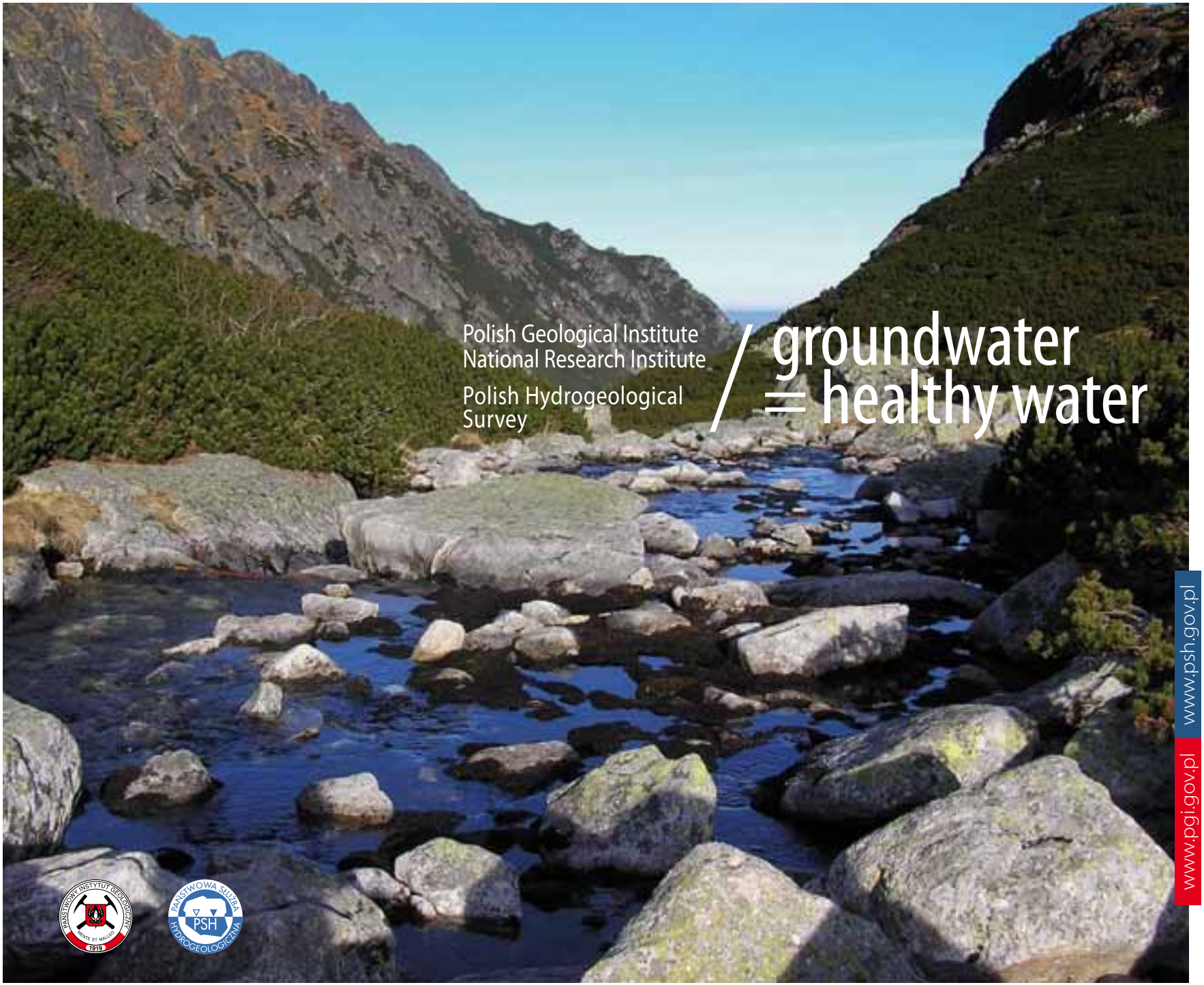
Polish Geological Institute
National Research Institute
Polish Hydrogeological
Survey
groundwater
= healthy water
www.pgi.gov.pl
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Cover: Roztoka Valley, Tatra Mountains
Photo M. Galczak

Polish Geological Institute
National Research Institute

Polish Hydrogeological
Survey

groundwater
= healthy water

Szklarki Waterfall, Karkonosze Mountains

Water is not just another commercial item – it is a part of our heritage, and must be protected, defended and treated as such.

(Water Framework Directive, 2000)

Water resources management serves the purpose of satisfying the needs of people and the economy, protecting waters and the environment connected with these resources.

(Water Act, 2001)

The Polish Hydrogeological Survey is carried out by the Polish Geological Institute

(Water Act, 2001)

Drilling of a groundwater investigation point in Udryń, NE Poland

Polish Hydrogeological Survey – mission and tasks

The mission of the Polish Hydrogeological Survey (PHS) is to limit the degradation of groundwaters intended mainly for consumption and to strive for sustainable management of groundwaters, which are the main source of water for consumption for approx. 70% of Poland's population. Depending on administrative competence, projects are carried out upon requests of the Ministry of the Environment, the Chief Inspector for Environmental Protection or the President of National Water Management Authority and are financed by the National Fund for Environmental Protection and Water Management.

The major tasks of the Polish Hydrogeological Survey:

- coordinating national groundwater monitoring programmes in order to assess the quantitative and qualitative status of national groundwater resources;
- undertaking groundwater monitoring in Poland's border zones;
- collecting, processing and archiving hydrogeological information and making it available to public;
- recognising and documenting Major Groundwater Reservoirs in order to establish their protection areas and to implement action programmes, which prevent their degradation;
- coordinating, supervising and creating serial digital hydrogeological maps;
- undertaking analyses and preparing reports on current hydrogeological situations and forecasts regarding changes in the current size of resources, as well as the condition and hazards related to groundwaters;
- warning public administration bodies against dangerous phenomena that take place in recharge zones and in groundwater intake zones;
- preparing and publishing informational and educational materials, as well as disseminating the knowledge and awareness as regards groundwaters among the public.

