Cave investigations in Namibia, IV. Aikab hemicenote, and other karst phenomena in the Etosha National Park

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ABSTRACT

Available speleological and biospeleological data for the Etosha National Park are summarised. Aikab hemicenote is described and mapped. It contains the second largest subterranean lake in southern Africa, at 0.9 ha. Tourist development of the already protected and ecologically robust Aikab is suggested as a counter measure to discourage development of other unprotected and ecologically sensitive cave lakes in Namibia. Information on the most possible location of the 'lost' Achawachab Cave is presented to stimulate efforts to find it. At least seven other minor karst phenomena are treated.

INTRODUCTION

The greater part of the Etosha National Park is situated in the Ovambo Basin. This basin, consisting of carbonate rocks of the Otavi Group, is largely overlain by sediments associated with that basin, e.g. Kalahari sand. However, the carbonate succession of the Otavi Group, forming the Northern Platform of the Damara Orogen (Miller 1983), directly underlies the area along the southern and western park borders (Fig. 1). The Otavi Group is subdivided into the lower Abenab and upper Tsumeb Subgroups. Outcrops of the Tsumeb Subgroup occur along the southern boundary in the form of undulating hills, with occasional isolated outcrops further north, e.g. at Halali and Helio. In the west the more dramatic positive relief is associated with an arm of the Tsumeb Subgroup outcropping in the Otjovasando area, and which marks the northward extension of the Otavi Group towards the Kunene River (Miller & Grote 1988). The parts of Etosha with carbonate bedrock are of interest due to their influence on the landscape, and therefore on the environment.

Landforms in areas where chemical solution of bedrock occurs (karst terrain), are characterised by closed depressions of various sizes, by disrupted surface drainage and by the development of caves and underground drainage systems (White 1988). However, the interior of Namibia has a semi-arid climate and karst topography is poorly developed. Large enclosed depressions, blind valleys, disappearing streams, and shallow phreatic-vadose tubes are virtually absent. Small scale solution features like lapiés and pinnacle fields are well developed, but the well integrated valley network suggests that surface drainage is important (Martini 1991). The distribution of caves per square kilometre is low, and such underground features, essentially of phreatic origin, are characterised by restricted extension and poor interconnection.

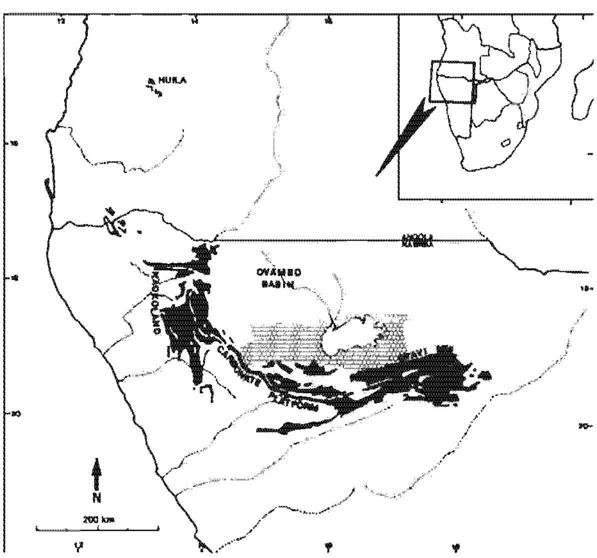

FIGURE 1: Carbonate rock outcrops (in black) in northern Namibia and southwestern Angola (after Irish 1991 and Miller & Grote 1988).

Karst areas are also of biological interest, partly because the accelerated infiltration of surface water influences the vegetation, but mainly due to the presence of subsurface cavities or caves. Caves have been recognized by the IUCN as habitat types of special concern, that often harbour unique endemic fauna (Wells *et al.* 1983: 230). Recent research interest revealed that Namibia is no exception in this regard, e.g. Irish (1992).

To date, karst landforms in Etosha have received little attention. To provide a small but pertinent information base for future development and conservation measures, we therefore list those known phenomena with negative relief below. We hope that it may stimulate additional research. We do not discuss the development of these features, as information on the genesis of karst landforms is readily available, e.g. White (1988) and references therein, and as we have a mainly biological interest in karst phenomena. We are certainly interested to receive any additional information on karst features in Etosha, particularly caves.

DESCRIPTIONS OF KARST PHENOMENA

1. AIKAB HEMICENOTE

General Comments

Aikab is situated on the southeastern border of Etosha at 19°20'51"S, 16°58'56"E (Figs 2 & 3). It is one of the most magnificent cave lakes in southern Africa, being the only

