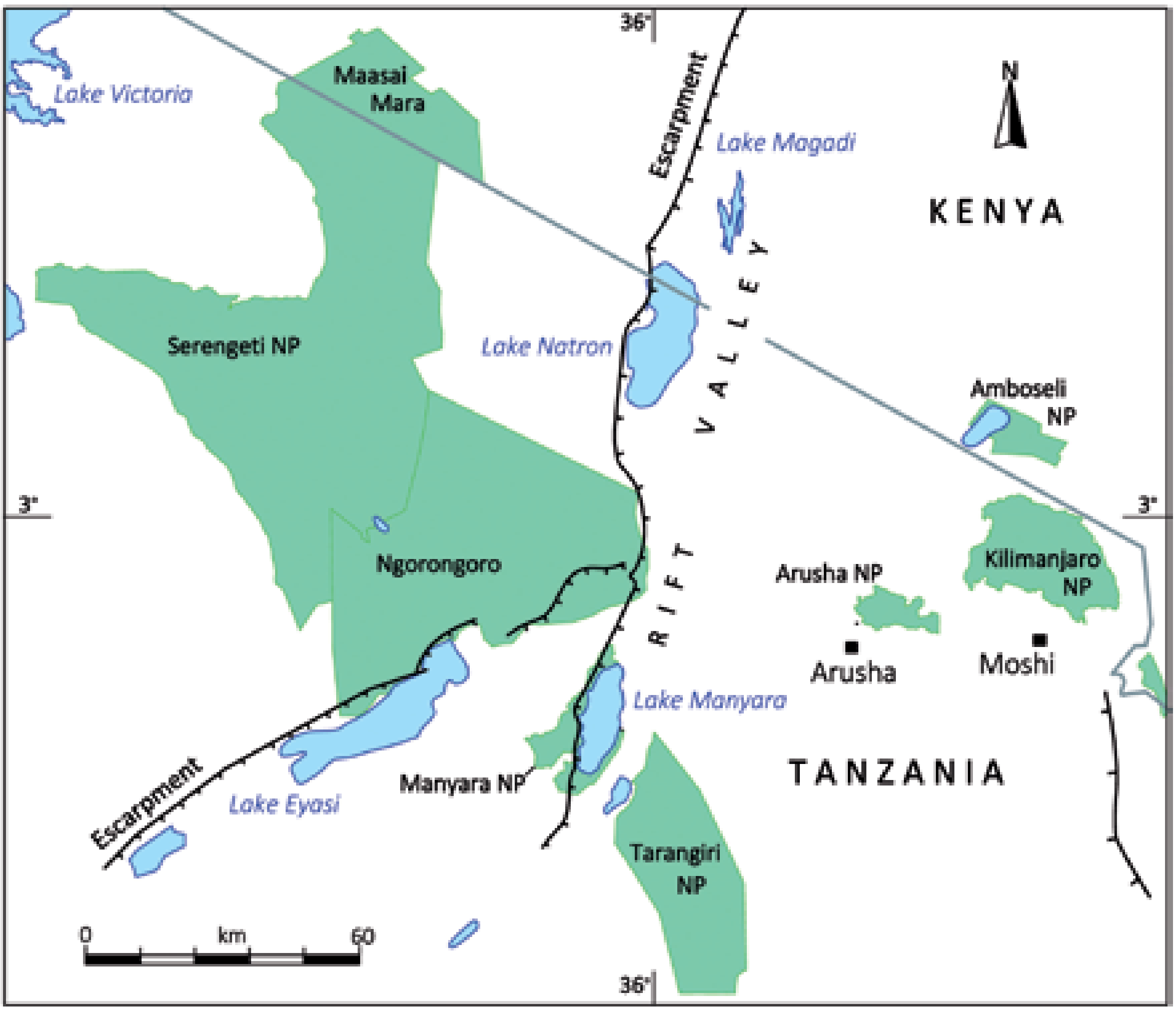
ARTICLES

northern tanzania:

Rift Valley and Neogene-Holocene Volcanism.



Map showing the National Parks of northern Tanzania.

