International Conference on
"Sustainability, risk assessment and revitalization of post-mining pits and spoil dumps"
RAFF and SUMAD projects' achievements

SELECTED HYDROGEOLOGICAL AND GEOMECHANICAL PROPERTIES OF POST-MINING WASTES USED IN THE RECLAMATION OF THE OPEN-PIT EXCAVATION - A CASE STUDY OF THE MACZKI-BÓR MINE FILLED WITH CARBONIFEROUS WASTE ROCKS

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HR EXCELLENCE IN RESEARCH

6-7 October 2022
Wrocław, Poland

RISK ASSESSMENT OF FINAL PITS DURING FLOODING

06.2019-11.2022

RAFF

Research Fund for Coal & Steel

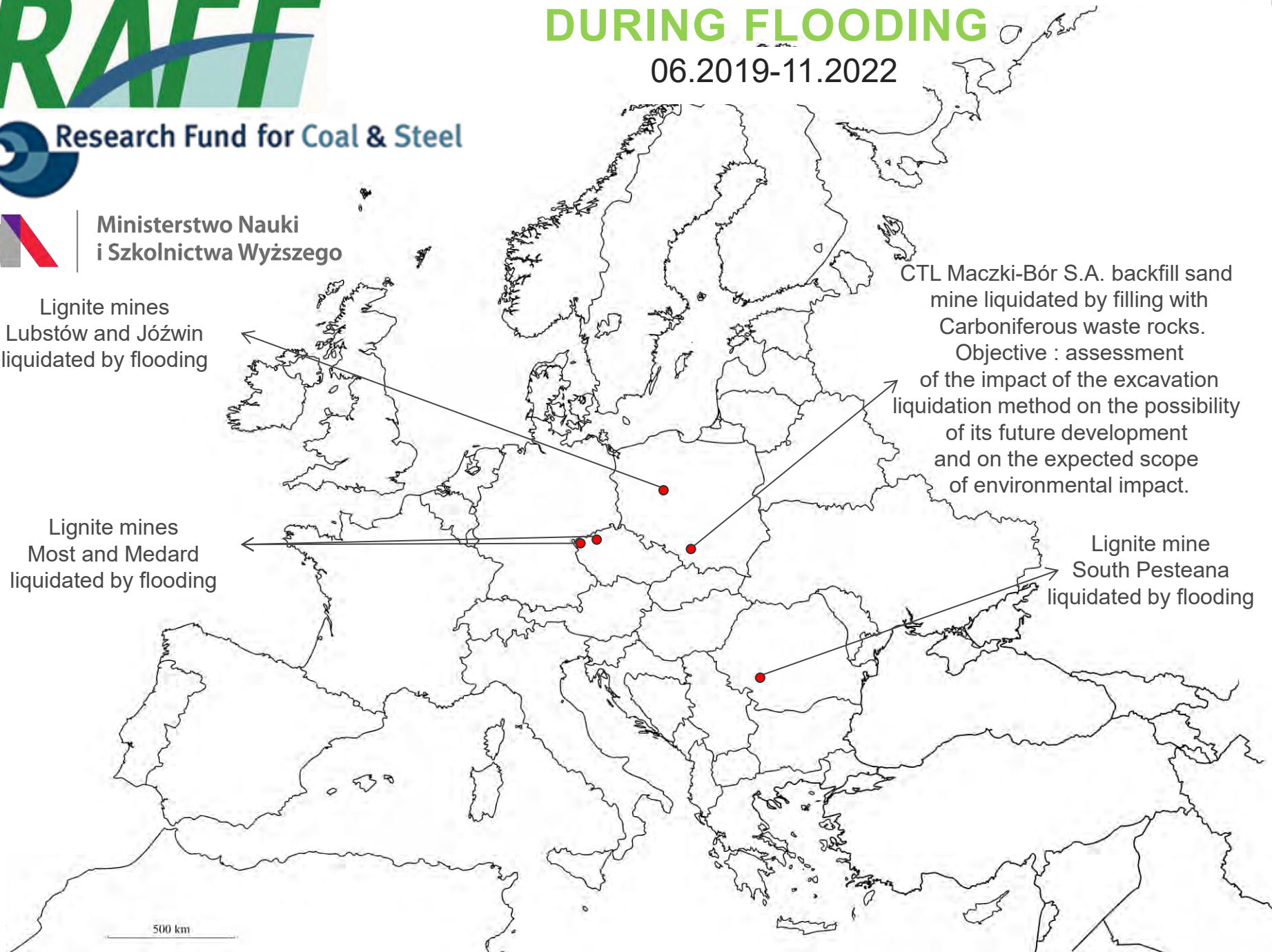
Ministerstwo Nauki
i Szkolnictwa Wyższego

Lignite mines
Lubstów and Jóźwin
liquidated by flooding

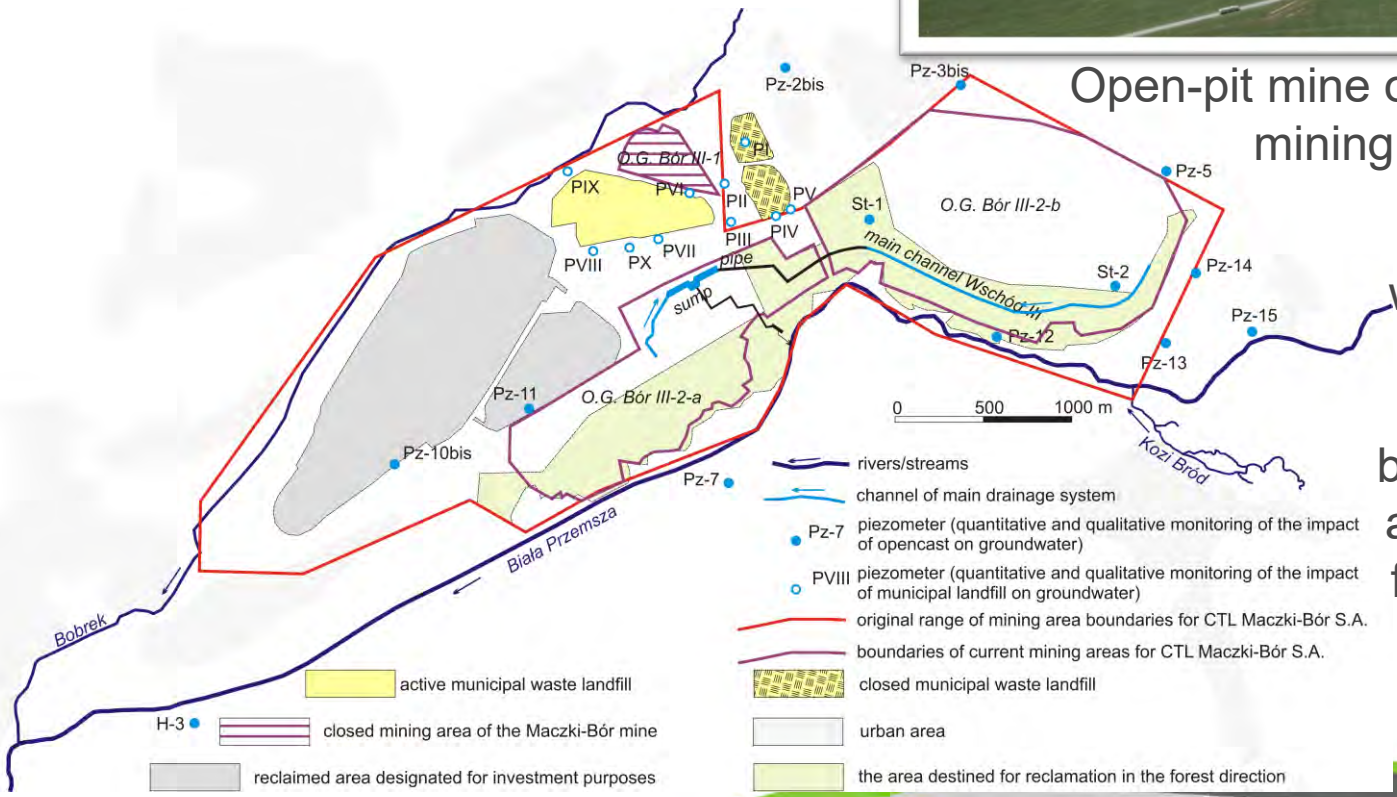
Lignite mines
Most and Medard
liquidated by flooding