Groundwater resources in Poland

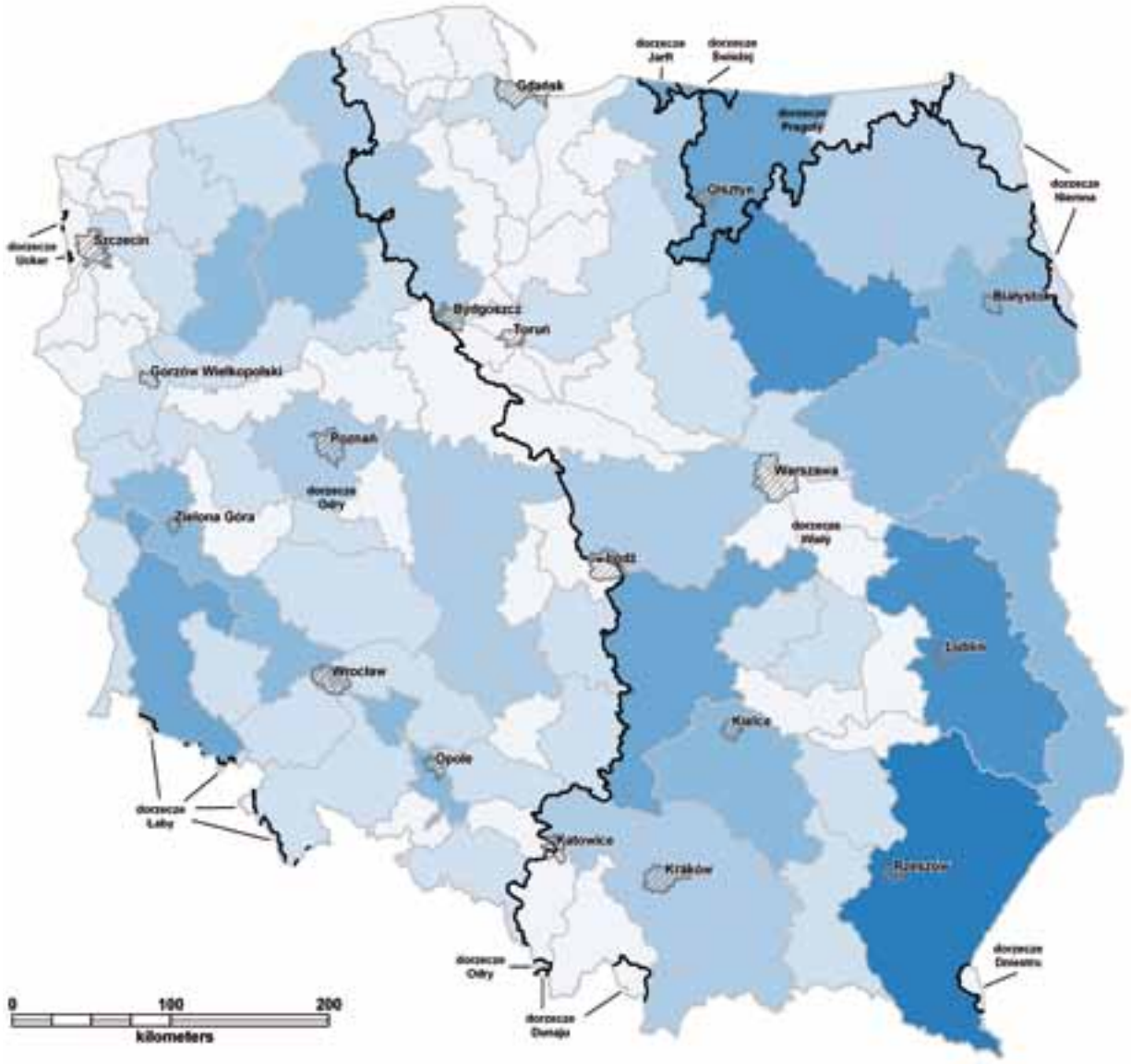
Disposable groundwater resources constitute the quantity of groundwaters whose intake from the hydrogeological system does not deteriorate their chemical condition, nor does it affect the desired condition of groundwater-dependent ecosystems. A hydrogeological balance system comprises a groundwater river basin along with the areas of groundwater inflow to intakes situated within the catchment divide.

The current total amount of disposable groundwater resources in Poland (according to the condition as at 28 Feb 2010) is approximately 37.4 M m^3/day.

Over 90% of the territory of the country contains very high and high reserves of disposable resources. Areas of average resource reserves cover 5.7%, whereas low and very low reserves can be observed in 1.9% of the country. In 1.4% of the country there is a danger of shortage of disposable groundwater resources (utilisation degree of groundwater resources of over 90%). Those are regions where dewatering systems for brown coal opencast mines operate and where high concentration of intakes of municipal and industrial agglomerations can be observed.

