Complex technology for bioremediation of ground-water environments contaminated with hydrocarbons and their derivatives

OVERVIEW OF RESEARCH FINDINGS

This method can be applied for ex situ and in situ cleaning of ground-water environments polluted with petroleum products and industrial hydrocarbons. It can be adapted to contamination types and levels and to the geological conditions of the polluted area. The technology stimulates and helps the forces of nature. It uses original biopreparations stimulating the biodegradation of pollutants and increasing their bioavailability. Since the cleaning process takes place in a closed water circulation system, it is safe for the environment. The method employs unique biopreparations and technological solutions enabling inoculation, the control of biogenic substance levels, and the reduction of secondary pollution of the environment with microorganism metabolites.

The cleaning of contaminated ground and water environments by means of the method is cheap, effective, thorough, eco-friendly, and safe (no sanitary or health hazards are involved), as well as profitable and beneficial for the environment and society.

The method is protected by the following patents:

1. Grabas K., Kołwzan B., Pawełczyk A., Steininger M.: "System for remediation of grounds contaminated with hydrocarbons" P-379673, 28 April 2006;
2. Kołwzan B., Grabas K., Pawełczyk A., Steininger M.: "Method of microbiological purifying of grounds from hydrocarbons" P-379258, 21 March 2006;
3. Grabas K., Kołwzan B., Nowicka E.: "Method of purifying sewage and water containing hydrocarbons" P-363726, 26 November 2003.

Surface waters at a former Russian air base polluted with aviation fuel

Ground bioremediation at a transshipment railroad station

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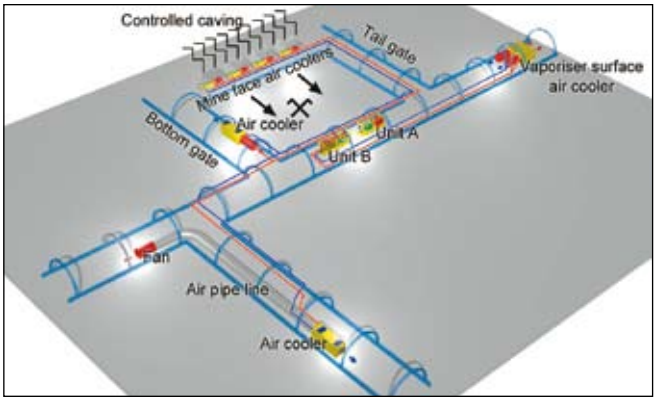
Air-conditioning in mines and tunnels
Ecological refrigeration machines with cooling power of 450 kW and over

OVERVIEW OF RESEARCH FINDINGS

The production of the machines is adapted to the needs of underground mines, where harsh temperature conditions must be coped with. TS-450 P refrigeration machines have been produced by PUH TERMOSPEC Sp. z o.o. and sold to Polish mines (2 machines) and Czech mines (12 machines). The estimated price of TS-450P ranges from EUR 125 000 to EUR 175 000 depending on additional controlling and measuring equipment.

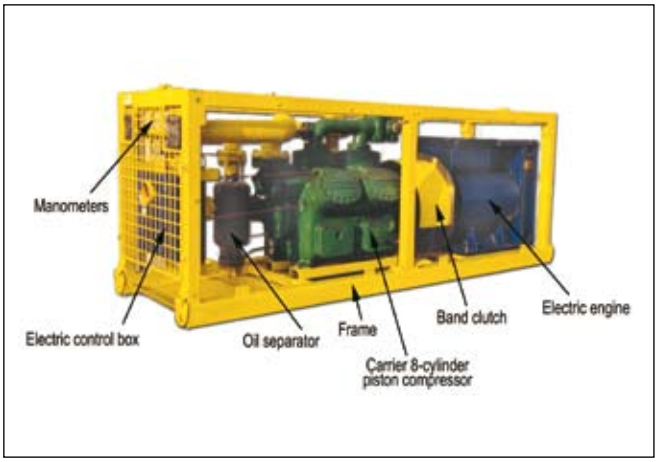
The entities interested in the machine are coal mines as well as copper and salt mines. Marketing research shows that within a few years the demand for indirect-use refrigeration machines with cooling power of 300-500 kW will increase to 10-20 machines per year. After production is launched, the machines may be sold on foreign markets.

