NOTICE CONCERNING COPYRIGHT RESTRICTIONS

This document may contain copyrighted materials. These materials have been made available for use in research, teaching, and private study, but may not be used for any commercial purpose. Users may not otherwise copy, reproduce, retransmit, distribute, publish, commercially exploit or otherwise transfer any material.

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specific conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.
3. From the Beginning, Life in the Great East African Rift

Abstract: The East African Rift is associated with the origins of our human ancestors, starting at least four million years ago. This Great Rift traverses most East African nations, from Mozambique to Ethiopia, with over 200 hot springs, active volcanoes, and volcanic deposits all along its margins.

Certain hot springs were long believed to have curative properties and volcanoes were the dwellings of wild animals or the devil.

Lake Nakuru and Lake Natron are inhabited by flamingos who feed in the hot acidic water and raise their young in the warm mud. By eating the blue-green algae, they obtain a reddish color, and legend has it that they are the resurrection of the phoenix.

In the highlands of Ethiopia are 1,000-year-old churches carved from cemented volcanic ash. Local legends tell that these churches were built on divine command with the aid of angels.

The top of a volcanic monolith in the same area, Amba Wahni, was a prison for royal relations of the king who might usurp the throne.

EARLY HUMANS

AFRICA IS RECOGNIZED AS THE VERY CRADLE OF THE HUMAN race (Weaver, 1985). Prehuman remains of Australopithecus anamensis, the earliest known human ancestors to walk erect and dated between 4.07 and 4.17 million years old, have been recently discovered in Northern Kenya (Wilford, 1998). Remains of Australopithecus afarensis have been found in the Afar badlands of Ethiopia. The most famous find is Lucy, an adult female touted as the oldest known hominid, having emerged as early as 3.6 million years ago. These people died

"BASALT, originally an African word. 'The Egyptians also found in Æthiopia another kind of Marble which they call Basaltes, resembling yron as well in colour as hardnes.'
—Pliny XXXVI,vii, §11"
close to rivers or lakes and probably were familiar with the hot springs of the area. Numerous human fossil remains and footprints have been preserved in the volcanic ash (tuff) of the Rift Valley, the most famous at Olduvai Gorge in Northern Tanzania. This is a 40-kilometer long, river-carved canyon about 90 m deep, dropping abruptly from the Serengeti Plain. It offers well-exposed strata of lakebed sediments and volcanic ash going back nearly two million years. Here Louis and Mary Leakey found examples of *Homo habilis* dated at about 1.8 million years old (Weaver, 1985). Tools made from volcanic rock are associated with this find, mainly as cobbles used as hammer stones and choppers. Better specimens of *Homo habilis* were found on the eastern side of Lake Turkana in Northern Kenya.

*Homo erectus*, dated at about 1.6 million years ago, was found on the western bank of Lake Turkana. Remains from more than 200 early *erectus* humans have been found along the slopes.

---

**The East African Rift System**

The East African Rift System, or The Great Rift, runs parallel to Africa's eastern coast for 5600 km (Stager, 1990). This furrow, formed from a series of cracks in the Earth's crust and the resulting highlands, has two branches. The western branch starts in Mozambique to the south and runs north along the border of Zambia and Tanzania, through Burundi and Rwanda, and into Uganda. The eastern branch starts in Central Tanzania and runs north through Kenya and Ethiopia, ending on the continent at Djibouti and Eritrea at the Afar Triangle bordering on the Red Sea and Gulf of Aden. The rift can be traced further north to the Dead Sea, Turkey, and the Horn of Africa through the Gulf of Aden. Enormous troughs, up to 2 km deep and 90 km wide, are formed along these cracks. Elongated lakes, also formed by the rift system along the western branch, include Malawi, Rukwa, Tanganyika, Kivu, Edward, and Albert. Shallow saline lakes along the eastern branch include among the larger Eyasi, Natron, Turkana, Abaya, Abbe, and Assal. Massive Lake Victoria lies between the two branches. The volcanoes Kilimanjaro, Africa's highest peak at 5895 m, and Mount Kenya at 5199 m, stand adjacent to the rift near the center. Hot springs, many at boiling temperatures, lie all along the rift.

