MALAŴI METEORITES 1899 - 1981

By M. J. Crow

Introduction

Malaŵi with its high altitudes is well suited for meteorite falls and finds of past falls. The Kota Kota (found 1905), Zomba (fell 1899), Mtola (fell 1944), Dowa (fell 1966) and Machinga (fell 1981) Meteorites are described and their classification discussed. Large fireballs which might have dropped meteorites are described, including the Southern Malaŵi fireball of 21st January, 1969, the explosion of which was felt by the Chileka seismograph, but the impact site was never located. The Chelinda crater, Nyika Plateau, may have been due to a metorite impact or flow of a supersaturated bog. If it is a meteorite impact, it is of great interest as such impact craters are very rare on the earth's surface. It is concluded that as meteorites can cause fear when they land; several are probably hidden around the country. As meteorite awareness increases, more finds and falls will be reported for scientific examination.

Meteors or shooting stars are extra-terrestrial bodies whose passage through the earth's atmosphere raised the temperature of the body so that the surface burns. Usually such "fireballs" burn out in the atmosphere. It is only when the meteors are large enough, or have special trajectories that they survive the descent through the atmosphere and the fireball drops a meteorite. A meteorite is thus an extra-terrestrial object which has fallen on the earth.

Origin of Meteorites

Strictly speaking there are several different types of meteorites and different origins are postulated.

1. **Comet debris**

   Comets are vast frozen snowballs of ice, frozen gases (water, methane and ammonia) and extra-terrestrial dust. As comets pass through space the ice melts and a path of dust-debris is left in its wake. As the earth moves through space every so often it passes through such cometry dust trails. This is marked by seasonal showers of shooting stars in the atmosphere. Occasionally the larger cometry fireballs hit the earth and explode with mighty blasts, but ice meteorites, if they survive the explosion, cannot last long.

2. **Asteroid debris**

   It is very difficult and unusual to observe the trajectory of an incoming meteorite. In the few cases where trajectories have been photographed and orbits calculated the results show that the meteorites were moving in elongated elliptical orbits with an apogee in the asteroid belt. The asteroid belt is formed of small planetary bodies in between the orbits of Mars and Jupiter whose positions are strictly defined by the gravitational forces exerted on them by Jupiter.

Collision of individual asteroids on converging orbits is believed to cause asteroid fragments to be expelled into eccentric orbits around the inner planets of the solar system, while other fragments fall back into the surfaces of the colliding asteroids (Fig. 1) As a result of numerous collisions some smaller asteroids are probably only accumulations of asteroid fragments held together by gravitational forces.

The majority of meteorites are believed to be of asteroid origin. The asteroids have been suggested to be the debris of planetary bodies, somewhat similar to the earth in composition. The basic classification of meteorites into irons, stony-irons and stones is analogous to the inner core, outer core, mantle and crust of the earth. Meteorites also give radiometric ages similar to that of the formation of the earth, between 4.5 - 4.7 billion years ago.

3. **Cosmic debris of interstellar origin**

The carbonaceous meteorites are chondritic meteorites with 0.5 -3.5 per cent carbon, and traces of organic carbon compounds. Isotope ratios such as that of neon which differ from those of the solar system, have suggested to some investigators that chondritic meteorites contain primordial cosmic debris of interstellar origin dating from the early days of the Universe (Hoyle and Wickramasinghe 1978).

Some carbonaceous meteorites might originate from the asteroid belt, as spectrophotometric data indicates that the darker further out asteroids resemble the carbonaceous chondrites while the closer asteroids resemble the chondritic and stony-iron meteorites.

CLASSIFICATION

The classification of meteorites is complicated, but a brief look at it will assist in understanding the significance of the Malaŵi Meteorites. Basically, meteorites can be classified as "irons", "stony irons" and "stones".

Irons are alloys of nickel and iron and are classified on nickel content and grain size. Irons comprise about half the known meteorites finds, but only 5 per cent of the falls.

Stony-irons are mixtures of iron and stony silicate material. They are subdivided on the nature of silicate minerals, mainly olivine and pyroxene associated with nickel-iron alloy. Stony-irons are rare, forming only 2 per cent of the falls.

Stones or stony meteorites are the most common type of meteorite comprising 95 per cent of the falls. They are divided into two main types, achondrites and chondrites. The chondrites are the most abundant (85 per cent of the falls) and contain ovoids or chondrules of intergrown silicate minerals, which are absent in the achondrites (10 per cent of the falls).

A widely used classification scheme for the chondritic meteorites is that of Van Schmus and Wood (1967) (Fig. 2), in which chemical groups of chondritic meteorites are defined on iron and pyroxene content, and are separated into six petrologic types based on increasing textural alteration.

