

## **Expert Council and Fieldwork Blog: focusing on fenites and geophysics as exploration tools; Chilwa Alkaline Province, Malawi**

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The Chilwa Province in Malawi is famous for its early Cretaceous carbonatitic and alkaline volcanism in addition to the excellent exposure of fenites (metasomatically altered rocks surrounding these complexes), providing a perfect destination for another HiTech AlkCarb Expert Council. Project partners from Mkango Resources Ltd, Alex Lemon and Will Dawes teamed up with SoS RARE partner, Sam Broom-Fendley from the Camborne School of Mines to lead over 49 expert geoscientists on fieldwork to six volcanic complexes.

Recent geophysical exploration surveys have shown that Malawi's mineral research potential could be greater than previously thought. Having issued more than 180 exploration licenses up to July, 2016<sup>1</sup>, interest is certainly building in regard to the potential new deposits of REE, uranium, niobium, copper and iron that are thought to lurk beneath Malawi's dusty surface. However, despite interest and recent investments, the contribution of minerals to Malawi's GDP remains low at less than 1 % since 2012<sup>2</sup>. As a result, much excitement surrounded the HiTech AlkCarb workshop in Zomba, as the largest geological research conference ever held in the country, with 10 of Malawi's leading geoscientists joining experts from around the world.

Lying at the southern end of the East African Rift system, the Chilwa Alkaline Province consists of a range of rock types including carbonatites, nepheline syenites and peralkaline granites in a basement of Precambrian gneisses and granulites<sup>3</sup>. Complexes are exposed at an intrusive erosion level, above the magma chamber with many dykes and breccia vents visible.

### **Day 1: Arrivals**

Upon arrival, the project team were greeted by the long sweaty lines of the Malawi passport/visa border control before being whisked away in a fleet of 14 4x4 off road vehicles and taken to the beautifully situated Sunbird Kuchawe hotel and conference centre on top of Zomba Mountain (fittingly, a large Chilwa alkali granite). After many had journeyed for over 48 hours, workshop attendees showed their commitment by sitting down to the first HiTech AlkCarb seminar session introducing the geology of Malawi. Talks were opened by Dr Alan Woolley of the Natural History Museum, a world renowned carbonatite specialist who has undertaken much work on the fenites surrounding carbonatites in Malawi. Following up on this geological overview, Sam Broom-Fendley prepared the group for what they would see at Songwe Hill the next day and Will Dawes from Mkango gave an exploration company's perspective on the Malawi prospects.

### **Day 2: Songwe Hill**

The Songwe Hill carbonatite complex is the flagship deposit of project partners Mkango Resources with a combined indicated and inferred REE resource estimate of 32 million tonnes<sup>4</sup>. After introductions between local and visiting geologists, the team were ferried up to the top of Songwe. In the meantime, a brave group of aspiring climbers braved the heat and steep slopes of the



*Trucks climbing the steep slopes of Songwe Hill*

then had the rare opportunity to view one of Mkango's halved drill cores displaying carbonatite as well as veined and brecciated fenites. Meanwhile, a breakout group ventured ~500 m from the camp to Chenga Hill to see a large breccia locality hosting extremely HREE-rich apatite.

Fieldwork started and finished before nightfall due to the distance of the complexes from Zomba and how dangerous the roads are at night – teeming with people, unlit bicycles, goats and chickens! This meant time for another early evening seminar session in which Sam Broom-Fendley discussed HREE (Heavy Rare Earth) mineralisation at Songwe Hill and Prof Frances Wall introduced monazite-rich carbonatites at Kangunkunde.

### **Day 3: Mantrap and The Knoll**

These two complexes lie within 1.5 km of Songwe, therefore we heard the same cries of “Azungu, Azungu!” (meaning white person in the native Chichewa language) as the day before, whilst kids waved at the convoy of 4x4 vehicles driving through their villages.



