

Investigation of Silali Basin as an Extra-Terrestrial Impact Crater (ETIC) Using Remote Sensing

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Abstract
For years, extra-terrestrial impact cratering was esoteric. However, impacts have become very important, mainly because they have been identified as the likely immediate cause of dinosaur extinction. Impact cratering by extra-terrestrial bodies including asteroids comets and meteorites is an important geologic process, not only for the minerals that it forms, but also because of the knowledge that it is dangerous to mankind and life on earth. There is also the fact that extra-terrestrial impact crater building is a continuous process that may be going on even this very minute, somewhere in the universe. Consequently, the earth, just like other members of the solar system is targeted by extra-terrestrial falling objects. The purpose of this study was to assess the effects of impact cratering on Kenya's environment, with focus on Silali basin. Silali basin is a depression that is found to the north of Lake Baringo; around Kapedo town. It is suspected to be an Extra –Terrestrial Impact Crater (ETIC). One objective of the study was to map out and characterize the Silali basin and provide evidence on the nature of its formation. To attain this objective, remote sensing was utilized to map the Silali basin. Satellite images were used to identify the nature of the crater and characterize it, since most large terrestrial impact craters are not identifiable from the surface of the earth. The images provided critical information that was used to map out the morphological aspects of the crater, some of which have long been buried by forces of denudation, together with tectonic and anthropogenic forces. Analysis of satellite images and ground pictures were supplemented by other research methods, including interviews, observation and sampling of various rocks. Information gathered has been presented in the form of analyzed satellite images, ground pictures, tables, Digital Elevation Models (DEMs), cross sections, aerial photographs, maps and discussions. This study has characterized the Silali basin as a possible ETIC and explained the nature of its formation.
Key words : basin, plate, cratons, meteorite and target rocks.

Introduction

Extra-terrestrial impact craters, on the earth's surface, are formed by the impact of an asteroid, comet or a meteorite on the Earth's surface. The mechanisms associated with impact cratering are diverse but generally, when a sizable solid body strikes the ground at high speed, shock waves propagate into the target rocks. At collision speeds of tens of kilometres per second, the initial pressure on the material engulfed by the expanding shockwaves is millions of times the earth's normal atmospheric pressure, which is 101,300 Newtons per square meter. This can squeeze dense rocks into 1/3 of their normal volume. Stress can then overwhelm target rocks to an extent that they initially begin to flow almost like a fluid. A decompression wave follows the advancing front wave into the compressed rock, allowing the material to move sideways. As more and more of the target rock becomes engulfed in the shock wave, which expands more or less radially from the point of impact, the flow of the target material behind the shock front, is diverted out along the wall of a rapidly expanding cavity created by the decompression wave. The compacted body now vaporized or melted moves outward with the divergent flow and lines the cavity, forming a conical sheet. Rocky material continues to flow outward until stresses in the shockwave drop below the strength of the target rocks. In large impact craters, the rock walls slump inwards, soon after excavation of the initial or transient cavity.

On the earth's surface, many of the extra-terrestrial impact craters have been flattened and or filled by erosion, deposition, volcanic resurfacing and tectonic activity. Consequently, only about 200 ETICs have been recognized and documented worldwide, the majority being in the geologically stable cratons of North America, Europe and Australia. Incidentally these are the areas where most exploration, involving ETICs, has taken place. High level remote sensing (Satellite Imagery) has made it possible for these features to be identified.
The Barringer Crater in Arizona, which is a meteor crater, was the first ETIC to be identified in 1920s by workers who discovered fragments (for instance, allochthonous) of the meteorite within the crater. Several other relatively smaller craters were also found to contain meteoritic (meteorite impactor) fragments. For many years, these remnants were the only accepted evidence of meteoritic impact on earth but over time, scientists have come to accept that Meteoritic Impact Craters can exist even without fragments. This is because fragments of

some of the meteors that hit the earth's surface may not have survived the impact of the collision and may have been completely pulverized. The very high temperatures generated by an impact can vaporize the meteorite all together or can completely melt and mix it with melted target rocks. Sometimes, non-terrestrial relative abundance of siderophile elements can be detected in the impact melt rock within large craters, giving a signature of the meteorite impactor.

An example of a meteorite in Kenya is Kiptabar hill in Cherangani forest, near Kapcherop Town, in Marakwet, Elgeyo Marakwet County. This is a rock that has not been much mentioned in scientific discussions but one that is unique because;

i) It is square in shape while the rest of the hills in the area are somewhat conical.
ii) It is isolated and not linked to any other hill, the way the other hills are part of the continuous landscape. Kiptabar looks like it was placed where it is, like a stone on a table.
iii) It is rocky, except for the parts that weathering has affected over the years, allowing vegetation to grow on it.
iv) It is dark in colour, probably because it burned up as it was hurtled through space. Laboratory tests of samples from the Kiptabar hill (rock) revealed that the rock is 93.8% silica.
v) Mythology of the Marakwet community holds that the rock fell from the sky. The story tells of people who were dancing in the area where the rock fell and a bird that warned them to move away because a rock was going to fall on them. Sensibly, they dismissed the warning with claims that a bird cannot talk. So the rock fell on them, covering them alive. The people believe that the cries of these people can still be heard echoing from the rock. These 'voices' were investigated by the study and they turned out to be echoes from the rock face, when people talk. There is also a probability that the rock is hollow from the inside, a likely reason why it did not drill the ground and disappear.
vi) When broken up, Kiptabar rock appears rough with its particles looking like stishovite- quartz particles that assume tetragonal shapes due to impact high pressure metamorphism.