Photo A. Sadurski

St. Katharine Spring at a side of Łysica mountain, Holly Cross Mountains



River basin districts (border)

Groundwater resources available for exploitation in the groundwater balance units (on the 28th of February 2010) [m^3/24h]

- <250000
- 250000-500000
- 500000-750000
- 750000-1000000
- 1000000-1250000
- 1250000-1500000
- 1500000-1750000

Groundwater resources available for exploitation in the river basin districts (on the 28th of February 2010) [m^3/24h]

River basin districts	Groundwater resources available for exploitation [m^3/24h]
Dniestru	27000
Dunaju	41086
Jarft	36155
Laby	28914
Niemna	214694
Odry	15247340
Pregoły	1266578
Świeżej	27779
Uckar	2946
Wisły	20384973

Map of disposable groundwater resources of Poland

Groundwater monitoring

Groundwater observations are carried out in the monitoring network, which includes observation, diagnostic and research monitoring points. It forms part of the national environment monitoring scheme.

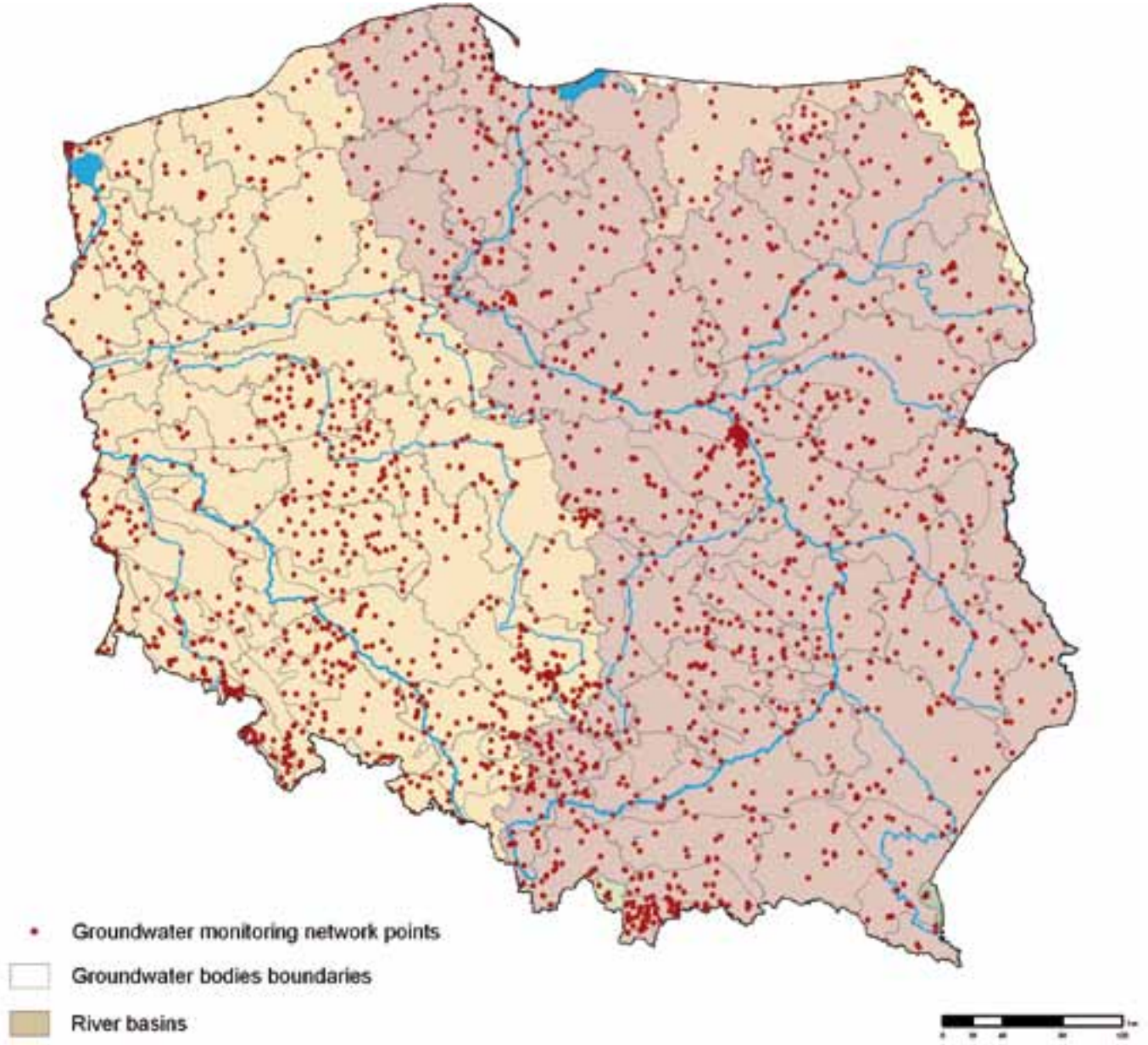
Monitoring of groundwater bodies is included as part of basic monitoring. Additionally, dedicated monitoring is carried out, such as in Poland's border zones or around large industrial facilities that pose a threat to national groundwater resources.

The groundwater monitoring network currently comprises 826 measurement points (boreholes and springs), and by 2012 this will include a total of 1200 points. Water samples for physicochemical analyses are collected once a year. The depth to water table or spring discharge is measured once a day or once a week apart from hydrogeological stations or other research points with installed automatic data loggers and transmission devices where measurements are carried out once an hour. The monitoring data is gathered in the GIS database. Interpretation of monitoring data permits syntheses, tabular presentations, cartographical visualisation and statistical analyses.

Continuous monitoring of national groundwater conditions with regards to their quality and quantity, carried out by the PHS, makes it possible to take timely actions preventing the negative results of human pressure. This is essential due to the considerable amount of time necessary for groundwater to clean up. In a case of emergency or a disaster that can trigger the necessity to disconnect water intakes and limit water supplies for people, hydrogeologists take actions that involve recognising the cause for groundwater contamination and defining an alternative source to provide people with water.