The stretching of the Earth and deposits of volcanic material form bold escarpments and dramatic valleys. The Ethiopian Highlands began some 20 million years ago. The rift system is fueled by hot magma upwelling from the asthenosphere, thinning and stretching the crust. Rising domes create the high elevations of Kenya and Ethiopia. Vast outpourings of lava coat the land and faults fracture the crust. At its highest point, the rift reaches 1900 m above sea level, and it is 156 m below sea level near the Red Sea. With time, movement of tectonic plates may split away the eastern portion of Africa from the main part of the continent along the rift, forming a separate land mass. The break is taking place at the rate of up to two centimeters a year.

There are numerous hot springs and fumaroles in the rift, and most are assumed to have been present in the past. Sixty-four hot springs are reported for Kenya, varying in temperatures from 22°C to 98°C (Kamondo, 1988), and all of these are associated with the rift system. A 45-megawatt geothermal power plant is in operation at Olkaria just northwest of Nairobi, the first geothermal electrical power in Africa. In Ethiopia, Djibouti, and Eritrea, there are at least 65 hot springs and fumaroles in the rift system, including the Afar area with reported temperatures of 40°C to 96°C (Endeshaw, 1988). Over 30 hot springs each exist in Uganda, Tanzania, and Northern Zambia. They are associated with the rift system.
Major continental rift fault and transform fault

Map of the East African Rift System.

Interpretation of a hammering tool chipped from volcanic rock and gullies bordering Lake Turkana (Leakey and Walker, 1985). *Homo sapiens*, the successor to *erectus*, entered the scene about 600,000 to 1,000,000 years ago, based on a recent discovery in Eritrea. Both *erectus* and *sapiens* migrated out of Africa, probably starting between one and two million years ago. Remains of *erectus* have been found in India, China, and Southeastern Asia, including the Heidelberg, Peking, and Java man. *Erectus* remains have not been found in Europe, although *sapiens* finds are numerous. The latter species is the ancestor of the Neandertal, appearing about 125,000 years ago in Europe and replaced by the Cro-Magnon about 30,000 to 40,000 years ago. Modern humans appeared about 10,000 years ago.
FEW LEGENDS CONCERNING HOT SPRINGS, FUMAROLES, AND VOLCANOES HAVE BEEN RECORDED OR passed down orally. As for the ancient traditions, the only picture that is available must be derived from archival records and surviving orally transmitted accounts. Generally speaking, African myths may be understood as imaginative traditions not only about the nature, history, and destiny of the world but also about the gods, humanity, and society. Each ethnic or tribal group in Africa has unique religious beliefs. While much of African mythology is religious in nature, as the tales convey sacred truths, not all myths are necessarily religious. Some may be primarily social and historical; even the gods may play somewhat secondary or inferior roles in them, or no role at all. These myths clarify the history and rationale of a social group, institution, tradition, custom, or social development (Mbitu and Prime, 1997).

The origin of mankind is usually linked immediately to the cosmogony in a creation myth. In these myths, humans may be placed on the Earth by a creator god, or they may arrive from the heavens or the sea. Other mythic groups include trickster myths, dilemma tales, proverbs and riddles, myths of destruction, and hero myths (Mbitu and Prime, 1997). African myths are not only lighthearted stories for children or pre-scientific explanations of the cosmos; they are insights—related through narrative, poetry, and ceremonial language—to a reality representing the experiences of unique, varied modes of existence. In short, they have been woven out of the substance of human experience: struggles with the land and elements, movements and migration, wars between kingdoms, conflicts over pastures and waterholes, and wrestlings with the mysteries of existence, with life and death (Courlander, 1996).

