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Integrated Watershed Management - Geogenic and anthropogenic impact on the ground- and surface water quality in the Krom Antonies River- Valley, South Africa.

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Introduction

Hydrogeological investigations are the instrument for understanding interactions between groundwater and geology. Based on this, statements about water availability and -quality can be made as well as the influence of agricultural use and settlements.

Within the project Integrated Watershed Management Research & Development Capacity Building as part of the program Welcome to Africa by the German Academic Exchange Service, a field trip has taken place into the Moutonshoek Valley, a small catchment in the western part of South Africa in March 2013. In close cooperation with the University of Cape Town, the responsible authorities and local residents, 30 water samples were taken out of the ground- and surface water, prepared and transferred to Germany. In addition to physical parameters such as the pH, the temperature and the electrical conductivity, which were taken on site, a considerable anion and cation analysis was implemented.

Through the analysis and comparison of chemical distribution maps, geographical and hydrogeological cross-sections and geological maps, it was possible to determine the natural composition of groundwater to make an assessment of the impact of agricultural land use and settlement onto the groundwater quality.

Scientific question

The ambition of the master thesis was to improve the implementation of the concept of Integrated Watershed Management (IWM) into a catchment with an already established water management infrastructure. During the fieldtrip three major questions where developed:

- How does the geology in the catchment look like and what kind of waters are present?
- Comparing the up- and downstream- waters: What is the geogenic and anthropogenic impact on the water-mineral composition?
- What about the water-quality, if there would be less (ground-) water available depending on climate change or other impacts and could anything be done to keep the water quality in its state?

In particular it was planned to collect up to 30 water samples of the Krom Antonies River itself, wells (boreholes) and springs distributed equally from up- to downstream and points of interest (Fig. 1) for an anion-cation analyses and to gather physical parameters.

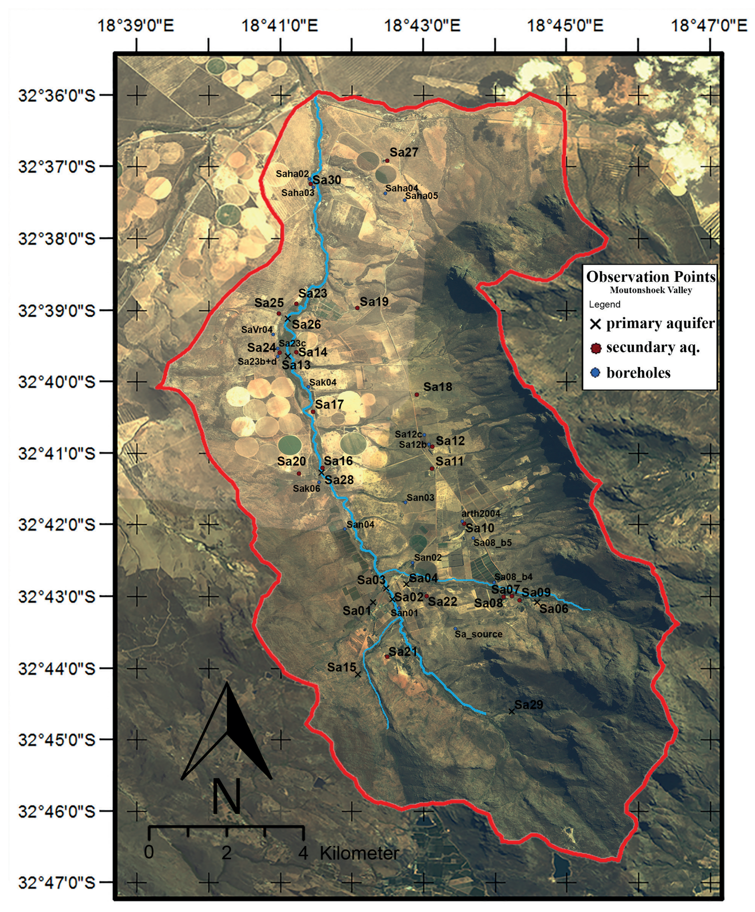

Figure 1: Selection of the Observation points in the study area. The black crosses are showing the position of shallow boreholes which only reaches the first aquifer about up to 20 m depth as well as river- and dam samples. The red dots are the positions of the boreholes deeper than about 20 m which reaches below the clay layer into the second aquifer. The map is based on LANDSAT images, edited with ArcGIS and image editing software.

