Bulletin d'Hydrogéologie No 17 (1999)
Centre d'Hydrogéologie, Universitc! de Neuchdtel
EDITIONS PETER LANG

Disturbance of geothermal field of the **Upper** Silesian Coal Basin due to mining activity

by Ewa Kurowska

Faculty of Earth Sciences, University of Silesia, Bedzinska 60, 41-200 Sosnowiec, Poland
e-mail: kurowska@ultra.cto.us.edu.pl

ABSTRACT

The thermal field of the Upper Silesian Coal Basin (USCB) is influenced by mining activity i.e. coal extraction, ventilation and dewatering of mines. Long-term mining, in some mines lasting even for hundreds of years, is the reason for essential changes in heat flow, hydrogeologic conditions and in consequence in distribution of temperature in rock massif which is manifested in pre-cooling of rocks in mines. On the basis of temperature and geological data acquired from wells, mine workings, and from geological and geothermal maps a diagram of rock temperature versus depth was composed. Geological conditions of coal extraction are varying between western and eastern parts of the coal basin, and have an influence on water content and air motion in mines in particular parts of the region; ventilation and water content in rock mass have substantial impact on the temperature distribution in mines.

KEYWORDS

Coal extraction, ventilation, dewatering, temperatures of rocks

1. Ventilation in mines

Taking into consideration the high values of geothermal gradients in mining provinces (in the Upper Silesian Coal Basin it is 3.4-3.9°C/100 m) (KARWASIECKA 1996), coal extraction would not he possible without ventilation of the mine workings. The temperature of the rock is of major importance to the climatic conditions in the workings, because 50% of the heat in mines comes from the rock mass. The intensity of heat exchange between rocks and air depends on initial rock temperature, amount of airflow in the workings, and the length of ventilation time. During air motion in the workings, cooling down of longwalls takes place and the cooling penetrates zones of a particular thickness in the rock mass; the higher the thermal conductivity of the rock, the deeper is the penetration. **The** greater the temperature difference between the ventilation air and the rock mass, the more intensive is the heat exchange process with rocks. For sandstones the range of cooling is 12-25 m, for shales 8-10 m and for coal 3-5 m (FRYCZ 1970). More recent research on rock temperature and distribution of heat flow around mine galleries has been conducted by Chmura (CHMURA et al. 1988) in the Halemba mine, at a depth of 1030 m. Chmura's research shows that the range of pre-cooling zones inside walls is quite variable; it can **vary** between 11 and 30 m for sandstones and **4.5** and 30 m for coal. The position of rock temperature isolines around workings is non-uniform. It depends on the lithology and also on the water content of the rock; the more water the rock contains, the higher is its thermal conductivity and the deeper is the zone of cooling.

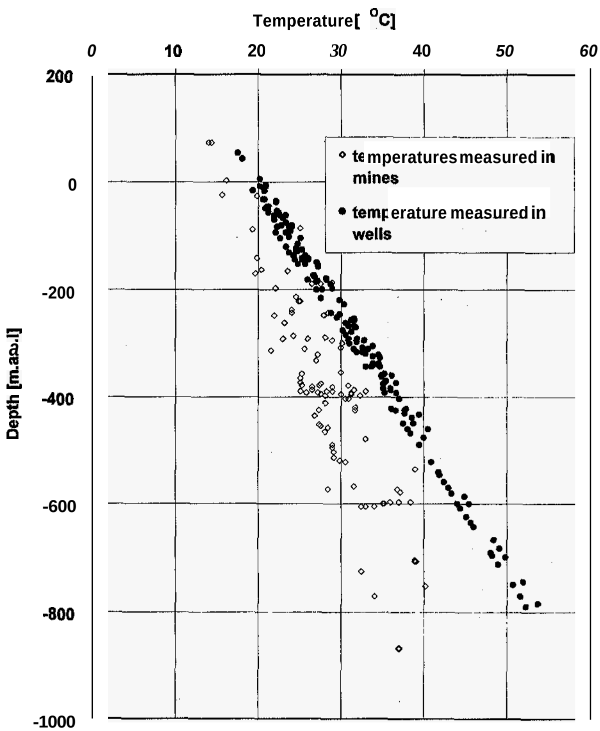

Figure 1: Relationship between temperature of rock and the depth of deposition

The natural-state rock temperatures measured in six mines in the noah-western part of the USCB and results of temperature logging in nine selected wells from the northern part of the area are presented in Figure 1.

