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Exploration Strategy for Mineralwater Resources

Abstract

The **methods of investigation** for underground water resources include a package of different very sophisticated methods, including proceedings from the petroleum prospection, the engeneering business, the applied geology, geophysics and geochemistry. Therefore an integrated team of experts is useful for the successful work in the field, the laboratory and the archive.

The combination of methods depends on the characteristic of the geological water reservoir, its solved mineral-components, and its eventual gas content. Especially in the circumalpine region much effort has to be spent on the different geological formations.

Nevertheless there are **risks** during the phases of exploration and production of mineral waters for sanitary purposes:

The geological risk (reservoir-size, permability etc.) in the stage of exploration, the technical risk (drilling depth, casing program) in the phase of drilling and the economical risk (production constance of quality and quantity, ecological dismiss) during the process of exploitation have to be taken in consideration.

Different **possibilities of constructing underground production buildings** for water resources have a considerable effect on the cost side of errection and working of the plant: conventional drilling wells for mineral waters in sedimentary basins, tunnels for thermal water in mountainous regions, special constructions for sanitary gas production (CO_2, H_2S, Rn) may be examples. Advanced technologies show the way for propriate resources management.

Long term protection of the reservoir rock is necessary for the prevention of man-made pollution influence, and for minimizing geological hazards. Important targets are the recognition of aquifer alteration, supply of mineral water resources, purity from micro-organics and sediment of the produced fluid, constant behavior in chemical characteristic, simplification of upkeep process, and the delay of eventual reconstruction.

Last stage may be the **readjustment** of the underground building in the case of sanitary or production problems. The right evaluation of above mentioned data supports the quick and secure handling of proceedings for the future successful production of additional resources.

1. DEFINITIONS

"Exploration strategy" means: What should be done for the successfull, long time production of the underground resource, which is the basis of the course of treatment in a rehabilitation centre.

"Mineral water resources" means the natural underground water for the curative use of sanitary purposes (spa, inhalation, drinking) of sick people, who may need these by advice of medical doctors. Mineral waters are produced from geogene aquifers. These reservoirs mean the connection and interaction of

- rock mass, porosity, fracturing;
- fluid containing dissolved minerals $\pm$ gases;
- bacteria and microbes.

So the terminus technicus "mineralwater" in this article does not mean the german title "Mineralwasser"!

2. METHODS OF INVESTIGATION

The **methods of investigation** for underground water resources include a package of different very sophisticated methods (Fig.1, MARSCH 1996a), including proceedings from the petroleum prospection, the engeneering business, the applied geology, geo-physics and geochemistry. Therefore an integrated team of experts (geologist, geo-physicist, hydrologist, technician, analytical chemist, physician) is useful for the successful work in the field, the laboratory and the archive (MARSCH & KOLLMANN 1996).

The combination of methods depends on the characteristic of the geological water reservoir, its solved mineral-components, and its eventual gas content. Especially in the circumalpine region much effort has to be spent on the different geological formations.

Untersuchung - Aufschließung - Beweissicherung

Geländekartierungen
Aufschließungen (Schurf, Schacht, Bohrung)
Literaturerhebung

Seismik, Geoelektrik
Optische Luft- u. Satellitbildauswertung
Einbindung meteorologischer Daten

GP/WP - Untersuchungen in Feld u. Labor
Pol.mikr.DS - Untersuchungen
Isotopenhydrologie
Färbeversuche
KVA

Kluftgefüge - Analysen
Brunnen-/ Quellkataster
PV (Pu.,- Aufsp., Schüttungsmessungen)
Handbohr - Kampagne
Bachprofile

BL - Logs
Topographische Vermessungen
Bodengasmessungen

Datenauswertung u. -kompilation
Graphische Darst. der Ergebnisse in Plänen/Schnitten
Medizin.- hygienische Überlegungen

Langfristige Sicherung von Wasservorkommen:
Schutz der Gewinnungsanlagen,
Schutz und Schonung der Resourcen

Fig.1: Methods for investigation and exploration of underground water resources

3. RISKS AND PROBLEMS

Nevertheless there are **risks** during the phases of exploration, production and exploitation of mineral waters for sanitary purposes (see Fig.2)

The geological risk (reservoir-size, permability etc.) in the stage of exploration, the technical risk (drilling depth, casing program) in the phase of drilling (MARSCH et al. 1990, MARSCH 1996b) and the economical risk (production constance of quality and quantity, ecological dismiss) during the process of exploitation have to be taken in consideration.