The paper did not delve into the mapping out of meteorites in Kenya-; however, a picture of Kiptabar hill is included in the data. This will be an illustration on the possible presence of extra terrestrial matter on the Kenyan land surface.

Plate 1.1: A Picture showing Kiptabar hill, Marakwet West, Kenya

The most recent known extra-terrestrial object to fall on Kenya is the Kimwiri meteorite that fell on a farm near Thika town, on Saturday, 16th of July, 2011. It is said that the stone fell on the farm at 1.017 hours and was accompanied by a thunderous sound and a tremor, after it had impacted on the land. In addition, the object blasted a small crater on the maize field, where it fell and displaced some dust that was visible from a distance. Included below is a satellite image, from Google maps, showing the area that the object fell on (Plate 1.2). Plate 1.3 is a picture showing the Kimwiri meteorite as it is today, while plate 1.4 shows the appearance of the meteorite the day it fell. Plate 1.5 shows the crater that was created by the meteoritic impact, hence the important need for the continued studies on ETICs, their associated events and features.

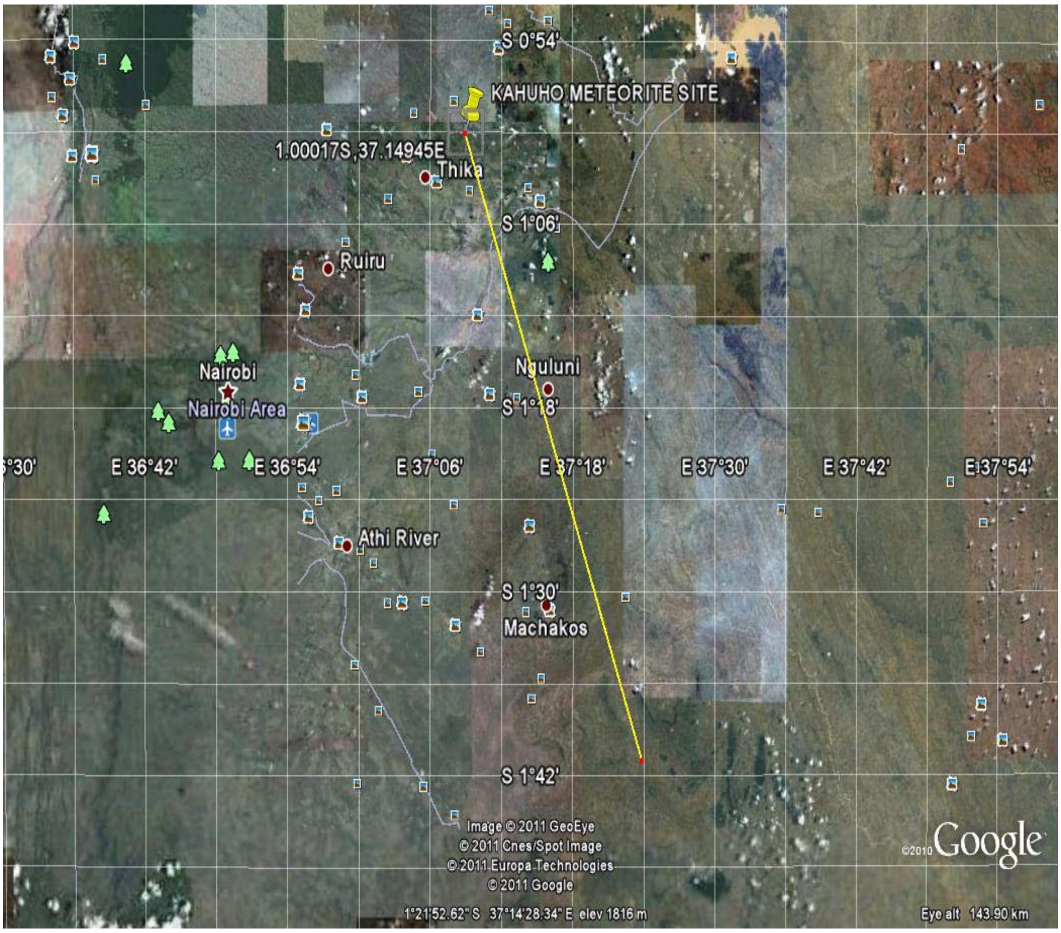

Plate 1.2: A GeoEye satellite image showing the location of the Kimwiri meteorite fall and the direction of flight from South East (courtesy of the Department of Mines and Geology-Kenya).