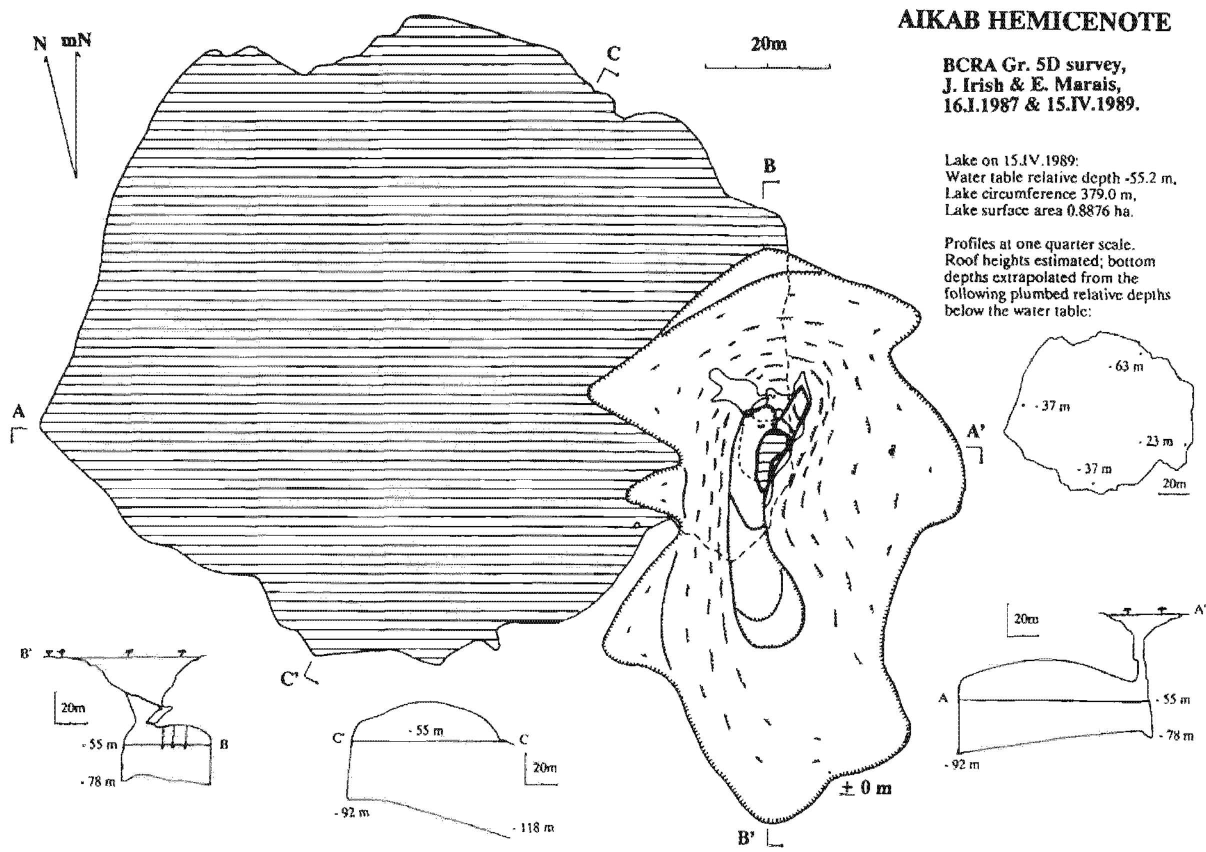

FIGURE 2: Aikab hemicenote. Plan and profiles.

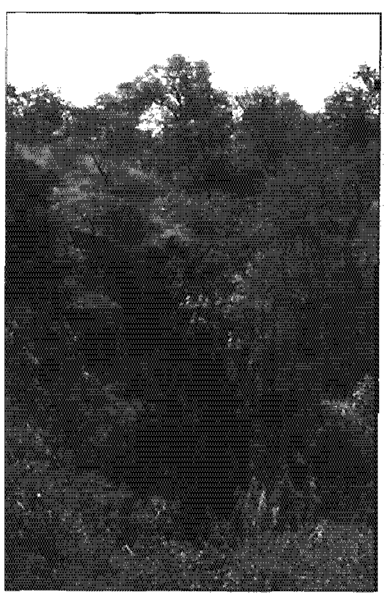

FIGURE 3: Photo - Aikab Hemicenote, view towards the north

known major water filled cave with a natural and easy access, while its size dwarfs the open karst lakes (cenotes) of Guinas and Otjikoto. The prefix hemi- indicates Aikab's large expanse of invisible cenote surface.

Aikab consists of a collapse doline or sinkhole leading vertically to a large water body. The depression is developed on a plain to the east of some low hills, and is inconspicuous in the dense mopane savanna. Even though known since the turn of this century, it had never been surveyed, and therefore its size was very much underestimated.

We use the name Aikab, being the version appearing on current official topographical maps (e.g. Surveyor General 1978). It is marked on some of the first topographical maps of Namibia (e.g. Hartmann 1904) as Ai!gab, or simply Aigab. The version T'kai T'kab, found on unpublished management maps of Etosha, is an attempt to phonetically render the click sounds, as are Txai-txab and Xai-qab, as used by Cooper (1983). The latter author gives the meaning as 'to scoop water with a long rope and then decant it into a smaller container before repeating the process'. Von Wrede (1970) ascribes the descriptive meaning of 'fold' or 'ripple' to the name.

Since the earliest times, the local Heikum San used Aikab as a water source, and it was also regularly used as a watering point by early travellers. In later years the water was extracted for use on the neighbouring farm, Lynplaas 436. The cave lake was also occasionally visited for recreational purposes by local farmers and visitors, hence the underground lakes on the farms Lynplaas or Mara 840, to which one occasionally hears reference, actually refer to Aikab. With the erection of the game and elephant proof fencing along the southern border of Etosha access to the hemicenote became much more restricted. Cables hanging down to the water give mute testimony that Aikab was used for recreational and sanitary purposes by the fence builders. At present it is rarely visited.