*Convoy driving through the villages*

carbonatite and almost made it to the top before the trucks returned for them. Trenches on the top of Songwe Hill revealed an outcrop of ankerite and synchysite-rich carbonatite, named ‘the tip of the iceberg’ by the Mkango team, surrounded by bright red altered fenite. Climbing back down the hill meant passing through a swathe of low grade fenite breccias before hitting large intrusions of late stage REE rich carbonatites containing fenite clasts and manganese veins. Returning back to the exploration camp, the group



*Songwe's 'tip of the iceberg' carbonatite surrounded by red fenite*

Mantrap is a confusing and poorly studied complex with large outcrops of breccia juxtaposed against basement gneiss, but has been identified as an area enriched in HREE by Mkango Resources. Phonolite and syenite also intruded into the basement gneiss and HREE-rich veins have been observed on The Knoll, consisting predominantly of calcite and associated with quartz lenses.

Following our morning excursion we were welcomed to the local school where Aoife

Brady, a previous Mkango Resources Chief Geologist, had funded 4 newly painted classrooms by running the London marathon.



*Local children in the classroom painted by sponsorship from Aoife Brady*

#### Day 4: Seminars and Sandpit Discussions

The session on geophysics was opened by Pete Siegfried, a geologist that has worked extensively on carbonatites and alkaline rocks across Africa, who talked about how geophysical techniques play a role in the search for and understanding of these complexes. After lunch, the fenite session was introduced by Alan Woolley, who has arguably seen more of these baffling metasomatic rocks than the rest of the room combined.



*Left: Alan Woolley showing fenites from Chilwa Island – photo credit: Eimear (NERC).*



*Right: Will Dawes from Mkango Resources discussing with geophysicists how to improve methods of searching for alkaline complexes – photo credit: Dylan McFarlane*



*Small-scale miner displaying wares of quartz, aegirine and zircon*

Throughout the previous days, workshop members had been writing questions and ideas to be discussed on post-it notes which were gathered together in the afternoon. ‘The Sticky Revolution’ was policed by Kate Moore of CSM, ensuring everyone was silent as they grouped the post-it notes into topics for discussion. Arranging themselves on to tables to discuss topics that most interested them, heated discussions then ensued within groups as workshop members tried to agree on which questions were the most important for future research.

Remaining at the hotel for the day provided an excellent opportunity to pour over the wares of small-scale miners that had come to display their crystals to a large group of appreciating expert eyes. These miners often face dangerously high cliffs and sheer edges in order to source the largest and highest quality crystals.



*Group photo of HiTech AlkCarb workshop attendees in gardens of Sunbird Kuchawe Hotel*

### **Day 5: Kangankunde**

Kangankunde contains the highest concentration of LREE in the Chilwa Province and was studied in detail by Prof Frances Wall for her PhD. The Ministry of Natural resources Energy and Mining very kindly arranged for our workshop to visit Kangankunde. Geologists soon turned into kids upon arrival as each hammered apart boulders of monazite-bearing ferroan dolomite carbonatite to find the shiny green monazite crystals.



*Monazite crystals (green) within ferroan dolomite carbonatite at Kangankunde Sunbird Kuchawe Hotel*

Drillcore collected in the 1980s by the French Geological Survey was stored in a long adit cut in to the carbonatite, which unfortunately caught fire. Today, the baked remains of this drillcore can be found scattered around the adit mouth as the site is frozen temporarily by a legal dispute between Lynas Corp. Ltd and Rift Valley Resources. However local entrepreneurs currently mine the adit for guano – bat droppings sold as a local fertilizer.

Following the morning of fieldwork, the workshop team were privileged to be invited to the Mota-Engil core shed near Blantyre where Paulo Rocha and his team had laid out boxes and boxes of



*Left: View down the airless adit from the 1960s. Right: Tundulu drill core laid out in the yard of Mota-Engil*

Tundulu drill core. A couple of happy hours were spent pouring over brilliant expanses of fenite breccias and carbonatite intrusions before the convoy headed off home for the evening seminar session focusing on exploration of alkaline complexes.

#### **Day 6: Tundulu**

Upon arriving at Tundulu we were greeted by an employee of Optichem, a Malawian fertilizer company who currently mine the apatite-rich carbonatites for phosphate. Before reaching the quarry the team found some sövite (calcite carbonatite) intrusions with large beautiful calcite crystals. The apatite-rich carbonatite is estimated to contain 1.8 Mt of phosphate and has been quarried away using blasting of the hillside, forming a very rubbly and unstable rock face.



