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THE USE OF ABANDONED OIL AND GAS WELLS IN POLAND FOR RECOVERING GEOTHERMAL HEAT

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ABSTRACT
Often, in spite of favorable geological conditions, drilling costs stop geothermal developments. On the other hand, many oil and gas fields are surrounded by hot waters which might be utilised as geothermal resources .This paper describes the requirements to be met by oil and gas traps for such purposes, and uses as a model case that of Grobla field near Cracow.

1. INTRODUCTION:

The Foreland of the Carpathians in Poland is rich in low temperature geothermal waters, both in Jurassic limestones and Cretaceous sandstones .The geothermal activity is manifested by thermal waters in boreholes situated between Bochnia and Tarnów cities; here the waters occur 1000-2000m below the surface. In this area small oil and gas fields are producing in the presence of ground water pressure, although some wells have been abandoned due to water invasion. The Grobla field near Cracow city was treated as a model case for geothermal utilization with wells which have to be closed for this reason. The field was chosen on account of the geothermal anomaly existing in this area and because of favorable reservoir conditions.

2, GEOLOGY OF GROBLA FIELD

Grobla field was discovered in 1963. The field is located in the central part of the Carpathians Foreland about 30km to NE from Cracow. At present there are 27 producing wells in Cenomanian sandstones (late Cretaceous) and the underlying Malmian limestones(late Jurassic). A structural map on top of the Cenomanian (Fig.1) does not depict a closure over the field area. The hydrocarbons must have migrated westward into the Mezosoic formation and been trapped by permeability failure related to wedge-out of Cenomanian sandstones and pinch-out of limestones porosity. Thus the seals include both stratigraphic and structural: from the west by loss of porosity; from north and south sealing by faulting; and from the east by pressing water contact.

Above the permeable deposits of Cenomanian there is an impermeable sealing sequence of late Cretaceous marl. The bottom seal is provided by the substratum rock build-up by non-porous Jurassic limestones. The Cenomanian formation is divided into two parts : low porosity conglomerates (western part) and high porous sandstones (eastern part) as shown in Fig.1.

The majority of production comes from the eastern part of the field where porosity of the Cenomanian sandstones ranges from 20-30%, whereas the Jurassic limestones are not productive. The western part produces mainly from low-porosity conglomerates. The maximum thickness of the production zones does not exceed 35 m and occurs along its eastern margin (Fig.2). The Cenomanian sandstones and conglomerates are probably fan deltas, interdeltaic and shallow marine deposits. The Jurassic limestones represent shallow marine deposits of transitional and coastal zones.

The oil and gas in the Grobla field is believed to have been generated from the under-laying carbonate formation of Carboniferous and Devonian age. It is interesting that the western part of the field shows mineralization of less than 2g/l and wellhead pressures equal hydrostatic, whereas in the eastern part mineralization ranges from 20-40g/l and wellhead pressures are from 1.0 MPa to 2.0 MPa. The field can be subdivided into two separate zones related to facies change from conglomerates to sandstones. After migration and accumulation of hydrocarbons this part of the Mesozoic basin may have undergone faulting along a line of facies change, causing different conditions for a second period of accumulation. During the years of exploitation for oil and gas, some wells suffered from brine flooding and were withdrawn from production. The oil-water contact is still moving to the west and more wells will have to be closed. In some, in the eastern part of the field, artesian outflow of water ranges from 30-50 m^3/hr.

3. CONDITIONS NECESSARY FOR USING WELLS IN OIL & GAS FIELDS.

Firstly, the field owner must be interested in geothermal utilisation of the abandoned wells.

For geothermal purposes the oil & gas field should have:

- Suitable wells for extraction of geothermal heat
- Stable temperature and constant production rate
- Suitable conditions for reinjection of reservoir waters
- Potential users of the heat energy nearby

To determine the above-mentioned geological conditions (stable temperature and production) it is necessary to determine:

- Structural and stratigraphic conditions of the reservoir and the field (usually well known at this stage of production)
- Exploitation conditions (types of fluids, water conditions, run of production, fluctuation of pressures)
- Geothermal parameters (temperature gradient ,reservoir pressure, possibility of production)
- Hydrological conditions (examination and description of infiltration zone and outcrop area of reservoir horizons, direction of fluid migration, fluid chemistry).