LEADER: Roger Scoon (rnscoon@iafica.com)

A 10 day post-conference field excursion starting and finishing in Johannesburg: 5 - 14 September 2016

- Monday: Fly ORT-Arusha (lodge)
- Tuesday: Arusha NP, caldera of Mount Meru (mountain huts)
- Wednesday: Lake Manyara NP (soda lake, hot springs); Ngorongoro Highlands (lodge)
- Thursday: Ngorongoro and Empakaai calderas (lodge or camp)
- Friday: Gregory Rift and Lake Natron (Tented Safari camp).
- Saturday: Oldoinyo Lengai or Lake Natron and Western Escarpment (Tented Safari camp).
- Sunday: Serengeti NP (lodge)
- Monday: Serengeti NP (lodge)
- Tuesday: Oldupai Gorge; fly Ndutu-Arusha (Lodge)
- Wednesday: Fly to ORT

Highlights

- Unique opportunity to visit some of Africa's most famous National Parks
- Hike at over 8000 feet in the caldera of Mount Meru, an active stratovolcano
- Unique splendour of the extinct Ngorongoro Caldera

- Visit the Gregory Rift and a chance to climb Oldoinyo Lengai the world's only active carbonatite volcano
- If timing is good see migration in the Serengeti
- Examine rock sequences that host some of the world's most important hominid finds at Oldupai Gorge

Note: The itinerary and costs are dependent on number of participants, so early booking will assist greatly. Costs are estimated at US$6-8,000. There will be opportunities to add on private trips to visit, for example, primates (gorilla, chimpanzee) in Uganda and Rwanda, or the volcanic areas of southern Kenya.

Geological Overview

The Gregory Rift, the easterly branch of the East African Rift System, is part of one of the most recognizable geological features on Earth. The first geologist to examine this area was Joseph Thomson, but it is John Walter Gregory who, in 1894 defined the concept of a rift valley as a series of linear faults. Rifting triggered abundant Neogene-age volcanism and includes active centres.

This part of northern Tanzania contains some famous national parks and conservation areas, as shown on the attached map. The excursion will visit the Arusha, Manyara, Ngorongoro, and Serengeti parks, as well as the wilderness area around Lake Natron. The airport is located near the regional town of Arusha so logistics restrict us to examining some young volcanic centres prior to the rift itself. The excursion will also provide an opportunity to see the Archean basement, to climb the active volcano of Oldoinyo Lengai, and visit Oldupai Gorge, the famous paleoanthropological site. Some days will be spent at altitudes of 8,000 feet and the temperate nature of the climate (with chilly nights) is surprising in an area so close to the Equator.

Geological Structure

The petering out and splitting of the rift south of Lake Natron into three branches, Eyasi, Manyara, and Pangani, is a consequence of the southward-propagating faults refracting off the Tanzania Craton. The Natron-Manyara branch is bordered to the west by a subgraben that hosts the Ngorongoro Volcanic Complex, an extinct complex of shield volcanoes. Individual cones occur in the rift, notably near Lake Natron, and a cluster of huge stratovolcanoes,

The barren escarpment of the Gregory Rift near Lake Natron.

The spectacular cone of Oldoinyo Lengai rises 2000 m above the floor of the Gregory Rift near Lake Natron.

including Meru and Kilimanjaro, occur on the eastern platform.

