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# OBJECTIVES AND ORGANIZATION OF THE GERMAN CONTINENTAL DEEP DRILLING PROJECT (KTB)

by

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(11 figures)

**ABSTRACT.**- The German Continental Deep Drilling Program (KTB) is a research project aimed at investigating the physical and chemical conditions and processes in the deep crust for better understanding the dynamics of intracontinental structural evolution. Scientific objectives include the origin and causes of geophysical anomalies and structures, the in-situ physical and chemical conditions, fluid systems and their influence on the crust, crustal structures and the evolution of the mid-European Variscides, and the installation of a deep earth observatory.

The drilling location in the Oberpfalz in northeastern Bavaria near the town of Windischeschenbach on the western flank of the Bohemian Massif was selected in 1986 after multiyear preliminary studies in the Schwarzwald and Oberpfalz. The drilling site is located at the suture zone between the Saxothuringian and Moldanubian zones of the Variscan orogen. According to geophysical, structural, and petrological investigations a highly structured crust can be expected.

The drilling site is also located near the Franconian line, one of the largest NW-SE-oriented Mesozoic-Tertiary strike-slip zones of central Europe. Information on wrench tectonics and mineralizations in shear zones should be obtained. The western prolongation of the Eger rift with Tertiary volcanism, thermal-spring activity, and microseismic activity extends through the drilling area.

A 3000-5000-m, fully cored pilot borehole was started on 18 Sept. 1987 with the drilling phase lasting until mid-1988 and will be subsequently followed by a testing and borehole measurement program of about 1 year. According to present plans, the superdeep borehole, at about a distance of 200 m from the pilot borehole, will be sunk to a target depth of 12 000-14 000 m from 1990 to 1997. A completely new rig will be designed to drill this well.

Currently, about 250 scientists and technicians are working on the project. A project management group was integrated in 1985 into the Geological Survey of Lower Saxony (NLfB) to run the project. A special research program was founded by the DFG in 1987 for coordinating the scientific studies.

**RESUME.**- Le programme allemand de forage profond en domaine continental (KTB) vise à la réalisation d'un projet de recherche destiné à rassembler un maximum d'éléments sur les caractéristiques physiques et chimiques de l'écorce profonde et sur les processus qui structurent son développement; il envisage de compléter nos connaissances sur la dynamique et les conditions de l'évolution crustale intracontinentale. Les objectifs scientifiques comprennent l'étude sur l'origine et les causes des anomalies géophysiques et des structures qu'elles recouvrent, le recueil de données numériques, physiques et chimiques, mesurées in-situ, l'évaluation de l'influence de la circulation des fluides dans la croûte, la reconnaissance des structures crustales liées à l'élaboration de la chaîne varisque en Europe moyenne, et l'installation d'un laboratoire de mesures en zone profonde.

L'emplacement du forage dans l'Oberpfalz, au nord-est de la Bavière, à proximité de la ville de Windischeschenbach sur le flanc ouest du massif de Bohême, a été sélectionné en 1986 après de nombreuses études préliminaires réalisées à la fois en Forêt Noire et dans l'Oberpfalz. Le site choisi se situe à la suture entre les zones saxothuringienne et moldanubienne de l'orogène varisque. D'après les données géophysiques, structurales et pétrologiques actuellement disponibles, le forage traversera un domaine crustal dont les caractéristiques tectoniques paraissent particulièrement élaborées.

Le site est également situé à proximité de la «Franconian line», qui en Europe centrale, est l'une des zones de décrochement mésozoïque-tertiaire, orientées NW-SE, les plus larges. Des informations sur la tectonique de cisaillement et les minéralisations dans les zones faillées devraient être récoltées. Le site forme par ailleurs le prolongement ouest du rift de l'Eger, caractérisé par son volcanisme tertiaire, l'activité de sources et la permanence d'ébranlements microséismiques.

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Un forage pilote, devant atteindre la profondeur de 3.000 à 5.000 m entièrement carotté, a été entamé le 18 septembre 1987 et devra être terminé pour juillet-août 1988; il sera suivi par une série de tests et de mesures, réalisées dans le forage lui-même, et étalées sur un an. D'après les prévisions, le forage profond sera implanté à 200 m du forage pilote et devra atteindre 12.000 à 14.000 m; il débutera en 1990 et s'achèvera en 1997. Une toute nouvelle tête de forage sera mise en oeuvre à cette occasion.

Normallement, environ 250 scientifiques et techniciens travaillent sur le projet. Un groupe logistique a été constitué, dès 1985, au sein du Service géologique de Basse-Saxe (NLfB) pour en assurer le management. Enfin, un programme de recherche spécial a été financé par la DFG en 1987, afin d'assurer la coordination des études scientifiques.

## 1.- DEVELOPMENTAL PHASES OF THE PROJECT

**1977** : Initial discussions in the Geocommission of the German Research Society (DFG) about a continental deep drilling project for supplementing the DSDP (Deep Sea Drilling Project). Formation of a working group.

**1980** : The consulting committee for large-scale research projects of the BMFT recommended the geological, technical, and organizational preparatory studies for such a project after hearings with the Geocommission.

**1981** : The Alfred Wegener Foundation and the German Geological Society narrow down the 40 proposed sites for a superdeep drilling to 12, and later to 4 :

- Hohes Venn (thin-skinned tectonics and geological evolution of the Variscan external zone),
- Hohernzollern graben (intraplate seismicity),
- Schwarzwald (continuous petrological profile between the lower upper crust and the upper boundary of the lower crust),
- Oberpfalz (evolution of the Variscan crust by analyzing one of the sutures in the internal zone of the orogene).

The Federal Minister for Research and Technology granted 4 million DM for the preparatory geological studies and for a study on the technical feasibility.

**1983** : International Workshop in Neustadt, Weinstrasse. Discussion of the provisional results. Selection of the Schwarzwald and Oberpfalz sites for a possible drilling. The basic drilling and borehole measurement techniques are decided on; the technological problems were worked out and the management was planned. The Geocommission released a memorandum on «KTB-Advances and Status»; they welcomed a decision on the drilling site and announced a concentrated preliminary study phase aimed at a final decision in 1986.

**1984** : Decision on the possible organization. The project is centered at the Niedersächsische Landesamt für Bodenforschung in Hannover because the industrial firms for geotechnology, the Bundesanstalt für Geologie und Bodenforschung, and the geoscientific research centers are concentrated in Niedersachsen and all cooperate closely.

**1985** : In February Minister Dr. H. Riesenhuber announced that the BMFT will sponsor the first large-scale geoscientific research project in Germany with a budget of 450 million DM. The project will entail a 10-14-km-deep scientific drilling over a 10-year time span.

In October the project group for the technical and scientific management will convene at the Niedersächsische Landesamt für Bodenforschung.

**1986** : The «Second International Symposium on the Observation of the Continental Crust Through Drilling» took place in Seeheim, Odenwald, on 19-21 October. Based on the results of the preliminary studies the decision on the final drilling was made : the Geocommission proposed the Oberpfalz as the KTB location. Organization of the project management at the Niedersächsische Landesamt für Bodenforschung. Final development of the drilling concept together with industry.

**1987** : Foundation of a DFG program concentrated on coordinating all geoscientific research with a yearly budget of about 5 million DM from the project funds of the BMFT.