The first widely published description of Aikab by Jaeger (1921: 12), described his research between 1914 and 1917. A translation follows: "The Aigab Doline. In an expanse of grey limestone flats, one suddenly finds oneself on the edge of a deep rocky doline (here Jaeger refers to a photograph in the same work, which may be the first published of a Namibian karst feature – author's note). It is about 40 m long, and half as wide. The sheer walls are covered with a black crust. One descends over large boulders. The doline becomes narrower, the shadows deeper, and the air cooler. After descending about 30 m, one finds oneself on a narrow terrace, projecting over another drop. The latter is a north to south orientated rift, 4 to 5 m wide at the top, but narrowing downwards to reach the water level 15 m below. The water is clear and blue, like that of Lake Guinas. The water surface is 6 m long and 3 to 4 m wide. I plumbed the depth of the water to 35 m. Through a narrow chimney, and then following a narrow ledge, one can proceed along the north side of the rift to within about 5 m of the water. From here the Bushmen haul up water with thin strips of bark attached to calabashes, tins or other containers. Small birds, doves etc. descend the rift to the water. I saw no fish. The rift continues in the adjoining rock both to the north and south. The dip is about 30° to the east, and the strike is mostly north to south. The dolomite here includes many small pebbles, hence its surface is not covered with the usual rills, but rather with scattered single, sharp knobs."

Von Wrede (1970) reported on a visit to Aikab in 1969, which includes a sketch map of the doline and lake. He dated the still existing cement dam and drinking troughs at Aikab to 1940, when they were built and used by a neighbouring farmer, De Jager. He claimed that the first person to descend to the lake was Dr. Otto Pleitz in 1928, and that their party was the second. His measurements were as follows: edge of doline to edge of hole: 30 m; from the last lip to the lake surface: 13.5 m; estimated size of lake: 100 x 40 m.

We visited Aikab briefly during 1987 and 1989, during which we surveyed the hemicenote. A preliminary survey and popular account of these visits was published by Irish (1991a). In 1992 a team of scuba divers, supporting a palaeoenvironmental research initiative, visited Aikab. The purpose of the visit was to retrieve submerged stalactites, and no time was available for underwater exploration of the cavity. The divers reached a maximum depth of 40 m.

An interesting point emerging from the historic records is the fluctuations in water level they document. Jaeger's measurements of depth to water, water surface area and plumbed depth are all consistent with a water table about 5 m below the last lip. Gerlach (1906, see below) also gives the depth to the water as 5 m. This implies a water table at a relative depth of -45 m (below the edge of the doline) in 1906/1917. Von Wrede's (1970) measurements indicate the water table at -53.5 m in 1969. Mr J. Loots (pers. comm., 1992) of the farm Lynplaas recalled the water level to be 3 m below the bottom ledge in 1979, at which time access to the main cavity was completely cut off. In 1989 we measured the water table to -55.19 m. In 1992 it was at -55.24 m and in 1993 at -57.14 m.

These historic observations are supported by at least seven major and a multitude of lesser water marks against the walls of the lake chamber, as well as underwater marks at depths of 6 and 9 m. These marks indicate major fluctuations of past water tables, and that water levels during such fluctuations may remain stable for some time. To date, we have not been able to record a rise of water levels for any Namibian cave lake. Water levels in those cave lakes at higher elevations are dropping at a rate of up to 1.8 m per year (Irish 1992; Wolf 1992; Jeutter 1994). Ground water monitoring stations maintained by the Ministry of Agriculture, Water and Rural Development confirm that major fluctuations of the water table might occur suddenly in the Otavi Mountainland Aquifer, e.g. on the farm Harasib groundwater levels had risen by almost 8 m during February 1977 (unpublished data, Dept of Water Affairs). These stations confirm a gradual decline in water table altitudes since 1978 (Table 1).

TABLE 1. December altitudes (masl) of the water table at different localities in the Otavi Mountainland Aquifer (unpublished data, Dept of Water Affairs, Windhoek). A place name and sixteenth degree grid locality is provided for each tabulated monitoring site.

Year	Bloubokdraai 1816Dd	1817Cc	Guinas 1917Ab	Otjikoto 1917Ba	Harasib 1917Db
1971			± 1183	1192.04	
1972				1195.82	
1973				± 1192	
1974				1195.26	
1975				1195.24	
1976				± 1198	
1977				1198.99	1547.54
1978			1193.99	1201.44	1553.82
1979			1194.58	1201.57	1550.86
1980		± 1114	1193.99	1202.38	± 1547
1981				± 1202	1543.74
1982					1540.63
1983	1081.24	1113.45	± 1189	1200.56	1537.62
1984	1081.33	1112.30	1188.77	1199.62	1535.36
1985	1081.44	1112.86	1189.75	1200.97	1533.48
1986	1081.37	1111.17	1189.09	1198.58	1531.96
1987	1081.72	1109.36	1187.32	1197.83	1530.07
1988		1108.91	1186.29	1197.90	1528.35
1989	1083.21	1109.41	1187.84	1196.62	1527.63
1990	1082.68	1110.57	1186.59	1197.45	1526.95
1991	1082.42	1109.88	1185.66	1196.80	1526.23
1992	1082.70	1111.24	1184.24	1195.13	1524.87
1993	1082.73	1111.36	1183.23	1195.74	1524.52
1994	1082.97	1109.70	1182.82	1195.83	1526.49

Description

The doline is developed in massive dolomite of the Elandshoek Formation of the Tsumeb Subgroup (Miller & Grote 1988). It is interesting to note that at least three of the other large karst lakes in Namibia - Otjikoto, Dragon's Breath and Harasib - are developed in the same formation. Development of the elongated doline seems to have been controlled by a major vertical joint or a minor fault striking 207°. The strata appear to have a strike of 255° with a dip of 37°N, though the bedding plane itself seems to dip 70° to the east. In general the bedding is poorly developed and heavily jointed in many directions. The bedding planes are characterized in part by granulate silicification parallel to the bedding plane as well as occasional bedding slip shears. Inside the elongated doline two prominent bedding planes, about 80 cm apart, are visible on the eastern sidewall as two parallel cracks. These bedding planes, along which dissolution has occurred, disappear into a shallow hole at the northern end. Wide ledges and low but wide passages along the sidewalls in the deep northern part of the doline have formed as a result of dissolution along the bedding plane.

