

Svekalapko Deep Seismics

Roland Roberts (Dept. of Earth Sciences, Uppsala University, Sweden)

The most important aim of the SVEKALAPKO Deep Seismic project is to elucidate the present-day structure and previous evolution of the deep lithosphere-asthenosphere system. Studies and correlation of large-scale lithospheric and crustal structure and development are in this context strongly related. Crustal studies provide an important key to understanding the evolution of the deeper structure and, conversely, a better understanding of the large-scale system will assist in correctly interpreting the crustal data. Crustal geological, geophysical, geochemical and geothermal studies are therefore also an important part of this project. The Deep Seismic results will undoubtedly play a key role in the interpretation of the large-scale structure and evolution of the SVEKALAPKO area.

Field campaign

During the autumn and early winter of 1998 about 150 mobile seismological recording instruments will be deployed in Finland and Northern Russia, about 50 of these being broad-band stations. Recording stations will be deployed by groups from Finland (Helsinki and Oulu Universities), Germany (GFZ, Potsdam and Stuttgart), Sweden (Uppsala University), Switzerland (ETH, Zurich), France (Fourier University, Grenoble and the University of Strasbourg), Poland (Warsaw University), Czechia (Academy of Sciences, Prague) and Russia (Academy of Sciences, Moscow and Apatity). In addition, several temporary stations are already being operated in the SVEKALAPKO area by the University of Utrecht, and these will remain in place during the SVEKALAPKO project. The seismological antenna so constructed will operate until the spring of 1999. Investigations will be concentrated on the analysis of signals from distant (teleseismic) earthquakes, but local and regional events will also be recorded and can be included in the analysis where appropriate. Several hundred suitable events are expected to be recorded.

Tomographic inversion

After initial data preparation and pre-processing, the arrival times of the first P-wave arrival at each station and for each event will be extracted from the data. This data will then be used with tomographic inversion techniques to reveal the seismic P-wave velocity structure down to 400km depths below the SVEKALAPKO area. A similar analysis of the first S-wave arrivals will reveal the corresponding S-wave velocity structure. Poisson's ratio, derived from com-

parison of P- and S-wave velocities can then be estimated. This is a powerful determinant for composition and physical state of the rocks at depth. To constrain crustal structure, existing crustal refraction data from the whole area will be re-examined and interpreted in a consistent and integrated manner.

Surface-wave and body-wave waveform analyses

Because of the large number of broad-band instruments in the array, it will be possible to carry out detailed studies of surface waves to reveal the velocity structure at several hundred kilometres depth. These broad-band stations also allow the application of sophisticated body-wave waveform analysis methods, including the receiver function method. This type of analysis is a recent development which can assist in recovering more detailed structures than would be possible with tomographic inversion and surface wave studies alone. The method identifies phases which are converted (from P- to S-waves) at velocity contrasts below the recording site. It is therefore sensitive to boundaries, and complements the tomographic techniques from which average velocities are derived.

Almost all stations will record three-component data. Anisotropy related e.g. to present-day or ancient stress regimes produces a distinct pattern in the polarisation characteristics of shear-wave data. Therefore analysis of S-wave polarisations can provide information about anisotropy and thus the stress regime.

Micro-array studies

Modern small-aperture seismological arrays are known to be an effective tool for remote monitoring of weak seismic events of different origin. As an example, mini arrays NORESS, FINESS and ARCESS monitor the local seismicity of the whole of Scandinavia. Besides being useful in the location of local events, small-aperture arrays provide data on parameters of small-scale velocity heterogeneity and attenuation losses, including scattering and absorption in the upper lithosphere. It is planned to deploy two broad-band micro-arrays in Finland, and also a short period small aperture array in Northern Russia.

Integrated analysis and interpretation

At a later stage, combined analyses including other types of data will be carried out. This will entail

the combination of some types of geophysical data in sophisticated numerical joint inversion schemes. These may include e.g. gravity, topography and seismic data. Results will also be correlated and integrated with other types of geological and geophysical data such as results of the large-scale magnetotelluric experiment which has been carried out in June/July 1998 and is described in this issue.