The achondrites are coarsely crystelline, contain little or no free iron and are mineralogically similar to certain terrestrial igneous rocks.

Meteorites in Africa

Africa with its large land area and range in latitude should be well situated for meteorite impacts. In general the record of meteorite falls and finds is poor, compared to America and Australia. This is because of the dispersed population, lush vegetation and the difficulty in separating possible meteorites from other dark coloured stones.

Malaŵi with its high altitudes (some areas are higher than 2km above sea level) and dense population by African standards, should be a good country for meteorite finds and locating falls.

METEORITE FINDS

Kota Kota (Nkhotakota)

The meteorite, known as Kota Kota, was located in the vicinity of the present Nkhotakota, by the then Collector of the Marimba District, Mr. A. J. Swann, who presented a specimen from it to the British Museum in 1905. Mr. Swann learned about this meteorite, which had fallen in his District several years previously, in conversation but was told that "as it was God's stone and came from the air, it was kept secret by a Chief and protected". After a year in attempting to locate the meteorite Mr. Swann managed to persuade his informants to bring him a fragment. A foot journey of 95 miles was made to collect the specimen, and no doubt the larger fragment still remains in the custody of the Chief where it fell.

The specimen retrieved weighed 333 grams and has the appearance of a nearly complete stone, rather than a fragment (Prior 1914). The outer shape is irregular and certain original faces are coated with traces of fused crust. Chondrules are present composed of pyroxenes with a matrix of pyroxene and plagioclase.

Subsequent work showed that the Kota Kota meteorite is composed mainly of enstatite (pyroxene). Only fifteen enstatite chondrites are known (Mason 1966). The Kota Kota meteorite is weathered, fine-grained, recrystallised and unusual in this type (E4 in the Van Schmus and Wood (1967) classification), in that it is full of chondrules. The main minerals present are clinoenstatite troilite (FeS) and some cristobolite (quartz variety). In chemistry the enstatite chondrites have a slight excess of silica (SiO_2) over magnesia (MgO) and other oxides.

Binns (1967) found in addition to the other minerals a small amount of olivine (fayalite) to be present, about 0.1 per cent of the stone. The olivine has irregular resorbed margins, cloudy cores and occurs within and adjacent to clinoenstatite grains in chondrules.

In considering the origin of this rare group of chondrites Mason (1966) suggested that the enstatite chondrites were formed due to the breakup of an asteroid through collision.

METEORITE FALLS

Zomba

On 25th January, 1899 at 0745 hours a detonation was heard in the Zomba area. Senior administrators surmised that the detonation was caused by a meteorite impact and immediately proceeded to collect "by aid of the telegraph and by personal interviews with witnesses, all the reliable evidence that could be obtained relative to so extraordinary a phenomenon".

A report by Mr. J. F. Cunningham, Secretary to the Administration and Mr. J. McClounie, Acting Collector of Revenues was forwarded by Mr. Alfred Sharpe, His Majesty's Commissioner and Consul General for the Protectorate of British Central Africa, together with several specimens, to the British Museum. A scientific account of the Zomba meteorite fall was published by Fletcher (1901).

The detailed account by Fletcher is a tribute to the thoroughness of the scientific collection of eye-witness data by the above officers. By telegraphing as far north as Karonga and as far south as Chiromo, it was established that the meteorite was seen at Chiromo, Blantyre and Fort Johnston (Mangochi) and to have travelled in an approximately eastern direction. It was seen, though the sky was cloudy, from places 130 miles apart.

The single detonation, heard at Chiromo, near Chikwawa, at Blantyre, Fort Johnston (Mangochi) and at Zomba, was described variously as an explosion, a loud report, and like thunder.

Reports soon came to the Residency in Zomba that several stones had fallen in villages east of Zomba. No less than ten were located, these being stones which fell near people or houses and it was considered that others remained to be found.

The distribution of the retrieved stones is shown in Fig. 3 taken from Fletcher (1901). It was deduced that the detonation was caused by the break-up of the meteorite and that the distribution of stones was caused by the resistance of the air on individuals of an initially closely packed swarm of meteorite stones subsequent to the break up of a parent meteorite body in the atmosphere. As the fragments are all encrusted, the break up must have taken place when their velocity was high enough for surface heating to occur.

The weights of the individual stones were as follows:

No. 1.	57 grams	6.	2622gms
2.	128gms	7.	822gms
3.	539gms	8.	638gms
4.	1502gms	9.	411gms
5.	354gms	10.	482gms

Stones numbers 3, 7, 9 and 10 were presented to the British Museum. The whereabouts of the remaining stones are not known. They were probably collected as souvenirs by the investigators and villagers.

