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Solving Problems of Lithosphere: The First Finnish Workshop on the Global Geoscience Transect (GGT) Project

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Abstract

The Finnish contribution to the GGT (Global Geoscience Transect) project concentrates on the SVEKA profile, crossing 600 km of Precambrian bedrock in the central Fennoscandian Shield. The first national meeting was arranged as a workshop at the University of Turku in April 14-15, 1992. More than 40 geoscientists participated in the workshop and 24 oral and 1 poster presentation were given. Geophysically the Finnish project includes deep seismic soundings, teleseismic studies, lithospheric EM soundings, heat flow studies, palaeomagnetic studies, gravity, magnetics and petrophysical studies. The geological studies include tectonics, metamorphism, geochemistry and geochronology. The SVEKA transect provides a unique opportunity to study the structure, development and present state of lithosphere in a shield area with bedrock ages ranging from Archaean (2800 Ma B.P.) to Middle Proterozoic (1200 Ma). We present a summary of the papers presented and discussed in the workshop.

Introduction

The Finnish GGT Project is one of the many geotransect studies presently carried out in different parts of the world in a framework provided by **ILP (International Lithosphere Program)** arranged by IUGG (International Union of Geodesy and Geophysics) and IUGS (International Union of Geosciences) (*Monger*, 1986). The project is supported by the Academy of Finland. At the moment six research institutes, universities and companies are involved in the project: the Geological Survey of Finland (GSF), University of Helsinki (UH), University of Oulu (UO), University of Turku (UT), Åbo Akademi (ÅA) and Outokumpu Finnmines Ltd (OKU). The project is planned to be carried out in 1992-96.

The first national workshop of geophysicists and geologists involved in the GGT project was held at the University of Turku in April 14-15, 1992. The workshop was hosted

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by the Department of Geology and Mineralogy of UT (H. Papunen). The meeting aimed at bringing together people working in different disciplines but with a common objective, the structure and evolution of the lithosphere in the central part of the Fennoscandian Shield. The 600 km SVEKA profile has been chosen as the Finnish GGT geotransect. It is a part of the suggested GISK Geotransect running from Greenland through Iceland, Scandinavia and Finland to the Kola Peninsula (Fig. 1).

The presentations were divided into four categories: 1) general studies (the whole SVEKA profile); 2) studies in regional and local scales; 3) studies in the Tampere-Vammala area; and 4) studies in southwestern Finland.

We present a brief summary of the papers presented at the workshop. More detailed information can be found in the volume of extended abstracts (*Papunen*, 1992) and in a summary by *Nironen* and *Pajunen* (1992).

