MINISTRY OF ENVIRONMENTAL PROTECTION
NATURAL RESOURCES AND FORESTRY

MINERAL RESOURCES OF POLAND 1995

POLISH GEOLOGICAL INSTITUTE
WARSAW 1996

MINISTRY OF ENVIRONMENTAL PROTECTION
NATURAL RESOURCES AND FORESTRY

MINERAL RESOURCES OF POLAND 1995

POLISH GEOLOGICAL INSTITUTE
WARSAW 1996

PREPARED IN POLISH GEOLOGICAL INSTITUTE IN ORDER OF GEOLOGY DEPARTMENT OF THE MINISTRY OF ENVIRONMENTAL PROTECTION, NATURAL RESOURCES AND FORESTRY

Editor: Stanisław PRZENIOSŁO

Prepared by:
A. Dziedzic, J. Muras, A. Pizon, A. Piotrowska,
S. Przeniosło, D. Siekiera, W. Szczygielski, E. Zdrojewska

Associate editors:
A. Jaszczuk, I. Wąsik

Graphics map preparing:
R. Bońda, A. Jaszczuk, D. Siekiera

Translated by:
A. Jaszczuk

Edition and English verification:
K. Radziwiłł

Accepted for printing
by Professor Stanisław SPECZIK
Director General of the Polish Geological Institute
December, 1996

Calculations and computer works were done
in the Economic Geology Department of PGI with using the system of
MANAGEMENT AND PROTECTION OF MINERAL RESOURCES IN POLAND "MIDAS"

ISBN 83-86986-16-6

Rakowiecka 4, 00-975 Warsaw
phone: 485351 fax: 495342 e-mail: stan@pgi.waw.pl

Wydanie I. Nakład 500 (+25) Ark. wyd. 6,8
Druk zak. w grudniu 1996 r.

Druk CBK - PAN Zam. nr 130p/96

Dear Reader,

The Polish Geological Service has been preparing for 42 years the annual "Raw Material and Groundwater Resources Balance of Poland" which contains information about the domestic raw material deposits. The high appreciation of value and suitability of this work which were expressed by the consumers, induce us to prepare this work "MINERAL RESOURCES IN POLAND 1995".

The lasting and increasing presence of foreign investors in Poland, also in the mineral industry, give reasons for publish the compendium of knowledge, prepared in English.

Information concerning the state of geological identification of deposits, their management, resources and magnitude of the output are summarised in this publication. Besides, data on the potential possibilities and development lines of the basic branches of mining and processing industries are presented. Information on the magnitude and directions of Polish imports and exports of raw materials completes the image of the domestic raw material economy and shows the position of Poland on the world raw material market.

The "Mineral Resources in Poland" present an important source of information for people interested in the development of mining and processing industries or in using domestic raw materials in their industrial investments in Poland, and also in the economy of raw material in our country.

Dr. Krzysztof Szamałek

Secretary of State
Chief Geologist of the Country

CONTENTS

PLATES

1. INTRODUCTION

In the Polish Geological Institute the "System of Management and Protecting of Polish Mineral Raw Materials MIDAS" has been introduced to meet the needs of concerning the geology of raw material deposits and allow estimation of the raw material domestic base. Actually information on 6791 deposits of various raw materials is accumulated in the system basis. This system was the source of data for preparing the work "Balance of Raw Material and Groundwater Resources in Poland". This publication, in Polish, is prepared annually since 1953.

The Polish version of the "Balance of Raw Material and Groundwater Resources in Poland as per December 31, 1995" was used as basis for the present publication "MINERAL RESOURCES IN POLAND • 1995". The tables concerning the magnitude of resources, output and Polish exports and imports of mineral raw material have been taken from the Polish work.

The raw materials have been classified into four groups, i.e. power, metallic, chemical and other ones. In the particular groups raw materials are given in alphabetical order. The coexisting raw materials are given in the same group as the main raw material, for instance helium is presented with natural gas in the group of power raw materials. The tables summarizing the magnitude and the directions of imports and exports are given only for raw materials of major importance in the international turnover. The criterion for including the particular raw material in the table was the magnitude of its imports and exports in 1995, which had to reach the minimum value of 10,000 thousand PLN. The number of countries in these tables has been limited in principle to those whose turnovers with Poland amounted to not less than 500 thousand PLN.

The biggest terminological difficulties in the translation into English concerned the classification of resources. For instance, it deserves noteing that in Polish the term "reserves" and "resources" are not distinguished and are cover by one term "zasoby".

The terminology and classification of the resources used in this work is in accordance with the United Nations International Framework Classification For Reserves/Resources (Solid Fuels and Mineral Commodities) (Workshop-1995), accepted by the UN Economic and Social Council in Geneva from 4th to 6th November 1996 Energy/ WP.1R.57 - 1996). The adaptation of Polish terminology to standards of the UN Classifi-cation is a constitution of earlier such attempts (M. Nieć 1995). For better understanding and making possible the use of the original Polish publications on the management of resources we present below the UN classification and the corresponding Polish terms after M. Piwocki, S. Przenioslo (in press).

The meaning Terms and their Definitions is given in the Glossary constituting the last part of this publication. It deserves noteing that the estimation of the Polish resources base has been made at the "Geological Study" level. The reserves explored in detail based on the Prefeasibility Study or Mining Report have been accounted for the total quantity of Resources - explored in Geological Study, so the Total Mineral Resources include the Mineral Reserves.

Table 1.1 United Nations International Classification for Reserves/Resources with Polish terms

<table>
<tr><th colspan="2" rowspan="2">UN International Framework</th><th>Detailed Exploration</th><th>General Exploration</th><th>Prospecting</th><th>Reconnaissance</th></tr>
<tr><th>National System</th><th>(A + B)</th><th>C_1</th><th>C_2</th><th>D_1, D_2</th></tr>
<tr><td>Feasibility Study and / or

Mining Report</td><td>Operat ewidencyjny zasobów złoża (Register work of deposit resources)</td><td>1. Proved mineral reserve (A + B) (111)
2. Feasibility (A + B) mineral resource (211)</td><td colspan="3">usually

not</td></tr>
<tr><td>Prefeasibility Study</td><td>Projekt Zagospodarowania Złoża (Project of deposit management)</td><td colspan="2">1. Probable mineral reserve (Zasoby przemysłowe) (121) (122)
2. Prefeasibility mineral resource (Zasoby nieprzemysłowe) (221) (222)</td><td colspan="2">relevant</td></tr>
<tr><td>Geological Study</td><td>Dokumentacja geologiczna (Geological documentation)</td><td>1 - 2 (331) Measured mineral resource</td><td>1 - 2 (332) Indicated mineral resource</td><td>1 - 2 (333) Inferred mineral resource</td><td>7 (334) Reconnaissance mineral resources</td></tr>
</table>

Mineability Categories: 1 – economic, 1-2 – intrinsically economic (economic to potentially economic)
2 – potentially economic 7 – undetermined

2. ANTHRACITE

The only identified deposits of anthracite in Poland named Wałbrzych-Gaj lie in the Lower Silesian Coal Basin (Dolnośląskie Zagłębie Węglowe (DZW)). They have been separated from the Chrobry Mining Plant and Victoria Mining Plant deposits.

The identified resources of anthracite correspond to the cut off established by the Minister of Environmental Protection, Natural Resources and Forestry. The mean qualitative parameters of Polish anthracite are as follows: ash content 5.6%, volatile matter content 7.9%, total sulfur content 0.9%, and minimum of calorific value 8390 kcal/kg (35130 kJ/kg). Anthracite occurs in 22 beds, whose thickness ranges from 0.6 m to 3.7 m, giving an average of 1.9 m. The exploitation was started in 1993 with output of 158 thousand tons.

The measured resources of Wałbrzych-Gaj deposit amount to 12.3 million tons, the indicated resources to 36.3 million tons which gives a total of 48.6 million tons, from which 20.9 million tons are classified as economic reserves.

The extraction of anthracite in 1995 was 276 thousand tons out of which 74 thousand tons were designed for export, mainly to United Kingdom, Czech Republic, Germany and Ukraine. Polish import of anthracite, amounting to 29 thousand tons, came from Ukraine.

3. COAL BED METHANE (CBM)

Exploitation of coal bed methane (CBM) requires on account of the forms of its occurrence special desorption technologies. Such exploitation is becoming more and more important in the world, and is considered to be a way of extracting gas from non-conventional sources.

The state of identification of CBM resources is shown in Table 3.1.

Proven initial resources occur in 36 deposits in the Upper Silesian Coal Basin (Górnośląskie Zagłębie Węglowe (GZW)). In the remaining coal basins, i.e. the Lower Silesian (Dolnośląskie Zagłębie Węglowe (DZW)) and Lublin (Lubelskie Zagłębie Węglowe (LZW)) ones no fields of CBM reserves have been proved (Plate 1).

In the area of exploited coal deposits the reserves extractable by methods of demethanization of mines are regarded as proven initial ones. The index of utilization of CBM in coal mines of the Upper Silesian Coal Basin amounts to about 0.2. In the case of natural gas this part of reserves is defined as extractable reserves.

In the case of CBM the industrial (economic) reserves are determinated separately - as proven initial reserves from the parts of deposit, which will subjected to demethanization. For CBM fields, in the Upper Silesian Coal Basin (with industrial (economic) reserves calculated in the Project of deposit management) these reserves represent 80% of the proven initial resources.

The CBM to be wasted in the course of ventilation of mines is regarded as subeconomic resources.

As regards fields of CBM being outside the exploited coal deposits, the resources possible for recovering are not defined, because the quantity of recoverable methane will depended on the method of exploitation.

Therefore we decided to present in the tables the resources separately for both kinds of areas. One we can state that approximately only one-third of CBM resources occurring in the

areas being outside the exploited coal deposits is comparable with the initial proven resources of CBM in the coal mines.

The methane output from the fields of proven initial resources amounted to 247 million m^3 in 1995 and was bigger by about 17% than in the previous year. The quantity of methane, names as "emission with ventilation from subeconomic resources", emitted in 1995 to atmosphere from the above-mentioned coal deposits amounts to 345 million m^3. These data can be useful for estimating atmospheric pollution by methane from mine ventilation. However, for full estimation of atmospheric pollution also mines in which the occurrence of methane was detected but the reserves of the gas have not been proved should be considered.

Table 3.1 Coal bed methane (mln m^3)

Specification	Number of deposits	Reserves/resources				Economic reserves
		Intrinsically economic			Potentially economic	
		Total	Exploration	Prospecting		
I. Total proved resources	**36**	**59308.88**	**1680.29**	**57628.59**	**92453.54**	**5281.31**
including:						
Resources in the hard coal exploitation regions	28 *	9271.26	1669.49	7601.77	79784.74	2189.31
Resources outside the hard coal exploitation regions	12 *	50037.62	10.80	50026.82	12668.80	3092.00
II. Prospected resources	10	57717.92	–	–	–	–
including:						
Resources in the hard coal exploitation regions	2 *	4016.24	–	–	–	–
Resources outside the hard coal exploitation regions	8 *	44711.72	–	–	–	–

* in eight deposits the raw material occur in the area of coal exploitation and outside this area

The highest potential of CBM is found in the Upper Silesian Coal where perspective resources were estimated in 1991 at about 350 billion m^3. The perspectives are considerably lower in the Lower Silesian Coal Basin where the perspective resources amounted to about 5 billion m^3. In the Lublin Coal Basin the possibility of CBM occurring is not excluded, but insufficient information does not allow numerical estimation. Estimation of the possibility of methane occurrence relates to zones with increased methane content defined by the limit of 3rd class of methane hazard (over 4.5 m^3 per ton of crude coal matter (csw). These zones pertain to beds of thickness exceeding 0.3 m lying at a depth 1600 m in the Upper Silesian Coal Basin, and of 1000 m in the Lower Silesian Coal Basin.

4. CRUDE OIL

In Poland, oil fields occur in the Carpathians (Karpaty), the Carpathian Foredeep (Zapadlisko Przedkarpackie), the Polish Lowland (Niż Polski) and on the Baltic Sea (Morze Bałtyckie) (Plate 1). In this publication only the onshore resources are considered.

In the Carpathians oil fields occur in several tectonic units, including: the Magura, Dukla-Michów, sub-Silesian, Silesian and Skole one, but most of them lie in the Silesian unit. They are mainly structural fields, more rarely structural-lithological ones, mostly of bedded type.

The Carpathian oil is of methane type. Its density ranges from 0.750 to 0.943 g/cm^3. It is free from sulfur and is mostly a paraffin oil containing 3.5 - 7% of paraffin. The reserves are small and they depend on the quantity and type of structures in which they occur. Initially in place resources mainly range from a few to over 400 thousand tons. The exploitation, lasting many years, has caused exhaustion of the reserves in this region.

Table 4.1 Crude oil (thousand tons)

Specification	Number of fields	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	Exploration	Prospecting	
I. Total proved resources	92	*4485	2761	1724	351
	88	**4324	2726	1597	351
	4	***161	34	126	0
including reserves of exploited fields					
Total	86	4146	2738	1408	26
	84	4133	2726	1407	26
	2	13	11	1	0
Carpathians (Karpaty)	46	1140	677	463	26
	45	1138	676	461	26
	1	1	0	1	0
Carpathian Foredeep (Zapadlisko Przedkarpackie)	10	1034	835	199	–
	9	1023	823	199	–
	1	11	11	0	–
Polish Lowland (Niż Polski)	30	1972	1225	746	–
	30	1972	1225	746	–
	0	0	0	0	–
including reserves of not exploited fields					
Total	5	291	23	267	325
	3	142	0	142	325
	2	148	23	125	0
Carpathians (Karpaty)	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
Carpathian Foredeep (Zapadlisko Przedkarpackie)	2	115	0	115	325
	2	115	0	115	325
	–	–	–	–	–
Polish Lowland (Niż Polski)	3	175	23	151	–
	1	26	0	26	–
	2	148	23	125	–
including reserves of abandoned fields					
Total	1	48	–	48	–
	1	48	–	48	–
	–	–	–	–	–
II. Prospected resources	40	5	–	–	–
	40	5	–	–	–
	–	–	–	–	–

* total resources, ** crude oil, *** oil condensate

Plate 1

MAP OF OCCURRENCE OF OIL AND GAS FIELDS

Resources:

- Oil fields — 0.2 2 mln t
- Oil and gas fields — 0.2 2 mln t
- Gas fields — 0.2 2 bln m³ / mld m³
- Underground gas stores — 0.2 2 bln m³ / mld m³
- Areas of prospects for CBM occurrence

Occurrence of oil- and gas-bearing formations:

- Oil- and gas-bearing rocks of the Carpathian Foredeep
- Oil- and gas-bearing rocks of Carpathian area
- Permian (Zechstein) oil- and gas-bearing formations
- Carboniferous oil- and gas-bearing formations
- Pre-Carboniferous oil- and gas-bearing formations
- Areas without prospects for oil and gas occurring (after S. Depowski and others 1993)
- Boundary of Zechstein formation (after R. Wagner)

In the Carpathian Foredeep oil fields occur in Tertiary sediments in Mesozoic sediments of platform type (mainly Jurassic carbonate rocks, rarely in Cretaceous sandstones) which are mostly lie under an impermeable Miocene clay sediments. They mainly are bedded fields, stratigraphically closed (either lithological or tectonic). In this region, it is light and medium weight oil (it is density being 0.811-0.846 g/cm^3). The oil contains 2.32 - 9.37% paraffin and the content of sulfur ranges, on the average, from 0.45 to 0.85 %.

In the Polish Lowland oil fields occur in Permian, Carboniferous and Cambrian rocks. They yield a medium paraffin (4.3 - 7.4%) oil with sulfur content exceeding 1% and density ranging from 0.857 g/cm^3 to 0.870 g/cm^3.

In the considered regions, beside oil fields, there are also oil condensate fields, containing 100 g of condensate per 1 cm^3 of gas.

The recoverable resources of the Carpathian fields amounted in 1995 to 25.5% of the country's resources, the Carpathian Foredeep fields to 25.6% and Polish Lowland fields to 48.9%.

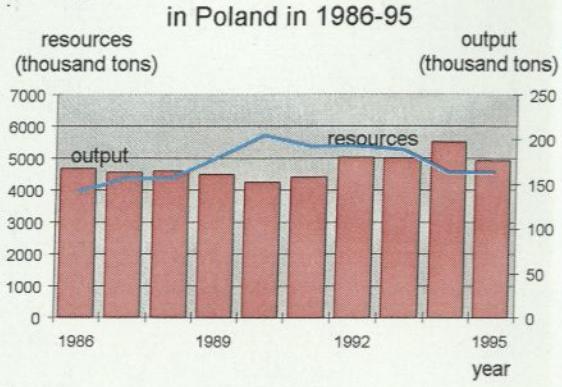
The magnitude of the initial proven oil resources of oil and oil condensate, as well as the state of their identification and management are shown in Table 4.1. From among 92 oil fields 85 are under exploitation, and their resources amount to 92% of the total Polish onshore resources.

The intrinsically economic onshore oil resources of Poland in 1995 (without the Polish economic zone of the Baltic Sea) amounted to about 4485 thousands tons.

The total economic reserves, amounting to 553 thousand tons, were estimated only for 26 oil fields. The marginal economic resources of these fields amount to 558 thousand tons. They include the remaining proven reserves which according to the actual technical and economic estimation will not be exploited till the end of the concession validity (which for the particular fields ranges from 2000 to 2035).

The production of oil from the Carpathian oil fields amounted in 1995 to 26.7% of the total Polish oil production, that from the Carpathian Foredeep to 18.7%, and that from the Polish Lowland to 54.4%.

Fig. 4.1 Crude oil resources and output in Poland in 1986-95



The intrinsically economic onshore oil resources of Poland in 1995 (without the Polish economic zone of the Baltic Sea) amounted to about 4485 thousands tons.

The total economic reserves, amounting to 553 thousand tons, were estimated only for 26 oil fields. The marginal economic resources of these fields amount to 558 thousand tons. They include the remaining proven reserves which according to the actual technical and economic estimation will not be exploited till the end of the concession validity (which for the particular fields ranges from 2000 to 2035).

The production of oil from the Carpathian oil fields amounted in 1995 to 26.7% of the total Polish oil production, that from the Carpathian Foredeep to 18.7%, and that from the Polish Lowland to 54.4%.

Table 4.2 Directions of Polish imports of crude oil

	Country	thousand tons	thousand PLN
	Total	**13036.60**	**3820946**
1	Russia	7895.12	2143878
2	UK	1858.66	596273
3	Norway	1223.00	398248
4	Iran	1141.16	360905
5	Algeria	495.58	211015
6	Byelorussia	200.06	49983
7	Kazachstan	172.00	43088
8	Czech Rep.	28.99	10088
9	Slovakia	16.24	5708
10	Turkmenistan	3.03	902
11	Lithuania	2.75	841

The production (Fig. 4.1) of oil and condensate amounted in 1995 to 176 thousand tons.

Imports of oil amounted in 1995 to 13,036.6 thousand tons. The directions and quantities of imports are shown in Table 4.2. Over 60% of imported oil came from Russia, 14.4% from the United Kingdom, 9.4% from Norway, 8.8% from Iran and 3.8% from Algeria. Imports of oil products (fuels, paraffin, oils, mineral jelly, waxes, etc.) amounted to 2938.4 thousand tons while exports to 1177.8 thousand tons (Table 4.3). Besides, imports included a small quantities of bitumens and natural asphalts (4.5 thousand tons).

Table 4.3 Directions of Polish imports and exports of oil products and natural bitumens

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Oil products							
	Total	**2938.35**	**1373335**		**Total**	**1177.83**	**343757**
1	Russia	577.90	218853	1	Germany	329.35	88520
2	UK	406.87	198781	2	Denmark	299.59	60672
3	Germany	270.53	166690	3	Belgium	48.66	28761
4	Sweden	330.00	144928	4	Norway	123.27	26480
5	Byelorussia	345.52	125439	5	Czech Rep.	117.77	24820
6	Slovakia	182.74	83153	6	Netherlands	33.29	22719
7	Netherlands	132.38	77380	7	Cyprus	68.10	14783
8	Lithuania	178.03	68639	8	Finland	15.51	11003
9	Norway	151.02	67795	9	Sweden	23.87	11003
10	Finland	136.50	57850	10	Austria	17.09	9535
11	Belgium	21.59	39125	11	Slovakia	40.33	8129
12	France	38.91	21104	12	UK	7.88	6031
13	Denmark	40.66	19428	13	Ukraine	3.92	5649
14	United States	33.68	18163	14	Russia	5.19	5190
15	Hungary	17.23	17577	15	Lithuania	4.96	4594
16	Czech Rep.	34.51	15872	16	Byelorussia	0.76	1695
17	Austria	6.39	12799	17	Romania	1.38	1627
18	Spain	10.48	4779	18	France	2.34	1585
19	Ukraine	10.51	3893	19	Slovenia	0.97	1495
20	Italy	1.16	3578	20	Bulgaria	1.00	1060
21	Romania	2.29	2070	21	The Bahamas I	4.71	1016
22	Belize	4.53	1752	22	Hungary	4.31	917
23	China	0.88	1601	23	Latvia	0.82	789
24	Ireland	3.00	752	24	Italy	0.95	718
25	South Africa	0.50	479	25	United States	1.06	712
Natural bitumens							
	Total	**4.52**	**8808**		**Total**	**1.81**	**1007**
1	Germany	1.40	3622	1	Russia	1.21	482
2	France	0.75	1579	2	Hungary	0.33	231
3	Netherlands	0.52	948	3	Ukraine	0.16	111
4	Belgium	0.17	557	4	Lithuania	0.03	72
5	Czech Rep.	0.73	510	5	Germany	0.06	66

The estimate of perspective resources shows that the possibility of an increase of the oil reserves is limited. Such an increase is possible mainly in the Polish Lowland, on the Baltic Sea (in the Polish economic zone) and in the Carpathians where exploration is actually under way.

According to the estimate of the Polish Geological Institute made in 1991 the prognostic oil resources in Poland (except for the Baltic Sea) total 72.5 million tons, including 46 million tons in the Polish Lowland, 17.5 million tons in the Carpathians and 9 million tons in the Carpathian Foredeep.

5. HARD COAL

Hard coal deposits occur in three basins: the Lower Silesian, the Upper Silesian and the Lublin one (Plate 2).

The Lower Silesian Coal Basin (Dolnośląskie Zagłębie Węglowe (DZW)) is characterised by a considerable thickness variability and small horizontal and vertical extent of coal-bearing formations. About 30 coal beds with thickness exceeding 1 m occur here. The identified and exploited deposits lie in a zone of outcrops over an area of about 350 km^2. The difficult geological mining conditions and unprofitable exploitation result in the closing of mines in this basin. The identified intrinsically economic resources are small in the basin and amount to about 150 million tons, and constitute only 0.25% of the whole identified intrinsically economic resources in Poland.

The area of the part of the Upper Silesian Coal Basin (Górnośląskie Zagłębie Węglowe (GZW)) (Plate 2) lying within Polish borders amounts to about 5800 km^2. The exploited deposits cover 30% of this area, the reserve deposits (identified but not exploited) with reserves identified with general and detailed exploration cover 23%, and the perspective areas cover about 27% of the whole area. Intrinsically economic resources were accounted for to the depth of 1000 m. The remaining area of the basin is mainly a region with prognostic resources and overburden exceeding 1000 m, and marginal parts of the basin with no expected economic resources of coal. Actually, over 80% of coal deposits in Poland occur in this basin.

The Lublin Coal Basin (Lubelskie Zagłębie Węglowe (LZW)) (Plate 2) is in the early stage of management. The exploration of its borders is relatively poor. The area of 9100 km^2 is assumed to be a perspective area for coal deposits and with thickness of the overburden ranging from 360 m to over 1000 m. The one exploited deposit occupies an area of 50 km^2 (0.5%), and deposits identified with general and detailed exploration to a depth of 1000 m cover about 67% of the area. In the remaining area the overburden exceeds 1000 m and the prospected potential resources have been estimated. The intrinsically economic reserves constitute a little more than 14% of total Polish coal resources.

The adaptation of coal mining to market economy has produced changes in the magnitudes of resources and output. In the recent years a distinct decrease of the resources has taken place. This is due mainly to the increased requirement balance criteria primarily as regards the minimal thickness of the coal bed established at 1.2 m the depth of the coal deposit at 1000 m. An other reason of the reduction of intrinsically economic reserves it is the classification of these reserves in some unprofitable coal mines as potentially economic resources.

The identified intrinsically economic resources of coal deposits as per 31st December 1995 amount to 60,185 million tons. The exploited resources of the deposit constitute actually about 40.3% of the intrinsically economic reserves and amount to 24,092 million tons.

Identified coal resources, economic resources, as well as their identification, qualitative characteristic of coal deposits and state of their management for the whole country are shown in Table 5.1.

The economic reserves of coal mines decreased in 1995 by 1071 million tons and amount to 12113 million tons. These reserves are established in the PZZ and represent 47.5% of the intrinsically economic resources of identified deposits.

