Geologic remote sensing and geothermal resources

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Radioactively generated heat in the core of the Earth is the driver of the Earth's internal heat engine. Heat moves to the surface through conductive and convective processes.

Typical temperature gradients in the Earth crust are in the order of 25 to 30 °C per kilometer depth (equivalent to a conductive heat flux of 0.1 MW/km2). However, near tectonic plate boundaries specifically near diverging plate boundaries (like in active rift systems such as the mid-Atlantic rift and the East African rift), converging plate boundaries (subduction zones; Indonesia, Philippines, Chili), and along recent volcanic in intraplate settings (Hawaii, Yellowstone/US) volcanic activity results in gradients as high as 150 °C per kilometer depth.

These high gradients through magma conduits trigger fluid circulation from fresh water from precipitation, ground water, lake water intrusion (meteoric water) which results in hot springs, steam vents. Heat from geothermal reservoirs can be used to generate energy (electrical power) by using the steam to drive turbines in case of high temperature (>200 °C) reservoirs.

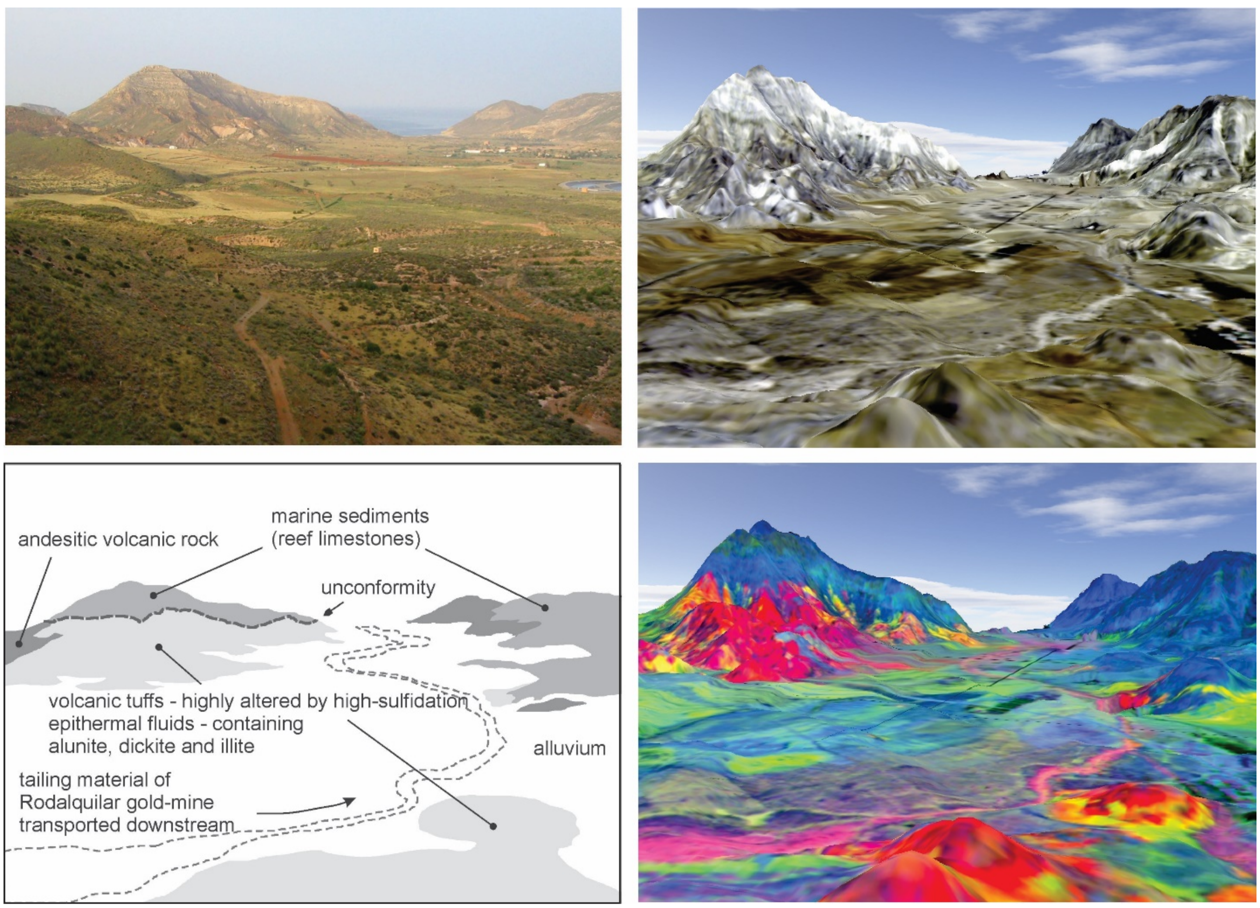
In case of normal geothermal gradients (30 °C /km) and low (<150 °C) temperature reservoirs, heat can be used for direct use involving heating of buildings, drying of agricultural products etc. Geothermal generated energy has a number of benefits: it is renewable, it provides a stable base-load power for several decades and it is environmentally friendly with low carbon dioxide emissions compared to alternatives like fossil fuels.

