# Chapter 3. Caves of the Beanka karst, Melaky Region, western Madagascar

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## Abstract

A northern extension of the Bemaraha karst, now within the Beanka Reserve, has been the subject of ongoing speleological investigation and documentation for some years. This work has revealed many caves, ranging from a few meters to over 1.5 km in length, and related karst features such as springs, deep gorges, underground streams, and dramatic surface erosion patterns (karren). The prospects for further discoveries are very good. Investigations into the potential of these caves as cultural, biological, and paleontological sites are only just beginning.

**Key words:** caves, karst, speleology, geology

## Résumé détaillé

Des recherches spéléologiques ont été menées depuis 1996 dans une extension septentrionale du karst du Bemaraha : la forêt de Beanka. Ces recherches ont permis de découvrir de nombreuses grottes d'une longueur allant de quelques mètres à plus de 1,5 km, avec les structures karstiques associées telles que pertes, sources, gorges profondes, rivières souterraines et de spectaculaires manifestations d'érosion en surface (lapiaz). De nombreuses grottes contiennent des emplacements où les chauves-souris sont perchées. On en a dénombré au moins 12 espèces. Les perspectives de découvertes de grottes supplémentaires sont excellentes. Les recherches sur le potentiel de ces grottes comme sites culturels, biologiques ou paléontologiques ne font que commencer. Les karsts étant peu propices à l'agriculture ou à la mise en place de villages, la région a été préservée dans un état relativement intact. Sa gestion future en tant que réserve naturelle aura pour but de préserver ses habitats ses caractéristiques physiques et les organismes vivants qui y sont associés.

**Mots clés :** grottes, karst, spéléologie, géologie

## Introduction

The 17,100 ha Beanka Reserve is located about 350 km north-west of Antananarivo and about 55 km east of Maintirano. It was created to protect a sample of the native biota of western Madagascar existing on a calcareous or limestone substrate. The inhospitable nature of the karst terrain has resulted in vastly reduced human pressure and, hence, the retention of more of the natural values than on the surrounding lands. The relatively high solubility of the limestone has resulted in both the rugged landscape and the underlying caves and subterranean drainage.

Apart from a few French geologists, little study of Madagascar's caves occurred until the 1980s and then expeditions tended to concentrate on the better known, and more accessible, areas such as Ankarana in the north, Narinda near Mahajanga, and Toliara in the south. The Tsingy du Bemaraha saw little caving activity until the 1990s; the first cave in the Beanka karst was only reported in 1998 and the real potential of the area was recognized even later. This paper brings together what has been documented about the caves of Beanka.

### Karst

"Karst is terrain with distinctive hydrology and landforms arising from the combination of high rock solubility and well-developed solution channel (secondary) porosity underground. Aqueous dissolution is the key process" (Ford, 2004). Karst landscapes are of fairly widespread occurrence in Madagascar, especially on belts of limestone that run more or less parallel to the west coast along almost its entire length (Middleton, 2004). In the center of this expanse of carbonate rocks lies the extensive Tsingy du Bemaraha, the environmental significance of which was first recognized by its reservation in 1927. In 1990, the area was the first in Madagascar to be inscribed on the World Heritage List of UNESCO. The listed area covers 152,000 ha, lying at least 20 km south of the Beanka Reserve. The Beanka Reserve (Figure 3-1) possesses many of the values which led to the World Heritage listing of the Bemaraha karst.