The doline, other than on the southern side, is bordered by steep cliffs. The southern route descends steeply over some large boulders to a wide ledge on the western side. This ledge gradually descends to form a terrace deeper within the doline. On the southern side at the top of the terrace an old log platform and cemented remains of bolts mark the site of a pump previously used by farmers to extract water. A minor fault, trending NW and dipping 39°N, is visible to the east of the old platform. On the northern side of the terrace a small chimney leads down to another ledge, which slopes down to form a lip above a chamber filled with water. On both sidewalls at this lip, two thrust planes, about 2 m apart, with an apparent WSW dip of 14°, are clearly visible. Secondary fractures can be seen inter-connecting these thrust planes. A narrow vertical slot in the centre of the doline, ± 5 m wide and 10 m in length, gives access to a large, partly submerged chamber. The water level in the chamber indicates the altitude of the ground water table at this point.

The large, partially submerged cavity is developed below the plain to the west of the doline. The cavity is roughly circular, with a circumference of about 380 m, varying from 100 to 120 m in diameter. The cavity walls above the water are almost perpendicular for most of the circumference, and in 1992 divers recorded the shallowest depth as -19 m below the water table. This depth was recorded on top of a large submerged debris mound below the vertical slot in the bottom of the sinkhole. For a brief period in the middle of the day direct sunlight reaches the submerged debris cone. Light reflected from the water and the submerged debris cone then illuminate the whole cave. In 1989 the water depth was plumbed in several places. The shallowest plumb value, -23 m below the water table, was recorded on the eastern side of the lake, directly below the lip on the northern side of the entrance to the lake chamber. Plumbing on the southern and western sides recorded depths of -37 m, while the deepest water, -63 m below the water table (or -118 m below the surrounding countryside), was recorded along the northern side. The northern sidewall occasionally shelves shallowly into the water, creating a low ceiling with some stalactite swarms, and suggesting that the submerged part of the chamber may extend in this direction.

The lake chamber's roof is estimated to be about 15 m above the present water level near the edges of the lake, rising to about 25 m in the centre. In general the roof is domed, with almost vertical eastern and western sidewalls. There are indications of cavities in the roof, used as roosting sites by bats. On the eastern side of the chamber, next to the entrance shaft, several root masses hang into the water, obviously from trees growing on the sides of the doline. These root masses house at least a multitude of cockroaches, but the root masses were not adequately sampled to reveal the full composition of the invertebrate guild inhabiting them.

Crystallized calcite rafts, leaf and guano debris drift on the water, and seem to be concentrated by convection currents in the chamber. These suspended materials obviously change position, as at one stage conservation officials observed this material below the entrance shaft and suspected troops of the South African Defence Force of washing in and polluting the water.

The lake's surface area, at a relative water table depth of -55.19 m, as surveyed on 15 April 1989, was 0.8876 ha. This makes it the second largest subterranean lake in Namibia (Irish 1991b) and southern Africa, exceeded in size only by Dragon's Breath. Small variations in size may be expected with shifts in water level. A water sample was submitted to the Department of Water Affairs in Windhoek for analysis (Table 2), which indicated a high salinity due to dissolved calcium and magnesium. The Mg/Ca ratio of 1.4 indicates apparent magnesium enrichment, which could be due to $CaCO_3$ precipitation from a saturated dolomite solution (Martini 1991). The water temperature was 24°C, and no thermal layers were reported by divers.

TABLE 2: Simplified water quality analysis of Aikab Hemicenote (unpublished data, sample number CH63802. Dept of Water Affairs, Windhoek)

Conductivity	90.0 mS/m
Total dissolved solids (calculated from conductivity)	594 mg/l
Sulphate as SO_4	20 mg/l
Nitrate as N	1.0 mg/l
Nitrite as N	<0.1 mg/l
Fluoride as F	0.4 mg/l
Total alkalinity as $CaCO_3$	466 mg/l
Phenolphthalein alkalinity as $CaCO_3$	0.0 mg/l
Sodium as Na	17 mg/l
Potassium as K	3.0 mg/l
Calcium as $CaCO_3$	197 mg/l
Magnesium as $CaCO_3$	276 mg/l
Total hardness as $CaCO_3$	473 mg/l
Silicate as SiO_2	26 mg/l
Turbidity	0.3 NTU

The microhabitats afforded by the doline differ markedly from that in the surrounding area. The difference can be ascribed to the higher humidity and smaller temperature fluctuations caused by the presence of a large, partially enclosed water body, and the sheltered aspect of the doline. Vegetation within the doline is markedly different from that outside, and includes hygrophilic forbs and ferns. It is expected that the smaller fauna will reflect this floral difference. The fauna in the doline itself is partly representative of the epigean zone. On several occasions western barred spitting cobras *Naja nigricollis nigricincta* Bogert (Elapidae) were observed in the doline.

The partly enclosed passages in the deeper parts of the doline reflect hypogean changes occurring in cave environments, with an absence of vegetation and some troglophilic faunal representatives like *Eurychora sp.* beetles (Tenebrionidae), cockroaches (Blaberidae), and spiders (Pholcidae).

