THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. V.—MAY, 1905.

ORIGINAL ARTICLES.

I.—FOUR AND A HALF MONTHS IN CRETE IN SEARCH OF
PLEISTOCENE MAMMALIAN REMAINS.

By DOROTHEA M. A. BATE.

(PLATES IX AND X.)

THE geological map of Crete shows that a large portion of the island is composed of ancient limestone, in itself almost a guarantee of the presence of Pleistocene cave deposits. In confirmation of this, Admiral Spratt in his most valuable work¹ mentions finding two such deposits, from one of which he obtained a few mammalian remains.

I arrived off Khania early one morning in the beginning of March, 1904. From the sea the town is picturesque, being built down to the water's edge and almost encircling its tiny harbour. At some distance inland the Aspro Vouno rise abruptly in places to a height of 8,000 feet; this massive ridge forms the backbone of the western district, the wildest and most rugged part of mountainous Crete. At this time of year the snow lies for a considerable distance below the topmost summits, and it is not until months later that it disappears, leaving, as on Ida, a few patches on sheltered slopes and in deep crevices, where it remains the whole year round.

Roughly speaking, Crete may be said to consist of a high and central limestone ridge, at the foot of which is a border of fertile country. In three places this fertile zone extends across the entire width of the island, separating this backbone into four more or less isolated masses. These are the Aspro Vouno and the Mount Ida group, which are more closely connected than the other divisions, the Lassethi Mountains and the hilly plateau of Sitaea. It is curious to note that differences exist, both in language and dress, between

¹ "Travels and Researches in Crete," 2 vols.; London, 1865.

difficulty detached from the hard substance in which they were embedded. Besides these some pieces of breccia containing the remains of small rodents were also procured. Unfortunately it was only possible to work here for a few hours, for, owing to the distance and rough track, it occupied four hours each way to and from Khania. The fact that this was the only deposit in which traces of a dwarf elephant were observed made it a matter of much regret that the investigations begun here could not be continued, but it was impossible to delay my departure from Crete beyond the 24th of the month.

The first trip into the country from Khania took me to the monastery of Gonia, near Kolymbari, which was reached on March 20th after a ride of several hours, chiefly along the seashore. The following morning no difficulty was experienced in finding the cave (Plate IX) already described by Admiral Spratt,¹ who obtained from it a few remains which he mentions as having been identified by Dr. H. Falconer² as those of "a goat, a roebuck, or stag, and of a small *Myoxus*." For several days some work was carried on here, but without much success, for the ossiferous deposit, which was very hard, extended only a little way inside the cave, and specimens worth preserving were difficult to obtain. A number of other caves on this side of the peninsula, including the Kimido Spilia of the Admiralty Chart, were examined, but without result.

Later, when staying at the tiny village of Kamara Kumuli, I was taken to a small cave or hole in the cliffs below, and somewhat to the south-west of Ravduka. In spite of the stalagmitic flooring of what remained of this cave being entirely broken up, presumably by the action of the waves, some few good specimens were obtained from a crevice half-filled with earth and sand. A portion of the bone breccia could be seen to extend for a short distance below the present level of the sea. The remains noticed here included only those of the two species of ruminants already mentioned.

On a trip to Malathiros, which lies some little distance in the hills inland, no bone caves were heard of, but more success attended a return to the coast still further west. At the western base of the Grabusa Akrotiri lies the small promontory of Kutri, or Phalasarna, to give it its ancient name, the site of the western town of the early civilization of Crete.³ At the northern edge of this cape, where the limestone cliffs are reduced to an insignificant height, a cave opening towards the sea was found to contain the remains of a large ossiferous deposit. That this must originally have been of considerable extent is shown by the fact that between the highest and lowest traces of bones is a distance of fifteen feet; these probably occurred in bands of about three feet in thickness and separated by layers of stalagmite. Two such bands were clearly traced at the inner end of the cave; in the upper remains of an

¹ Op. cit., vol. ii, pp. 194-5.

² I have been unable to find any account of these remains published by Dr. Falconer.