Photo W. Komorowski

Groundwater monitoring station in Polesie, Świętokrzyskie voivodeship



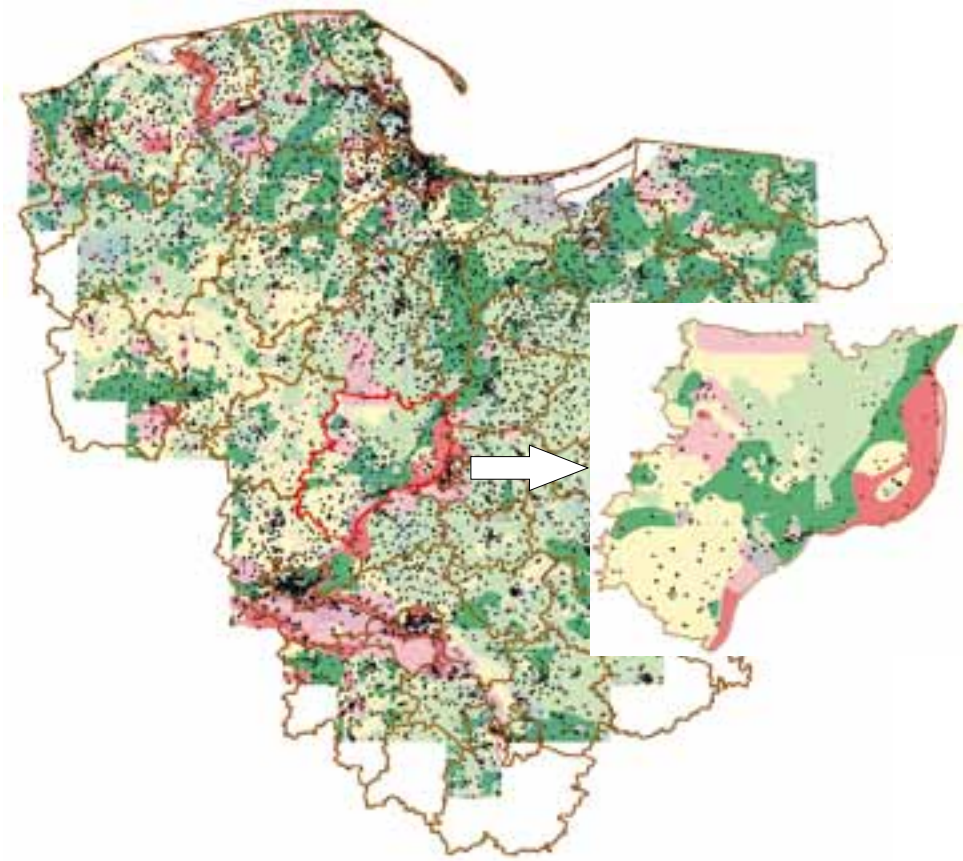
Distribution of groundwater monitoring network in Poland

Hydrogeological cartography

Hydrogeological cartography has been developing intensely in Poland since the 1950s, both as serial reference maps covering the whole country (1:300,000 and 1:200,000) and as thematic maps at detailed scales prepared in the 1960s and 1970s during the process of documenting the hydrogeological mining areas and large groundwater intakes. This answered the needs of the time related to the planned economy, hydrotechnical investments and provision of water to people, agriculture and industry. A synthesis of the knowledge of occurrence conditions and storage capacity of useful aquifers are included in hydrogeological atlases of Poland, scale 1:500,000.

Another stage in the development of hydrogeological cartography in Poland was the development of a digital Hydrogeological Map of Poland (MhP) between 1996 and 2004, scale 1:50,000, which offers a broad description of useful aquifers that are the primary source of water for people, industry and agriculture. Since 2005 cartographical works have continued connected with describing shallow groundwaters directly affecting the surface waters, land ecosystems and a considerable part of the farmlands and woodlands.