*Left: Large calcite crystals within sövite intrusion. Right: Textures in apatite-rich carbonatite – photo credit: Sam Broom-Fendley*

Breaking away from the pack, Dylan and I went to explore the ring of ridge-like hills surrounding the carbonatite intrusions consisting of fenitized basement and highly resistant K-feldspar rich fenite breccias. These fenites display beautiful veining and small scale carbonatite intrusions.

#### **Day 7: Nkalonje**

A small breakaway group of eudialyte enthusiasts led by Alan Woolley were taken to the Junguni intrusion in the Liwonde National Park. The rest departed for Nkalonje, consisting of fenitized



*Small carbonatite veinlet altering the pre-existing fenite*

basement with intrusions of carbonatite and nepheline syenite on the eastern lobe, and predominantly trachyte and dolerite on the western lobe. This western lobe consists almost entirely fenite breccia. Therefore the workshop group split this day, with those most interested in carbonatites hiking straight to the top of the eastern lobe, and those concerned with fenites making their way up the western lobe.

One of the most prominent features of the breccia at Nkalonje is the preferential enrichment of clast edges with K-feldspar, making them more resistant to weathering. Preferential erosion of the inner clast has left the hollowed out clasts protruding from the outcrops.

That evening, the workshop group got dressed up in their glad rags for the gala dinner. The event started off formal with speeches from Prof Frances Wall, Alex Lemon and the Honourable Bright Msaka SC (Minister for Natural Resources, Energy and Mining). However the night ended on a less formal note with most of the team finding themselves on the dance floor, moving to the tunes of Malawian music celebrity Lucius Banda.



*K-feldspar rich clast rims protruding from around preferentially weather clast interiors*



*Left: Prof Frances Wall addressing local dignitaries and the workshop group at the Gala Dinner. Right: Malawian music celebrity Lucius Banda playing for the group*



### **Day 8: Farewells and wildlife**

With a few sore heads within the group, the majority of workshop experts departed the hotel, headed for Blantyre airport and their respective destinations all round the world. A hard-core group of six remained (Frances wall, Alex lemon, Will Dawes, Sam Broom-Fendley, myself and local geologist Chikondi) and readied themselves to move down Zomba Mountain to less luxurious quarters at Annie's Lodge.

Whilst Alex and Will ensured everyone departed through customs without a glitch, Sam, Frances, myself and our driver, Kondwani (aka Happy) headed to Hippo View Lodge for a much needed afternoon of leisure. From there we chartered a boat down the Shire River and in to the Liwonde National Park. For the next hour we got a little too excited as we saw many herds of hippos wallowing in the shallow water; a small herd of elephants on the bank of the river; many crocodiles sunning themselves on the banks; and flocks of exotic of birds.



*Top left: Beware of hippos sign along the Shire River. Top right: Herd of hippos wallowing in the river. Bottom left: Small herd of elephants on the bank of the river. Bottom right: Crocodiles basking on the river banks*

### **Day 9: Thambani**

A 5.30 AM start saw our reduced convoy of only two vehicles heading toward Mkango's license area in Thambani to investigate some trenches. Returning back to the hotel, we passed through a village which was known for its high concentration of zircon. Alex, Will and the Malawian family in who's yard we stood, watched in amusement as the geologists scrambled around in the dirt with apparent 'zircon fever', pulling out perfectly formed prismatic crystals up to 2 cm long.