³ Spratt, op. cit., vol. ii, chap. xix.

antelope were most plentiful, while in a lower one horns and teeth of a deer predominated.

In the cliffs less than a hundred yards to the south-west is another cave which can only be reached from the sea. This is smaller and narrower than the one described above, and contains only a very fragmentary remnant of an accumulation of mammalian remains. Besides this some few specimens were brought in by one of my men, who said he had procured them from a cave on the east coast of the Grabusa promontory and about two hours walk from Kalivjannee, but I was unable to go and verify this information. Previously, when at the eastern base of this Akrotiri, a great number of fossilised remains of a large echinoderm were noticed in the low sea-cliffs at this spot.

Before leaving Mesoghia,¹ whence the Kutri cave was worked, a visit was paid to Sphinari on the coast at some hours distance to the south. Its position is somewhat isolated, and it is claimed by the inhabitants to be an outlying village of the Enneakhoría. A walk of less than an hour along the cliffs on the south side of the small bay brought us to the partially submerged remains of a cave deposit, now almost entirely destroyed. Of the cave itself this is the only trace to be seen; some teeth and bones of ruminants and part of the dentition of a rodent were obtained here.

No other deposits were found west of Khania, but before describing those discovered in the east of the island a few remarks on the former may not be out of place. Apart from the interest of the mammalian remains contained in them the situation and condition of these deposits suggest a number of problems as to the probable method of their origin, to which it seems difficult to supply any satisfactory explanation. The Kutri cave may be noticed with more detail, presenting as it does phenomena somewhat similar to the smaller Kutri cave, that near Ravduka, and the deposit close to Sphinari. The lowest trace of bones is only about 10 feet above the sea, while the whole floor bears unmistakable traces of having been largely broken up and to a great extent washed away. On the walls of the cave is a distinct sea-level mark now about 20 feet above the water. In confirmation of this it seems to have been satisfactorily proved by the observations of Admiral Spratt² that a local³ "déplacement négatif" to the extent of 22 feet has taken place at this point of the coast, and that *within historical times*, making it a matter of certainty that this has occurred since the accumulation of the ossiferous deposit.⁴ A similar alteration of the

¹ This is an isolated homestead which, although close to Kalivjannee, is called Mesoghia, no doubt after the villages of that name to which it probably belongs.

² Op. cit., vol. ii, chap. xix, pp. 195-6, etc. Suess also gives a list of records in this connection; see "La Face de la Terre," vol. ii, pp. 700-1 and 740.

³ That this was only local is proved by the fact that in the east of the island a contrary movement has occurred also within historic times. See Spratt, op. cit., vol. ii, pp. 21-2, etc., and Suess, op. cit., vol. ii, pp. 700-1.

⁴ Admiral Spratt even says in discussing the disappearance of the harbour at Tripiti, on the south coast, which was described by the author of the "Stadasmus," that this is "another proof of the great upheaval along the coast having taken place since a late Roman period, the date of the 'Stadasmus' being considered to be about that time" (op. cit., vol. ii, p. 246).

coastline, though in a greater or less degree, is recorded by this author for nearly the whole of the west coast of Crete.

It might be assumed that the ossiferous remains were introduced into the cave by the sea, but on the other hand several facts seem to suggest a different explanation. The appearance of the interior of the cave points conclusively to its having been invaded by the sea subsequently to the deposition of the mammalian remains as already mentioned above. The material in which these are embedded is exactly similar to that found in other caves differently situated, and does not contain sea shells, though a few occurred, together with a small quantity of sand, in a hole or crevice. Some of these were adhering to pieces of bone which were exposed at this spot, but none were found enclosed in the solid matrix in conjunction with the mammalian remains. A considerable quantity of coarse sand was also observed in a crevice containing a number of remains in the cave near Ravduka.