We could not reach areas in the main submerged chamber which could be inhabited by non-aquatic cave fauna, e.g. the cavities in the roof, and did not find any obvious remains of cavernicolous fauna floating on the water. Marais & Irish (1989) recorded an unusual find of *Typhlops schlegelii* Bianconi (Typhlopidae), and also mentioned the occurrence of unidentified cockroaches in the root columns. Bats roost along the roof of the main cavity. They were not sampled, but the bat fauna can be expected to consist of the usual trogloxenic species known to occur in the area, *Rhinolophus spp.* (Rhinolophidae), *Miniopterus schreibersii* (Kuhl) (Vespertilionidae), *Nycteris thebaica* Geoffroy (Nycteridae), *Tadarida aegyptiaca* (Geoffroy) (Molossidae), *Hipposideros caffer* (Sundeval) (Hipposideridae) and *H. commersoni* (Geoffroy) (M. Griffin, pers. comm.). Owl pellets ejected by a barn owl (*Tyto alba* (Scopoli), Tytonidae) roosting just above the entrance pit contained skulls of several individuals of *H. commersoni*, confirming at least its presence at Aikab.

The aquatic fauna of Aikab cannot be regarded as strictly stygobiotic due to illumination for at least part of the day. Divers retrieved invertebrates from depth. Isopoda caught on the walls and on submerged cave formations turned out to be a unique species *Namibianira aikabensis* Kensley of an aquatic genus restricted to Namibian caves (Kensley 1995). Some Oligochaeta, Platyhelminthes and mollusc shells were retrieved from the submerged debris mound, but have yet to be identified.

In 1992 submerged stalactites were located at the northern and southern sides of the cavity, and samples were removed from 3 and 11 m water depths respectively. Dating sequences and geochemical analyses of the samples will be used to estimate regional ground water levels at different times, from which Quaternary climate patterns could be inferred. The submerged stalactites were covered by a dark secondary mineralization, obviously due to deposition of trace elements in the ground water. Cross sections of the removed stalactites revealed several such secondary deposits as dark rings, followed by renewed $CaCO_3$ deposition. The samples therefore present the opportunity to obtain information on several periods of low (more arid than present) and high (as arid or less arid than at present) water tables, while clues as to atmospheric conditions during the more arid periods could possibly be obtained from the geochemistry and isotope configuration of the $CaCO_3$ growth rings.

2. ACHAWACHAB AND UNSUSIB CAVES

These two caves are situated somewhere in the southeastern parts of the Etosha National Park, but their precise locations are presently unknown. The following descriptions are translated from Jaeger (1921: 14): "Achawachab Cave consists of several cavities along a fault running more or less north to south. The entrance is in a 2 m deep, circular depression, the floor of which consists of grey soil containing scattered small quartz and limestone pebbles. Through a 4 m wide shaft one proceeds vertically downwards to reach level bottom after 8 m. A wide high arched passage leads to the north. Its ceiling is totally eroded and its floor, consisting of greyish black soil, is covered in rubble. The passage becomes narrower towards the bottom and continues into the depths as a crack. At a place about 4 m from the entrance, one goes downwards through a tight hole to reach water after another 4 m. The water is about 1 m deep. Especially at the entrance to the passage the rocks are smoothly polished.'

'Unsusib Cave. Sunk into a shallow depression is a 2 m wide and 6 m deep hole. The bottom is filled with water, and shows a low extention to the west. According to the Bushmen, this passage runs for about 10 m due west, and then emerges into a large, roomy cave, that contains water also in the dry season. During the rains both the underground passage and the vertical entrance hole, are water filled. The bedrock is shallow granular dolomite."

The following account is translated from Gerlach (1906). Though the cave is called 'Awachab', the description corresponds so well that there is little doubt that it refers to the same place as Jaeger's Achawachab.

"So we arrived on the morning of September 26th [1906] at the water point Awachab, where subterranean water flows. One of our riders showed the way. If one does not know the place well, one would not find the water. I climbed down myself. First a fairly large shaft descends vertically for about 8 m. Then one arrives in a roomy cave, 12 m long, 5 m wide and 4 m high. Here it is pitch dark, and, when one has no candles, one has to light a fire. In the middle of the cave is another 5 m deep hole, large enough so that a smallish man can be lowered down on a rope. At last the water is reached. A streamlet flows around a small plateau, from which it is easy to draw water. Several men are required to hoist the water in fodder bags, attached to thongs." An account of a journey to Aikab follows. Aikab (evidently the lower part of the doline) is described as "only one hole of 5 m to the water".

We believe that Achawachab and Unsusib caves are situated near to each other (see below) and have attempted to narrow down the possible area where they may be located. Unsusib appears on no map we have seen, nor have we found any reference to it other than that by Jaeger, but Achawachab first appears (as Awachab, and with the note "viel Wasser, Höhle im Kalk") on the map of northern Namibia prepared by Hartmann (1904). Though excellent for its time, the map is inaccurate. Absolute positions of known places are mapped up to 10 geographical minutes displaced from their true positions, while their relative positions are often also badly wrong. Despite these deficiencies, we attached some importance to Hartmann's map, since it represents the earliest source available to us, and the notes on the map suggest that Hartmann personally visited Achawachab.

The earliest map on which both absolute and relative positions for known places in the area are tolerably accurate, and for which the included detail again suggests personal knowledge of the area, is the provisional 1912 Landesaufnahme map. The name Awachab appears on several other maps of northern Namibia, persisting up to about 1930, but all seem to represent copies of the preceding two base maps, rather than new first hand information.

The absolute position of Achawachab on the Landesaufnahme (1912) map is at 19°12.3'S 16°45.8'E (A on Fig. 4). The absolute position of Achawachab on Hartmann's map is situated much further to the east and incompatible with the true relative positions of known surrounding places, therefore we disregarded it.