CTL Maczki-Bór S.A. backfill sand mine liquidated by filling with Carboniferous waste rocks. Objective : assessment of the impact of the excavation liquidation method on the possibility of its future development and on the expected scope of environmental impact.

Lignite mine
South Pesteana
liquidated by flooding



CTL Maczki-Bór S.A.



Open-pit mine operating since 1952, mining in two fields

Since 1972, along with the progress of the exploitation fronts, the pit has been recultivating on an ongoing basis by filling the basin with mining waste.

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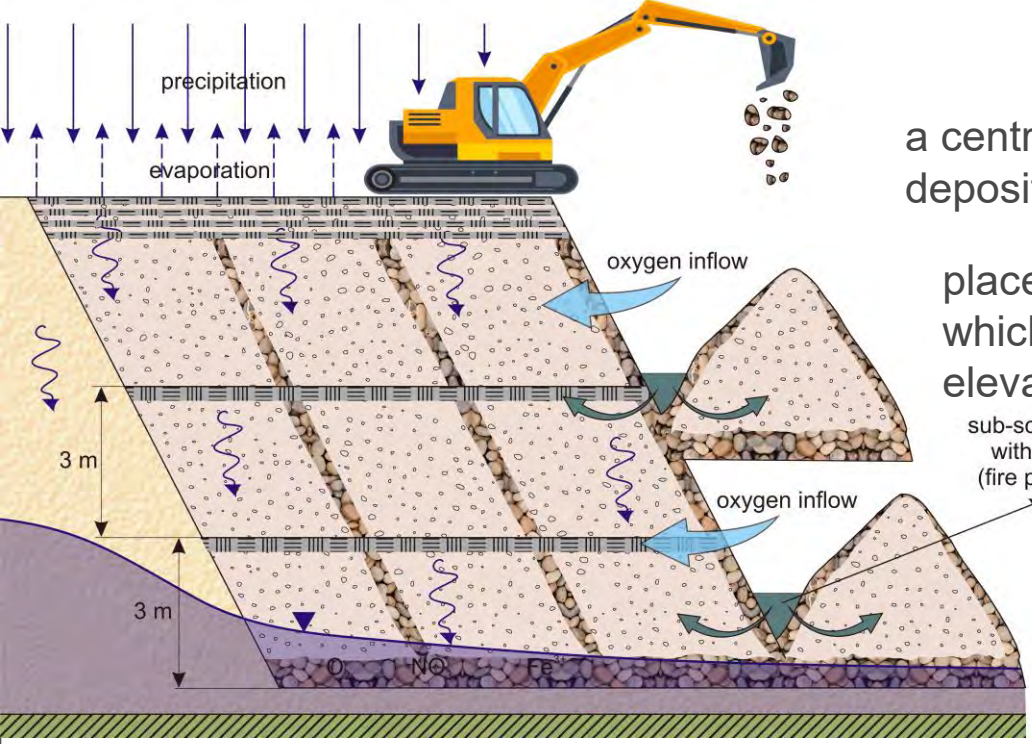
Bór-Zachód field (western)

a central dump with a large area and volume of deposited wastes

placement of rock material from the ground level, which corresponded to the location of the target elevation of the dump's top

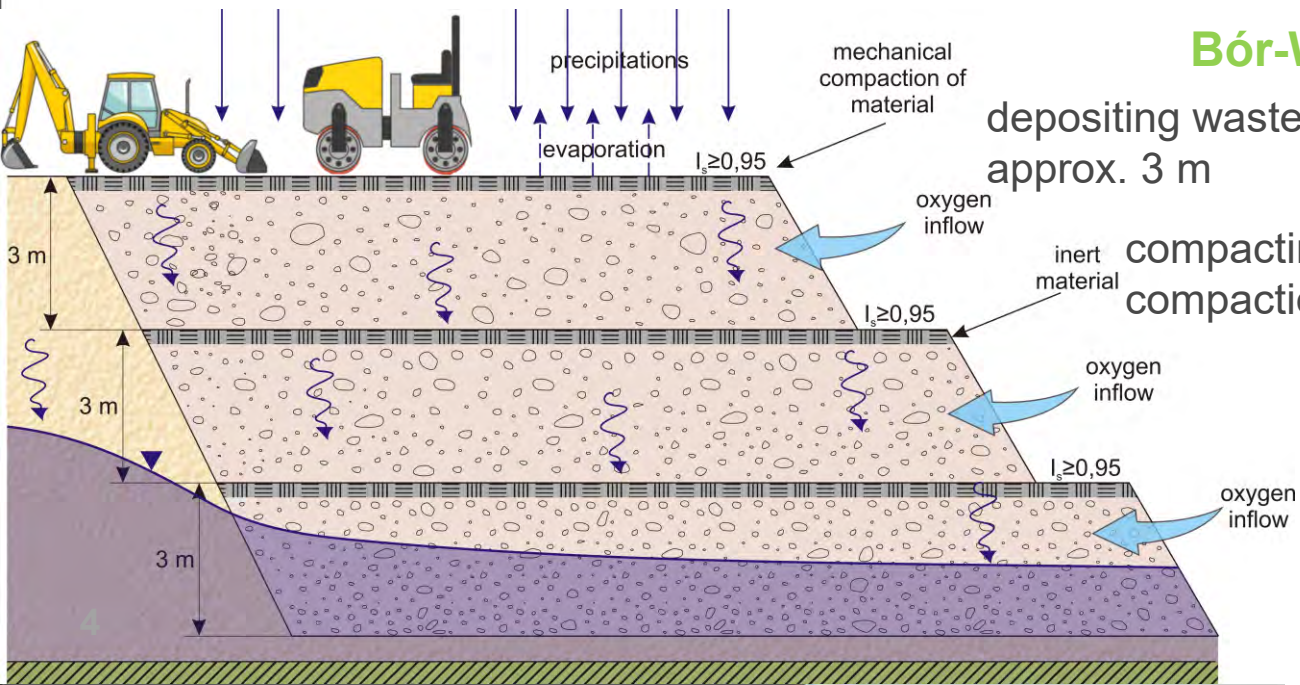


sealing of the heap with the use of slags, ash-slag mixtures, ash-water pulps and placement of clay material