On 18 Sept. the KTB drilling project was officially begun with the erection of the derrick for a 5000-m-deep predrilling. Drilling began on 22 Sept.

In mid-October 400 m will have been reached. After casing a mining-drilling technique developed for this project will be tested which will reach 3000 m by mid-1988 and will continue to 5000 m.

**1989-1990** : Start of the main drilling.

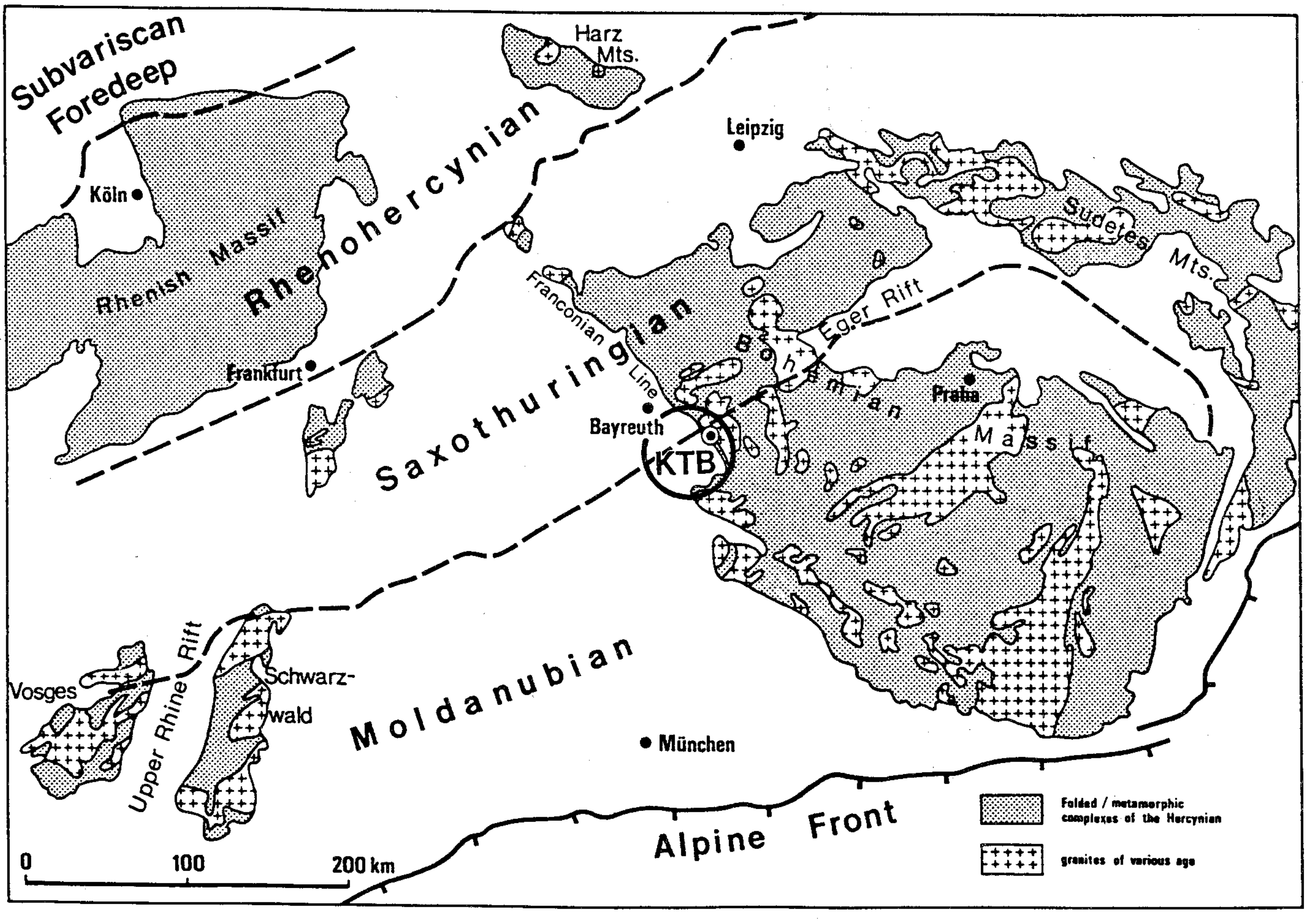



Figure 1.- Variscan crustal units and position of the KTB-drilling site.

## 2.- TARGETS AND RESEARCH TOPICS

The overall objective of the KTB can be defined as the «fundamental investigation and evaluation of the physical and chemical conditions and processes in the deeper continental crust for better understanding the structure, composition, dynamics, and evolution of intracontinental crustal regions».

That is, the KTB focusses on the middle continental crust, its structure, its thermodynamic state, its properties, and the processes presently operative in it as well as on the paleoprocesses.

Amont the major research themes are :

(1) Recording the present thermodynamic state of the continental crust and evaluation of the processes presently operative in it.

(2) Composition, gradients, and discontinuities from the geophysical and geochemical point of view.

(3) Transport phenomena, transport mechanisms, and transport processes.

(4) Reconstruction of paleoconditions and paleoprocesses.

(5) Structure, rheology, and tectonic evolution of the continental crust.

(6) Installation of a deep-earth laboratory and observatory.

The objectives of the KTB are an outstanding challenge for measuring and drilling technology and project management since they include :

- a deep borehole of at least 14 000 m depth which from top to bottom will penetrate high-grade metamorphic crystalline rocks with intruded granites, and which will certainly encounter large ductile and brittle deformed zones,
- bottom temperatures of up to more than 300°C,
- maximum coring and core recovery, at least 30% of drilled section,
- the integration of a large field laboratory for geochemistry, structural geology, and geophysics in the project organization,
- a very comprehensive logging program all the

