A geophysical investigation for sustainable water management

With the realization that human exploitation of the planets resources has put us in an unsustainable situation, with ever increasing global temperature, erratic weather patterns and droughts, geophysical investigations are more important than ever before. Instead of having to dig through soils or bore expensive holes in the ground, geophysical methods provide an abundance of information about the subsurface at great depthsBAckground. About the

This particular article focuses Transient Electromagnetic Method (TEM) that has been used in an attempt to map geometrical properties of a so called alluvial fan in Punata, Bolivia. Alluvial fans are deposits of unconsolidated material, such as gravel and sand, that form where a river from a mountain reach flat land, allowing all the suspended material settle in a plume shape. These formations often hold great amounts of groundwater, which can be exploited for human benefit. Such is the case in Punata, where the rapid agricultural and population growth has led to overexploitation, with sinking groundwater levels and water shortages.

In order to know how much water the fan actually holds it is important to know the distribution and depth of material with different grain size. Gravel allows for a lot of water to be stored, while finer material such as clay do not let water pass through easily. So how do you know what is beneath the surface without digging? Well fortunately, gravel and clay not only transport water at different rates, but also electricity. Clay is very conductive while gravel is more resistive (does not conduct electricity very well). By sending a magnetic field into the ground, electricity will be induced in the subsurface depending on how resistive it is. The current in the ground will create a new, proportional, magnetic field which can be measured by the TEM-instrument. By running mathematical calculations on the measured data it is possible to create a so called resistivity-model which show how poorly the ground conducts electricity at different depths (Fig 1). With the model in hand it is possible to make assumptions of material type and depth.

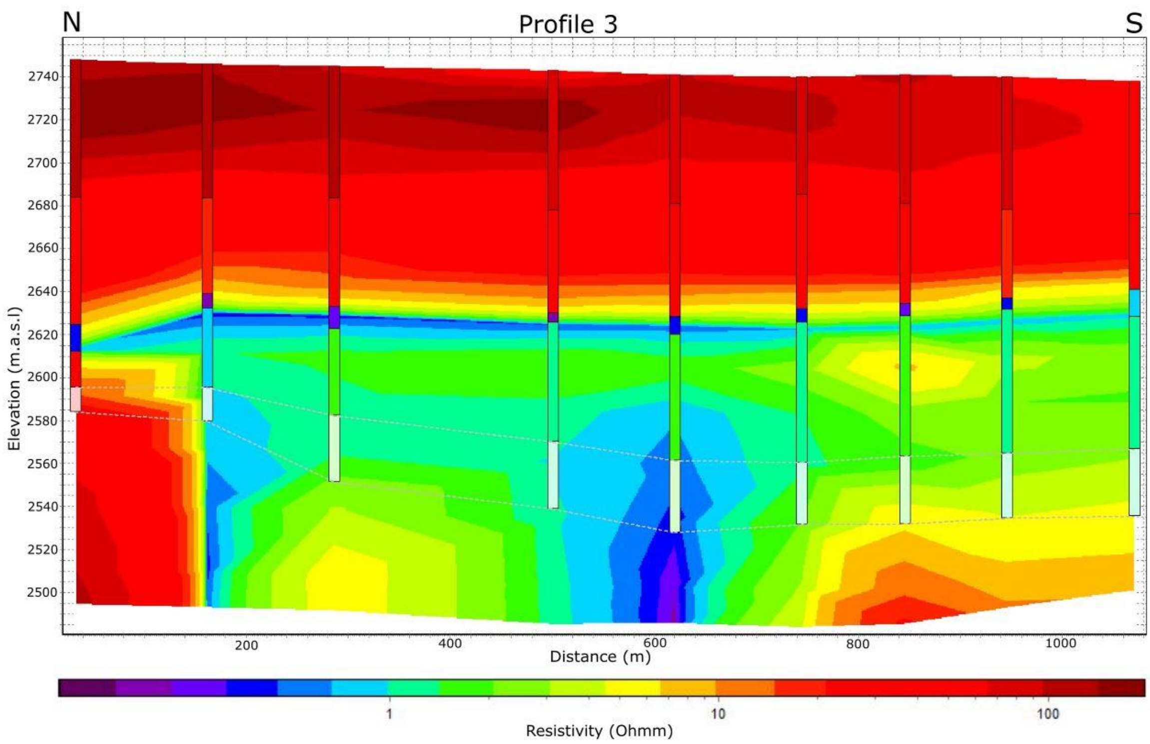

Fig 1. This is a typical resistivty profile created with TEM. The y-axis is meters above sea level and the x-axis represents the distance along the profile. The different colours represent resistivty, which means red parts are less conductive than green and blue parts.

Figure 1 is an example from the Punata alluvial fan where you can see that the material above 2640 meters above sea level (m.a.s.l) has a fairly high resistivity (30 – 2000 Ohmm) and then it very suddenly becomes <1 Ohmm. However, the very low resistivty is only in a thin horizon and below the resistivty increases again. As we know it is an alluvial fan and what material could be expected, this profiles tells us that the top layers (red) consists of gravel and sand, and the green/yellow parts is clay. Now the important discovery is the very thin line of something even less resistive than clay, which can only be brine. Brine is water with salt content much higher than seawater which allows it to conduct electricity very well. It is also much denser than freshwater (no salt) which means it will always sink to the bottom. If the clay beneath it could transport water, the brine would sink even further, but because it does not, we know that it represents the bottom of the groundwater reservoir.

Of course not every detail will be told through these kind of profiles, but it is a fast and efficient way to get a hint of what you are dealing with.