The above analyses are important because the inflow of ground water to the well zone depends on many things, including:

- Regional extent of reservoir horizons (aquifers)

- Character of the traps (possibility of communication the reservoirs water with external waters)
- Distribution of outcrops (widely exposed and direct infiltration zones)
- Uplift of the reservoirs (to produce artesian conditions)

The most favourable case occurs when there is an aquifer of regional extent having widely exposed and uplifted zones of infiltration. Well pressure behaviour during exploitation can provide a good indication of the steady inflow from behind traps.

4. RESULTS OF ANALYSIS.

- Geological analysis of the Grobla field have allowed us to establish that generally both reservoir complexes: Cenomanian sandstones (late Cretaceous) and Malmian limestones (late Jurassic) represent a common hydraulic system open from the west (Cracow Jura Upland) and the east (St.Cross Mountains). In these uplifted zones the outcrop area of the reservoir complexes lie about 300m higher than in the Grobla field, creating artesian conditions in several wells.

- Dislocations crossing both complexes permit the communication of the accumulated fluids with deeper zones which is probably an important reason for the geothermal anomaly.

- Grobla field includes two hydrogeologicaly separated structures :
  - Western Zone with low-mineralized reservoir water (below 2g/l) and with hydrostatic head-well pressure
  - Eastern Zone where groundwater mineralization exceeds 20g/l and wellhead pressure comes up 2.0 MPa.

  The boundary of the zones is situated along a facies change in Cenomanian deposits: from conglomerates to sandstones (Fig .1) Its deep nature is probably connected with a pre-Cenomanian dislocation renewed after primary migration (probably in the Tertiary).

- High wellhead pressures and optimum reservoir parameters in the Eastern Zone indicate this zone is the most favourable for geothermal purposes in spite of higher mineralization
- Temperature of the geothermal fluids in the Grobla Field is about 40 °C at a depth of 800 m (fig. 3). Utilising this water for heating will require use of heat pumps
- The average self-outflow from a single well is only 30 m^3/h. It is planned to use a geothermal doublet in conjunction with pumping to improve this.

- **5. CONCLUSIONS.**

In the year 2000 it is anticipated that four wells will be closed in the eastern zone of Grobla field which is the part considered to be the most profitable for geothermal investments (considerable and artesian outflows).

Potential users (citizens of Drwinia village) could in the future use about 2.0 MW of heat energy from one geothermal doublet in this area. Investment cost in this case would be less than about $ 1.0 million (two wells, 800 m deep). After successful testing, this project may open the way for the use of geothermal resources in other oil and gas field where production is ending and wells are undergoing flooding.

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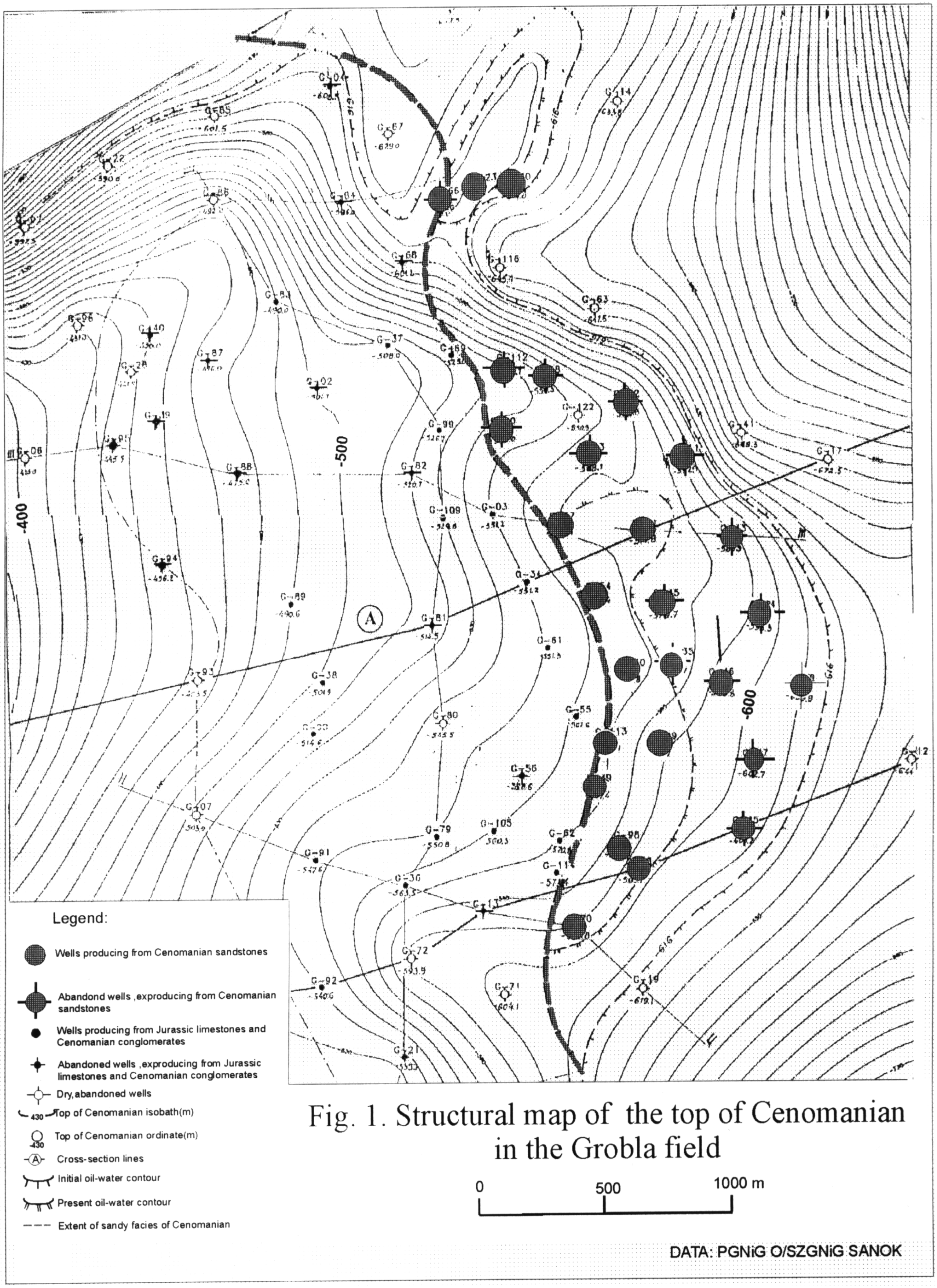

