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## Geological model of western Bohemia related to the KTB borehole in Germany

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**Abstract:** The volume presents results of the project "Geological model of western Bohemia in relation to the deep borehole KTB in the FRG" implemented in the years 1991–1994. The project included cooperation of specialists from several geoscience institutions in the Czech Republic, coordinated by the Czech Geological Survey.

A new model of structure and evolution of the Earth's crust in western and southwestern Bohemia is presented, together with 20 specialized chapters on geology and geophysics, which significantly improve our knowledge of the region. Two hundred km long deep reflection seismics line (9HR), reaching from near Kraslice (NW) to Prachatice (SE), was measured and provided information on the structure of the Earth's crust. The region of the project, extending both sides of the 9HR line, is bounded by the state border with the FRG in the SW and by the line Žatec-Přibram in the NE. Several geological units of the internal Variscides comprise the region: the Saxothuringian Zone (Krušné hory Mts.-Erzgebirge), the Mariánské Lázně Complex (MLC), the Teplá-Barrandian Unit (Bohemicum) (TBU), and the Moldanubian Zone. Information was obtained on crustal position of the MLC, its continuation to the SE (beneath the TBU), internal structure of the TBU with numerous SE-dipping reflections, showing vertical extension through much of the crustal thickness, and a probable continuation of the TBU nearly 30 km towards SE from the Central Bohemian Suture beneath the Moldanubian Zone. A remarkable contrast in reflection seismic properties between the TBU and the Moldanubian Zone was observed. Data from the regional geophysical survey including detailed gravimetry and airborne magnetic and radiometric methods are used for the interpretation of geology and structure of the Earth's upper crust.

The geological chapters on the main units integrate results of new geological, tectonic, geochemical, and geochronological study with geophysical data and the previous information. Specialized geophysical chapters present magnetotelluric, deep geo-electrical, palaeomagnetic, seismological and geothermic data and interpretations and results of study of physical properties of metamorphic rocks from the KTB borehole. Geochemical chapters include stable isotope data (C, O, S), mainly from the TBU and the Moldanubian Zone, results of study of palaeofluids preserved as fluid inclusions in rocks and minerals, a review information on epigenetic hydrothermal mineralizations, and data on Sr and Nd isotopic composition of the young basaltic rocks.

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## List of abbreviations

AMS	anisotropy of magnetic susceptibility
AMT	audiomagnetotelluric
BM	Bohemian Massif
CBP	Central Bohemian Pluton
CEU	Cadomian European Unit
D1 – Dn	phase of deformation (1, 2, ...,n)
DSS	deep seismic sounding
F1 – Fn	folding (folds, fold axes) due to n-phase of deformation
Ga	10 <sup>9</sup> years
IAT	island arc tholeiites
IAB	island arc basalts
IV	induction vectors
KTB	Kontinental Tiefbohrung, Continental Deep Borehole
KTB-VB	Kontinental Tiefbohrung – Vorbohrung, Continental Deep Borehole – pilot borehole
KTB-HB	Kontinental Tiefbohrung – Hauptbohrung, Continental Deep Borehole – main borehole
LREE	light rare-earth elements
M-boundary	} Mohorovičić discontinuity, Moho
M-discontinuity	
M-transition	
Ma	10 <sup>6</sup> years
MLC	Mariánské Lázně Complex
MORB	mid-ocean ridge basalts
MPC	Moldanubian Plutonic Complex
MT	magnetotelluric
MV	magnetovariational
N-MORB	normal mid-ocean ridge basalts
OIC	older intrusive complex
P, LP,MP, HP	pressure, low-, middle-, high-pressure
P-T	pressure-temperature
P-T-t	pressure-temperature-time
REE	rare-earth elements
RMP	remanent magnetic polarization
S1–Sn	schistosity due to n-phase of deformation
T, LT, MT, HT	temperature, low-, middle-, high-temperature
TBU	Teplá-Barrandian Unit
WPB	within-plate basalts
YIC	younger intrusive complex
ZEV	Erbendorf-Vohenstrauß zone
ZTT	Teplá-Domažlice zone
503M	} designations of seismic lines
9HR	
VI/70	

Additional abbreviations restricted to a single chapter are explained in the text.

