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THE FIRST IN POLAND RECONSTRUCTION OF DEEP WELL MSZCZONÓW IG-1 TO HEATING TARGETS

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ABSTRACT

In August 1996 Mineral and Energy Economy Research Institute Polish Academy of Science began a research project titled: "The pilot station of exploitation water and heat from the reconstruction well Mszczonów IG-1 ". Research section was titled: "Mszczonów IG-1 well adjustment to geothermal deposit exploitation needs for a heating network use."The base for the research was given by an agreement among State Committe of Sciences, Mszczonów Urban District and Polish Academy of Sciences MEERI. Mszczonów IG-1 well is placed in central Poland, about 40 km SW from Warsaw. It was the first such reconstruction in Poland that concerned mainly:
elaboration of reconstruct methodology and test Lower Cretaceous water-bearing level existing at depth 1602 - 1714 m beneath the surface of the area; execution of reconstruction technical labor and deposit facilities, probin water-bearing formation, geophysical test, result scientific description put into documentation.
Performed job certified geothermal waters of:

flow rate	60 m^3/h
depression (S)	24.6 m
temperature	41.5°C
mineralization	490 mg/dm^3
water class	HCO_3-Cl-Na-Ca

depth of water level at 49 m beneath the surface of the area
The results confirmed supposed values and served as a base to next elaborations dedicated to the water heat engineering targets and the water as a consumer good.
Implementation is planned to conclude in Sept. 1999. The plant (the third one after Podhale and Pyrzyce) intends to be set to work in Dec. 1999.

INTRODUCTION

In Poland in 70 - 80% of area geothermal water levels were identified at depths reaching 4000 m.The layers are formed mainly of sandstone and carbonates.
Main geothermal water containers originate from Jurassic (mainly Liassic and accidentally Dogger and Malmian), Cretaceous (mainly Lower Cretaceous) and older, with little superficial range, Cambrian, Devonian, Permian and Tertiary.
Temperature of occurring water depends on bed level depth as well as geothermal grade, amounting in the majority of Poland between 35 and 70 m.
Total water volume accumulated in Poland amounts about 6500 km^3.

The above approximation was performed on the base of data obtained from thousands of wells made all over Poland. Majority of them has been closed out or excluded from oil or natural gas exploitation by now. The closed out wells have been under interest of MEERI PAS as possible subject of water or geothermal heat exploitation.

In 1996 MEERI PAS Geothermal Laboratory realized a unique in Poland reconstruction of an old, closed out well, adjusting it to geothermal plant purposes. The financial expenses were covered by State Committe of Scientific Research and Mszczonów Urban District.

Forceful trends of ecologically clean heat source search were strongly marked out in three regions of Poland. In Podhale region in the South, where the first in Poland geothermal plant was set up, geothermal and natural gas powered heating plant in Pyrzyce, North-West of Poland, that has been working since 1996, and finally in Mazovia region, central part of Poland. In the latter area there is a town named Mszczonów. It lies in one of the richest geothermal region, called grudziądzko-warszawski. (**Fig.1.**).

A RESEARCH AND RECONSTRUCTION WORK COURSE

There are two deep wells in the area of Mszczonów town: Mszczonów IG-1 and Mszczonów IG-2. Mszczonów IG-1 well, placed on the town edge, was chosen to be reconstructed and to start water and heat industrial exploitation. (**Fig.2.**)

The geothermal project intended to use Lower Cretaceous water-bearing formation, existing here at depth of 1600 - 1700 m. The level was perforated in 1976/77 by Mszczonów IG-1 well, that was done for certain parametric-structural targets as a part of Warszawa Syncline and Warszawsa Antycline research. The well was closed out at 4119 m depth.

One of more important results was to render accessible water-bearing collector, existing in sand formations of Lower Cretaceous, and probe it (with contemporaneous procedures). Following parameters describe it:

- depth of water level 50.5 m beneath the surface of the area
- depth of the bed 1602,5 - 1714,0 m beneath the surface of the area
- flowrate - 10 m^3/h at depression of 0.5 - 1.0 m (capacity is designed by the compressor and boiler)
- flowratecalculated - 200 m^3/h t depression about 20 m
- temperature - about 45°C
- mineralization - about 1.0 g/dm^3.