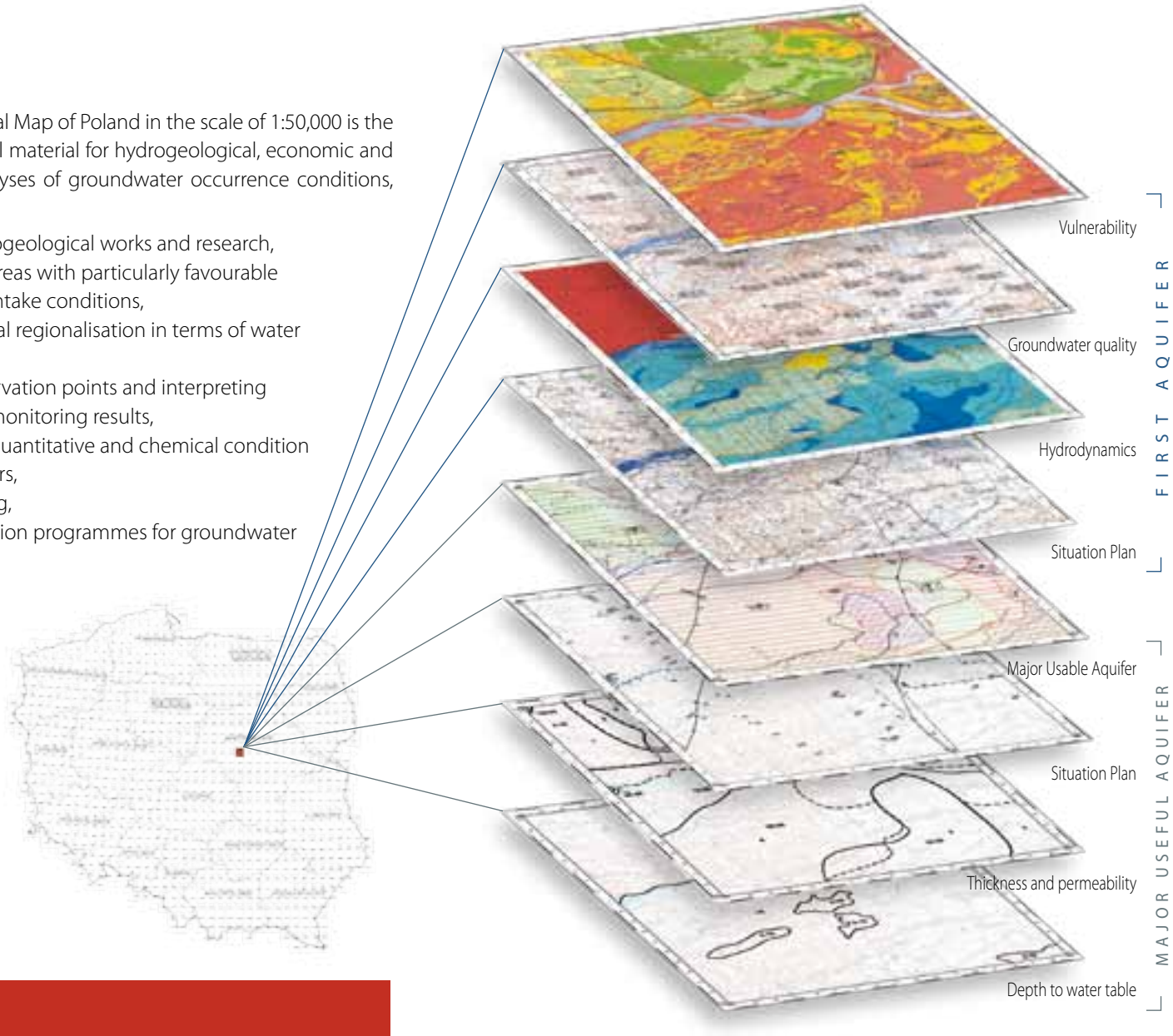
The Hydrogeological Map of Poland uses the GIS environment, which makes it possible to obtain graphic and descriptive data, to verify it, to resymbolise digital data to a cartographical form, to print maps and to archive the data. The spatially continuous GIS database for the hydrogeological map of Poland permits selective analysis and publication of informational layers within any defined boundaries (voivodeship, district, river basin etc.)



Display of the spatial GIS MhP database, which allows to select attributes within defined boundaries

The Hydrogeological Map of Poland in the scale of 1:50,000 is the basic cartographical material for hydrogeological, economic and environmental analyses of groundwater occurrence conditions, especially for:

- planning hydrogeological works and research,
- searching for areas with particularly favourable groundwater intake conditions,
- hydrogeological regionalisation in terms of water and economy,
- planning observation points and interpreting groundwater monitoring results,
- assessing the quantitative and chemical condition of groundwaters,
- spatial planning,
- developing action programmes for groundwater protection.



Example of the structure of the GIS MhP database with selected layers from Modlin Twierdza sheet

Marine hydrogeology

There are studies on the origin of salty waters in aquifers of the coastal zone, locally endangered with seawater ingression or ascension of brines from the Mesozoic ground. Research works are carried out also in the Baltic Sea.

The groundwater circulation system has been identified and numerical models of water bodies have been developed for coastal areas. Works connected with calculating groundwater discharge and the charges of the substances they contain, transported directly to the Baltic Sea, are currently in progress.

The zones of intensive undersea discharge in southern Baltic are under constant observation. Pockmark structures, showing evidence of undersea discharge, are used for this purpose. Also seismo-acoustic methods are used in hydrogeological studies, especially side-scan sonar profiling. Samples of sediments from the sea bottom and seawater are collected for chemical analyses and changes in water salinity and temperature are recorded.

< *Hel Peninsula - view from a harbour in Władysławowo*

Laser scan of a cliff in Gdynia-Orłowo

Water inflow into a mining path in the zinc and lead mine „Olkusz – Pomorzany", 2001

Mining hydrogeology

Since the 19th century mines have been drained in Poland, which has made it possible to exploit strategic natural resources up to a depth of over 1100 m. After the World War II, large-scale dewatering processes of brown coal opencast mines began, which required designs of drain systems and forecasts of their impacts.

In the aspect of the still considerable impact of mining on groundwaters, works connected with recognising and assessing mining waters are being conducted. These waters are channelled to the Vistula and the Oder Rivers through surface and underground sediment traps. Large sedimentation basins are also studied.

Monitoring covers hazards for aquifers in the vicinity of hard bituminous coal mines, brown coal mines, as well as iron ore, zinc ore, lead ore mines under liquidation. Acid mining waters pose a serious ecological threat in the area of former mine works. Currently, the most significant problems pertain to reclamation of mining excavations and post-mining areas.

Therapeutic waters

The first hydrogeological tests in the Polish Geological Institute pertained to mineral waters with therapeutic properties. The results concerned the chemical composition and physical properties, as well as occurrence conditions of the waters. In the territory of Poland, 3 areas with waters of different composition have been determined: the Polish Lowland, where Cl-Na brines predominate, accompanied by sulphate and sulphide waters; the Carpathians with the Carpathian Foredeep, where carbonated waters (mainly oversaturated by CO_2) are used and also sulphide and chloride waters of very diverse chemical composition occur; and the Sudetes with a range of foothills with carbonated waters and waters containing carbon dioxide and small quantities of many trace elements.

In over 70 places in Poland these waters are used for balneotherapy. Current studies use determinations of isotopes and noble gases to explain their origin, their chemical composition, their vulnerability, the residence time in the rock mass and the renewability of mineral waters, including the therapeutic ones.