The net output of coal amounted in 1995 to 135,523 thousand tons. After violent decrease during the previous years (Fig.5.1) it reached a level of 130-140 million tons, forecasted for the nearest future.

Coal exploitation was accompanied by production of 33,479 thousand tons of mining wastes 8311 thousand tons of which were used for various purposes (for example, levelling, engineering works, etc.), and 25,168 thousand tons were dumped on coal mine own dumps or so called central dumps.

Fig. 5.1 Hard coal resources and output in Poland in 1986-95

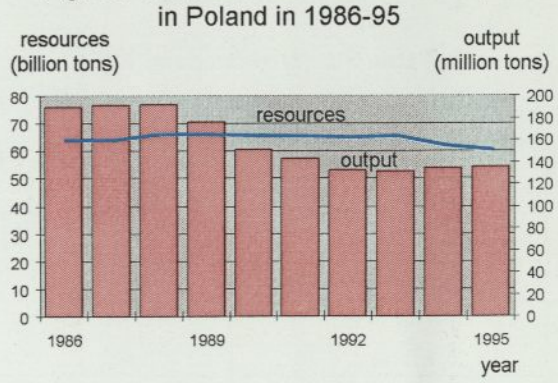


Table 5.1 Hard coal (mln tons)

Specification	Number of deposits	Reserves/resources					Economic reserves
		Intrinsically economic				Potentially economic	
			Categories of explorating				
		Total	A+B	C1	C2	marginal economic submarginal	
Total resources	124	60185	5315	14947	39922	15804 12454	12113
including reserves of deposits in exploitation							
Total	70	24092	5274	9224	9595	7928 12135	11461
including resources of not exploited deposits							
Total	45	35923	38	5648	30238	7524 213	608
1. Exploration	29	13476	38	5648	7790	3099 213	608
2. Prospecting	16	22447	0	0	22447	4425 0	0
including abandoned deposits							
Total	9	169	4	76	90	353 105	44

Mine drainage reached 296.1 million m^3 of water in 1995 and 110.7 million m^3 (37.4%) of this water was utilized, while 185.3 million m^3 was drained to rivers and streams of the Vistula and Odra drainage basin.

In the Lower Silesian Coal Basin the mine water is drinking, industrial or salt water (with a salt content of 0.5-35 g/l) to brine (with over 35 g/l). Almost 54% of the total drinking and industrial waters totalling 144.2 million m^3 were commercially utilized. As regards salt water and brine 22.9% and 9.3%, respectively, were utilized.

In the Lublin Coal Basin mine water is drinking and industrial water and its utilization is very limited (23.9%).

More than 23.5% of excavated coal is designed for exports. The directions of Polish exports of coal, coke, semi-coke and coke chemical products are shown in Table 5.2 and imports of coal and chemical coke products in Table 5.3.

Table 5.2 Directions of Polish exports of hard coal /including anthracite/, coke, semi-coke and chemical-coke products

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Hard coal							
	Total	**31869**	**2989179**				
1	Ukraine	8739	708743	18	Norway	191	28002
2	Finland	3089	290418	19	Bulgaria	177	25672
3	Germany	2952	274121	20	Portugal	255	23956
4	Denmark	3170	239983	21	Turkey	178	22453
5	Czech Rep.	2745	212058	22	custom stores	179	21564
6	UK	1264	146980	23	Romania	156	19880
7	Slovakia	1288	141711	24	unknown	131	13062
8	Netherlands	1164	120631	25	Spain	58	6424
9	Austria	838	112544	26	Egypt	48	6103
10	Sweden	1078	102955	27	Panama	45	5114
11	Brazil	827	101023	28	Byelorussia	47	2924
12	France	728	80780	29	Macedonia	12	2211
13	Russia	692	78475	30	Iran	9	1643
14	Hungary	752	71014	31	Luxembourg	10	1053
15	Ireland	308	54713	32	Chorvatia	7	907
16	Belgium	384	38117	33	Djibouti	11	827
17	Italy	302	29157	34	Lithuania	6	610
Coke and semi-coke							
	Total	**3331**	**790313**				
1	Germany	1002	223356	13	Hungary	34	8139
2	Belgium	490	120325	14	Slovakia	42	7791
3	Brazil	344	90821	15	Bulgaria	20	4920
4	Austria	308	72066	16	Romania	13	4547
5	Czech Rep.	276	60161	17	Finland	17	3333
6	Italy	149	38903	18	Byelorussia	8	2598
7	United States	155	38620	19	Iceland	6	1574
8	Spain	158	33681	20	Ireland	4	1478
9	Netherlands	132	31979	21	Slovenia	5	1309
10	Sweden	62	15756	22	Chorvatia	4	1007
11	Norway	53	14870	23	Macedonia	2	728
12	UK	41	9989	24	Costa Rica	2	662
Chemical-coke products							
	Total	**404**	**110477**				
1	Germany	133	32214	8	Belgium	10	1899
2	Czech Rep.	84	23377	9	France	4	1569
3	Denmark	69	14955	10	Slovakia	5	1331

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
4	Spain	59	12409	11	Austria	6	1203
5	UK	5	7993	12	Finland	2	821
6	Russia	20	7041	13	Hungary	1	689
7	Italy	3	4748	14	Costa Rica	0.3	79

Table 5.3 Directions of Polish imports of hard coal /including anthracite/, coke, semi-coke and chemical-coke products

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Hard coal							
	Total	**1498**	**172803**				
1	Czech Rep.	1069	122938	3	Russia	135	14759
2	custom stores	264	27921	4	Ukraine	27	6171
Coke and semi-coke							
	Total	**34**	**10927**				
1	Czech Rep.	22	6252	2	China	12	4633
Chemical-coke products							
	Total	**58**	**37458**				
1	Germany	24	27124	5	Hungary	1	717
2	Czech Rep.	21	4241	6	Netherlands	1	634
3	Slovakia	4	1708	7	Ukraine	3	609
4	Belgium	1	782	8	Byelorussia	0	363

6. HELIUM

Helium, element belonging to group of noble gases, is chemically neutral. On account of its cryogenic properties helium is used in low temperature technologies and in superconductors. The main source of helium are fields of natural gas with a high nitrogen content. In the USA gas fields containing a minimum of 0.3% of helium are considered as helium-bearing sources. In other countries, however, helium is sometimes separated from poorer gas sources. The recognised helium-bearing regions include: the middle-eastern part of the USA - over 90% of the world's exploitation. Outside the USA helium is extracted in Poland and Russia (from fields in the Orenburg region). Some amounts of helium are also produced in China, India, the Netherlands, Algeria and Canada. In 1995 Poland ranked fourth in the world as regards helium production.

Helium occurs in almost every gas field in the Polish Lowland (Niż Polski), however, it was proved only at 16 sites. The content of helium in natural gas ranges from 0.02 to 0.45%. It is extracted from gas with a helium content exceeding 0.27% in the Nitrogen-Separation Plant in Odolanów. The extraction of helium was started in Poland in 1971 and reached its maximum state in the middle eighties.

The reserves exploited in 1995 accounted for 77% of the proven initial reserves. The intrinsically economic resources amount to 45.86 million m^3.

Plate 2

MAP OF OCCURRENCE OF HARD COAL AND LIGNITE DEPOSITS

Hard coal deposits:

- In exploitation
- Not exploited
- D.Z.W. Lower Silesian Coal Basin
- G.Z.W. Upper Silesian Coal Basin
- L.Z.W. Lublin Coal Basin

Lignite deposits:

- In exploitation
- Not exploited

Occurrence of coal-bearing formations:

- Tertiary lignite-bearing formations (after M. Piwocki)
- Carboniferous hard coal-bearing formations
- Areas without prospects for coal and lignite occurrences
- Boundary of occurrence of coal-bearing Carboniferous formation

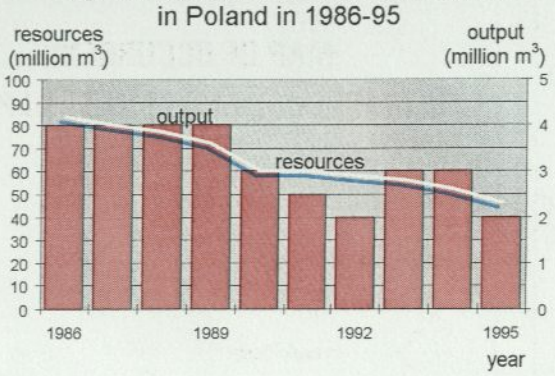
POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Rivers
- Reservoirs

Elaboration: S. Przeniosło
Graphic and technical computer elaboration: R. Bońda D. Siekiera

Fig. 6.1 Helium resources and output in Poland in 1986-95



Helium extraction in 1995 amounted to 1.92 million m^3. Since ten years both the reserves and extraction show decreasing tendency (the reserves decreased from 84 million m^3 in 1986 to 46 million m^3 in 1995, and the exploitation decreased in the same period from 4.09 million m^3 to 1.92 million m^3).

The whole of helium extraction is intended for export, mainly to the USA, where from the equipment for helium extraction is acquired.

7. LIGNITE

In Poland lignite occurs in Tertiary sediments, which stretch mainly in the Polish Lowland (Niż Polski) and in small areas in the Carpathians (Karpaty) and the Carpathian Foredeep (Zapadlisko Przedkarpackie), as well as in measures of the Upper Cretaceous or Lower Jurassic (Plate 2).

In Tertiary measures, lignite forms single beds, lentils or complexes of beds in sediments belonging to periods from Paleocene to Upper Miocene. The most important from the economic aspect are, however, the Middle Miocene sediments. The surface of the Tertiary lignite-bearing area in the Polish Lowland amounts to almost 100.000 km^2. The identified deposits with intrinsically economic resources cover an area of about 930 km^2, and together with the estimated perspective deposits - about 4500 km^2.

The identified deposits occur mainly in the western, southern and central parts of the country. The identified intrinsically economic resources of lignite amount to 14,184 million tons, including 3013 million tons of briquette lignite, 1875 million tons of lignite for low temperature carbonisation, and 0.8 million tons of bituminous lignite (Table 7.1).

Table 7.1 Lignite (mln tons)

Specification	Number of deposits	Reserves/resources				Economic reserves
		Intrinsically economic			Potentially economic	
		Total	A+B+C1	C2		
Total resources	82	14184.42	4594.34	9590.08	4937.13	2197.52
including reserves of deposits in exploitation						
Total	12	2450.18	2255.92	194.26	174.75	2196.19
1. Mines in operation	11	1720.84	1549.11	171.73	140.10	1528.33
2. Mines in construction	1	729.35	706.82	22.53	34.65	667.86
including resources of not exploited deposits						
Total	63	11721.36	2326.26	9395.10	4757.79	1.33
1. Exploration	28	2541.97	2251.48	290.48	783.50	0.23
2. Prospecting	35	9179.39	74.77	9104.62	3974.29	1.10
including abandoned deposits						
Total	7	12.88	12.16	0.72	4.60	0.00

Resources of exploited deposits constitute 17.3% of the identified intrinsically economic resources and amount to 2450 million tons. The deposits are exploited in 5 open pit mines: Adamów, Bełchatów, Konin, Sieniawa and Turów; a new Szczerców open pit mine being now under construction.

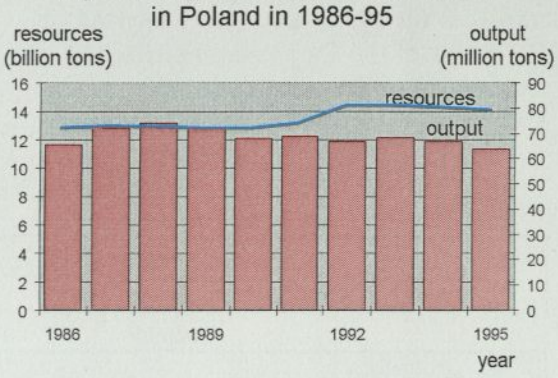
The prognosis of lignite output should not include the area of Poznań graben, i.e. the deposits of Czempin, Krzywin and Gostynin. These deposits may not be exploited in the foreseeable future in view of the land surface and arable land protection. Their resources amount to 3690 million tons.

The lignite economic reserves of the exploited deposits amount to 2196 million tons and constitute 89.6% of their intrinsically economic identified resources.

The lignite output in the period 1986 to 1995 is shown in Fig. 8.1. In 1995, the output amounted to 63,545 thousand tons, the Bełchatów deposit accounting for 52.0% and the Turów deposit for 18.9%.

Almost the whole lignite output was consumed by power stations, and only 466 thousand tons was exported to Germany for about 34 million PLN.

Fig. 7.1 Lignite resources and output in Poland in 1986-95



Lignite mining generates a large dump of overburden. In Poland the biggest dump lies at the Bełchatów open pit. The overburden located on outer dumps is not considered according to the NSA (Chief Administrational Court) verdict to be a waste.

Mine waters, pumped during lignite exploitation, are drinking and industrial waters. From among the total of 224.8 million m^3 of mine water, about 90% comes from the Bełchatów open pit, but only 0.9% of it is utilised.

8. NATURAL GAS

Natural gas fields occur in the Carpathians and in the Carpathian Foredeep, as well as in the Polish Lowland: pre-Sudetic and Wielkopolska regions and in the Western Pomerania (Pomorze Zachodnie) (Plate 1). Gas occurs in separate fields or together with oil or oil condensate. About three-fourths of gas resources are found in Miocene and Rotliegendes sediments and the remaining ones occur, among others: in Carboniferous, Zechstein, Jurassic and Cretaceous rocks.

In the Carpathians, gas occurs in Cretaceous and Triassic rocks, both in separate fields and together with oil fields or oil condensate. Gas of the Carpathian fields is exploited in gas-pressure conditions. The gas has a high methane and low nitrogen content (usually over 80% of methane and on the average a few per cent of nitrogen). The gas reserves and their exploitation are fairly small in this region.

In the Carpathian Foredeep, the gas fields occur in Jurassic, Cretaceous and Miocene sediments. The gas has a high methane and low nitrogen content (from about 70% to 98.8% of methane and 3-22% of nitrogen). These are structural-lithological, multibedded, rarely massif fields, occurring in gas-pressure conditions.

In the Polish Lowland the gas fields occur mainly in the pre-Sudetic and Wielkopolska regions (Permian sediment), as well as in the Western Pomerania (Carboniferous and Permian rocks). The gas has usually a high nitrogen content (from a dozen or so to over 80%). There are, however, fields in Zechstein Main Dolomite with a nitrogen content of 95.7-97.6% and only 3.1% of methane.

Over half (53%) of the proven initial resources (in 1995) occurred in lowland fields. Resources of the Carpathian Foredeep accounted to 46% of the country resources, while the Carpathian resources to only about 1%.

In Table 8.1 the recoverable resources/reserves of natural gas are presented, account being taken of their recognition rate and management.

Table 8.1 Natural gas (mln m^3)

Specification	Number of fields	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	Exploration	Prospecting	
I. Total proved resources	*248	146328	113679	32648	120
	** 67	6106	4099	2006	3
	***180	140221	109579	30641	117
including reserves of exploited fields					
Total	174	117599	98639	18959	3
	58	2529	2098	431	3
	116	115069	96540	18528	0
Carpathians (Karpaty)	38	1301	757	543	3
	27	177	65	111	3
	11	1124	692	431	0
Carpathian Foredeep (Zapadlisko Przedkarpackie)	55	59347	48477	10870	–
	6	327	326	0	–
	49	59020	48150	10869	–
Polish Lowland (Niż Polski)	81	56949	49403	7546	–
	25	2025	1706	318	–
	56	54924	47697	7227	–
including reserves of not exploited fields					
Total	61	28032	14710	13321	81
	3	3568	2000	1568	0
	58	24464	12710	11753	81
Carpathians (Karpaty)	3	100	0	100	78
	0	0	0	0	0
	3	100	0	100	78
Carpathian Foredeep (Zapadlisko Przedkarpackie)	20	7114	4930	2184	3
	0	0	0	0	0
	20	7114	4930	2184	3
Polish Lowland (Niż Polski)	38	20818	9780	11037	–
	3	3568	2000	1568	–
	35	17250	7780	9469	–
including reserves of abandoned fields					
Total	13	696	329	366	35
	6	8	1	7	0
	7	687	328	359	35
II. Prospected resources	42	48	–	–	–
	31	48	–	–	–
	10	0	–	–	–

* total, ** in and oil condensate deposits, *** in gas deposits

The remaining proven resources of natural gas amounted to 146,328 million m^3 (as per 31st December 1995).

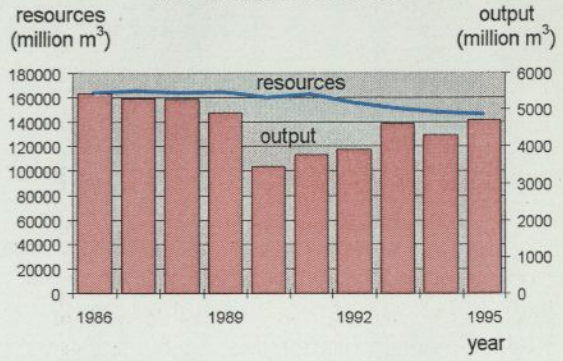
The resources of the exploited gas fields amounted to 117,599 million m^3, which constituted 80% of their total amount. From the total of 248 gas fields 174 fields are in exploitation (70%) (Plate 1).

The total economic reserves, amounting to 14,754 million m^3, were confirmed for 59 gas fields. The total marginal economic resources for the same gas fields amount to 8973 million m^3. These resources include the recoverable reserves, which according to the actual technical and economic estimate will not be extracted till the end of the licence validity (for the particular fields this time ranges from 1999 to 2037).

The fields intended for stores of natural gas have been excluded from exploitation. The reserves left in these gas fields are treated as a gas pillow (buffer capacity) and will not be exploited as long as the store exist. Till the end of 1995 five fields with a total reserve of 4687.5 million m^3 have been designated for underground stores.

The gas output amounted in 1995 to 4716 million m^3. The contribution of the particular regions to this output was as follows: the Lowland 65%, the Carpathian Foredeep 34%, and the Carpathians only 1.0%.

Fig. 8.1 Natural gas resources and output in Poland in 1986-95



The gas resources and their exploitation in Poland for the years period 1986 to 1995 are shown in Fig 8.1. These resources show a stable decreasing tendency for this period while the output after the turning point in 1995 shows a steady fairly dynamic increase.

In 1995, the gas output covered 48% of the country's demand. The deficit was balanced by imports (mainly from Russia 99.7%) which amounted to 5047 million m^3. Polish exports of natural gas and other natural gaseous hydrocarbons amounted to about 29 million m^3. Germany was the main consignee (about 76%). The directions and quantities of gas imports and exports are shown in Table 8.2.

Table 8.2 Directions of Polish imports and exports of natural gas

Import				Export			
	Country	thousand m^3	thousand PLN		Country	thousand m^3	thousand PLN
	Total	**5047009**	**980091**		**Total**	**29344**	**6936**
1	Russia	5032971	967594	1	Germany	22273	5799
2	Germany	2110	8916	2	Czech Rep.	3680	429
3	Ukraine	11105	3113	3	Ukraine	2898	293
4	Czech Rep.	824	468	4	Sweden	264	271

Prognostic gas resources, estimated at about 650 milliard m^3, points to the possibility of finding new fields. The most prognostic resources lie in the Polish Lowland 75%, the Carpathian Foredeep and the Carpathians account for 21% and 4%, respectively.

9. COPPER ORES

Copper ores of industrial meaning occur in Lower Silesia (in the northern-Sudetic syncline) and in the pre-Sudetic monocline (Plate 3). Copper mineralization is connected with Zechstein Kupferschiefer and with upperlying sandstones and underlying dolomites.

The main deposits being in exploitation lie in the monocline near Lubin. The intrinsically economic resources of copper ores have decreased since 1971 because of their exploitation and change of evaluation criteria. The decrease of the resources has been considerable in the recent years due to that all ores occurring below the depth of 1250 m have been excluded from the country's balance. The intrinsically economic resources amounted in 1995 to 2319 million tons of ore with a content of copper of 44.6 million tons (Table 9.1).

Table 9.1 Copper ores (mln tons)

Specification	Number of deposits	Reserves/resources				Economic reserves
		Intrinsically economic			Potentially economic	
		Total	A+B+C1	C2		
I. Total resources	14	*2318.92 ** *44.60*	2188.67 *42.75*	130.25 *1.85*	114.22 *1.25*	876.61 *18.53*
including reserves of deposits in exploitation						
Total	4	1743.99 *33.19*	1743.99 *33.19*	0.00 *0.00*	45.41 *0.55*	839.05 *17.88*
including resources of not exploited deposits						
Total	7	504.25 *10.62*	408.69 *9.14*	95.56 *1.48*	31.00 *0.43*	14.38 *0.31*
1. Exploration	5	365.91 *7.57*	270.35 *6.09*	95.56 *1.48*	25.85 *0.30*	14.38 *0.31*
2. Prospecting	2	138.34 *3.05*	138.34 *3.05*	- *0.00*	5.15 *0.13*	0.00 *0.00*
including abandoned deposits						
Total	3	70.68 *0.79*	35.99 *0.43*	34.69 *0.36*	37.81 *0.27*	23.17 *0.34*

* ore, ** *metallic copper*

Over 75% of the total resources (1744 million tons) occur in deposits in exploitation. Only relatively small resources in marginal deposits are still to be managed (to the west and to the north from the deposits in exploitation). The resources occur mainly at a depth from 1000 m to 1250 m. Separate managing of these deposits will be troublesome. The parameters of the ores occurring below 1250 m are almost the same as those of the actually exploited ones. They have been classified as potentially economic ores because of the high temperature of the massif and therefore difficult conditions and high costs of exploitation.

The economic reserves of the exploited deposits amount to 839 million tons of ore and 17.9 million tons of copper. Besides, some

small quantities of economic reserves occur in the deposits where exploitation has been abandoned.

The output (Fig. 9.1) of copper ores in 1995 amounted to 24.1 mln tons of the ore, of which metallic copper amounted to 433 thousand tons.

The considerable part of the copper production from domestic deposits is destined to exports (Table 9.2). In 1995 exports of copper amounted to 213.2 tons, mainly electrolytic - cathode, wirebars, ingots and also as a alloys and copper compounds. Imports of copper amounted to 19.8 thousand tons, mainly as alloys, copper compounds and also wastes and scrap.

Fig. 9.1 Copper ore resources and output in Poland in 1986-95

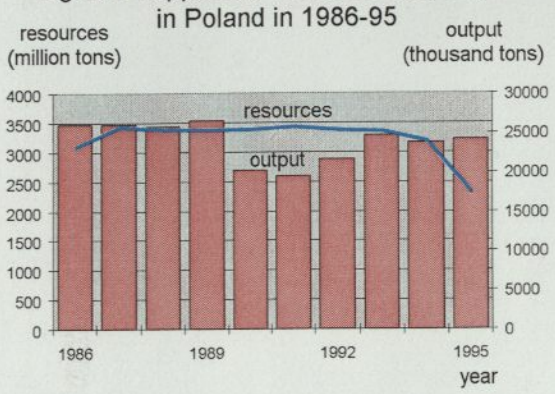


Table 9.2 Directions of Polish imports and exports of copper

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	**19.823**	**65841**		**Total**	**213.180**	**1461917**
1	Chile	14.790	35917	1	Germany	56.483	373271
2	Germany	1.473	11235	2	UK	46.611	346385
3	Kazachstan	0.741	5025	3	Netherlands	36.560	254605
4	Slovakia	0.323	2458	4	France	31.086	220812
5	Ukraine	0.542	2174	5	Hungary	11.894	85957
6	Australia	0.305	2141	6	Sweden	9.485	68143
7	Russia	0.627	2094	7	Austria	7.783	54067
8	Byelorussia	0.474	2084	8	Czech Rep.	4.022	27562
9	United States	0.226	1471	9	Slovakia	3.940	16527
10	Slovenia	0.076	412	10	Norway	1.285	5079
11	Belgium	0.016	148	11	Canada	1.860	2566
12	Czech Rep.	0.018	133	12	Belgium	1.140	1739
13	Austria	0.004	118	13	Singapore	0.281	1129
14	Bulgaria	0.011	99	14	Taiwan	0.159	1114
15	Italy	0.035	96	15	Italy	0.159	1015
16	Finland	0.102	54	16	Ukraine	0.172	884

Extracted from copper ores are following elements: Ag, As, Au, Ni, Pb, Re, Se, Zn. Silver extraction is the most important in Polish economy. Over 93% is exported. The magnitude of the production of extracted metals amounted in 1995 to:

- metallic silver: 964.28 tons
- crude lead: 12,100 tons
- metallic selenium: 56.74 tons
- nickel (nickel sulfate): 1675 tons
- metallic gold: 0.474 tons.

The quantity of processing wastes of the copper mining amounted in 1995 to 24,086 thousand tons. They are deposited in settling ponds.

From the copper mines 32.66 mln m^3 of water were recovered (drinking and salt waters and brines).

