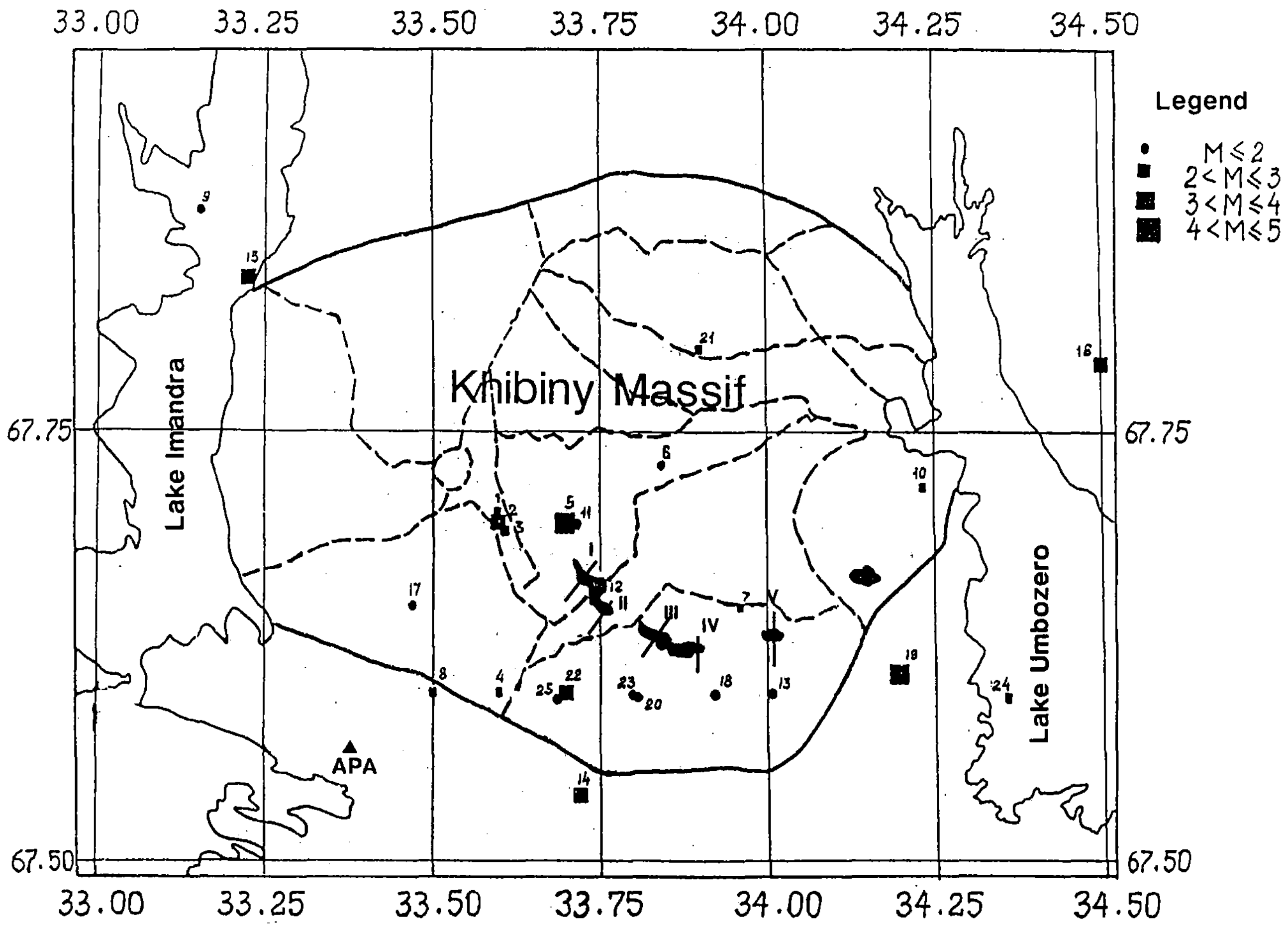


Fig. 7.7.6. Relative position of earthquakes and mines in the Khibiny Massif. The location of the Apatity seismic station (APA) is also shown. The mines (I-V) are shown in more detail in Fig. 7.7.5.