Bór-Wschód field (eastern)

depositing wastes in layers with a thickness of approx. 3 m

compacting the wastes with layers to the compaction index Is≥0.95



sealing of the heap with the use of power plant wastes and clay material from domestic sand exploitation

LABORATORY TESTS OF HYDROGEOLOGICAL AND PHYSICAL-MECHANICAL PARAMETERS

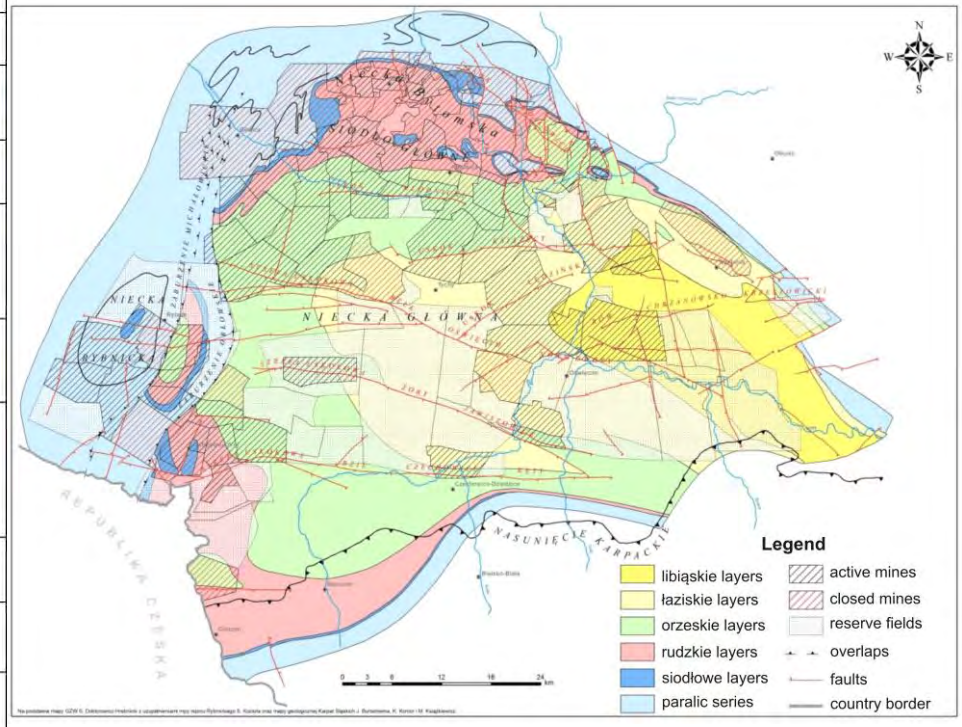
fresh rock debris - collapse of roof rocks during longwall mining of hard coal in the Upper Silesian Coal Basin

rock material deposited in the open pit excavation - a mixture of various age-old Carboniferous waste rocks

Division of the Carboniferous recommended by ICS (2008)		The division used in scientific studies			The division used in mining
era	age	litostratygraphic cells			
Pensylvanian	middle	moscow	WESTPHALIAN D	Cracow Sandstone Series	libiąskie layers (seam 110 – seam 119) → libiąskie layers, group of seams 100
			WESTPHALIAN C	Cracow Sandstone Series	łaziskie layers → łaziskie layers, group of seams 200
			WESTPHALIAN B		orzeskie layers (the level of the facial change; tuffite) → orzeskie layers, group of seams 300
			WESTPHALIAN A		załęskie layers
	lower	bashkir	NAMUR C	Upper Silesian Sandstones Series	rudzkie layers → rudzkie layers, group of seams 400
			NAMUR B	Upper Silesian Sandstones Series	siodłowe layers (seam 510 – seam 510; stratigraphic gap) → siodłowe layers, group of seams 500
Mississip	upper	serpukov	NAMUR A	Upper Silesian Sandstones Series	jejkowickie layers (the level of the facial change; stratigraphic gap)
				Paralic Series	grodzkie layers → porębskie layers → porębskie layers, group of seams 600
					jaklowieckie layers → jaklowieckie layers, group of seams 700
					florowskie layers* → gruszowskie layers → gruszowskie layers, group of seams 800
					sarnowskie layers* → pietrzkowickie layers → pietrzkowickie layers, group of seams 900

* according to Doktorowicz-Hrebnicki division for Dąbrowa region (1935)

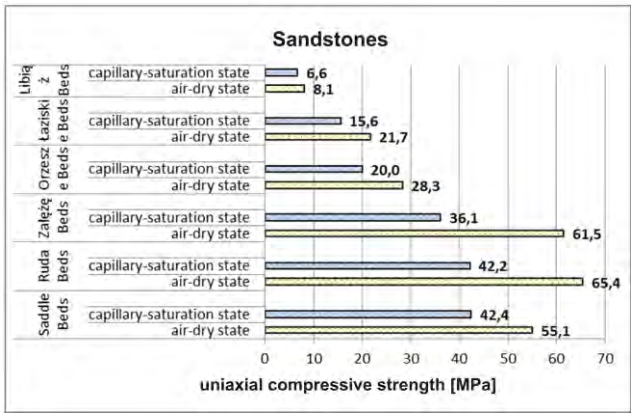
sandstones mudstones claystones

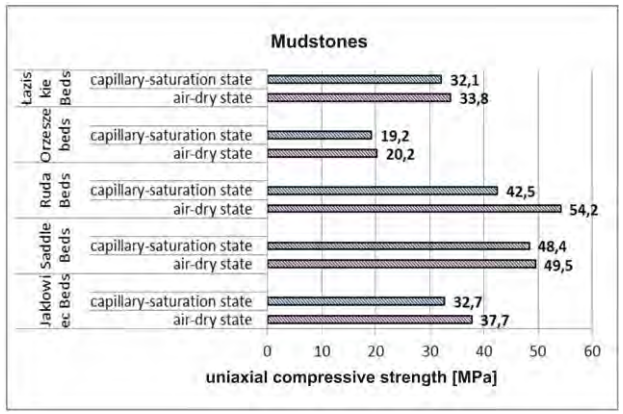


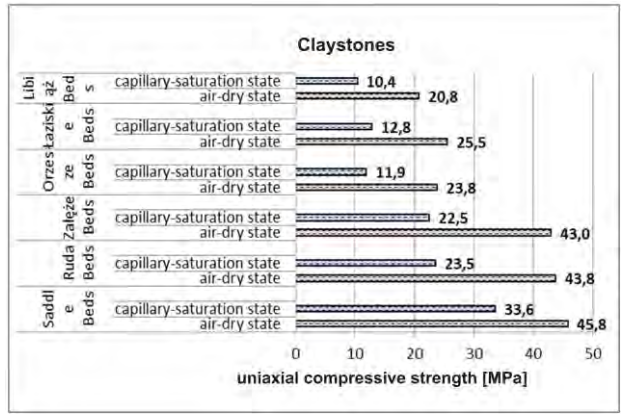
Laboratory tests of the mechanical parameters of rocks were carried out on samples of sandstones, mudstones and claystones selected from the hard coal mines.