The yellow line shows the path followed by the Kimwiri meteorite. The rock followed a SE-NW direction, before landing on the maize field around Thika, a place that lies approximately on longitude $37^{0}10'$ E and latitude $1^{0}01'$ S. It fell at a place called Kahuho, on Kimwiri farm.

Plate 1.3: A picture of the Kimwiri meteorite, taken where it sits at the commissioner's office, Department of Minesand Geology -Kenya.

Plate 1.4: A pictureshowing the Kimwiri meteorite, taken the day it landed. (Photograph courtesy of the Department of Mines and Geology -Kenya).

Plate 1.5: A picture showing the crater created by the Kimwiri meteorite (courtesy of the Department of Mines and Geology -Kenya).

Another recent impact event on Kenyan soil is the Kuresoi- Nakuru County, fireball event that took place around 7:30 pm local time, on Thursday, 27th February 2014. This entailed a space object that cruised through the Kenyan space, sighted by many and landed on Kipara village- Kuresoi (approximately, 0^o3'S, 35^o5'E) burning down a mud-walled-grass-thatched house. It appears that the event involved an object that burnt up into tiny fragments. It did not blast a crater on the floor of the house but caused a fire, elicited a loud bang and a tremor when it hit the house, all of which are characteristics of an impact event. Notably, the rock fragments were so small that a magnet was used to collect them. They are believed to be pieces of the heavenly body that hit Kuresoi and are, thus, suspect meteoritic fragments.

Plate 1.6: A picture of an impact burned house at Kipara- Kuresoi, Nakuru County, taken on Friday, 7th March 2014.

The picture shows the eastern section of the house that was burnt down by the flaming heavenly body that hit it. The object is reported to have hit the house from the East. The red mud is brick burnt earth that comprises of the floor and the walls of the house. Unfortunately, the picture was taken after the floor had been dug up by mineral prospectors. The vegetation near the house remained but showed signs of heat effect. The ground was still burning up downwards.

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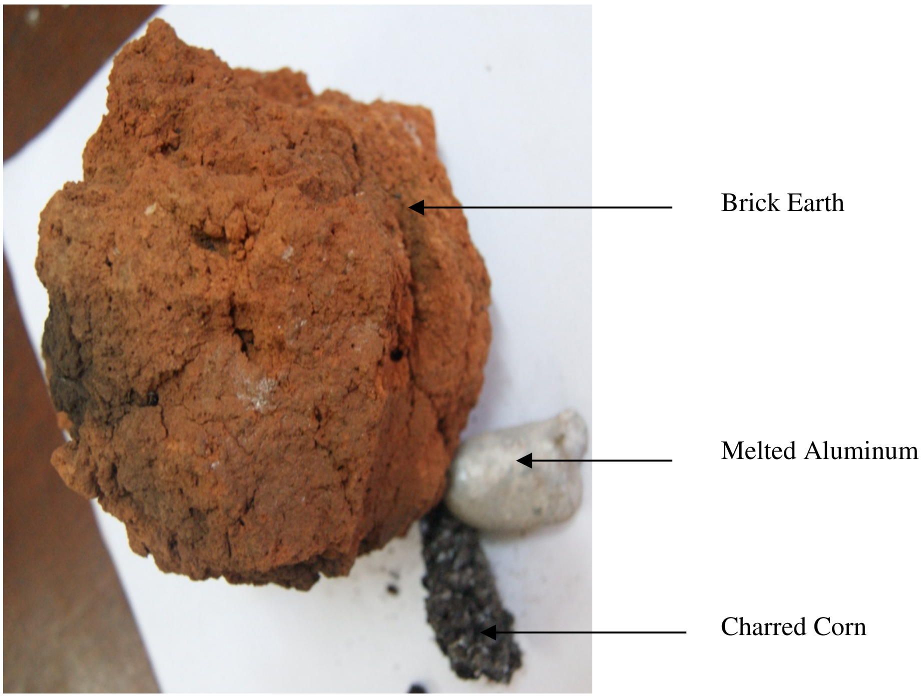

Plate 1.7: A picture of samples collected from the Kuresoi impact site.

As stated earlier, the heavenly body appears to have exploded and left behind tiny rock particles that are rich in iron. A magnet was used to pick the rock particles from the crumbled soil and some of the iron dust appears to have wrapped itself around the red earth, as shown by plate 1.8.

Plate 1.8: A sample of magnetic rock fragments collected from Kuresoi impact site.

Extra-terrestrial impact Craters are divided into three categories according to their morphology, namely:

1. **Simple Craters -** Simple craters are relatively small with a smooth bowl shape.
2. **Complex Craters** - In larger craters, though, gravity causes initially steep crater walls to collapse downward and inward, forming a complex structure with a central peak, pit or peak ring and a shallower depth

3. **Basins** - is an ETIC whose diameter is large and with the increasing diameter, a ring of peaks appear within it, transiting the complex crater into a basin.

Silali crater is a basin because its diameter exceeds 4 kilometers, the accepted crater radii for ETICs that are considered basins.