The machine is promoted by AGH University of Science and Technology and PUH TERMOSPEC Sp. z o.o., at conferences, meetings at mines, exhibitions and via the Internet at: www.termospec.pl.

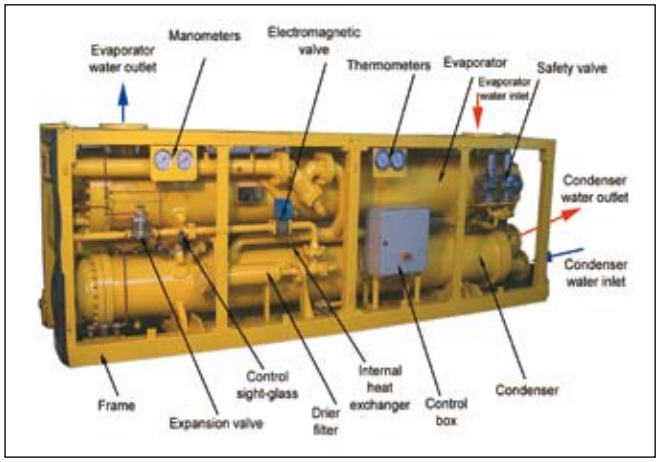


The indirect-use TS-450 refrigeration machine is designed for cooling air in underground pits, tunnels, etc. It is comprised of the following:

1. machinery unit A equipped with a compressor, engine and automatic control devices



2. machinery unit B equipped with an evaporator, condeser and automatic control and safety devices



Technical data

Machinery unit TS-450P/ZM A-B		
Type	TS-450P/ZM-A (Unit A)	TS-450P/ZM-B (Unit B)
Cooling power	450 kW	
Dimensions	height: 1.178 mm	height: 1.180 mm
	width: 870 mm	width: 870 mm
	length: 3.000 mm	length: 3.635 mm
Compressor	Carrier 5H126	
Electric engine (explosion proof with flameproof enclosure)	Manufactured by "CELMA" or "DAMEL" -132kW, 1000 or 500V, 50Hz	
Refrigerant	R507, R404A	
Evaporator		Shell-and-tube (460kW)
Condenser		Shell-and-tube (560kW)

Air coolers

	Cooler type			
	CP-200	CP-250	CP-300	SCP-40
Power rating	200 kW	250 kW	300 kW	40 kW
Dimensions	height: 950 mm	height: 950 mm	height: 950 mm	height: 460 mm
	width: 820 mm	width: 860 mm	width: 900 mm	width: 410 mm
	length: 2750 mm	length: 2850 mm	length: 2850 mm	length: 1550 mm
Weight	1450 kg	1500 kg	1600 kg	220 kg
Air pressure drop	800 Pa	900 Pa	1000 Pa	600 Pa
Air flow rate	6.0 m^3/s	7.5 m^3/s	10.0 m^3/s	1.5 m^3/s
Air temperature				
Inlet	32^{0}C	32^{0}C	32^{0}C	30^{0}C
Outlet	21^{0}C	21^{0}C	22^{0}C	15^{0}C
Condensed water rate	195.4 kg/h	228.1 kg/h	266.1 kg/h	-

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A hybrid system for assessing gas flow parameters

OVERVIEW OF RESEARCH FINDINGS

ATU 2001 is a four-channel thermoanemometer module – a thermometer for measuring the flow velocity and temperature of air and other gases for laboratory, technological, and industrial applications. Owing to its various operating modes, ATU 2001 works both as a constant-current thermometer (CCT) as well as a constant-temperature thermoanemometer (CTA) in each of four channels. The measuring system is adapted to operate with one-, two- and three-fiber sensors. It cooperates with a measurement card (of various types depending on system requirements, such as the number of channels, sampling frequency, and data bus). The system is managed by software (ATU2001) developed specifically for operating the measuring device. The basic software version serves to operate the thermoanemometer. The software is modified depending on the configuration of the measuring system.