The determinations were made in the uniaxial stress state, for the rock samples in the air-dry state and in the state of capillary saturation.

Uniaxial compressive strength

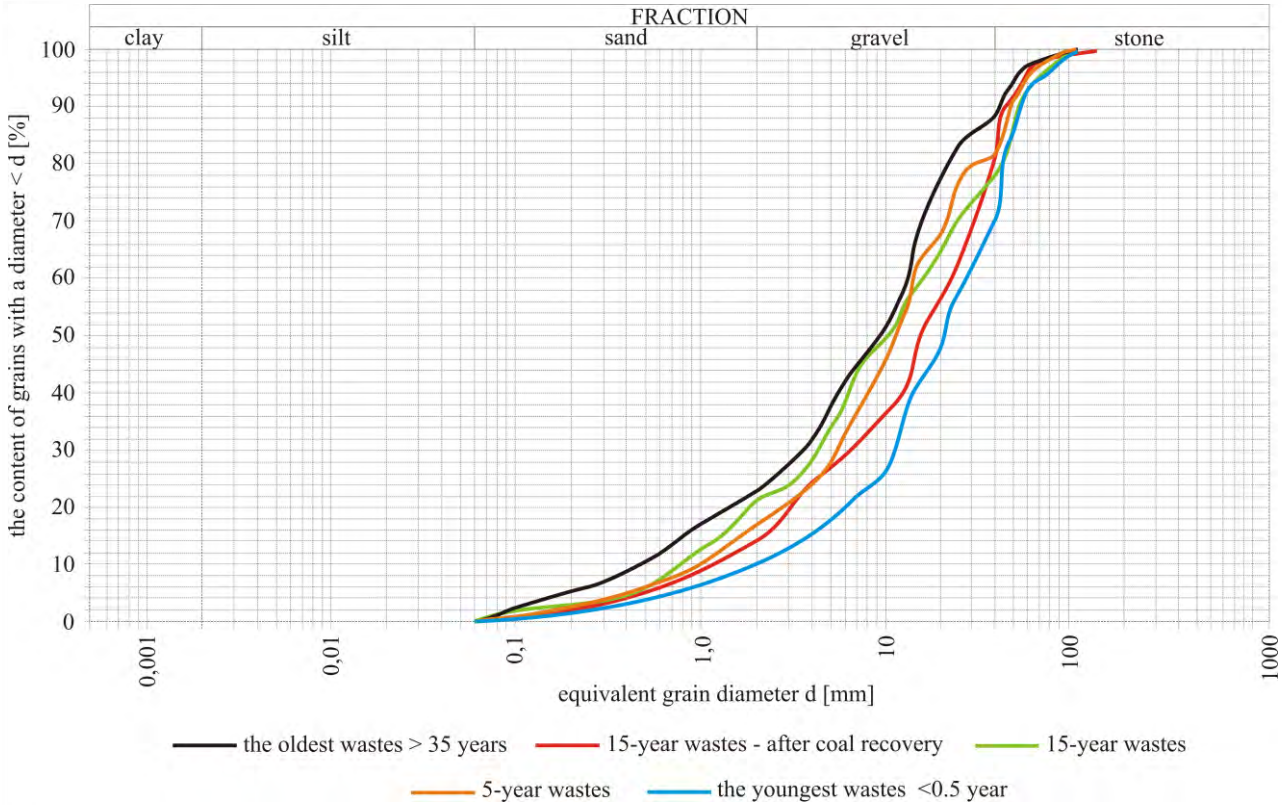






Rock material sampled from the top of the reclaimed opencast excavation

- grain composition,
- uniformity coefficient,
- bulk density,
- compressibility,
- open porosity,
- permeabiliy



gravel fraction

from 57% in 15-year waste to 68% (for 15-year waste after coal recovery)

stone fraction

from 12% (the oldest wastes) to 30% (the youngest wastes)

Sample		Skutta method				Kidybiński method
		½ h	4 h	48 h	together	
>35 years	sandstone	A	A	A	AAA	1,0
	mudstone	A	A	A	AAA	0,6
15 years (coal recovery)	sandstone	A	A	A	AAA	1,0
	mudstone	A	A	A	AAA	1,0
15 years	sandstone	A	A	A	AAA	1,0
	mudstone	A	A	A	AAA	0,8
5 years	sandstone	A	A	B	AAB	1,0
	mudstone	A	A	A	AAA	1,0
< 0,5 year	mudstone	B	D	F	BDF	0,6

The most susceptible to the influence of water are mudstones from the youngest material, which have been disintegrated or have been strongly fractured in the tests carried out with both methods.

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Skutta method

A)

B)

C)

Kidybiński method

A)

B)

C)

