5.1 Hydrogeological Regions

The Map "Hydrogeological Regions" is divided into map units that can be described and distinguished on the basis of hydrogeological parameters, i. e. those parameters that describe the properties of the rocks and topography that determine the flow and chemical composition of groundwater. A standard columnar section gives the sequence of hydrogeologically important formations within the areas of each map unit, giving bed thicknesses, information about groundwater level and hydraulic conductivity.

Methodology

Map 5.1 "Hydrogeological Regions" depends, like Map 1.5 "Lithology" and Map 1.6 "Hydrogeology" on the digital data of the 1 : 1 000 000 Geological Map of Germany. The geological and lithological attributes were first interpreted in terms of their hydrogeological parameters. The rocks were then classified in terms of hydrogeological units. Therefore, the map units defined in this way correspond to the map units for large parts of the lithological map.

The surficial deposits shown on the lithological map, however, do not always contain groundwater. For this reason, the properties of the underlying rocks are also used to characterise the map units. Certain kinds of surficial deposits, e. g. loess and alluvial loam, are assumed to have a groundwater cover function. The boundaries of the underlying beds are derived from the geological map by interpolation.

Rock units that have similar permeabilities can have different hydrogeological significance, depending on the topography. For example, the amount and quality of groundwater in a sandy aquifer in a valley in the mountains is strongly determined by the properties of the surrounding slopes. It will be considerably less and of different quality than that in a similar sandy aquifer in the wide plains of northern and southern Germany. For this reason, the hydrogeological map units are defined as subunits of the major landscape units (Table 1).

Table 1 Hydrogeological characterisation of the groundwater regions

hydrogeological regions	
subregion	**hydrogeological description**
coastal region	
coastal dunes fine sand near the coast	pore-water aquifer with local fresh water occurrences in contact with saline water
coastal marsh clay and silt	low-permeability confining layer, usually overlying a saline aquifer
region of unconsolidated rocks	
river valleys urstromtals, low terraces	pore-water aquifers, usually high yield; at shallow depth
high terraces, sandur sandy geest	pore-water aquifers, usually high yield; sometimes subdivided by aquicludes
Tertiary basin sediments Molasse, fine sand and clay, lignite	pore-water aquifers, sometimes high yield; often affected in northern Germany by mining
moraines boulder clay, sand, end moraines	usually aquitards; large local variations in permeability
German uplands ñ slightly indurated rocks	
sandstones, conglomerates mountains and plateaus	groundwater in fractures, sometimes in pores; locally high yield
limestones mountains and plateaus	karst aquifer, often high yield from fractures and karst cavities
volcanic rocks volcanic cones, pipes, and lava flows	groundwater in fractures, seldom in pores; locally high yield from unweathered rock
marlstones calcareous marl and clay marl	aquicludes, low yield, moderately mineralised
gypsum and gypsum-bearing rocks Gipskeuper marl, Permian Gypsum	groundwater in fractures, usually low yield, highly mineralised; locally karstified
siltstones and claystones laminated silt stones, shale and clay	aquicludes, low yield
valley fill alluvial deposits, low terraces	pore-water aquifers, often with an alluvial loam cover; locally important groundwater occurrence
German uplands ñ strongly indurated and crystalline rocks	
dolomites and limestones usually only local occurrences	karst aquifer, often high yield from fractures and karst cavities
grauwackes and quartzites	groundwater in fractures, seldom in pores; normally low yield from fractures
highly jointed crystalline rocks granites, porphyries, orthogneises	groundwater in fractures, normally low yield, locally moderate yield; pore water in weathered rock
slightly jointed crystalline rocks paragneises, old volcanic rocks	groundwater in fractures, normally very low yield
slates crystalline schists, phyllites	aquicludes, closely spaced joints; no significant groundwater occurrences
tuff pumice, tuffite, basalt layers	aquifers, locally highly porous; high yield possible in valleys
valley fill alluvial deposits, low terraces	pore-water aquifers; locally important groundwater occurrences
Alpine region	
limestones, calcareous marlstones	Groundwater in fractures and karst cavities; usually at considerable depth
sandstones, calcareous sandstones	local groundwater occurrences in fractures
marlstones	aquitard, low yield
coarse gravel alluvial deposits, low terraces	often high yield pore-water aquifers

The standard sections

The standard columnar sections in 5.1 "Hydrogeologische Regionen – Typprofile I und II" show the underground structures in the different hydrogeological regions, complimenting the map by providing quantitative information for each region. For each map unit, a schematic lithological log was compiled from the published literature, showing the main lithological units in the area. Assignment of color is like on the map.