The lithology of the water-bearing level:

1602,0-1714,0 m Middle Albian – Barremian
1602,0-1645,0 m close-grained gey sandstone, changing partly into dark-grey sandy mudstone with little silexes consistent, to the floork dark-grey medium grained sandstone with loamy binder
1645-1651,8 m black and balc-grey mudstones with a lot of muscovite, oflen sanded up, weakly consistent changing into weakly consistent claystones

1651,8-1714,0 m sandstones (as above) with a little coal, with fragments of fauna, black mudstones with a lot of muscovite dust.

Lower Cretaceous formations in other, neighboring wells, have got porosity about 20-29% and permeability o approximately 1480 mD.

According to an Agreement set between State Committee of Scientific Research, Mszczonów Urban District and Polish Academy of Sciences MEERI, research and development works started on 1st Aug. 1996.

As a first stage "Reconstruction and probing of Lower Cretaceous water-bearing level methodology" was elaborated. Data and materials obtained so far were analyzed in the task as well as particular reconstruction work realization, including suggestion of particular technical, research and measurement job conceivable contractor.

The analysis enabled to estimate a domain of following tasks:

- drill works associated with confirmations and documents required by law regulations
- completion water-bearing zone by facing 9 5/8" pipe perforation at the bed's depth using body and frameless method as well as water-bearing zone acidification treatment effectiveness.
- performing a purificatory pumping treatment by water air-lift or with submerged pumping device.
- performing hydrodynamic tests, measurement pumping using specifically selected deep-well pump and an investigation set recording water level in the well.
- performing of hole geophysical investigation that enables inquiry of well and container zone technical condition.
- running physical and chemical analysis of geothermal waters.

Drilling works were made according to the confirmed Project, elaborated by Geological Enterprise "Polgeol".
The works have been done by Pervig Drill - The Drilling and Mining Works CO Warsaw.

The real condition of casing was different from the foreseen one in the reconstruction Project. Pipes 9 5/8" were not reaching the top. Their roof occurred at about 23 m depth. During next technical (drilling) works the lacking part was completed, mainly due to safe inserting and withdrawing of drilling devices and exploitation pump.

Another surprise discording with the Project was 9 5/8" pipe damage about 60 m beneath the surface of the area, revealed while pump mould penetration. It has to be underlined that the damage was not found during drilling devices penetration while boring cement plugs, which ones neither were placed at the indicated depth, moreover, one of them revealed to be made of steel, obliging to use different piercing tools than used to drill cement plugs. The above pipe damages were removed. Pipe technical condition was examined with hole caliper and additionally by concerned part video survey.

Right after the above activities have been exercised, concerned as additional comparing to the Project, the Contractor judged the technical hole condition as good.

The next task to fulfill during Reconstruction was to perforated completion a water-bearing zone.

The job was preceded by exercise procedure offer analysis. Body perforators were analyzed, characterized by high reliability and perforated zone depth precision as well as perforation efficacy control, but simultaneously a long time of extended interval exercise (that we have inside the mentioned hole) and a very elevated perforation cost.

The second technique is formless perforation that is characterized by high performance speed, sometimes very long deposit intervals, very high practical reliability while single pipe column perforation, and almost ten times lower cost comparing to form perforation technique. However, it lacks effectiveness control and leaves post-perforation waste material.

Finally facing 9 5/8" pipe perforation was exercised in two depth intervals: 1602,5 - 1645,5 m and 1663,0 - 1714,0 m, in accordance with postulates described in reconstruction Project, with body perforator (**Fig.2.**).
The perforation having been done waste material occurrence was examined in the bottom of the hole. The charge roof was found at about 1734 m, so it was almost 60 m high.

After perforation treatment a water level firmed up at about 53 m depth. The well treated in this way was put under three investigation series: first one - purificatory pumping, second one - measurement pumping, third one - final research rendering the hole accessible for heating targets.

First cycle - *purificatory pumping*. Such treatment performance was analyzed in two cases: water air-lift and submerged pumping device use.

Preliminary purification was decided to be done with high-pressure compressor (**Fig.3.**). Compressing set consisted of 450 m of pipe ϕ 5" and 402 m of pipe, 1 1/4" diameter. Obtained effectiveness of aerated deposit water amounted up to 36 m^3/h maximum, free water surface oscillated around 80 m beneath the surface of the area. It is important, that significant addition of sand by white quartz pelite from completion horizon was found. The above fact based long-term second stage of putificatory pumping, with use of two compressors and deeper placed pipe set, to execute.