Few of these myths relate to experiences with hot springs, fumaroles, and volcanoes. But some do. The myth that follows is of the Menasa Bet-Abrehe, the Cushitic people of Northern Ethiopia descended from ancient immigrants from Arabia. Here, certain years are remembered for the wonders and signs that occurred, and one year from the time of Emperor John and of Ras Alula (1870-1890) is called the “Year of the Earthquake” (Courlander, 1996):

“In this year there was an earthquake in the whole Tigre country. About noontime the Earth was torn asunder and trembled much; and the mountain fires [volcanoes?] were kindled. And many large boulders that are now in the plain fell down from the mountains at that time, they say. And with the stones that fell down, some people were wounded in the country of Menasa Bet-Abrehe.
And in the clefts of the Earth fire was also seen, they say. And there are persons who have seen a cow swallowed by the Earth. And the earthquake stopped after a short while. And also the fires were soon extinguished. Even those that were born in that year are living as young men. And this time is very well known.”

Ol Doinyo Lengai, situated 200 km to the west of Kilimanjaro near Lake Natron, is one of numerous volcanoes scattered over the bottom of the East African Rift Valley. Lengai has two special characteristics: it is the only constantly active volcano east of the rift, and the composition of its lava flows is unique and geologically important. The magma moves out of the African mantle through ample beds of limestone, and it is the source of an extraordinary lava, silica-deficient but calcium- and sodium-rich. Since the lava contains no silica, it appears as a kind of molten limestone or carbonatite. Lengai was considered beneficial by local tribes, who believed that eruptions heralded the arrival of wild animals for hunting and farming. *Ol Doinyo* in the Masai language means “God’s Place” (McQuire and Kilburn, 1995).

Erta Ale volcano is situated at the bottom of the Danakil Depression, 120 m below sea level, in Ethiopia. The lava is basalt that forms a lake of 4000 square meters. For the Ethiopians, Erta Ale is the mountain dwelling of the devil. A recent explorer told his local guides that he had met no one at the bottom of the crater. They replied with humor that there were only little timid devils there, but the big one, the real one, is there behind the crest of the caldera, and it would do no good to go and see him (McQuire and Kilburn, 1995)!

The Masai, a pastoral and hunting people of Kenya and Tanzania, have myths and traditions for many natural phenomena such as the sun and moon, the stars, sunrise and sunset, the rainbow, comets, lightning, night and day (Courlander, 1996). When the Masai feel a shock from an earthquake, some say that a number of warriors are going on a raid, others that a mountain is trembling. When smoke or steam issues from the Earth, as from the active volcano Donyo Engai (Ol Doinyo Lengai) and steam jets near the Gilgil River northwest of Nairobi, the Masai say that there is a large deposit of chalk lying beneath the surface, that what one sees is dust. They are referring to the carbonatite lava, which, on contact with air and while cooling, changes rapidly from black to chestnut—and within a few hours from chestnut to white. The white volcanic material, in the form of fine cinders and dust, covers the foot of the volcano and the Masai land (McQuire and Kilburn, 1995).
GEOTHERMAL FEATURES AND USE

UGANDA

In many parts of Uganda, the inhabitants have long believed that certain springs have curative properties. Some of the springs are visited by people traveling from long distances to reach them. The most noted are those at Kitagata, otherwise known as Mugabe's Bath. Here there are two springs with temperatures of about 40° C, one of which is fenced off for the use of the Omugabe (or local ruler) and some chiefs, while the other is used by ordinary people. Since the waters contain only about 0.025 grams of dissolved salts per liter (25 ppm), the belief in their medicinal properties seems unlikely to have much foundation in fact (Dixon and Morton, 1970). (This same paper shows a contradictory value of 1,500 ppm for this spring.) Other springs thought to have curative properties are located at Panyamur and Palabek.

Henry M. Stanley, the famous African explorer, visited a hot spring in Uganda during his travels in 1876 (McClure, 1891). Captain McClure writes of Stanley's aborted trip to Lake Albert and the visit to the Mtagata hot springs:

"After parting with his cowardly escort, he proceeded to explore the streams and lakes to the north and west [of Uganda]. Then, returning to his generous host, he asked for guides to take him to the hot springs of Mtagata, the healing properties of which he had heard of far and wide from the natives. These were cheerfully given, and after a march of two days he reached them....