Thermometer measurement chain:
- A constant current operating mode
- Measurement range – 0 to 100°C
- Sensor current – established for a given channel
- Gain – established for a given channel
- A low-pass output filter
- Voltage measurement output – 0 to +10 V
- Maximum output voltage – up to +12 V

Thermoanemometer measurement chain:
- A constant temperature operating mode
- Measurement range – 0 to 100 m/s
- Sensor heat – established for a given channel
- Input control signal – TTL/CMOS
- A low-pass output filter
- Voltage measurement output – 0 to +10 V
- Maximum output voltage – up to +12 V

Power supply system:
- External power supply – ~230 V, 50 Hz, aprox. 10 W
- Internal power supply – +12 V, stabilized
- Reference voltage – +10 V
- The sensor protection system – in transient states

Module dimensions:
- Width – 250 mm
- Height – 55 mm
- Depth – 175 mm

The anticipated production scale of the device will depend on demand; presently it stands at 1 item a month. The product will be promoted and sold via the Internet (www.img-pan.krakow.pl). Its estimated price will depend on the system configuration (the number of sensors, measurement channels). The system is patented under patent numbers PL 175301 and PL180025.

The system offers the following advantages: non-invasive, multipoint measurement of flow velocity and temperature; measurements of velocity and temperature fields; measurements of flow velocity vector components; measurements with the detection of sense of a velocity vector; measurements in non-isothermal flows; measurements of fast-changing flows; measurements of turbulence intensity; measurements in the range of very small flow velocities; measurements entailing low costs.

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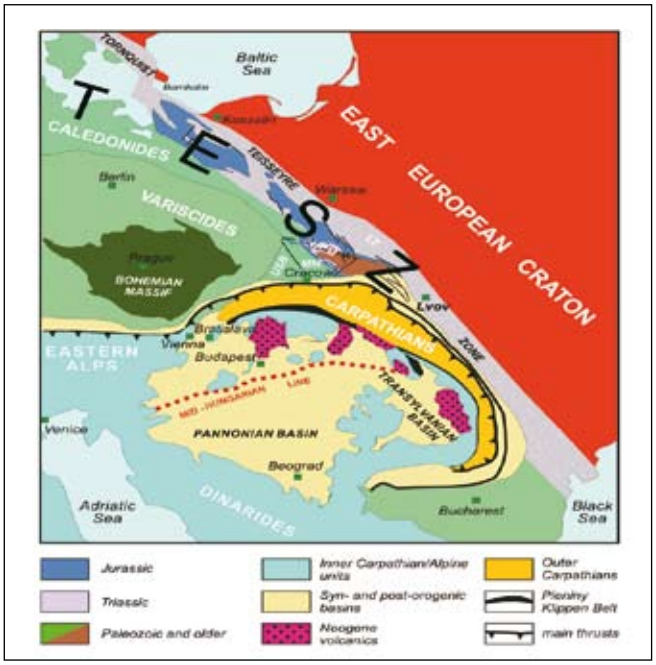
The geodynamics of Central Europe – geophysical research on the Earth's lithosphere carried out in Central Europe in 1997-2006 at the initiative of and under the supervision of Poland

OVERVIEW OF RESEARCH FINDINGS

In 1997-2003, thirty-five scientific and industrial institutions from 15 European countries, the USA, and Canada conducted a large program of researching the Earth's lithosphere in Central Europe using the seismic methods that constitute the foundations of modern geophysics. These were the seismic experimental projects known as POLONAISE'97, CELEBRATION 2000, ALP 2002 and SUDETES 2003. The CELEBRATION 2000 (**C**entral **E**uropean **L**ithospheric **E**xperiment **B**ased on **RE**frac**tion**) study was carried out in the area of Western Russia, Belarus, Poland, Slovakia, Hungary, Austria, the Czech Republic, and Germany using 1350 modern seismic stations (about 70% of all stations available in the world), mainly provided by American research centers in Washington and California. These were the greatest geophysical research undertakings of their type ever performed. The work carried out by approximately 1200 geophysicists and technicians lasted 30 days and nights from 1 to 30 June 2000. The headquarters of the project, headed by the Polish team, was located on the premises of PGNiG (the Polish Oil and Gas Company – Geofizyka Kraków) in Płaszów near Kraków. All the activities conducted by numerous teams across an area of 500 000 km^2 required a reliable communication system and a precision of up to 10^{-3}s.

Fig. 1. Simplified tectonic map of the Central Europe between the Baltic Sea, Adriatic Sea and Black Sea. Study area of seismic experiments POLONAISE'97, CELEBRATION 2000, ALP 2002, SUDETES 2003. TESZ – Trans-European Suture Zone; HCM – Holy Cross Mountains; USB – Upper Silesia Block; MM – Malopolska Massif.