The stones are covered with a thin crust, brownish-black to black in colour which in most cases is smooth, but occasionally is scoriaceous or wrinkled, and covered with protuberances. Nos. 9 and 10 were different, as each had one side covered with pit-like depressions.

The minerals form a fine-grained groundmass of olivine, enstatite and plagioclase with some larger crystals chiefly of olivine and a few chonrules composed of olivine crystals, sometimes with particles of nickel-iron around the chondrule outer boundary, and also containing some plagioclase. Also present are small irregular grains of nickel-iron and smaller black particles of nickel-iron, triolite or chromite set in the crystalline groundmass.

Fletcher (1901) reported in detail wet chemical analyses which he performed. In summary the following mineral composition was determined:

	Per cent
Nickel-iron	8.61
Olivine	42.44
Enstatite	34.80
Oligoclase	8.77
Troilite	4.85
Chromite	0.53
	100.00

Possibly because of Fletcher's exhaustive investigations no further work has been done on the Zomba meteorite swarm. It is presently classified as an L6 chondrite (Van Schmus and Wood 1967).

Mtola

Inkosi M'Mbelwa II wrote to the District Commissioner Mzimba on 20th June 1944 to report the fall of a stone from heaven at Mtola Nyanjagha Village, at about 1000 hours on 17th June, 1944. Tom Nyanjagha described the finding of the stone in an eyewitness account. He was sitting outside his house when he heard a "great rumbling and saw a sparking in the sky. Later we heard a thud and every one in the village went in the direction of the sound". A hole was found which was 300mm in diameter and 200mm deep "at the bottom of which we found a mass looking like black porridge. It was very soft and also very hot to touch. I took it out of the hole, but as it was hot I left it on the ground. I noticed my fingers had left some marks on it."

The meteorite was forwarded to the geologist, Mr. F. Savage, for identification. Savage described the weight of the meteorite "as two pounds and six ounces and dimensions of about four by three by two inches. It is irregular in shape and with angular and subangular edges and is probably only a portion of a much larger meteorite mass which broke up during its flight. Externally it is black, and some faces are coated with a black glassy, bubbly substance not unlike enamel paint in appearance. This substance is undoubtably a sort of glass produced by the fusion of the outer portion of the rock. Immediately beneath this black fused skin the meteorite is pale grey in colour and fine-grained. Streaks of black fused substance radiate away from a point of the rock; these are flow lines produced by air pressure and they show that the meteorite travelled with this point forward and that the molten material was blown back onto its aftermost faces, where it accumulated.

There are several small, shallow depressions in the rock, strongly reminiscent of finger marks, in fact Tom Nyanjagha, the first man to pick up the meteorite firmly believed that he left impressions of his fingers upon it! Actually it can be shown that the 'marks' were already on the rocks before it reached the ground and they very probably represent areas where the rock was completely burned away or from which small portions were flung off during flight."

The Mtola meteorite was never fully described. Savage called it an aerolite composed mainly of olivine and pyroxene with a little feldspar. The meteorite was placed in the old Geological Survey Museum in Zomba, now a store of the University located below the old Ministry of Works Headquarters Building facing the Post Office. At the time of the move of the Geological Survey to the present premises on the Liwonde Road in 1955, all unlabelled museum specimens were thrown out, including it is believed the Mtola meteorite. These unlabelled specimens were dumped along the fence with the C.C.A.P. Mission grounds, where many can still be seen, while others were incorporated in the foundations of newer buildings.

Dowa

The Dowa meteorite fell around 1 p.m. on 25th March 1976 at Chinguno Village about 3km northeast of Dowa (Fig. 4). The 1lb 6oz. meteorite fell with a thunderous noise heard in Dowa. A second smaller meteorite fell at Moyo Village 3km north of Dowa at around the same time.

The Dowa Meteorite had smooth sides and was mainly composed of coarse olivine crystals, feldspars and minor metallic minerals.It might be an achondritic meteorite.

Although the meteorite was later displayed at the Boma, its present whereabouts are not known to the writer.

Machinga

The Machinga Meteorite is the largest meteorite to be recovered in Malaŵi so far in this century. It fell on 22nd January 1981 at around 1000 hours (local time) in the Ndendeuli dambo, close to Mlelemba Village (15°12'44"s, 35°14'32"E), which is about 8km southwest of Machinga (Fig. 5). The flight of the meteorite was heard in Zomba and Malosa, where it was thought to be a jet airplane, and the impact was heard over a radius of 13km and sounded like an airplane crash. Eyewitnesses reported that a fountain of earth and sand was thrown up by the impact during which the meteorite buried itself in the dambo to a depth of about 750mm and debris was scattered within a radius of 40m of the impact site.