Mineral waters have been used for therapeutic purposes since the Middle Ages. They are partially distributed nationally as bottled drinking waters.

Photo Uzdrowisko Rymanów S.A.

Thermal waters

The Polish Hydrogeological Survey studies thermal waters using a database from 6 deep boreholes made in the area of Poland. They make it possible to determine two basic properties of the rock mass: potential discharge of the intake and water temperature at the outflow from the borehole. Study results for the heat flow unit support the statement that temperature distribution in rock mass depends not only on remanent and radiogenic heat but also on climatic changes in the Pleistocene and the occurrence of permafrost. The remains of the permafrost were documented this year in north-eastern Poland at a depth of 360 m. Below this depth, the chemical composition of groundwaters is different as a result of cryogenic transformations.

The largest resources of 30-100°C waters were recognised in aquifers of the Jurassic and the Cretaceous periods. These waters are used for heating and leisure purposes in the 6 existing geothermal power stations. Further stations are under construction. In spas, thermal waters have been used for medicinal purposes for a long time.

Photo J. Chowaniec

Graduation Tower nr 3 in Ciechocinek Spa. The tower has been in operation since the middle of the XIXth century.

< *Celestyna Mineral Water Drinking Room in Rymanów Zdrój Spa*
< *Well head of the Bańska thermal intake*

Mineral waters

Poland belongs to countries rich in mineral waters. These waters occur at various depths, mainly deeper than fresh groundwaters. Variability of geological structure and hydrogeological conditions cause the genesis of mineral groundwaters and their composition very diverse, which is reflected particularly in the Carpathian region.

The origin and age of mineralised Carpathian waters is, to some extent, still a mystery. The studies conducted to date have made it possible to explain the origin of the waters. Chloride and sodium waters, hydrogencarbonate and chloride and sodium waters, as well as highly carbonated waters, simple and with chloride, are regarded as mixtures of fossil waters, in the past subjected to diagenetic processes with carbon dioxide, or as standard groundwaters with carbon dioxide. The general scenario suggests that the waters of a Paleogene sea have been buried in sediments and hidden deep beneath the ground. During diagenesis and the transformation of smectite into illite, the waters released from the mineral structures caused a reduction in general mineralisation, including the concentration of chloride ions, a drop in δD and an increase in $\delta^{18}O$ of waters. In parts of the rock mass accessible by deeply situated carbon dioxide, intensive transformation of albite to kaolinite took place, accompanied by silicate release, sodium ion and increased alkalinity of waters. Local mixing processes led to further decrease in the mineralisation of Carpathian groundwaters. Due to their highly mixed nature and the high concentration of 'dead carbon,' it makes sense to assess the age only in the case of simple carbonated waters, which is done using determinations of isotopic composition, especially of hydrogen.

Apart from isotopic tests, PHS runs data bases containing information about mineral groundwaters including fossil waters. We carry out also cartographic studies dedicated to their use and annual water balance analyses.

Geohazards

We deal with hazards caused by surface mass movements – landslides, soil creeping, rockslides and floods. Prepared between 2003 and 2006, *The Map of Areas in Danger of Being Flooded in Poland* is an important tool assisting flood risk management.

Landslides are a serious hazard in the mountain and foothill ranges in the south of Poland and in river valleys. They are formed during heavy rains and accompanying floods. Statistically speaking, in the Carpathians there are 2 landslides of roads or railways per 1 km. Currently, monitoring of the endangered mountainsides is being introduced and their stability is checked by means of mathematical modelling.

Studies are carried out in the area of mining damage in order to indicate the places of particular risk connected with coal and metal ore exploitation. Such places include but are not limited to mining voids that have not been removed and changes in the position of the groundwater table.

Gully erosion in the area of escarpments, especially on loess soils, poses hazard to technical infrastructure. We research loess soils, determine their physical and mechanical properties and study the relations pertaining to changes in these properties caused by a change in groundwater level. We also review gorge reinforcements and assess their effectiveness.

The radioactive landfill in Różan has been monitored and assessed since the beginning of 1990s. Analyses as regards the closing of the landfill and long-term monitoring of the environment after its operation ceases are being carried out.