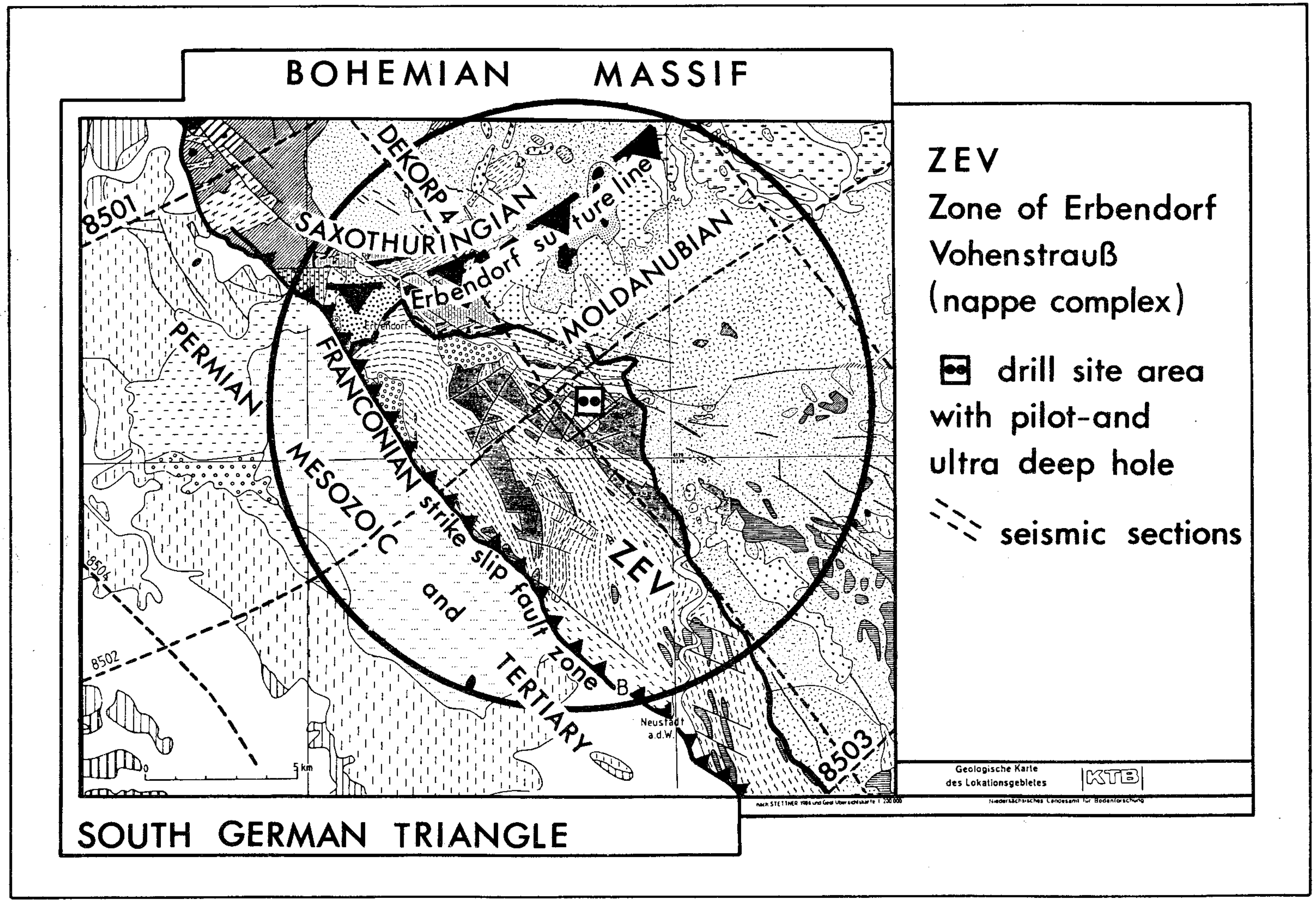



Figure 2.- Geological map of the KTB-drilling site and area of intensive geophysical (3D-geophysica) and geological field study.

way to the bottom with approx. 100 different tools and,

- an open-hole section at the bottom after the completion of drilling, serving as a long-term measuring station (deep-earth observatory).

The KTB drilling site is located on the western margin of the Bohemian massif, a few kilometers south of the structurally important Saxothuringian/Moldanubian boundary of the central European Hercynian orogen and several kilometers east of one of the most important Permian-Mesozoic strike-slip zones of central Europe, the Franconian line. The borehole will be sunk in the Moldanubian segment (fig. 1).

From geographical and political aspects, the drill site is located in northern Bavaria in the Oberpfalz province near the towns of Windischeschenbach and Erbendorf about 40 km southeast of Bayreuth.

## 3.- IMPORTANT ASPECTS FOR SITE SELECTION BETWEEN OBERPFALZ AND SCHWARZWALD

The geological, petrological, and geophysical results of the pre-site investigations in the Schwarzwald and the Oberpfalz emphasize that both target areas would be excellent candidates for a superdeep research borehole and would certainly contribute to the main objectives of the program listed in the introductory chapter. In the course of the pre-site studies, however, it also became quite apparent that despite certain similarities there are also some fundamental differences between the two which have to be weighed against one another when deciding on the final drill site.

The outstanding research theme of a superdeep borehole in the **Oberpfalz target area** arises from its location in the suture zone between two major basement units in the internal zone of the Hercynian orogen between the Moldanubian (MO) and the Saxothuringian (ST) units (fig. 2). Suture zones are key areas for studying the growth and evolution of the continental crust because here the basic processes of lateral crustal accretion can be investigated. Furthermore, they are deep-reaching fault zones which penetrate the entire crust and could even reach down into the uppermost mantle, thereby representing crustal portions of far-reaching and extensive material transport. In the Oberpfalz area this suture zone is already so deeply eroded that a super-deep borehole could penetrate into the roots of a suture zone.

In the Oberpfalz, Lower Paleozoic extensional tectonics were followed by widespread compressional tectonics ending in the Upper Carboni-

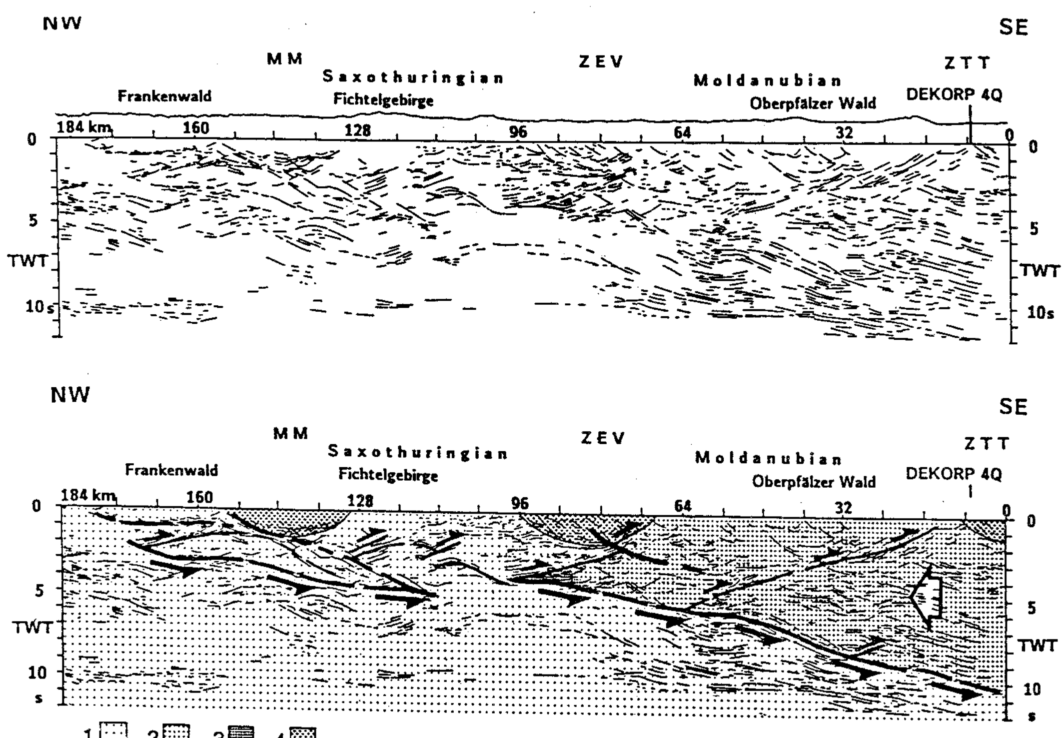



Figure 3.- Structural interpretation of the DEKORP 4 profile in terms of a multiple wedging process; 1 = Saxothuringian crust, 2 = Moldanubian crust, 3 = Erbendorf body, 4 = nappes; for further explanation see text (Vollbrecht, Weber & Schmoll).