Alike the first stage, obtained efficacy was about 50 m^3/h and free water surface was placed at about 80 m beneath the surface of the area addition of sand (quartz pelite) was stabilized at similar level. The treatment having been done the charge roof was found at about 1711.5 m beneath the surface of the area.

After having executed the two pumping stages the first geophysical *measurement round - Production Log* (PL) - having absorptive part designation as an aim, was set in operation (**Fig.4.**). The operation was performed with DDI, CH/PL Cased Hole apparatus, made by Halliburton.

Inside an interval between 1575.0 and 1711.0 m following measurements were done:

- gamma-neutron log
- collar locator

- temperature log
- drill stem test
- temperature gradient
- measurement set transfer speed
- flow log

After result interpretation having been done water has been recuperated from three narrow (of little strata's depth 2 - 4 m) intervals, placed inside upper zone, rendered accessible by perforation. The whole bottom part of the deposit layer is not producible in spite of found identical deposit features (lithological) and quality of the executed perforation. After research having been done, the backfilled part of the hole has been removed. The cement plug roof, placed at 1793 m depth, revealed.

The next, second round - the well adjustment to the geothermal plant purposes - was *Measurement Pumping.* It was done using a pumping set and registering device, which arrangement displays Fig.5. The pumping was being executed during 21 days while a hole free water surface level change and temperature were being registered.

The referred delineation of liquid free surface change was registered with created by MEERI PAS computer system that was characterized by:
- constant data registering, visualization and archiving.
- long measurement round
- measurement frequency changeability
- heavy-duty ability rugged condition work ability
- assembly ease
- further data processing ease.

The system proved to be correct in 100% and collected material enabled a very legible liquid free surface change plot elaboration. It has gotten to be underlined that quartz pelit outflow phenomenon appeared occasionally then and was associated with violent (usually a few minutes lasting) water free surface augmentation. At the attached chart (**Fig.5.**) those changes reveal between 20.04 and 27.04. Afterwards the water level was very stable, on the other hand addition of sand stopped and flowing water was very clear.

After the pumping treatment a round of geophysical measurements was repeated by:
- measurements in the interval of 1500.0 - 1790.0 m with following sondes: gamma ray, collar locator, neutron, concret log
- in the interval of 1570.0 - 1740.0 m Production Log (PL)

Regarding that former absorptiveness measurements revealed irregular absorptiveness in the upper part of the rendered level and a lack of the latter in the bottom part, it was probable that this round will give a similar display (**Fig.6.**).

The test results were unusually interesting, mainly due to fact that prevailing absorptiveness was found in the bottom zone. Its percentage was valuated to 72% meanwhile upper zone absorbed 28% of total forced in water. So there we delt with upside-down situation comparing to the display preceding long-term measurement pumping.

deposit investigation run in the research round was pulsation test.

The tests were executed at efficacy equal to 25, 45 and 75 m^3/h and dynamic free water surface was obtained at depths of 65, 73 i 79 m respectively. A chart displaying the test course associated with pressure recovery register is shown on Fig.7. Water samples were drawn while pumping to perform physical and chemical analysis in order to resolve: deposit water chemical composition, deposit liquid corrosive properties, evaluation of deposit water usability - other than for geothermal use, deposit water flowing into surface water-course confirmation as well as its age and origin.

Below there is a short chemical analysis of deposit water sample taken from Mszczonów IG-1 well while purificatory pumping.

- pH	8.15	
- iron	1,20	mg/dm^3
- manganese	0,08	mg/dm^3
- calcium	42,80	mg/dm^3
- magnesium	8,60	mg/dm^3
- chlorides	23,10	mg/dm^3
- fluorides	0,40	mg/dm^3
- sulfates	11,50	mg/dm^3
- phosphates	0,60	mg/dm^3
- free carbon dioxide	2,20	mg/dm^3
- dry residue	377,00	mg/dm^3
- sodium	55,50	mg/dm^3
- potassium	16,50	mg/dm^3
- bicarbonates	292,80	mg/dm^3
- silica	23,00	mg/dm^3
- aluminum	0,00	mg/dm^3

The last, third research round, *Final Investigation*, aims to confirm parameter constancy and water quality. The investigation run while this paper was being written involved 40 days long pumping period with efficacy equal to 65 m^3/h during 18 days and about 55 m^3/h during 22 days. The following parameters were registered then: free water surface level, water flow, pressure in the pipeline, temperature. Every 12 hours following factors were measured: pH, red-ox, water conductivity with simultaneous flowed out deposit sand sample drawing.
Once per twenty-four hours total collected sand mass was drawn out. The assembled material is being under specialized chemical and mineralizational investigation now.