Geology

The study area is bounded in the east, west and south by hills and mountains formed by quartzitic sandstones of the Table Mountain Supergroup, namely the Piekenier-, Graafwater- and Penisula Formation (1, 2). Due to the high resistance to weathering, the Table Mountain Rocks builds up the topographically highest areas of the study area. The basement, which is overlain by a few tens of meters of unconsolidated alluvial and clay deposits, is composed out of the lithologies of the Mal-mesbury Group (Piketberg Formation), a low- to medium grade metasedimentary sequence alternating Chloride Schist, interbedded diverse calcareous rocks and altered marble (3, 5). North-westerly trending faults in this basement induced the intruding of the Riviera Granite Pluton in at least one part of the study area (3, 4).

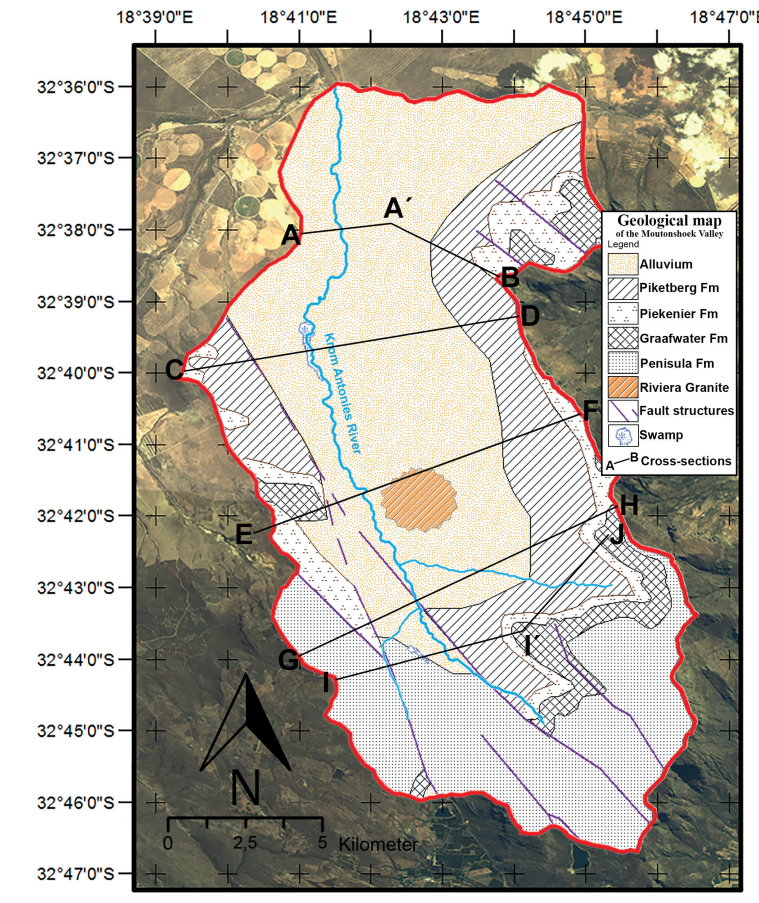

Figure 2: Geological map of the Moutonshoek Valley (after DE BEER 1990 and ROZENDAAL 1994). The estimated shape of the Riviera Granite is not representative. Imagery: LANDSAT prepared with ARCGIS 10.1.

Cross-Sections

The vertical exaggerated cross sections (Fig. 3-7) were modeled on the basis of the topography and geology. The expected groundwater head is based on a few available measured groundwater heads (and its interpolation), known borehole-depths and recorded swampy regions as well as the vanishing Krom Antonies River interpreted as the intersect between river and groundwater head.