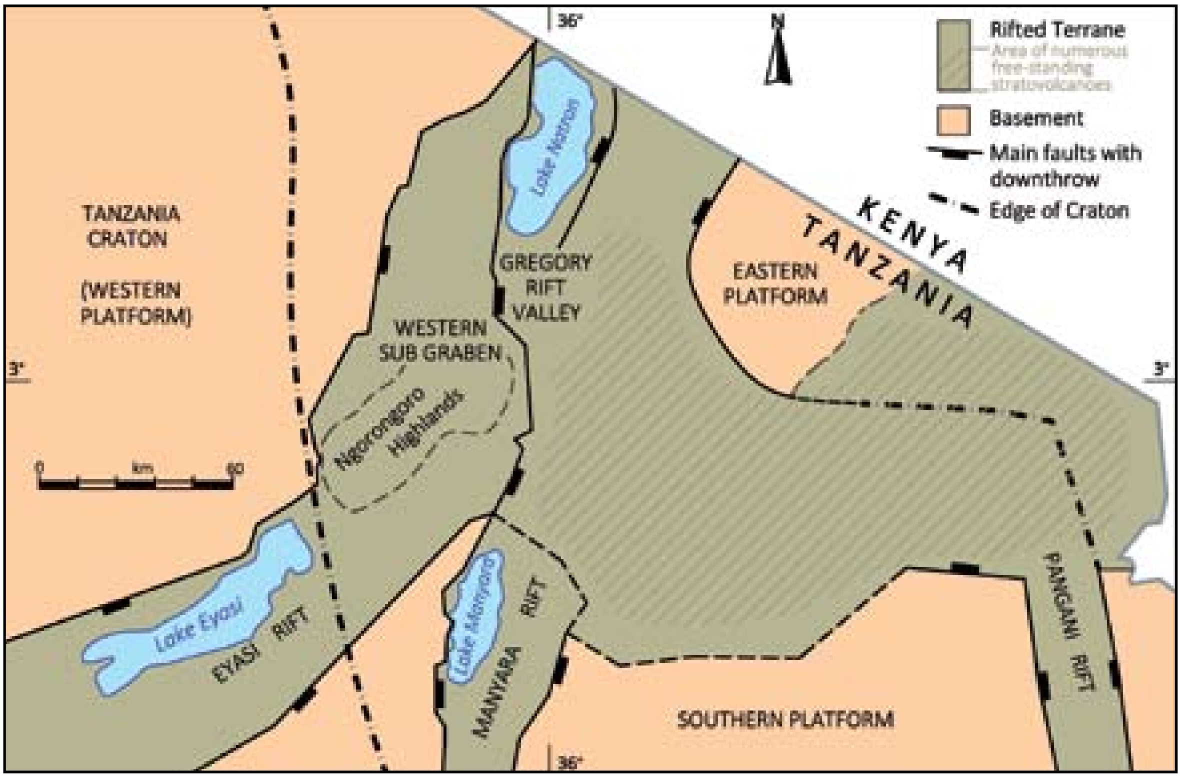
The partial separation and extension of the African Plate into Nubian (west) and Somali (east) Plates has probably been driven by a thermal plume located in the upper Mantle. The general drift northward of the Nubian Plate is complicated by the eastward drift of the Somali Plate. There has been 130 km of extension at the northern tip of East Africa during the last 40 Ma. The Gregory Rift differs from the Western Rift in that it contains small, mostly alkaline lakes, and volcanism within the rift and on the eastern platform is very extensive.

Rifting, which commenced in the Miocene in Ethiopia reached northern Tanzania in the Pliocene (3-1.8 Ma). The currently active faulting commenced at 1.2 Ma. The two ages of faulting correlate approximately with two ages of volcanism, known as the older (Pliocene and Lower Pleistocene) and younger (Upper Pleistocene-Holocene) groups.

Mount Meru

With a height of 4562 m and diameter of 25 km, Mount Meru is a giant stratovolcano. The annular ring of forest on the lower slopes is a characteristic of most high peaks in East Africa. The main geological features are a rocky summit ridge, a giant horseshoe-shaped caldera with near-vertical internal cliffs, and undulating topography with small lakes and marshes on the lower eastern slopes. Meru is regarded as active as there was minor activity in the last century.

The ash cone and upper slopes of the Mount Meru caldera.



Simplified structural map of northern Tanzania.

The excursion will include a visit to the subsidiary volcano of Ngurdoto that includes a discrete summit crater that has been preserved as a "park-within-a park". The highlight will be a hike with an armed ranger (the park has large herds of elephant and buffalo) into the caldera at over 8,000 feet with views of the internal walls. (Unfortunately time will not permit an ascent of the summit: this requires four days.) The main cone at Meru was built up in the period 200,000-80,000 BP. The partial disintegration of the cone and formation of the caldera is dated at approximately 7,000 BP. Formation of the caldera may be compared with the 1980 eruption of Mount St Helens as massive debris avalanches travelling up to 35 km were created. We will visit the Momella lakes that were created from hollows associated with the avalanche deposits. The most recent at Meru activity is formation of the giant Ash Cone.