The meteorite weighed 93.2kg on recovery and its maximum dimensions are 410 x 320 x 310mm. It is a dark black, multisided block with curved, smooth and pitted faces with areas of spalling and scarring. The surface is covered with a thin, black fusion crust 1mm thick (Fig. 6).

The fresh meteorite is light-grey in colour and is intensely internally fractured. It is composed of closely packed chondrules, silicates and metallic minerals. The most common mineral is olivine, followed by orthopyroxene, kamacite and taenite and small amounts of plagioclase feldspar. A preliminary study of the chemistry and mineralogy indicates that the Machinga Meteorite is an L-6 chondrite group meteorite (Van Schmus and Wood (1967) classification.)

An interesting conclusion of the study by Crow et al (1981) of the Machinga Meteorite is that the intense internal fracturing predates the impact with the earth, as there is minor late fresh mineral growth within it. This mineral growth was likely caused by the heat generated as a result of a previous impact in space, perhaps the impact which fragmented the parent body, probably an asteroid.

METEORS AND FIREBALL EXPLOSIONS

Fireballs are commonly seen in Malaŵi. Fireballs mark the passage of meteors through the earth's atmosphere. The larger ones may drop meteorites. In this section some of the larger meteors are discussed which exploded in the atmosphere or on impact with the ground. Meteorites may be found in the area of the explosion, unless the meteor was volatised in the explosion.

Karonga

On 29th September 1953 a brilliant fireball crossed the sky at about 8 p.m. in a north-south direction. A loud explosion followed three minutes after the disappearance of the light, and was reported between the Songwe River and Hara. The explosion sounded like the report of a naval gun and as there was no earth tremor it was concluded by the Senior Agricultural Superintendent at Karonga, Mr. A. C. Williams, that the meteor had exploded in the sky, contrary to a report in the *Nyasaland Times* that it hit the earth.

Mikolongwe

On 18th January 1955 the Director of the Geological Survey wrote to the Veterinary Officer at Mikolongwe Veterinary Station asking him to look into a reported meteorite fall near Mikolongwe which had occurred on 22nd December, 1954. His information source was a Mr. F. Y. M. Mulangati who reported that "Something came out of the sky which burst with a loud bang and made a large hole in the ground 12 yards wide. Also one side of a house came down." Unfortunately Mr. Mulangati did not give his full address and this interesting report could not be followed up.

Chelinda Crater, Nyika Plateau

During the night of 23rd April 1960 the wife of the Forester of the then, young pine plantation at Chelinda, was awakened by a rumbling sound. The next morning the Forester, Mr. John Kanyika, found a mudflow had made a large dam in the Chelinda river, within the plantation, but claimed that no pines had been damaged.

This mudflow created widespread interest and was visited in early May 1960 by the Chief Conservator of Forests, Mr. R. G. Willan. Mr. Willian considered that the mudflow was caused by heavy rain supersaturating a seepage bog, which became mobile and flowed down the hill. Willan (1962) wrote "the bog itself has almost the appearance of a bomb crater, the soft covering having been washed out leaving the underlying harder clay exposed".

Mr. W. M. Ndovi of the Forestry Department visited the landslide about a week later and was told that it could have been the result of a meteorite. Mossman (1972) visited the crater in 1961. Though he was not certain of its exact whereabouts, there is no doubt that he refers to the Chelinda crater from his references to the adolescent pine plantation and the mud flow. However, he incorrectly gives the formation date as 1959 rather than 1960.

Mossman was told that the night the crater formed "an object fell into the plantation, and the fall was accompanied by a bright light and a loud explosion and was directly followed by a short-lived windstorm, a portion of the plantation was destroyed in the vicinity of the crater; trees were scorched and flattened radially outward for 100m and a small landslide resulted." Mossman measured the crater to be 80m in diameter and 6m deep.

When Mr. P. N. Mosley visited the crater in 1981 the meteorite impact origin of the crater and mudflow was accepted by the Chelinda residents. The stream draining the crater is even called "Manyenze" or star river.

Unfortunately no physical trace of a meteorite has been recorded. Mossman only found a few iron particles, which might or might not have been meteoritic in origin. If the crater and mudflow were caused by a meteorite impact, the meteorite might have been related to the Lyrid ice meteor shower (April 19-24th). As fresh impact craters on the earth's surface are very rare, and it would seem that the Chelinda crater could be an example of one, the crater deserves careful investigation, even at this late date.