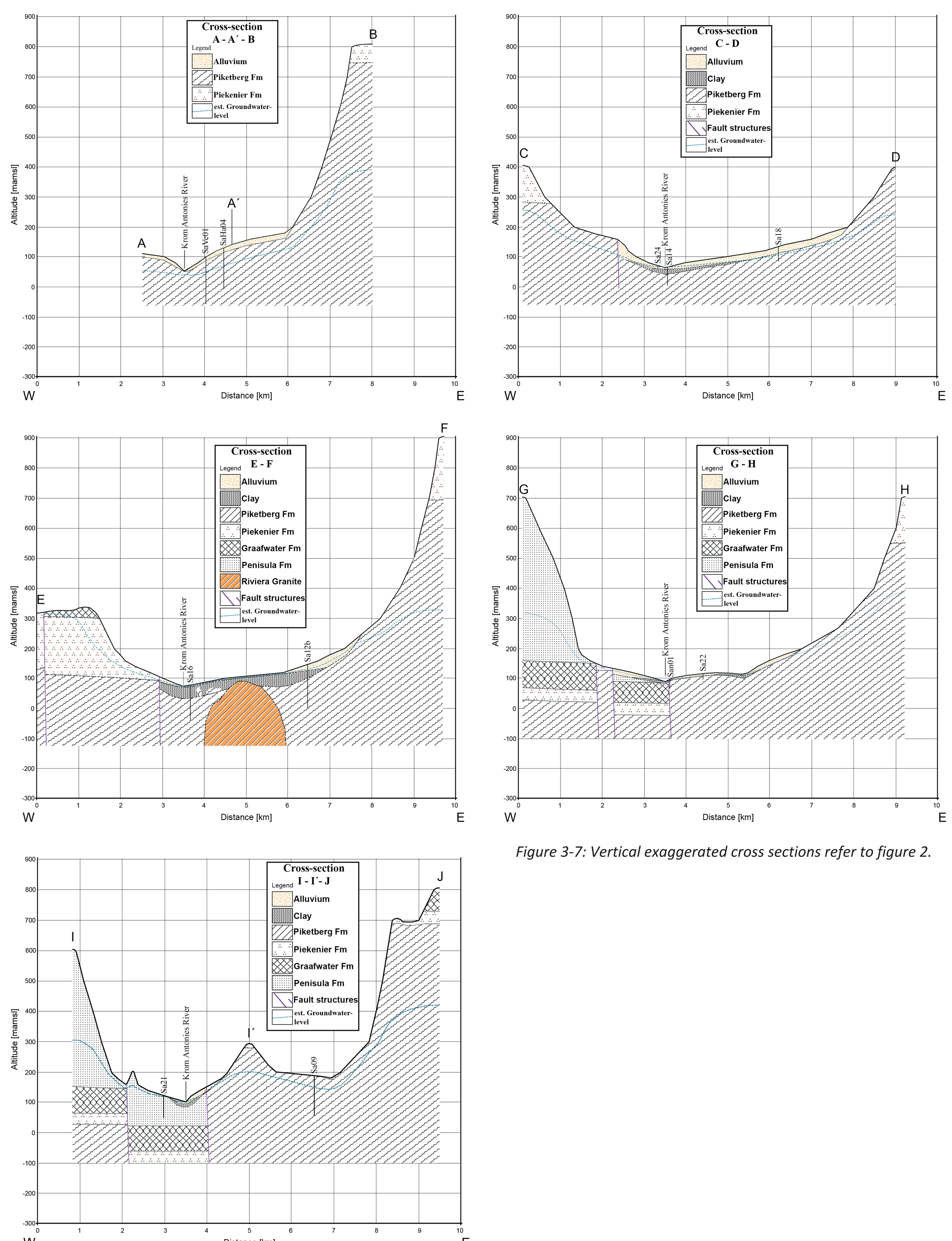

Figure 3-7: Vertical exaggerated cross sections refer to figure 2.

Hydrochemical distribution maps

The hydrochemical distribution maps are based on the results of the hydrochemical analyses of the observation points. Divided in the first- (river samples and shallow boreholes) and second aquifer (boreholes >20m), the spatial distribution of the anions and cations were interpolated with ArcGIS 10.1 using the Inverse Distance Weighting method afterwards by image editing to include basic boundary conditions like the topology, groundwater flow direction or connectivity between groundwater and river. Below the distribution of the conductivity is shown as an example.