All the rock temperature data collected in mines and wells clearly show the relationship between rock temperatures and their depth, but Fig.1 shows the linear increase in rock temperature with increasing depth for the temperatures measured in wells, while temperatures measured in mine workings are differentiated. In wells at a depth of 250 m (at sea level), rock temperature is 20°C, and at a depth of 1050 m (800 m b.s.l.) the temperature is about 53°C; thus, the geothermal gradient in the depth interval from 250 m (sea level) to 1050 m (800 m b.s.l.) is about 4°C/100 m. Temperatures measured in mine workings are variable at particular depths, and the increase of rock temperature with depth is non-linear. At a depth of 250 m (at sea level) the temperature is 16°C. At a depth of about 650 m (400 m b.s.l.), the temperature varies between 24 and 32°C, and at a depth of 1050 m (800 m b.s.l.) the temperature is about 32°C. Thus the temperature at this level is about 20°C lower than the temperature in the well. According to measurements in mines at the same depth interval, the geothermal gradient oscillates between 2.5°C/100 m and 3.8°C/100 m. This testifies the pre-cooling of the rock mass due to mining activity, especially ventilation (KUROWSKA 1999).

2. Water content in mines

Water content in the USCB is investigated in the context of mining activity, for which the amount of water flowing from the surrounding rocks into the workings is of great importance **for** safety. The amount of water flowing into the mine depends on rock structure, permeability and existence **of** natural water-migration paths (fissures and faults). In shallow mines inflows are greater and more dependent on precipitation than in deep mines (KORMAN 1978). In mines where coal seams are in sandstone formations, the amount of inflowing water is distinctly greater than in mines where coal is recovered from shale formations (claystones and siltstones).

The lithology and thickness of cover is another factor influencing water inflow into mines. Quaternary deposits are generally permeable. Where they are deposited directly onto sandstone Carboniferous rocks, waters have easier access to coal mines. Siltstones and claystones of Tertiary formations are impermeable; thus mines beneath have small inflows (WILK 1965). Mines in the north-western and western part of the USCB, located in Paralic Series and Siltstone Series, and where impermeable Miocene cover occurs, are considered as small-inflow mines. The largest inflows occur in mines of the eastern part, where the Upper Silesian Sandstone Series and Krakow Sandstone Series are mined, and where permeable Triassic and Quaternary cover occurs (table 1).

Mining activity is the reason of drainage **of** rock mass and flowing off the water from cooler, higher part of the rock massif down to the mine. During that process rocks on deeper levels are cooled and water is heated. Water inflow in mines of USCB and temperatures of rock mass is presented in table 1. The distinct decrease of temperature of rocks in eastern part of basin is due to low thickness and kind of the cover, intensive dewatering and higher thermal conductivity of rocks.

Table 1: Conditions of coal mining in selected mines of the USCB (GOSZCZ & ROGOZ 1991, KNECHTEL et. al. 1980, GEOLOGICAL DOCUMENTATION...)

Zone of the USCB	**Western part of USCB**		**Eastern part of USCB**	
Mine	Knurów	Debiensko	Jaworzno	Jan Kanty
Depth of mine [m b.t.s]	700	700	600	300
Average thickness of cover [m]	300	100	50	2-30
Type of cover	Sealing Tertiary (Miocene) claystones and siltstones, and Quaternary sediments		Quaternary sandstones and clays	Quaternary sandstones, clays, Triassic limestones, marls and dolomites
Recovered formation	Siltstone Series – Orzesze beds and Upper Silesian Sandstone Series - Ruda Beds		Krakow Sandstone Series - Lazy Beds and Siltstone Series - Orzesze Beds	
Inflows [1000 m^3/24 h]	15-20	17-19	101	66
Temperatures of rock mass [°C] at 450 m b.s.l.	31-36	29-31	25-27	22-27