The Southern Malaŵi fireball

At around 10.30 p.m. on Tuesday 21st January 1969 a brilliant fireball with red, green and yellow tints, crossed southern Malaŵi from west to south-east and was reported to have been seen in Blantyre, Limbe, Zomba and Lilongwe. Mrs. G. D. Hayes at Naminkwenya Estate, 24km from Limbe, recorded that the fireball disappeared from sight in the Mulanje area, possibly into Mocambique. The disappearance was followed by a rumbling thunder-like sound which lasted for a minute. Neighbours' windows shook in the ensuing earth tremor.

The meteorite impact was recorded on the Chileka seismograph at 10.32 p.m. (GMT). The tremor had a local magnitude of 1.8 and was considered to have occurred about 30-40km south and east of Chileka.

Although enquiries were made, no crater or explosion scars have ever been reported, and if the fireball dropped a small meteorite, it has never been found. It seems possible that the fireball exploded just above the ground and the meteorite was vapourised during the explosion.

Discussion

Despite its small area Malaŵi had had quite a few meteorite falls reported in the past eighty years. Undoubtedly there have been other meteorite falls which have not come to general notice. There are good reasons for this. The landing of a meteorite can be a frightening event being unexpected and associated with strange sound and light effects.

For example, the Dowa meteorite nearly hit a man who was working in his garden, and most of his fellow villagers took to their houses for several days foresaking cooked food in the meantime. In such circumstances when the meteorite is thought to be a missile aimed by enemies, it may well be destroyed subsequently. The Machinga meteorite did not land so close to people and members of the local community dug it up shortly after its landing. Its arrival in Zomba aroused great interest and religious services were held at the impact site which had to be fenced off since there were so many visitors.

The social effects of meteorites might well be a fruitful area of study. From the scientific viewpoint a rare meteorite type has been found in Malaŵi (Kota Kota) and a possible impact crater (Chelinda), besides other falls. As more awareness of the nature of meteorites is established, it will be more likely that meteorite finds and falls will be brought forward for scientific investigation.

Acknowledgements

Many people have kindly given information about meteorites in Malaŵi. I would like to thank Mrs. G. D. Hayes for her account of the Southern Malaŵi Fireball and copies of contemporary press releases; Dr. R. L. Johnson for drawing my attention to the Chelinda crater, Mr. W. M. Ndovi for details of the crater and mudflow and Mr. P. N. Mosley for further information on the phenomenon in late 1981; Mr. A. Mndala for his description of the Dowa meteorite; Mr. J. E. R. Emtage for writing about the "Agrimal Meteorite" and Mr. M. G. Walter for his account of its finding and burial.

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APPENDIX

The "Agrimal Meteorite"

When the Agrimal Factory was being built in May 1967 a global object 30-36 inches in diameter was encountered during excavations for the foundations of the office block at a depth of six feet below ground level.

The General Manager, Mr. M. G. Walter, is the only remaining eyewitness of the trouble this object caused which he described as follows: "When it was found the builders excavated around it and attempted to lift it with a crane. When this was not successful they tried to break it with a paving hammer, again without success. The builders then built a fire around it which was kept alight for three days after which cold water was thrown on it hoping that it would fracture. This also failed and so a pit was dug alongside it and it was moved away from the line of the foundation by means of hydraulic jacks. As the foundations were filled in it was covered up."

In view of the unusual impression it made and its physical properties, the Agrimal object might well have been a meteorite. As there was no sample collected, we will never be sure.