Plate 3

MAP OF OCCURRENCE OF METAL RAW MATERIAL DEPOSITS

Copper ore deposits

In exploitation Not exploited

Boundary of the depth of deposit (1250 m below surface)

Zinc and lead ore deposits

In exploitation Not exploited

Not exploited deposits:

- Iron ore deposits
- Nickel ore deposits
- Tin ore deposits
- Arsenic and gold ore deposits

Areas of deposits occurrence:

- Tertiary formations of the Carpathian Foredeep
- Carpathian area
- Triassic ore-bearing dolomites
- Other Mesozoic formations
- Permian (Zechstein) formations
- Carboniferous formations
- Paleozoic rocks of Sudetes and the Holy Cross Mountains
- Pre-Cambrian platform formations
- Limit of Kupferschiefer formation
- a b — Boundary of the dolomite-limestone transition zone a - sure b - uncertain
- Limit of the Upper Silesian Coal Basin

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Rivers
- Reservoirs

Elaboration: S. Przeniosło
Graphic and technical computer elaboration: R. Bońda D. Siekiera

10. GOLD

Gold occurs in Zechstein copper ores in the pre-Sudetic monocline (Plate 3). It is extracted during the processing of these ores. Gold resources have not been explored as yet. Preliminary prospecting indicates that the occurring here resources amount to several dozen tons.

The company KGHM Polska Miedź S.A. extracted in 1995 474 kg of gold from the Lubin-Małomice, Polkowice, Rudna and Sieroszowice copper deposits.

Gold also occurs in the Sudetes in the deposit of gold and arsenic ores in Złoty Stok (Plate 3). The arsenic ores were explored in 1954-1960 and their magnitude amounts to 714.4 thousand tons of intrinsically economic ores containing 25.5% thousand tons of As. The resources remaining in the deposit amount to 536.5 thousand tons of ore, containing 19.6 thousand tons of As.

The resources of gold have been estimated at 2000 kg in the intrinsically economic ore and 490 kg in the potentially economic one. The average gold content amounts to 2.8 gram per 1 ton of ore. So far 25% of the total resource have been exploited, so about 1500 kg of gold remains. At present no exploitation is conducted because there is no demand for arsenic, besides it has toxic properties.

The prospected resources of clastic gold in the Sudetes are estimated at about 2300 kg (A. Wojciechowski 1993).

Exports of gold amounted in 1995 to 620 kg, mainly in the form of crude gold, and valued 13.9 thousand PLN.

11. IRON

In accordance with the decision of the Minister of Environmental Protection, Natural Resources and Forestry (from 1994) sedimentary iron ore resources have been excluded from the domestic raw material resources balance because they do not meet the requirements of potentially economic resources. In this way 37 deposits were cancelled: 20 in the Częstochowa region, 1 in the vinicity of Kalisz and also 12 in the Kielce, 2 in the Łęczyca and 2 in the Pomerania region.

Table 11.1 Iron ores (mln tons)

Specification	Number of deposits	Reserves/resources				Economic reserves
		Intrinsically economic			Potentially economic	
		Total	A+B+C1	C2		
Total resources	3	*1340.11	726.01	614.10	606.50	0.00
		**388.20	214.00	174.20	104.50	0.00
including resources of not exploited deposits						
Total	3	1340.11	726.01	614.10	606.50	0.00
		388.20	214.00	174.20	104.50	0.00
1. Exploration	1	1076.60	726.00	350.60	475.20	0.00
		314.90	214.00	100.90	81.40	0.00
2. Prospecting	2	263.51	0.01	263.50	131.30	0.00
		73.30	0.00	73.30	23.10	0.00

* ore, ** *metallic iron*

Table 11.2 Directions of Polish imports and exports of iron

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	**10981**	**866287**		**Total**	**851**	**287714**
1	Ukraine	6172	350600	1	Germany	245	119617
2	Russia	2655	216819	2	Spain	128	31416
3	South Africa	1440	93119	3	Italy	53	17580
4	Brazil	487	44933	4	United States	7.7	12766
5	Czech Rep.	50	31226	5	Netherlands	18	11566
6	Germany	12	26121	6	UK	18	11359
7	Norway	24	17703	7	Czech Rep.	146	10596
8	China	1	15585	8	South Korea	33	9492
9	Sweden	101	14183	9	Belgium	7.6	9206
10	France	10	13898	10	Slovakia	35	8547
11	Slovakia	5.2	12912	11	Austria	31	8287
12	UK	1.5	5803	12	Sweden	27	7724
13	Kazachstan	2.6	4170	13	Taiwan	26	7194
14	Belgium	0.5	3825	14	Norway	18	5396
15	Hungary	0.4	2477	15	Saudi Arabia	10	4038
16	Netherlands	0.5	2303	16	Switzerland	8.6	2817
17	Italy	0.3	2239	17	Byelorussia	6.1	2802
18	Macedonia	0.5	1598	18	Ireland	6.0	1660
19	Austria	0.1	1508	19	Finland	2.7	1294
20	Switzerland	14.8	1408	20	Denmark	14	1253
21	United States	0.2	1201	21	France	3.3	1005
22	Lithuania	0.2	641	22	Honk Kong	1.3	

As a result only the magnetite-ilmenite ore deposits (Table 11.1) occurring in the Suwałki basic massif (the Krzemianka and Udryń ones) have remained in the domestic resource balance (Plate 3).

The resources of these magnetite-ilmenite ores amount to 1340 mln tons with a content of 388 mln tons of iron, 97.7 mln tons of TiO_2, and 4.1 mln tons of V_2O_5. Actually these deposits are not exploited and on account of their big depth of the occurrence their exploitation does not seem to be economically justified.

The total domestic demand for iron ores is covered by imports. These imports amoun-ted in 1995 to 10,981 thousand tons, mainly in the form of concentrates or ores and pig iron. The total imports and exports of iron ores, concentrates and iron products, i.e. ferroalloys, alloy pig iron and non-alloy pig iron, Fe compounds, wastes and scrap, granules and powders are presented in Table 11.2.

12. NICKEL

Polish nickel ore deposits occur in Lower Silesia (Plate 3). They are deposits of oxide ores of weathering type connected with massifs of the serpentinized basic and ultrabasic rocks. These nickel ores were exploited till 1983, when exploitation of the Szklary deposit was terminated.

The explored in detail intrinsically economic resources of the deposit amount to 14.6 mln tons of ore and 117.0 thousand tons of metal (the average content is 0.8% Ni). In some deposits only with potentially economic ores occur.

Apart from occurring in the weathering types ores nickel accompanies copper ore deposits in the pre-Sudetic monocline (about 44 thousand tons of this metal) and is reclaimed from these ores. Nickel obtained from copper ores amounted in 1995 to 1.68 thousand tons of nickel sulfate.

The exports of nickel amounted in 1995 to 1.4 thousand tons and imports to 2.0 thousand tons (Table 12.1).

Table 12.1 Directions of Polish imports and exports of nickel

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	2.014	43077		Total	1.423	4947
1	Russia	1.302	27688	1	Canada	0.948	2375
2	Germany	0.193	4253	2	Czech Rep.	0.382	2298
3	Finland	0.174	3240	3	Byelorussia	0.019	145
4	Italy	0.150	3183	4	Germany	0.025	48
5	Norway	0.052	1133	5	Ukraine	0.002	21
6	Belgium	0.037	807	6	Austria	0.026	17
7	France	0.024	769	7	UK	0.019	17

13. SILVER

In Poland silver occurs mainly in copper ores of the Zechstein formation in Lower Silesia. Only a small quantity of silver coexists with lead and zinc in Zn-Pb ores in the Silesia-Cracow region.

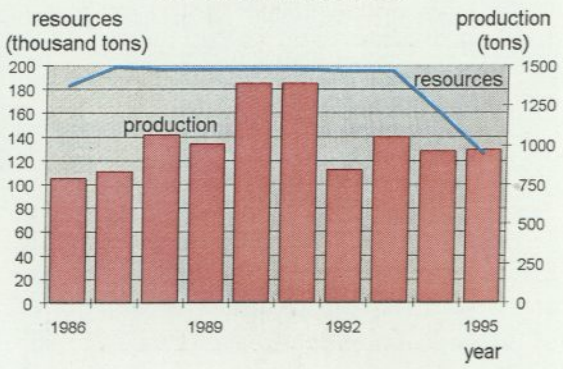
The total resources of silver in Poland are counted to over 126 thousand tons, of which only 4.4 thousand tons is connected with Zn-Pb ores.

Mining production of silver (Fig. 13.1) amounted in 1995 to 964.3 tons. Over 90% of the silver is exported (Table 13.1).

Table 13.1 Directions of Polish exports of silver

	Country	thousand tons	thousand PLN
	Total	897.7	366725
1	Belgium	351.0	144041
2	UK	181.2	73998
3	Germany	170.4	69708
4	Netherlands	132.0	53226
5	Switzerland	40.3	16178
6	Italy	11.5	4936
7	Spain	10.0	4110

Fig. 13.1 Silver resources and production in Poland in 1986-95



14. TIN

Tin occurs in the Sudetes in two deposits: Gierczyn and Krobica (Plate 3). The resources of these deposits were classified as potentially economic ones and their magnitude was estimated at about 2.9 mln tons of ores with an average tin content of about 0.48%.

The whole Polish demand for tin is covered by imports which amounted in 1995 to 1.4 thousand tons (Table 14.1).

Table 14.1 Direction of Polish import of tin

	Country	thousand tons	thousand PLN
	Total	1.397	27931
1	China	0.586	9007
2	Malaysia	0.507	8364
3	Netherlands	0.157	7834
4	Germany	0.045	985

15. TITANIUM

Titanium occurs in titanium-magnetite deposits in the Suwałki massif in north-eastern Poland (the Krzemianka and Udryń ones). The titanium resources are estimated at 97.7 mln tons with an average TiO_2 content of 7.3%. These deposits are not in exploitation, and their economic exploitation does not seem possible because of the big depth of the deposit.

The whole country's demand is covered by imports, mainly of titanium ores and concentrates. Imports amounted in 1995 to 79 thousand tons and exports (of titanium compounds) to 16 thousand tons (Table 15.1).

Table 15.1 Directions of Polish imports and exports of titanium

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	79.3	75352		Total	16.1	72233
1	Germany	2.5	16341	1	United States	4.1	16151
2	Norway	51.0	13128	2	Italy	2.0	8601
3	Canada	18.7	11532	3	Germany	1.8	8467
4	United States	1.0	6254	4	France	1.8	8047
5	Ukraine	1.8	5942	5	UK	1.1	5164
6	Netherlands	0.7	4523	6	Sweden	1.0	4402
7	UK	0.7	4126	7	Spain	0.8	3675
8	Belgium	0.6	3725	8	Finland	0.6	3236
9	Czech Rep.	0.8	3207	9	Netherlands	0.6	3022
10	Italy	0.3	1743	10	Belgium	0.5	2414
11	France	0.2	1223	11	Denmark	0.3	1533
12	Finland	0.1	736	12	Indonesia	0.3	1481
13	China	0.1	475	13	Brazil	0.2	1150
14	South Africa	0.3	460	14	Hungary	0.1	641
15	Spain	0.1	440	15	Lithuania	0.0	624
16	Slovenia	0.1	440	16	Bulgaria	0.1	602

16. VANADIUM

Vanadium occurs in Zechstein copper ores in the pre-Sudetic monocline and in titanium-magnetite deposits in the Suwałki massif in north-eastern Poland.

The resources of vanadium accompanying copper ores amount to about 248 thousand tons. This element is not extracted in the course of processing the copper ores.

Vanadium resources in the Suwałki deposits are estimated at 4100 thousand tons with an average vanadium content of less than 0.3%. Vanadium is the most valuable compound in these deposits. The low content of this metal, big depth of occurrence of the deposit and environment protection problems connected with possible exploitation make the economic exploitation doubtful.

The Polish economy's demand for vanadium is small. Imports of vanadium (vanadium ores and concentrates and also vanadium compounds) amounted in 1995 to 6.6 thousand tons.

17. ZINC AND LEAD ORES

Zinc and lead ores occur in deposits of various genetic types. In Poland only stratabound deposits, connected with formation of carbonate rocks, have industrial meaning. They occur in the Silesia-Cracow region, which constitutes the northern and north-eastern surrounding of the Upper Silesian Coal Basin (Plate 3). The deposits lie in several deposit regions, i.e. the Bytom, Chrzanów, Olkusz and Zawiercie ones. The Bytom region has only a historical meaning. Exploitation was conducted there since the Middle Ages and now only potentially economic ores are left. Actually the exploitation continues in the Chrzanów and Olkusz regions. The deposits of the Zawiercie region have not been exploited as yet.

Apart from the deposits in Silesia-Cracow area some concentrations of zinc and lead accompany copper ores in the pre-Sudetic monocline. They are, however, of small practical meaning, though some quantities of lead are extracted from the copper concentrates during their metallurgical processing.

In the Silesia-Cracow region zinc and lead mineralization occurs in rocks assigned to all periods from Devonian to Jurassic. This region is built of Permian-Mesozoic rocks, which lie monoclinally on Paleozoic measures. Ores of industrial meaning are only those connected with Middle Triassic dolomites and first of all with the so-called ore-bearing dolomites. These ores occur as pseudobeds, horizontal lentils or nests.

Zinc and lead ore resources of the Silesia-Cracow region have undergone great changes during the last fifty years (S. Przeniosło and others 1992). This was due to that on the one hand intensive research was conducted and on the other hand the resources of oxide ores of zinc have been excluded from the country balance (since their processing is a big hazard to the natural environment). The magnitude of zinc and lead ore resources, and the state of their identification and management are shown in Table 17.1.

The intrinsically economic resources of zinc and lead ores amount to 208.3 million tons and are equivalent to 8.14 million tons of zinc and 3.6 million tons of lead. Over 31% of ore resources occur in deposits in exploitation (64,3 million tons of the ore). In these deposits 45.7 million tons of ores with a content of 2 million tons of zinc and 0.83 mln tons of lead have been classified as economic reserves.

For last dozen or so years the annual output of zinc and lead in Poland ranges from 4 to over 5 million tons of ores, including from 140 to 250 thousand tons zinc (Fig. 17.1) and from 40 to 90 thousand tons of leads (Fig. 17.2).

In 1995 the output amounted to 5314 thousand tons yielding 204 thousand tons of zinc and 70 thousand tons of lead.

Table 17.1 Zinc and lead ores (mln tons)

Specification	Number of deposits	Reserves/resources				Economic reserves
		Intrinsically economic			Potentially economic	
		Total	A+B+C1	C2		
I. Total resources	20	*208.34	128.03	80.31	133.70	45.69
		**3.60	2.35	1.26	0.96	0.83
		***8.14	5.55	2.59	3.05	2.00
including :						
Sulfide zinc ore		191.69	123.36	68.33	94.48	45.69
		2.82	2.12	0.70	0.47	0.83
		7.93	5.46	2.47	1.98	2.00
Oxide zinc ore		0.53	0.53	0.00	28.97	0.00
		0.00	0.00	0.00	0.18	0.00
		0.04	0.04	0.00	0.97	0.00
Lead ore		16.12	4.14	11.98	10.26	0.00
		0.79	0.22	0.56	0.31	0.00
		0.17	0.05	0.12	0.11	0.00
including reserves of deposits in exploitation						
Total	4	64.33	63.96	0.37	6.78	45.69
		1.01	0.99	0.02	0.04	0.83
		2.60	2.59	0.01	0.17	2.00
including resources of not exploited deposits						
Total	14	144.01	64.07	79.94	93.20	0.00
		2.59	1.36	1.23	0.61	0.00
		5.54	2.95	2.58	1.75	0.00
1. Exploration	6	68.60	64.07	4.53	25.47	0.00
		1.39	1.36	0.03	0.17	0.00
		3.07	2.95	0.12	0.52	0.00
2. Prospecting	8	75.41	0.00	75.41	67.73	0.00
		1.20	0.00	1.20	0.44	0.00
		2.47	0.00	2.47	1.24	0.00
including abandoned deposits						
Total	2	0.00	0.00	0.00	33.72	0.00
		0.00	0.00	0.00	0.31	0.00
		0.00	0.00	0.00	1.13	0.00

* ore, ** *metallic lead,* *** *metallic zinc*

The domestic mining production of zinc and lead is does not cover the demand of the processing industry, so the deficit is covered mainly by imports of concentrates. A considerable part of zinc and lead production is destined for exports. (Table 17.2).

During processing of zinc and lead ores considerable amounts of wastes are produced. In 1995 2.7 million tons of wastes were generated, 2.5 million tons of which were utilized and the rest were dumped in settling ponds.

In 1995 140.8 million m^3 of mine water was removed from the zinc and lead mines and over half of it (73.7 million m^3) was utilized. This is drinking and industrial water with low mineralization.

Fig. 17.1 Zinc and lead ore resources and output in Poland in 1986-95

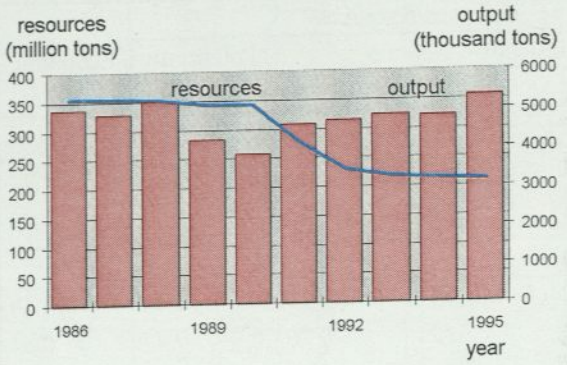


Fig. 17.2 Zinc resources and output in Poland in 1986-95

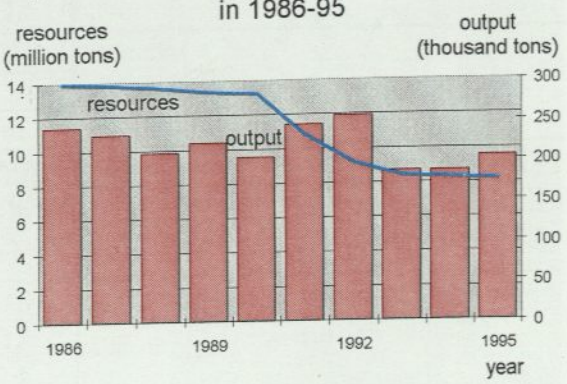


Table 17.2 Directions of Polish imports and exports of zinc

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	76.896	64620		Total	119.723	219041
1	Peru	26.338	20851	1	Czech Republic	17.636	43480
2	Canada	17.889	12516	2	Germany	18.319	42530
3	Sweden	9.094	7156	3	Italy	16.862	37755
4	Chile	9.676	6047	4	Slovakia	6.387	15756
5	Belgium	1.885	5936	5	Russia	17.476	13403
6	Switzerland	6.858	5402	6	Uzbekistan	11.689	9447
7	Norway	3.371	3170	7	Romania	3.898	8694
8	Czech Republic	1.119	1530	8	Hungary	3.435	8230
9	Germany	0.156	625	9	Austria	2.781	6791
10	Slovakia	0.296	527	10	Netherlands	2.740	5747
11	Finland	0.042	312	11	Singapore	2.516	5516
12	Italy	0.022	138	12	Norway	5.180	4312
13	Kazachstan	0.049	125	13	Ukraine	4.359	3823
14	Netherlands	0.029	100	14	France	1.235	2885
15	UK	0.017	73	15	Surinam	0.882	2232
16	Austria	0.012	68	16	Belgium	0.557	1189
17	Denmark	0.001	26	17	Malaysia	0.454	1049
18	Russia	0.011	8	18	Luxembourg	0.413	1019
19	France	0.021	8	19	Philippines	0.427	1007
including: ores and concentrates							
	Total	72.910	54185		Total	39.120	30282
1	Peru	26.279	20627	1	Russia	17.377	13065
2	Canada	17.889	12515	2	Uzbekistan	11.689	9447
3	Sweden	9.094	7249	3	Norway	5.044	4092
4	Chile	9.676	6047	4	Ukraine	4.022	2964
5	Switzerland	6.858	5402	5	Bulgaria	0.988	713

18. ELEMENTS COEXISTING IN ORES AND IN OTHER RAW MATERIALS

Metallic elements coexist mainly in ore deposits. Many of them, coexisting in zinc, lead and copper ore deposits, are extracted or can be extracted in the course of processing of these ores. Rare and dispersed elements have also been found to occur in salts and brines. The resources of these elements are presented in Table 18.1.

Table 18.1 Comparison of resources of coexisting elements occurring in ores and other raw materials (in thousand tons).

Elements	In copper ores	In zinc and lead ores	In other raw materials deposits	Total
Boron	-	-	6.00	6.00
Bromine	-	-	7.20	7.20
Br - J (brines)	-	-	3.21 mln m^3	321 mln m^3
Zirconium	-	-	2.00	2.00
Gallium	-	0.18	-	0.18
Germanium	-	0.14	-	0.14
Cadmium	-	78.84	-	78.84
Cobalt	165.64	-	-	165.64
Molybdenum	120.70	-	-	120.70
Nickel	43.67	-	-	43.67
Rhenium	0.06	-	-	0.06
Thallium	-	12.23	-	12.23
Titanium (Ti)	-	-	12.00	12.00

The considered group of raw materials contains also such metals that do not occur in deposits in Poland or are not reclaimed. The domestic demand for these metals (mainly aluminium, chromium, cobalt, magnesium, manganese, titanium and wolfram) is fully balanced by imports or possibly by utilization of non-mineral waste raw materials (Table 18.2).

Table 18.2 Directions of Polish imports and exports of aluminium, cobalt, chromium, magnesium and manganese

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Aluminium							
	Total	**255.08**	**319772**		**Total**	**38.91**	**128802**
1	Russia	31.00	136225	1	Germany	15.13	49923
2	Germany	20.52	42500	2	Czech Rep.	4.76	21359
3	Ireland	95.31	37305	3	UK	5.32	20376
4	Sweden	4.13	22720	4	Austria	5.58	17602
5	Slovakia	19.02	16788	5	Italy	1.67	5962
6	Hungary	40.47	16513	6	Sweden	0.84	3393
7	Czech Rep.	4.33	12304	7	Netherlands	2.53	3093

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
8	Spain	6.68	4347	8	Japan	0.61	2736
9	Australia	14.04	4189	9	Slovakia	0.31	1294
10	China	8.83	3680	10	Norway	0.50	934
11	Norway	0.57	3428	11	Turkey	0.25	352
12	Ukraine	1.93	3071	12	Luxembourg	0.17	341
13	France	0.59	2397	13	Slovenia	0.20	302
14	Austria	0.44	2377	14	Byelorussia	0.04	216
15	Brazil	3.15	1787	15	Spain	0.05	205
16	Netherlands	0.42	1639	16	Russia	0.35	191
17	United States	0.45	1409	17			
18	United Arab Emirates	0.22	1275	18			
19	UK	0.27	1244	19			
Cobalt (only import)							
	Total	**0.110**	**10209**				
1	Belgium	0.047	3702	4	Finland	0.010	1251
2	Russia	0.023	1396	5	UK	0.009	973
3	Zambia	0.010	1347	6	Sweden	0.004	827
Chromium							
	Total	**84.65**	**27939**		**Total**		**21019**
1	South Africa	57.40	14923	1	Germany	15.66	6682
2	Kazakhstan	25.38	5408	2	United States	10.76	2646
3	Germany	0.42	4774	3	Italy	0.65	2243
4	Netherlands	1.30	1853	4	UK	0.44	1928
				5	France	0.48	1673
				6	Lithuania	0.37	1072
				7	Spain	0.51	971
Magnesium							
	Total	**53.03**	**40477**		**Total**	**1.30**	**811**
1	Slovakia	14.96	7154	1	Netherlands	0.69	435
2	China	12.38	6765	2	Czech Rep.	0.40	201
3	Brazil	12.37	6527	3	Sweden	0.14	76
4	Russia	0.61	5554	4	Lithuania	0.02	67
5	Ireland	5.14	4911	5	Croatia	0.04	30
6	France	2.38	3198				
7	Germany	2.69	2152				
8	Austria	1.12	1545				
9	UK	0.87	874				
Manganese (only import)							
	Total	**167.40**	**48508**				
1	South Africa	98.42	27486	4	China	0.30	1317
2	Ukraine	36.00	10811	5	Belgium	0.37	973
3	Brazil	31.69	6124	6	Gabon	0.49	462

CHEMICAL RAW MATERIALS

19. BARITE AND FLUORSPAR

Barite deposits occur in Lower Silesia (Dolny Śląsk) and the Holy Cross Mountains (Góry Świętokrzyskie) (Plate 4).

In Lower Silesia four deposits have been explored, and two of them (Boguszów and Stanisławów) are exploited. Barite of the Lower Silesia deposits occurs in fissures in the form of veins of varying length and thickness, and with a high dip. It occurs in paragenesis with calcite, fluorspar, sulfides and metal oxides.

