THE CONTRIBUTION OF ISOTOPE-HYDROGEOLOGICAL INVESTIGATIONS TO MINING SAFETY

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ABSTRACT

Information about application of isotopes, stable and radioactive as well, with respect to mining and mining safety is given. The identyfication of undrground waters of different origin is possible and the correlation with open or closed hydrological systems real. A system of monitoring is represented.

Water-problems are nearly always relevant in connection with mining. It is necessary to dewater large open pit mines to enable mining, to prevent influx of groundwater or brines into mines, to use the precious resource groundwater and to recultivate after finishing the mining process. So there are a lot of problems concerning,

- the endangering of mining and mines
- the stability of slopes and shafts
- the balance of groundwater influx with respect to quantity and quality/mineralisation
- the exploitation and use of mine waters
- the groundwater protection in connection with discharge and recharge/groundwater uplift, respectively and recultivation.

Isotope hydrogeological methods, i.e. the application of environmental or artificial stable or radioactive isotopes in hydrogeology, are a useful remedy to solve such problems (1). By means of environmental isotopes as global tracers one has the opportunity to estimate genesis, groundwater flow-velocity and direction and mean residence time of groundwater as well (2).

These are a fundamental information, for mining in connection with groundwater with respect to safety and water management and environmental protection as well.

By means of stable isotopes such D and ^{18}O one can estimate the origin of water, mainly meteoric (cf. CRAIG-line) of different climatic conditions, i.e. different times. In connection with Tritium it is possible to identify open and closed

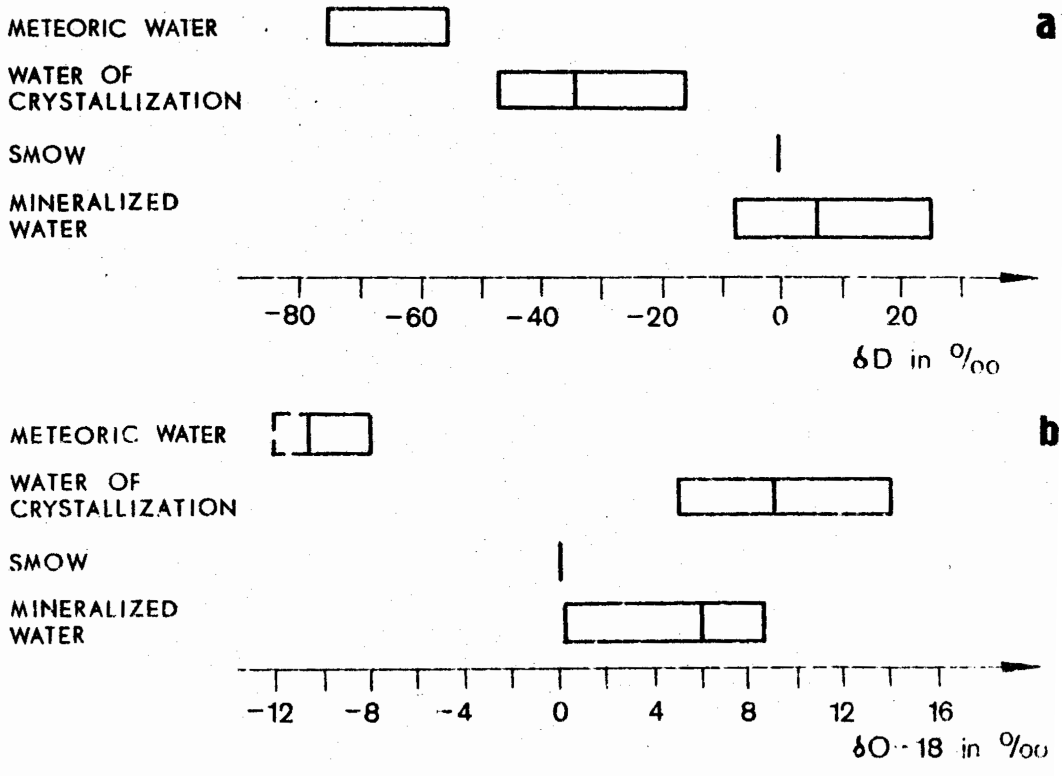

Fig.1 DIFFERENTIATION OF RECENT AND PALEOWATERS BY D AND ^{18}O (AFTER /4/)