As an alternative the only manner in which it seems at all possible that these remains could have been deposited in the caves when under water would be through the agency of an underground river with its outlet below the surface of the sea. Accumulations might then have formed in a backwater or eddy, or even in the main stream when it had become sufficiently reduced to allow of this. The partial destruction of the deposits by sea action would take place when the sea and cave eventually occupied relative positions that would allow the surf to break in with some force. In Crete, as in other limestone countries, these subterranean streams are by no means uncommon;¹ as examples mention may be made of the swallow-holes, locally known as khonos or katavothron, which carry off the waters from a number of hill-encircled upland basins. Besides these are several streams with a large flow of water which abruptly rise out of the ground, as near Haghiots Nikola, at Armyro west of Candia, and at Armyro on the coast at the south-west corner of Armyro Bay.

On the whole it seems easier to believe that these bone breccias were originally formed on the floors of land caves subsequently submerged beneath the sea, from which they have again been gradually elevated to the extent already noted.

To account for the disappearance of the walls and roof of some of these caves, such as at the deposit near Cape Maleka and several others in the east of the island which have not been submerged, is not difficult. For even where the action of the sea has played no part, or only to the extent of surf breaking in during storms, the effects of weathering on these practically barren limestone rocks is very rapid and severe. As a factor of possible importance in the destruction of the caves, it may be remembered that Crete lies within the zone where earthquakes are of by no means infrequent occurrence; a particularly severe one doing much damage to many of the towns occurred as late as 1856.

¹ An interesting paper dealing with this subject is "Submarine Gullies, River Outlets, and Fresh-water Escapes beneath the Sea-level," by H. Benest, Assoc. M. Inst. C. E.: *Geog. Journal*, October, 1899, vol. xiv, pp. 394-413.

EASTERN CRETE.

In the beginning of May, shortly after returning to Khania from a second trip in the west, a start was made for the east, where I remained until shortly before leaving the island in the latter end of July. Candia was reached, after a somewhat wandering course, including Lake Kurnas, Myrthio (from whence one of the small beds of fossil wood mentioned by Raulin¹ was visited), Kria Vrisis, Phaestos, and Haghia Dekka, near which is the enormous underground quarry known as the Labyrinth.

Along the coastline east of Candia no cave deposit was found until Melato, in the eparkhia of Mirabello, was reached. Here one was discovered on the bare hillside to the north-west of the village, and between it and the sea. No part of the former cave was to be seen except a few fragmentary portions of the stalagmitic flooring showing above the ground, and containing remains of a pigmy hippopotamus.

To the east of this my wanderings were continued through the fertile plain of Mirabello, and on by a road never very far from the coast to Sitaea. Thence to the monastery of Toplou, Eremopoli, with its ancient ruins, and Palaikastro, the site of important archaeological excavations made under the auspices of the British School of Athens. A return was made across the limestone plateau in which Khandra is situated, by Daphnaes and Rhukaka, down the gorge to Kavusi, where the former route was joined.

The only cave deposits found in this part of the island were situated in the rugged limestone cliffs bordering the southern end of the Bay of Kharoumes, not many miles south of Palaikastro. At the foot of these cliffs and only from a few feet to a few yards above the sea were discovered one small bone cave and, on either side, portions of the stalagmitic flooring of two others; all being situated close together and extending for a distance of about a hundred and fifty yards. The most northerly of these deposits, which is at a greater height than, and at a little distance from, the cave, contained only bones and teeth of the small hippopotamus which also occurs at Melato. The remains in the cave and in the other deposit² proved to be those of ruminants similar to those found in the caves of the west of the island.³

Some little distance further along the coast in a south-easterly direction is another cave, in which the floor is entirely broken up and heaped with huge boulders; at its inner end, however, a few bones and a piece of a deer's horn were observed. These were embedded in the roof, which at this spot is partly composed of red earth. The position of these remains seems to be a strong argument in favour of the idea that, at all events in this instance, they must

¹ Op. cit., vol. i, p. 181, and Spratt, op. cit., vol. ii, pp. 270-1.

² A few land-shells were obtained here, and have been identified by the Rev. R. Ashington Bullen as *Helix pellita*, Fer.