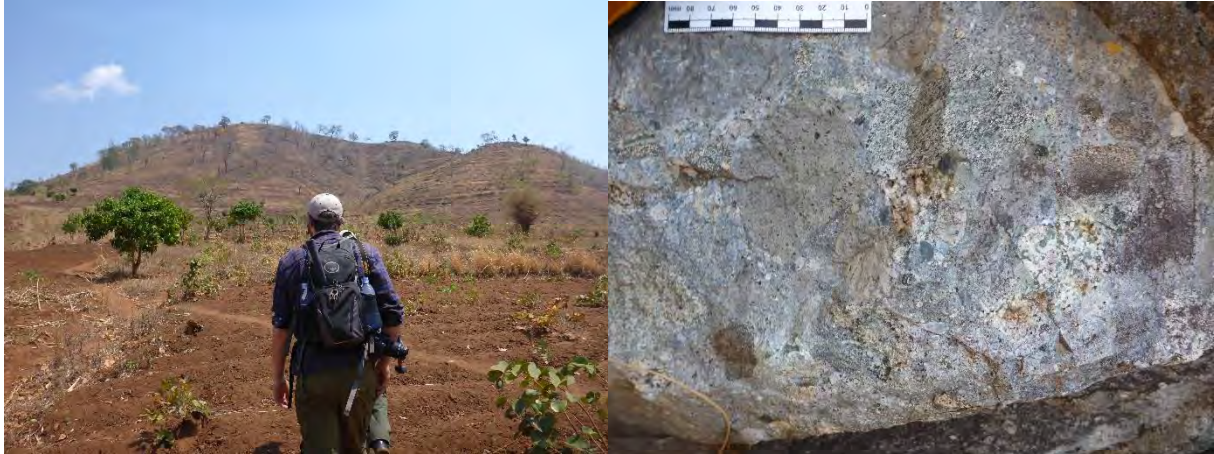


*Geologists scrabbling in the dirt looking for zircons – photo credit: Frances Wall*

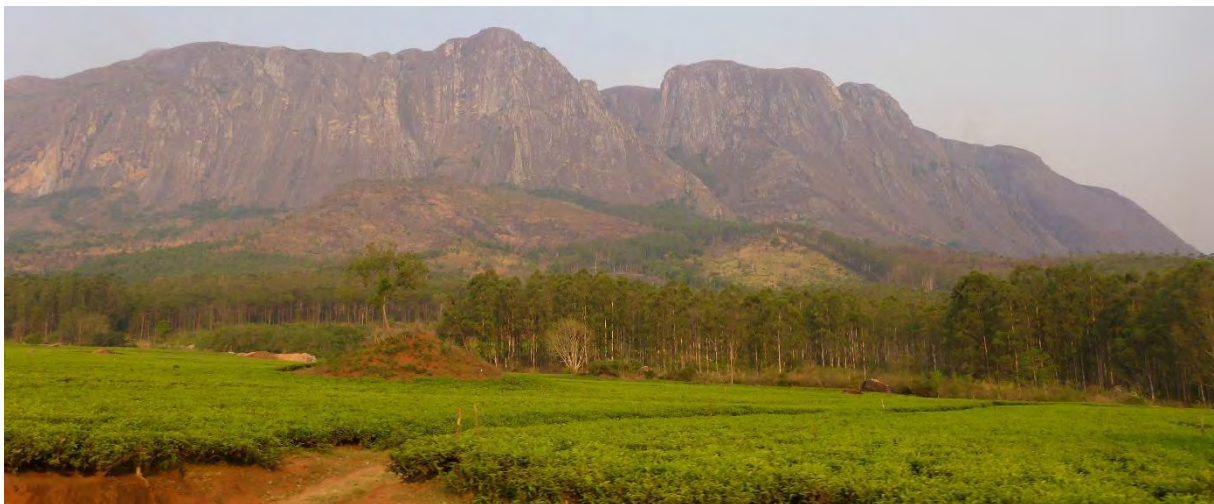
### **Day 10: Universities and Namangale**

Whilst Frances Wall and Alex lemon spent the day visiting MUST (Malawi University of Science and Technology) and Chancellor College (University of Malawi), meeting with current lectures and discussing future collaborations, the remainder of the small team travelled to Namangale.

Namangale is a steep sided hill on the Phalombe Plain which shows up as a strong thorium radiometric anomaly within Mkango's license area. The hill predominantly consists of various forms of fenite breccias and phonolite breccias with intrusions of phonolite, trachyte and carbonatite veinlets. Returning back to the hotel after a long hot day sampling on top of the hill, we drove past the famous teas plantations in the foothills of Mount Mulanje.



*Left: The small team about to climb up Namangale Hill. Right: Phonolite breccia*



*Tea plantations in the foothills of Mount Mulanje*

### **Day 11: Back to Kangankunde**

Upon this visit the team wasted no time in climbing straight over the top of the complex, sampling the fenite breccias on top and then down the fenite spur to the south west. Near the apex of the hill radiating strontianite and monazite pseudomorphs after burbankite could be found within the carbonatite intrusions.

As before, the group went back to visit the core shed of Mota-Engil after sampling Kangankunde, but this time with rare permission to sample the Tundulu drill core. Myself and Sam spent several hours 'speed logging' the core and sampling



*Radiating strontianite pseudomorphs after burbankite within the carbonatite intrusions*



with the help of Frances, leaving with exceptional examples of the fenite, breccias and intrusions at Tundulu.