Conducting all these experiments was made possible by the use of a new methodology for seismic research, enabling very expensive experimental work to be significantly reduced. All the major European geological structures between the Baltic Sea and the Adriatic Sea – particularly in Poland, which is of key significance in the geodynamics of the European continent – were encompassed by a system of state-of-the-art seismic profiles with a total length of 20 000 km. The research area and the location of the seismic profiles are presented in the geological figures shown here (Figure 1, 2). According to the international scientific community, this area is the Earth's region with the best studied crust structure and lower lithosphere to the depth of 60-100 km. Examples of the research results obtained during the projects POLONAISE'97 and CELERBRATION 2000 are presented in Figures 3, 4, 5.

All the experiments were conducted at the initiative of the Polish team, under the auspices of the Association for Deep Geological Investigation of Poland – a non-profit organization established for this purpose.

The obtained results, often of revolutionary nature, formed the basis for a new geological and geophysical interpretation of the Earth's lithosphere, which is of

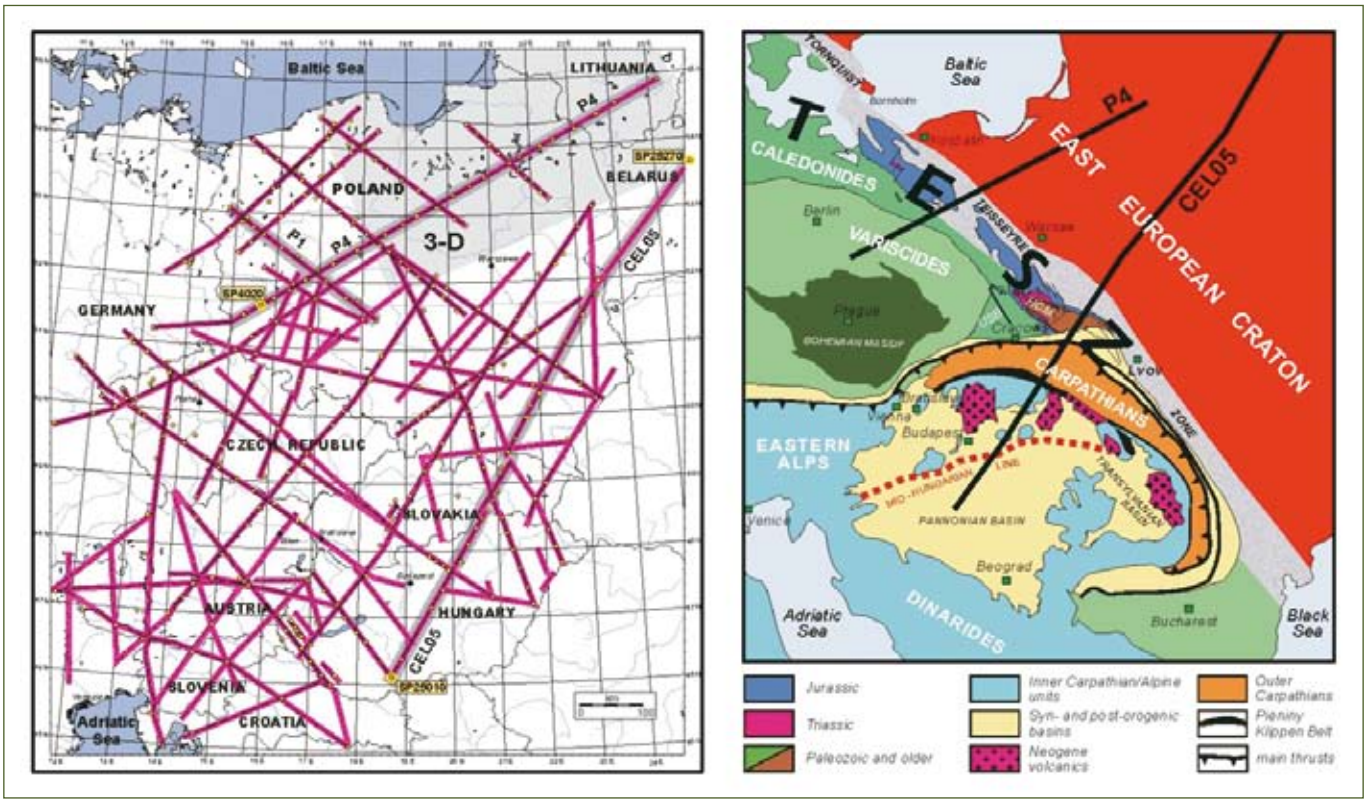


Fig. 2. Location of seismic profiles in the international modern seismic experiments POLONAISE'97, CELEBRATION 2000, ALP 2002, SUDETES 2003 (left side). White circles – shot points for generation of seismic waves; P1, P4 and CEL05 – main profiles for seismic experiments POLONAISE'97 and CELEBRATION 2000. Total length of all profiles is about 20,000 km. Basic seismic profiles for geodynamics of the Central Europe P4 and CEL05 (right side). TESZ – Trans-European Suture Zone.