"He found a crowd of diseased persons here, trying the effect of the water. Naked men and women were lying around in the steaming water, half-asleep and half-cooked, for the water showed a temperature of one hundred and twenty-nine degrees [F, or 54° C]. The springs were, however, of different temperatures. The hottest one issued from the base of a rocky hill, while four others twenty degrees [F] cooler [about 43° C] came bubbling up out of black mud, and were the favorites of the invalids. Stanley camped here three days, and bathed in the water and drank it, but could perceive no effect whatever on his system."

Salt has been obtained at Lake Katwe since well before Stanley's visit over 100 years ago. During the 1960s the output ranged from 2,900 to 9,900 tonnes per year. Based on recent drilling, it is estimated that the lake contains over 20 million tonnes of mixed salts (Dixon and Morton, 1970).

KENYA AND TANZANIA

Situated in the rift valley in southern Kenya and northern Tanzania are a series of elongated lakes from Lake Nakuru to Lake Natron. Volcanic ash collected in these lake basins
turns the water basic or alkaline. These are the soda lakes, forbidding places of extreme heat, little fresh water, and meager food supply—bodies of water so full of soda or sodium carbonate that they burn almost anything that tries to enter. Hot springs on the shores and in the lakes can reach 60°C, hot enough to scald and kill almost any living creature.

Amazingly, the lesser flamingo (*Phoenicopterus minor*) is well suited to this hostile environment. The region’s four million flamingos form tribes thousands of birds strong that live by feeding in the volcanic lakes, which, although caustic, teem with microscopic *spirulina platensis*, a type of blue-green algae (*Nature*, 1998). The flamingos must adapt to each lake they inhabit and be able to “read” the water in order to survive, for a mistake can bring a scalding death.

Legend relates that the fire bird built a nest of frankincense and set it aflame. The bird remained in the nest and was consumed by the fire. Then something stirred in the ashes, and a brilliant bird reappeared more beautiful than before—the phoenix—the immortal bird resurrected from fire to live another 500 years. It is the algae of the lakes that contain scarlet pigment that gives the flamingos their firebird color, thus the association with the phoenix. The adult birds incubate their eggs in the 60°C mud for a four-week period. Long ago, when people saw the chicks emerging from the lake, they thought they were the resurrection of the phoenix, coming for a drink at the shore. The Phoenicians traded these scarlet-colored flamingos, believing they would bring immortality.

The most alkaline of these shallow, corrosive bodies of water is Lake Natron in Tanzania, just south of the Kenyan border. High mineral concentrations of sulfur, chlorine, phosphorus, and soda cause the water to turn caustic. The pH is as high as 10.5, which the flamingos can withstand. However, the skin underneath their feathers needs an occasional rinsing in clean water, which can be obtained from streams running into the lakes. If the soda doesn’t wash off, it can solidify on the birds’ feathers and prevent them from flying. Lake Nakuru in Kenya is also home to many flamingos. However, these and adjacent lakes have almost dried up in the past, threatening the birds’ habitat. The lake depths are quite variable, with a maximum depth of about three meters. Agriculture and livestock raised in the lake catchment area and effluents from sewage treatment plants threaten to pollute the lake.

In addition to providing food and breeding space for millions of flamingos, the soda lakes of this portion of the Rift Valley also hold great commercial value. In the past and yet today, salt has been extracted from the lake. When a lake dries up, the lake surface becomes a crystalline mass
and workers can walk directly upon it to harvest the crust for use by the local population. Today, sodium carbonate is a major ingredient in producing glass, ceramics, and paper, as well as a source of pink table salt. The Elmola tribe of less than 500 members fishes these saline lakes for tilapia.