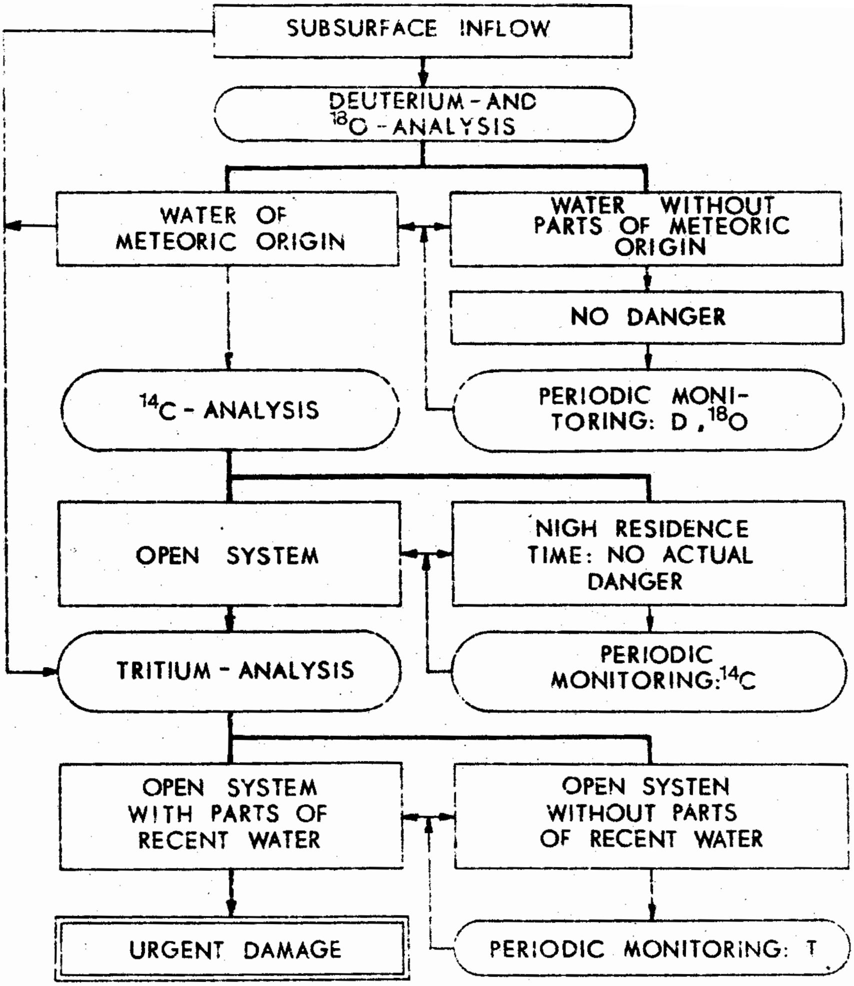

Fig. 2 Monitoring system by isotope investigation (after /3/)