fundamental significance for both basic and applied research related to hydrocarbon prospecting.

The dissemination of obtained research results. In 1998-2006 the results were published in 70 printed works, including 40 articles in prestigious international journals scored highly by Thompson Scientific. Most authors of the published works are Polish. The results were also presented at a number of international symposia and congresses in Europe, the USA, and Japan, as well as during prestigious symposia: "Challenges to Earth sciences in the 20th century" (Karlsruhe, Germany, invited paper) and "The dynamics of the Earth and the Planetary System" (Stockholm, the Swedish Academy of Sciences, invited paper). *The Oxford Guide to Modern Science* ranks the seismic project CELEBRATION 2000 as an experiment bringing science into the 21st century. The website of the National Science Foundation in Washington depicted the POLONAISE'97 and CELEBRATION projects as model examples of international cooperation in large scientific undertakings, underscoring the excellent preparation and implementation of the Polish-led experiments.

Funding. The program of seismic research on the Earth's deep crust structures and lower lithosphere (to the depth of 60-100 km) was successfully implemented in keeping with the highest caliber of world research owing to wide international cooperation with a number of research centers in the USA, Canada, and Europe, as well as harmonious collaboration among the Polish institutions financing the Polish part of the research.

Here we should mention:

1. PGNiG S.A. (extrabudgetary funds),
2. the National Fund for Environmental Protection and Water Management upon the request of the Ministry of Environmental Protection (extrabudgetary funds),

3. the State Committee for Scientific Research,
4. funding from the Institute of Geophysics (Polish Academy of Sciences) and the Institute of Geo physics at Warsaw University.

The project also received considerable financial help from the National Science Foundation in Washington and American university centers as well as the Geological Survey of Canada. In total, the costs of work in Poland were mostly (ca. 70%) covered by extrabudgetary funds and foreign funds.

The Chief National Geologist commissioned the preparation of an expert study on "Evaluating the implementation of the policy pursed by the Ministry of Environmental Protection in the field of deep regional geological research and recommending ways of updating that policy" based to a large extent on the presented results of seismic investigations on the Earth's lithosphere. The author of this expert study, Prof. Aleksander Guterch, was put in charge of an interministerial team appointed to develop a special program of deep research drillings in the Polish part of the Carpathians and in Western Poland, the most promising areas for hydrocarbon prospecting. These (very costly) undertakings are predicted to be financed by industrial institutions and by the Ministry of Environmental Protection from the National Fund for Environmental Protection and Water Management. The team's work has been underway since February 2007 and the study project is already at a very advanced stage.

The geophysical activities conducted within the framework of the European project called the Southern Permian Basin Atlas, coordinated and financed by the geological services and oil industries of Belgium, Denmark, Holland, Germany, Poland and Great Britain, are also relatively advanced. An important aim of the project is to stimulate the oil industries of these countries to carry out further investigations in Europe, based on new achievements in the area of deep geophysical research into the Earth's lithosphere. It will constitute a comprehensive scientific synthesis encompassing a large area of Europe aimed at a new generation of oil geologists – the Millennium Atlas No. 2: Petroleum Geology of the North-Western and Central Europe. Coordination of the second part of the project, devoted to the execution of necessary synthetic geophysical research work in the area ranging from Great Britain and the North Sea to Poland, was entrusted to Poland. These activities are at an advanced stage and are slated for completion by the end of 2007.