³ A few fragmentary remains of a large proboscidean were found in the rocks close to this cave. They have not yet been examined, but will probably prove to be of earlier age than Pleistocene.

have been introduced through the agency of water. The same was probably also the case in the other cave close by, in which it can be seen that, previous to the stalagmitic flooring having been disturbed, part of the bone breccia had reached to within about a foot of the roof, and this in the portion of the cave where the present entrance is situated. A curious point in connection with, though perhaps hardly in support of, this theory is that the different species were not found indiscriminately mixed together in any one deposit. The remains of the antelope and deer seem to be invariably associated, though the proportions in which they occur may vary in the different layers of the floor, as in the Kutri cave (p. 196). Bones and teeth of small rodents were, in one or two cases, found in the same deposit as the above; similarly they occurred in a fragmentary portion of the upper layer of the breccia near Cape Maleka, which besides these only contained remains of a pigmy elephant. Further, no other species was observed in either of the two cave deposits in which portions of a dwarf species of hippopotamus were found, although one of these, as already mentioned, was situated only a few yards from a cave containing remains of ruminants.

As long ago as about the year 1842¹ some remains of a small hippopotamus were obtained at Candia by Captain Graves, R.N., though it was not known where they came from. Somewhat later further specimens were procured at Kritsa, a large village on the eastern base of the Lassethi Mountains, by M. Raulin,² who was told that they had been found in the upland basin of Katharo. This spot he visited, and subsequently described, but without finding any specimens in the deposits in which they were said to occur. Owing to this information Kritsa was visited at the earliest opportunity, and here a small number of isolated hippopotamus teeth were brought in by the villagers, and at length an old man appeared who professed to know the locality from which they came. The following day he took us to the upland basin of Katharo, which is about three hours from Kritsa and nearly 4,000 feet above the sea. Although already past the middle of May, at this height it was bitterly cold, a keen wind bringing with it a damp and all-enveloping fog. This spot is not permanently inhabited, only a few shepherds staying here with their flocks during the summer months, when they and their beasts obtain shelter in rudely built and indescribably filthy hovels; the only other buildings being one or two small dedicatory chapels. A few crops of corn and vetches struggle for existence, while a number of fruit-trees grow in shelter of the northern hills. This mountain valley runs almost due east and west, and is about two miles long and from half to three-quarters of a mile wide. Completely encircled by hills, its surface presents an undulating appearance, particularly at its eastern extremity, and it is intersected by a number of streams all flowing westward, in accordance with the general inclination of the valley. These have

¹ Spratt, *op. cit.*, vol. ii, p. 386.

² *Ibid.*, pp. 386-7.

excavated their courses in places to a depth of eight or ten feet, showing that the ground to this extent consists of reddish yellow and grey clays topped by a layer of darker soil varying in thickness from a couple of inches to one and a half or two feet. At the western extremity of Katharo, where the hills are lowest, the streams have broken through the rocky barrier, cutting a deep and narrow gorge by which the accumulated waters find a way to the more extensive upland basin of Lassethe, which lies nearly a thousand feet below.

My guide first took me to the top of a rounded hillock in the eastern half of the valley, where a few fragmentary remains were found lying on the surface, where some débris evidently of volcanic origin, such as lava, etc., was also observed. During the next few days trial trenches were dug in a number of places in this vicinity, teeth and bones of a pigmy hippopotamus being found in varying quantities and at different depths. At the spot shown in the photograph (Plate X) the remains occurred somewhat sparingly in a band of bluish grey clay about one and a half to two feet thick. In a channel cut by a stream through yellowish clay others were found in great numbers at a depth of six to eight feet below the surface. Here the infiltration of water made them very rotten and difficult to extricate intact; however, eventually a number of teeth and jaws and a large series of perfect limb bones were obtained.