Alkaline Lakes

Alkaline lakes are important components of the ecology of northern Tanzania. They are restricted to the rifts and larger calderas and may be associated with thick sequences of Neogene-age sediments. The Manyara NP is well known, partly for pioneering studies of elephant behaviour but also for large concentrations of water birds. Lake Natron is the main breeding ground of flamingo in East Africa, a consequence of the high proportion of dissolved sodium carbonate derived from the natrocarbonatite volcanoes. The brines are so poisonous that the flamingo could not survive if their filtration systems were not so efficient. The extent of Lake Magadi, the largest lake in the Ngorongoro Caldera has varied since the Pleistocene.

Forested slopes and lake-filled depression of the Empakaai Caldera.

Ngorongoro Volcanic Complex

The extinct cones and calderas of the Ngorongoro Highlands, an area some 100 km north-south and 80 km west-east, is associated with the older phase of volcanism. Cones and shoulders of calderas rise over 2000 m above the valley. Eight discrete centres are recognized, but it is Ngorongoro (2.25-2.01 Ma) with one of the largest and best preserved calderas on Earth that is the most well known. With an internal diameter of some 20 km, internal walls 350 m in height, and with only localized areas of collapse and debris flow, the caldera is justifiably famous. We will visit the Lerai section which has been studied in some detail: geochemical trends are consistent with a stratified magma chamber of which the silicic top and basaltic

The forested escarpment and Lake Manyara.

base was inverted by sequential eruptions. Two flows of rhyolite ignimbrites located toward the top of the section are associated with the caldera event.

Escarpments

The escarpments are observed as near-vertical walls, and at Lake Natron we will examine the huge thicknesses of volcanic ash and lava associated with the western wall of the Gregory Rift.

Oldoinyo Lengai

The natrocarbonatite volcanism in this area is restricted to the younger activity. Oldoinyo Lengai is the most widely studied of these centres and includes a near symmetrical cone (2,880 m) typical of active volcanoes that have undergone minimal erosion. The high sodium content causes the lava to react rapidly with meteoric water so that despite being erupted as dark-coloured flows the lavas oxidize to light-coloured secondary minerals within a few days. The primary mineral (sodium calcium carbonate or nyerereite), was identified by J B Dawson from examining newly erupted flows; after a few days the sodium in the nyerereite is replaced by calcite.

Recent eruptions occur every 15-25 years. The first event to be observed was in 1904. Eruptions in 1966-7 were unusually violent and excavated a summit crater with a depth of 150 m and diameter of 400 m. The ashfall reached as far as the Serengeti Plains, 150 km to the west. For the fit – the ascent is very strenuous – the opportunity to climb the cone and walk into an active crater is an opportunity not to be missed. During a visit in May 1995, numerous ash and spatter cones were active and shiny white, smooth-topped pahoehoe flows (from the 1992 eruption), although severely oxidized, were still intact.

Serengeti

Large areas of the Serengeti NP are underlain by the 2.8-2.5 Ga old Tanzania Craton. The eastern plains include distinctive koppies of coarsely-crystalline granite-gneiss. The greenstones form bushy ridges in the central and southern parts of the park. The prevailing easterly winds have spread ash from the rift-hosted volcanoes onto the Serengeti Plains. This movement of ash may have influenced the famous migration. The ash has affected the water table by development of a near-surface layer of hard pan to form an ecological area known as the "short grass plains". This is distinct from the "long grass plains" where Basement rocks occur and the water table is deeper.