Fig. 1. Structural map of the top of Cenomanian in the Grobla field

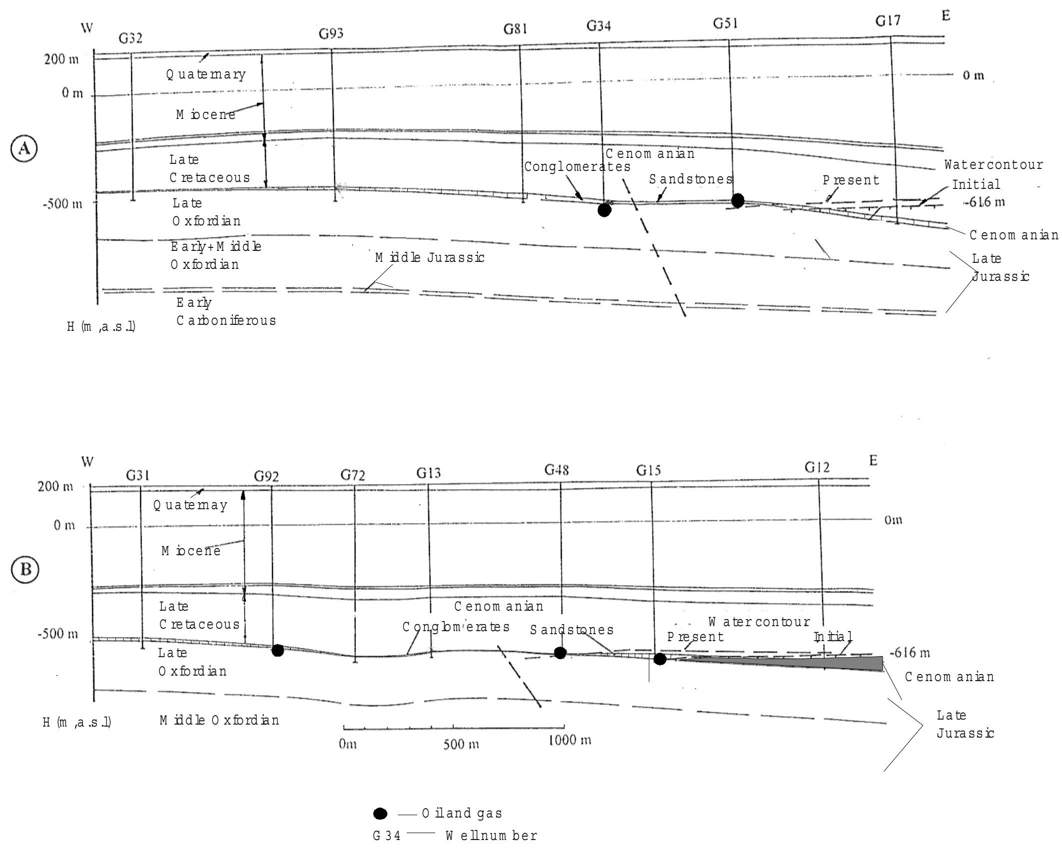

Fig.2.Geological cross-section through the Grobla field (location of cross lines on Fig.1)