Area of Study: Silali Basin

The research covers the Silali basin/crater, also known as Silale, which is found in East Pokot/Turkana East, within the mid graben of the Great Rift Valley, 50 km north of L. Baringo and near Kapedo Town. It is located on Latitude $1^{0}10'$ N and Longitude $36^{0}12'$. The basin or crater is named Kotong, by the Pokot community living around it, which means a depression. The Turkana people call it Silali while the Pokot call it Silale. The basin covers an area of about $850km^2$ and has a NNE diameter of about 5 km and a ESE diameter of 8 km. It can be estimated that the impactor's size, could be 0.25-0.4 km in diameter or $42.5km^2$in area, on the basis of the rule that an impactor's size is 1/20 the crater's size (Beatty et al., 1999). Consequently, the Silali impact event may have been a great event. Geographically, the area is in southern Turkana but administratively, it is at the border of Turkana East and East Pokot districts. Factually, the area is a social hot spot because it is a cattle rustling area. Separately, it is an area whose ownership is disputed between the Pokot and the Turkana communities, hence frequent fights over pasture. In addition, the Silali area is very rich culturally, being endowed with special archeological sites.

Plate 1.9: A map of Kenya (not to scale) showing the study area; circled by a red line and pointed by a white arrow. Map adapted from Google Earth maps.

Materials and Methods

Natural and false colour satellite images (Landsat, SPOT, GeoEye and ASTER images) were important and useful in this study because of their high resolution and clarity in the appearance of the features on the earth's surface. Hand taken ground pictures of features around and within the Silali basin were also acquired. First, these were a means of data collection but were used to record and present whatever information was collected. An aerial photograph was used to confirm features found in the satellite images. It provided an important means of comparing data.

Qualitative research interview was used to obtain the understanding of the people, living in the proximity, about Silali basin's existence and any folklore that has been passed on through generations with regard to its formation. The researcher visited the Silali area, to observe the nature of the basin, its environs and associated features. The observation that was done in this study was mostly non- participatory.

Probability sampling was also done. This is because it gave each area of the field a chance (greater than zero) to be sampled, or to be selected as a site for collecting a sample.

Laboratory testing was essentially carried out to establish the chemical composition of rock samples collected from within and around the basin, with the aim of finding out whether the rocks from the area of study bore minerals and mineral formations that are associated with ETICs.
Geophysics was used to determine the gravity, seismic and magnetic signatures of the Silali basin and to ascertain whether the basin is actuallyan ETIC.

Silali's ETIC Characteristics
1. Circular Morphology and a depression
The Silali basin/crater has a near circular shape. Silali crater can be classified as a complex crater, because of its hummocky floor, or a basin, because its diameter is above 4 km (it is 5-8km). Silali's floor is hummocky/ lumpy, as shown by the satellite images. The crater floor contains small craters, volcanic cones and ridges besides slumped rock materials. Silali basin does not display a clear peak ring but there is an outline of a peak ring. There is a possibility that the cratering that led to the formation of the Silali basin may have triggered a spate of volcanicity within the main crater and around it. There is also another possibility that the area may have been hit more than once by extra terrestrial bodies, as it happened to Arounga crater in Chad. Multiple impact cratering, in Silali, is suggested by the presence of minor craters within the basin and around it, together with the fact that the Silali basin appears to be a basin formation within another basin. The mini craters, as stated, are about five in total and are circular.