# INTRODUCTION

S. VRÁNA, V. ŠTĚDRÁ

The project "Geological model of western Bohemia in relation to the deep borehole KTB in the FRG" was formulated at the Czech Geological Survey during a preparation period from 1985 to 1990. Several versions of the project submitted before 1989 were not approved by the former Czech Geological Office. The final version of the project for the years 1991–1994 was accepted in 1990 by the Ministry for Environment of the Czech Republic, that completely financed the activities within the project. The Czech Geological Survey co-ordinated all the research, interpretation and publishing works.

The main objective of the studies was formulation of a model of structure and evolution of the Earth's crust in western and south-western Bohemia (Fig. 1) and the improvement of the knowledge of geology and geophysics of the region. The project was drawn up with respect to the location of the borehole KTB 1 near the state border between the Czech Republic and the Federal Republic of Germany (Fig. 2). The KTB locality represents some of the best studied parts of the Earth's crust on the world-wide scale. This is expressed in the large numbers of samples analyzed, the complexity of methods used, and also the advanced state of geoscience emerging from these efforts. The implementation of our project in the years 1991–1994 used the advantage of the temporarily increased interest in geology of the border region in northern Oberpfalz, northern Bavaria and western Bohemia. An evaluation and integration of the relevant geological and geophysical information, obtained in the KTB Program, was therefore also one of goals of the project, comprising co-operation of several geoscience institutions in the Czech Republic.

The program KTB in the FRG, as a German national research program, involved participation of foreign and international drilling companies contributing some of the most advanced technologies. Scientists from number of countries took part in the program. The results of the German KTB program are contained in the series of Reports published by the Niedersächsische Landesamt für Bodenforschung, Hannover, and in a large number of individual papers referenced in a special bibliography volume (Lauterjung 1991). The bilateral exchange of the information on the main geological units occurring near the borehole and both sides of the state border was of considerable significance. A bilateral agreement on scientific and technical co-operation, "Erkundung und Modellierung der Mitteleuropäischen Erdkruste im Umfeld des Kontinentalen Tiefbohrprogramms der Bundesrepublik Deutschland (KTB)", was signed by representatives of the Niedersächsisches Landesamt für Bodenforschung, Hannover, and the Český geologický ústav, Praha, in December 1990.

The project of the Czech Geological Survey on western Bohemia used, in addition to new works, geological and geophysical information compiled during several decades of regional mapping and specialized geophysical measurements. Some subareas, not covered by the previous programs of geophysical survey, namely a belt about 10 km wide along the state border in W and SW Bohemia, was surveyed (Fig. 3).

S. Vrána headed the project since the preparation stage in early 1990, since 1992 in co-operation with V. Štědrá. Several meetings of specialists participating on the project were organized to integrate and interpret data. The manuscripts of chapters submitted for this volume were repeatedly attended by the editors and authors to obtain a coherent terminology on the geological units and an improved presentation; several chapters were translated to English by the editors.

This volume presents a set of 21 chapters, corresponding to the variety of the main working topics in the framework of the present project. Data and insights into structure and Earth's crust evolution in this part of the Bohemian Massif and formulation of a new geological and geophysical model of the region, are the common denominator of all these specialized studies.

The main results of the project are reviewed in the chapter A. Since the geophysical methods provide continuous information on the region studied and on physical properties of the Earth's crust, the next three chapters B1–B3 deal with regional gravimetry, airborne magnetometry and radiometry, and the 9HR seismic profile. To achieve a coherence of information, the geological chapters C1–C6 outline main geological and geophysical features of the individual tectonic units. They present numerous new data and interpretations resulting from specialized geological studies in the framework of the present project. This information should also serve as a guide for those readers of specialized chapters D1–E4, who are interested in a wider geological context.