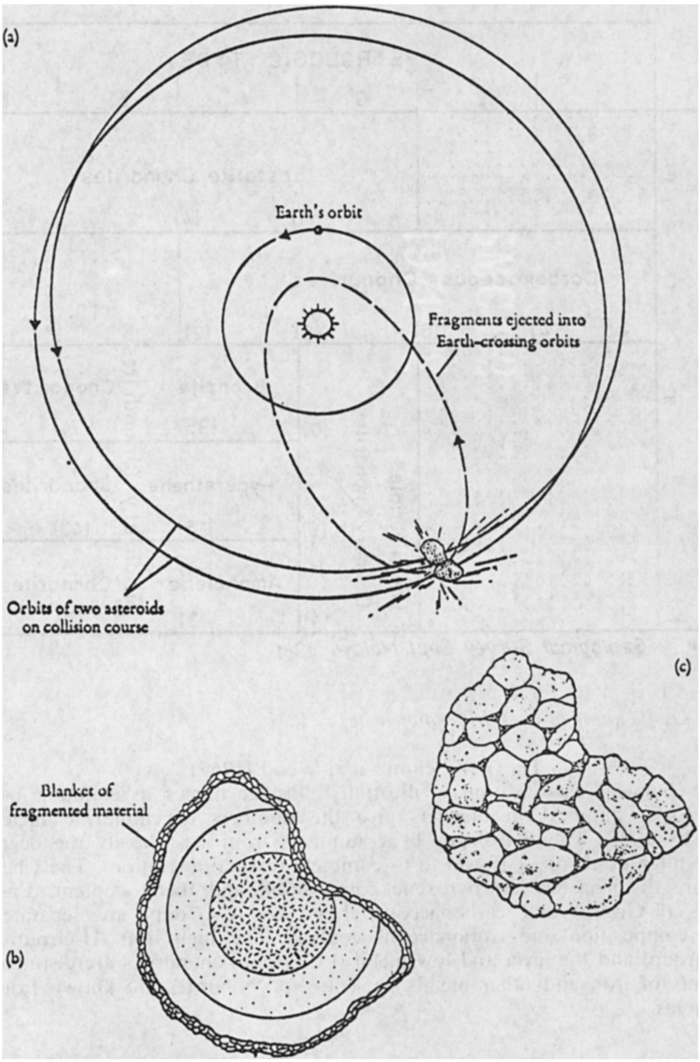


Fig. 1 *The origin of meteorites and the nature of asteroids.*
(a) Meteorites which arrive on Earth may result from collision between asteroids in the asteroid belt. The collisions may cause particles to be ejected on highly elliptical orbits, enhanced by perturbations by Jupiter.
(b) A differentiated asteroid after a collision may have a large chunk of itself missing, but much material ejected in the collision will fall back, forming a blanket of fragmented material covering the entire surface.
(c) Successive collisions in the crowded asteroid belt may reduce the whole asteroid into a jumbled heap of loose fragments. It is unlikely, however, that significant loss of mass will take place, since most fragments will fall back gravitationally after impact. Many asteroids are therefore probably orbiting heaps of broken boulders.

After Francis (1981)

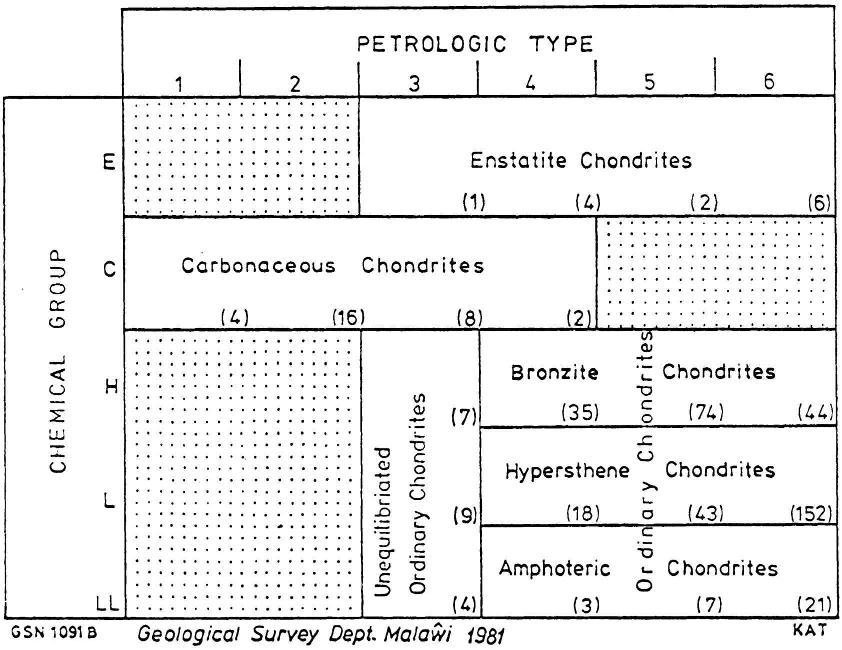


Fig. 2 *Classification of chondritic meteorites.*

The Van Schmus and Wood (1967) petrologic-chemical classification is illustrated. Proper names in common use are given and the numbers in brackets give the numbers of chondritic meteorites classified by 1967. The Petrologic Type numbers from 1-6 classify the degree of petrologic alteration from 1 (fresh) to 6 (complete textural alteration). The Chemical Groups are distinguished on pyroxene composition and metal content. Enstatite chondrites (E-Group) and carbonaceous chondrites (C-Group) are separated on pyroxene composition and carbonaceous content. The high iron (H-Group), low iron (L-Group) and low iron and low metal (LL-Group) chondrites are distinguished on amounts of iron and other metals present. No chondrites are known from the stippled areas.