The geological remote sensing group of ITC has been active in scientific studies of mineralized hydrothermal systems in relation to understanding ore formation for many years. Recently we embarked on research using remote sensing to study geothermal systems. There are a number of ways geologic remote sensing can be used.

Optical and hyperspectral remote sensing of the earth surface enables the mapping of mineral alteration related to understanding geothermal processes. Thermal remote sensing makes it possible to map temperature anomalies related to geothermal manifestations such as hot springs, fumaroles etc. whilst emissivity spectra also enable the mapping of minerals (quartz, feldspars etc) that are spectrally featureless in the SWIR.

Downhole hyperspectral (combined SWIR-TIR) imaging of drill cores of geothermal systems provides further insights into the subsurface temperature and geothermal potential. SAR interferometry is a means of monitoring the geophysical behavior of geothermal reservoirs during exploitation of the resources. Long term monitoring of geothermal systems allows to look at seasonal and long term effects of climate change on systems behavior.

The interested reader is referred to a recent review paper the group has published (van der Meer, F.D., Hecker, C.A., van Ruitenbeek, F.J.A., van der Werff, H.M.A., de Wijkerslooth, C. and Wechsler, C. (2014) Geologic remote sensing for geothermal exploration : a review. In: International Journal of Applied Earth Observation and Geoinformation : JAG, 33, pp. 255-269).



Top left: field photograph Rodalquilar hydrothermal system, Top right: 3D perspective derived from HyMAP data, Bottom left: geology of the area, Bottom right: reddish colors are high-sulfidation mineralization, green colors are lower temperatures dominated minerals, Blue colors are unaltered volcanics (Image maps are produced by Frank van Ruitenbeek)

Since 2014 ITC has led a bilateral Netherlands-Indonesian project with 11 partners from academia and industry developing curricula and conducting research to advance the uptake of geothermal resources in Indonesia (www.geocap.nl). More recently ITC signed an MOU with the Kenyan Energy Company KEnGEN responsible for geothermal energy production from the Olkaria and related fields in central Kenya.

In 2017 ITC was awarded the Tanzania Dutch Energy Capacity Building (TDECB) project that develops a series of activities in Tanzania to help them set up sustainable energy education and knowledge infrastructure to enhance their curriculum in energy related topics. The TDEBC project centres on training staff, developing education and research programmes, investing in equipment, and improving the gender balance. The project offers a solution for the Tanzanian shortage of well-educated people in the energy sector.

Oil and gas are not great for the environment, but are preferable to coal and charcoal, which are mainly used now in Tanzania. Clever use of oil and gas reserves allows the revenues to develop renewable energy sources such as geothermal and solar energy in the future.

The project led to the launching of the Tanzania Energy Platform which is a knowledge infrastructure for energy and energy related topics in Tanzania. The Honorary Chair of the Platform is Vice-President of Tanzania, Prof Dr Samia Suluhu Hassan, the Platform features membership of educational institutes and Tanzanian and international companies and organizations involved in energy production in Tanzania. The platform regularly organises workshops, will discuss and advice on energy topics, and maintains a website (https://energyplatform.ne.tz/).

In the near future we aim to extend these activities to other African countries in the east African rift tectonic area. Geothermal energy provides a stable base-load power that is environmentally friendly with low carbon dioxide emission. Besides standard geophysical and geochemical exploration methods, optical SWIR mineral mapping, TIR temperature/heat flux measurements and InSAR subsidence monitoring can aid in exploring geothermal fields.