Project: Glasgow University Rift Valley Expedition (GURVE)

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The aim of GURVE was for a 12-person strong team to explore geothermal sites situated within the East African Rift (EAR). The initial scope of the project was to visit the Butajiri-Silti Volcanic field in Ethiopia and the Menengai Shield Volcano Caldera, Kenya (Fantale). Due to logistical and budgetary constraints the GURVE expedition ultimately focused solely on Menengai, which allowed for additional and more thorough exploration of the surrounding region. The leadership team for the expedition consisted of Dr. Neil Burnside (academic supervisor and regional hydrological research program), PhD candidate Helen Robinson (caldera geochemistry and logistics) and 3rd year undergraduate Hillary Mulholland (geological mapping). During the trip the student team member where split into 3 groups and rotated between each of the group leaders for their respective areas of work. The funds awarded by the GNHS contributed to the team's accommodation costs in Kenya.

The East African Rift (EAR) runs the length of Ethiopia, Kenya, Uganda, Rwanda, Burundi, Zambia, Tanzania, Malawi and terminates offshore of Mozambique. Rift extension in this area has led to a thinning of the Earth's crust and allows for hot buoyant magma to rise closer to the surface and heat local groundwater, providing a large potential resource for geothermal energy. Kenya has embraced this resource and has enthusiastically pursued geothermal development in order to provide low-carbon and sustainable energy to its people.

Menegai Volcano is situated 10km north of Nakuru, the 4th largest city in Kenya, and thought to have last erupted ~350 years ago. From 1997-2000, satellite radar imagery recorded proximal land deflation which may indicate magma draining from the surface. Magma drainage and localised lowering of pressure can potentially lead to caldera collapse and explosive eruption. Other recent activity, such as steaming and altered grounds, micro-seismicity, fumarole activity, and high subsurface temperatures (150°C/km as compared to global average 25°C/km), provide substantial evidence to suggest there is a superheated body of magma at shallow depths.

The main goal of the expedition, carried out between the 20th of June and 9th of July 2016, was to give the student members a flavour of geological and hydrological investigation and field work. The main hope was that the work carried out during the trip would provide a baseline for further scoping work and ultimately robust evidence for major grant applications. The students were split into three groups of three based on their degree programme, course level and long term career interests. Each group spent 3 days with their group leader to focus on either hydrology, soil gas or geological mapping work. The rest of this report will focus on the hydrological part of the trip as that was under the current authors supervision.

Water characterisation can be used to help identify the scale of a geothermal resource, optimal target extraction points and provide advice on the best strategy for geothermal operations (e.g. reinjection of water to manage reservoir pressure). Water chemistry can also provide key information on water provenance, water-rock interactions and subsurface mixing processes- in essence it can be used to determine connectivity between surface and subsurface water bodies. The hydrological team visited many locations throughout Nakuru and Baringo Counties and secured a total of 45 samples from surface water bodies (including rivers, lakes, and thermal springs) and geothermal test wells (currently venting to test flow rates). Water physiochemistry (temperature, pH, conductivity, alkalinity) will be determined in the field (using Ultrameter and digital titration) and collected samples were later analysed for major anions and cations, silica, heavy metals and stable

isotopes within the University of Glasgow School of Engineering and the Scottish Universities Environmental Research Centre (SUERC).

One of the issues being tackled with these analyses is potential geothermal related flooding of Rift lakes. Since 2013, five of the nine lakes along the rift have rapidly risen by up to 3m. The flood levels have thus far shown little sign of receding and it is unlikely that regional rainfall (900mm/y) can be solely responsible. Local residents have reported negative impacts on homes, businesses, wildlife and tourism in response to the flooding. Rising reports of poor health conditions, such as stomach pains and tooth damage, may also be linked to these flooding events. A major indicator of hydrothermal contamination is elevated concentrations of fluoride, so this is being investigated as part of the analytical programme.

Student team members observe health and safety advice whilst visiting a venting geothermal well in the Menengai Caldera.

Caroline Crawford gets the celebrity treatment as she explains the science behind the Lake Bogoria Hot Springs.

The trip has been a resounding success, and the team is very grateful to GNHS for their contribution. The students really enjoyed their time in Kenya, and the experience they have gained will serve them well in their future endeavours. The analytical work has been completed and the results are currently being interpreted, written up and used to support on-going grant applications. The experience that the author has gained from this trip has already been put to good use as it has formed the basis for two successfully awarded scoping study grants (£40k EPSRC ISF, £7.5k ESRC IAA) associated with building evidence for major Global Challenge Research Fund (GCRF) proposals.