In the span of 12 - 15 July 1999 the third round of geophysical measurement will be run, involving the depth finder set used in former two rounds (after purificatory and measurement pumping), completed with gamma-gamma PGG and neutron depth finder measurements for experimental extratubular space investigation.

ACKNOWLEDGEMENTS

The work over reconstruction Mszczonów IG-1 well was forerunning and from the very beginning performed in a very careful and diligent way. This attitude was additionally enforced by severe financial discipline caused by limited financial means destined for the research.

It should be univocally declared, that the above effect attainment of MEERI PAS, as task Realizer, and this paper author own one, as the responsible on PAS's behalf for task execution, were possible owing to such particular institutions as: State Committee of Scientific Research, Mszczonów Urban District, Geotermia Mazowiecka S.A., PG "Polgeol", Pervig-Drill.

A special appreciation for cooperation is owned to Mr. Marek Balcer - the head of Geotermia Mazowiecka S.A. and simultaneously Mszczonów Urban District representative in Project realization, Mr. Jerzy Grzegorz Kurek and Mr. Marian Jackowski - the chief magistrate of Mszczonów Urban District. Those persons determined a fluent job course and further geothermal project entire development.

Author of this paper, as the head of the task as well as Geothermal Laboratory Manager, wants to favour the whole Laboratory Team, especially: Sławomir Graczyk - Geothermal Laboratory Assistant Manager, Antoni Barbacki, Ph.D. eng., Barbara Uliasz - Misiak, Ph.D. eng., Beata Kępińska, Ph.D. eng., Grażyna Hołojuch, M.Sc. eng., Agnieszka Kazanowska, M.Sc. eng., Leszek Pająk, M.Sc. eng. and Paweł Wojnarowski, M.Sc. eng. who were the real local research and task executors.

District Name	District Area [km²]	Geological Formations	Volume of Geoth.Water [km³]
Grudziadz-Warsaw	70,000	Cretaceous/Jurassic	2,766
		Triassic	334
		Total	3,100
Szczecin-Lodz	67,000	Cretaceous/Jurassic	2,380
		Triassic	270
		Total	2,850
Fore-Sudety-Swietokrzyski	39,000	Permian/Triassic	155
Coastal	12,000	Permian/Carboniferous/Devonian/Liassic/ Triassic	21
Lublin	12,000	Carboniferous/Devonian	30
Baltic	15,000	Cambrian/Permian/Mesozoic	38
Podlasie	7,000	Cambrian/Permian/ Mesozoic	17
Fore-Carpathian	16,000	Triassic/Jurassic/Cretaceous/Tertiary	362
Carpathian	15,000	Triassic/Jurassic/Cretaceous/Tertiary	100

Fig.1. Geothermal regions and subbasins of Poland and their characteristics (Ney, Sokołowski 1987)

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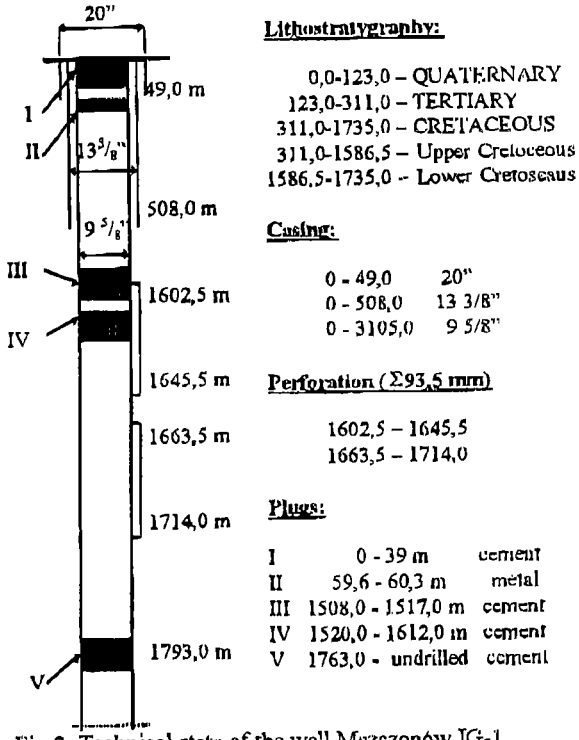