Flood in the Vistula River valley near Sandomierz, 2010 >

Landslide in the Carpathian Mountains (2010); Kłodne

Photo M. Konieczyńska

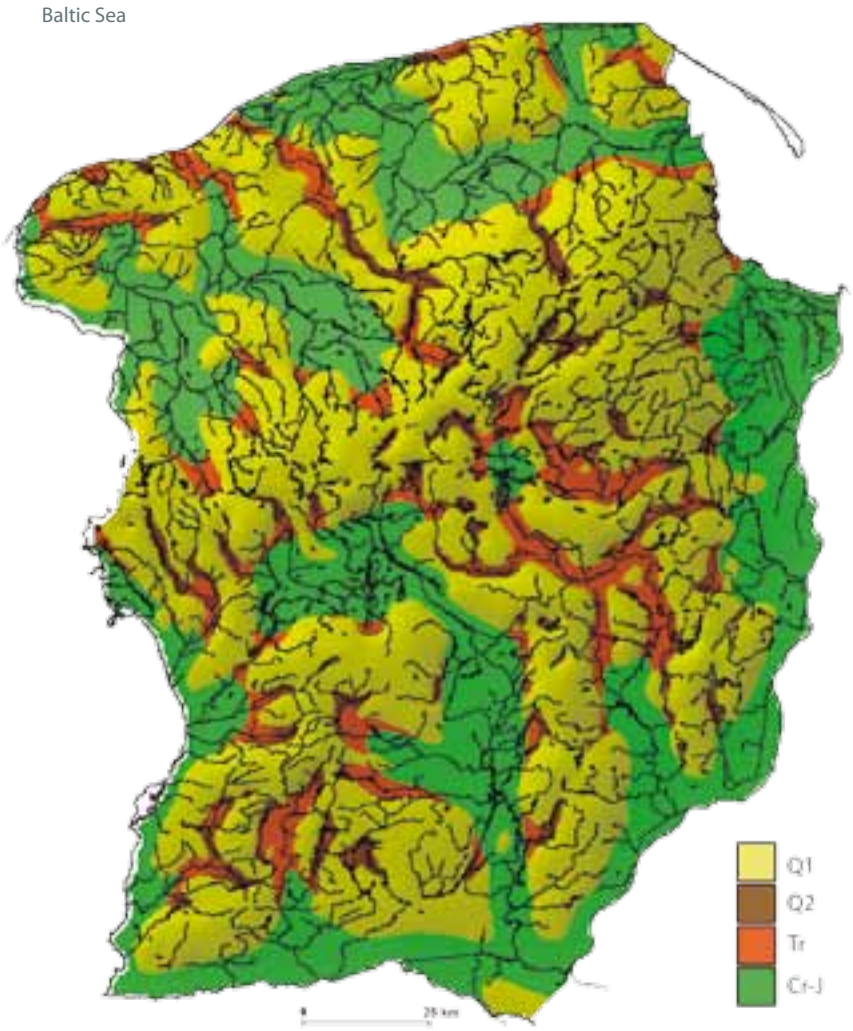
Photo M. Ścibisz

Groundwater flow modelling

The Polish Hydrogeological Survey uses mathematical modelling as a tool in regional hydrogeological studies. The majority of Poland is covered by groundwater flow models built to assess the disposable groundwater resources in river catchment areas.

The chemical condition of waters and forecasts of their potential changes are assessed using chemical equilibrium models – thermodynamic modelling.

The Polish Hydrogeological Survey supervises an extensive project the purpose of which is to delineate protection areas of the Major Groundwater Reservoirs in Poland. This project uses mathematical groundwater flow modelling.



The regional groundwater flow model of the Eastern Pomerania. Superposition of the four groundwater tables calculated by the model are shown as the colored surfaces: Q1 – Upper Quaternary aquifer water table, Q2 – Lower Quaternary aquifer water table, Tr – Neogene and Paleogene aquifer water table and Cr-J – Mesozoic aquifer water table.

Geoinformation

The largest collection of data regarding hydrogeological boreholes in Poland is the Central Hydrogeological Data Bank, known as the HYDRO Bank, containing information on 134 thousand documented hydrogeological features in Poland. The *Intake Database* provides information on the use of groundwater intakes. The data come from over 11 thousand intakes and along with the *Disposable Groundwater Resources Database* is the basic source of information necessary for undertaking water management

Data on groundwater observation and research can be found in the *Groundwater Monitoring Database*, which includes data regarding groundwater quality and quantity used while assessing groundwater condition in Poland, preparing hydrogeological forecasts and announcements, bulletins and annual reports. Another database is the *Major Groundwater Basin*, used also for the benefit of planning and managing groundwater resources within river basins. If detailed hydrogeological information is needed as regards spatial planning, selection of areas for groundwater intake construction, establishment of their preliminary location conditions, establishment of hydrogeological conditions for define protected areas or geological and hydrogeological work designs, the *Hydrogeological Map of Poland* database, in the scale of 1:50,000, can be used. This enormous data collected in the system is an outcome of the efforts of numerous hydrogeologists working on the project between 1996 and 2004. The map is regularly updated.

Basic information on groundwater resources collected in the databases can be easily reached through the PHS website (http://www.psh.gov.pl) or directly through the e-PHS portal (http://epsh.pgi.gov.pl/epsh/) and the IKAR geographic portal (http://ikar.pgi.gov.pl), which makes it possible to search metadata as well.

Activated in 2009, the e-PHS geographic portal (http://epsh.psh.gov.pl/epsh) provides access to information directly from numerous databases available for all users.

Central Chemical Laboratory

The Central Chemical Laboratory determines chemical composition and physical properties of over six thousand samples of groundwaters from Poland per year. The Laboratory is also equipped for effective chemical preparation of soil samples and organic substances, including: microwave furnaces, lyophilisers, dry block heaters, extractors and extract concentration systems. The equipment used to determine elements and chemical compounds include: UV-VIS, AAS, XRF, ICP-OES and ICP-MS, FT-IR spectrometers, as well as chromatographs HPLC, GC, GC-MS and coulometers.

The Laboratory holds a certificate of the Polish Centre for Accreditation Nr AB 283 in the area of general environment and physicochemical properties, which confirms conformity with the standard PN-EN/ ISO 17025: 2005 Ap1:2007 as regards the competence of testing and calibration laboratories.

Within quality control, the Laboratory participates in prestigious interlaboratory comparisons, which involve environmental and geological sample tests.

Photo B. Ruszkiewicz

Establishing filtration coefficient of cohesive soils using "Trautwein" device.

< *GC-MSD/Headspace (5973/7694E) gas chromatograph with detector and mass spectrometer*

< *Inductively coupled plasma optical emission spectrometry ICP-OES*

Laboratory of Hydrogeology and Engineering Geology

The Laboratory of Hydrogeology and Engineering Geology of the Polish Geological Institute – National Research Institute studies soil and rock samples for their physical, chemical and mechanical properties.

The Laboratory has modern research equipment, which permits comprehensive studies of soil samples carried out in accordance with Polish and international standards for the benefit of: geotechnical science, engineering geology and hydrogeology.