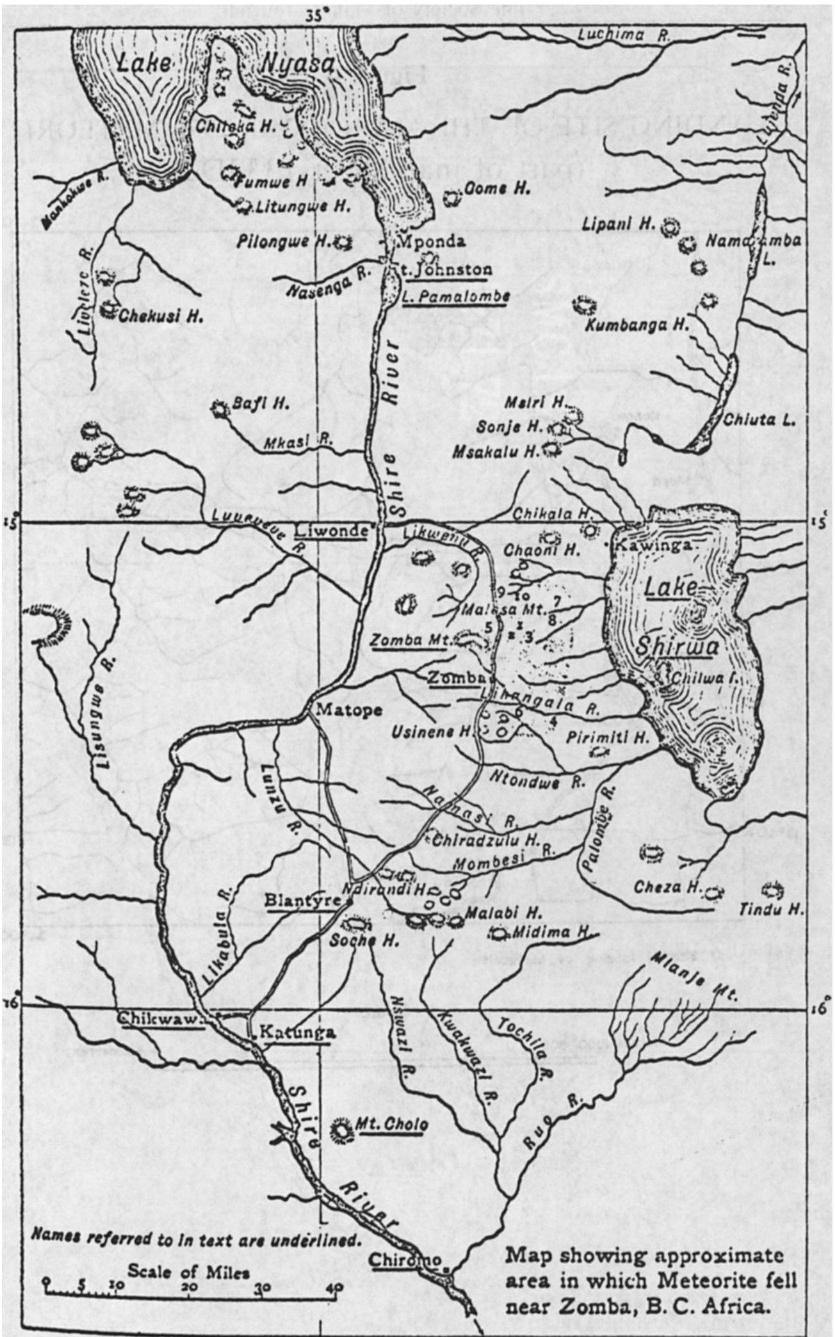


Fig. 3 *Fall sites of the Zomba Meteorite, 25th January, 1899. After Fletcher (1901), Plate I*

Figure 4

LANDING SITE OF THE MARCH 25th 1976 METEORITE
(part of map sheet 1333D2)