All distribution maps can be seen in the master-thesis, available for download at: http://bit.ly/1FmDRmU

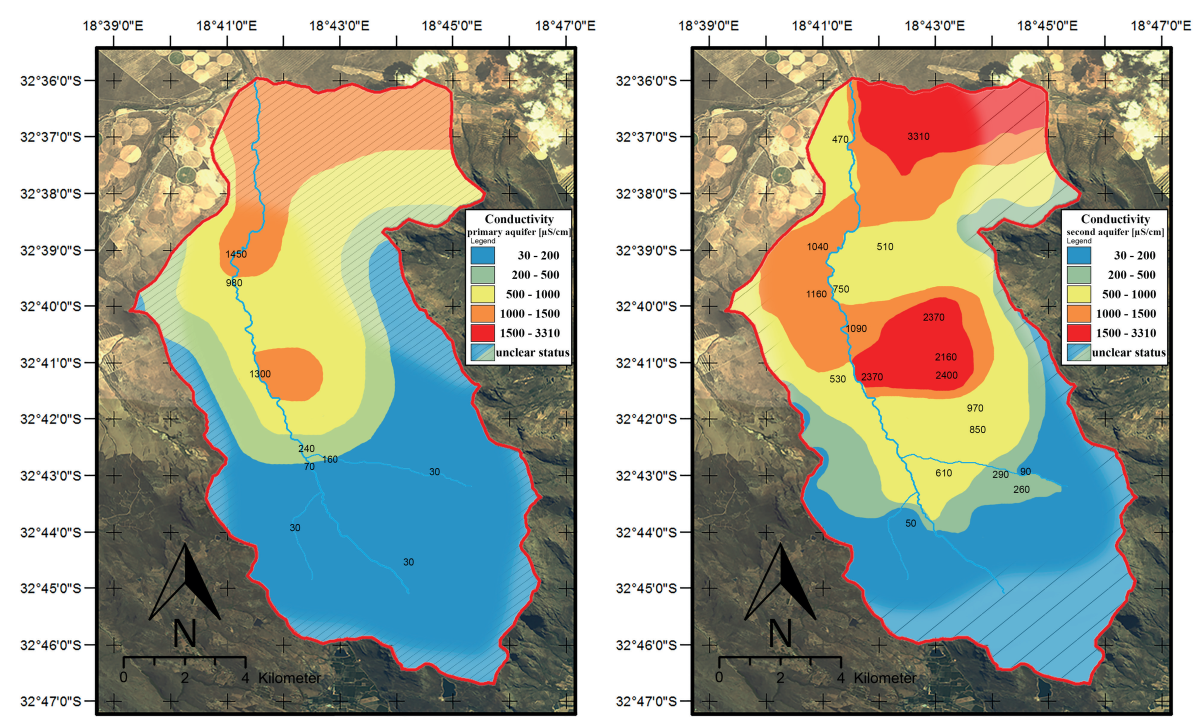

Figure 8 and 9: Spatial distribution maps of the conductivity in the second- (left) and primary (right) aquifer. The conductivity in the catchment ranges from about 30 µS/cm in topographically higher areas and upstream in the primary aquifer, up to 3310 µS/cm in specific locations. Probably influenced by surface runoff, the conductivity in the first aquifer increases slowly (Fig.24) up to 1450 µS in the last measured sample downstream. The second aquifer (Fig.23) got a conspicuous hot spot near the Riviera Granite Dome as well as in the direction of its groundwater flow.

Conclusions

30 ground- and surface water samples have been analyzed for pH, temperature, conductivity, nitrite, nitrate, ammonium, sulfur, hydrogen-carbonate and additive anions and cati ons (anions: chloride, sulfate, phosphate, fl uorine, bromine, silicon, sulfur; cations: calcium, magnesium, sodium, potassium, iron, manganese, arsenic, strontium). Of these 15 were irrigation wells, eight drinking water sources, six river spots and one dam sample.

The comparison of the primary and secondary aquifer along with the given geology has proven to be a great indicator to distinguish between human and geogenic impact on the ground- and surface water. The quality of the ground water in the catchment is high variable. This depends mostly on the host rock and the increased infltration of fertilizer downstream. The rate of the electrical conductivity, used as an indicator for water quality, extends from 30µS/cm upstream to 3300 µS/cm downstream. Downstream increased values of Chloride, Nitrate and Arsenic bonds caused by human and natural sources have been identified.

References

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[5] **Council for Geoscience South Africa** http://www.geoscience.org.za/

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