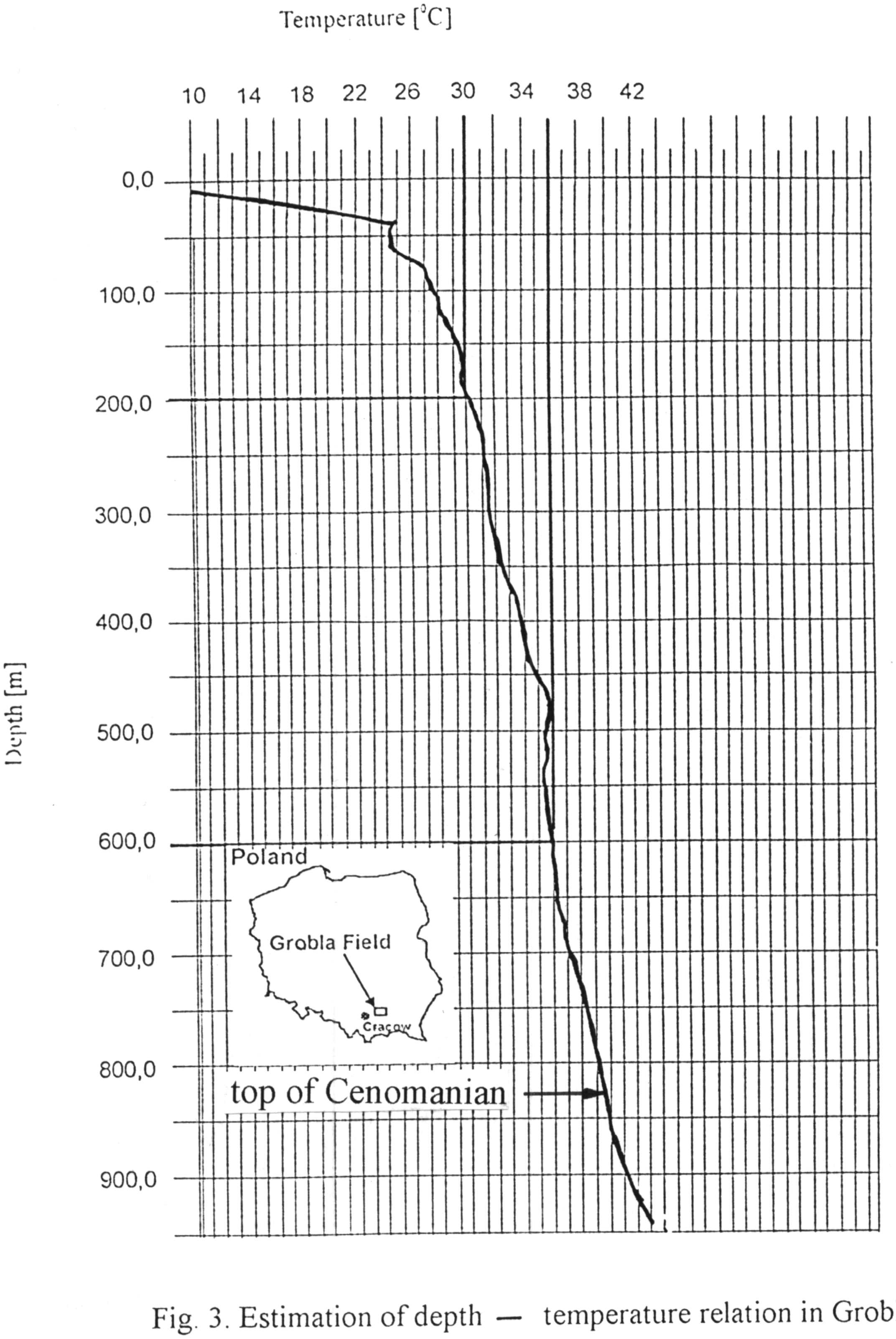

Fig. 3. Estimation of depth — temperature relation in Grobla field