The "Shifting Sands" on the eastern plains of the Serengeti, near Oldupai Gorge, are isolated dunes composed of black ash derived from Oldoinyo Lengai. The largest of the dunes reveals a classic crescent-shape and is 9 m in height and 100 m in length. It is

Part of the active northern crater, Oldoinyo Lengai.

migrating west at the rate of approximately 17 m/year. The track left behind the dune is visible and includes a trail of different species of fossilized dune beetles. Movement of sand particles by wind and bouncing of grains off the ground, a process known as saltation, is thought to cause a negative charge, thus creating an electrical field which suppresses dispersion of individual grains.

Oldupai Gorge

Oldupai Gorge (formerly known as Olduvai) has revealed highly significant discoveries, including Homo habilis (1.9-1.6 Ma), Paranthropus boisei (1.8-1.2 Ma) and Homo erectus (1.2-0.70 Ma). Fossil evidence suggests Homo sapiens arrived at Oldupai around 17,000 BP. Many animal fossils have also been found at Oldupai, including numerous extinct species. The gorge is some 48 km in length, and forms a steep-sided incision into the Serengeti plains. The drainage pattern of the Serengeti is generally toward Lake Victoria; Oldupai is part of an old river system related to a paleo-basin on the margins of the rift that drains eastward. The geology of the gorge was studied in great detail by Richard Hay, over a period of more than 40 years. The Oldupai sequence is divided into seven beds. Most of the important finds were made in sequences of volcanic ash (from Ngorongoro and Olmoti) and clay within Beds I (2.1-1.7 Ma) and II (1.7-1.1 Ma). Bed III (700,000 BP) consists of a 10 m-thick sandstone, but the clay-rich Bed IV (300,000 BP) has yielded abundant Hominin fossils. Beds V-VII consists of windblown ash from Kerimasi and Oldoinyo Lengai, the latter having been dated at 17,000 BP.

CONCLUDING REMARKS

The volume and pervasiveness of the volcanism in the Gregory Rift of northern Tanzania is almost without parallel. The fall-out of radioactive ash associated with

Isolated sand dune of black volcanic ash (derived from Oldoinyo Lengai), eastern plains of the Serengeti.

Oldupai Gorge showing the basal lava (black) which is overlain by fossil-rich Beds I and II of the Oldupai sequence.

the younger, nephelinite and carbonatite volcanism, it has been suggested, may account for rapid speciation of both cichlid fish (e.g., in Lake Victoria) and of Great Apes and Hominids.

Photographs from visits in 1995, 1998, and 2005.

graphite petrography

Introduction

Industrial minerals such as graphite have recently become the focus of attention for many listed exploration companies, particularly due to developments in battery technologies and new product opportunities such as graphene. Consequently the race has been on to report larger tonnage exploration targets and resources, with certain projects being described, for example, as world class or highest grade.

Although resource tonnes and graphitic carbon content (grade) are important metrics, the evaluation of graphite projects (as with other industrial minerals) is more complex; key attributes in addition to deposit size and grade, are product flake size distribution and purity (Scogings, 2014; Scogings and Chesters, 2014).

Graphite purity is particularly important for the higher value end uses like lithium-ion batteries and is a key determinant in saleability of the product. Producing high purity graphite may also adversely affect the cost of production, as additional processing to make the product saleable will increase the operating cost.

Graphite flake size distribution is one of the more debated project factors. However a number of facts about flake size are currently true; firstly, the larger the flake the higher the purity of the graphite product is likely to be and secondly, the larger and purer the flake size the higher is the selling the price.

Graphite prices related to flake size and purity

Graphite type	Purity (% Carbon)	Size (mesh)	Size (Microns)	Low (US$, CIF)	High (US$, CIF)
Flake	94 to 97	+80	+180	1,050	1,150
Flake	94 to 97	+100 -80	+150 -180	900	1,000
Flake	94 to 97	-100	-150 + 200	750	800
Flake	90	+80	+180	750	850
Flake	90	+100 -80	+150 -180	700	800
Flake	90	-100	-150 + 200	600	650
Flake	85 to 87	+100 -80	+150 -180	550	600
Amorphous	80 to 85	-200	-75	430	480
Amorphous	70 to 75			500 (ex-works)	550

SOURCE: Industrial Minerals Magazine 30th April 2015 www.indmin.com