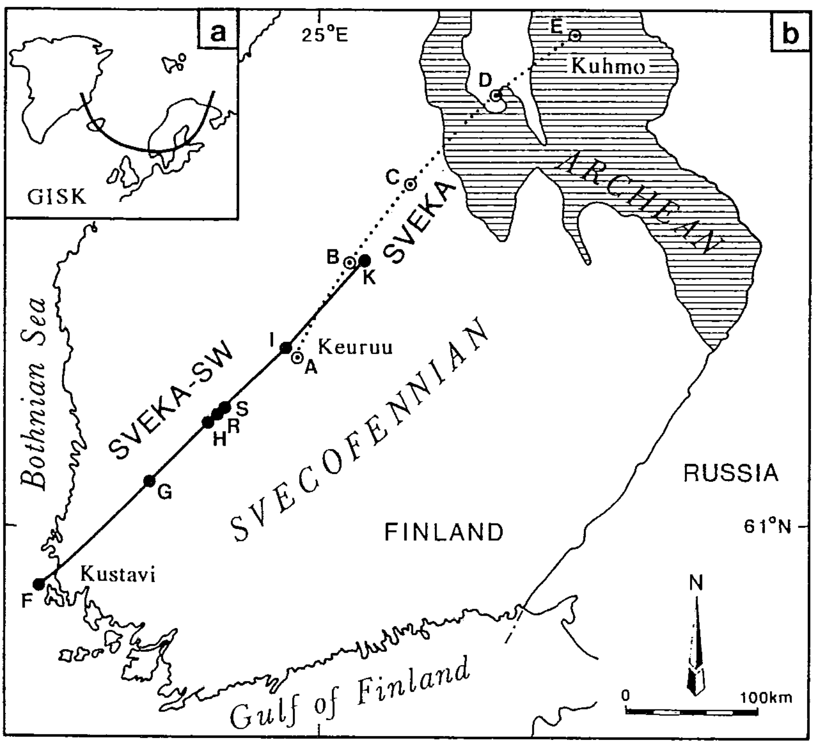

Fig. 1. a) The suggested location of the GISK (Greenland-Iceland-Scandinavia-Kola) geotransect of which the SVEKA profile is a part; b) The location of the SVEKA profile. Letters A to S denote DSS shot points. The stippled line indicates the original SVEKA profile shot in 1981 and the solid line the continuation (SVEKA-SW) to the southwest which was shot in 1991.

General studies

A general overview of the GGT project and geology of the SVEKA profile was given by K. Korsman (GSF). The Sveka profile is characterized by a thick crust, with Moho depths ranging from about 48 km in the southwest to 58 km in the northeast. The evolution of the lithosphere has involved periods of rapid formation of new crust and anomalously high input of heat during metamorphic episodes.

Seismic studies on the Sveka profile were started already in 1981 when the SVEKA profile was shot. A review of SVEKA and other deep seismic soundings in the Fennoscandian Shield was given by H. Korhonen (UH). In 1991 a continuation of the "old" SVEKA profile was shot to southwest (SVEKA-SW in Fig. 1). Thus the SVEKA profile runs about 600 km from the coast of the Bothnian Sea to inland in the northeast near Finnish-Russian border (Fig. 1). U. Luosto (UH) reported of the latest interpretations of the DSS soundings. The results indicate a steady increase of Moho depth between shot points F and I. There are also distinct indications of a low velocity layer (LVL) in the upper crust.

According to a teleseismic experiment (P. Mäntyniemi, UH) made in 1989, and to a tomographic interpretation of the recorded seismic events, crustal P-wave velocities are anisotropic in the northeastern end of the Sveka profile. Interpretation of the anisotropy (texture vs. structure) remained open.

The BABEL (Baltic and Bothnian Echoes from the Lithosphere) project has compiled important observations on the seismic structure of the crust under the Bothnian Sea and Bay (P. Heikkinen, UH). These results which are still under processing will certainly be relevant to the SVEKA studies since the southwestern end of SVEKA extends to one of the Babel lines. Reflection data show differences in Moho responses between Bothnian Bay in the north and Bothnian Sea in the south. Horizontal reflectors extending 150-200 km and detected at depths of 9-10 km under the Bothnian Sea were interpreted by Heikkinen as dolerite sills.

Geothermally the Sveka profile is characterized by heat flow density and radiogenic heat production decreasing from the southwest towards northeast (I. Kukkonen, GSF). One-dimensional geothermal models for crustal temperatures indicate Moho temperatures of the order of 400-500 °C. The sensitivity of typical conductive geotherm calculations for convective disturbances in the upper crust was underlined by Kukkonen.

Deep electromagnetic studies (MT and MV) have revealed several crustal conductors and conductive zones in the Finnish bedrock. These results were reviewed by S.-E. Hjelt and T. Korja (UO). A lively discussion emerged on the interpretation of the conductors. Fluids and graphite were the most popular alternatives, but a distinct difference must exist between the nature of conductors in the upper and lower crust.

The crustal thickness variations in the central part of the Fennoscandian Shield area were discussed by A. Korja (UH). The thinner crust in southern Finland was attributed to extensional tectonics during the Middle Proterozoic when the rapakivi intrusions were emplaced. Several alternative models of crustal and lithospheric evolution were presented.