We have the following equipment:

- triaxial and uniaxial compression devices used to determine soil strength parameters,
- mercury porosimeter to measure the porosity and dry density of soil samples,
- laser particle sizer, which permits a granulometric analysis of cohesive and non-cohesive soils,
- oedometers for incremental and continuous loading to determine the stress-strain parameters of soil.
- devices for testing the coefficient of permeability of poorly permeable soils including tests with oil-derived substances and model solutions.

The Laboratory performs also analysis for geochemical maps and carries out field studies, such as geotechnical penetration tests and core logging.

The Laboratory provides expert opinions and studies as regards determination of engineering geological conditions for spatial planning, building foundations, landfill location, water reservoir, roads and highways, escarpment and slope stability assessments, determination of physical and mechanical properties of soils and rocks.

Disseminating information on groundwater

A significant aspect of the activity of the Polish Hydrogeological Survey involves raising the awareness of the public in the area of groundwater use. Consumers do not tend to think about the origin of the water they drink and they are often unaware that it comes from groundwaters that is "invisible" on the surface and the quantity of which exceeds that of surface waters by tens of times. Education in this respect starts as early as primary schools, through various contests, dedicated classes, exhibitions and brochures.

The basic information on the condition of groundwaters in the country is made available by the following cyclic publications: informational groundwater bulletins, hydrogeological annual reports, guidelines of the Polish Hydrogeological Survey, handbooks and other. Direct access to information on Polish groundwater resources is provided by a website of the PHS (www.psh.gov.pl) and the e-PHS geoportal.

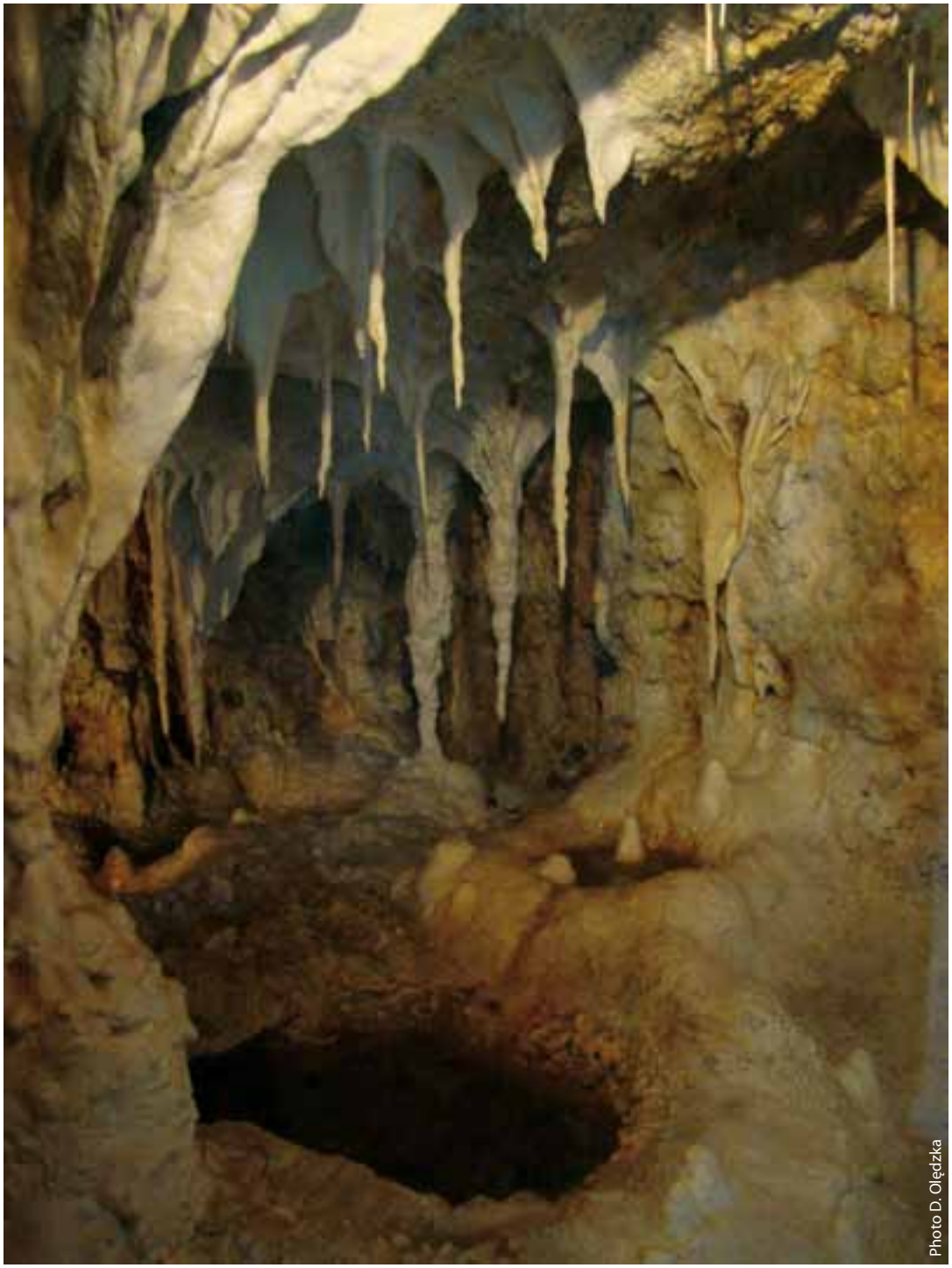


Photo D. Olędzka

A cave model used for education of young visitors in the Geological Museum of the Polish Geological Institute – National Research Institute

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