A) > 35-years wastes

B) 15-years wastes

C) <0,5 year wastes

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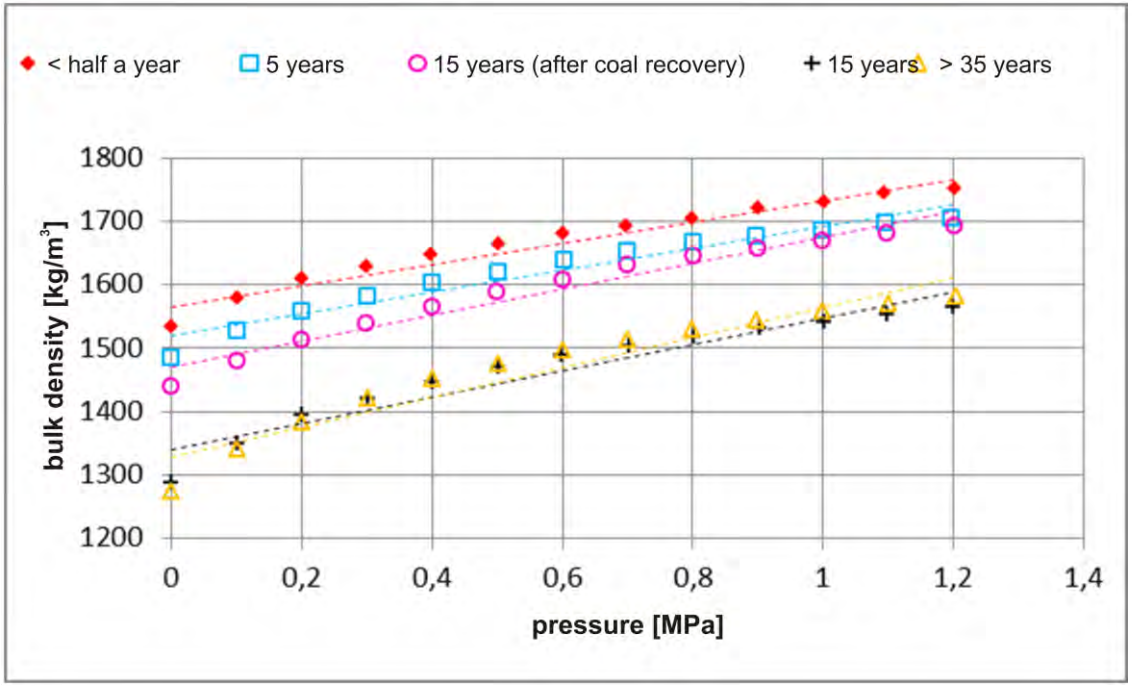
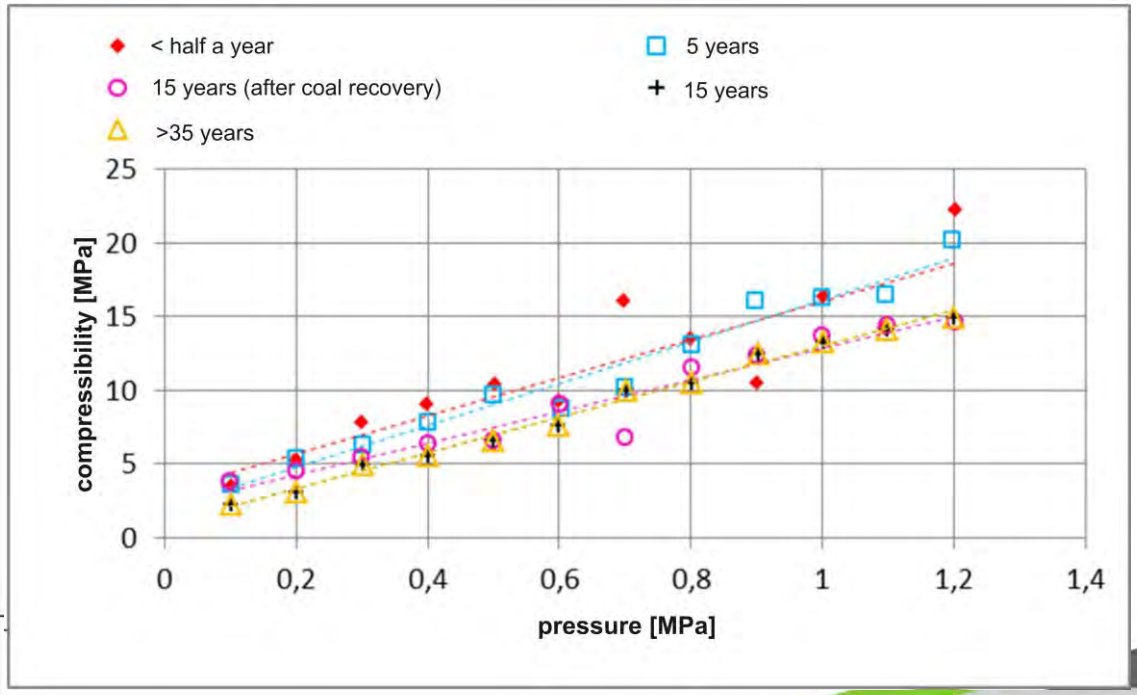
- preparation three laboratory samples from each sample of waste weighing 12 kg each,
- the same grain composition as samples of waste collected directly from the heap,
- determination of physical and mechanical parameters (compressibility, bulk density) and hydrogeological parameters (water absorption/porosity and permeability)

Compressibility and bulk density

- placing the vessel with the sample in a strength press and cyclical compression of the sample with pressure up to 1.2 MPa (every 0.1 MPa),
- measurement of changes in density and compressibility of rock material at individual load levels





- the longer the waste disposal time, the greater the difference between the bulk and compacted density values,
- high and very high correlation between the pressure and the values of the bulk density and the values of the compressibility modulus,
- a 4-7-fold increase in the value of compressibility modulus was found for the maximum pressure of 1.2 MPa in relation to the lowest pressure (0.1 MPa)