Fig.2. Technical state of the well Mszczonów IG-1

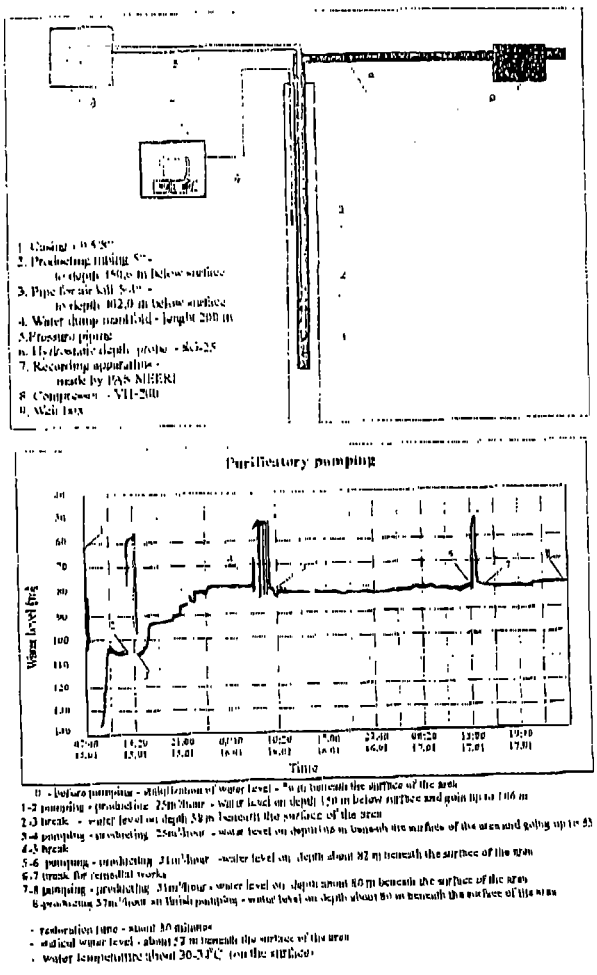


Fig.3. The pumping set and registering device from purificatory pumping in the well Mszczonów IG-1 .

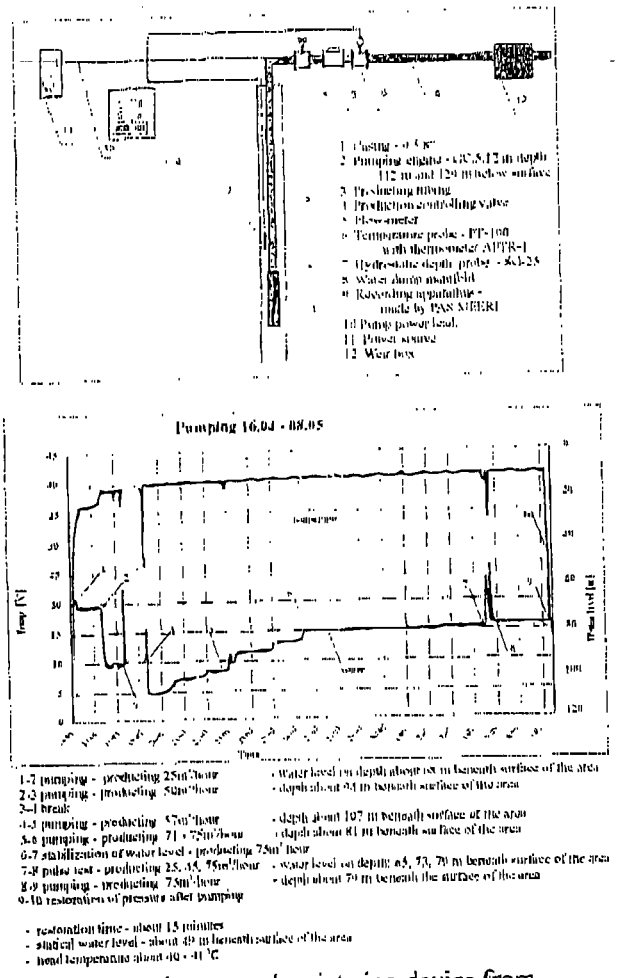


Fig.5. The pumping set and registering device from measurement pumping in the well Mszczonów IG-1 .