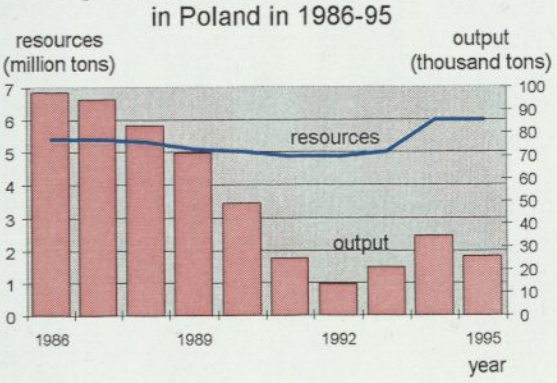
The average content of $BaSO_4$ amounts to about 80%. Fluorspar forms irregular bands. Its content ranges from a few to over a dozen and so percent and usually increases with depth.

In the Holy Cross Mountains (Góry Świętokrzyskie) barite occurs in Strawczynek in the Lower Devonian carbonate rocks in the form irregular nests and bands. This deposit is not exploited in view of its low $BaSO_4$ content (about 30%) and small size of the resources.

Table 19.1 Barite (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	5	6.34	2.23	4.11	0.08
including reserves of deposits in exploitation					
Total	2	5.83	2.21	3.62	0.00
including resources of not exploited deposits					
Prospecting	1	0.36	0.00	0.36	0.08
including abandoned deposits					
Total	2	0.15	0.02	0.13	0.00

Fig. 19.1 Barite resources and output in Poland in 1986-95



The explored resources of barite amount to 6.34 million tons of which 5.8 million tons constitute exploited deposits (92%).

The magnitude of barite resources and present state of their identification and management are presented in Table 19.1.

The resources and output of barite in the period 1986-95 are presented in Fig 19.1.

In the last decade the state of reserves was almost constant amounting to about 5 million tons. An increase of reserves was noted in the period 1993-1995 when they reached the level of 6.3 million tons.

From 1986 to 1992 the output decreased systematically from 98 million tons to 14 thousand tons. In the last years the output has been fluctuating between 20 thousand and 35 thousand tons.

In 1995 the barite output amounted to 26 thousand tons which does not satisfy the domestic demand and must be completed by import, especially by import of higher quality barite. Imports of barite, witherite and barium compounds amounted in 1995 to 9.4 thousand tons (Table 19.2). Fluorspar intrinsically economic resources explored in two deposits in Lower Silesia amounted to about 140 thousand tons. Also, 373.7 thousand tons of barite-fluorspar were explored there in the same region. Fluorspar is not exploited because it occurs mainly in deeper parts of the deposit.

The whole demand for fluorspar is covered by import. The import of fluorspar and fluorine compounds amounted in 1995 to 9.8 thousand tons. In the same period of time 0.11 thousand tons of barite and barium compounds, as well as 3.38 thousand tons of fluorine compounds were exported.

The barite resources may increase in the vicinity of the actually exploited deposits in Lower Silesia.

Table 19.2 Directions of Polish imports of barite and barium compounds, and fluorspar and fluorine compounds

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Barite and barium compounds							
	Total	9.35	8974				
1	Germany	1.93	3320	3	Slovakia	3.03	1025
2	Czech Rep.	2.74	3320	4	Russia	1.45	1011
Fluorspar and fluorine compounds							
	Total	9.75	8620				
1	Germany	0.81	2693	4	France	0.65	952
2	China	5.15	2222	5	Mexico	1.45	572
3	UK	1.44	1492				

20. CLAY RAW MATERIAL FOR PRODUCTION OF MINERAL PAINTS

Mineral pigments are the main materials for production of mineral paints. They are also used for oil paints, varnishes, enamels, putties etc. In the production of mineral paints chalk, barite, gypsum and burnt lime are also used as mineral fillers and weighting agents.

The most important mineral pigments are: ochre, umbra, terra di Siena, iron minium, browns and earth green. In Poland so far two deposits of ochre, argils and ochre claystones have been explored in the Kielce voivodeship (Plate 4). In these deposits, in argilic measures of Rhaetic-Liassic, ochres make lens accumulations. The intrinsically economic resources amount to 596 thousand tons.

The imports of mineral pigments (mainly from Germany and Austria) amounted in 1995 to 621.8 tons and their exports were (mainly to the United Kingdom, Lithuania, Ukraine and Russia).

21. DIATOMACEOUS ROCK

Diatomite is a silica-argillaceous, light-weight, porous rock of strong sorptional properties, which makes it suitable for use as support filling agent, purifying material, filtering material and insulating agent in the chemical, food and building industries.

In Poland as yet no typical diatomite deposits have been discovered, however, in the Carpathians (Plate 4), within the Krosno measures, diatomaceous rock occurs in the Leszczawka region of an average SiO_2 content of 72%, apparent density - 1.42 g/cm^3, bulk density - 0.49-1.28 g/cm^3, and porosity - 28.5%.

The magnitude of intrinsically economic resources of diatomaceous rock and state of their identification and management are presented in Table 21.1.

Table 21.1 Diatomites (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	4	10.03	3.29	6.74	2.74
including reserves of deposits in exploitation					
Total	2	1.05	0.46	0.60	0.00
including abandoned deposits					
Total	2	8.98	2.84	6.15	2.74

The explored intrinsically economic resources amount to 10.03 million tons. Two mining plants operate in the Leszczawka region. The output of the diatomaceous rock in 1995 was 2.37 thousand tons.

The actually used enrichment technology does not allow to extract from diatomaceous rock products of good quality, so their use is fairly limited (production of light-weight building aggregates and carrier of plant protection agents). In this situation import of high-quality diatomite is indispensable.

There are possibilities of increasing diatomaceous rock reserves, because the perspective reserves in the Leszczawka region amount to about 10 million tons. Considerably bigger perspectives of discovering diatomite deposits relate to menilite series of Krosno measures in the Błażowa and Godów regions (Rzeszów voivodeship), and also in the Dydynia-Krzywe region (Krosno voivodeship).

22. PHOSPHORITES

Phosphorite deposits lie in the north-eastern surrounding of the Holy Cross Mountains (Góry Świętokrzyskie), in the outcrops of Albian sediments (Plate 4).

The thickness of phosphorite-bearing measures ranges from 0.2 to 4.0 m. These measures hade at a small angle to northern east. They are water containing phosphorite deposits. The percentage of P_2O_5 in the concretions is low and ranges from 13% to 22%. The content of the concretions over 2 mm of diameter totals from 280 to 900 kg of phosphorite per 1 m^2 of the whole deposit.

As regards lithology two types of deposits can be distinguished:

(1) cemented - concentrations cemented by sandy marl,

(2) not cemented - concretions in loose or compact quartz sands with glauconite.

The explored resources of phosphatic concretions amount to 42.4 million tons, which include 7.35 million tons of P_2O_5. At present

the phosphorites deposits are not exploited in Poland and the exploitation will probably not worth in a future.

The whole Polish demand for phosphatic raw material is covered by imports. Imports of phosphorites, phosphate fertilizers and phosphate compounds amounted in 1995 to 1,709.4 thousand tons. At the same time exports of these materials amounted to 133.5 thousand tons.

The magnitude, value and main directions of imports are presented in Table 22.1 and of exports in Table 22.2.

Resources of the prospecting region of the north-eastern surrounding of the Holy Cross Mountains (Salomin-Gościeradów region), estimated at about 21.4 million tons (including 3 million tons P_2O_5 concretions), can be treated only as reconnaissance mineral resources.

Table 22.1 Directions of Polish imports of phosphorites and phosphate compounds

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Phosphorites							
	Total	1706.71	165454				
1	Morocco	743.22	69771	5	Togo	56.10	6514
2	Tunisia	544.74	47187	6	Israel	57.33	5581
3	Russia	173.99	23338	7	India	25.00	2262
4	Algeria	105.88	10670	8	Sweden	0.11	75
Phosphate compounds							
	Total	2.49	7564				
1	Germany	0.87	2542	4	Belgium	0.20	842
2	Italy	0.32	1041	5	France	0.19	652
3	Netherlands	0.22	949	6	UK	0.17	452

Table 22.2 Directions of Polish exports of phosphorites, phosphate fertilizers and phosphate compounds

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Phosphorites							
	Total	39.29	7771				
1	Czech Rep.	39.26	7765				
Phosphate fertilizers							
	Total	68.87	19.392				
1	Czech Rep.	35.56	7820	4	Slovakia	6.78	1175
2	Germany	13.97	5490	5	Denmark	2.03	802
3	UK	9.93	3821	6	Senegal	0.60	284
Phosphate compounds							
	Total	25.34	16711				
1	Czech Rep.	19.64	11533	4	Austria	0.95	487
2	Germany	3.52	2572	5	Netherlands	0.26	446
3	France	0.36	656	6	Russia	0.20	301

23. POTASSIUM-MAGNESIUM SALTS

Potassium-magnesium salts were found in bedded Zechstein measures, in Puck Gulf region and in the Kłodawa salt dome (Plate 4).

In the Puck Gulf region salts of sulfate type (polyrock salts) occur. They form irregular bunches and bands in anhydrite and in rock salt at the depth of 740 m to 900 m. The content of K_2O ranges from 7.7% to 13.7%. As yet four deposits have been explo-red whose total inferred resources amounted to 597 million tons (51 million tons of K_2O).

In the Kłodawa salt dome salts of chloride-carnallite type occur. They lie along the eastern border of the salt dome and form folded and, in some places, pressed beds, which hide deep at 70 degrees. Carnallite salts are polluted, and the average K_2O content amounts to 8.5% and that of MgO - 8.1%. The explored carnallite salt resources in the Kłodawa salt dome amount to 72 million tons 16% of which have been subjected to exploration.

Table 23.1 Potassium salt (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	5	669	12	657	19
including reserves of deposits in exploitation					
Total	1	72	12	60	0
including resources of not exploited deposits					
Prospecting	4	597	0	597	19

The state of identification of resources and management of potassium-magnesium salt deposits are presented in Table 23.1.

The magnitude, value and main directions of exports and imports are presented in Table 23.2.

Table 23.2 Directions of Polish imports and exports of potassium-magnesian salts, potassium fertilizers and potassium compounds

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	767.07	156133		Total	6.78	9430
1	Byelorussia	591.34	105103	1	France	0.87	2309
2	Germany	121.65	31995	2	Germany	1.49	2084
3	Russia	27.31	7665	3	Czech Rep.	0.52	668
4	France	1.65	2914	4	Netherlands	0.35	655
5	Czech Rep.	1.16	1634	5	Hungary	0.52	638
6	Israel	1.24	1154	6	Slovakia	0.40	540
7	Sweden	0.51	1103	7	Italy	0.14	382
8	China	0.21	666	8	Denmark	0.22	325
9	Italy	0.20	593	9	Austria	0.27	321
10	Netherlands	0.54	590	10	Belgium	0.18	307
11	United States	0.37	563	11	Slovenia	0.22	282
12	Belize	3.18	537	12	Senegal	1.10	217
13	Ukraine	13.22	499	13	Sweden	0.12	140

Plate 4

MAP OF OCCURRENCE OF CHEMICAL RAW MATERIAL DEPOSITS

Resources:

- Native sulfur deposits — 100 mln t
- Rock salt deposits — 4000 mln t
- Potassium salt deposits — 400 mln t
- Barite deposits — 4 mln t
- Barite and fluorspar deposits — 4 mln t
- Area of phosphorite occurrence
- Siliceous earth deposits
- Diatomaceous rock deposits
- Deposits of clay raw materials for production of mineral paints
- Deposits in exploitation

Areas of deposits occurrence:

- Tertiary formations of the Carpathian Foredeep
- Carpathian area
- Mesozoic formations
- Permian (Zechstein) formations
- Carboniferous formations
- Paleozoic core of the Holy Cross Mountains
- Crystal rocks of Sudetes
- Boundary of Zechstein formations occurrence
- Boundary of areas of Zechstein and Mesozoic deposits occurrence

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Rivers
- Reservoirs

Elaboration: S. Przeniosło
Graphic and technical computer elaboration: R. Bońda D. Siekiera

The total resources of potassium-magnesium salts in Poland in polyhalite and salts of chloride-carnallite type deposits amount to 669 million tons. Two thousand tons of these salts were extracted in 1995 from the Kłodawa deposit.

The country's demand for this raw material is covered by import. In 1995, 11.48 thousand tons of potassium salts, 755.6 thousand tons of potassium fertilizers and potassium compounds were imported, and 6.78 thousand tons of these products were exported.

24. ROCK SALT

Poland has numerous and rich rock salt deposits. Their occurrence is connected with Zechstein and Miocene formations. Zechstein salt deposits occur in northern Poland and in the pre-Sudetic Monocline (bed deposits) and in central Poland (dome deposits). The deposits of Miocene salt-bearing formation (tectonic deformed bed deposits) occur in the southern Poland, in the marginal zone of the Carpathian thrust (Plate 4).

The existence of salt-bearing measures has been ascertained on the Baltic coast between Łeba and Puck (Plate 4). The explored resources in this region, amounting to over 21 billion tons constitute 26.3% of the country's salt reserves. These deposits are not exploited.

In central Poland salt dome deposits have been discovered and explored, and their resources have been estimated at almost 52 billion tons, which constitutes 65% of the country intrinsically economic resources. In 1995, 97% of the whole country salt was exploited there.

Some deposits, lying in the southern salt region, have been exploited since the Middle Ages (Wieliczka-Bochnia - historical notes regarding their exploitation exist since the 12th century), but others have been explored after the Second World War. The latter have reach resources and have not been exploited as yet.

The southern region account for 5.4% of the explored intrinsically economic rock salt resources. In 1995, 2.6% of the whole domestic' production came from this region.

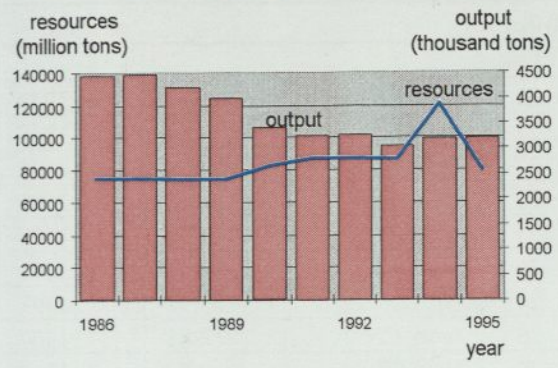
In the pre-Sudetic monocline (Monoklina Przedsudecka), only one explored rock salt deposit exist, and its resources amount to 2.9 billion tons (3.6% of the total resources in Poland).

Actual magnitude of rock salt resources and state of their identification and management are presented in Table 24.1.

Table 24.1 Rock salt (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	20	80445	41483	38962	24056
including reserves of deposits in exploitation					
Total	6	8521	4554	3967	3417
including resources of not exploited deposits					
Total	12	71736	36850	34886	20483
1. Exploration	5	27540	25889	1651	10018
2. Prospecting	7	44195	10960	33235	10465
including abandoned deposits					
Total	2	188	80	108	156

Fig. 24.1 Rock salt resources and output in Poland in 1986-95



The total rock salt resources amount to 80,445 billion tons.

The output in 1995 amounted to 3.21 million tons and constituted 22.5% of the losses due to exploitation and waste.

The economic reserves (7462 million tons) represent 9% of the intrinsically economic resources and 87% of the exploited deposit resources.

Actually six salt mines are in operation, including the only one that is a shaft mine (Kłodawa) exploiting dry salt suitable for alimentary purposes. The intrinsically economic resources of the exploited deposits (8521 million tons) constitute 10.6% of the total rock salt reserves.

In Fig 24.1 the rock salt resources and output in Poland in 1986-95 are presented.

The exports amounted in 1995 to 530.6 thousand tons of industrial rock salt, alimentary salt and brine, and to 736.5 thousand tons of sodium compounds. In the same time a little quantity of industrial salt, food salt and brine (a total of 31.3 thousand tons) were bought abroad. Imports of sodium compounds amounted to 56.7 thousand tons.

Magnitude, value and main directions of import are presented in Table 24.2 and export in Table 24.3.

Table 24.2 Directions of Polish imports of halite and sodium compounds

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Halite							
	Total	31.27	1943				
1	Byelorussia	30.07	993	2	Germany	0.46	726
Sodium compounds							
	Total	56.67	42359				
1	Finland	8.04	8937	8	Belgium	1.41	1874
2	Spain	20.07	6852	9	Slovenia	0.74	1251
3	Germany	6.20	6272	10	Italy	0.18	699
4	Netherlands	1.90	4836	11	Slovakia	3.02	657
5	Sweden	2.97	2999	12	France	0.40	651
6	United States	3.73	2233	13	Russia	0.62	650
7	Austria	4.86	2060	14	Hungary	1.02	639

Table 24.3 Directions of Polish exports of halite and sodium compounds

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Halite							
	Total	530.57	62033				
1	Czech Rep.	301.77	30467	7	Chorvatia	9.23	2167
2	Germany	34.74	8258	8	Austria	5.63	1103
3	Slovakia	77.02	6784	9	France	8.18	964
4	Hungary	27.40	3493	10	Denmark	7.25	751
5	Yugoslavia	14.24	2933	11	Belgium	7.25	686
6	Finland	23.82	2647	12	Netherlands	5.26	522

	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
Sodium compounds							
	Total	736.50	270516				
1	Czech Rep.	130.86	45129	21	Lithuania	5.73	1952
2	Germany	95.53	32820	22	Slovenia	2.54	1858
3	France	84.21	29361	23	Brazil	5.84	1829
4	Sweden	76.34	22830	24	Chile	3.68	1680
5	UK	62.85	18282	25	Ukraine	2.30	1672
6	Finland	35.74	13143	26	Malaysia	2.56	1452
7	Norway	38.73	11311	27	Uruguay	3.91	1397
8	Russia	8.90	11194	28	Ivory Coast	2.81	1360
9	Denmark	22.60	8646	29	Hong Kong	2.50	1319
10	Slovakia	20.40	6838	30	Dominicana	3.18	1197
11	Hungary	13.98	6546	31	Chorvatia	3.64	1181
12	Nigeria	15.01	5382	32	unknown	2.11	1159
13	Netherlands	6.72	5262	33	Guatemala	3.15	1118
14	Argentina	10.08	4682	34	China	1.31	1110
15	Venezuela	13.63	4536	35	Ecuador	2.37	907
16	Colombia	10.40	3682	36	Costa Rica	2.89	885
17	Austria	8.72	3270	37	Peru	1.98	701
18	Belgium	5.14	3079	38	Italy	0.71	685
19	Thailand	4.10	2599	39	Cuba	2.09	680
20	Spain	5.68	1953	40	Ghana	1.75	646

The explored rock salt resources make possible a great salt mining development, mainly as regards the not exploited salt dome deposits in central Poland and bed deposits of the pre-Sudetic monocline (especially in the copper deposits occurrence sites).

25. SILICEOUS EARTH

Explored deposits of siliceous rock (decalcified gaizes) occur in tectonic troughs on the surrounding of the Holy Cross Mountains (Góry Świętokrzyskie) and in lob forms covered by Oligocene sediments in the Lublin Upland (Wyżyna Lubelska) (Plate 4). Siliceous earth is used, after refinement, among others in chemical industry as catalyst carrier in the synthesis process, carrier of mineral fertilizers and pesticide suspensions, as component of synthetic moulding sands and for the needs of refinement and filtration.

Siliceous earth occurs at a depth of 35 m, and forms measures of thickness exceeding a dozen or so metres. The content of SiO_2 ranges from 84.9% to 89.4%, and the content of R_2O_3 from 5.5 to 8.0%, and the bulk weight is 263-580 g/l.

The intrinsically economic resources of four deposits of siliceous earth amount to 2.2 million tons, and almost half of them are explored in detail. Since 1991 siliceous rock has not been exploited in Poland.

The magnitude of intrinsically economic resources of siliceous rock, and the state of their identification and management are presented in Table 25.1.

High quality siliceous earth is all imported. Imports of siliceous earth, diatomaceous earth, terra cariosa and diatomite amounted in 1995 to 6.2 thousand tons. In the same time 6.8 thousand tons of these materials were exported. The above-mentioned materials were imported mainly from the Western Europe (Iceland, Belgium, Germany) and from the United States.

Table 25.1 Siliceous earth (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	4	2.21	1.08	1.13	1.01
including abandoned deposits					
Total	4	2.21	1.08	1.13	1.01

The utilization of siliceous earth resources of explored deposits is very low. The existing processing plants are capable of producing only the lowest quality product, i.e., insulating meal. At the same time the demand for refined products from imports is increasing.

The value and main directions of exports and imports of diatomite, siliceous and diatomaceous earth are presented in Table 25.2.

Table 25.2 Directions of Polish import and export of diatomites, siliceous and diatomaceous earth

Import				Export			
	Country	thousand ton	thousand PLN		Country	thousand ton	thousand PLN
	Total	6.22	8092		Total	6.84	1005
1	United States	3.31	4115	1	Germany	1.82	323
2	Iceland	0.71	1109	2	Netherlands	3.66	312
3	Belgium	0.71	823	3	Czech Rep.	0.63	126
4	Germany	0.37	789	4	Ukraine	0.03	116
5	Czech Rep.	0.60	536	5	Austria	0.29	46

Perspectives of increasing the resources of siliceous earth exist in the region of Upper Cretaceous outcrops on the western (Małogoszcz - Bełchatów - Sieradz zone) and the north-eastern surrounding of the Holy Cross Mountains and in the Lublin Upland.

26. SULFUR

In Poland among all sulfur-bearing raw materials the deposits of native sulfur are the important for the country's economy. The deposits occur in the northern part of the Carpathian Foredeep, in Torton rocks, mainly in gypsum-origin limestones (Plate 4). Sulfur fills small caverns and chaps, and its content in the rock can reach 70%, the average is about 25 - 30%. The concentrations of sulfur are limited to elevated structures formed during the tectonic rebuilding of the foredeep at the end of Badetian. The sulfur accompanying copper, zinc and load ores is of small importance and is used for sulfuric acid production.

In 1995 three deposits were exploited by production well.

The magnitude of the sulfur resources and their state of identification and management are presented in Table 26.1.

The resources of native sulfur deposits in the Carpathian Foredeep increased continuously from their discovery in 1953 till 1976. This was the result of intensive identification works which brought new promising discoveries. The most dynamic increase of resources was noted in the years 1965 - 1976. The resources in 1976 exceeded 1 billion tons.

Table 26.1 Sulfur (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	13	740.76	681.19	59.57	51.26
including reserves of deposits in exploitation					
Total	4	404.51	404.51	0.00	14.30
including resources of not exploited deposits					
Total	6	281.19	222.52	58.68	11.44
1. Exploration	3	170.84	170.84	0.00	0.01
2. Prospecting	3	110.36	51.68	58.68	11.43
including abandoned deposits					
Total	3	55.05	54.16	0.89	25.52

Table 26.2 Directions of Polish exports of crude sulfur

	Country	thousand tons	thousand PLN
	Total	1462.50	198698
1	Morocco	616.46	82779
2	Tunisia	246.83	34202
3	Brazil	232.44	28041
4	Sweden	92.77	13810
5	Italy	75.24	11030
6	France	37.31	6154
7	UK	35.52	5362
8	Chorvatia	29.72	4019
9	Egypt	27.50	3444
10	Israel	24.38	3157
11	Netherlands	18.57	2956
12	Switzerland	15.06	1773
13	Slovakia	7.41	1334
14	Czech Rep.	0.92	190

In the next years a gradual decrease of the resources had been noted caused due to exploitation of the deposits and recently also to the unfavourable situation on international markets. In view of this the resources of deposits in inferior exploitational conditions or of deposits largely exhausted were neglected in the balance. At present the resources of native sulfur amount to 741 million tons, which include over 20% of sulfur in protective pillars. The exploitable reserves amount to 54.6% of the total resources.

The sulfur output increased as dynamically as the resources and reached in 1980 over 5 million tons and maintained that level in the next years. At the beginning of the nineties regression began due to the lowering of prices of sulfur on international markets where cheaper sulfur from desulfurization of bituminous raw materials appeared. The output of native sulfur in Poland in 1995 was 2392 thousand tons which yielded 2313 thousand tons of commercial product.

In 1995 exports of sulfur (Table 26.2), sulfuric acid and sulfur compounds amounted to 1.7 million tons. In 1995 imports of sulfur compounds, refined sulfur and sublimed sulfur, as well as sulfuric acid amounted to 3.7 thousand tons (Table 26.3).