All rocks are assigned to one of the following hydrogeological units: aquifer (L), aquitard (G), and aquiclude (N). The aquifers are classified according to the type of porosity: pore-water aquifer, fissured aquifer, and karst aquifer. The aquitards are classified according to whether they consist of consolidated or unconsolidated rocks. A further distinction is made on the basis of the chemical properties of the rocks: predominantly siliceous, carbonaceous, sulphatic, or organic. These subdivisions yield ten classes of aquifers (L1 – L10) and six classes of aquitards (G1 – G6). Aquicludes occur only as the base of an aquifer and are not subdivided.

Permeability values and bed thicknesses are given, as well as the location of the groundwater table in unconfined aquifers or the potentiometric surface in the case of a confined aquifer. Because these values are averages from drilling data and depend strongly on the local situation, they can only give the order of magnitude. From the depth data, however, approximate values can be derived for the following hydrogeological parameters: thickness and type of cover, aquifer thickness and depth to groundwater table, and whether the aquifer is confined or unconfined.

Because the chemical properties of the aquifers and cover rocks determine the chemical properties of the groundwater, the boundaries of the hydrogeological map units were also used for the Map 5.7 "Geogenic Groundwater Quality".

Map Structures

The *coastal region* is characterised by the influence of the North Sea or Baltic Sea. There are limited groundwater occurrences on the North Sea islands, for example, owing to intrusion of saline water from the sea.

Large parts of northern and southern Germany are relatively flat *regions of unconsolidated rocks* (sand, gravel, boulder clay). Because the deeper rocks are usually not the same kind as the surficial deposits, this map unit is subdivided according to type of landscape: the river valleys in the Alpine piedmont regions and the urstromtals of northern Germany are classified together, and the high terraces in southern Germany and the sandy areas above the urstromtals in northern Germany are in the same class. Frequent changes in the groundwater cover (e. g. alluvial loam and peat) occur in these areas. Extensive areas of near-surface boulder clay are classified separately; however, major groundwater occurrences can exist below the boulder clay. Examples are the deep glacial erosion channels in northern Germany. Areas of unconsolidated Tertiary basin sediments are also classified separately. They are found mainly at the northern margins of the German Upland region and the Alps and in the Alpine piedmont. In many of these areas, their hydrogeological properties have been influenced by lignite mining.

The uplands between the coast and the Alps are divided into two regions with different hydrogeological properties:

The *region of slightly indurated rocks* contains mostly stratified Mesozoic rocks. In southern Germany, these are extensive areas of cuesta landscape, in which the stratigraphically successive hydrogeological units are adjacent hydrogeological map units. The valleys are thus divided into small branching units that must be considerably generalised at the small scale of this map. In northern Germany, these rocks have been folded into anticlines and synclines, yielding a different pattern of map units than in southern Germany.

The *region of strongly indurated and crystalline rocks* contains mostly Paleozoic rocks. These rocks are highly deformed at high pressure and temperatures; they have a very low pore volume and groundwater can flow only in fractures. Most of these rocks, except for the plutonic and high-grade metamorphic rocks, have few fractures. Local groundwater bodies occur in karst areas, in valley sediments, or in areas of tuff overlying the basement.

The *Alpine region* is a narrow strip along the southern margin of the map sheet. Owing to the high topographic relief, groundwater occurs practically only in the sediments of the valleys. Groundwater in the rocks of the ridges cannot be developed in wells; it flows from springs associated with fractures.

Practical Information

The boundaries of the hydrogeological regions are based on the properties of the rocks and are therefore generally not the same as the surface water divides, a fact which is shown on Figure 1. The boundaries of the groundwater bodies within river basins, as required for the implementation of the European Water Directive, can be obtained by overlaying a map of the river catchment areas on the map of the hydrogeological regions. Each groundwater body would consist of various hydrogeological regions or parts of them. The digital data needed to draw such a map in the scale 1 : 1 000 000 exist in the Bundesanstalt für Geowissenschaften und Rohstoffe.
For the elaboration of a more differentiated map in a larger scale, e. g. 1 : 200 000, the hydrogeological mapping units have to be subdivided further on, according to their regional characteristics.

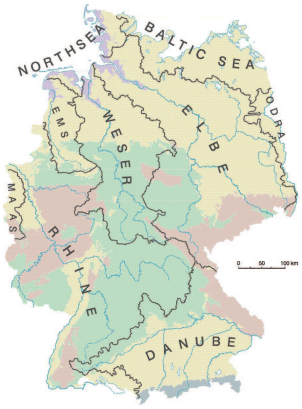

Fig. 1 Overlaying of the hydrogeological regions with first order river catchments