1.6 Hydrogeology

Groundwater is worldwide the most important natural resource and hence deserves special attention. Groundwater is the source of 73 % of the drinking water supplies in Germany. Because groundwater is not uniformly distributed with respect to amount and quality – with respect to neither areal distribution nor depth – it is important to know the location and size of groundwater occurrences.

Hydrogeological maps show the complex system of water and rock, their properties and relationships. They show information on topography, geology, climate, hydrology, as well as on groundwater and aquifer properties of the rocks. There are two main types of hydrogeological maps:

- general hydrogeological maps
- special thematic maps (e. g. Map 5.1 "Hydrogeological Regions" and Map 5.2 "Groundwater Yields")

Methodology

The main source of data for the map was the digital 1 : 1 000 000 Geological Map of Germany (GK1000) (BGR 1993). This digital database provided stratigraphic, petrographic, lithographic and genetic data. The 292 map units of the GK1000 were reclassified according to hydrogeological criteria. Two fields were added to the existing database of lithological, petrographic, stratigraphic and genetic data: type of aquifer and a condensed lithology description. Permeability data corresponding to the Hydrogeological Mapping Guidelines (BGR & GEOLOGISCHE LANDESÄMTER 1997) and typical rock occurrences were included.

Because petrographic descriptions were not included in the descriptions of all of the geological map units of the digital GK1000, the petrographic data was supplemented with data from standard geological publications (e. g. WALTER 1992).
At some places on the map, the areas shown on the GK1000 had to be changed to better show the hydrogeological relationships. This was particularly the case in areas of loess and sand dunes, as well as a few places where hard rock crop out in areas of unconsolidated rock (Magdeburg and Torgau).

A problem with preparing a map of groundwater occurrences by hydrogeological interpretation of the petrography, lithology and petrogenesis of the GK1000 is that the GK1000 shows only the rocks outcropping below the soil. One of these problems is the classification of coastal marshes and areas of sandur in Schleswig-Holstein. On the hydrogeological map, therefore, the coastal marshes are classified as aquicludes and sandur areas are classified as aquifers.

Because data on thin near-surface deposits, e. g. loess, alluvial loam, marsh, and peat, does not provide sufficient information about the hydrogeological conditions in an area, such deposits are shown with a mixed symbol indicating the cover sediments and the underlying aquifer. Representation of the boulder clay and marl from the glacial periods in Germany is a special case. These are not shown as "cover", owing to the large variations in thickness, the large areas, the considerably varying lithology and associated fracturing.

The permeability of the rocks was quantified according to the Hydrogeological Mapping Guidelines (BGR & GEOLOGISCHE LANDESÄMTER 1997). Map 5.2 "Groundwater Yields" provides information for depth ranges derived from the yields of water works. This information thus has a different basis than the permeability classes shown on Map 1.6.

Data on salt water intrusion zones was taken from analog hydrogeological maps (1 : 1 500 000 International Hydrogeological Map of Europe, Sheet C4 – Berlin and the Hydrological Atlas of the Federal Republic of Germany 1978).

Map Structures

Map 1.6 is a 1 : 2 000 000 hydrogeological map. The aquifers are shown in two classes according to their area and productivity (expressed as permeability). A distinction is made between the different kinds of flow paths (pores, joints and fractures, karst cavities) in the rock (Fig. 1):

- *Pore aquifers*: mostly unconsolidated rocks (e. g. sand and gravel), in which the groundwater flows in the pores. Such rocks have a wide distribution, e. g. the North German lowlands, the Alpine foreland, the Upper Rhine graben, and in river valleys. They are geologically young rocks (less than about 60 million years) and were formed by glaciers or rivers.
- *Combined pore and fractured aquifers*: mostly sandstone (sometimes only partially consolidated), in which the groundwater flows in both pores and fractures formed after consolidation of the rock. They occur in the mountains of Hesse and in the Molasse basin of southern Germany.
- *Fractured and karst aquifers*: in hard rocks, e. g. limestone or basalt. The groundwater flows in fractures, which in limestone are made larger by dissolution of the rock. The best known examples are in the Schwäbische Alb and Fränkische Alb (Swabian and Franconian Jura) and in the Vogelsberg region.
- *Aquitards and aquicludes*: This group includes many kinds of rocks, which retard or prevent the flow of groundwater due to the absence of pores and fractures (e. g. clay and claystone, slate, granite). Large areas in which aquitards and aquicludes predominate are, for example, the Rheinisches Schiefergebirge, the Schwarzwald (Black Forest), and the Bayerischer Wald (Bavarian Forest).

In addition, outcropping rocks are classed in 19 types of rocks and four types of thin cover rocks.

Water-table contours in m above sea level are not shown owing to a lack of data in areas of consolidated rock.

Zones of saline water associated with salt beds in inland areas are shown on the map, as well as zones of salt-water intrusion along the coast. Areas in which the natural groundwater conditions are strongly affected by mining are also shown.

Further information about the kinds of aquifers, their thicknesses and depth to the groundwater table is shown on Map 5.1 "Hydrogeological Regions" and the accompanying columnar sections. The conditions for obtaining groundwater for the drinking water supply are good in most parts of Germany (Map 5.2 "Groundwater Yields").

Practical Information

The data on Map 1.6 "Hydrogeology" can be linked with other hydrogeological data. The digital data for this map is stored in the databases of the BGR hydrogeological information system together with other data, mostly at a scale of 1 : 1 000 000 and 1 : 200 000.
The methods used to prepare Map 1.6 are being used to prepare the 1 : 200 000 Hydrogeological Map of Germany.
The map is of special significance for fulfilling the European Water Framework Directive.

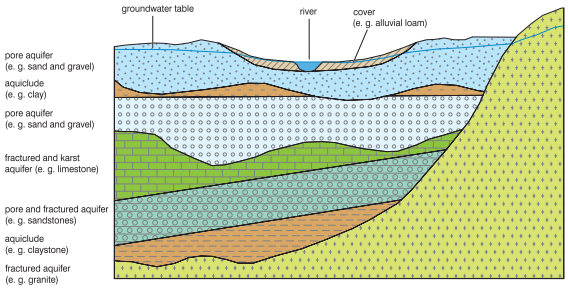

Fig. 1 Schematic representation of the aquifers according to the kind of groundwater flow paths