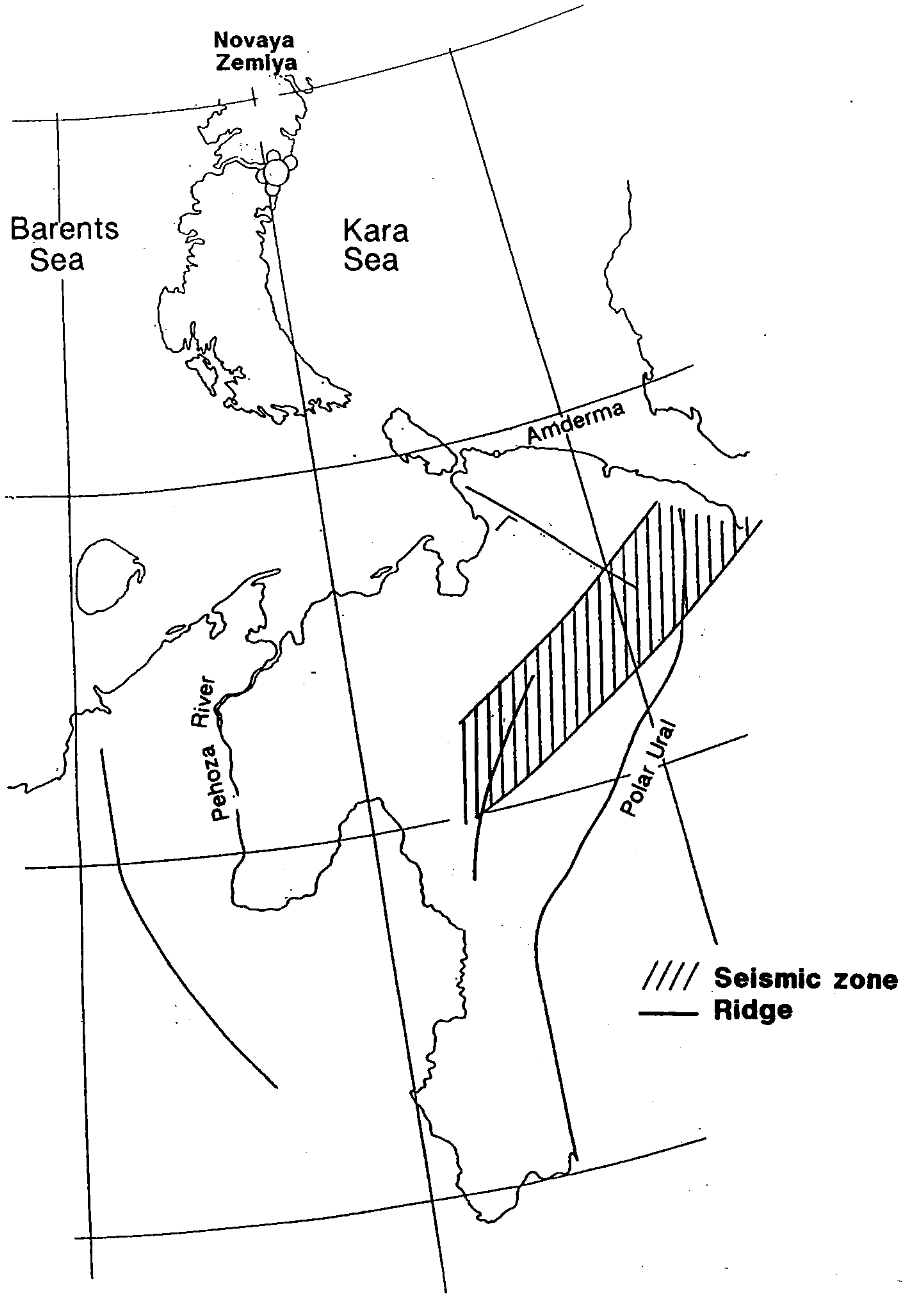


Fig. 7.7.7. The seismic zone southeast of Amderma. Epicenters of the Novaya Zemlya earthquakes (Table 7.7.2) are also shown.