3. Temperatures in Staszic mine

Differences between the temperatures of rocks, temperatures measured on sidewalls, and temperatures of the air in workings were confirmed by temperature surveys performed by the author. The temperatures were measured with an electronic thermometer at a depth of approximately 720 m ± 12 m. According to the map of rock temperatures compiled for the 720 m level in the Staszic mine, the rock mass temperature oscillates between 30.5 and 33.25°C. The rock temperatures were approximately 32-33°C in the places where the measurements were taken. All temperahue survey results are presented in Figure 2. The temperature of rocks on sidewalls is about 8-10°C lower than the natural rock temperature. This is the result of ventilation, which lowers the temperature in workings down to a maximum of 28°C. The temperature of air in workings at the 720 m level in the Staszic mine was as expected. The temperature of water flowing out of the wall into the workmgs was 28.4 and it was about 3.6-4.6°C lower than the rock temperature, and higher than the temperature measured on the sidewall. This indicates that water probably comes from the cooler, higher part of the rock massif and is heated during its migration down to the mine.

Temperature of the air pumped out to the surface in Staszic mine is about 14-19°C (about 216-480 thousands $m^3/24$ h).

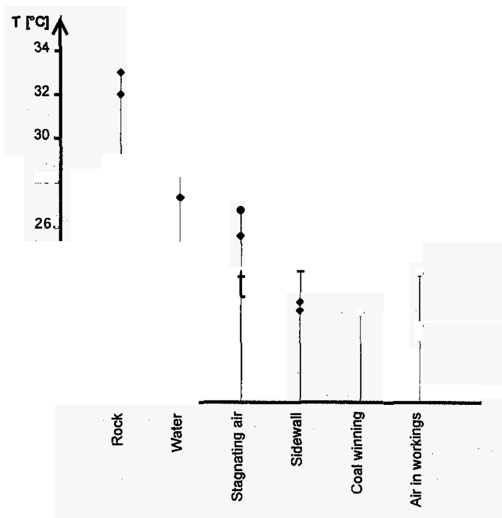

Fig. 2: **Temperatures** *measured at* **the** *720 m level* in *Staszic mine (central part of basin).*

4. Conclusions

Rock temperature increase in wells shows a linear correlation with increase of depth, while in mine workings the temperature increase is non-linear, being variable at a particular depth. This testifies the pre-cooling of the rock mass due to ventilation.

Temperatures **of rocks** in western part of the basin **are** higher than temperatures in the eastern part. One of the reason of that situation is variable amount of water percolating from the surface and from surroundingrock mass down to workings.

With the deepening of mining and the increase of temperature of exploited rocks, more heat is pumped out with ventilation air and mine waters. This heat from deep mines is a potential source of thermal energy, ready for direct **use** on the surface **(MALOLEPSZY** 1998).

References

CHMURA K., CHUDEK M. & TWARDOCH S. 1988. Testing of Thermomechanical Properties Around Workings in Halemba Mine (in Polish). Przegl. Górn., 9: 5-23.

FRYCZ A. 1970. Air Conditioning in Mines (in Polish). Silesia Press, Katowice.

GOSZCZ A. & ROGOZ M. 1991. Budget of water inflow to the coal mines in Upper Silesian Coal Basin (in Polish). In: Konferencja na temat: Kierunki zagospodarowania zasolonych w6d z kopaln wegla kamiennego. GIG, Katowice: 5-16.

KARWASIECKA M.1996. Geothermal Prospects of the Upper Silesian Coal Basin (in Polish). Technika Poszukwan Geologicmych, 3-4: 28-32.

KNECHTEL J., MARKEFKA P. & ZGRYZA S., 1980. The Maps of Undisturbed Rock Temperatures within the Upper Silesian Coal Basin of Horizons -450, -550, -660, -750 m Komunikat GIG No 719, Katowice.

KUROWSKA E.,1999. Geological Factors Influencing the Thermal Field Distribution in the Nw Part of the Upper Silesian Coal Basin. Technika Poszukian Geologicznych.

MALOLEPSZY Z. 1998. Modelling of Geothermal Resources within Abandoned Coal Mines, Upper Silesia, Poland. In: UNU Geothermal Training Programme Reports, Reykjavik 217-238.

WILK Z. 1965. Water Content Related to Dimension and Depth of Mines in East Part of the Upper Silesian Coal Basin (in Polish). Prace geologicme PAN, 24, Warszawa.

GEOLOGICAL DOCUMENTATION OF COAL DEPOSIT IN THE STASZIC KNUROW GLIWICE SZCZYG_OWICE SOSNICA, MAKOSZOWY & PSTROWSKI **MINES.** Archive materials of mines.