If the right evaluation of risks is missed, planning and errection of engineering constructions in the circumalpine landscape (MARSCH 1999) may cause special **problems** in the stages of mineralwater exploration and production:

- delay of handling after cavity opening without wall support may cause the distension of slope mass-movement;
- far sinking of the water table in the phase of production may cause an input of surface water and O_2, reduction of mineralisation and change of gas content;
- no surface seal or bad surface seal against soil and atmospheric influences may cause organic alteration by influence of microbes;
- inadequate timing of different measures on the well - locations may cause delay of time, get complications, wasting money.

In every case the negative effect means costs are rising up.

GEOLOGISCHES RISIKO ....bei der Erkundung
Muttergestein
Speichergestein/Teufe
Poreninhalt
Klüftigkeit
Deckschichten

TECHNISCHES RISIKO ....bei der Aufschließung
Bohren/Verrohren
Meß-/Testphase
Förderung/Instandhaltung

ÖKONOMISCHES RISIKO ......bei der Gewinnung
Menge
Qualität
Bakteriologie
Juristische Parameter
Ökologische Entsorgung

ZIEL : Punktebewertung als Entscheidungshilfe
für unterschiedliche Explorationsziele

Fig.2: Geological, technical and economical risks in the stages of exploration, production and exploitation of mineral water resources

4. TYPES OF CONSTRUCTION BUILDINGS

Different **possibilities of constructing underground production buildings** for water resources have a considerable effect on the cost side of errection and working of the plant:

- The upstream part contains measures like slit, shaft or drilling borehole. Different engineering constructions: flat wells, deep drilling wells, deviated wells, horizontal wells, or even special constructions are used as a part of the underground production building (exploration of water resources);
- wall casing material and diameter, filter type and pump system must be adequate to the water-mineral-gas type (production of water resources);
- The downstream part is the tunnel system in the alpine region, also micro tunnelling, furthermore distribution pipelines, and eventual work over treatment plants (STEHLIK 1996) (transport and work over of water and gas resources).

5. LOGISTIC AND COST STRUCTURE

All these parameters discussed above influence the **logistic and cost structure of the mineral water exploration** process. Five steps of decisions are important (Fig. 3):

- Ranking of priorities (data collection and feasibility);
- Governmental restrictions (technical project planning);
- Erection of the first engineering construction;
- Evaluation of the discovered resource (which water for which purpose);
- Medical expertise for the right application.