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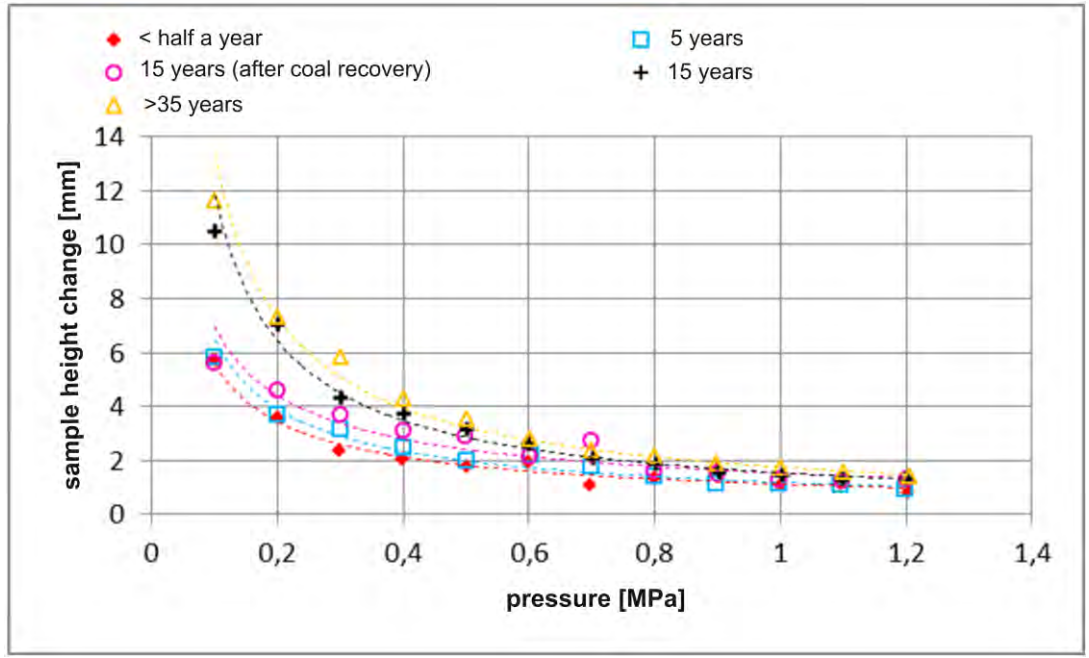
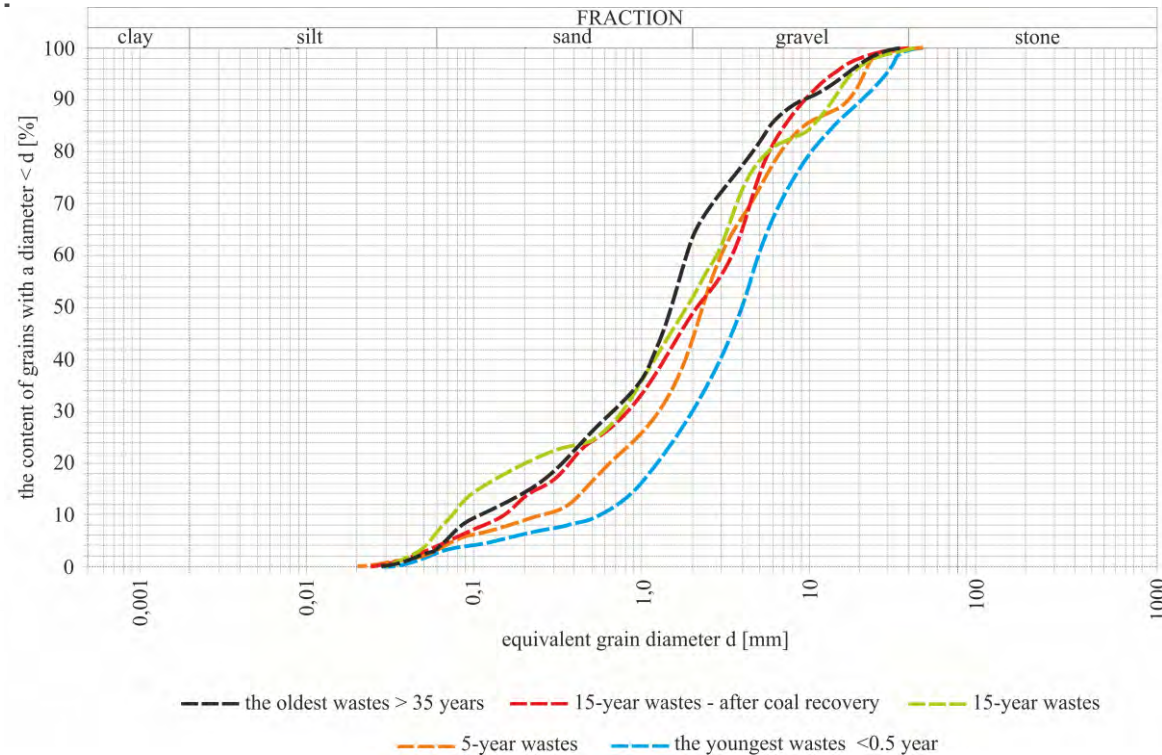
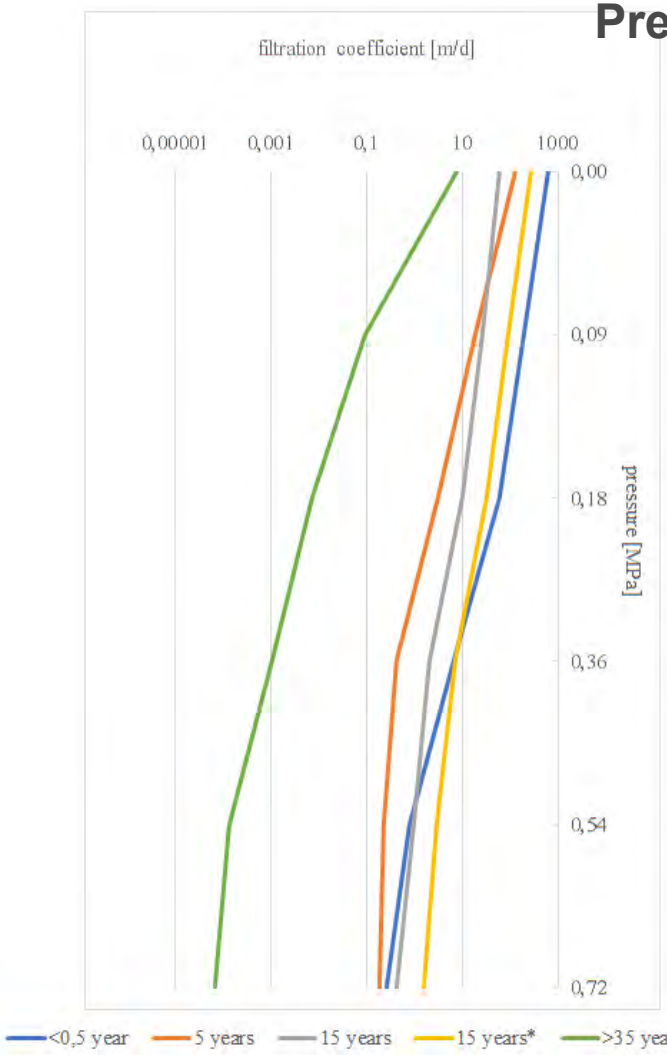
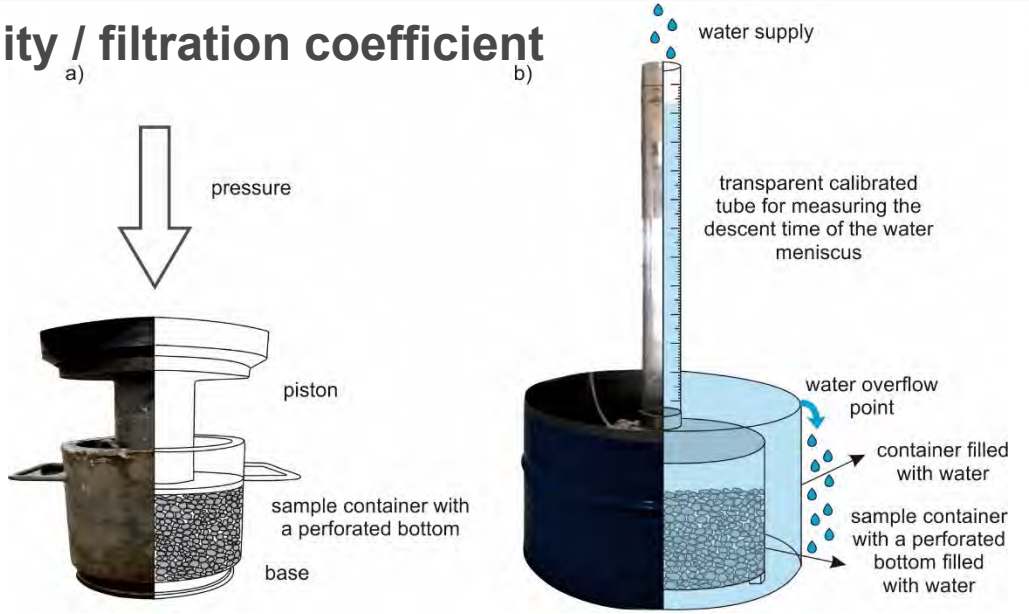
- the greatest change in height of all samples takes place after the first compression cycle,
- in the pressure range of 0.0-1.2 MPa, the height of the samples is reduced from 24.5 mm (the youngest sample) to 46.3 mm (the oldest sample),
- relative height stabilization of all samples takes place from pressures of about 0.8-0.9 MPa.
- compression of samples regardless of their age resulted in the disappearance of the stone fraction,
- after testing the density and compressibility of the rock material, the value of the sample heterogeneity index decreased in all samples.