**ETHIOPIA**

Menelik II, Emperor of Ethiopia from 1889 to 1909, transformed the country from a collection of semi-independent states into a united nation. As ruler of the kingdom of Shoa, in Central Ethiopia, he conquered the Oromo people to the south and annexed their land. He founded the city of Addis Ababa, which became the national capital in 1889. One of the reasons for selecting this site on the Ethiopia plateau was the location of the hot springs. The springs had been used by the local people for many years and legend has it that Menelik’s queen, Taytu, liked this location because she, too, enjoyed the thermal waters.

In the highlands of Ethiopia are over 50 Christian churches, many carved in natural rock. Those that remained hidden were spared destruction by armies and rulers. Most are almost 1,000 years old and have been used for worship by Ethiopia’s Orthodox Christians since the Middle Ages. The most famous are the 11 churches of Lalibala, carved from volcanic rock and decorated with brilliant Byzantine-flavored frescoes depicting the lives of Christ and the saints of the Ethiopian Church (Gerster, 1970). The churches of Lalibala are just as impressive today as they were when the Portuguese Chaplain Francisco Alvares visited them in the 1520s, despairing when his accounts were received with disbelief.

The complex of churches and chapels at Lalibala were carved about 800 years ago. The roof line of the churches was the top of a bank of pink tuff (cemented volcanic ash) on the shoulder of a mountain. Workers freed large rectangular blocks of tuff by trenching straight down into this naturally soft rock. Artists sculptured these blocks into houses of worship, removing material from the inside to construct vaulted chambers. Four of the shrines come together as a single monolith in a maze of tunnels, galleries, shafts, and alleyways. One of the churches, the elegant Church of St. George (Bieta Georgis or the “House of George”), is built as a cruciform shape in the surrounding rock.

The area is named for King Lalibala, who may have ruled toward the end of the 12th century. He was of the Zagwe dynasty and could trace his lineage to Moses. He was a usurper, a mountain war lord who seized power from the reigning king when the kingdom was weak. He
gained his reputation by manufacturing a large number of iron tools for cutting and hewing stone and paid for the construction of the churches. Local legend says he built the churches on divine command and with the aid of angels. The church also had a military side, as excavations have yielded remnants of fortifications. At least two of the rock-hewn structures used as churches are believed to have first served as a royal palace and reception hall (Gerster, 1970).

Speculation is that the workers might have been foreigners, particularly Egyptian Copts. These structures are similar to Aksumite rock shrines and Egypt's Abu Simbel, even resembling ancient constructions in Central Anatolia and India. Legend, on the other hand, gives a different story, one that says King Lalibala was taken to heaven and shown the design of the churches God wanted him to construct. Upon returning to Earth, the angels joined in the labor of the construction of 10 earthly replicas of the churches, which is reported in the Royal Chronicles (Courlander, 1996):

“When he began to construct these churches angels came to help him in each of the operations; there were thus a company of angels at work as well as a company of men, for angels joined the workers, the quarrymen, the stoncutters, and the laborers. The angels worked with them by day and by themselves at night. The men would do a cubit's work [about 18 inches] during the day, but would find a further three cubits completed on the morrow for the angels had worked through the night. Seeing this the workers exclaimed, 'How wonderful! We did a cubit yesterday and today we have four!' They doubted whether angels were doing this work because they could not see them,
but Lalibala knew, because the angels, who understood his virtue, did not hide from him; the angels were his companions and for that reason did not hide from his sight.”

Today on major religious holidays, pilgrims visit these churches, tripling Lalibala's population of about 9,000 people. Residents and visitors trade goods, exchange gossip, and crowd themselves into the sunken courtyards of the churches, which reverberate with their chants and the beating of drums.

Amba Wahni, the 550 m Ethiopian mountain where Princes of the Blood were imprisoned. By Lyle Mabbot, from In Search of Sheba by Barbara Toy, with permission
Northwest of Lalibala at Wahni is a volcanic monolith with an interesting history. Amba Wahni was the last of the Princes’ Prison Mountains, a high peak where princes of royal blood, all eligible to ascend the throne, were imprisoned to remove any threat they might pose to the existing king. Only when the oldest was to be crowned king was a Prince of the Blood brought down from the lofty heights; all the rest remained imprisoned (Toy, 1961).