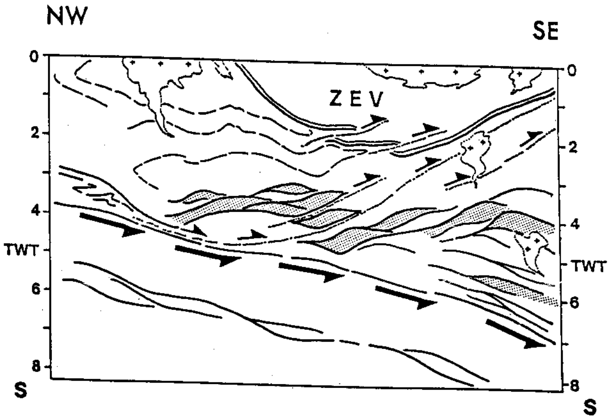



Figure 4.- Structural interpretation of the Erbendorf high-velocity body, after Heinrichs (unpublished); explanation see text.

ferous. The margin of the Moldanubian/Saxothuringian crustal segments and the interior structure of the Moldanubian segment are presumably determined by terrains. The seismic structures provide evidence for the assumption that the drilling will make it possible to investigate the fundamental mechanisms of Hercynian crustal evolution. A differential into upper and lower crust is not so clearly developed here as in the Schwarzwald.

Following Variscan convergence strong posttectonic granite plutonism developed. In the Permo-Mesozoic the Bohemian massif is lifted up and the large Franconian strike-slip zone forms, which is connected with the formation of divergent wrench troughs like the Weiden basin. In the Tertiary the drilling area is affected by the westward prolongation of the Eger rift. Its effects are basalt volcanism, inhomogeneities in the upper mantle, increased heat flow with thermal springs, and relicts of microseismic activity.

Thus, the central European basement offers the opportunity to gain fundamental knowledge on the geodynamics of the most significant collisional event in the earth's history, in the course of which Pangea was formed.

The Bohemian massif is the largest basement complex in Europe and has been intensively studied by colleagues in Czechoslovakia, the German Democratic Republic, Austria, and the Federal Republic of Germany. Once the evolution of the Bohemian massif is known, the central European crustal development involving the African, North American and Greenland, and east European plates can be understood. There is presently no sure evolutionary model. The KTB and the international seismic programs have laid the foundation for initial cooperation between these countries.

The detailed structural, petrological, and radiometric investigations have resulted in a consistent and well-founded model for the structural and geodynamic evolution of the target area as was never so accurately obtained for any other region of the Hercynian orogen. It will, therefore, be an important task of the Oberpfalz group to convincingly demonstrate that deep drilling in a very structurally complex crustal portion, like a suture zone, can indeed provide significant contributions to the fundamental questions of structure and geodynamic development of the continental crust. A particular advantage of the target area is that the major geological units established with the surface geology are very clearly illustrated by reflection seismics and could probably be traced in their deeper continuation. The Oberpfalz site, therefore, offers an excellent opportunity to reveal the nature of seismic reflectors and to explain structurally, lithologically, and petrophysically the seismic reflection data, thus making an interpretation of the geophysical crustal image possible.

The alternative drill site near Haslach in the central Schwarzwald is located in a lithologically rather uniform, polymetamorphic basement block which is bound by two important convergence zones, the ST/MO boundary in the zone of Baden-Baden in the north and the Paleozoic zone of Badenweiler-Lenzkirch in the south. A major, as yet unsolved problem of great geological importance is the question of the tectonic position of the central Schwarzwald gneiss mass : Is this block of pre-Hercynian crystalline primarily autochthonous, or was it displaced by Hercynian tectonics and decoupled from its previous substratum ? In any case, the Moldanubian basement of the central Schwarzwald with its evolutionary history reaching back into the Precambrian provides a representative example of older reactivated crustal portions within the Hercynian orogen. The metamorphic crustal events are indeed very similar to those of the Oberpfalz, but are approx. 50 Ma older. According to the pre-site investigations a geologically and lithostratigraphically relatively simple and uniformly constructed crustal profile can be expected in contrast to the Oberpfalz.

The Hercynian development of the Schwarzwald is mainly documented by its intensive granitic plutonism, which marks the transition from compressional to extensional tectonics. An outstanding characteristic of the Schwarzwald crust is its overprinting by a late-Hercynian extensional process which is distinguished by the formation of intramontane depressions and a widespread rhyolitic magmatism, indicating very high temperatures at the crustal base toward the end of the Hercynian orogeny. During this extensional phase compressional tectonics take place in the Oberpfalz area.

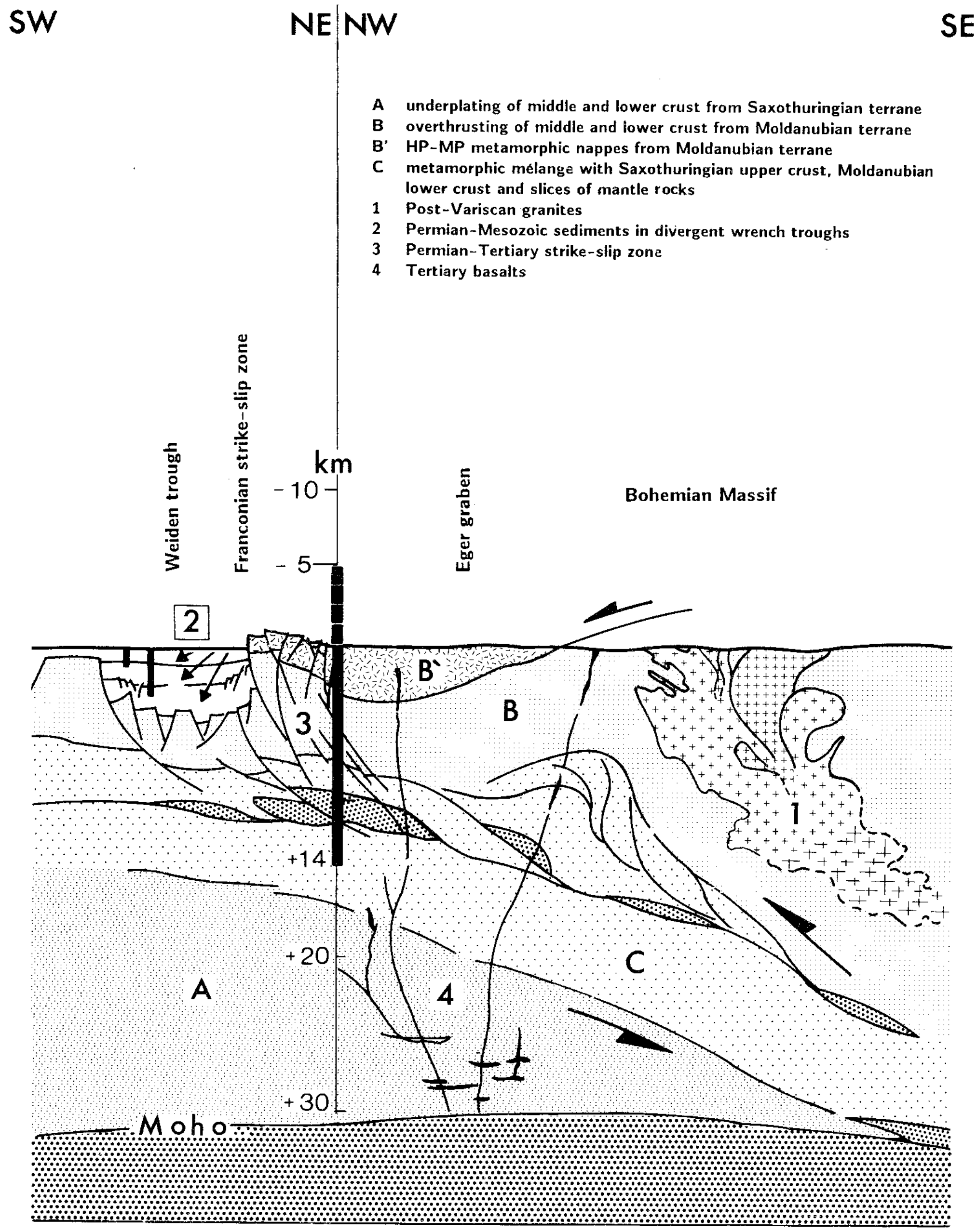



Figure 5.- KTB-drilling site with major crustal structures.

