Exploration of water resources for Africa’s food production

The global demand for affordable food products increases steadily with the growth of the world population. However, the potential area of arable land is not without limits, which necessitate an increasingly intensive agriculture with the use of modern fertilizers.

Ever increasing efforts are put in the exploration and exploitation of the raw materials for the production of these fertilizers. Since decades the Danakil Depression in the northern part of the East African Rift system forms the focal point of geological investigations and small mining activities. The detailed exploration of potash for the purpose of fertilizer production was pushed forward only in the last decade by internationally operating mining companies. It became apparent that the combination of deep-lying potash and the hydrological conditions in the depression do not allow for open-cast mining. It became evident that the most suitable exploitation method for the potash transpired to be the so-called solution mining – where the potash salt is leached in solution wells by relatively fresh groundwater which is subsequently pumped into evaporation ponds.

The sustainable supply of suitable water for the leaching process is – apart from, obviously, the availability of potash – one of the central preconditions for investment security and the success of the mining enterprise. In the fall of 2011 the Canadian mining company Allana Potash requested Fugro Consult GmbH in Berlin to conduct a hydrogeological feasibility study for the investment, based on scientific data from newly to be drilled groundwater observation holes, water production wells and other investigative methods.

The investigation concept was developed in close cooperation with Ercosplan GmbH in Erfurt, a company specialized in consulting on planning and execution of potash exploration and exploitation.

Site Conditions

The East African Rift Valley extends from Mozambique in the south to Syria in the north. The rift structure is the result of the drifting apart of the Arabian and African Plates, which is still connected to the African Plate. The project area is located in the so-called Afar Triangle in the northern part of the Rift...
zone. Subsequently an over 1,000 meter thick salt sequence was deposited, of which the present day Danakil salt flats form result. The tectonic drift is accompanied by the genesis of major (for example Mount Dallol) as well as numerous minor volcanic structures.

The lowest-lying parts of the Danakil Depression are situated at ca. 130 meter below sea level. At the western boundary of the Depression a 600 to 800 meter high escarpment forms the beginning of the Ethiopian Highlands, which - after an interruption of some lower lying intermediary valleys – continue to rise to an elevation of more than 2,500 meters above sea level.

The transition between the highland and the salt flats in the depression is formed by vast gravel expanses in the form of alluvial fans, consisting of coarse grained sediments which are often cemented with silty material.

The existence of old wells supplying the village of Hamadela with water, as well as the results of mining efforts in the nineteen-sixties to the west of Mount Dallol, suggest that the water necessary for the solution mining could be extracted from the fan structures at the western edge of the depression. Given the high temperature in the depression – which can rise to 54 °C – as well as the very low precipitation rate, it can be assumed, a priori, that the water balance is negative. Therefore the main objectives of the investigation program were to determine the groundwater availability, the ground-water recharge and the groundwater quality.

Figure 1: Canyon in the fan structures at the western edge of the Danakil salt plain

Figure 2: Nordmeyer DSB 3/14 drilling rig (NBB Hamburg)
Investigation program
The investigation program was executed between 2012 and 2015 in the following work stages:

■ A geophysical investigation with transient electromagnetics up to a depth of ca. 400 meter.
■ A geological structural analysis, based on satellite imagery, for the identification of hydrogeological relevant tectonic elements.
■ The determination of water balances of the topographical catchment areas.
■ Drilling operations for the construction of groundwater monitoring points.
■ Drilling and construction operations for pumping wells for pump tests and later use as water supply wells.
■ The execution of 42day aquifer stress pumping test with monitoring.
■ Water sampling from all wells for the analysis of inorganic parameters and isotopes in order to determine the quality and genesis of the groundwater.
■ Groundwater modeling for estimating the water balance components.

Results
As a result of the investigation activities it could be established that considerable volumes of groundwater are present in the fan structures to the west of the salt plain that are suitable for the leaching of potash. Water with a mineralization unsuitable for human consumption can still be used for potash solution mining.

The pump tests, the isotope investigations and the geohydraulic modeling results revealed a considerable groundwater recharge from the adjacent Ethiopian highland to the fan structures. The recharge was estimated to be sufficient to cover sustainably the total yearly water demand for the operations of the mining company. In principle the water is abstracted and used before it can evaporate in the salt plain, as it would have done as well without potash mining.

With the internationally aligned team from Fugro Consult GmbH, Hamburg based drilling company NBB Nord Brunnenbau and African Water from South Sudan it has been shown that drilling and well construction activities can be performed far from the domestic market, without making concessions to the quality standards.

Further information: www.fugro.de