The nearest known locality to Achawachab on either map, is the waterpoint Tsam, situated east of Kamaseb at 19°3.4'S, 16°44.2'E (Surveyor General 1979). Both maps have Achawachab and Tsam about 15 km apart, but in different directions. Transposing these to a modern map, based on the true position of Tsam, we arrived at two possible locations for Achawachab. These are indicated as B (Hartmann's map) and C (Landesaufnahme map) on Fig. 4. We repeated this for the three additional surrounding localities of Aikab, Obab and Gobaub. For Hartmann's map this resulted in widely scattered possible locations for Achawachab, confirming the inaccuracy of the map. In the case of the Landesaufnahme map the locations were closely clustered (D, E and F on Fig. 4), confirming its relative accuracy.

The five points B-F lie within a 3 km diameter circular area situated about 4 km southwest of Dungaries (Fig. 4), with point A removed 4 km towards the west. Achawachab and Unsusib are most probably situated within or near the circle.

For confirmation, we turned to the table in Jaeger (1921:15). It lists the distance from the Etosha Pan, entrance altitudes, and water table altitudes for a number of karst phenomena. Achawachab and Unsusib are both listed as being 22 km removed from the Etosha Pan. Their entrance altitudes are given as respectively 1144 m and 1132 m, with water tables at relative depths of -12 and -6 m. We base our conviction that the two caves are situated near to each other on the similarity of this data.

On the Landesaufnahme map the southern end of the Batia/Springbokfontein inlet is mapped exactly 22 km from Achawachab, but since the position of the inlet is mismapped too far south, we attach no significance to the stated distance. Jaeger's altitudes for the other places in his table were compared with their true altitudes, and found to show a standard deviation of 4.43 m. The combined possible altitude range for the two caves then becomes about 1128-1148 m. The altitude range in the area indicated on Fig. 4 is about 1139-1148 m.

Lastly, the Landesaufnahme map indicates palm trees along the route between Tsam and Achawachab, just north of the latter. *Hyphaene petersiana* Klotzsch (Arecaceae) is absent or rare in the whole area indicated, but there is an isolated stand at Dungaries. Examination

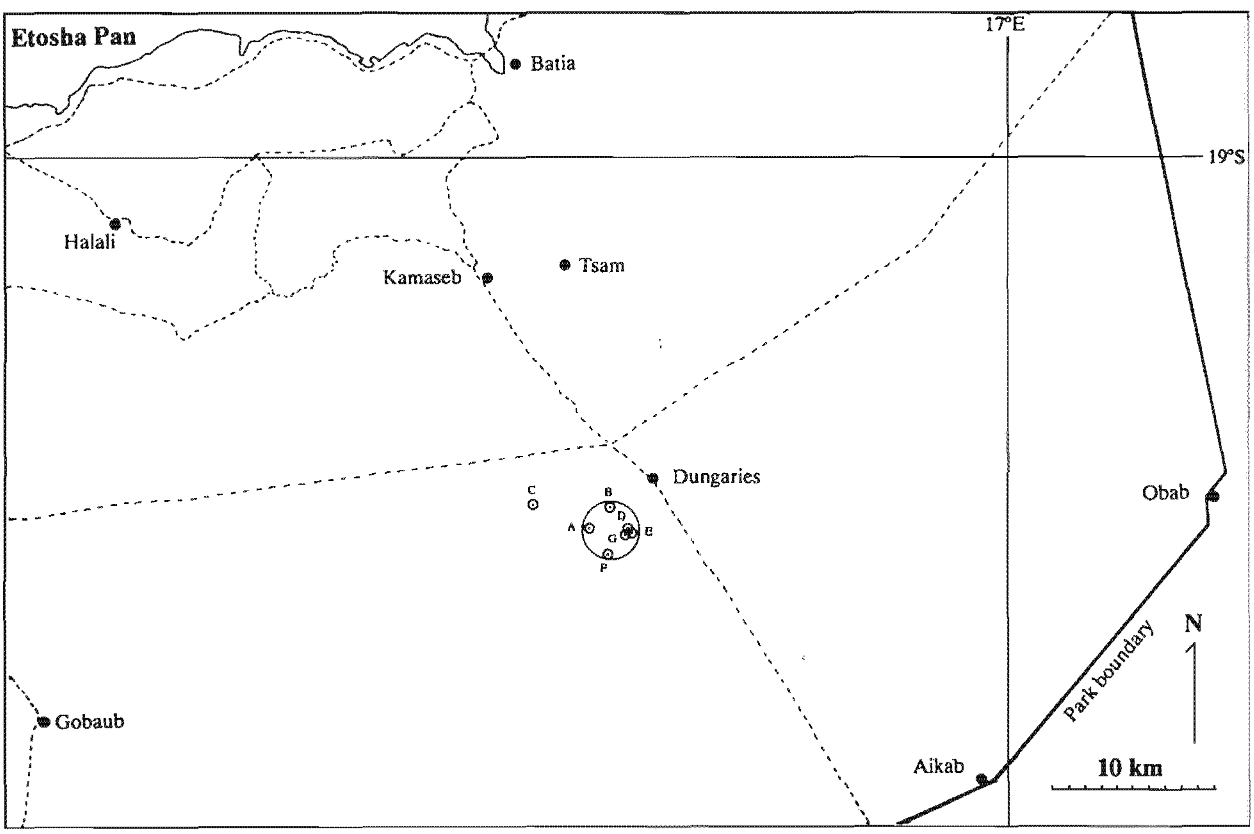

FIGURE 4: Southeastern part of Etosha National Park, showing the area where the 'lost' caves of Achawachab and Unsusib are most probably located (large circle), as well as places (A to G) mentioned in the text.

of aerial photographs (Job 725, strip 10, numbers 699,700) of the area southwest of Dungaries was inconclusive. There is an enigmatic big black spot (ca. 250 m diameter) at about 19°12.1'S, 16°46.4'E (G on Fig. 4), but no depth could be discerned under stereoscopic examination.