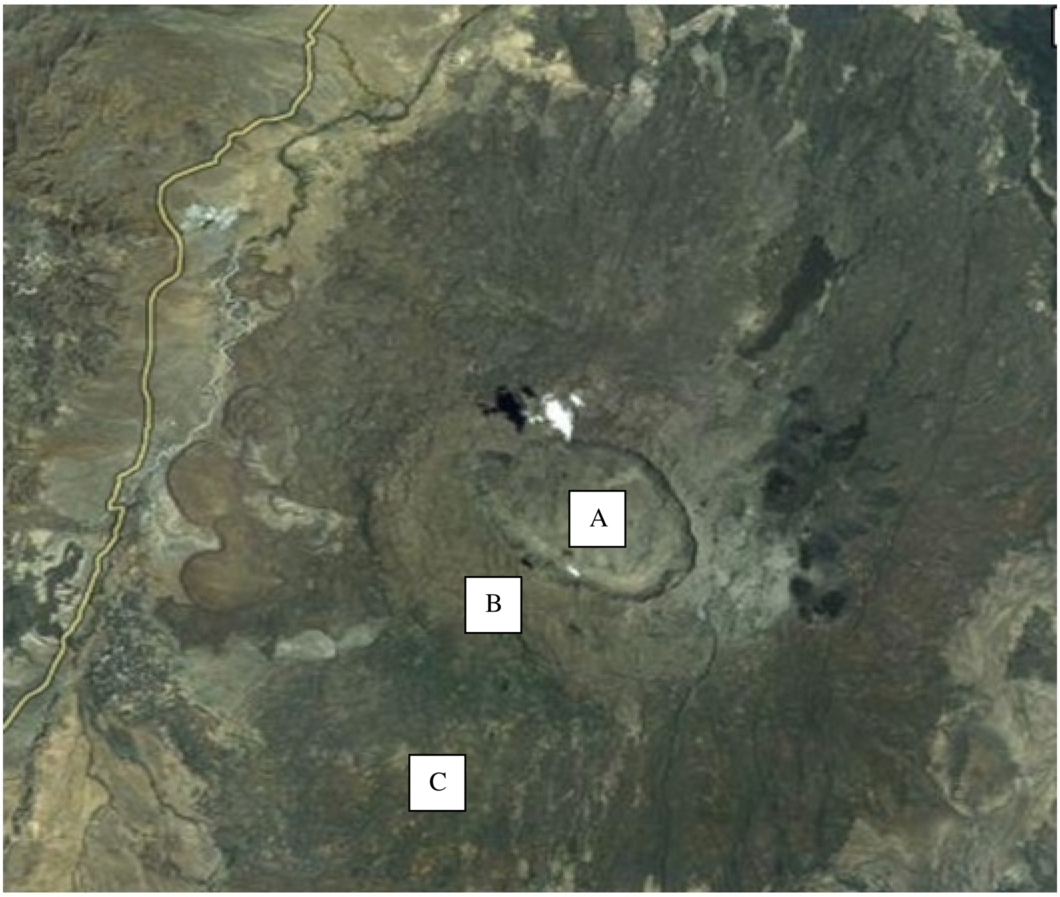

Plate 4.4: A naturalcolour SPOT satellite image showing the Silali crater

Marigat- Kapedo road (yellow), Suguta River (characterized by whitish sediments) and the outer basin around Silali. (A) isthe Silali crater, (B) are the almost circular walls that surround the crater and (C) is the outer basin surrounding the crater. The hot springs feeding the Suguta River can be seen as white patches extending from the base of the basin's wall towards the river, westwards of the basin. Plate 4.2 was adapted from Google maps. The Silali basin has been said to be nearly circular, in this discussion, because its circular shape appears broken to the North-West, giving the crater an incomplete heart shape, as it appears on the satellite images. Landslides and geological processes, such as volcanicity and tectonic movements, are responsible for the disfiguration of the Silali basin.

On observation, the basin's walls, in some places, are relatively higher than the 300m, given as the general height of Silali basin's rim from its floor. Incidentally, the Silali complex does not appear like a volcano per se because the basin does not sit on a distinctive edifice. Between Silali basin and Kapedo Town, lies the Suguta River, to the west. The river has various names upstream, for instance in East Pokot, it is called River Kinyang, around Kinyang and Amaya areas. Interestingly, the river appears to lie within a fault line and is characterized by hot water falls near Kapedo Town. The falls are fed by hot water springs on the Eastern plains, between the river and the Silali basin, which is part of the wider basin, or the 'outer basin'.

2. Geophysical Proof

a) Gravity Signature

ETICs that have been studied before, register a negative gravity anomaly or a gravity low. The gravity low is circular and extends slightly beyond the crater rim. Figure 4.1 is a Bouguer gravity data image, showing the gravity mapping of Silali basin and surrounding areas. Probably because of complex formation, involving a possible impact, volcanicity and subsidence, Silali basin, unlike all ETICs, registers a high gravity reading of between 100 mCal as shown by Figure 4.1. However, the data is too sparse to give a detailed picture of localised anomalies (Mariita, 2003).

The large positive anomaly, located in the central part of the area (between Lake Baringo and Emoruangikokolak volcanic centre) runs in a N-S direction, just like the faults running through Silali basin. This could be related to the axial high anomaly that could be a heat source for the area's geothermal system (Mariita and Keller, 2007).