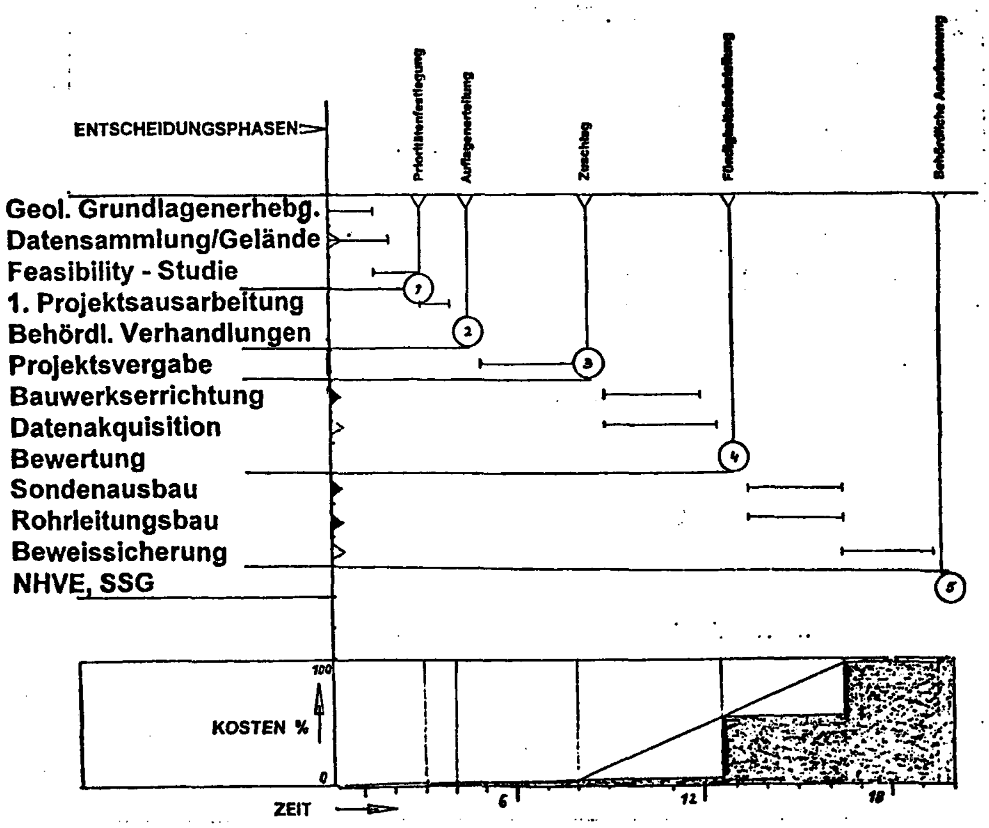

Fig.3: Logistic of the mineral water exploration

6. LONG-TIME-EVALUATION AND LONG-TERM-PROTECTION

Especially the **long-time-observation** of the underground reservoir is necessary for the propriate resources management:

- production rate (ls^{-1}) and cumulative production (m^3)
- sinking of water table (m below surface)
- eventual change of mineralisation (mgl^{-1}, μScm^{-1})
- temperature development (^oC)
- gas content (%)
- isotope content (^3H, ^{14}C etc)
- synchrone observations on neighbour wells

versus time over some months of a mineral water reservoir under investigation.