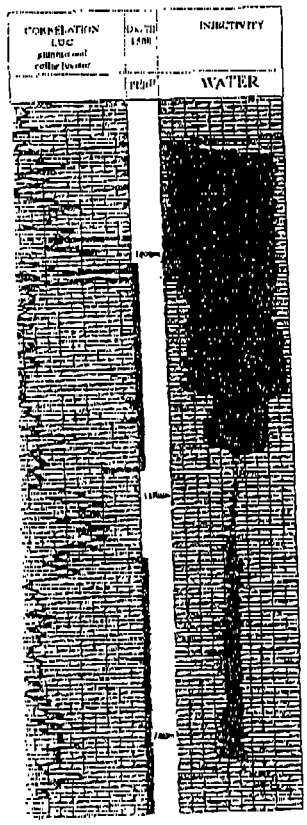


Fig.4. Production-Log - well Mszczonów IG-1 7.03.1997 r.

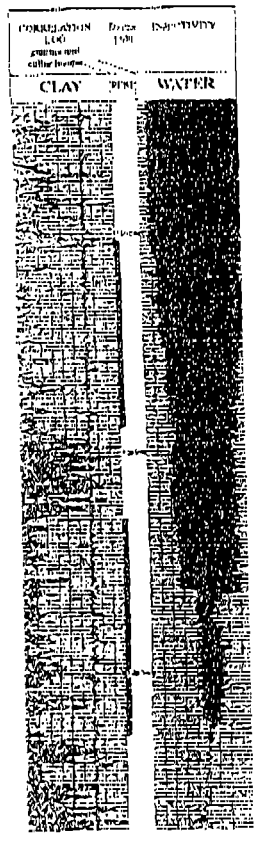
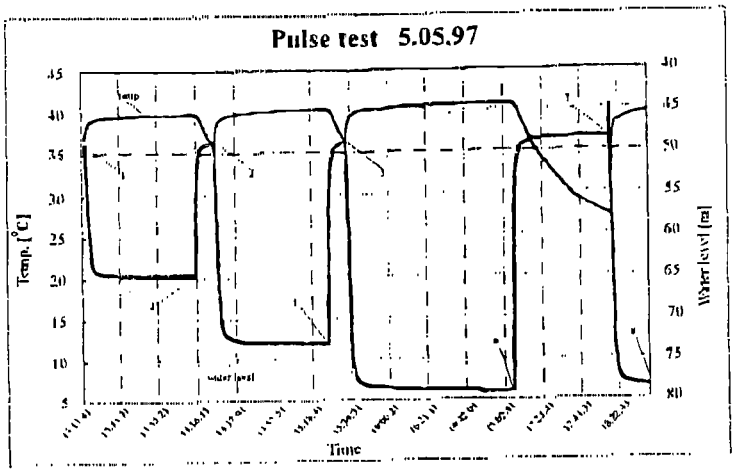
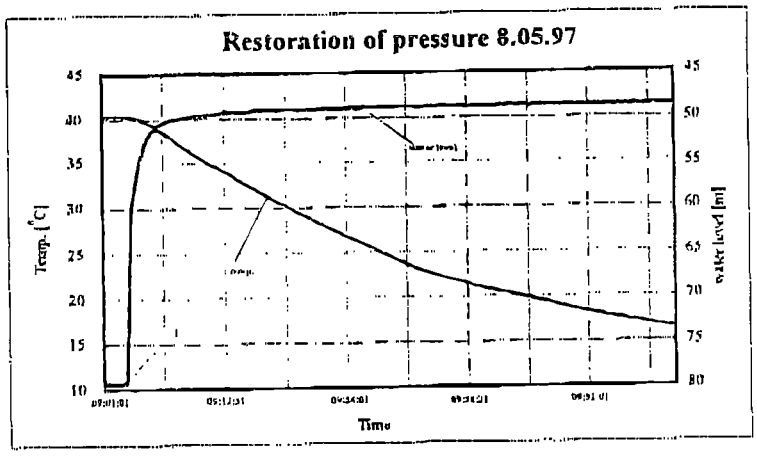


Fig.6. Production-Log -well Mszczonów IG-1 20.05.1997 r.



1-2 pumping - producting 25m³/hour
2-3 break
3-4 pumping - producting 45m³/hour
5-6 pumping - producting 75m³/hour
6-7 break
7-8 pumping - producting 75m³/hour

Fig. 7. Pulse test in the well Mszczonów IG-1



1-break

- restoration time about 15 minut
- statical water level about 49 m ppt

Fig. 8. Restoration of pressure after pumping in the well Mszczonów IG-1