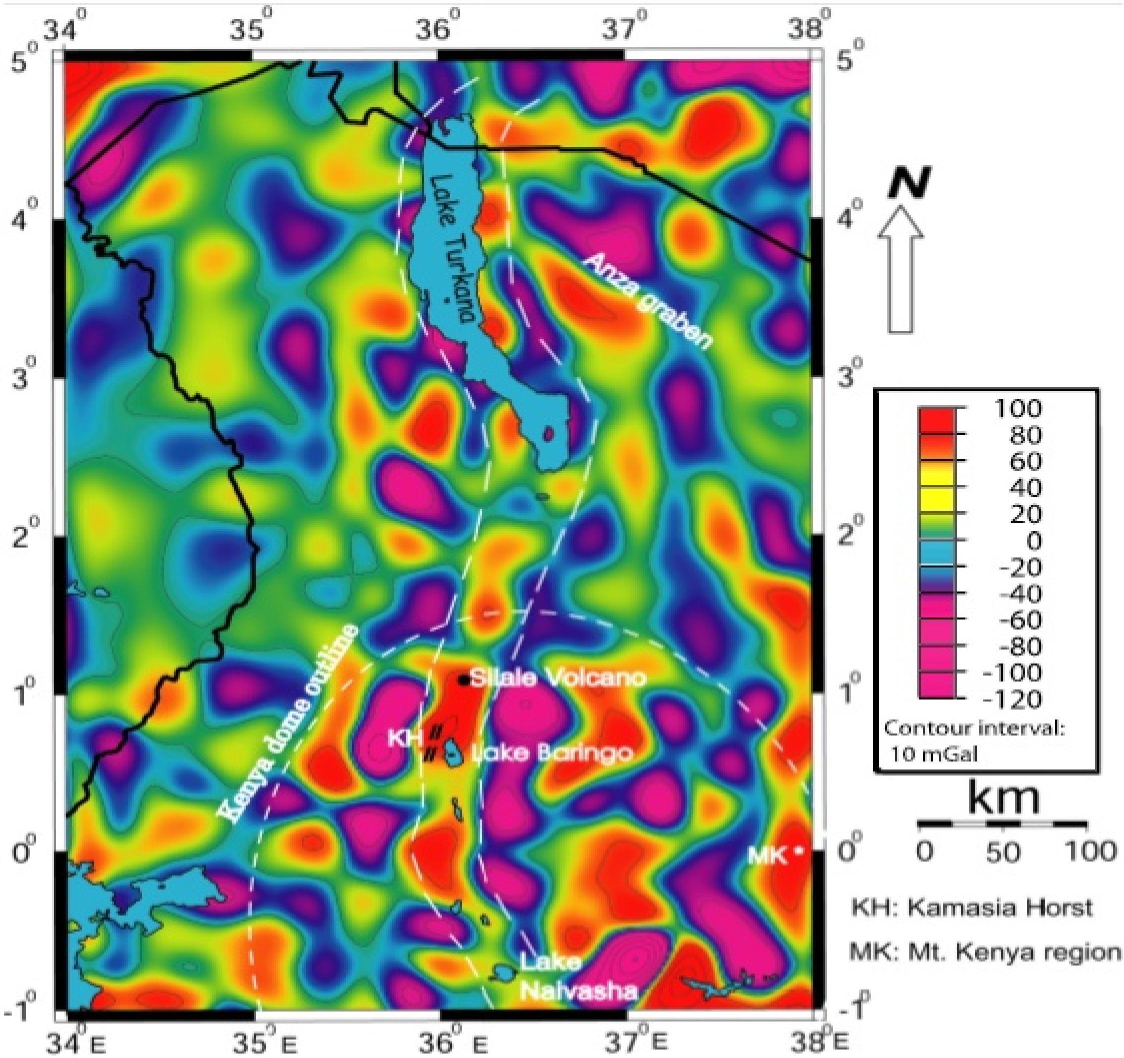

Figure 4.1: Band-pass filtered gravity map of the northern part of the Kenya rift. Wavelengths passed 30-150 km (Mariita and Keller, 2007).

b) Magnetic Signature

The magnetic anomalies associated with ETICs are usually more complex than gravity anomalies because of the complexities of rocks and their magnetism. Silali's case is even more complex because of the thermal characteristics of the crater and their effects on the rocks within and around the crater. Silali is a volcanic hot spot and the heat within it may have reset the magnetism of the rocks in the area, in relation to the earth's magnetic field. Chemical change in rocks, due to metamorphism accruing from volcanicity or impact, may have affected the magnetism of the rocks as new chemical components were formed in the area's geology. The whitish rock areas of the basin's wall are areas of metamorphic rock while the dark areas are occupied by varied volcanic rocks, which are the predominant rocks around the basin, except for the ejecta, sediments and other rocks. These are the materials that ripple away from the crater rim, all around the crater. The white rocks are breccias found on the northeastern walls of the basin, as evident on the ground and from Literature. According to Dunkley and a team of researchers, the lower layers of the north-eastern wall of the caldera comprise of massive trachyte lithic breccias while the northern wall has up to 10 m of polymict lava lithic rich breccias (Dunkley et al., 1993).

Generally, though, ETICs register a magnetic low or subdued zone ranging in amplitude from tens to a few hundred nanoteslas, looking at it regionally. Shock effects in an ETIC, though, can increase or decrease magnetism in an area (Dabizha & Fedynsky, 1975).Regionally, the area is marked by a series of high amplitude magnetic anomalies. The wavelengths of these anomalies are less than 2.5 km, their amplitudes showing broad peaks reaching several hundred gammas and their shapes are either isometric or oval. These high magnetic markers would suggest massive basalts in the subsurface (Dabizha and Fedynsky, 1975). Silali basin has basalts but it is suspected that there may be impact melt buried beneath the basin's floor, which may be posting a high magnetic anomaly. While in the study area, it was noted that magnetism in Silali basin is quite shifty and variable, from month to month.