*Left: Fenite breccia from Tundulu drill core with rounded clasts. Right: In the Mota-Engil core yard. Left to right: Paulo Rocha (Mota-Engil), Holly Elliott, Sam Broom-Fendley, Frances Wall*

### Day 12: Farewells and Songwe

Frances, Alex and Will left for Blantyre airport on this morning, leaving just Sam, Chikondi and myself to head back to Songwe with our driver. The plan was to spend two days sampling Songwe and the first was to be spent traversing the steep south-western side of the hill and round on to the saddle between Mauze, the large nepheline syenite intrusion behind. At this point we were less than a kilometre from the Mozambique border! The traverse was mostly through brecciated and fenitized nepheline syenite with large mica accumulations and pegmatites.



*Left: View of Mauze nepheline syenite from the side of Songwe Hill. Right: Pegmatite within Mauze nepheline syenite.*

### Day 13: Songwe re-visited

This day was a fenite finding mission, however the road cuttings that appeared to have the best exposure, were too altered for good samples. After sampling the fenite breccias near the top of Songwe, we headed back down and across to Chenga Hill. Here, large vertical exposures of clast supported fenite breccia could be found at the base of the hill. After climbing Chenga, the top of the

hill appeared to be fenitized basement gneiss containing beautiful pegmatites similar to those observed on Mauze the previous day.

#### **Day 14: Geological Survey of Malawi**

Having a small break from fieldwork, Sam and myself spent the morning in the Geological Survey of Malawi, talking to the head geologist, Charleson Eliyasi, and visiting the library. The department is currently in the process of refurbishing and digitising their publications, however they have a rich resource in the form of old memoirs and bulletins dating back to the 1930s, in addition to maps and reports made by historical mapping and exploration expeditions.



*Fenite breccia exposure at base of Chenga Hill*

#### **Day 15: Back to Nkalonje**

On our last day in the field we headed back to Nkalonje, to sample the north-east fenite lobe. Half way up a low-lying outcrop exposed beautiful veined fenites with apparent segregation between aegirine-rich and feldspar-rich areas. Intrusions of sövite could also be found within previous exploration trenches near the top of the hill, showing large rhombohedral crystals of calcite.



*Left: Highly veined Nkalonje fenite with apparent segregation between aegirine-rich and feldspar-rich areas. Right: Sövite with large rhombohedral crystals of calcite.*

#### **Day 16 and 17: Packing and leaving**

Having underestimated the length of time it would take to pack our numerous samples into boxes, we spent the majority of the day sorting and packing our 189.5 kg of rock into 9 boxes. It wasn't until the boxes were more tape than cardboard that we felt they had a good chance of returning to us

intact. Before heading to the airport the next day we stopped off at a shopping centre in Blantyre to purchase a supply of traditional Malawian products – tea, coffee and gin!

### Special Thanks:

The HiTech AlkCarb team at CSM would firstly like to thank Alex Lemon and Will Dawes from Mkango Resources for doing a brilliant job hosting and organising the workshop. Behind the scenes organization was also carried out by Dylan McFarlane and Kate Moore from CSM. Particular thanks goes to Sam Broom-Fendley of CSM for his large contribution to the field guide, his leading of fieldwork and remaining as a field guide for our sampling mission after the departure of the rest of the team. Thanks goes to Mota-Engil for allowing HiTech AlkCarb to view and sample their drill core, and finally to the invited experts for attending.



*Sam Broom-Fendley taking a short break on top of Nkalonje on our last day of fieldwork*

<sup>1</sup> <http://www.africanindy.com/business/malawis-mining-boom-5385684> [Accessed 25/10/2016]

<sup>2</sup> Annual Economic Report 2015, Malawi Government, Budget Document No 2

<sup>3</sup> Woolley, A. (2016) The Chilwa Alkaline Province. Fenite and Geophysics as Exploration Tools HiTech AlkCarb Expert Council 2 Field Guide

<sup>4</sup> Swinden, S. and Hall, M. (2012) NI 43-101 Technical Report and Mineral Resource Estimate for the Songwe Hill Rare Earth Element (REE) Project, Phalombe District, Republic of Malawi. The MSA Group (Pty) Ltd

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