Amba Wahni is a pinnacle of volcanic tuff, rising with sheer faces from the valley floor to a height of about 550 m. Its top is rounded and against its sides are placed the buildings, walls, and passageways of the prison. The sides are of the pinnacle are too steep to climb, and a stairway with a guard tower at the top was used to gain access to the prison. Today the steps have eroded away and the only access to the ruins is by helicopter.

In the 17th century, King Fasilidas chose Amba Wahni as a prison for his relations, and it was still in existence when James Bruce came to the country in the 18th century. Bruce heard many tales about the mountain, although he never set eyes on it. Johnson based his Rasselas, Prince of Abyssinia on the concept of Amba Wahni, although he later severely criticized Bruce’s account, implying that even Johnson himself thought this was just another Ethiopian legend or traveler’s tale.

Many of the princes spent their whole lives on the mountain, leaving only if they were chosen to be king. It is reported that as many as 400 princes lived on its summit at one time. Heavily guarded, they had little contact with the outside world. Soon after Bruce’s departure from the country, the custom was abandoned due to civil wars. All the princes were released from the
Remains of the church roof on top of Amba Wahni. Between the buttresses, square tiles of tuff are placed, similar to those in the palaces of Gondar. *From In Search of Sheba* by Barbara Toy, with permission

mountain, some as young boys, the others as old men. Amba Wahni was deserted and forgotten, only recently rediscovered and visited by Barbara Toy (1961).

**CAMEROON**

The greatest concentrations of geothermal phenomena are found in the East African Rift Valley, but known geothermal springs are also found in Northwestern Africa: Algeria, Tunisia, and Morocco. A phenomenon that received widespread attention was the eruption of a lethal jet of carbon dioxide from Lake Nyos in Cameroon, West Africa. Carbon dioxide escapes from hot rock into groundwater and enters lakes where it is concentrated and, under pressure, can escape in an explosive eruption. The 1986 release killed 1,700 villagers and 3,000 cattle (Stager, 1987).

Several legends exist about such explosions. One story, reported by an anthropologist, concerns a king who hanged himself after being tricked by the ruler of a rival people. The deceased leader’s body formed a lake that later exploded, killing many of the enemy. Other legends tell of the sudden death of cattle, of fish raining down from exploding lakes. There are more than 30 crater lakes in Cameroon that have the potential for similar eruptions. Lake Kivu in Rwanda,
perhaps the world’s most gaseous lake, holds huge volumes of carbon dioxide as well as highly flammable methane gas.

**THE FUTURE IS THE PAST**

**HUMANS HAVE PROBABLY USED GEOTHERMAL HOT SPRINGS AND STOOD IN AWE OF VOLCANIC eruptions along the Great Rift for well over one million years. This area is the origin of human-kind and its first encounters with geothermal phenomena. Recent volcanic eruptions, the continuous flow of hot springs, and modern geothermal wells—all indicate that the African people continue interacting with geothermal forces as natural features while developing spas and agricultural, heating and cooling, and electrical power generation projects.**

“The fool would say, ‘This world is a virgin girl.’ The wise man knows the world is old.”

—From a Hausa poem
REFERENCES


Note: The world map printed in this and succeeding chapters is courtesy of Corel Corp. Ltd.

The Author:

John W. Lund, Director
Geo-Heat Center
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, Oregon 97601 USA
Telephone: 541.885.1750
Fax: 541.885.1754
E-mail: lundj@oit.edu
"The Bath of the Queen of Sheba" at Hammei Tiberias, taken before her marriage to King Solomon, a legend recounted in the text. From the *Book of Astrology*, by Abu Maʿashar al-Balkhi, in Arabic. Iran or Iraq, 14th century. Bodleian Library, University of Oxford. MS. Bodl. Or. 133, folio 35 b, reprinted with permission.