The presence of these hippopotamus remains shows that the deposit in which they occur is almost certainly of fresh-water origin, and this is easy to believe when it is remembered that before a channel was worn through the barrier of surrounding hills there was probably no outlet for the accumulated waters, which in that case would transform the valley into a lake or swamp, according to the season of the year. A view of the neighbouring enclosed plain of Lassethe encourages this idea, for here the only egress for the streams is by means of a swallow-hole, or khonos; should anything cause this to become blocked the drainage of both Katharo and Lassethe would be forced to remain in the latter, soon forming it into a marsh and possibly a lake after the melting of the snow off the surrounding mountains. Admiral Spratt mentions¹ that in spite of a swallow-hole in the upland basin of Omalo, in the Aspro Vouno, the centre of it is converted into a lake for some months during the winter.

Considering the ordinary habitat of the hippopotamus, it is curious to find numerous remains of a small species at the unusual height of nearly 4,000 feet above sea-level, and that amongst rugged and barren mountains. The above-mentioned author considered² that their occurrence in this situation "involves the necessity of conceiving great physical changes in the relative levels of sea and land since they existed in Crete." His suggestion of a depression in this part of the island to the extent of some 3,500 feet would seem

¹ *Op. cit.*, vol. ii, p. 176.

² *Ibid.*, p. 387.

to be disproved by the discovery of similar, and presumably contemporary, remains nearly 4,000 feet below Katharo. May it not be that this upland basin, then a lake or marsh, became a last stronghold of a dying race of hippopotamus? This does not seem so improbable if we imagine a slightly warmer climate to have been then prevailing, and with it the consequent existence of a vastly greater amount of vegetation.

CONCLUSION.—It will be seen from the above that during my stay in Crete thirteen deposits containing remains of Pleistocene mammals were found, though only four were worked to any extent. These are all situated in the northern half of the island, for it was found impossible in this time to explore more than a comparatively small area, and that imperfectly; the southern coastline was practically unvisited. This was partly due to the distances to be traversed and the slow rate of progress over rough country; the total disappearance in many cases of all traces of the caves save a portion of the stalagmitic flooring greatly added to the difficulties of their discovery.

The following is a list of Pleistocene ossiferous deposits found:—

1. Cave deposit near Sphinari, West Crete. (p. 197.)
2. Cave, Cape Kutri, West Crete. (p. 196.)
3. Cave, Cape Kutri, West Crete. (p. 197.)
4. Hagios Basilis (cave), near Ravduka, West Crete. (p. 196.)
5. Tripiti cave, near Gonia Monastery, West Crete. (p. 194.)
6. Cave between Khania and Suda, West Crete. (p. 194.)
7. Cave at Hagios Georgios, Khania Akrotiri, West Crete. (p. 194.)
8. Cave deposit below Katholiko Monastery, West Crete. (p. 195.)
9. Cave deposit near Cape Maleka, West Crete. (p. 195.)
10. Cave deposit near Melato, Mirabello, East Crete. (p. 199.)
11. Cave deposit (3?), Kharoumes Bay, Sitaea, East Crete. (p. 199.)
12. Cave, Kharoumes Bay, Sitaea, East Crete. (p. 199.)
13. Fresh-water deposit, Katharo, Lassethi Mountains, East Crete. (p. 201.)

The mammalian remains found in the above have not yet been specifically determined, but are known to include the following: antelope, deer, elephant, hippopotamus, shrew (*Crocidura*), and at least two small species of rodents. Of these the elephant and hippopotamus represent dwarfed races, whilst the antelope will probably be found to belong to a hitherto undescribed form. It is hoped that it will be possible before very long to publish a detailed account of these remains. I take this opportunity to express my sincere appreciation of all the help and encouragement I received from many kind friends both at home and in Crete.

EXPLANATION OF PLATES.

PLATE IX.—Tripiti Cave, near Gonia Monastery, West Crete.¹

PLATE X.—Men at work in the upland basin of Katharo, Lassethi Mountains, East Crete.

¹ Ossiferous remains occur in the cliff-face immediately below the mouth of this cave, as well as inside (see Spratt, *op. cit.*, vol. ii, p. 195).

Men at work in the upland basin of Katharo, Lassethie Mountains, East Crete.