Seismic Signature

Reflection seismic surveys allow for imaging of an ETIC's seismic signature, though the presence of rock fractures and breccias can make seismic readings complex. Past studies have shown that the eastern Rift Valley has moderate seismic activity, except for its southern tip in Tanzania (Nyblade and Langton, 1995). Silali basin and its environs are seismically active, though the waves are not equally distributed. This may be the reason behind Silali basin's present day sinking as evidenced by massive slumping of the basin's walls. The reservoir of magma in the mid-graben could be a part of a mantle plume beneath Silali basin.

d) Electrical Signature

The conductivity of rocks is heavily dependent on their water content. The presence of fluids in impact induced structures, due to the presence of fractures and increased soil and rock pores, leads to a decreased resistivity and an enhanced conductivity. Use of resistivity sounding can help map the electrical characteristics of an ETIC, as was done by Lichoro (2013) in Silali. Lichoro (2013) did a total of 154 TEM soundings in Silali basin since 2010. Two different TEM systems (Zonge and V8 phoenix TEM equipments) were applied to gather resistivity data for Silali basin. Generally, all the cross-sections show evidence of a discrete low resistivity layer below Silali crater and to the east of the caldera which is in line with the interpretation of a possible magmatic heat source (Lichoro, 2013). This magmatic heat source would be the mantle chamber beneath Silali basin or the 'localized' mantle plume in the area. It is important to note that, Silali basin's resistivity may have been made complex by its formation and its volcanic ties so that it is not just low, as would have been expected in an ETIC, but a mix of low-high- low, as seen across the profiles.

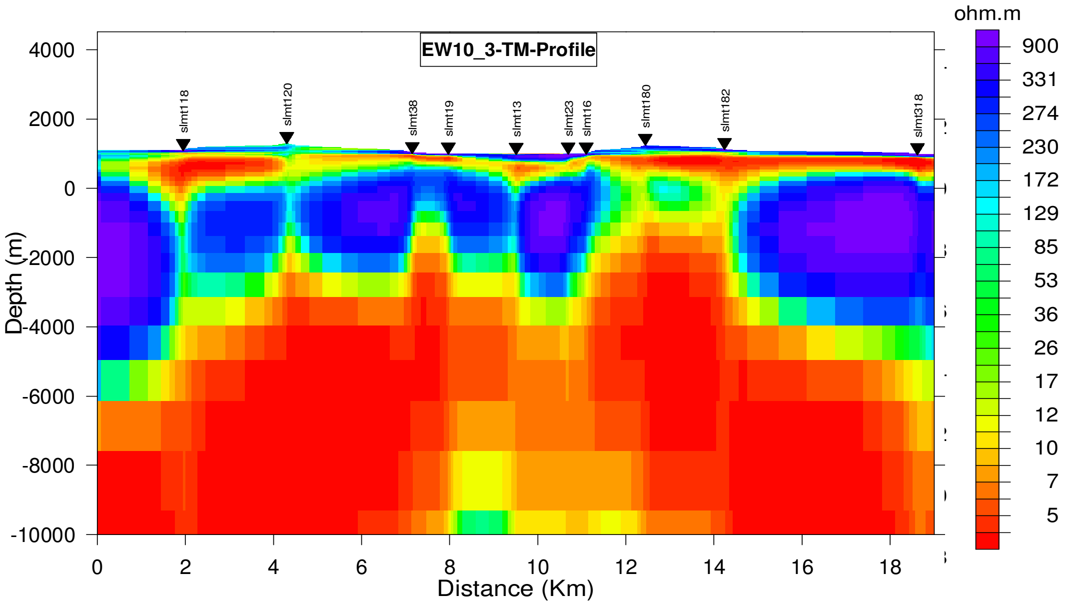

Figure 4.2: A WinGlink image showing Silali basin's resistivity (adapted from Lichoro, 2013).

3. Silali's Geology

The geology of the Silali basin comprises of:

a) Allochthonous materials

Allochthonous materials such as rock fragments around the rim are present. This is the material that appears to have been displaced during cratering. The fractured rock, on the outside walls of the basin, is very similar in appearance to the rocks found on the interior walls. This means that the rocks and the rough dust (mixture of small rock particles and fine dust) found on the outside walls of Silali basin, may be part of pulverized rock that was pushed out of the basin after impact.

b) Impact ejecta

According to McCall and Hornung (1972), the whole of the Silali volcano has an enveloping of an alluvial apron (sediments). Thus, the presence of massive rough dust deposition (or 'apron of alluvium') on the flanks of Silali basin, instead of magma deposition, is evidence that Silali basin may be a product of an extra-terrestrial impact rather than volcanicity. This rough dust is not volcanic tuff because it is not uniform in color or in physical composition. It is more like a juxtaposition of pulverized rock materials and dust that has been cemented together. It is important to note that the basin is rich in volcanic rocks and the broken up rock materials mentioned here, may have been cemented together by Silicate minerals that are present in the rocks or by impact melt if indeed Silali is an ETIC. Usually, ballistic sedimentation will occur first after an impact, followed by melt rich 'ground hugging flows' (https://en.m.wikipedia.org/wiki/ejecta). The possibility of an impact event behind the basin's formation can be inferred from the presence of broken up obsidian in the impact dust around the basin. Dense obsidian layers are found in the materials making up Silali basin's western walls. The rock also appears as thin lines within the layers of the basin's wall in other places. It is only an impact event that can crush or pulverize the walls of the old Silali volcanic shield, excavate a crater and push rock fragments and dust over the crater walls. It should be acknowledged that Silali basin's walls have no lava deposition. Secondly, the crater is not a product of a vent eruption and thirdly, the ring structure is not eruptive in terms of magma emission. Consequently, the material making up the dust apron around the basin, though volcanic to a large extent, is not a product of magma deposition or volcanic tuff. The material is a mix of whatever rock materials made up the volcanic shield from which Silali basin was formed, obsidian included. The obsidian particles were picked from a handful scoop of the dust that is called ejecta in this study. The dust is rich in many rock particles but obsidian was picked to show that the rocks inside Silali basin may have produced the dust around the basin. As stated earlier, there is absence of massive lava deposition on the flanks of Silali basin, according to observation and from Lichoro's (2013) work. If Silali basin was entirely a product of volcanic activity, there would be presence of lava deposition within and all around the basin's flanks.