Plutonic bodies were little studied in the present project. A concise overview of Variscan and pre-Variscan plutons in geological chapters, largely using information compiled by Klomínský-Rajpoot (1993, in press), contains references and new radiometric data on plutonic rocks.

The authors have chosen a synthesizing type of presentation, rather than publishing exclusively new results, as it will hopefully allow insights in crustal geology of this important part of Variscides especially for the international readership. List of institutions participating on the project:

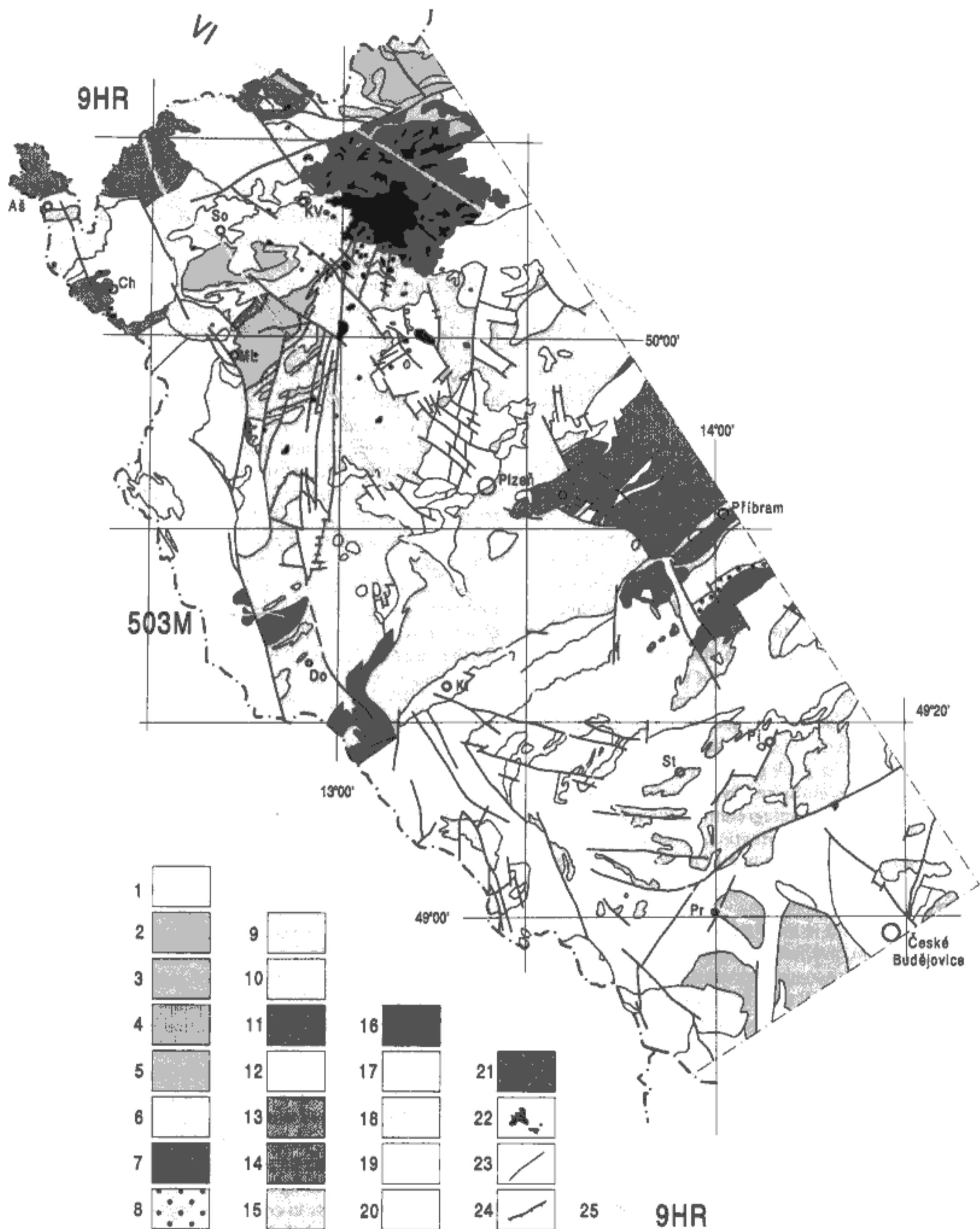
Czech Geological Survey, Prague

Geofyzika, Inc., Brno

Geophysical Institute of the Academy of Science, Prague

Faculty of Science, Charles University, Prague

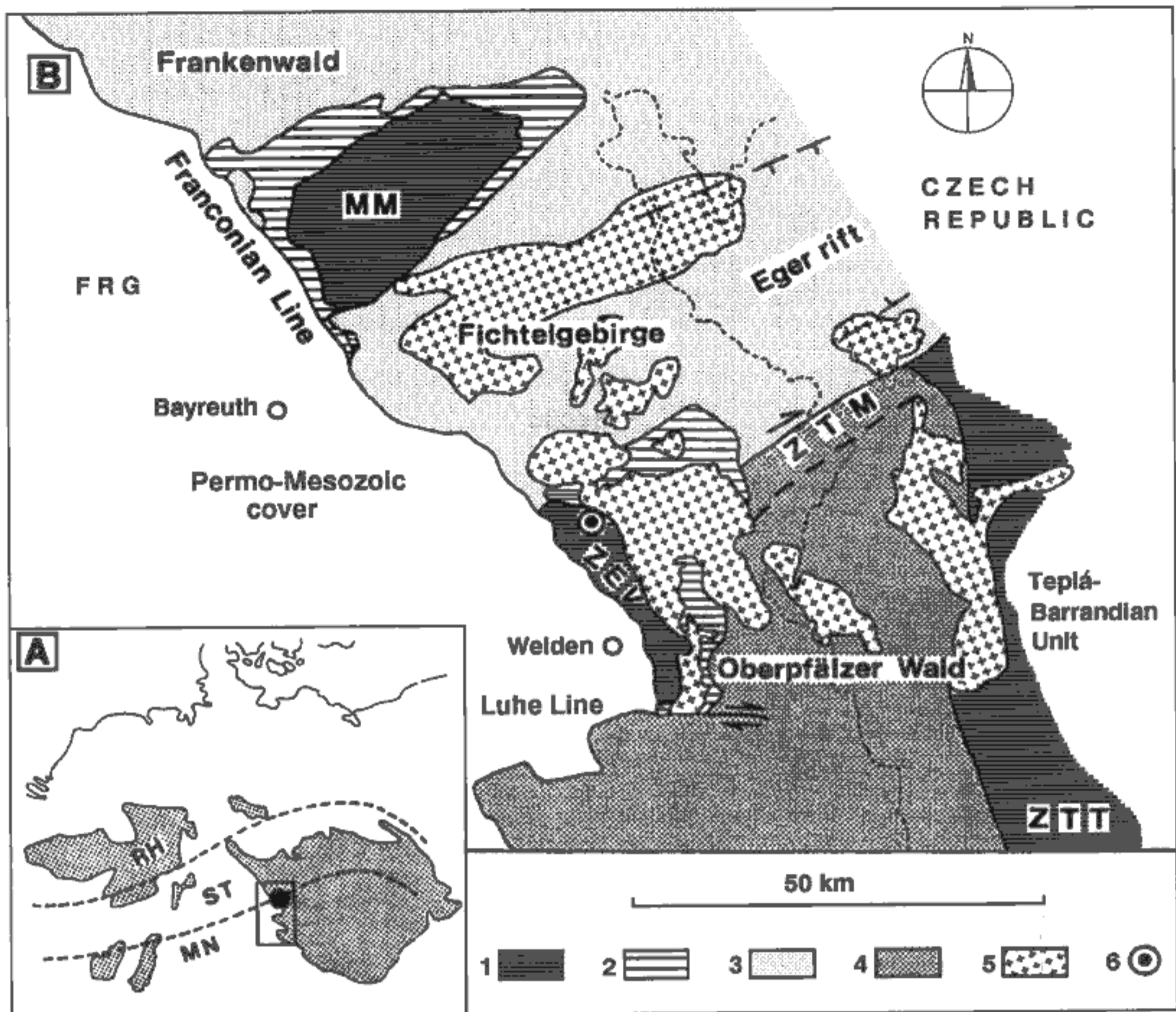
Geological Institute of the Academy of Science, Prague



1. Geological map of western and south-western Bohemia, Czech Republic, showing location of the 9HR and 503M seismic profiles. Geology is based on 1 : 500 000 map, complemented by data from 1 : 50 000 maps.