Fig. 26.1 Sulfur resources and output in Poland in 1986-95

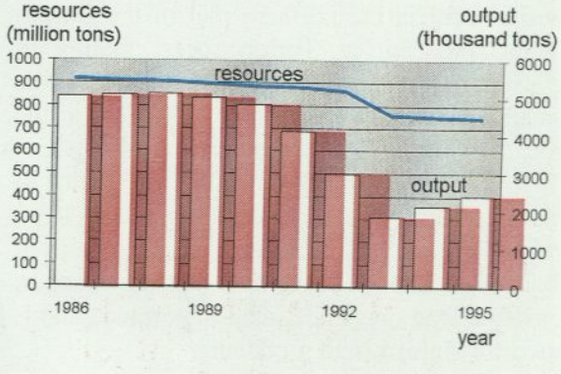


Table 26.3 Directions of Polish imports and exports of sulfuric acid and sulfur compounds

Import				Export			
	Total	3.70	7454		Total	255.34	14049
1	Czech Rep.	0,85	2328	1	Czech Rep.	120.80	5485
2	Germany	0,36	1548	2	Netherlands	37.43	2292
3	China	0,46	1091	3	Slovakia	32.62	1539
4	Sweden	1,38	542	4	Spain	15.90	882
5	UK	0,14	436	5	France	15.98	871
6	France	0,12	364	6	Germany	6.79	860
7	Russia	0,01	296	7	Sweden	12.67	744
8	Belgium	0,09	245	8	Belgium	10.14	530
9	Austria	0,02	195	9	Hungary	0.40	256
10	Ukraine	0,09	125	10	Austria	0.34	211

The magnitude, value and main directions of exports and imports of sulfur acid and sulfur compounds are presented in Table 26.3.

Reconnaissance resources amount to 32 mln tons of sulfur and are related to occurrence of copper, zinc and lead sulphide ores.

OTHER RAW MATERIALS

27. AMBERS

The Baltic amber, i.e. succinite, occurring in Poland has a Mohs' hardness of 2-2.5, density 0.96-1.096 g/cm^3, melting point 287-300^{0}C, refractive index 1.539-1.542, and colour from pale-yellow to reddish-brown.

The amber ascertained in Poland occurs in Tertiary and Quaternary formations (Fig. 27.1).

The biggest accumulations of amber in Tertiary sediments occur in the northern and southern marginal zone of the Eocene Sea.

In the northern zone amber has agglomerated in the sandy-silty sediments with glauconite in the Eridan river delta (the so-called chłapowsko-sambijska delta) and this material has been transported by the river from Fennoscandia. Now this area lying in the Gdańsk Gulf (Zatoka Gdańska) zone has the greatest concentrations of amber. The best explored is the Chłapów region where the amber-bearing stratum of almost 18 m thick was discovered at a depth of about 100 m, and has a maximum capacity 6 kg/m^3. The magnitude of the resources was estimated at about 640 thousand tons (M. Piwocki 1995).

In the southern zone of the Eocene Sea the amber-bearing sediments (silts and sands with glauconite) were also formed in the delta zone, the so-called Parczew delta. The recharge area was the Ukraine shield. Similar sediments have been accumulated at the same time in Ukraine in the Klesów delta (Kijów and Charków series). In the Parczew region the amber deposit has been well explored at the bottom of the Górka Lubartowska natural aggregate deposit. Here the amber-bearing stratum about 7 m thick occurs at an average depth of 15 m. Within this deposits the resources have been estimated at about 10 tons (B. Kosmowska-Ceranowicz 1995).

The third amber occurrence in Tertiary sediments is the Możdżanowo region in the Słupsk voivodeship. Ambers occur here in the Lower Oligocene and Pliocene sands and gravels, which form a post-glacial cake between Quaternary sediments. The amber-

bearing series lies at a depth of 11 m and is on an average of 1.7 m thick. The perspective resources of these areas are estimated at over 20 tons. Within the Możdżanowo natural aggregate deposit 10 tons of amber have been explored in detail (I. Olkowicz-Paprocka 1995).

Fig. 27.1 The amber occurrence in Poland

The biggest Quaternary sediments of amber have been accumulated due to the glacier and post-glacial rivers transport from Tertiary sediments (mainly from sediments of the chłapowska-sambijska delta).

The greatest amber concentrations were discovered in Kurpie (Łomża voivodeship) and also in the Bory Tucholskie region (northern part of Byd-goszcz voivodeship) where it occurs in the outwash fan measures.

Big amber concentrations are also encountered on the Baltic beaches from Kołobrzeg to the eastern border of Poland where this raw material occurs in the fossil measures of Holocene beaches.

In Poland to about 600 explored amber occurrences have been ascertained.

It is estimated that the annual consumption of amber in Poland (mainly in jewellery) amounts to about 150 tons. This raw material comes mainly from imports (mostly individual). These imports account for about 70% of the demand. The remaining demand is balanced by deliveries from amber collectors or from unlicensed exploitation sites (washed out).

28. BACKFILLING SANDS

In the mining industry the Quaternary sands are used as backfilling for exploited excavations. These sands are sandy and sandy-gravel sediments of fluvioglacial origin, connected with Middle Poland Glaciation. Also aeolian and Pleistocene river terrace sands are used.

Deposits of sands useful as backfilling were identified in the area of intensive, underground mining mainly of coal and of copper ores, i.e. in Upper Silesia (Górny Śląsk) (Plate 8). An important balance criterion for this raw material is the distance between the deposit and the mines using stowages. This distance should not exceed 50 km for the copper mining basin.

In the Upper Silesian Coal Basin (Plate 8) four regions of occurrence of backfilling sands can be distinguished. The eastern region (where the largest amounts of this raw material

are exploited) where the following measures occur: sandy sediments of fluvioglacial and aeolian accumulation of the Błędowska Desert (with a maximum thickness of 70 m); sandy sediments of outwash fans near Dziećkowice and Imielin; sandy fluvial sediments 11 m thick near Kuźnica Warężyńska; sands of accumulation terraces on the Vistula river bank near Oświęcim.

The western region includes the south-eastern margin of the Silesia Upland and part of the Racibórz Basin. Sandy-gravel sediments 15 m thick occur here in the Odra proglacial valley which are connected with the Middle Poland Glaciation.

The northern region includes wide area of the Mała Panew river valley where thick covers (maximum 40 m) of fluvioglacial, aeolian and fluvial sands occur.

The southern region lying between Żary, Oświęcim and Tychy is a wide area of occurrence of fluvioglacial sands of 20-25 m thickness.

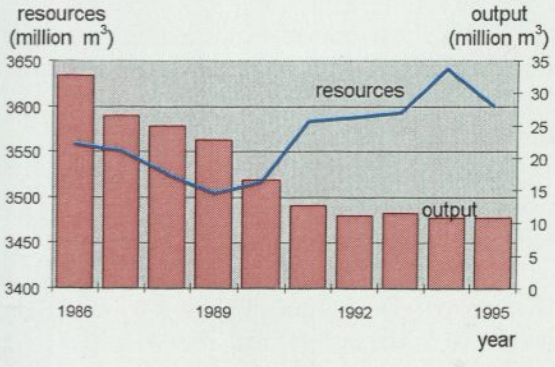
The Lower Silesian Coal Basin is poor in backfilling sands. Sandy and sandy-gravel sediments of fluvioglacial accumulation of about 10 m thickness occur near Jaworzyna Śląska.

In the region of copper ore exploitation near Lubin, between Przemków, Chocianów and Legnica sand-gravel outwash fans occur, which are connected with the Middle Poland Glaciation, and have a thickness of maximum 40 m.

Table 28.1 Backfilling sands (mln m^3)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	37	3598.23	2966.77	631.46	402.22
including reserves of deposits in exploitation					
Total	10	1221.54	1032.02	189.52	14.09
including resources of not exploited deposits					
Total	20	2187.64	1759.97	427.67	202.99
1. Exploration	16	1847.31	1757.15	90.16	62.94
2. Prospecting	4	340.32	2.82	337.51	140.05
including abandoned deposits					
Total	7	189.05	174.78	14.27	185.14

Fig. 28.1 Backfilling sands resources and output in Poland in 1986-95



The intrinsically economic resources of this raw material amount to 3598 million m^3, i.e. 6117 million tons.

The magnitude of resources of backfilling sand, and state of their identification and management are presented in Table 28.1.

Resources explored in detail amount to almost 82% of the total quantity of the intrinsically economic resources.

The output of backfilling sands in the recent years has been steady and amounted in 1995 to 10,827 thousands m^3 (i.e. 18,406 thousand tons) (Fig. 28.1).

The mining wastes connected with the exploitation of backfilling sands amounted to 364 thousand tons, all of which was collected on dumps.

During drainage of open-pits 36.4 million m^3 of water were pumped off, 53.5 million m^3 which were fed to rivers.

Possibilities exist of deposits in the area of Lublin Coal Basin. In the northern part of this basin, upland outwash fans of thickness of 20-25 m occur, in the Lubartów region shallow outwash fans covers occur and in the Wieprz river valley sands forms accumulation terrace with thickness of about 15 m. These regions have not been explored as yet.

29. BENTONITES AND BENTONITIC CLAYS

Bentonitic raw materials are clay rocks, whose dominant component (determining their utilized properties) are minerals of the smectite group. Bentonites are altered rocks of the same structure as the primary rocks. Bentonitic clays are bentonites in secondary deposits, which were redeposited sometimes at large distances. They contain various, sometimes considerable amounts of foreign components. Bentonites and bentonitic clays differ as regards the percentage of minerals from the smectite group. Their content in bentonites exceeds 75%.

In Poland bentonitic raw materials occur in the Carpathians, the Holy Cross Mountains, in the Upper Silesia Coal Basin and in the Sudetes (Plate 7).

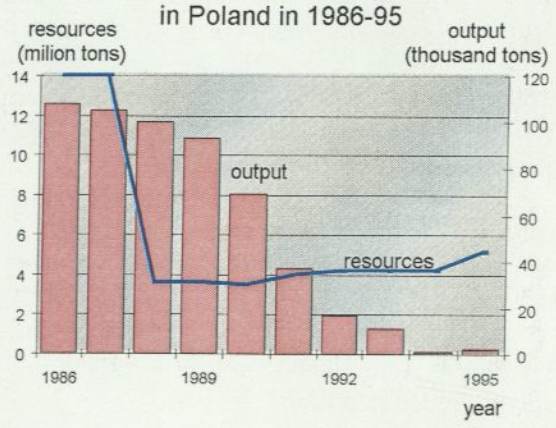
The intrinsically economic resources of bentonite raw materials amount to 5.09 mln t.

The state of identification and management of bentonites and bentonitic clay resources are presented in Table 29.1.

Table 29.1 Bentonitic raw materials (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	10	5.09	2.57	2.52	0.91
including reserves of deposits in exploitation					
Total	1	0.51	0.30	0.21	0.00
including resources of not exploited deposits					
Total	6	3.24	1.52	1.71	0.69
1. Exploration	4	2.31	1.52	0.79	0.69
2. Prospecting	2	0.92	0.00	0.92	0.00
including abandoned deposits					
Total	3	1.34	0.75	0.59	0.22

Fig. 29.1 Bentonites and bentonic clays resources and output in Poland in 1986-95



These raw materials were utilized in the founding industry as a founding bentonite of 3rd class, as decolouring earth and also as component of drilling fluids.

In Fig 29.1 resources and output of bentonitic raw materials in Poland in the years 1986-1995 is presented.

Actually only one deposit is exploited (Krzeniów). The output of these raw materials decreased in the last decade from over 100 to 2 thousand tons.

This decrease is connected with the low quality of the raw material, which does not allow production of high quality founding materials, and limits the applications and demand for use as drilling fluid.

Higher quality bentonites are imported. This import amounted in 1995 to 55.5 thousand tons (Table 29.2).

Table 29.2 Directions of Polish imports of bentonite

	Country	thousand tons	thousand PLN
	Total	55.46	10606
1	Germany	12.29	5985
2	Slovakia	38.92	2694
3	Netherlands	0.99	825
4	UK	0.25	629
5	United States	0.07	310

30. BUILDING AND ROAD STONES

The group of building and road stones includes different types of igneous, metamorphic and sedimentary rocks (Plate 6). In Poland such igneous rock deposits occur as basalts, gabbros and diabases, granites, granodiorites and syenites, melaphyres, porphyries and keratophyres, and phyric tuffs. Among metamorphic rock deposits are: amphibolites, gneisses, hornfelses, quartzites, schists, marbles and serpentinites. Sedimentary rock deposits include: dolomites, marls, limestones, gaizes (cherts), sandstones and conglomerates, as well as siliceous rocks (chalcedonites).

The actual resource base of building and road stones in Poland amounts to 7.9 billion tons explored in 489 deposits (Table 30.1).

Table 30.1 Building and road stones (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	489	7882.8	4661.8	3221.0	531.3
including reserves of deposits in exploitation					
Total	173	3402.2	2774.7	627.5	120.5
including resources of not exploited deposits					
Total	158	3923.3	1454.9	2468.3	382.6
1. Exploration	108	1942.5	1411.9	530.6	125.5
2. Prospecting	50	1980.7	43	1937.7	257.2
including abandoned deposits					
Total	158	557.3	432.1	125.2	28.2

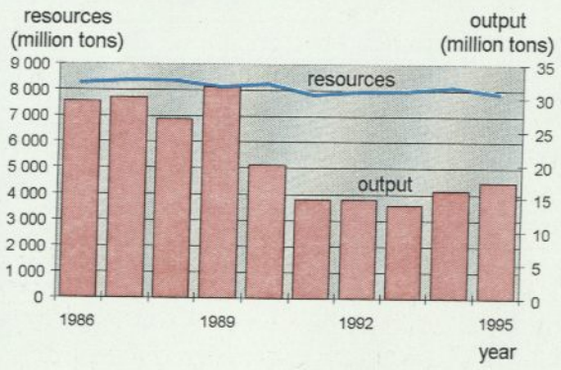
The variation of reserves in the past twenty years indicated an intensive increase of resources owing to the identification of new deposits before 1981 when an increase of reserves from 5 to over 8 billion tons took place. Since 1982 the level of reserves of the above-mentioned raw materials has oscillated around 8 billion tons. The decrease of reserves in several deposits substantially exceeding the annual output observed in 1991 and in 1995 is due to that resources whose exploitation would be in conflict with the natural environment have been deducted from the domestic balance.

Table 30.2 The resources and output of different types of building and road stones (mln tons)

Raw material	Intrinsically economic resources	Output	Number of deposits
T o t a l	**7882.73**	**17.33**	**489***
Igneous rocks - total	3593.18	9.67	152
Basalts	621.12	5.43	45
Gabbros and diabases	463.94	0.57	5
Granitoids	1424.43	1.23	73
Melaphyres	382.66	1.81	16
Porphyries and keratophyres	682.80	0.62	12
Phyric tuffs	18.27	0.00	1
Metamorphic rocks - total	659.32	1.09	41
Amphibolites	61.87	0.13	6
Gneisses and hornfelses	165.98	0.15	10
Quartzites	1.67	0.00	1
Marbles	404.26	0.52	19
Serpentinites	25.54	0.29	5
Sedimentary rocks - total	3630.23	6.57	304
Dolomites	588.87	2.10	30
Sandstones and conglomerates	1421.59	1.53	160
Siliceous rocks	30.97	0.13	4
Limestones and marls	1588.80	2.81	110

* a total of 9 deposits contain two raw materials for manufacturing both building and road stones.

Fig. 30.1 Building and road stones resources and output in Poland in 1986-95



The exploitation of building and road stones is conducted in 176 deposits whose reserves are 3.5 billion tons (almost 44% of the total resources). In the resource balance of Poland additional 156 deposits suitable for management are noted, whose total resources accounted to 3.9 billion tons. In the same number of deposits the extraction was abandoned even though they still contained 0.5 billion tons of resources.

As mentioned above, the building and road stone deposits occur mainly in southern Poland (Fig. 30.1). The largest part of these raw materials in the resource balance of Poland occur in Lower Silesia where nearly 53% of resources occur. These are mainly igneous and metamorphic rocks; sedimentary rocks appear in small quantities. The remainder are mainly resources of sedimentary rocks occurring in the following regions: the Holy Cross Mountains (24%) - mainly limestones and sandstones, the Carpathians (13%) - sandstones, and the Silesia-Cracow Upland (9.7%) - limestones. Small limestone deposits occur in the Zamość region and Bydgoszcz voivodeship and they are used both for production of crushed aggregates and as a raw material in the cement industry. In northern Poland single deposits of erratics are encountered.

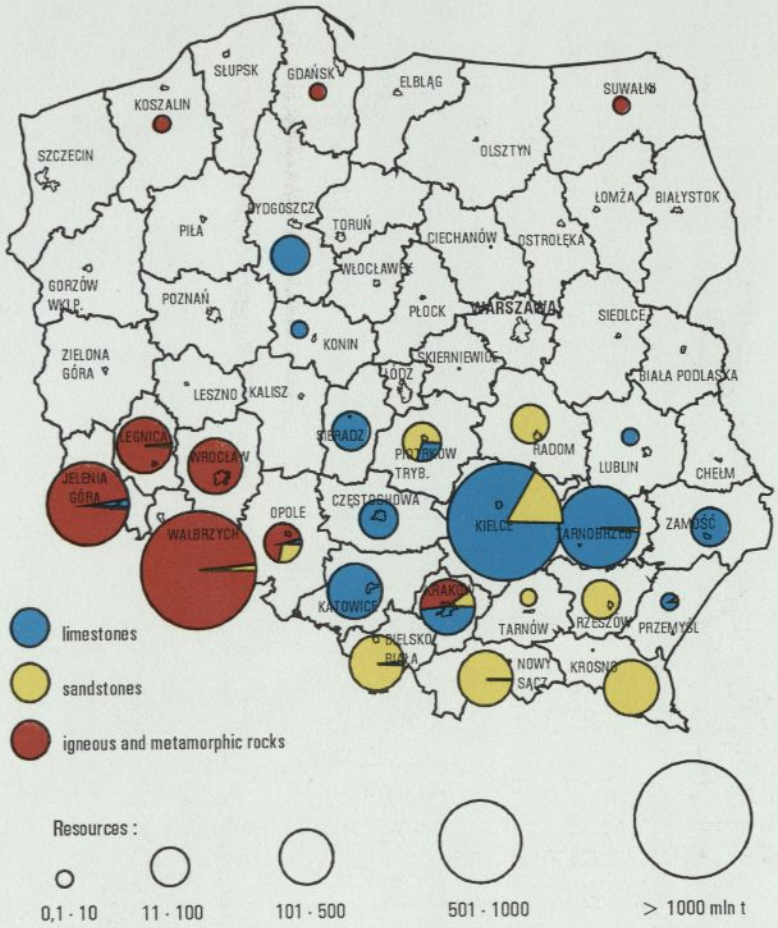
The output of building and road stones has considerably varied in the past decade. The maximum output was noted in 1990 (Fig. 30.2). These magnitudes show the management potential of this group of raw materials. The present level of exploitation, amounting to 17.3 million tons (1995), is close to half of that in the peak period.

As regards the use of building and road stones, two general groups can be distinguished, i.e. block stones and aggregates. Some lithologic types are suitable only for aggregates. They include: basalts, amphibo-

lites, diabases, gabbros, gneisses, quartzites, melaphyres, porphyries and keratophyres, as well as serpentinites. Other types, such as marbles or granites, are exploited only for obtaining block stones. The general rule is that block stones are extracted everywhere where it is possible. Mine wastes obtained after extraction of blocks are used as crushed aggregates. Among sedimentary rocks making up the largest number of deposits, such as limestones and sandstones, only some are suitable for block extraction.

Crushed aggregates are generally a high grade raw material of much better quality than natural aggregates. The quality of aggregates depends on the type of raw material and its quality parameters in the deposits. Therefore some of the raw materials are exploited on a huge scale exceeding the potential of the resources base of Poland. One of such raw materials are basalts.

Fig. 30.2 The distribution of resources and principal lithologic types of building and road stones in Poland



31. BUILDING CERAMICS RAW MATERIALS

Building ceramics raw materials are first of all clay Quaternary and Tertiary sediments, and rarely older ones: Cretaceous, Jurassic, Triassic, Permian, Carboniferous and Cambrian.

Quaternary measures, mainly glacial and fluvioglacial sediments, i.e. glacial tills, silts, marginal lake clays, commonly occur in northern and central Poland, and aeolian sediments (loesses) in southern Poland. Older than Tertiary clay sediments occur almost solely in southern Poland (Plate 5).

The intrinsically economic resources of building ceramics raw materials, as well as the state of their identification and management are shown in Table 31.2. The intrinsically economic resources of building ceramics raw materials totalled at the end of 1995 1898 mln m^3 (equivalent to about 3796 mln tons).

The resources of deposits in exploitation amount to 20.6% of the total resources, the not exploited deposit resources to 72.1% (including 15.7% of resources in deposits explored and 84.3% in prospected deposits) and the abandoned deposit resources to 7.2%.

The economic reserves were estimated as yet for 354 deposits (from among the 521 exploited deposits) and they total 257.31 mln m^3 (i.e. about 514.62 mln tons), which constitutes 65.7% of the exploited deposits.

Plate 5

MAP OF OCCURRENCE OF RAW MATERIAL DEPOSITS FOR BUILDING CERAMICS

Deposits with resources:

In exploitation	Not exploited
< 1.5 mln m³	< 1.5 mln m³
1.5 - 3 mln m³	1.5 - 3 mln m³
> 3 mln m³	> 3 mln m³

Areas of deposits occurrence:

- Loess and loess loam
- Quaternary (glacial till, clay and marginal lake silt, river aggradations)
- Miocene-pliocene (clays and silts)
- Tertiary of the Carpathian Foredeep (marine clays)
- Oligocene (septarian clay)
- Carpathian flysch (clay-slate)
- Jurassic (claystones and siltstones)
- Triassic (claystones and siltstones)
- Upper Paleozoic (clays and clay-slate)
- Paleozoic rocks of Sudetes and the Holy Cross Mountains (claystones and residual clays)

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Voivodeship boundaries
- Rivers
- Reservoirs

Elaboration: W. Szczygielski
Graphic and technical computer elaboration: R. Bońda D. Siekiera

Table 31.1 Types of building ceramics raw materials and their main applications

Age		Raw material	Main uses					
			1	2	3	4	5	6
Quaternary	Holocene	clays and alluvial tills	+			+		
	Pleistocene	loess and loess loam	+		+			
		clays and marginal lake silts	+			+	+	
		clays and Elbląg silts	+	+		+	+	
		glacial tills	+					
Tertiary	Pliocene	clays (Gozdnica series)	+	+	+			
	Mio-pliocene	Poznań clays	+	+	+	+	+	+
		land clays	+			+	+	
	Miocene	marine clays	+			+	+	+
	Oligocene	septarian clays	+			+	+	
	Eocene-Oligocene	clay-slates of the Carpathian flysch	+	+		+		
Cretaceous		Cretaceous clays and clay--slates	+					
Jurassic	Dogger	Dogger clays (ore-bearing)	+			+	+	
	Liassic	Liassic clays	+	+		+	+	
Triassic	Keuper-Rhaetian	Keuper and Rhaetian clays	+	+		+	+	+
Permian		clays	+	+				
Carboniferous		clays and clay-slates	+	+	+	+		

(1-3) - thick products: 1 - full brick, 2 - building clinker, 3 - road clinker;
4 - hollow products; 5 - thin products; 6 - roof products

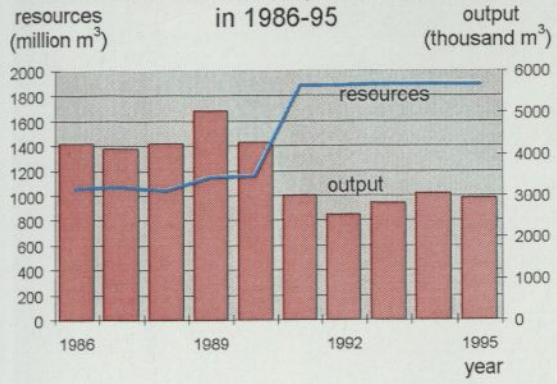
Table 31.2 Building ceramics raw materials (mln m^3)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	1166	1897.5	615.1	1282.4	57.1
including reserves of deposits in exploitation					
Total	521	391.47	334.11	57.4	16.0
including resources of not exploited deposits					
Total	283	1368.6	156.4	1212.2	24.9
1. Exploration	207	215.0	156.4	58.6	14.2
2. Prospecting	76	1153.6	0.0	1153.6	10.7
including abandoned deposits					
Total	362	137.5	124.6	12.9	16.1

The output decreased in the course of 1995 by 109 thousand m^3 (3.6%) to reach 2928 thousand m^3 (about 5856 thousand tons) (Fig 31.1). Half of the domestic output comes from smaller deposits with reserves of less than 1500 thousand tons, and balance comes from deposits with reserves of more than 1500 thousand m^3 which account for about 15.2% of all deposits and contain 67% of the intrinsically economic resources of the deposits in exploitation.

The considered raw materials are exploited in every voivodeships, with the exception of the Konin, Radom and Szczecin

Fig. 31.1 Building ceramics raw materials resources and output in Poland in 1986-95



ones. In 1995 the biggest output was noted in the Częstochowa voivodeship 288 thousand m^3, followed by the Warsaw (216 thousand m^3), Kalisz (196 thousand m^3), Tarnobrzeg (151 thousand m^3) and Wrocław (143 thousand m^3) ones.