Research Results

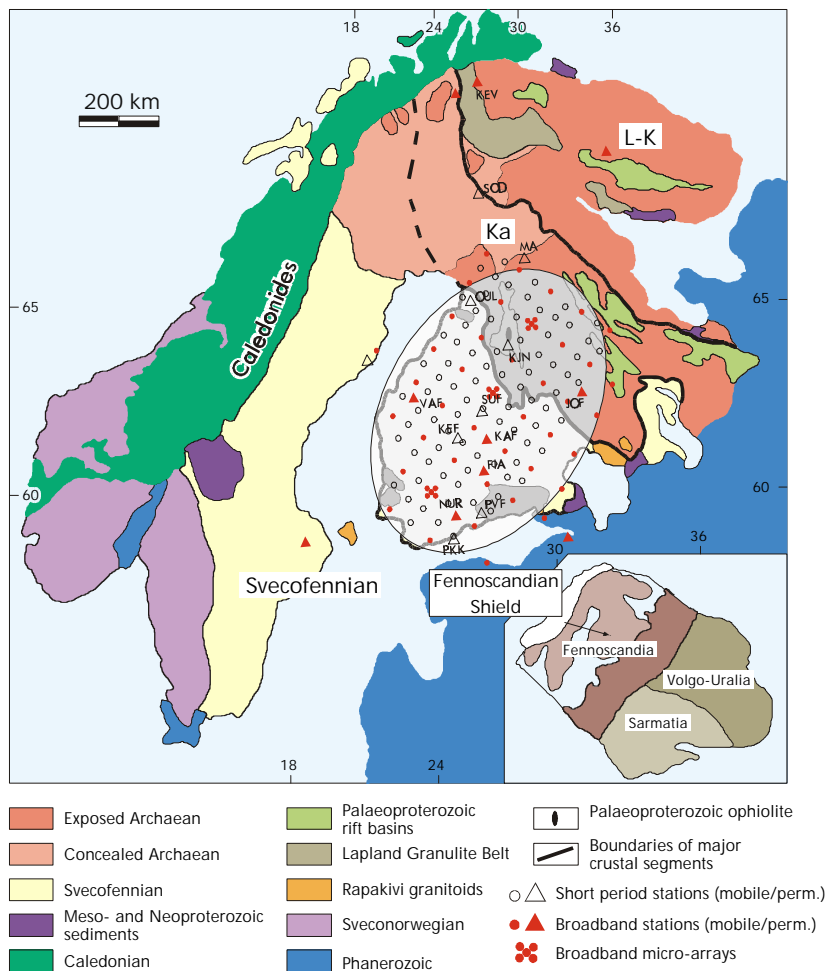
Central questions to be addressed by the SVEKALAPKO project, and to which we hope to find answers, are:

1. What are the actual properties and structure of the lithosphere-asthenosphere system beneath the central Baltic (Fennoscandian) Shield?
2. When was the thick crust and lithosphere formed

and how did the crust originate?

3. How could the lithosphere become and stay over at least 1Ga as thick as it is supposed to be?
4. Why has the crustal burial and relaxation history been so varied across the area?
5. What was the plate-tectonic setting of the northern Baltic Shield in the Proterozoic?
6. Are the variations in crustal thickness reflected in the shape and thickness and internal structure of the lithosphere and how does this influence present-day plate-tectonics?

To attempt to answer these questions, it will be necessary to collate the data and results from many different geological and geophysical methods. It is, however, clear that the deep seismic data is of fundamental importance when addressing all of the major questions listed above.



Simplified geological map of the Baltic Shield and surrounding (modified from Boyd et al., 1985 (General geological map of the Baltic Shield; Geol. Survey of Finland, Bull. 333, appendix) and Öhlander et al., 1993 in Gorbatshev, 1993 (The Baltic Shield. Precambrian Research 64 (Spec. Vol.), 430 pp.); inset showing the subdivision of the East-European Craton from Gorbatshev and Bogdanova, 1993, in Gorbatshev, 1993). Generalised tectonic boundaries between the Lapland-Kola Orogen (L-K) and the Karelian Province (Ka) and between the latter and the Svecofennian Orogen are shown as heavy lines. The light ellipse indicates the principal area of deployment of seismic stations. Note, however, a series of mostly permanent stations outside this area which increase the size of the seismic antenna with lower resolution.