1 – gneisses and migmatites with layers of quartzite, crystalline limestone, calc-silicate gneiss, and amphibolite, Moldanubian Zone, 2 – gneisses and migmatites, Krušné hory, Smrčiny, and Horní Slavkov Crystalline Units, 3 – granulites, including amphibolites and ultramafic rocks, 4 – serpentized peridotite of the Mariánské Lázně Complex, 5 – amphibolites and eclogites of the Mariánské Lázně Complex, 6 – Teplá-Barrandian Unit Precambrian, Blovice Formation of the Kralupy-Zbraslav Group, very low-grade to high-grade metamorphosed sediments and volcanites, 7 – Teplá-Barrandian Precambrian, Davle Formation of the Kralupy-Zbraslav Group, anchi-metamorphosed and contact-metamorphosed sediments and volcanites, 8 – metamorphosed subvolcanic granitoids of the Teplá-Barrandian Unit Precambrian, Davle Formation





2. Geological sketch of the western part of the Bohemian Massif, showing location of the deep borehole KTB near Windischeschenbach, Oberpfalz, Federal Republic of Germany (Weber-Vollbrecht 1986).

A - surface outcrops of Variscides in central Europe: RH - Rhenohercynian Zone, ST - Saxothuringian Zone, MN - Moldanubian Zone; B - Geology of the region: 1, 2 - Münchberg Massif, Erbendorf-Vohenstrauss Unit (ZEV), Teplá and Domažlice Crystalline Units (ZTT), 3 - Saxothuringian Zone, 4 - Moldanubian Zone, 5 - late- and post-tectonic granitoids, 6 - location of the deep borehole KTB.

Institute of the Physics of the Earth, Faculty of Science,  
Masaryk University, Brno  
Aquatest, Inc., Prague  
Institute of Mineral Raw Materials, Kutná Hora.