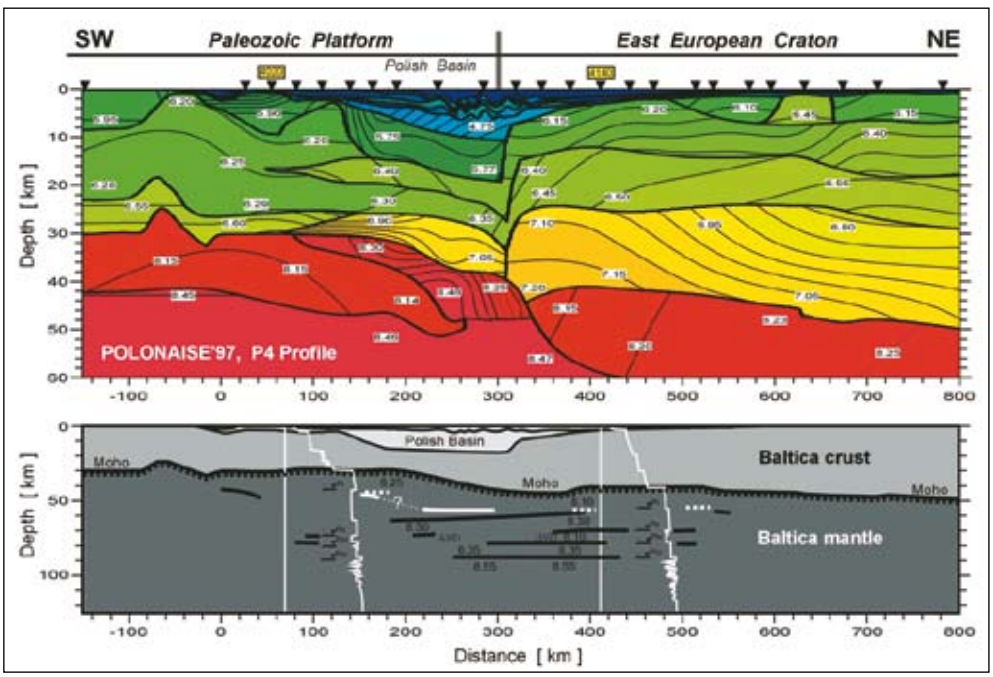


Fig. 3. Seismic structure of the Earth's crust (upper Figure) and lower lithosphere (bottom Figure) along POLONAISE'97 profile P4 (location shown in Fig. 2). The profile P4 runs across the Trans-European Suture Zone almost perpendicularly to the edge of the East European Craton. The thick solid lines – layer boundaries; Thin lines – isovelocity contours (in km/s); Moho is crust-mantle boundary; Black triangles – shot points along profile; Thick black and white lines – seismic reflectors from lower lithosphere.