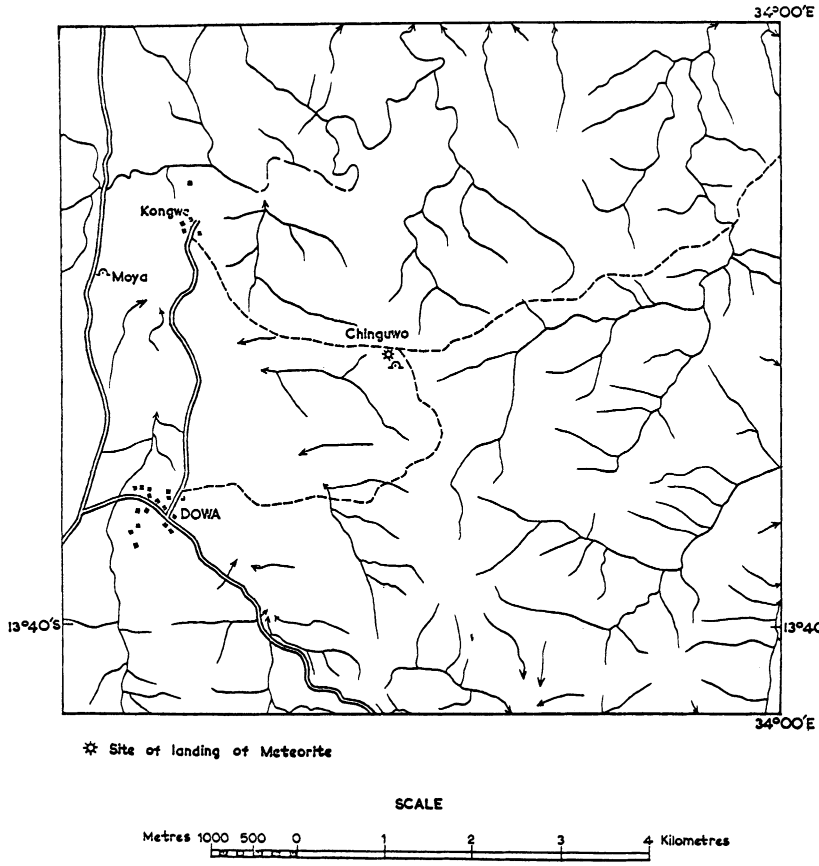
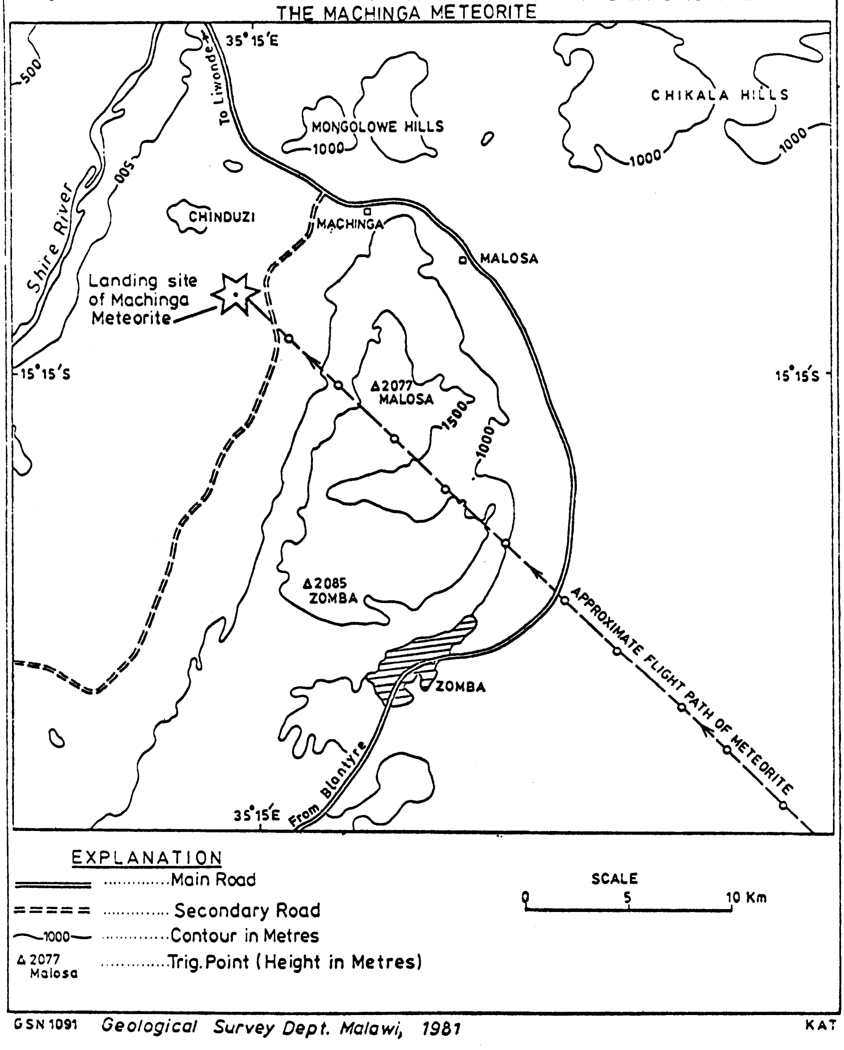


FIG. 5 LOCATION MAP SHOWING APPROXIMATE FLIGHT PATH AND LANDING SITE OF THE MACHINGA METEORITE



GSN 1091 *Geological Survey Dept. Malawi, 1981* KAT

Fig. 6 *The Machinga Meteorite.*

A large surface is pitted with "thumb print" impressions and covered with black fusion crust. To the top left is a scar area where a piece has broken off, probably in the atmosphere. Transportation damage on the earth can be seen on the left side and bottom right.