The most important conclusion to be drawn from the investigation of the rock fluids is that the central Schwarzwald basement presently exposed at the surface was affected by a thorough degassing associated with a pervasive fluid migration at the former level of the middle crust. In view of the lithology primarily $CO_2/CH_4/N_2$ gases must have been present. However, the fluid prints of the older metamorphic events have been completely extinguished by this degassing. A high residual porosity has been preserved up to the present erosional level. It is, therefore, concluded that the basement portion presently exposed at the surface was part of a low-velocity zone at the time of the HT/LP metamorphism. The channelway alteration operative during the basement uplift caused sealing of the open residual permeability by hydration reactions and formation of new minerals (Behr & Frentzel-Beyme, 1987).

Whereas the Oberpfalz target area provides excellent conditions for studying of paleoprocesses in the continental crust, the Schwarzwald target area appears to be especially well suited for studying the present state and recent processes in a still «living» crust. The particular scientific attraction of the Schwarzwald target area is founded on the results of the various geophysical methods which revealed a clearly differentiated

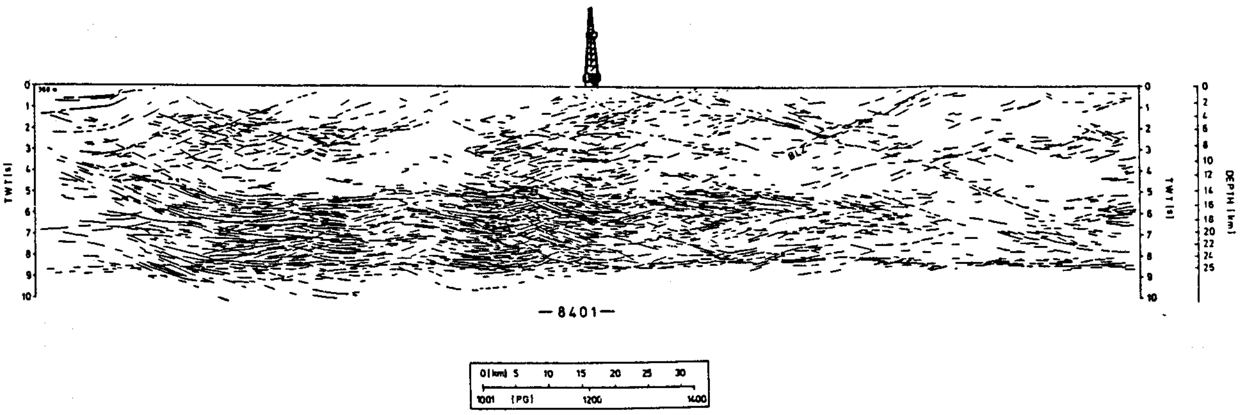



Figure 6.- Line drawing following the migrated sections of the reflection seismics on the Schwarzwald NS-profile (Lüschen *et al.,* 1985).

crust with interesting geophysical phenomena. At

the site-selection meeting the Schwarzwald grou
the site-selection meeting the Schwarzwald group will have to prove convincingly that the geophysical results obtained are representative for larger portions of the Hercynian crust and that a super-deep borehole in the Schwarzwald could provide fundamental knowledge for the understanding of the geophysical structure of intracontinental crustal areas.

With respect to the drilling technique the temperature is among the most important factors in evaluating the risks for the planned super-deep borehole. Presently, 300°C are regarded as an upper temperature limit for the bottom-hole temperature. Thus, the question of temperature prognosis will play a central role in site selection. According to present data and their interpretation a temperature of 300°C is expected to occur at a depth of about 14 000 m in the Oberpfalz target area, whereas in the Schwarzwald target area this limit might already be reached at a depth of about 10 000 m. However, the reliability of these temperature estimations still has to be evaluated and the extent of what the predicted temperatures would be lowered by accounting for convective heat transport. Especially in the Schwarzwald target area there are many indications that subrecent to recent convection processes could have greatly influenced the present thermal structure of the crust and could be responsible for the observed high near-surface heat flow and temperature gradients.

### 3.1.- THE MOST IMPORTANT RESULTS ON THE SEISMIC CRUSTAL STRUCTURE AND THEIR INTERPRETATION IN THE OBERPFALZ REGION (figs 3-5)

- There is an excellent correlation between the surface geology and seismic structure of the upper crust.
- The upper and middle crust are marked by an unusually high seismic reflectivity that extends southward toward the Moho.
- The nappe complexes of Münchberg, ZEV, and Hoher Bogen are recognized as bowl-shaped trough structures whereas the Fichtelgebirge is portrayed as an antiformal stack.
- Beneath the Paleozoic of the ST a reflector is developed which presumably represents a crust/mantle décollement and which dips to the south toward the crust/mantle boundary. South of the suture zone the lower crust is marked by distinctive groups of predominantly S-dipping reflectors.
- The velocity-depth structure of the crust derived from wide-angle reflection seismics indicates the existence of a high-velocity layer (also dipping southward) at a depth below 12 km as the most distinctive geophysical element in the drilling area. For accurate geological interpretation it remains to be seen whether this velocity-depth structure can be structurally, stratigraphically, and petrographically defined, or whether it reflects mainly petrophysical characteristics such as differences in permeability, pore filling, and density in an otherwise largely homogeneous crust (fig. 4).
- The Moho occurs at a depth of approx. 32 km with a slight updoming to 30 km where the

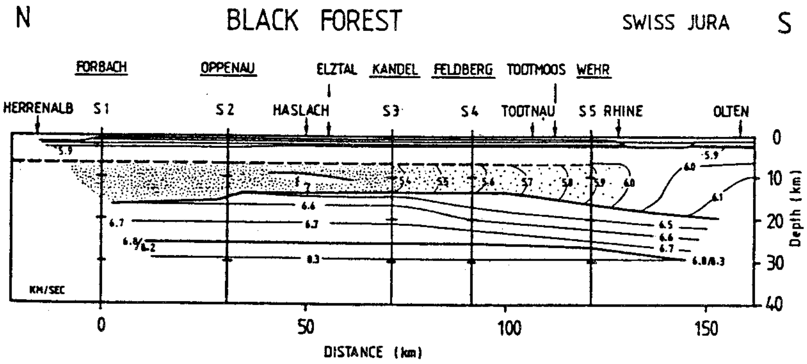



Figure 7.- Velocity-depth model of the crust beneath the Schwarzwald (KTB Excursion Guide Schwarzwald 1986).

profile intersects the Eger Rift. However, indications of mantle steps at the intersections with reflectors suggest that in post-Hercynian times no further convective movements occurred in the upper mantle.