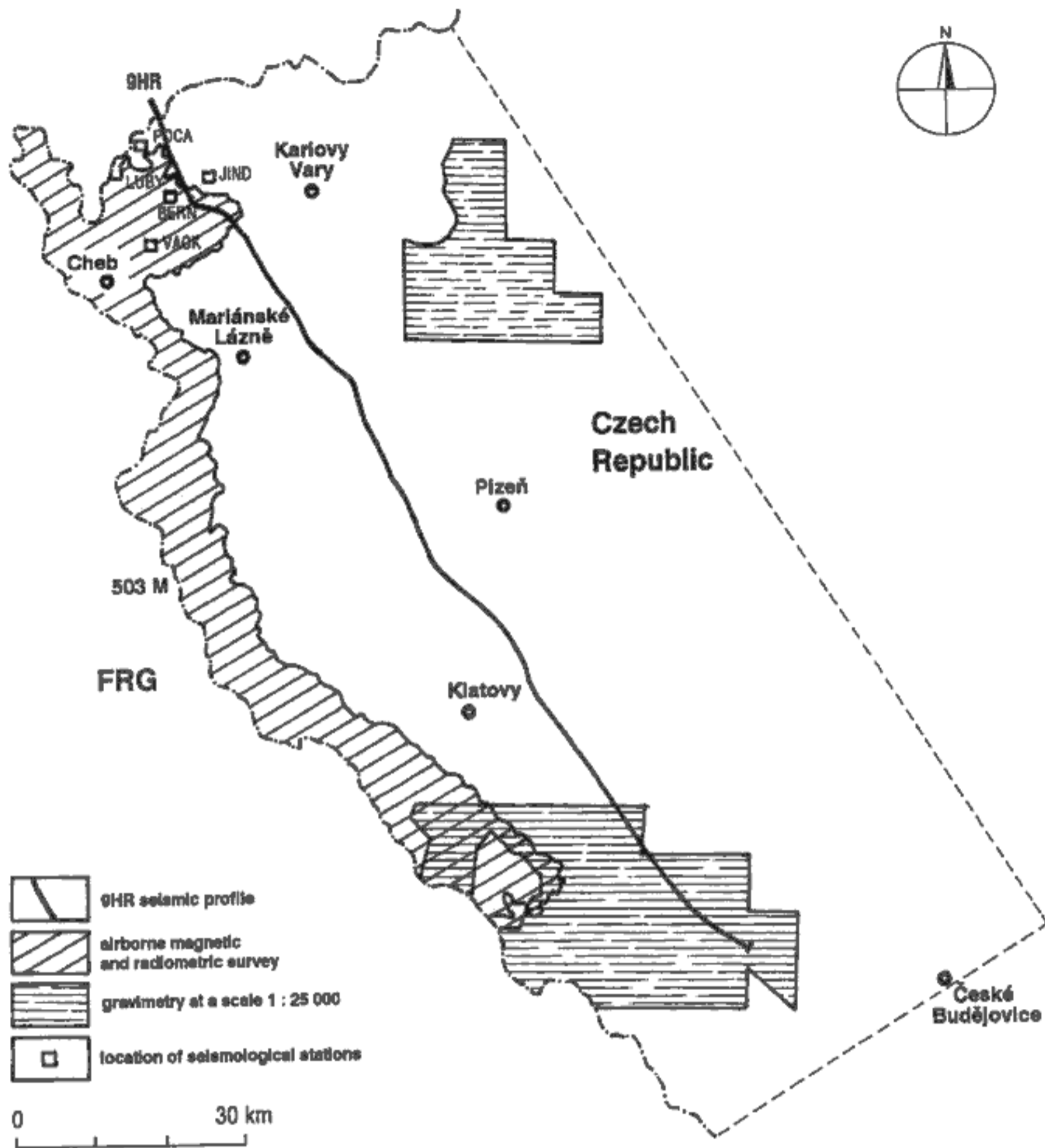
The results of this project have been presented in the following ways:

1. Annual abstracts for 1991, 1992, and 1993 (in English).

2. Internal reports, largely presenting data for the period 1991 to 1993. These unpublished reports, in Czech, are deposited in the Archives, Czech Geological Survey, Prague, and in Geofond, Prague.

3. Final report, presenting data and interpretations for the whole period of the project (in Czech). The present volume essentially presents the English version of the final report, in part modified and updated.

← of the Kralupy-Zbraslav Group, 9 - Teplá-Barrandian Unit Precambrian, Štěchovice Group, anchi-metamorphosed and in part contact-metamorphosed sediments, 10 - mica-schists and gneisses of Varied units of the Krušné hory crystalline complex, with layers of quartzite, crystalline limestone, amphibolite, and eclogite, 11 - Cambrian sediments of the Teplá-Barrandian region, 12 - Cambrian and Lower Ordovician (Tremadoc) volcanites of the Teplá-Barrandian region, 13 - Vogtland-Saxony Palaeozoic, sediments and minor volcanites, 14 - Ordovician to Devonian sediments and volcanites of the Teplá-Barrandian region, 15 - orthogneisses and leucocratic migmatites, 16 - gabbroids (mainly Cadomian), 17 - granitoids (Cadomian and Variscan), 18 - melagranites and melasyenites (Variscan), 19 - Permian-Carboniferous sediments, 20 - continental Upper Cretaceous and Tertiary sediments, 21 - Tertiary basaltoid tuffs, 22 - Tertiary volcanites, 23 - faults, 24 - thrusts, 25 - line of seismic profile.



3. Location of several types of geophysical works conducted in western Bohemia in the framework of the present project (1991–1994). The region of the project is defined by the international boundary and by the broken line at the NE and SW.