After two years, 1993-1994, of growth of output it decreased slightly for in 1995. The process of liquidations of large enterprises exploiting several deposits is continuing, though several of such enterprises are quite prosperous in the new market conditions.

The prognostic total resources of building ceramics raw material are estimated at 3442 million m^3 as per 1st January 1981.

This forecast, however, relates only to resources of clay raw material suitable for hollow and thin-walled products and light-weight ceramic aggregate ("keramzyt"). It assumed that poorer quality raw materials (for full brick production) are distributed in large amounts all over the country. The minimal deposit reserves taken into consideration were those of 0.8 mln m^3.

The most promising as regards the possibilities of identification of deposits of this type are: Miocene-Pliocene clays (50.7% of prognostic resources), Miocene marine clays (21.1%) and Quaternary clays and marginal lake silts (16.9%). The remaining ones are: clay-silts of the Carpathian flysch (4.2%) and also Dogger clays (3.9%), Liassic clays (1.9%) and Triassic clays (1.3%).

In voivodeships where there is a deficit of reserves compared with the demand and there are difficulties in increasing the reserves, the most important will be clays and marginal lake silts. Their prognostic resources amount there to 56.2% and are almost twice as big as the prognostic resources of the Miocene-Pliocene clays (which rank second). Clay materials stored on dumps during exploitation of lignite, hard coal, sulfur, siderites and refractory clays so far hardly utilized also deserve mentioning.

32. CERAMIC CLAYS

Kaolinite clays are used in noble ceramics as clay raw materials. Two types of these clays are distinguished as regards technology, i.e. colour of the ceramic body after burning - whiteware and stoneware clays.

The whiteware clays occur only in the Sudetes (Plate 7), mainly in the Cretaceous formations in the north-Sudetic basin and in Tertiary formations, where they accompany lignite in the Turów deposit.

The intrinsically economic resources of this raw material amount to 56.6 mln tons, of which only one deposit (Bolko) of 0.45 mln tons is in exploitation. In some deposits, mainly those with large resources, occurring there clay is flushed. The available useful fraction amounts to about 30%.

The intrinsically economic resources of whiteware ceramic clay (for faience and semi-vitreous China-ware), state of their identification and management, are presented in Table 32.1.

The stoneware clay deposits occur in the Sudetes where they accompany whiteware clays in Cretaceous sediments in the north-Sudetic basin and in Tertiary sediments. Furthermore the raw material deposits occur in the Silesian-Cracow (Rhaetic and Liassic) and also in the Holy Cross Mountain (Roethian, Rhaetic and Liassic) regions.

Table 32.1 Whiteware ceramic clays (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	7	56.67	4.73	51.93	0.78
including reserves of deposits in exploitation					
Total	1	0.45	0.45	0.00	0.05
including resources of not exploited deposits					
Total	4	53.69	2.02	51.66	0.00
1. Exploration	1	2.02	2.02	0.00	0.00
2. Prospecting	3	51.66	0.00	51.66	0.00
including abandoned deposits					
Total	2	2.53	2.26	0.27	0.73

The intrinsically economic resources being explored in 24 deposits amount to about 96.9 mln tons, of which one-third occurs in eight deposits being exploited. The ceramic clay output amounted in 1995 to 159 thousand tons of stoneware clays and 5 thousand tons of whiteware clays.

The intrinsically economic resources of the stoneware clays, state of their identification and management are shown in Table 32.2.

Table 32.2 Stoneware ceramic clays (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	24	96.86	28.68	5	16.20
including reserves of deposits in exploitation					
Total	8	31.59	16.56	15.03	6.14
including resources of not exploited deposits					
Total	10	59.19	7.30	51.88	8.40
1. Exploration	4	7.30	7.30	0.00	2.30
2. Prospecting	7	51.88	0.00	51.88	6.11
including abandoned deposits					
Total	6	6.09	4.82	1.27	1.64

33. CHALK

Under the name chalk we understand two types of deposits that occur in Poland: Cretaceous chalk and lacustrine chalk. They differ in chemical and petrographic composition, origin and practical utilisation. The Cretaceous chalk is utilized in the rubber, paper, chemical, pigment and cement ones industries, and lacustrine chalk (accompanying mainly calcareous gyttja) is utilized as a calcareous fertilizer in agriculture.

The Cretaceous chalk is a calcareous, slightly coherent and porous rock. It occurs in 16 deposits (bedded deposits covered usually by an overburden of varying thickness) in eastern and north-eastern Poland voivodeships (Plate 6). These deposits are 7 m to 16 m thick

and the overburden thickness reaches 15 m. Now 10 deposits could be exploited and in 1995 the exploitation was conducted in 4 deposits.

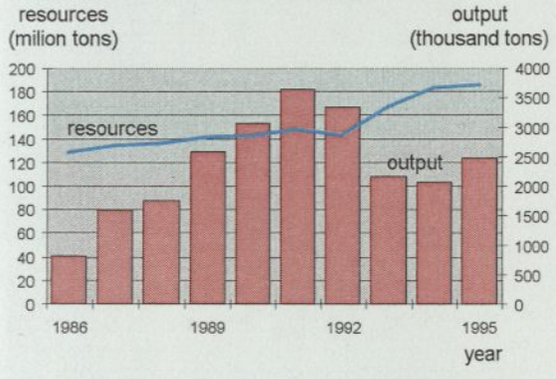
Lacustrine chalk occurs in northern and central Poland. It is a calcareous sediment of stagnant waters, often with an admixture of clay minerals and detritus. In the lacustrine chalk overburden peat often occurs.

The state of chalk resources and their identification and management are presented in Table 33.1.

Table 33.1 Chalk (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	152	186.97	100.44	86.54	13.03
including reserves of deposits in exploitation					
Total	58	45.99	42.65	3.34	1.87
including resources of not exploited deposits					
Total	75	119.16	55.17	63.99	0.15
1. Exploration	48	71.86	55.17	16.69	0.00
2. Prospecting	27	47.30	0.00	47.30	0.15
including abandoned deposits					
Total	19	21.82	2.61	19.21	11.11

Fig. 33.1 Chalk resources and output in Poland in 1986-95



The state of intrinsically economic resources amounts to 186.97 mln tons including those in exploited deposits (25%). The economic reserves, calculated for 32 lacustrine chalk deposits and two Cretaceous chalk deposits, amount to 28.37 mln tons, which constitutes 62% of the resources of exploited deposits.

The output amounted in 1995 to 2475 thousand tons (Fig. 33.1).

The chalk imports (mainly from Austria, Germany and the Czech Republic) amounted in 1995 to 8.4 thousand tons, and exports to 1.6 thousand tons (mainly to the Czech Republic).

The magnitude of the identified chalk resources and the possibility of identification of new lacustrine chalk deposits (mainly in northern Poland) and Cretaceous chalk (in the southern east) allow for increasing the output of this raw material.

34. CLAY RAW MATERIALS FOR LIGHTWEIGHT AGGREGATE PRODUCTION

Clay raw materials occurring in many deposits in the whole country are suitable for lightweight aggregate production. The explored deposits intended for this use, lie mainly in the Gdańsk voivodeship and in the eastern part of Poland (Siedlce, Lublin, Zamość).

Plate 6

MAP OF OCCURRENCE OF COMPACT ROCK RAW MATERIALS DEPOSITS

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Voivodeship boundaries
- Rivers
- Reservoirs

Elaboration: S. Przeniosło
Graphic and technical computer elaboration: R. Bońda D. Siekiera

Resources:

- Dolomites deposits — 50 mln t
- Gypsum and anhydrite deposits — 20 mln t
- Chalk deposits — 1 20 mln t
- Vein quartz deposits
- Feldspar raw materials deposits — 10 mln t
- Deposits of limestones and marls for cement industry — 10 200 mln t
- Deposits of limestones and marls for lime industry — 10 100 mln t

Building and road stones deposits:

- sedimentary rocks — 10 25 mln t
- metamorphic rocks — 10 25 mln t
- igneous rocks — 10 25 mln t
- Deposits in exploitation
- Deposits not exploited

Areas of deposits occurrence:

- Quaternary
- Miocene-pliocene
- Tertiary of the Carpathian Foredeep
- Carpathian flysch
- Cretaceous
- Jurassic
- Triassic
- Upper Paleozoic
- Paleozoic rocks of Sudetes and the Holy Cross Mountains

Table 34.1 Clay raw materials for lightweight aggregate production (mln m^3)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	49	191.66	48.09	143.57	4.61
including reserves of deposits in exploitation					
Total	3	24.67	24.67	0.00	1.30
including resources of not exploited deposits					
Total	43	166.31	22.74	143.57	3.32
1. Exploration	10	25.85	22.74	3.11	0.06
2. Prospecting	33	140.46	0.00	140.46	3.26
including abandoned deposits					
Total	3	0.68	0.68	0.00	0.00

The intrinsically economic resources of clay raw material suitable for production of lightweight aggregate, the state of their identification and management are presented in Table 34.1.

The magnitude of the intrinsically economic resources of clay raw material for lightweight aggregate production amount to 191.66 which is equivalent to 383.3 mln tons. The resources explored in detail amount to 25.1% of the total explored resources, and 12.9% of the intrinsically economic resources occur in deposits in exploitation. The economic reserves were calculated for three deposits in exploitation and amount to 14.19 mln m^3.

The output of the considered raw materials amounted in 1995 to 129 thousand m^3 (258 thousand tons).

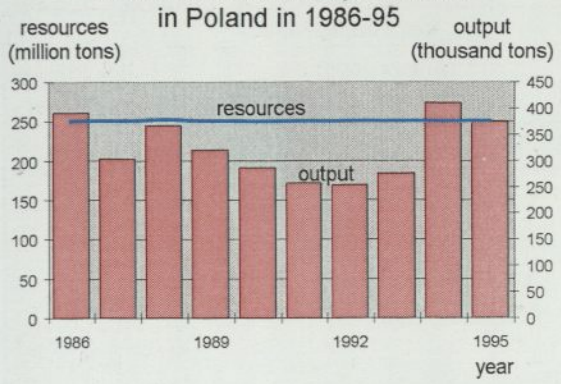
35. CLAY RAW MATERIALS FOR CEMENT PRODUCTION

Clay raw materials used for correction of the cement kiln charge, occur commonly in the whole country. Their resources have been explored mainly in southern and south-eastern Poland, where the cement industry is located. The intrinsically economic resources amount to 248.55 mln tons, including 13.2% occurring in deposits in exploitation. The state of their identification and management is shown in Table 35.1.

Table 35.1 Clay raw materials for cement industry (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	22	248.55	210.42	38.13	13.71
including reserves of deposits in exploitation					
Total	4	32.75	32.75	0.00	1.97
including resources of not exploited deposits					
Total	15	142.94	104.81	38.13	2.28
1. Exploration	14	110.02	104.81	5.21	2.28
2. Prospecting	1	32.92	0.00	32.92	0.00
including abandoned deposits					
Total	3	72.86	72.86	0.00	9.46

Fig. 35.1 Resources and output of clay raw materials for cement production in Poland in 1986-95



The state of resources exploration is high since over 84% of the total intrinsically economic resources have been explored in detail. The resources of deposits in exploitation constitute 13.2% of the total explored resources.

The economic reserves of all deposits in exploitation amount to 27.9 mln tons, which constitutes 85.5% of the intrinsically economic resources of the deposits being in exploitation.

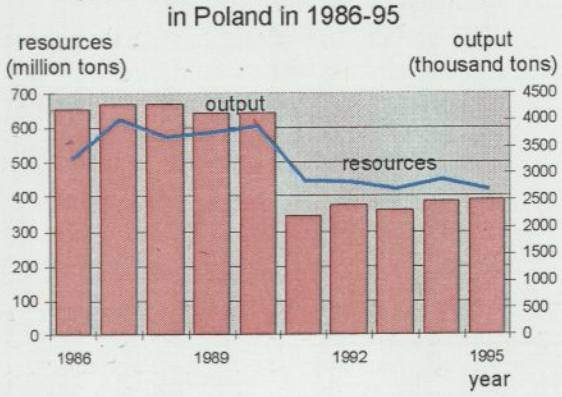
The output amounted in 1995 to 373 thousand tons.

36. DOLOMITES

Dolomites are used in the metallurgical industry as fluxes, in an agriculture as magnesium-calcium mineral fertilizer, in ceramic industry, and also as building and road materials (crushed aggregate, grits etc.).

Dolomite deposits suitable for the metallurgical industry occur mainly in the Katowice voivodeship (Plate 6). They are bedded Tertiary (Middle and Lower Muschelkalk) or Middle Devonian deposits.

Fig. 36.1 Dolomite resources and output in Poland in 1986-95



Dolomites for the ceramic industry occur in Lower Silesia (Dolny Śląsk) (Plate 6), where they form lentil deposits in metamorphic shales. Two deposits lie in this region: Rędziny and Ołdrzychowice-Romanowo. The dolomites from the latter deposit are of excellent quality, but in spite of this they are used for production of grits. The resources of the dolomites in these two deposits are classified as road and building stone resources.

The bedded Devonian dolomites are quite numerous in the Holy Cross Mountain region. The majority of these dolomites can not be exploited because they occur in ecologically protected areas (landscape parks, ground water accumulation regions).

The dolomite deposit resources and the state of their identification and management are presented in Table 36.1.

The intrinsically economic resources amount to 422 mln tons. Over 60% of these resources occur in six deposits in exploitation. Four explored deposits remain to be managed, as well as numerous prospective areas - mainly in the Silesian-Cracow region and several in the Holy Cross Mountains.

The output of dolomite for the metallurgical and agricultural industries amounted in 1995 to 2519 thousand tons (Fig. 36.1).

In spite of the domestic resources which could be exploited the demand for dolomite flour (of extra high quality) is covered by imports. Imports amounted in 1995 to 17.0 thousand tons and exports only to 7.9 thousand tons.

Table 36.1 Dolomites (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	10	421.99	292.85	129.13	28.12
including reserves of deposits in exploitation					
Total	6	278.96	210.54	68.42	24.28
including resources of not exploited deposits					
Total	4	143.03	82.32	60.71	3.84
1. Exploration	1	0.98	0.98	0.00	0.55
2. Prospecting	3	142.04	81.34	60.71	3.29

37. FELDSPAR RAW MATERIALS

The deposits of feldspar raw materials lie in Lower Silesia (Dolny Śląsk) and in the Silesia-Cracow region (Plate 6). They consist of feldspar and quartzic-feldspar rocks rich in alkalies. These rocks are leucogranites in Lower Silesia near Strzeblów and Kopaniec, phyric granites in the Jelenia Góra basin, and quartz-feldspar as a raw material accompanying the kaolin deposit. Other rocks occur in the Silesia-Cracow region, i.e. potassium trachyte and Kwaczalska arkose.

The intrinsically economic resources of feldspar raw materials amount to 89.8 mln tons.

Actually two deposits are in exploitation and their resources amount to 13.5 mln tons. These deposits are leucogranite (near Strzeblów) and weathering waste of the Karkonosze Mountain phyric granites (near Jelenia Góra) ones. Five deposits with 75.6 mln tons of total resources remain in the group of not exploited deposits. Furthermore for over 20 areas in the Sudetes the prospective resources have been estimated at more than 160 mln tons (J. Jerzmański 1993).

The states of identification and management are presented in Table 37.1.

The output of the feldspar raw material amounted in 1995 to 46 thousand tons.

Imports of feldspar raw material amounted in 1995 to 30.9 thousand tons worth 7588 thousand PLN.

Table 37.1 Feldspar raw materials (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	8	89.79	20.29	69.50	13.18
including reserves of deposits in exploitation					
Total	2	13.49	13.49	0.00	0.00
including resources of not exploited deposits					
Total	5	75.57	6.07	69.50	13.18
1. Exploration	2	14.19	6.07	8.12	0.00
2. Prospecting	3	61.38	0.00	61.38	13.18
including abandoned deposits					
Total	1	0.73	0.73	0.00	0.00

38. FLINTSTONES

Flintstones occur in calcareous rocks in the Cracow-Wieluń Upland, in the Lublin Upland and in the surroundings of the Holy Cross Mountains. The only two explored deposits of flintstones (ornamental ribbon flintstones) in the Kielce voivodeship have not been exploited so far. The total resources of these deposits amount to 28 thousand tons.

39. FOUNDRY SANDS

Foundry sands show a high temperature sintering point and are the basic material for making moulding and core compounds, which are used for making casts from metal alloys. The sands consist of a sand matrix (over 65% of the total weight), i.e. quartz sand grains of 0.02-3.0 mm in diameter, and a natural binding agent consisting of a fraction of grain size less than 0.02 mm in diameter. Two types of sands were distinguished as foundry sands: pure quartz sands containing a maximum 2.0% of the binder and natural sands containing from 2.0% to 35% of the binder. Now 7 types of foundry sands are distinguished depending on the content and mineral composition of the binding agent. An important feature of the raw material is also its sintering point. For casting steel a sintering point of 1400^{0}C is required, for casting iron 1350^{0}C, and for casts from non-ferrous metals 1200^{0}C.

Deposits of foundry sands occur mainly in the central and southern parts of Poland (Plate 7). These deposits form usually beds, only in the Częstochowa region they occur in karst fillings in the Jurassic limestones. This raw material occurs in the measures of various periods: Jurassic, Cretaceous, Tertiary and Quaternary.

Jurassic foundry sands occur in the western part of the Cracow-Częstochowa Upland (the area between Gorzów Śląski and Żarki - sands and slightly compact sandstones belonging to Lower and Middle Jurassic rocks) and in the north-west and the north-east of the surrounding of the Holy Cross Mountains (sands and slightly compact sandstones belonging to Liassic rocks near Szydłowiec, Wąchock, Skarżysko-Kamienna and Jagodno and also sands and sand sediments belonging to Middle Jurassic rocks near Opoczno and Iłża).

Cretaceous sands occur mainly in the Tomaszów Basin where they accompany glass-making sands and in Lower Silesia (in the middle-Sudetic synclinorium near Bolesławiec (slightly compact Coniacian sands).

Table 39.1 Foundry sands (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	83	363.36	206.21	157.15	6.03
including reserves of deposits in exploitation					
Total	14	125.16	125.01	0.15	3.34
including resources of not exploited deposits					
Total	39	218.26	65.03	153.23	2.24
1. Exploration	18	68.98	65.03	3.95	2.10
2. Prospecting	21	149.27	0.00	149.27	0.13
including abandoned deposits					
Total	30	19.94	16.17	3.77	0.46

MAP OF OCCURRENCE OF CERAMIC AND REFRACTORY RAW MATERIALS DEPOSITS

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

- Voivodeship towns over 300 000 of inhabitants
- Voivodeship towns
- Other towns
- State boundaries
- Voivodeship boundaries
- Rivers
- Reservoirs

Elaboration: S. Przeniosło D. Siekiera
Graphic and technical computer elaboration: R. Bońda

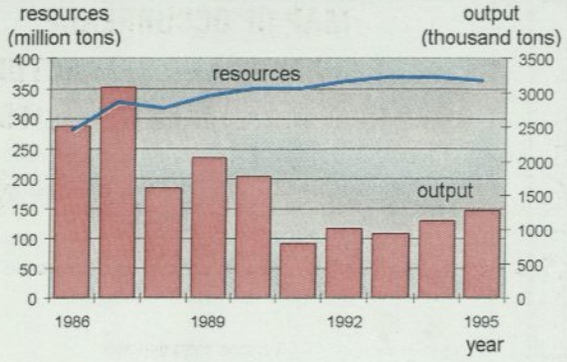
Resources:

- Bentonitic raw materials deposits
- Ceramic clays deposits — 3 mln t
- Foundry sands deposits — 2 20 mln t
- Kaolin raw materials deposits — 10 mln t
- Magnezites deposits
- Refractory clays deposits — 3 mln t
- Refractory quartzites deposits — 1.5 3 mln t
- Refractory shales deposits — 5 .10 mln t
- Shales deposits — 5 10 mln t
- Deposits in exploitation
- Deposits not exploited

Areas of deposits occurrence:

- Quaternary
- Miocene-pliocene
- Tertiary of the Carpathian Foredeep
- Carpathian flysch
- Cretaceous
- Jurassic
- Triassic
- Upper Paleozoic
- Paleozoic rocks of Sudetes and the Holy Cross Mountains

Fig. 39.1 Foundry sands resources and output in Poland in 1986-95



Tertiary sands are Miocene and Oligocene land sediments (Lower Silesia), region of Konin-Koło-Turek, surrounding of the Holy Cross Mountains and in northern Poland in Pomerania, and also sea sediments. Sands of sea origin occur near Świniary and Tarnobrzeg and also in the Lublin Upland.

Karst origin sands occur between Częstochowa and Zawiercie in karst hollows in Jurassic rocks. The structure of the deposits is often complex and they are filled with natural sands with a high sintering point.

Quaternary sands (Pleistocene and Holocene ones) occur in almost every part of the country, but they are usually of low-quality and show a low sintering point.

The magnitude of foundry sand resources and state of their identification and management are presented in Table 39.1. The intrinsically economic resources of foundry sands in all deposits amount to 363.36 million tons. Resources of the exploited deposits amount to 34.4% of total resources.

The exploitation of foundry sands in 1995 amounted to 1281 thousand tons. The changes of foundry sand reserves and their output in the last decade (1986-1995) are shown in Fig 39.1.

In the course of draining the mines 1404.2 thousands m^3 of drinking and industrial waters were pumped off and 65% of this quan-tity was utilized in economy. In the production of foundry sands 107.4 thousand tons of processing wastes were generated and collected on dumps of which 34.7 thousand tons were utilized.

In view of the unfavourable location of foundry sand deposits, (mainly in the south of Poland) while foundries are distributed on the whole territory of the country there is a need of conducting research-proving works in the northern part of Poland.

40. GLASS SANDS

Glass sands are the main raw material for the glass industry and their quality determines the quality of glass. Quartz flours of the same granulation as sands are used sometimes for optical glass products and for the best quality lead glass but this is usually due to the deficit of glass sands of highest purity.

Glass sands occur in Poland (Plate 8) in 32 deposits six of which are in exploitation and in five exploitation has been abandoned. The glass sand resources, the states of their identification and geological management are summarized in Table 40.1.

The deposits as well as the resources lie mainly in two voivodeships and regions: in the Piotrków Trybunalski voivodeship (Tomaszów region) and in the Jelenia Góra voivodeship (Bolesławiec region). The total country's resources of glass sands amount to 591 mln tons of which 83% are in the first region and 12% in the Bolesławiec one. The remaining 5% of domestic resources occur in several smaller deposits lying in different voivode-ships: Piła (1.6% of the total resources), Tarnobrzeg (1.3%) and Konin (1.2%).

In the Bolesławiec region (northern part of the north-Sudetic basin) glass sands occur in Cretaceous formations. The deposits of the Białogóra series near Tomaszów are also Cretaceous ones. The quartz sands occurring in the Tarnobrzeg region accompany the Miocene sulfur deposits.

Table 40.1 Glass sands (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	32	591.41	304.52	286.89	98.61
including reserves of deposits in exploitation					
Total	6	54.21	47.52	6.69	4.06
including resources of not exploited deposits					
Total	21	535.05	254.84	280.20	94.54
1. Exploration	12	303.22	254.84	48.37	54.25
2. Prospecting	9	231.83	0.00	231.83	40.29
including abandoned deposits					
Total	5	2.15	2.15	0.00	0.02

The output of glass sands in Poland concentrates, like the deposits in the above-mentioned regions, i.e.: Bolesławiec and Tomaszów ones from where from over 84% of the total output come.

The output in the Bolesławiec region is so big because of the high quality of the raw material in this region. The best glass sand classes occur in this region (from first to fourth) but over 80% of the resources are classified as 1st to 2nd class. Sands of 1st to 2nd class do not occur in the remaining exploited deposits, while sand of 3rd class occurs in the Tomaszów region.

The demand annual output amounting to about 1 mln tons is the measure of the country's consumption which points to the minimum levels of imports and exports.

41. GYPSUM AND ANHYDRITES

Of importance in Polish economy are Miocene gypsum deposits occurring mainly in the Nida valley and the Zechstein gypsum and anhydrite deposits accompanying copper deposits in Lower Silesia (Plate 6).

The Nida valley is one of the richest gypsum-bearing regions in Poland. Gypsum occurs here in the considerable area just under the ground surface or under a little thick overburden (1.5-15 m). The gypsum bed thickness ranges from a minimum of 10 m to a maximum of 46 m. The content of $CaSO_4 \cdot 2H_2O$ amounts to 85-95%.

The Zechstein gypsum and anhydrite deposits contain varying quantities of the raw material and occur in complex geological conditions.

Apart from the resources in the explored deposits, considerable prospective resources (over 56 billion tons) have been explored in the overburden of the copper ore deposits in the Legnica-Głogów copper region.

The magnitude of the intrinsically economic resources of gypsum and anhydrite in the explored deposits amounts to 330 mln tons.

The resources explored (generally and in detail) amount to 71% of the intrinsically economic resources of these deposits, and the resources of the exploited deposits to 38.1% of the intrinsically economic resources.