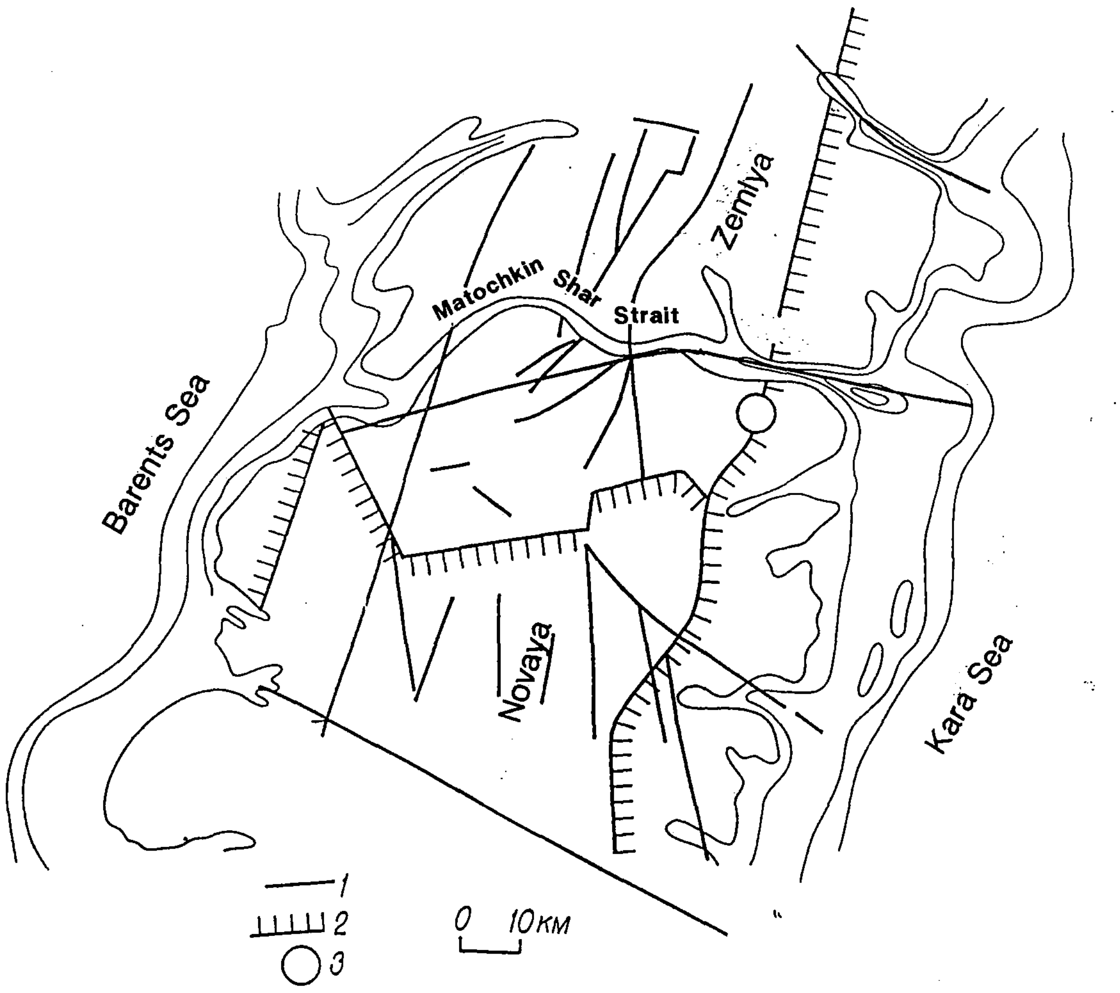


Fig. 7.7.8. The position of the earthquake of 01.08.86 with some neotectonic features: 1) faults; 2) boundaries of blocks; 3) epicenter.