Studies in regional and local scales

The structure and evolution of the Archaean Kuhmo greenstone belt (approximately on the shotpoint E) has been studied by E. Luukkonen (GSF). According to his model the greenstone belt was formed in a riftogenic basin which was compressed in E-W direction. The deformation history is, however, complicated. According to J. Yliniemi (UO) the Moho is about 10 km deeper on the western side than on the eastern side of the Kuhmo greenstone belt.

Complicated metamorphic history has been revealed by J. Paavola and P. Hölttä (GSF) in the Archaean granulite blocks on the Archaean-Proterozoic border (near shot-point D). The granulites represent a very deep section of the crust since they have equilibrated at depths exceeding 25-30 km. The present block structure, nicely revealed by airborne magnetic maps shown by Hölttä, developed about 2300 Ma ago when diabase dykes intruded the granulites.

Geochemistry of the early Proterozoic ophiolite complex of Jormua (near shot point D) was discussed by P. Peltonen and A. Kontinen (GSF). Geochemically the formation resembles present mid-ocean ridge basalts, excluding certain (Th, Ta, Nb) trace element anomalies.

Tampere-Vammala area

Several authors discussed the evolution of the Tampere schist belt (near shot point G). Once again, complicated metamorphic and tectonic histories have been revealed in this area which was metamorphosed in two episodes about 1830-1890 Ma ago. K. Korsman (GSF) and co-workers divided the Tampere-Vammala area into five blocks which show different peak pressure and temperature values. A suture zone running approximately E-W was suggested between the Tampere and Vammala blocks.

The Vammala block, which is known for its Ni-bearing ultramafic intrusions, represents the deepest section in the zone, as reported by P. Peltonen (GSF). Using thermobarometric studies of olivine-spinel mineral pairs and conductive thermal modellings, Peltonen concluded that the intrusions were emplaced during the peak of metamorphism and that the subsequent slow cooling of the intrusions took place together with the surrounding bedrock.

Magnetic maps and petrophysics of the Tampere schist belt shows an interesting dichotomy in its northern border toward the central Finland granitoid complex. Reported by T. Ruotoistenmäki (GSF), the same lithologies on different sides of the border line have distinctly different magnetic susceptibilities and densities. This was attributed to a metasomatic destruction of magnetite by CO_2 bearing fluids on the southern side.

South-western Finland

Gravity studies can be effectively used for estimating the extension and volume of diabase and sandstone in the rapakivi-sandstone area of Satakunta (between shot points F and G). These studies, being a continuation of several other gravity studies by S. Elo (GSF), provide models for the Satakunta sandstone and diabase formation. The present thickness of the Jotnian (appr. 1300 Ma) Satakunta sandstone is 250-400 m as based on gravity interpretations.

Palaeomagnetic studies provide alternative methods to determine emplacement depth of intrusions and their wall rock temperatures. L.J. Pesonen (GSF) and co-workers reported that the method is based on samples collected along a profile perpendicular to an intrusion contact. Measuring the magnetic blocking temperatures and calculating the thermal effect in the wall rock by conductive modelling, the emplacement depth and the wall rock temperature can be estimated.

Anisotropy of magnetic susceptibility of diabase dykes was shown to be a good indicator of magma flow direction (R. Puranen, GSF). The technique is useful in determining whether the anisotropy is due to flow in a molten state or due to later deformation. A case history from the Keuruu dykes (near shot-point A) was discussed.

General discussion

Discussion following the presentations was concentrated on the problems of how to compile the data collected so far and to be collected in the next years. Previous experiences on integrated interpretation of geoscientific data along geotraverses (such as the EGT POLAR profile) indicate that a continuous co-operation is needed between scientists from different disciplines. It was generally accepted that workshops similar to this one are needed annually.

Conclusions

The Turku workshop was a good start for the Finnish GGT project. Several questions arised and many of them were already discussed in the workshop, but still many remain. The authors would like to underline the following points: 1) What are the major unsolved problems along the SVEKA profile? 2) Geotectonic models of the lithosphere are needed for further testing with new data and in planning of new experiments. 3) One of the main aims of the global GGT projects is to produce digital data sets for creating integrated cross-sections of the lithosphere. This work has not yet been started in the framework of the Finnish GGT project.

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