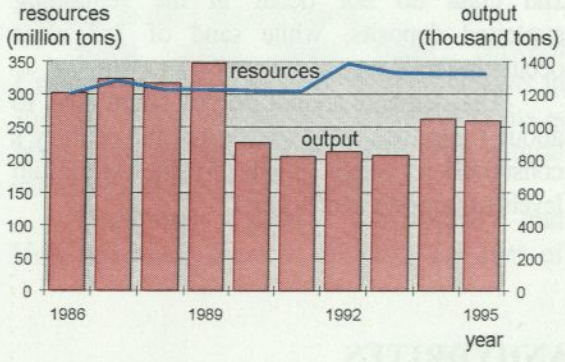
The economic reserves of the explored deposits amount to 114.52 mln tons and constitute 91% of the intrinsically economic resources.

The state of gypsum and anhydrite intrinsically economic resources and the state of their management are presented in Table 41.1.

Table 41.1 Gypsum and anhydrites (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	16	330.00	234.44	95.55	33.76
including reserves of deposits in exploitation					
Total	4	125.83	100.21	25.62	6.78
including resources of not exploited deposits					
Total	8	127.80	90.41	37.39	13.16
1. Exploration	6	94.55	90.41	4.14	13.16
2. Prospecting	2	33.26	0.00	33.26	0.00
including abandoned deposits					
Total	4	76.36	43.82	32.54	13.83

Fig. 41.1 Gypsum and anhydrites resources and output in Poland in 1986-95



The gypsum and anhydrite output amounted in 1995 to 1038 thousand tons.

Fig 41.1 presents the resources and output of gypsum and anhydrite in Poland in the period 1986-1995. The domestic resources of gypsum and anhydrite allow to cover the whole Polish demand. Imports mainly of: gypsum plaster, gypsum building products and a little gypsum amounted in 1995 to about 125.5 thousand tons, and exports of these materials amounted to 42.6 thousand tons.

The magnitude, value and main directions of gypsum imports and exports are presented in Table 41.2.

Table 41.2 Directions of Polish imports and exports of gypsum, gypsum plasters and gypsum building materials.

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	125.52	65882		Total	42.62	15434
1	Germany	60.95	31288	1	Germany	4.95	4057
2	Norway	43.63	17053	2	Russia	4.07	3739
3	France	4.68	4799	3	Ukraine	3.18	2254
4	Czech Rep.	8.87	3640	4	Czech Rep.	8.35	968
5	Austria	1.97	3131	5	Byelorussia	0.58	803
6	Italy	0.48	1221	6	Finland	15.96	696
7	Sweden	1.81	896	7	Netherlands	0.26	638
8	Netherlands	0.47	826	8	Hungary	1.39	562
9	Belgium	0.62	665	9	Sweden	0.04	286
10	Greece	0.66	580	10	Denmark	0.48	257
11	UK	0.31	517	11	Belgium	0.20	243

42. KAOLIN

The Polish term "kaolin" relates to a rock with a high contain of the kaolinite mineral, which is characterized by the possibility of extracting from it the kaolin raw material (by, for example, mechanical processing). This Polish term corresponds in British terminology approximately to "China clay" or "ball clay".

Residual and sedimentary kaolin deposits can be utilized in their natural forms in the refractory material industry for chamotte products. Other uses like the ceramic, paper, rubber, chemical and food industries require an enriched material obtained by flushing, flotation, acid job, electrophoresis, etc.

In Poland kaolin deposits lie in Lower Silesia (Plate 7). They are related with the massifs of granites and acid metamorphic rocks in the Sudetes and pre-Sudetic block.

The deposits of kaolin are of residual or redeposited types and occur where the mother rocks appear. In the north-Sudetic depression sandstones with kaolinite binder occur. All deposits are Tertiary ones.

The intrinsically economic resources of kaolin raw materials amount to 213 mln tons. The state of resources of these raw materials and the state of their management are presented in Table 41.1.

Table 42.1 Kaolin raw materials (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	13	213.12	139.57	73.55	49.11
including reserves of deposits in exploitation					
Total	1	77.01	77.01	0.00	7.44
including resources of not exploited deposits					
Total	10	123.46	49.91	73.55	41.67
1. Exploration	5	52.22	49.91	2.31	29.67
2. Prospecting	5	71.24	0.00	71.24	12.00
including abandoned deposits					
Total	2	12.65	12.65	0.00	0.00

The exploitation of kaolin raw materials was conducted in the Maria III deposit near Bolesławiec and amounted in 1995 to 269 thousand tons. The demand of Polish industry is balanced by imports. Imports of kaolins amounted in 1995 to 91 thousand tons, including 9.9 thousand tons of crude kaolin and 81.5 thousand tons of burned kaolin. Only 11.0 thousand tons of kaolin were exported in the same period of time (Table 42.2).

Table 42.2 Directions of Polish imports and exports of kaolin and kaolin clay

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	91.41	27394		Total	11.01	800
1	UK	37.61	11792	1	Denmark	10.15	718
2	Germany	17.47	6636	2	Germany	0.78	56
3	Czech Rep.	21.29	5432	3	Lithuania	0.05	19
4	Spain	1.90	1191	4	Ukraine	0.00	7
5	Ukraine	11.00	835	5	UK	0.00	2
6	Austria	1.56	626				

43. LIMESTONES AND MARLS FOR CEMENT AND LIME INDUSTRIES

Limestones and marls are used in the production of cement and lime (building and industrial lime) and also in metallurgy and food industry (beet manufacture).

These raw materials occur in Poland in the following regions (Plate 6):

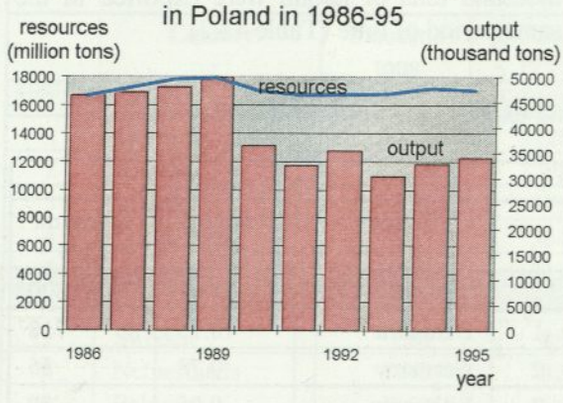
- Lower Silesia – Cambrian and Triassic formations,
- Silesian-Cracow area – Triassic, Jurassic and Cretaceous formations,
- Holy Cross Mountains – Devonian, Triassic, Jurassic, Cretaceous and Tertiary formations,
- Carpathians – Cretaceous formations,
- Lublin area – Cretaceous formations,
- Kujawy-Pomeranian area – Jurassic formations.

The magnitude of the explored resources of limestones and marls for lime and cement industry and also the state of their management are presented in Table 43.1. The intrinsically economic resources of the deposit amount to 17,108.43 mln tons. The resources explored by detailed exploration constitute 53.7% of the total explored resources, 32% of the explored resources occur in deposits in exploitation.

Table 43.1 Limestones and marls for cement and lime industry (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	178	17108.4	9183.4	7925.0	1799.8
including reserves of deposits in exploitation					
Total	40	5470.6	4527.0	943.6	301.0
including resources of not exploited deposits					
Total	98	11268.3	4296.2	6972.1	1438.3
1. Exploration	61	5386.0	4189.0	1197.0	733.8
2. Prospecting	37	5882.3	107.2	5775.1	704.5
including abandoned deposits					
Total	40	369.5	360.3	9.2	60.4

Fig. 43.1 Resources and output of limestones and marls for cement and lime industries in Poland in 1986-95



The economic reserves, calculated for 37 explored deposits of calcareous materials, amount to 4771 mln tons, which constitutes 87.2% of the total resources of all deposits in exploitation.

The output of calcareous raw materials amounted in 1995 to 34,063 thousand tons, including 21,984 thousand tons for the cement industry, and 12,079 thousand tons for the lime one.

Fig 43.1 shows limestone and marl resources and their output in Poland in the period 1986-1995.

The resources of limestones and marls for cement and lime industries cover the total country's demand and make possible considerable exports of limestone processed products. Exports in 1995 amounted to 812.1 thousand tons of clinker, 3223.3 thousand tons of cement and 800.7 thousand tons of building

and industrial lime. Imports in the same year amounted to 61.4 thousand tons of clinker, 17.5 thousand tons of cement and 20.4 thousand tons of building and industrial lime.

The magnitude, value and main directions of imports and exports are shown in Table 43.2. The existing base of the explored resources of the above-mentioned raw materials will balance Polish industry demand for a long time yet. Actually the perspective resources concentrate in the following regions: Holy Cross Mountain, Opole, Częstochowa and Lublin areas and amounted to a totally of over 90 billion tons.

Table 43.2 Directions of Polish imports and exports of cement, clinker and lime

Import				Export			
	Country	thousand tons	thousand PLN		Country	thousand tons	thousand PLN
	Total	99.3	17985		Total	4836.0	479736
1	Estonia	64,3	5430	1	Germany	4637.0	455347
2	UK	3,6	3358	2	Netherlands	66.3	9812
3	Denmark	5,1	3238	3	Sweden	65.8	6201
4	Germany	2.5	1219	4	Austria	42.0	4034
5	Spain	0.6	926	5	Denmark	12.9	1812
6	Byelorussia	14.1	855	6	Macedonia	0.4	559
7	Slovakia	2.6	771	7	Ukraine	3.5	434
8	Italy	0.5	743	8	Russia	1.5	393

44. MAGNEZITES

Magnezites occur in ultrabasic rock massifs. In Poland magnezite deposits occur in serpentinite massifs in Lower Silesia (Plate 7): Gogołów-Jordanów, Grochowa-Braszowice, Szklary and Sobótka. All the explored deposits lie in the Wałbrzych voivodeship. These are vein deposits with veins 3 m thick, of the complex geological structure and of varying raw material quality. Magnezites in Polish deposits are compact and amorphous. These magnezites, in distinction from crystal magnezites, are used only in limited quantities as an additive to magnezites used in refractory material production.

The resources and state of their management are shown in Table 44.1.

Table 44.1 Magnezites (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	6	11.89	2.69	9.21	4.58
including reserves of deposits in exploitation					
Total	2	5.80	2.69	3.11	2.40
including resources of not exploited deposits					
Prospecting	4	6.10	0.00	6.10	2.18
including abandoned deposits					
Total	40	369.5	360.3	9.2	60.4

Table 44.2 Directions of Polish imports of magnezite and magnezite products

	Country	thousand tons	thousand PLN
	Total	53.47	35013
1	Brazil	23.92	13832
2	China	17.73	8132
3	Austria	4.58	6478
4	UK	2.58	3196
5	Germany	0.25	893
6	France	0.10	778
7	Ireland	0.48	546
8	Netherlands	0.11	352
9	Slovakia	3.19	264

Half of the explored magnezite resources occur in two deposits being exploited (Braszowice and Wiry) and they amount to 11.9 mln tons.

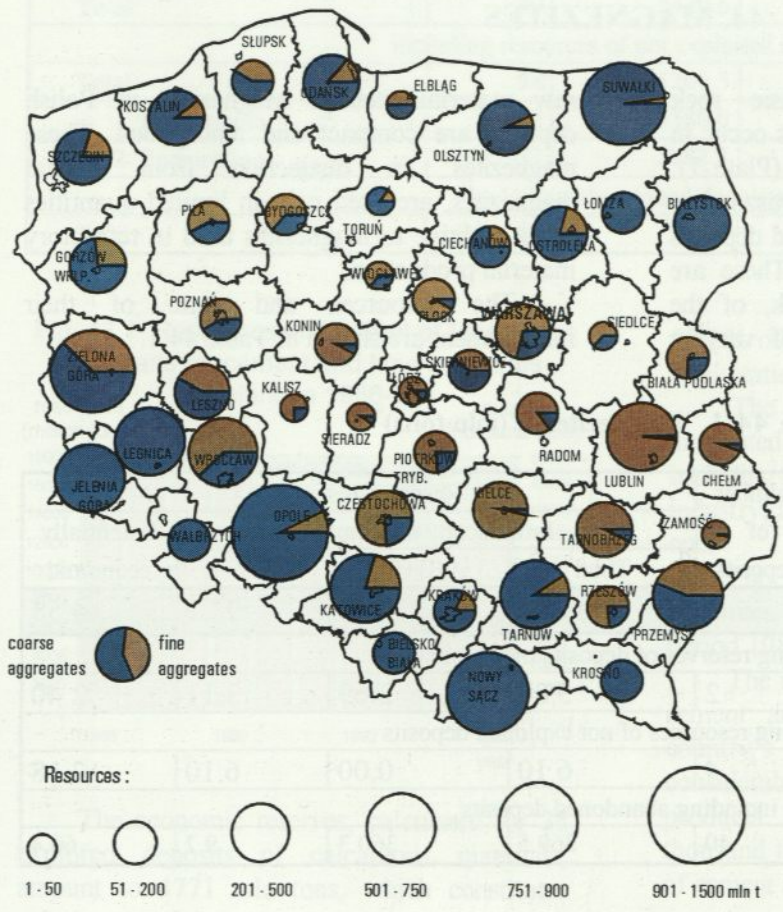
The output of magnezite amounted in 1995 to 26 thousand tons. This quantity did not cover the domestic demand, especially in view of the quality of these magnezites. In this situation imports of magnezite are significant and amounted in 1995 to 53.47 mln tons.

The mined magnezite raw materials are used in great quantities in the production of magnesium fertilizers for agriculture. Magnezite for the refractory material industry and for the metallurgy comes from imports.

The directions of Polish imports of magnezites and magnezite products are summarized in Table 44.2.

45. NATURAL AGGREGATES

Fig. 45.1 The distribution of natural aggregate resources in Poland

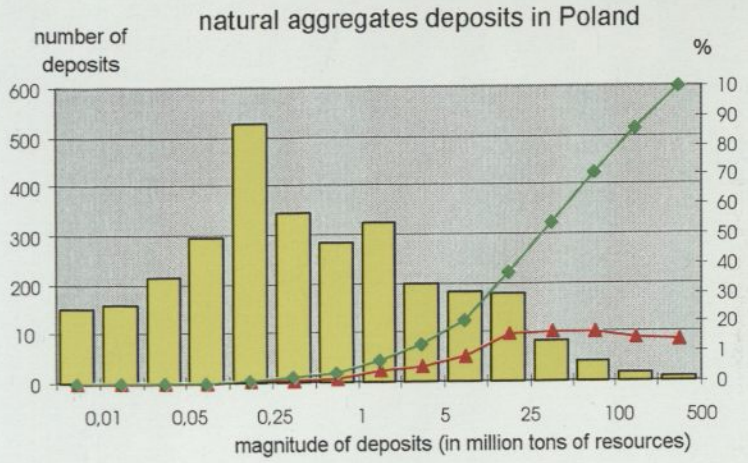


The resource base of natural aggregates exceeds than 14 billion tons in 3008 deposits. These deposits are distributed throughout Poland in all voivodeships.

The identification and management structure of the resources is shown in Fig 45.1.

Plate 8 presents the localization of natural aggregates deposits with resources over 1 mln tons in the particular ones. There are 1030 such deposits. Their total resources constitute almost 97% of the domestic resources. This plate does not presented the localization of small deposits important only locally. Although their numerously number (1978), their total resources amount to only 3% of domestic resources ones. Frequency of occurring of various magnitude deposits of natural aggregates in Poland are shown in Fig. 45.2.

Fig. 42.2 Frequency of resources magnitude in natural aggregates deposits in Poland



Unfortunately the natural aggregate potential of the particular regions of Poland is diverse. The most valuable are coarse-grained aggregates (gravel and sand-gravel mix). Fine-grained aggregates include sands.

The richest in natural aggregate deposits are voivodeships located along the south-western state border (from Zielona Góra to Nowy Sącz), i.e. in the so-called Sudetic-Carpathian zone. This zone is featured by a large potential and, especially in the Sudetic area, by the good quality of gravels. Deposits of fundamental meaning are those of river origin (terrace sediments of mountain and submountain rivers). In the Sudetic part mainly sand-gravel deposits of Pleistocene lower terraces occur in which crystalline rocks, quartz and sandstones dominant. The best natural aggregates occur in the Bóbr river region.

In the Carpathian part the basic constituent of river aggregates is flysch rock, particularly sandstones, which lowers their quality. The main raw material base are deposits occurring in the lower flood-plain and over flood-plain terraces and also in alluvial cones, and in their petrographic content flysch rocks dominate. The Dunajec river valley is an exception as there large quantities of crystalline and calcareous Tatra mountain rocks occur.

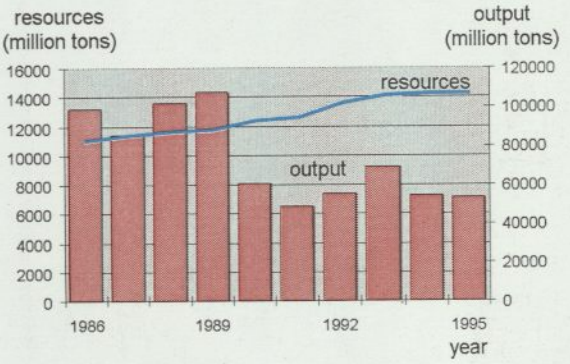
In northern and central Poland - in the Polish Lowland - the most important are deposits of glacial origin (accumulative frontal moraines) and fluvioglacial origin (outwash fans and eskers).

The northern area of the Polish Lowland is characterised by the occurrence of coarse aggregates composed of igneous rocks of Scandinavian provenance with an admixture of weaker and even detrimental local rocks, such as: limestones, flintstones and siliceous sandstones.

In the central and the southern parts of the Polish Lowland sand deposits with a substantial admixture of sedimentary rocks are prevalent, especially in eastern Poland where sands with a substantial admixture of limestones, marls and gaizes are prevalent which lower the quality of natural aggregates. These zones include voivodeships with the lowest natural aggregate potential, i.e. Włocławek, Siedlce, Łódź, Kalisz, Sieradz and Zamość.

The southern part of the Baltic Sea (Słupsk Shoal) is famous for marine deposits of natural aggregates.

Fig. 45.3 Natural aggregates resources and output in Poland in 1986-95



In Poland there are 1144 operating pits with total resources of about 3.6 billion tons which constitute 25% of this raw material potential (Table 45.1).

The aggregate output was diversified in the period - from 1985 through 1995 (Fig 45.3) and varied from 46.5 million tons in 1991 to 102 million tons in 1988. The output at the time of the economic transformation in Poland (1990-1995) varied from 46.5 to 68 million tons and is about half of the peak output. This shows the potential which can meet the future major demand.

Natural aggregate exports amount to 3680 thousand tons in 1995 and 97% of them were

Plate 8

MAP OF OCCURRENCE OF ROCK CLASTIC RAW MATERIAL DEPOSITS

POLISH GEOLOGICAL INSTITUTE

0 50 100 km

Voivodeship towns over 300 000 of inhabitants

Voivodeship towns

Other towns

State boundaries

Voivodeship boundaries

Rivers

Reservoirs

Elaboration: A. Piotrowska
Graphic and technical computer elaboration: R. Bońda D. Siekiera

Resources:

1 5 20 mln t — Natural aggregate deposits

20 mln t — Glass sands deposits

10 100 mln m³ — Backfilling sands deposits

2 mln t — Quartz sands for production of cellular concrete

2 mln t — Quartz sands for production of lime-sand brick

Deposits in exploitation

Deposits not exploited

Areas of deposit occurrence:

Glacial and fluvioglacial accumulation of the North Poland Glaciation and also fluvial and aeolian ones

Glacial and fluvioglacial accumulation of the Middle Poland Glaciation and also fluvial and aeolian ones

Fluvial accumulation and also area with extraglacial and outwash fan sediments in the Holy Cross Mountains and the Cracow-Częstochowa Jurassic

Fluvial and aeolian accumulation on Cretaceous bedrock

Fluvial and aeolian accumulation of the Carpathian Foredeep

Fluvial accumulation (Carpathians and Sudetes)

Boundary of the North Poland Glaciation

Boundary of the Middle Poland Glaciation

destined for Germany. Only a very small quantity of this raw material (about 2.7%) was exported to the Czech Republic. Besides, 661 thousand tons of sands other than siliceous and quartz ones were exported to these two countries.

Table 45.1 Natural aggregates (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	3008	14194	5156	9038	446
including reserves of deposits in exploitation					
Total	1248	3007	2502	506	103
including resources of not exploited deposits					
Total	1211	10629	2285	8343	303
1. Exploration	876	2623	2285	338	121
2. Prospecting	335	8005	0	8005	182
including abandoned deposits					
Total	549	558	369	189	40

46. PHYLLITE, QUARTZ AND MICACEOUS SHALES

The raw material from the various metamorphic shales is utilized as a dust carrier of plant protection agents and as a bituminous board dusting agent (phyllite and micaceous shales) and also as a component refractory mortars (quartzic shales).

In Poland the shale deposits lie in the Sudetes (Plate 7). The total intrinsically economic resources of the 4 deposits explored here amount to almost 23.4 mln tons. Three of these deposits are in exploitation and their total intrinsically economic resources amount to 23.0 mln tons and their economic reserves have been estimated at only 10.5 mln tons.

The output of shales amounted in 1995 to 64 thousand tons and the biggest (55 thousand tons) was the output of micaceous shales for bituminous board dusting agent.

47. QUARTZ SANDS FOR PRODUCTION OF CELLULAR CONCRETE AND LIME-SAND BRICK

The following types of sand are used in the whole country for production of cellular concrete and lime-sand brick: pure fine-grained Quaternary sands of glacial and fluvioglacial origin and also fluvial and aeolian sands. The minimum content of silica required for lime-sand bricks amounts to 80% and for cellular concrete to 90%.

The state of identification of the above-mentioned sands is sufficient, and their distribution is fairly uniform in the whole country (apart from the Carpathians) (Plate 8). Qualitatively the best quartz sands for the cellular concrete and lime-sand brick industries are the fluvioglacial and dune sands. The most suitable raw material are aeolian sands, characterised by a high content of silica, good grain segregation and roundness, and small capacity of foreign matter.

Among the aeolian sands occurring in the country we distinguished two groups: coastal dune and inland dune ones.

The coastal dunes, occurring in the narrow area along the Baltic shore are not

economically used on account of their shore protecting function.

The sands of the inland dunes, occurring in a great part of Polish territory are composed mainly (about 70% of the mass) of the 0.1-0.5 mm fraction.

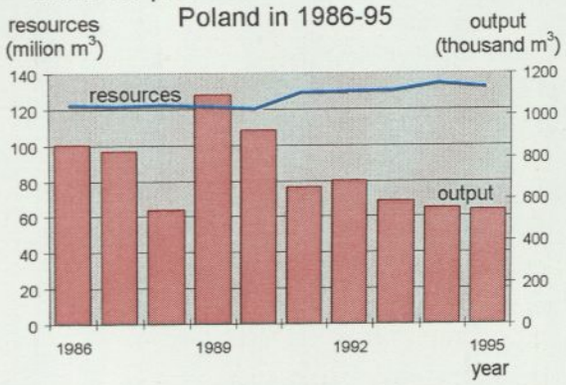
The total intrinsically economic resources of quartz sands used in above-mentioned industry amount to about 404 million m^3 (which is equivalent to 727 million tons of weight). From this total quantity 133 million m^3 (238 million tons) are quartz sands for cellular concrete and 271 million m^3 (488 million tons) for lime-sand brick production.

The magnitude of resources of quartz sands used for production of cellular concrete, and the state of their identification and management are shown in Table 47.1.

Table 47.1 Quartz sands for production of cellular concretes (mln m^3)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	57	132.47	40.36	92.12	1.35
including reserves of deposits in exploitation					
Total	19	27.49	23.15	4.34	0.54
including resources of not exploited deposits					
Total	36	104.27	16.49	87.78	0.82
1. Exploration	11	23.23	16.49	6.74	0.34
2. Prospecting	25	81.04	0.00	81.04	0.47
including abandoned deposits					
Total	2	0.72	0.72	0.00	0.00

Fig. 47.1 Resources and output of quartz sands for production of cellular concrete in Poland in 1986-95



The intrinsically economic resources of quartz sands for cellular concretes production explored in detail amount to 30.5% of the total resources of this raw material, and 20.7% of the resources occur in deposits in exploitation.

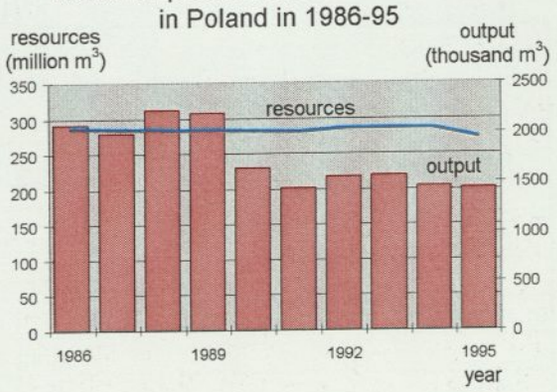
The economic reserves calculated for 9 deposits amount to 14.05 million m^3.