We present our assessment of the possible location of these two caves, in the hope that especially participants in future aerial game counts may spot at least the larger Achawachab Cave.

3. BLOUBOKDRAAI HOLES (Raymond se Gat)

In the calcrete hardpan in the Klein Namutoni/Bloubokdraai area are 30 to 40 small sinkholes and potholes (R. Dujardin 1989, pers. comm.). The largest of these solution features, which we did not visit, is reputedly situated about 75 m east of the tourist road, just north of Klein Namutoni fountain, and large enough to walk into. The majority are too small for humans to enter. Figs 5 and 6 depict one of the larger potholes, situated less than 1 m south of the road at the sharp northern turn of the Bloubokdraai circular route at 18°50.1'S, 16°57.1'E. This pothole has a small surface opening leading vertically into a low dome shaped chamber, with the upper part of the chamber in calcrete and the lower part in soil. Shallow depressions in the same area seem to indicate collapsed or sediment filled solution features of the same nature.

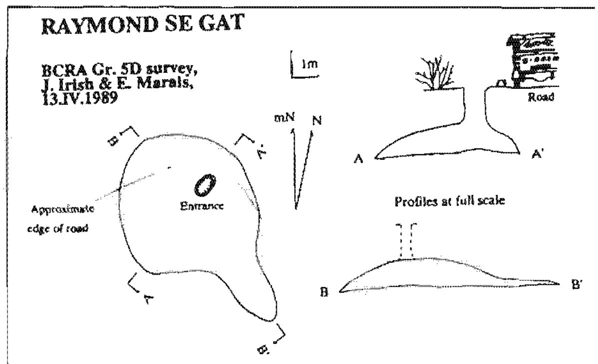

FIGURE 5: Raymond se gat (hole at northern end of Bloubokdraai circular route). Plan and profiles.

FIGURE 6: Photo - entrance to small calcrete cave on Bloubokdraai. Note trunk of *Combretum imberbe* to the left.

These potholes are of some biological interest. They are frequently used as lairs by leopard (*Panthera pardus* (L.), Felidae) (R. Dujardin pers. comm.), as roosting sites for bats, and inhabited by troglophilic invertebrates like cockroaches (Blaberidae) and *Smeringopus similis* Kraus (Pholcidae). Other invertebrate species included the amblypygid *Damon variegatus* (Perty) (Tarantulidae) and the opilionid *Lawrenciola damarana* (Lawrence) (Assamiidae), which are usually found in humid microenvironments. We noticed that many of the smaller holes had trees (usually *Combretum imberbe* Warwa, Combretaceae) growing from them, or contained the remains of dead trees. Whether the holes simply facilitate growth of trees on the otherwise unfavourable hardpan, or whether maybe the trees are a causal factor in hole formation (e.g. by accelerated solution processes due to the presence of acidulated water associated with vegetation), is not clear. Conrad *et al.* (1967) reported similar concentrations of small pseudokarst phenomena, called "daïas", from northwestern Africa, but did not discuss a possible genetic model.

4. HALALI CAVE

The dolomitic hill within the Halali Rest Camp area contains a small cave at 19°02'18"S, 16°28'23.5"E. It is called Tsumasa Cave in the trail guide by Peard (*ca.* 1985). The length of 40 m and depth of 30 m claimed in this brochure is an exaggeration (Fig. 7).

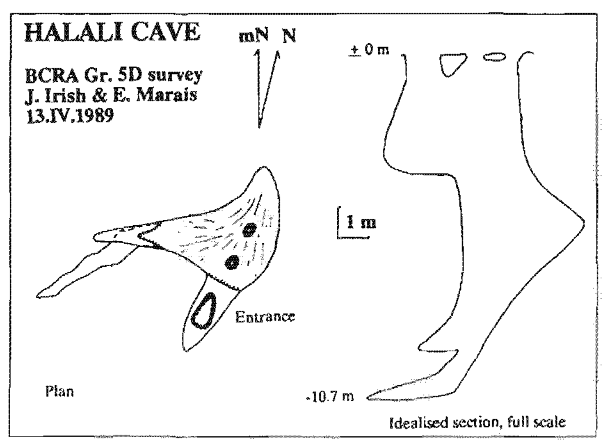

FIGURE 7: Halali Cave. Plan and profile.

The cave is inhabited by troglophilic invertebrates and bat parasites, including *Eurychora sp.* (Tenebrionidae) beetles, *Uloborus sp.* (Uloboridae) and *Steatoda sp.* (Theriidae) spiders, and *Argas sp.* (Argasidae) ticks. The bat population of 400 mentioned by Peard is another exaggeration, though a composition of *Hipposideros caffer*, *Nycteris thebaica* and two *Rhinolophus spp.* is probably correct.

5. VREDEKOPPIES CAVES

In the hills opposite the farm Vrede 435 is a system of narrow solution passages in dolomite at about 19°23'S, 16°55'E. Mr M. Paxton, a conservation official based at Halali at the time, directed us to this system in 1987. We briefly visited and explored these passages, but did not examine them systematically. The system consists of a couple of interlinked solution passages, though not extensive. Although daylight penetrates almost all parts of the system, some bats, e.g. *Nycteris thebaica*, roost in the system.