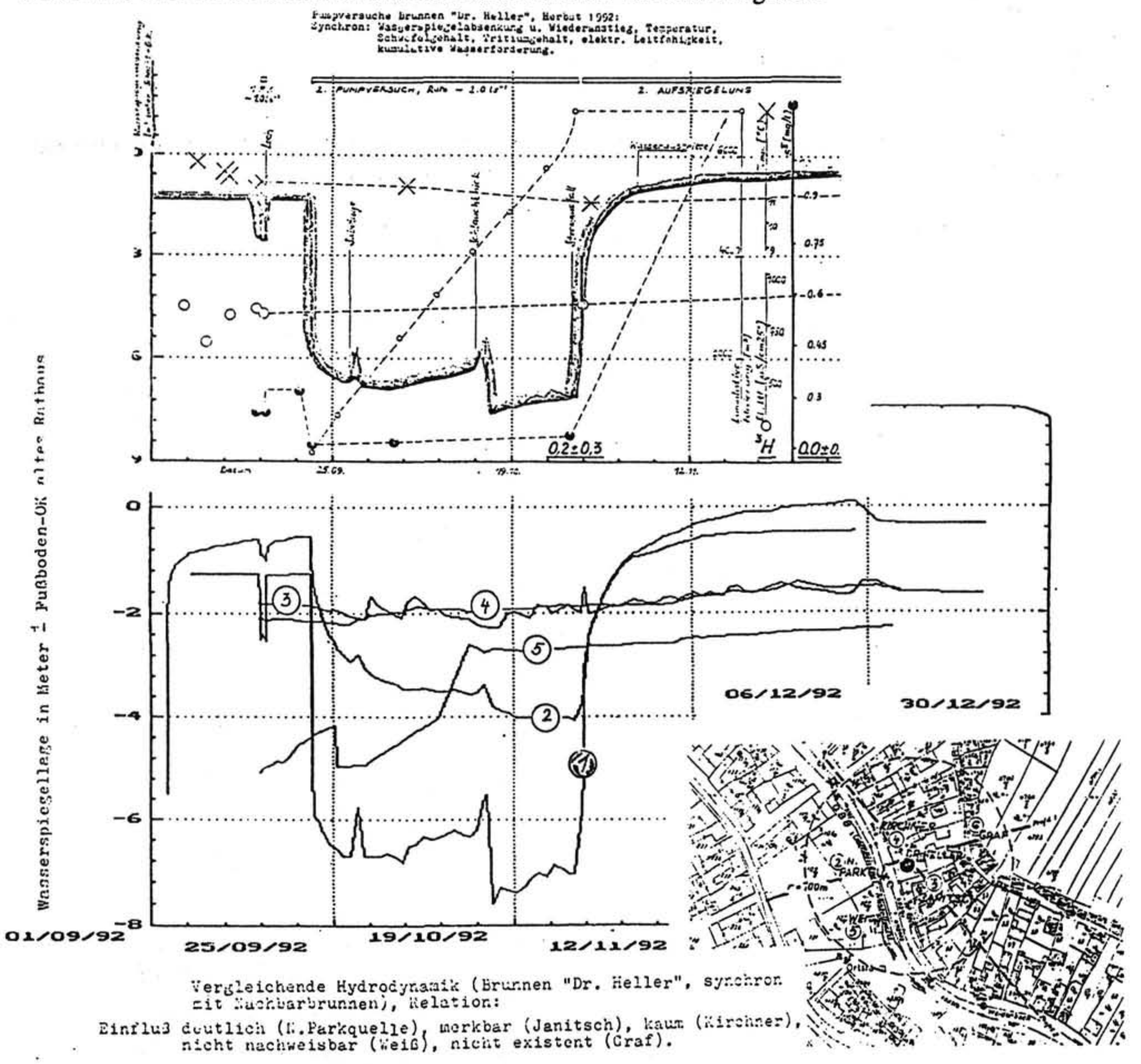

Fig.4: Long time evaluation of mineral water resources

The isotope element distribution can be used for additional evaluation of age and origin of the mineralized formation water. This evaluation is necessary to protect the production system, and to take care of the underground.

Long term protection (MARSCH 1997) of mineral water resources and the reservoir rock is necessary for the prevention of man-made pollution influence, and for mini-mizing geological hazards. Important targets are

- recognition of / prevention from aquifer alteration
- supply of water resources
- purity from micro organics and sediment of the produced fluid
- constant behavior in chemical characteristic
- simplification of upkeep process
- delay of eventual reconstruction

Last stage may be the **readjustment** of the underground building in the case of sani-tary or production problems. The right evaluation of above mentioned data supports the quick and secure handling of proceedings for the future successful production of additional resources. Advanced technologies show the way for propriate resources management.

7. INNOVATIVE CONTRIBUTIONS OF THE GEOLOGIST

In this publication the **innovative contributions of the geologist** to all these problems should also be mentioned:

- The possibility to applicate deep wells for special purposes.
- The application of technical progress to further production from aberrant aquifers:
  - from crystalline rock types;
  - from nappe boundaries or steep dipping tectonic fault systems (MARSCH 1995);
  - from aquitards;
  - from layered fluid reservoirs.
- The reinjection of fluids and gases for water disposal or pressure support in producing aquifers.
- The exploration for curative gases (CO_2, H_2S, Rn; MARSCH 1998) .
- The security protection of existing resources.

Fig. 5 finally shows the possibility for the organizing structure for special field projects in the discipline of fully integrated geomedicine: The connection between different contractors (drilling companies, logging specialists, laboratory chemists etc.), the report to the governmental representative, the scientific, technical and economical advices of the team of experts, and the cost control for the orderer under the management of a licensed technical planning bureau.

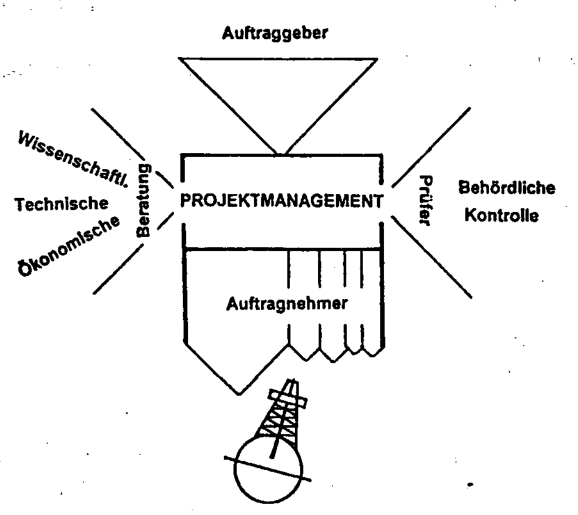

Fig.5: Possibility for the organizing structure for special field projects

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