The magnitude of output of quartz sands for cellular concrete production, for the last decade (1986-1995) is presented in Fig 47.1.

The raw material output amounted in 1995 to 549 thousand m^3.

The magnitude of resources of quartz sands for lime-sand brick production, and state of their identification and management are shown in Table 47.2. The resources explored in detail amount to 50.5% of the total resources. The exploited deposits contain 26.9% of resources.

Fig. 47.2 Resources and output of quartz sands for production of lime-sand brick in Poland in 1986-95



The economic reserves calculated for 40 deposits amounts 56.06 mln m^3.

The output of quartz sands for lime-sand brick production amounted in 1995 to 1434 thousand m^3 and was the same as in the preceding year. The utilization of processing wastes from the deposits in Iława II and Pasym amounted to 35.8 thousand tons.

The magnitude of output of quartz sands for the production sands for the production of lime-sand brick in the last decade is presented in Fig 47.2.

The common occur in Poland of the considered raw material (except for the Carpathian region) makes probable the perspective increase of its resources.

Table 47.2 Quartz sands for production of lime-sand brick (mln m^3)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	101	271.21	137.08	134.13	6.82
including reserves of deposits in exploitation					
Total	42	72.98	69.53	3.45	1.14
including resources of not exploited deposits					
Total	49	189.66	63.72	125.94	2.10
1. Exploration	26	65.15	63.72	1.43	2.10
2. Prospecting	23	124.51	0.00	124.51	0.00
including abandoned deposits					
Total	10	8.57	3.83	4.74	3.58

48. REFRACTORY CLAYS

In the industry of refractory materials clays are used which are called for short refractory clays. These are kaolin clays of high refractory properties (above 1500^{0}C) which are used in their natural form as an agent for binding chamotte products and also as a burned clay used for weakening of mass in refractory products forming.

The refractory clay deposits occur in Lower Silesia near Strzegom and in the vinicity of Łęknica and also in the northern surrounding of the Holy Cross Mountains (Plate 7).

The refractory clay resources and the state of their management are presented in Table 48.1.

Table 48.1 Refractory clays (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	18	58.34	56.36	1.97	110.48
including reserves of deposits in exploitation					
Total	6	8.65	7.04	1.62	1.03
including resources of not exploited deposits					
Exploration	7	49.02	48.73	0.29	106.02
including abandoned deposits					
Total	5	0.66	0.60	0.06	3.44

The intrinsically economic resources of refractory clays amount to 58.3 mln tons. The state of identification of these resources is very high. The resources explored in detail amount to 97% of the total explored resources. The reserves of deposits in exploitation amount to 15% of the total explored resources. The economic reserves amount to 5.9 mln tons.

The refractory clays output amounted in 1995 to 261 thousand tons and about 91% of the total output came from the Rusko-Jaroszów deposit.

Exports of the refractory clays, mortars and refractory masses amounted in 1995 to 7.3 thousand tons and imports of these clays amounted to 1.3 thousand tons.

49. REFRACTORY QUARTZITES

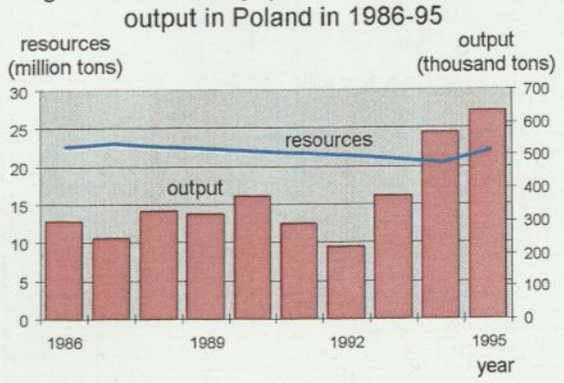
Quartzites are the basic raw materials for the industry of refractory siliceous materials. In Poland quartzite deposits suitable for refractory materials industry occur in Lower Silesia and the Holy Cross Mountain regions (Plate 7). In Lower Silesia, near Bolesławiec, the deposits are Tertiary ones and form unregular banks and lentils. In the Holy Cross Mountains the Cambrian or Devonian quartzites form banks in clays and clay-shales.

The state of intrinsically economic resources of refractory quartzites, their identification and management are presented in Table 49.1.

Table 49.1 Quartzites (mln t)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	20	21.93	13.25	8.68	4.74
including reserves of deposits in exploitation					
Total	2	15.05	9.40	5.65	0.00
including resources of not exploited deposits					
Total	7	5.95	3.23	2.72	3.84
1. Exploration	6	5.25	3.23	2.02	3.84
2. Prospecting	1	0.70	0.00	0.70	0.00
including abandoned deposits					
Total	11	0.93	0.62	0.32	0.80

Fig. 49.1 Refractory quartzites resources and output in Poland in 1986-95



The intrinsically economic resources of refractory quartzites amount to 21.9 mln tons, of which 15 mln tons are resources in deposits being exploited which constitute 68.6% of the total intrinsically economic resources of this raw material. The economic reserves amount to 10.5 mln tons and relate to two deposits: Bukowa Góra and Bukowa Góra II.

Exploitation of quartzites is conducted in the Bukowa Góra deposit in the Holy Cross Mountain region. It amounted in 1995 to 635 thousand tons (Fig. 49.1).

Imports of quartzites amounted in 1995 to 4 thousand tons and exports to almost 82 thousand tons.

50. REFRACTORY SHALES

The explored resources of refractory shales occur in hard coal deposits in Lower Silesia in Nowa Ruda mine and in Upper Silesia in Ziemowit mine (Plate 7). The prospected refractory shale resources have been estimated during hard coal exploration in the Siersza deposit as an accompanying raw material. For several years refractory shales have not been exploited.

The state of the intrinsically economic resources of the refractory shales are presented in Table 50.1.

Table 50.1 Refractory shales (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	4	11.18	6.85	4.33	4.30
including reserves of deposits in exploitation					
Mines in operation	1	-	-	-	1.74
including resources of not exploited deposits					
Exploration	1	9.26	5.89	3.38	0.79
including abandoned deposits					
Total	2	1.92	0.97	0.95	1.77

51. VEIN QUARTZ

Vein quartz finds application in the following industries: metallurgical, refractory materials and ceramic ones. Its most pure forms are used in the glass, chemical and electrotechnical industries.

In Poland vein quartz deposits lie in the Sudetes in the crystal Precambrian and Paleozoic formations (Plate 6). They forms veins and lentils. Most occurrences have already been explored. The deposits are characterized by varying thickness and big dips of the veins and lentils, and also by the varying quality of the material.

The state of the intrinsically economic resources of the vein quartz deposits are presented in Table 51.1.

Table 51.1 Vein quartz (mln tons)

Specification	Number of deposits	Reserves/resources			
		Intrinsically economic			Potentially economic
		Total	A+B+C1	C2	
Total resources	7	7.15	4.98	2.17	0.35
including reserves of deposits in exploitation					
Total	2	4.38	2.49	1.89	0.31
including resources of not exploited deposits					
Exploration	3	1.83	1.77	0.06	0.00
including abandoned deposits					
Total	2	0.94	0.72	0.22	0.05

The intrinsically economic resources of vein quartz in the 7 explored deposits amount to 7.15 mln tons. There are possibilities of finding new deposits in the Sudetes (where small occurrences are characterized by very good quality), and the perspective resources are estimated at about 4 mln tons.

Two deposits are in exploitation: Stanisławów (Jelenia Góra voivodeship) and Taczalin (Legnica voivodeship). Their total economic reserves amounted to 2.3 mln tons. The annual quartz output varied in the last decade from 24 to 102 thousand tons.

The output of vein quartz in 1995 amounted to 39 thousand tons.

The domestic demand is balanced by the small imports of quartz amounting to 0.8-3.9 thousand tons per year.

52. THE ACCOMPANYING AND WASTE ROCK RAW MATERIALS

The accompanying rock raw materials, as it was mentioned in the introduction, have been considered in the parts of the present work which discuss the particular raw materials, irrespective of whether they are the coexisting or accompanying ones. Rock raw materials accompany copper ores (anhydrite), lignite (ceramics clays, natural aggregate, building ceramic clay and kaolin raw material), hard coal (refractory shales, bentonitic raw materials) deposits. In some deposits, where the rock material is the main mineral, the accompanying raw material are other rock raw materials such as quartz sands for lime-sand brick production, foundry sands, building ceramic clay, clay raw material for lightweight aggregate and for cement industry, etc. (also in these cases they have been considered in the section discussing the particular raw materials).

Mineral wastes obtained during exploitation of various raw material deposits can be treated as waste raw materials. They are utilized in engineering works, for road building and reclamation deformed ground, etc. We do not present the balance and magnitude of waste on dumps because these wastes are often dumped on central dumps, where they are not accounted for by the users of deposits.

The magnitude of total waste rock raw materials produced in 1995 amounted to 34 mln tons, 12.1 mln tons of which (35.5%) were utilized.

EXPORTS AND IMPORTS OF MINERAL RAW MATERIALS

The value of the exports of mineral raw material amounted in 1995 to 9,217,871 thousand PLN and was by 24% higher than those in the preceding year. The imports amounted to 9,186,994 thousand PLN and exceeded by 31.4% those in 1994. The values of exports and imports of mineral raw material, and their magnitudes in 1995 are presented in Table 1.

The most important as regards the value of exports raw materials in 1995 were: hard coal and coal derivatives (32.4% of the total export value), raw materials and products of copper metallurgy (15.9%), cement (4.9%), silver (4.0%), nitrogen and multicomponent fertilizers (7.6%), petroleum products (3.7%), zinc (2.4%), iron and ferroalloys (3.1%), sulfur (2.7%) and aggregates (1.1.%).

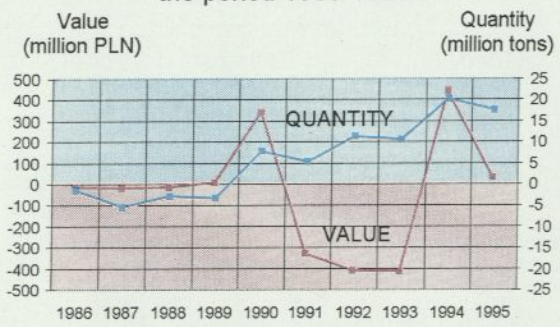
The highest values of imports related to such raw materials as: crude oil (41.6%), petroleum products (14.9%), natural gas (10.7%), iron ores (9.4%) and aluminium ores (3.5%), phosphoric (2.1%) and potassium (1.7%) raw materials.

The balance of exports-imports turnover in 1995 in forms of value and quantity was positive and amounted to 30,877 thousand PLN. The variation of the balance by value and quantity for the last decade is shown in Fig 1.

Table 1 Mineral raw material imports and exports in 1995

Group of raw materials	Import / Export				Balance	
	Quantity (thousand tons)	%	Value (thousand PLN)	%	Quantity (thousand tons)	Value (thousand PLN)
Total	38 373	100.0	9 186 994	100.0		
	55 783	100.0	9 217 871	100.0		
					17 410	30 877
Power	22 714	59.2	6 583 769	71.7		
	37 401	67.0	4 468 876	48.5		
					14 687	-2 114 893
Metallic	11 732	30.6	1 648 502	17.9		
	1 367	2.5	2 654 429	28.8		
					-10 365	1 005 927
Chemical	2 811	7.3	550 451	6.0		
	5 655	10.1	1 388 440	15.0		
					2 844	837 989
Rock	1 116	2.9	404 272	4.4		
	11 361	20.4	706 126	7.7		
					10 245	301 854

Fig. 1 Balances of Polish imports and exports in terms of value (*) and quantity in the period 1986-1995



* calculated from PLZ to PLN for the period 1986-1994

The highest increase indexes of turnover in imports were observed for metallic raw materials, the next were the rock and chemical ones. The lowest growth of turnover in imports was in the group of power raw materials. The comparison of contributions to imports of mineral raw materials in per cent for the years 1994-95 is presented in Fig. 2.

In exports the highest increase of value took place in the groups of chemical and power raw materials. The contributions of the particular groups of raw materials in per cents to the value of exports are presented in Fig 3.

Fig. 2 Contribution of mineral raw materials to the value of Polish imports in per cent in the years 1994-95

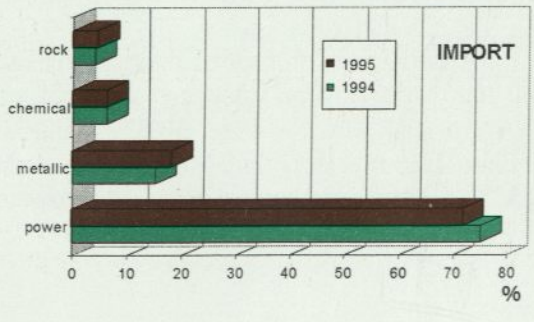
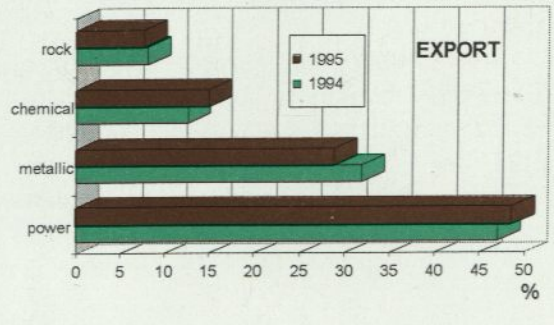


Fig. 3 Contribution of mineral raw materials to the value of Polish exports in per cent in the years 1994-95



The total import magnitude increased in 1995 by 14.4% as compared with that in 1994, the export magnitude increased in the same time by 3.9%. The highest increase was observed in imports of rock raw material (38.3%). Imports of metallic raw materials increased by 26.7% and that of chemical ones by 11.5%. Imports of power raw material increased by 8.5%. The magnitude [mln tons] of mineral raw material imports in 1994-1995 is shown in Fig 4.

In exports we also observe an increase in the group of chemical (8.0%) and power (7.2%) raw materials (Fig. 5). The magnitude of exports of metallic raw materials did not change with respect to the preceding year, while exports of rock raw materials decreased in 1995 by 6.6%.

The major part of imports of mineral raw materials came from Russia, Ukraine, the United Kingdom, Republic of South Africa, Norway, Czech Republic, Belorussia and Iran.

As regards exports of mineral raw materials the greatest quantities were sold to Germany, Ukraine, Czech Republic, Denmark, Finland, the United Kingdom, Slovakia and Brazil.

Fig. 4 Magnitude of mineral raw material imports in 1994-95

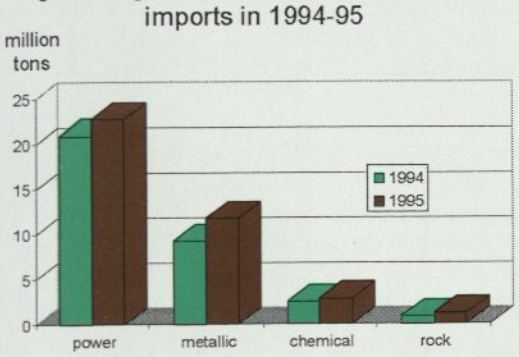
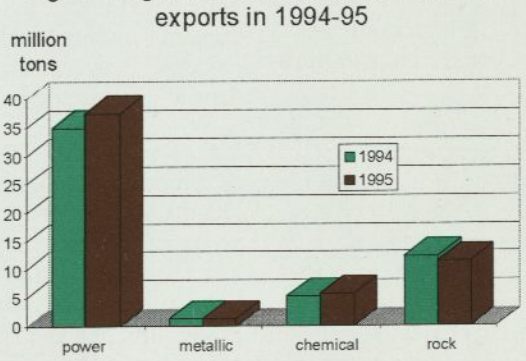


Fig. 5 Magnitude of mineral raw material exports in 1994-95



GLOSSARY

Definition of Stages of Mineability Assessment

Mining Report
(equivalent in Polish mining practice - "operat ewidencyjny zasobów złoża" - "register work of deposit resources")

is understood as the current documentation of the state of development and exploitation of a deposit during its economic life including current mining plans. It is generally made by the operator of the mine. The study takes into consideration the quantity and quality of the minerals extracted during the reporting time, changes in Economic Viability categories due to changes in prices and costs, development of relevant technology, newly imposed environmental or other regulations, and data on exploration conducted concurrently with mining.
It presents the current status of the deposit, providing a detailed and accurate, up-to-date statement on the remaining reserves and resources.

Feasibility Study

document which would be an equivalent to the whole range of Feasibility Study is not prepared

Prefeasibility Study
(equivalent in Polish nomenclature is "projekt zagospodarowania złoża" - "project of deposit management", but not in the whole)

provides a preliminary assessment of the Economic Viability of a deposit and forms the basis for justifying further investigations (Detailed Exploration and Feasibility Study). It usually follows a successful exploration campaign, and summarized all geological, engineering, environmental. legal and economic information accumulated to date on the project.
In projects that have reached a relatively advanced stage, the Prefeasibility Study should have error limits of ± 25%. In projects less advanced, higher errors are to be expected. Various terms are in use internationally for Prefeasibility Studies reflecting the actual accuracy level. The data required to achieve this level of

accuracy are reserves/resources figures based on Detailed and General Exploration, technological tests at laboratory scale and cost estimates e.g. from catalogues or based on comparable mining operations.

Geological Study

("dokumentacja geologiczna złoża" - "geological documentation")

is generally carried out in the following four main stages: Reconnaissance, Prospecting, General Exploration and Detailed Exploration (for definition of each stage see below). The purpose of the Geological Study is to identify mineralization, to establish continuity, quantity, and quality of mineral deposit, and thereby define an investment opportunity. A preliminary evaluation of Economic Viability is obtained by applying meaningful cut-off values for grade, thickness, depth, and costs estimated from comparable mining operations.
The resource quantities estimated may indicate that the deposit is of intrinsic economic interest, i.e. in the range of economic to potentially economic.

Definition of Stages of Stages of Geological Study

Reconnaissance

(Prognozowanie i prace rekonesansowe)

reconnaissance study identifies areas of enhanced mineral potential on a regional scale based primarily on results of regional geological studies, regional geological mapping, indirect methods as well as geological inference and extrapolation. The objective is to identified mineralized areas worthy of further investigation towards deposit identification.

Prospecting

(Poszukiwanie)

is the systematic process of searching for a mineral deposit by narrowing down areas of promising enhanced mineral potential. The methods utilized are outcrop identification, geological mapping, and indirect methods such as geophysical and geochemical studies. Limited trenching, drilling, and sampling may be carried out. The objective is to identify a deposit which will be the target for further exploration. Estimates of quantities are inferred, based on interpretation of geological, geophysical and geochemical results.

General Exploration

(Rozpoznanie wstępne)

involves the initial delineation of an identified deposit. Methods used include surface mapping, widely spaced sampling, trenching and drilling for preliminary evaluation of mineral quantity and quality (including mineralogical tests on laboratory scale if required), and limited interpolation based on indirect methods of investigation. The objective is to establish the main geological features of a deposit, giving a reasonable indication of continuity and providing an initial estimate of size, shape, structure and grade. The degree of accuracy should be sufficient for deciding whether a Detailed Exploration are warranted.

Detailed Exploration

(Rozpoznanie szczegółowe)

involves the detailed three-dimensional delineation of a known deposit achieved through sampling, such as from outcrops, trenches, boreholes, shafts and tunnels. Sampling grids are closely spaced such that size, shape, structure, grade, and other relevant characteristic of the deposit are established with a high degree of accuracy. Processing tests involving bulk may be required.

Definition of Economic Viability Categories

Economic

(zasoby przemysłowe)

quantities, reported in tonnes/volume with grade/quality, demonstrated by means of a Prefeasibility Study or Mining Report, in order of increasing accuracy, that justify extraction under the technological, economic, environmental and other relevant conditions, realistically assumed at the time of the determination.
The term economic comprises both normal economic and exceptional economic.

Normal Economic

normal economic reserves are reserves that justify extraction under competitive market conditions. Thus, the average value of the commodity mined per year must be such as to satisfy the required return on investment.

Exceptional Economic (conditional economic)

(both terms are not used as yet in Poland)

exceptional (conditional) economic reserves are reserves which at present are not economic under competitive market conditions. Their exploitation is made possible through government subsidies and/or other supportive measures.

Potentially Economic

(pozabilansowe)

quantities, reported in tonnes/volume with grade/quality, demonstrated by means of a Prefeasibility Study or Mining Report, in order of increasing accuracy, not justifying extraction under the technological, economic, environmental and other relevant conditions, realistically assumed at the time of the determination, but possibly so in the future.
The term potentially economic comprises both marginal and submarginal as defined below.

Marginal Economic

(pozabilansowe grupy " b")

marginal economic resources are resources which at the time of determination are not economic, but border on being so. They may become economic in the near future as a result of changes in technological, economic, environmental and other relevant conditions.

Submarginal Economic

(pozabilansowe grupy "a")

submarginal economic resources are resources that would require a substantially higher commodity price or a major cost-reducing advanced in technology to render them economic.

Intrinsically Economic (economic to potentially economic)

(geologiczne bilansowe)

quantities, reported in tonnes/volume with grade/quality, estimated by means of a Geological Study to be of intrinsic economic interest. Since the Geological Study includes only a preliminary evaluation of Economic Viability.

Definition of Mineral Reserves and Mineral Resources

Total Mineral Resource

(ogólne zasoby bilansowe)

is a naturally occurring concentration of mineral raw material in or on the Earth's crust of economic interest and with specified geological certainty.

Mineral Reserve

(zasoby przemysłowe)

is the economically mineable part of Total Mineral Resource

Remaining Mineral Resource

(not used in Poland)

is the balance of the Total Mineral Resources that have not been identified as Reserves.

In accordance with the stage of **Geological Studies** the following subdivisions of Resources are made:

Measured Mineral Resources	Based on Detailed Exploration (A + B)
Indicated Mineral Resource	Based on General Exploration (C_1)
Inferred Mineral Resource	Based on Prospecting (C_2)
Reconnaissance Resource	Based on Reconnaissance, *provided that quantities can be estimated* (D_1, D_2)

BIBLIOGRAPHY

BĄK B., PRZENIOSLO S., 1993 - Perspective resources of raw materials in Poland (state on 31.XII.1990) (in Polish). PGI Warsaw.

Balance of Raw Material and Groundwater Resources in Poland as per December 31, 1995 S. Przenioslo ed., 1996 (in Polish). PGI Warsaw.

DEPOWSKI S., KRÓLICKA J., SIECIARZ E., SIECIARZ K., 1993 - Evaluation of utilization of the Polish gas reserves. PGI Warsaw.

DEPOWSKI S., KRÓLICKA J., SIECIARZ E., SIECIARZ K., 1993 - Map of the crude oil and natural gas deposits in Poland 1:750 000. PGI Warsaw.

JERZMAŃSKI J., 1993 - Feldspars (Feldspar and quartz-feldspar raw materials). In: Perspective resources of raw materials in Poland (state on 31.XII.1990) (in Polish). PGI Warsaw.

KOSMOWSKA-CERANOWICZ B., LECIEJEWICZ K., 1995 - Amber deposits in the south coast of Eocene sea. In: 2nd Seminary - Baltic amber, types and deposits in Poland. Gdańsk-Warsaw March 1995.

NIEĆ M., 1995 - Polish Approach to Resources/Reserves Classification. In: Proceedings ... Hannover.

OLKOWICZ-PAPROCKA I., 1995 - Amber deposit in Możdżanowo region near Słupsk. In: 2nd Seminary - Baltic amber, types and deposits in Poland. Gdańsk-Warsaw March 1995.

PIWOCKI M., 1993 - Lignite. In: Perspective resources of raw materials in Poland (state on 31.XII.1990) (in Polish). PGI Warsaw.

PIWOCKI M., 1995 - Amber occurrence in Chłapowo region. In: 2nd Seminary - Baltic amber, types and deposits in Poland. Gdańsk-Warsaw March 1995.

PIWOCKI M., PRZENIOSLO S., (in press) - Propose of using a new international resources classification in Poland. Prz. Geol. PGI Warsaw.

Proceedings of Workshop on Reassessment of Coal and Mineral Deposits under Market Economy Conditions. UN ECE, BGR, Hannover, 4-6 December 1995.

PRZENIOSLO S., BĄK B., RADWANEK-BĄK B., SMAKOWSKI T., 1992 - Analysis of the zinc and lead ores management in Poland (state on the end of 1990). PGI Warsaw.

UNITED NATIONS INTERNATIONAL FRAMEWORK CLASSIFICATION FOR RESERVES/ RESOURCES- Solid fuels and Mineral Commodities. ENERGY/WP.1/R.57, 16 July 1996. Working Party, 4-6 November 1996, Geneve.

WOJCIECHOWSKI A., 1993 - Gold. In: Perspective resources of raw materials in Poland (state on 31.XII.1990) (in Polish). PGI Warsaw.