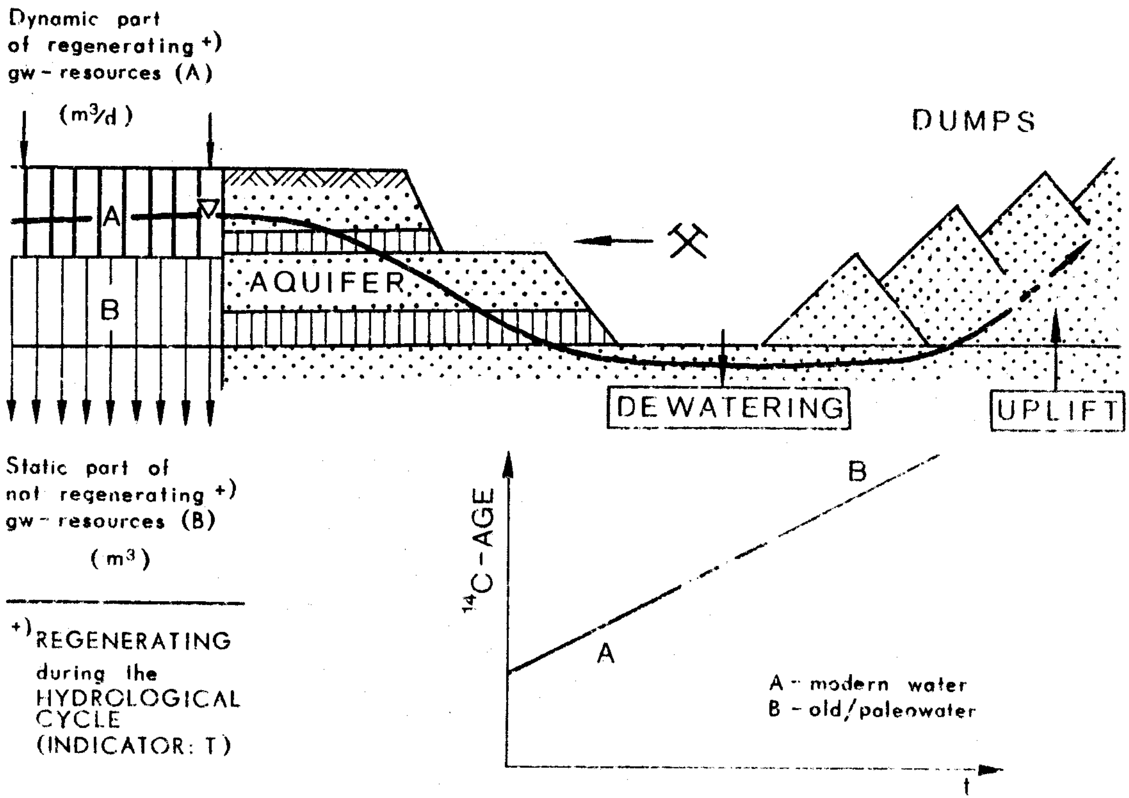

Fig.3 MODERN AND OLD GROUNDWATER IN CONNECTION WITH LIGNITE - MINING

hydrologic systems and hydraulic communications. The radionuclides T, ^{32}Si, ^{14}C with halflifes of 12.3 a, 105 a and 5730 a give the opportunity to date groundwater flow regimes in mining regions between 0 and 50.000 years. This unique method, based on the radioactive decay of these nuclides, which are components of groundwaters ($^{3}H^{+}$) or dissolved compouds ($HC^{*}O_3^{-}$; $Si^{*}O_2$):
follows the equation $C(t) = \int_0^{\infty} Co(t-\tau)\, f(\tau)\, e^{-\lambda\tau}\, d\tau$,

wherein $C(t)$ - measured concentration of a radionuclide
$Co(t-\tau)$ - input concentration
$f(\tau)$ - function of age-distribution.

The principle of interpretation is the following (3):

1. ^{3}H charasterizes waters infiltrated after 1952 (bomb-tritium). If there is no ^{3}H in groundwaters, the water is older than 35 years. If the ^{3}H-concentration in grounwaters is similar to those of actual precipitation with similar variations one can postulate a direct and fast hydraulic communication between groundwaters and surface waters.

2. ^{14}C-measurements and ^{32}Si-investigations as well, especially in combination with ^{3}H allow the determination of quantities of groundwater mixture of different ages and different origin (paleowater and young water).

3. By D and ^{18}O it is possible to differ recent and paleo-infiltrated waters, waters of different origin (Fig.1).

4. The ratio of $^{234}U/^{238}U$ characterizes very old paleowaters and the redox milieu. ^{226}Ra and ^{222}Rn are sensible indicators for faults and movements because of the high mobility of noble gases.

One of the most important and economically relevant problems is to identify the amount, origin and age of groundwater influx into mining areas. High quantities of recently infiltrated water are dangerous. They are characterized by high tritiumconcentrations, a high ^{14}C-content, δD between -55 and -80‰, $\delta^{18}O$ between -2 and -18‰.

Otherwise concentrations and rations, respectively, of relict waters paleowaters and crystal waters or interstitial waters as well are without tritium without or less ^{14}C; δD between -45 and +25‰; $\delta^{18}O$ between 0 and +15‰. Open and dangerous hydrological systems are indicated by recent meteoric infiltrations (4). If one suggests open systems hydrogeological, geophysical and geochemical investigations are necessary to save mining or to make it more sure. A isotope hydrogeological monitoring system is represented in Fig.2.

In connection with dewatering by mining and less water recharge old groundwaters out of recharge were exploited and the water balance becomes highly disturbed. Isotope-hydrological investigations are able to clarify the complicated groundwater origin, hydraulic communications between aquifers, groundwater age and residence time, respectively.

After dewasting the aquifers by browncoal / lignite-mining a hydrogeclogical landsoape of dumps remains and the most important task is to replenish groundwater to the primary level, the groundwater level uplift (5).

In humid zones it is real, in arid zones it seems to be impossible, because of less or no groundwater recharge. So we find in arid zones a more or less decreasing groundwater level as an irreversible process. The portion of modern water is an indicator for the degree of replenishment and trend of uplift. ^{14}C- and ^{36}Cl-dating gives informations about the regional and longterm dynamics. Result from these dating one can estimate the capacity of groundwater resources and the amount of dynamic / regenerating and static parts of groundwater balance (Fig.3).

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