- The observed seismic structure of the crust in the target area is interpreted by the geologists as a late-Hercynian, intracontinental northward thrust orogen. This most probably functioned as a detachment in the middle crust and is associated with antiforms and culmination zones.

## 3.2.- THE MOST IMPORTANT PRELIMINARY RESULTS ON THE SEISMIC CRUSTAL STRUCTURE IN THE SCHWARZWALD REGION ARE : (fig. 6, 7)

- The crust beneath the Schwarzwald shows a pronounced three-fold division into a strongly reflective and laminated lower crust rich in horizontal to subhorizontal reflectors, a poorly reflective middle crust, and a relatively transparent upper crust with a number of distinct, mostly inclined reflectors both N and S dipping. The prominent reflectors of the upper crust flatten with depth and apparently end in the middle crust. However, it is also possible that they reach down into the lower crust where they are overprinted by a younger subhorizontal system of lamellae.
- The most prominent reflector in the upper crust develops out of the zone of Badenweiler-Lenzkirch.
- There is a strongly reflecting «bright spot» of limited lateral extension at a depth of 9-10 km in the planned drilling area.
- The velocity-depth structure of the crust, as derived by wide-angle refraction-seismic surveys, shows a steep increase in the P velocities in the uppermost crust, a significant low-velocity zone at a depth of between 7-14 km with P velocities of 5.4-6.0 km/sec, and a discontinuous increase in the P velocities to values of above 6.5 km/sec at a depth of 15-18 km (Conrad discontinuity).
- A combination of reflection and refraction data, which were obtained on almost identical profiles, reveals that the low-velocity zone is located immediately above the laminated lower crust, and that the top of the laminated zone coincides with the Conrad discontinuity.
- Due to a Cretaceous/Tertiary mantle updoming in the upper Rhine region the crustal thickness beneath the Schwarzwald is only 25-26 km.

There have been intensive discussions on the nature of the seismic lamellae in the lower crust and their possible relation to the Tertiary crustal rejuvenation. However, a genetic relationship between the formation of the lamellae and the late-Hercynian volcanism was also considered.

## 4.- THE KTB IS AS A WINDOW THROUGH THE EARTH'S CRUST

The very detailed mapping and geological study of the surface geology and the sedimentary cover in central Europe will now be supplemented by a window through the earth's crust. The borehole will only offer a view through the present upper crust, but accompanying projects will indirectly extend the 14 000-m drill profile to about 35 000 m downward through the lower crust to the mantle and upward by analyzing those rocks already eroded away. In figure 8 these projects are shown in relation to the KTB.

- During the preliminary investigations a seismic profile network of about 540 km in length was recorded in the Oberpfalz during the DEKORP

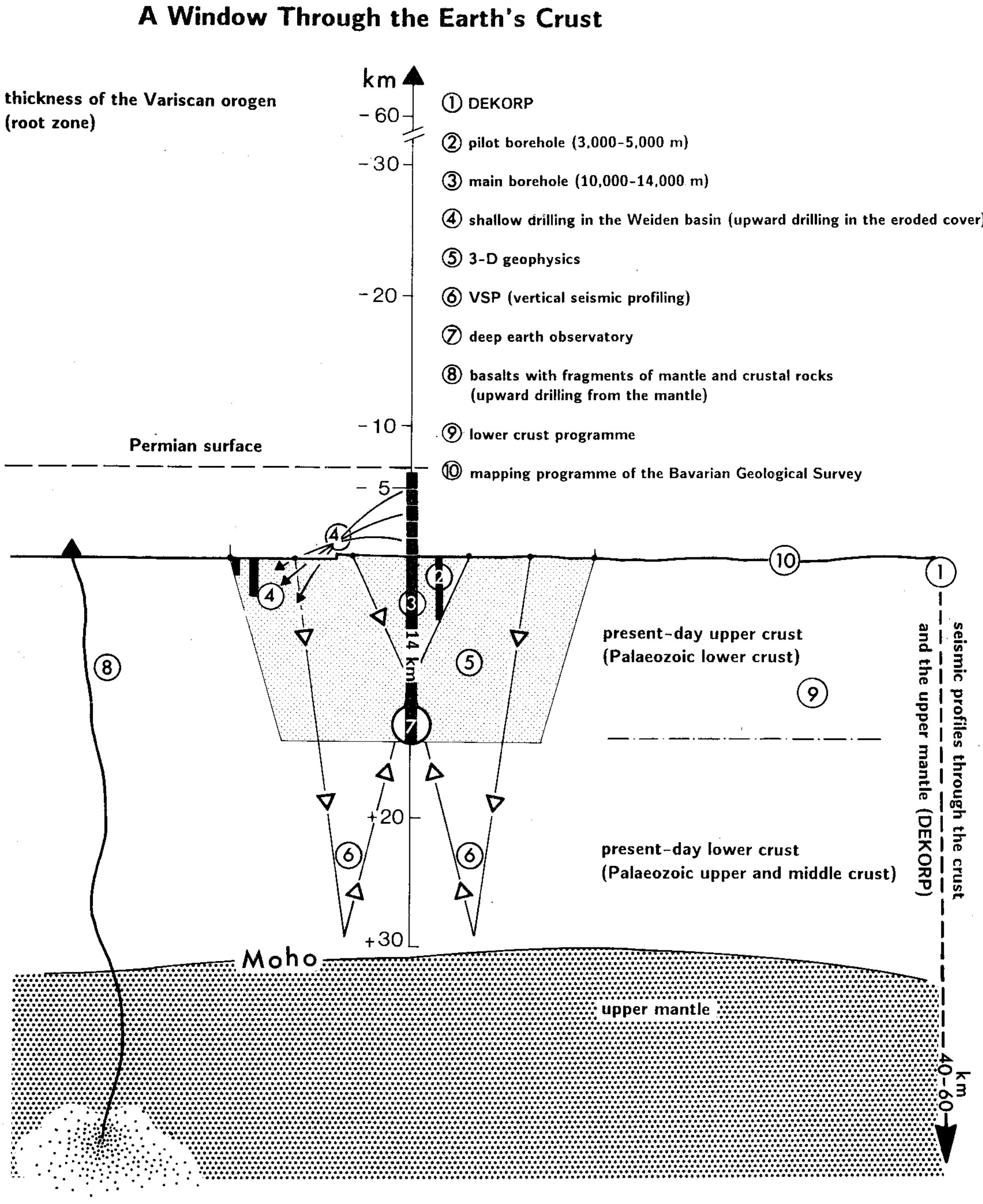
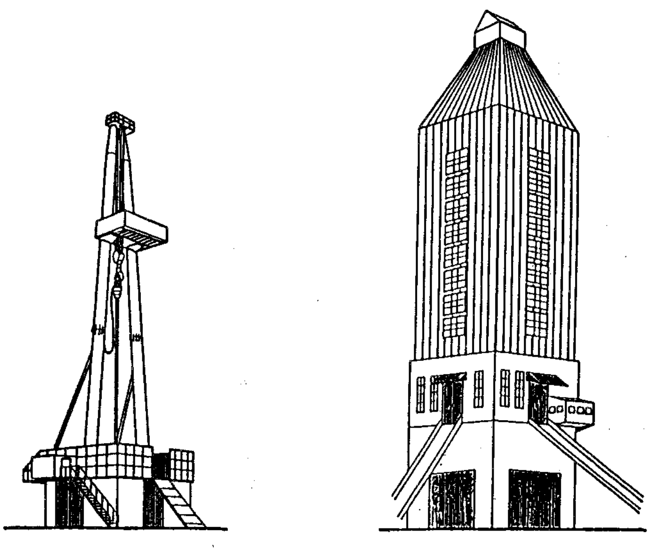