c) Breccias

Breccia is found in the crater. The lower layers of the north-eastern wall of the caldera, for instance, comprise of massive trachyte lithic breccias while the northern wall has up to 10 m of polymict lava lithic rich breccias

(Dunkley et al., 1993). Polymict breccias are breccias whose particles are cemented in a way that they form a matrix.
Suevite was not found in the crater; though the sediments dug out of the crater floor may need to be examined more.

d) Silali's shatter cones

As mentioned earlier, the upper layer of rock making up the inner walls of Silali basin appears like a mass of shatter cones. The broken pieces display conical fracture surfaces, just like the Chemolingot shatter cones and other shatter cones. Shatter cones form mostly on fine grained brittle rocks, just like the rock layer in question. Plate 4.5 shows the Silali rock layer shatter cones.

Plate 4.5: A picture showing Silali basin's shatter cones

The rock (dark) shown on plate 4.5 is of volcanic origin and is more exposed on the inside of the basin. On the outside of the basin, it is buried by the rough dust that envelopes Silali basin. It appears to be made up of what appears to be shatter cones and is continuous all around the basin; at an almost uniform height. The rock is rapidly breaking up and this has made it more rugged as parts of it are chipped off. Several blocks of the rock layer are found scattered along the wall of the basin, with a few on the basin's floor. They form a part of the heavily fractured rock on the Silali basin's wall, both inside and outside.

Conclusion

Silali basin has suffered its share of deformation by tectonic, volcanic and denudational forces, just like all the other ETICs of the earth. The effect of tectonic forces on Silali basin is even more pronounced because the basin lies between the two arms of the Great Rift Valley, in a region that is tectonically active. The basin also appears to have undergone serious subsidence after impact. Some more dating of the basin's rocks and floor drill cores may need to be done to determine the time lapse between the impact event and the time of subsidence. Despite this, Silali basin still retains some ETIC characteristics. For instance; its shape is nearly circular, its inner walls are slumped, it has breccias, it has ejecta around it, it has an active magma chamber and volcanic features, it has a ring fracture and its floor is hummocky. At the same time, the basin has some volcanic characteristics such as the presence of volcanic rock, volcanic cones, hot springs and fumaroles. Although the volcanic nature of Silali basin is explained as a product of extra-terrestrial impact on a volcanic shield, the basin needs to be investigated more for its impact origins. As it is, the basin may be said to be an ETIC with volcanic roots. It is also an ETIC whose formation may have triggered volcanic activity. Its formation is thus complex and this may be the reason why some of the scholars who have studied it proposed the existence of an older crater before the current one, a proposition that others disagreed with but one that the research at hand agrees with.

In conclusion, Silali basin is a probable ETIC; a complex impact crater, which has both ETIC as well as volcanic characteristics. The volcanic rocks may be pegged on the origin of the basin as an ETIC that formed on a volcanic shield. As for the volcanic cones within and around the basin, they may be said to be products of solidified magma that exited the floor of the earlier crater via the many fractures that were formed by impact. As stated elsewhere, it is this outflow of magma from the floor of the older crater that caused the crater's subsidence and produced the present crater, the Silali basin, about 62-66 million years ago. The present Silali basin appears to be very porous because there is no evidence of stagnant rain water on the basin's floor.

There is need to investigate Silali's past climate from evidences provided by the prehistoric cave dwellings and paintings found to the southeast of the basin. This will yield information on Silali's past and the likely effects of the basin's formation. The only challenge is that the area is very inaccessible because it is in a deep jungle and can only be accessed on foot or by a chopper.
McCall and Hornung (1972), mentioned that the 'black hills' to the northeast of Silali basin are made up of pure black glass. It was not possible to access these hills for sampling, because of insecurity. Knowing that ETICs are associated with diaplectic glass or impact glass, it is important to check out the black hills and ascertain their glass mining potential. The whole 'outer basin' and beyond should also be prospected for glass because impact glasses are known to form thousands of kilometers away from their impact origin (http://www.unb.ca/passc/impactDatabase/Africa.html). Lake Bosomturi, in Ghana, is an ETIC that is believed to be the source of Ivory Coast's tektites and micro-tektites in the nearby ocean sediments (http://www.unb.ca/passc/impactDatabase/Africa.html).

There is also need for more research on ETICs in Kenya and the rest of Africa to enhance the continent's and country's geological data, as it is in the rest of the world.

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