6. SOIL CAVE

In 1987 we examined a possible karst feature located by aerial photograph analysis. It is situated on the western side of a small hill, about 250 m from the Etosha boundary opposite the farm Olifantslaagte 433 at about 19°24'S, 16°51'E. The phenomenon proved to be a small sinkhole developed in a partly consolidated scree slope. A minor cave consisting of one tight passage about 1 m wide and 15 m long extended from the eastern side of the sinkhole. We did not probe the passage fully, as it was unlikely to continue and we wished not to disturb a barn owl breeding in the passage.

7. GUMSES

The management maps of Etosha include a locality called 'Gumses' or 'Tgumses'. Cooper (1983) renders it Qgumses, and Paxton (1986) as !Gomses. It is located next to a firebreak about 7 to 8 km east of Gobaub, and estimated to be at 19°18.5'S, 16°29.5'E. We were unable to locate Gumses in 1989. It is reported to be a simple round shaft about 1 m in diameter and an unspecified 'few meters' deep, with a flat bottom in which water rises after rains (M. Lindeque 1989, pers. comm.). It is evidently a similar phenomenon as Unsusib Cave.

8. OTJOVASANDU CAVES

We have had numerous reports of caves and sinkholes in the Dolomietberge of the Otjovasandu area, but have so far not been able to visit any ourselves. Reports appear to refer to at least three separate features, and we list these in the hope of stimulating further investigation.

a) Just south of Dolomietpunt, along the eastern edge of the hills, are a series of deep cracks in the hillside, harbouring bat colonies (M. Lindeque 1989, pers. comm.). They are not visible on 1:50 000 aerial photographs.
b) Further south in the Dolomietberge, northwest of Dolomietpoort, a sinkhole was discovered while on horse patrol (J. Grobler 1987, pers. comm.). Aerial photographs showed a possible small sinkhole at about 19°03'S, 14°30'E.
c) A hole or holes exist to the southwest of Pioniersdam (L. Scheepers 1989, pers. comm.). Examination of the aerial photographs for this area was inconclusive.

9. CRATER SINK

Relevant aerial photographs and topographical maps indicate an oblong, flat bottomed depression at 19°11.5'S, 17°04.5'E. We calculated it to be about 300 x 200 m in size, and about 15 m deep. No roads lead there, and we were unable to trace anyone who has visited it. From the geology of the area and the shape of the depression visible on two aerial photographs (Job 722) and the 1:50 000 topographical map (Surveyor General 1977), we concluded it to be a karst depression. While apparently not including a sinkhole, it resembles karst features similar to the better studied Hoais Depression (Schneiderhöhn 1920; Jaeger 1921). The aerial photographs and topographical map also indicate a similar, but very much smaller and shallower, depression about 4 km NNE of the large crater at 19°09.5'S, 17°05.8'E. The proximity of these two large phenomena indicate that smaller, less visible karst features could occur in the area.

DISCUSSION

Namibian speleology is still in its infancy, and the remote nature of much of Namibia's karst areas limit the steps that can be taken to generate information. Although carbonate rock occurs over a fairly large area of Etosha, known caves are few and small. This situation is not unexpected, given the low rainfall and the less soluble nature of the mainly dolomitic stratigraphy. The basis of our present knowledge rests on the examination of aerial photographs. It is clear that only a few of the more obvious karst features could be found in this way. Less obvious sites can only be found by systematic ground exploration of preselected areas. A good basis for selection is if observers report likely sites, as happened here for e.g. the Bloubokdraai and Vredekoppies Caves. Many Namibian caves, invisible on aerial photographs, and some inhabited by unique fauna, were found by casual observers active in the area for other purposes.

From a conservation perspective, allowing regional investigation of likely areas in Etosha by interested parties would be inadvisable. Rather, observers should record and report promising sites, especially aberrant features observed during aerial game censuses and routine patrols in remote areas. Such sites can then be examined systematically by qualified investigators.

Cavernicolous fauna is usually associated with extensive and accessible cave systems. With the exception of Aikab, and possibly Achawachab, all of the presently known caves in Etosha are very small, hence there are almost no species restricted or endemic to them. This may be more a factor of the paucity of information, than a characteristic of the caves. Additional information on likely cave sites could change the present situation.

The role of the elevated karst area to the south on groundwater availability in Etosha is well known. The occurrence of the endemic isopod in Aikab implies that additional representatives of the stygobiotic fauna of the Otavi Mountainland can be expected to occur in Etosha. Confirmation is dependant on finding additional sites with access to the groundwater, e.g. Achawachab or Unsusib, or examination of water from boreholes.

Some initiatives are in existence to develop selected Namibian caves as tourist attractions. It will be a pity if a naturally inaccessible cave, e.g. Dragon's Breath Cave, were allowed to be developed, with accompanying disastrous changes to the cave environment, while a much more accessible and spectacular feature like Aikab remains undeveloped. Access to Aikab could easily be regulated, while it has the additional advantages of being situated close to an established gate in the Etosha fence and next to a district road. Safety features could easily be installed, and the cave could become a major tourist attraction. Because it is already open to the atmosphere, major changes to the cave environment are unlikely. Serious consideration should be given to the possibility of developing Aikab as a tourist attraction, which would lower the feasibility of developing more fragile caves and therefore will contribute to the conservation of sensitive habitats elsewhere.

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