Figure 8.- KTB and related research activities.

program. This was supplemented by about 100 km of very detailed wide-angle measurements with shooting spacings of a few kilometers permitting a good two-dimensional resolution of the velocity structures. In doing so, a richly structured upper and lower crust was proven which according to our present interpretation is essentially determined by intensive Variscan convergence tectonics. The Saxothuringian/ Moldanubian boundary is a guiding structure from which S-dipping reflectors extend down to the Moho. High- and low-velocity zones are intercalated. One of these zones, a larger body with Vp > 7 km$^{-1}$, is of particular interest; its explanation is also one of the aims of the investigation. From 1984 to 1987 an additional 800 km of seismic profile through the Hercynian crustal units in the southern part of the Fed. Rep. of Germany was recorded by DEKORP. These data now allow a comparison of the crustal structures in the Oberpfalz with the seismic properties of the Hercynian crust.

- The deep drilling will also be accompanied by extensive 3-D geophysics which will study a crustal block of about 14 000 m in edge length (drilling depth) in detail. In addition, electrical conductivity structures in the crust are of great interest. The entire Hercynian crust of central Europe, particularly in the Oberpfalz region, is marked by layers of increased integrated conductivity. At the drilling site such zones have been revealed at very shallow, intermediate and about 10 000 m depth. 3-D geophysics is one of the prerequisites for interpreting logged data, and correlating them with geological structures will help to interpret borehole measurements in crystalline rocks.
- Using various VSP (Vertical Seismic Profiling) methods, the lower crust below the pilot and main boreholes will be studied further.
- The surface will be mapped in great detail with respect to structural geology, petrology, and hydrogeology for better interpreting the integrated 3-D geophysical structures.
- Information on the earth's mantle will be collected, using not only geophysics but also through the investigation of Tertiary basalts which partly contain mantle/crust xenoliths. A younger Tertiary divergence structure, the Eger graben, runs parallel to the Hercynian Saxothuringian/Moldanubian structural boundary. The offshoots of the tectonic and magmatic structures of the Eger graben are tangent to the drilling site.
- Permo-Mesozoic divergent wrench troughs with transgression elements and a sedimentary filling of up to 4000 m run parallel to the Franconian strike-slip fault system. By analyzing cores from the sedimentary troughs, uplift and erosion can be estimated. With respect to the interpretation of the KTB drill log this is of great importance as there is a Carboniferous orogenic root at a depth of 60-80 km according to phase-petrological data. The position of this root and the mecanism of subcrustal erosion have not yet been determined. Since the Permian only 5000-7000 m have been eroded at the surface. In this way an «upward» extension of the drilling is possible.
- Long-term observations of the present variations in the earth's magnetic field, of the amount of stress in the lower part of the upper crust, of microseismic activity, and of crustal degassing, etc., will be made by an observatory installed at the bottom of the ultradeep borehole.
- A number of other programs will decisively increase the possibilities of interpretation for




**RIG SPECIFICATIONS:**

| | PILOT HOLE | ULTRA DEEP HOLE |
|---|---|---|
| heigth of rig | 49 m | ca. 80 m |
| length of stands | 27 m | 40 m |
| hook load rating | 2040 kN | 6000 kN |
| installed power | 3700 kW | 8000 kW |
| mud pump power input | 1490 kW | 3720 kW |

Figure 9.- Rig specification.

the KTB. The central segement of the European Geotraverse Project (EGT) with a compilation of all geophysical, structural, and geological data runs just west of and about parallel to the margin of the Bohemian massif.

- One of the main DFG programs on the nature and properties of the lower crust also includes studies on the HT-LP-metamorphic overprinting of HP to MP metamorphites which is characteristic of the Hercynian basement.
- Supported by the state of Bavaria the KTB will be accompanied by a mapping program on the western portion of the Bohemian massif which will greatly improve interpretation beyond the region studies with 3-D geophysics.

## 5.- THE TECHNICAL CONCEPT

The technical concept was worked out by Prof. Dr. H. Rischmüller (Technical Director).

Two wells will be drilled, i.e., a pilot hole with a final depth of at least 3000 m, possibly 5000 m, and the ultradeep well with a maximum depth of 14 000 m. The final depth of the pilot hole corresponds to the planned depth of the anchor casing in the ultra-deep well so that neither coring nor

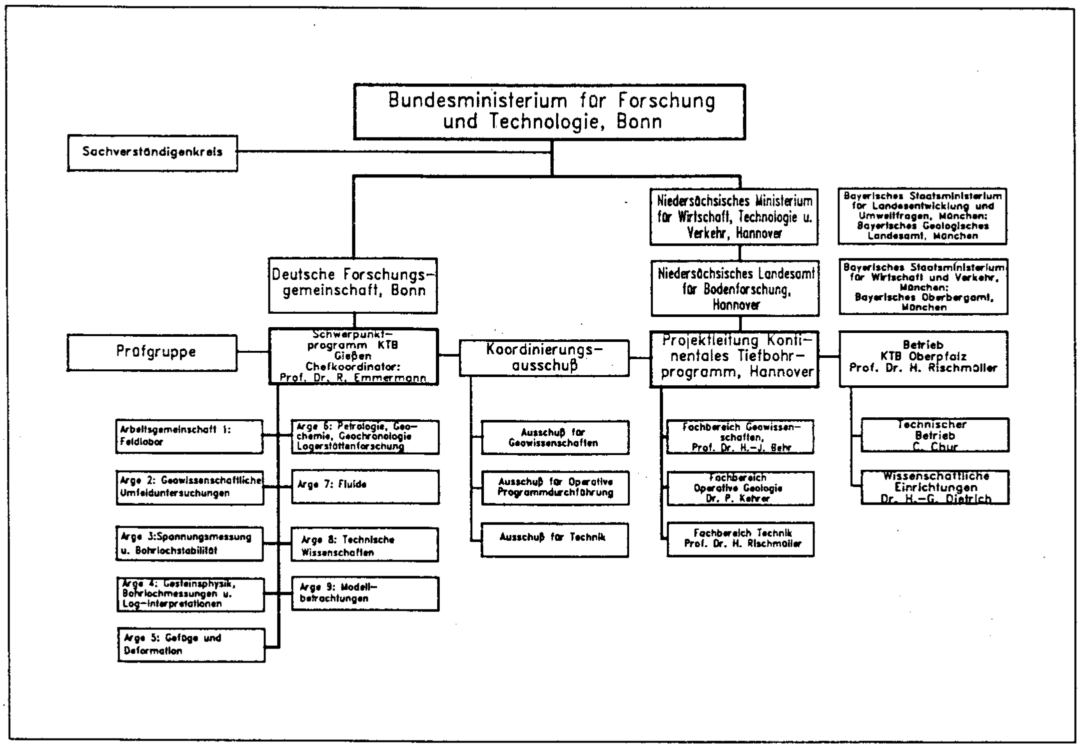



Figure 10.- KTB-organisation.

geophysical borehole measurements will have to be made down to this depth in the ultradeep well. Drilling strategy for this section is to sink the hole as vertically as possible using downhole equipment especially designed and optimized for this purpose, such as well-known conventional techniques or a self-adjusting autopilot for vertical drilling, the so-called «Zielbohrstange».

