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# Combining hydrologic and geologic data to determine recharge areas in hard rocks, an example from the Eastern Alps, Austria

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Tectonic structures as faults and/or fault zones and slope tectonics take a great influence on water flow in hard rocks. They may represent hydraulic barriers or conduits, or a combination of both. Accurate predictions of water flow is often a critical aspect e.g. in tunnel design, the long-term stability of dams, and especially for determining recharge areas of springs as related to water quality protection. The discharge rates in respect to the topographic divided areas of springs (catchments) provide the understanding of the drainage directions of complex hydrogeologic systems. To determine the recharge areas (areas surrounded by groundwater-divides) the structural geologic data analysing the tectonics and the slope tectonics have also to be considered. With a conceptual approach hydrologic and structural geologic data were combined to determine recharge areas of springs draining a carbonatic fractured aquifer.

The investigation area belongs to the Sattnitz-Conglomerate-Plateau extending in the north of and parallel to the Karawanken mountain range as a tableland in the south of the Klagenfurter Basin. The investigation area is the western part of the Sattnitz-Conglomerate-plateau built up by carbonatic conglomerates with a thickness up to 200 m and an extent of approximately 6 km$^2$. The conglomerates are of pliocene age and are composed of coarse grained, mainly carbonatic components cemented with a carbonatic matrix. The plateau is completely underlayed by a premesozoic crystalline basement and grained miocene silt and clay sediments containing coal layers as a permanent aquicludefine. The area has no streams and drains mainly to the west and north over several springs. The major springs were equipped with data loggers measuring continuously discharge, electric conductivity and temperature over several years. The major spring, its discharge rangs between approximately 25 l/s to more than 400 l/s, is situated in the northwest of the investigation area and drains approximately 70 % of the investigation area. The catchment area (topographic divided area) of the spring is about ten times too small for the spring discharge in respect to the calculated discharge rates of the investigation area.

Based on the hydrogeologic mapping and the hydrologic monitoring data it was concluded that there exists a discharge superplus in the west and north of the investigation area and strong discharge deficit in the south and east. Based on the discharge monitoring of the springs the averaged discharge rate of the plateau was calculated by 15 to 20 l/skm$^2$. The investigation area is strongly influenced by faults and slope tectonics caused extensional structures on which karst morphologic phenomena like sink holes, dolines and depressions are bound.

A lineament analyses was conducted with a GIS based on a digital elevation model and then evaluated with field mapping. The lineaments were analysed structural geologically distinguishing between extensional and compression strain regimes. The strain attributes were assigned to the lineaments based on their orientation.

Concerning the results of the lineament analyses the topographic divided areas (catchments) of the major springs were iteratively enlarged to a possible extent of the recharge areas based on the calculated discharge rate of 15 to 20 l/skm$^2$. The so determined recharge areas show balanced discharge rates, so that the superpluses and deficits of the catchment areas could be balanced.