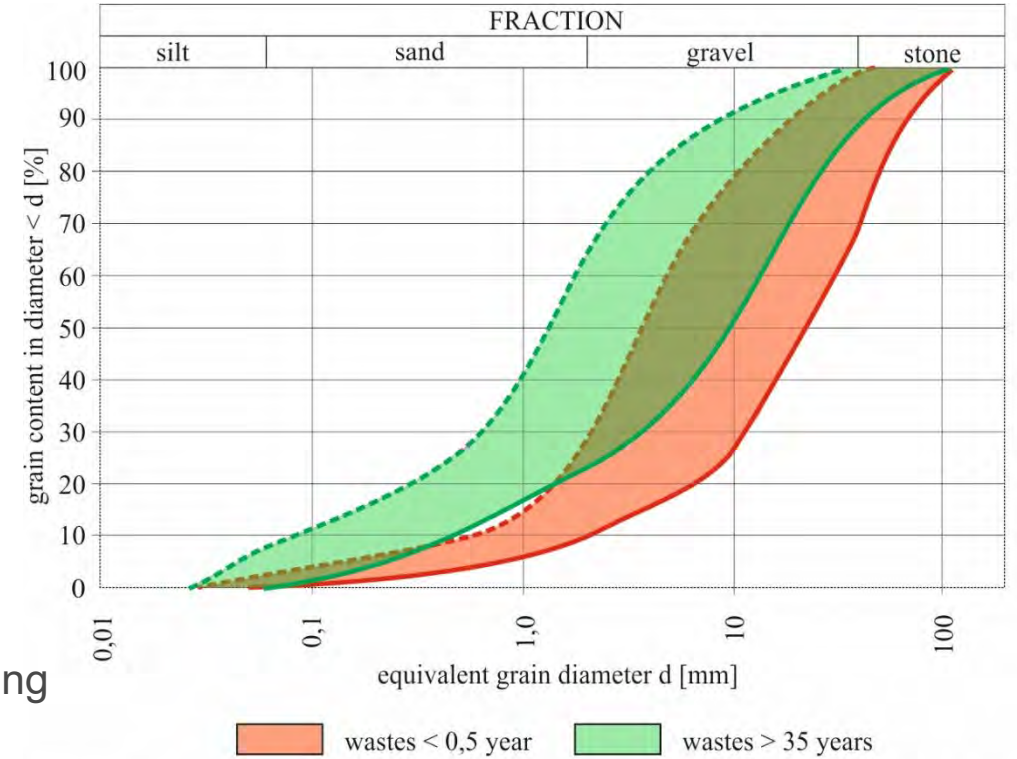
Premeability / filtration coefficient

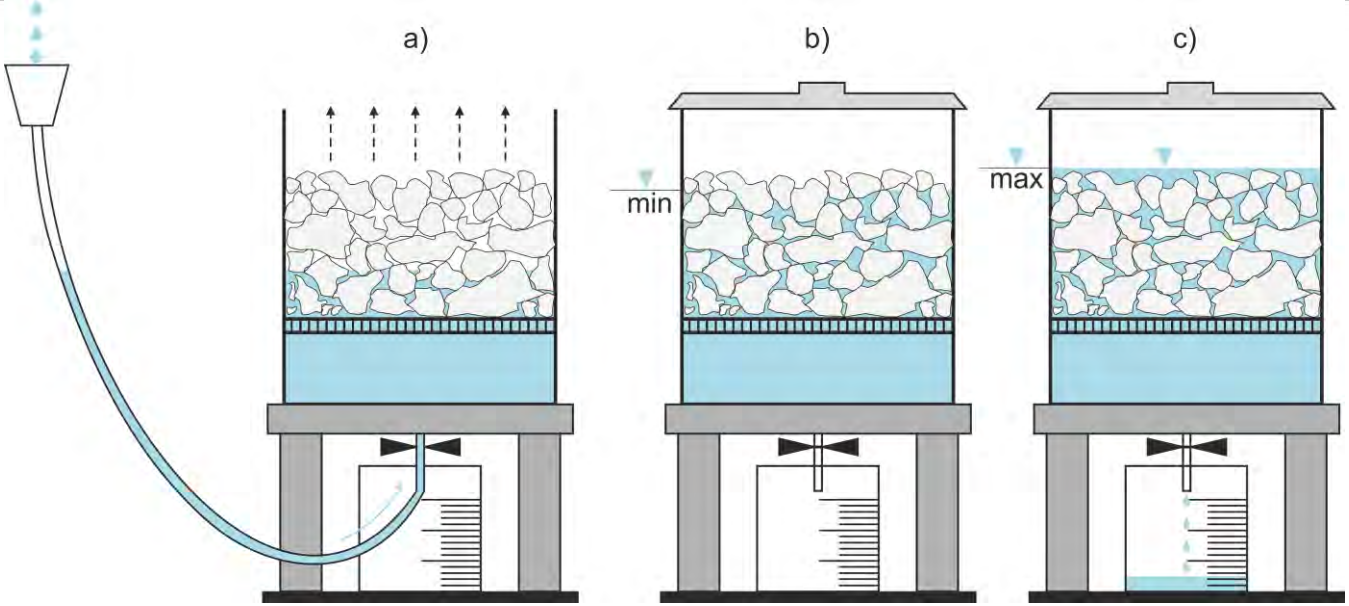




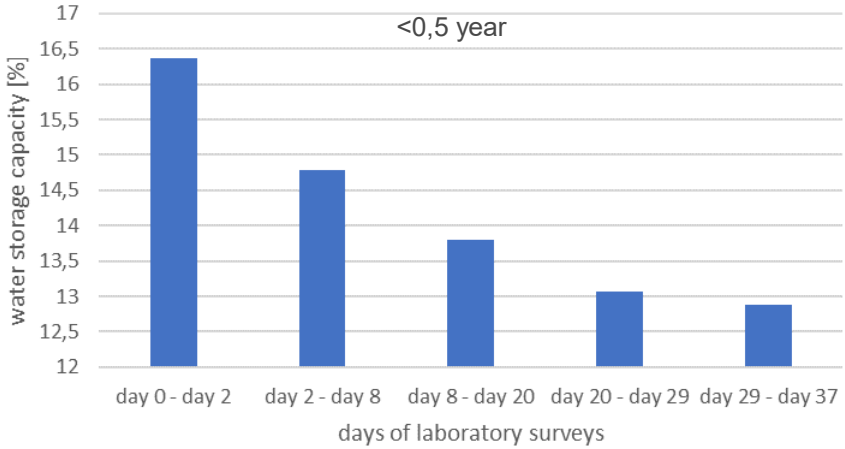
$$k_{10} = \frac{k_t}{0{,}7 + 0{,}03t}$$