The maximum drift diameter of a number of essential logging tools makes a bit size of 6 in. necessary for the pilot hole. Continuous coring and extensive logging guarantee a maximum of geoscientific data from this section. In addition, the pilot hole will give information of the temperature profile, problem horizons (well-bore stability and high-pressure zones), and the performance of bits and tools. Last not least, the newly formed working groups will be trained on the job.

New and improved technology will be applied for drilling the pilot hole, i.e., a medium-size drill rig equipped for high-RPM wireline coring with impregnated bits will be used. Thin-lipped core bits are expected to double the rate of penetration, as compared with rotary drilling. The wireline coring technique reduces the number of round trips as every drill bit stays downhole until it is completely worn. However, a completely new internal and external flush-mining drill string larger than CHD 134 had to be designed and manufactured, in addition to the handling equipment, the high-speed top drive, and so on. A low-friction mud superior to the conventional one was developed.

The drilling and casing concept for the ultradeep well meets the maximum flexibility requirements, in case of technical difficulties and geological contingencies. The deeper sections of 5000-10 000 m depth will be drilled with a 10 5/8 in. bit, large enough to set the 9 5/8 in. casing immediately, in case of borehole instabilities and breakouts. In the upper section, we use the so-called slim-line casing design with clearances between borehole wall and casing which are much smaller than conventional ones. Several designs of this kind have been already installed world-wide. The benefit is twofold : the volume of rock to be drilled is nearly one half of that with conventional clearances, meaning a faster rate of penetration, and the large and unstable bottom-hole assemblies for straight-hole drilling can be dispensed with. Starting with the intermediate section at about 8000 m depth, high-strength and light-weight drill strings will be needed, and downhole motors, either turbines or positive displacement motors adapted to the hostile environment of the borehole, will be used. Coring and logging in the intermediate section will be maximized since in the deepest section below 10 000 m a drastic reduction in coring and core recovery must be expected.

According to the studies done by the German drilling industry an ultraheavy drilling rig must be developed for the ultradeep drilling. The essential data of this rig are given in figure 9, compared with the rig for the pilot drilling. During an ultradeep drilling working time is divided up into about 1/3 for drilling, 1/3 for round-trip time, and 1/3 for borehole measurements. The unproductive tool change should be reduced to a minimum. Based on the suggestions of the aforementioned studies. The proven components of the iron rough neck, to drive, and pipe-racking system are combined into a fully automatic pipe-handling system. By doing so and by lengthening the drilling pipe to 40 m the round-trip time can be reduced by more than 1/3. In principle, for the main drilling as much proven material and technology should be used as possible, and in standard sizes since there is a wide range of auxilary tools and fishing equipment available. In the middle section of the borehole, drilling motors, preferably turbines, will be installed. This section will be completely cored and measured. In the deepest section of the borehole below 10 km drilling turbines and highly durable drilling pipe will be used and a drastic reduction in cored material will most likely have to be tolerated.

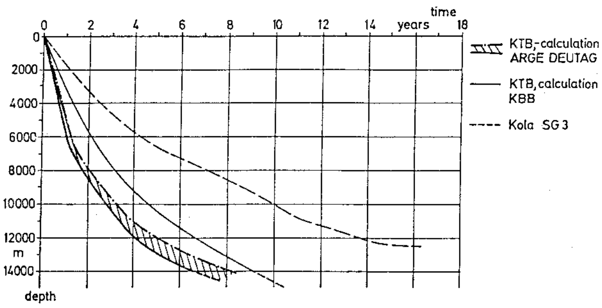



Figure 11.- Drilling time.

## THE ORGANIZATION OF THE KTB

The present organization scheme is shown in figure 10. The chart reveals three divisions : the university research program, the project management, and the on site operation. It is the basic principle of the project organization to attain - with plurality and freedom of science - the comprehensive and interested participation of a great number of outstanding scientists at the university level as well as to secure the cooperation of all engineering and technical personnel of industry and the universities.

The university research is funded by the German Research Society (DFG) and is coordinated by a committee including EMMERMANN, ALTHAUS, and GIESE. The DFG funds the individual projects of the university groups and institutes, of geological surveys, and individual scientists. The projects will be approved by experts through a special reviewing process with the participation of the board of directors of the project management group. For assistance in initiating new and interesting projects and research concepts and in the reviewing process, as a forum of participation for the greatest possible number of scientists, and to improve the integration of the projects into the overall KTB structure, 9 working groups have been founded after the drilling site decision. Meanwhile, practically all scientists who are interested in the project - presently more than 250 - are participating in working groups. Top-ranking experts were obtained as working group chairmen.

The operational part of the KTB is the project management in Hannover, which is a division of the Niedersächsisches Landesamt in Hannover (NLfB). It now comprises 45 employees in the four groups, i.e., geosciences, operational geology, technology and administration. After a necessary increase in manpower, the administration will be provided as a service of the joint administration department of the hosting state and federal geological agencies (NLfB and BGR).

For drilling of the pilot hole starting this month, the operational on site group «KTB Oberpfalz» was established, reporting to the project management in Hannover.

The link between the special research program of the German Research Society and the project management is the advisory committee, consisting of three sections corresponding to the project management organization. It comprises 20 well-known experts from industry, scientific institutes, and geological surveys, in addition to the members of the board of directors of the project management, the chief coordinator of the scientific program as well as representatives of the Bundesministerium für Forschung und Technologie and of the Ministerium für Wirtschaft, Verkehr und Technologie von Niedersachsen, and the German Research Society.

It should be mentioned that there have been difficulties and friction in the early phase of this large-scale project composed of different elements. Since mid 1986, however, when the project management became fully operational, the project was efficiently pushed forward with the result that the pilot hole will be started only one year after the decision on the drill site had been made.

## 7.- COSTS AND TIME SCHEDULE

The financial expenditure for the project is not in any way comparable with commercial drilings due to the exclusive objective of scientific research. A 5000-m-deep gas drilling in the Rotliegende of the Permian costs about 10 millions DM. The 6775-m-deep Lilienthal Z1 drilling near Bremen done by the BEB cost about 25 million DM; the 5654-m-deep Preussag drilling Sulzberg 1 near the Alps in the geologically difficult West molasse cost about 55 million DM. The KTB drilling with a maximum depth of 15 km, however, will cost an estimated 200-250 million DM. About 50 % of this will be required for the depths below 10 000 m. In addition 16 million DM will be necessary for the preliminary geoscientific studies, 23 million DM for a 3000-m-deep pilot drilling, 50 million DM for the geoscientists at the universities in the DFG program, and ca. 100 million DM for project administration, for the contracts to third parties, and for the geoscientific technical control and supervision at the drilling site. Correspondingly, the BMFT calculates the total project costs at 450 million DM, as an upper limit, and a duration of 10-15 years.

This project is also of employment-political significance. About 300 qualified workers will be required for the job.

There is also a great volume of contracts to suppliers and construction and maintenance companies (pipes, drilling site, streets, provisions, and disposal). The estimation of drilling time involves of course a high degree of uncertainty. Figure 11 shows the relation between the estimation of KTB and KOLA-SG3.

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