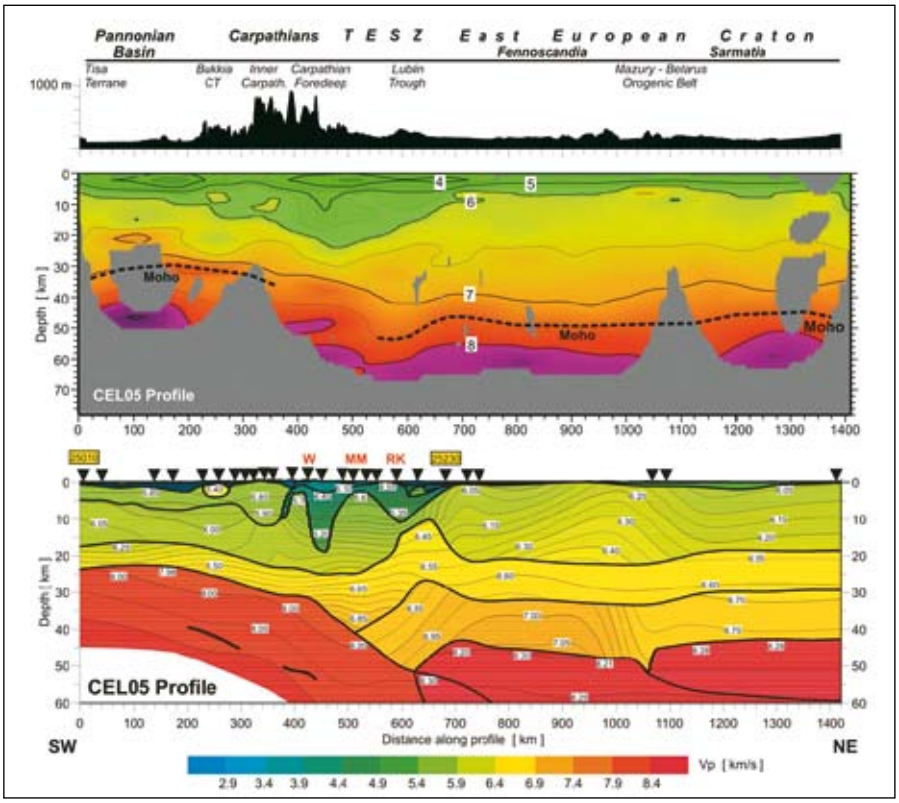


Fig. 4. Two dimensional seismic model of the Earth's crust for CELEBRATION 2000 profile CEL05 (location in Fig. 2) obtained by tomographic inversion of P wave first arrival travel times (upper Figure) and by ray-tracing modeling (bottom Figure).
Thick solid lines – layer boundaries; Thin lines – isovelocity contours in km/s; Moho is crust-mantle boundary; Black triangles – shot points. At the top of the model, topography along the profile is shown.

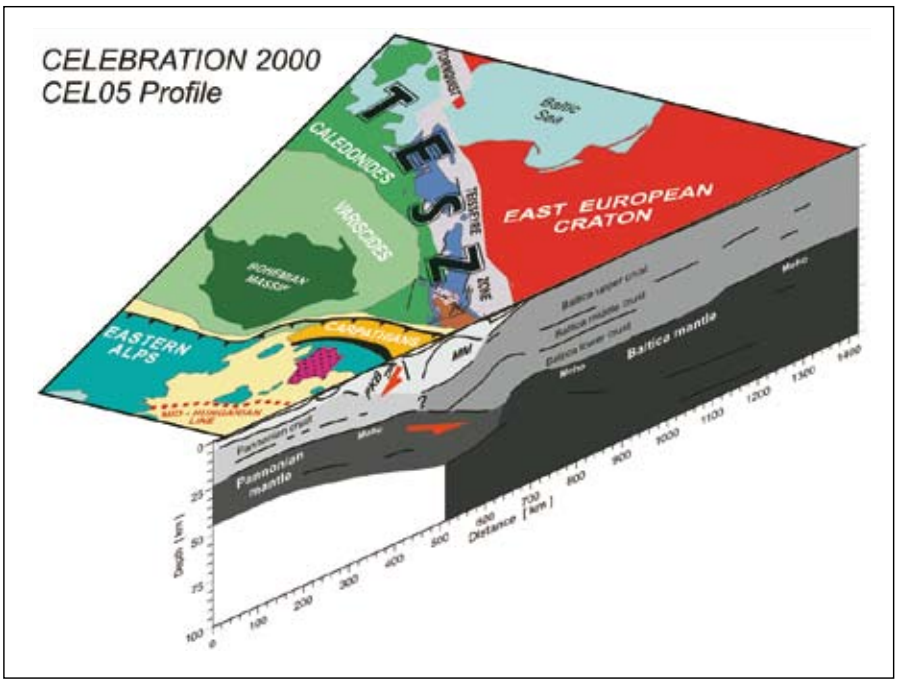


Fig. 5. Model of the lithosphere beneath CELEBRATION 2000 CEL05 profile (Fig. 2) to 100 km depth together with tectonic map of Central Europe. Note mantle lithospheric reflectors about 15 km deeper than the Moho boundary, up to 75-80 and ~95 km depth.
TESZ – Trans-European Suture Zone; HCM – Holy Cross Mountains.

Recent years of intensified activity on the part of international organizations dealing with the physics and structure of the Earth's interior have showed that without such research projects a complete understanding of the evolution of the lithosphere, i.e. the Earth's 100 km deep external layer, is impossible. New hypothesis and prognoses or the interpretation of Earth's deep structures will remain virtual without such modern experimental work confirmed by observations from deep research drillings. The conclusions drawn from such research have fundamental scientific and practical significance. American oil consortia, in close cooperation with scientific institutions, have already decided to carry out investigations at the previously unthinkable depth of 10 000 m, and have succeeded. Advances in extraction techniques open up the possibility of harnessing oil and gas from these deep Earth layers.

The project and analyses were carried out in cooperation with a Polish team comprising 20 individuals from different scientific centers. Technical work was carried out in cooperation with the groups from PGNiG's geophysical enterprises GEOFIZYKA Toruń S.A. and GEOFIZYKA Kraków S.A.

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