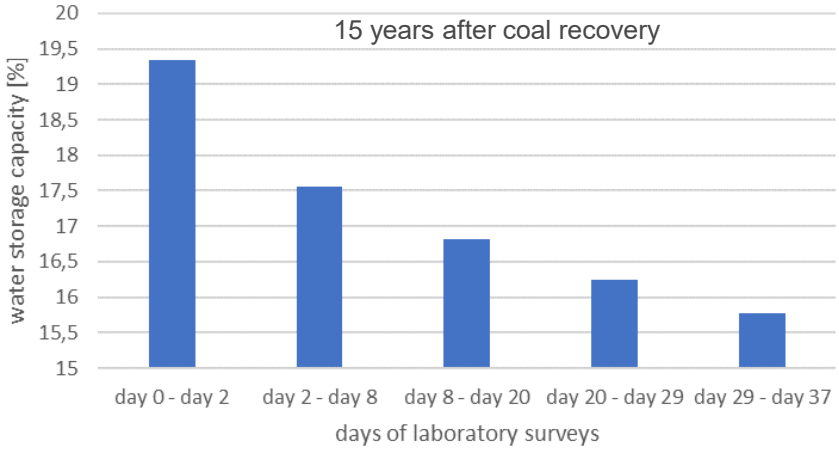
value of the filtration coefficient obtained during the test at the temperature t of tap water [°C]

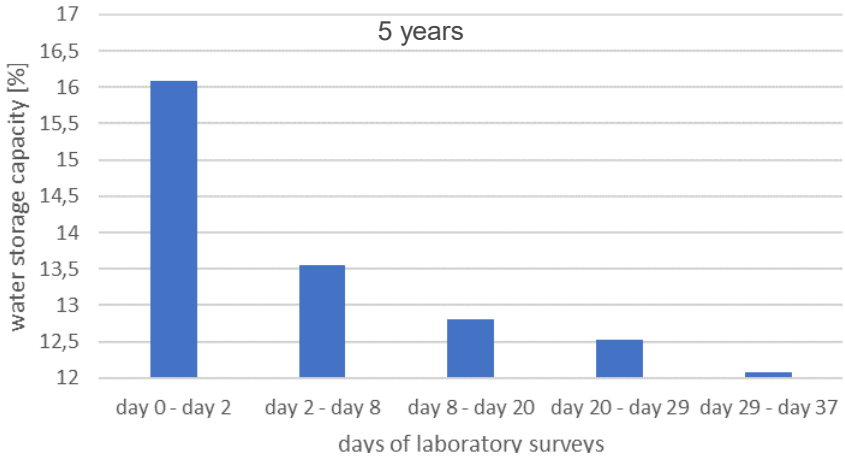


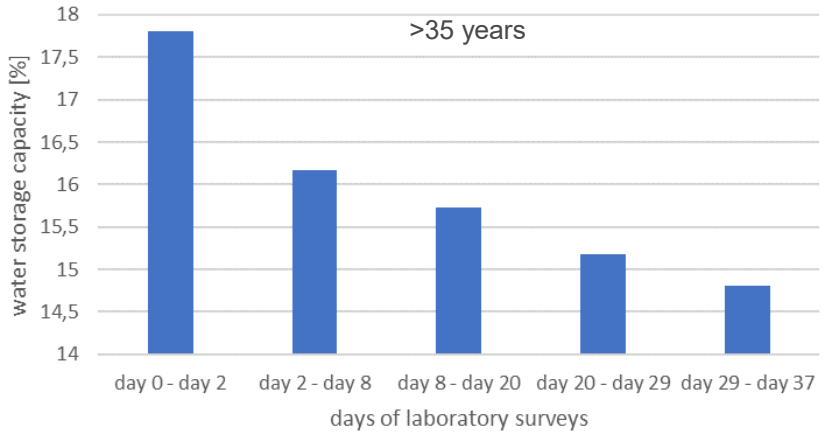


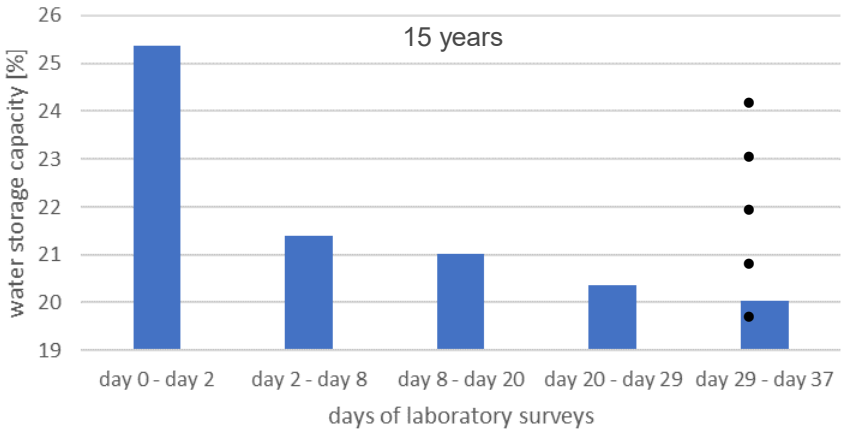
Porosity











from 14,8% to 17,8%, for the oldest sample > 35 years old,
from 15,8% to 19,3%, for a 15-year sample after coal recovery,
from 20,0% to 25,4%, for a 15-year sample,
from 12,1% to 16,1%, for a 5-year sample,
from 12,9% to 16,4%, for the youngest sample < 0,5 year.

CONCLUSIONS

- the older the geological rocks, the greater their resistance to uniaxial compression in the air-dry state,
- the cohesion of water-saturated rocks is lower than the cohesion in the air-dry state,
- rock rubble samples are characterized by good susceptibility to compaction during the formation of the dump,
- the vertical profile clearly shows the differentiation of hydrogeological parameters (permeability), the values of which depend on the type of rocks, the method of their deposition, geological age, and the impact of groundwater,
- change in the physical condition of the deposited rock rubble in the landfill in the CTL Maczki-Bór S.A. backfill sand mine results from the technology of backfilling, increasing vertical pressure and the natural processes of weathering of rocks,
- the target direction of reclamation of the opencast excavation, as well as the used technology (stratified storage, mechanical compaction), despite intensive weathering processes and increasing vertical pressure inside the dump, should constitute safe conditions for the foundation of buildings,

THANK YOU FOR YOUR ATTENTION

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