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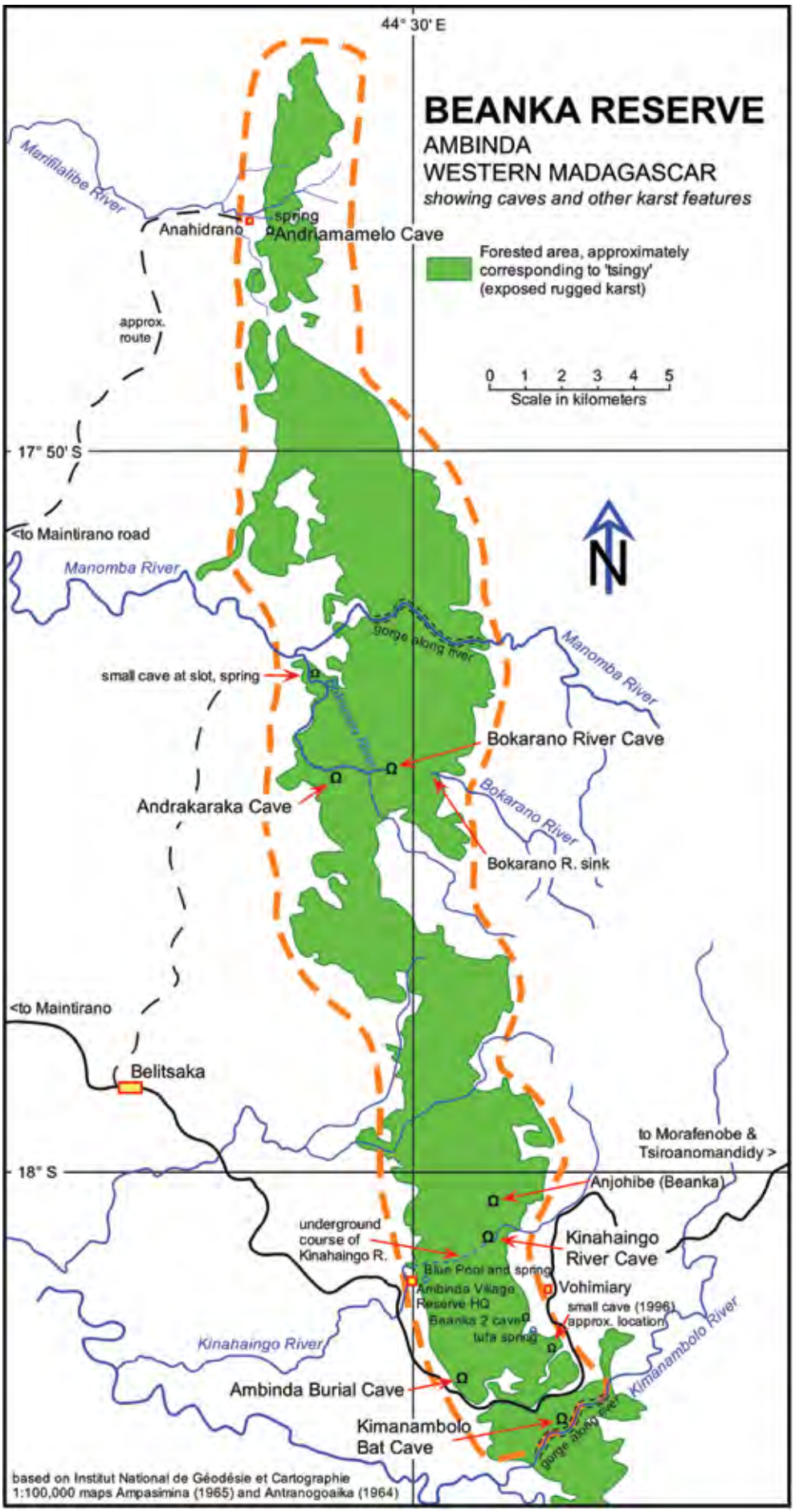


**Figure 3-1.** The Beanka Reserve (dashed outline), showing the locations of caves and other features. The shaded area, mapped as forest, approximates the outcropping limestone, or *tsingy*.

## Historical outline

The author first visited the Beanka karst while on an expedition to the northern Tsingy du Bemaraha with Owen Griffiths and colleagues in June 1996 (Middleton, 1998). At the time the area was just regarded as the far north of the Tsingy du Bemaraha (Figure 3-2), though no caves had yet been reported. We found only one (about 30 m long and housing a few bats) (Figure 3-3) and at the time we did not have the good sense to ask the local people about others.

**Figure 3-2.** Limestone cliffs on the eastern side of the Beanka karst are among the highest in the reserve. (All photographs by G. J. Middleton.)

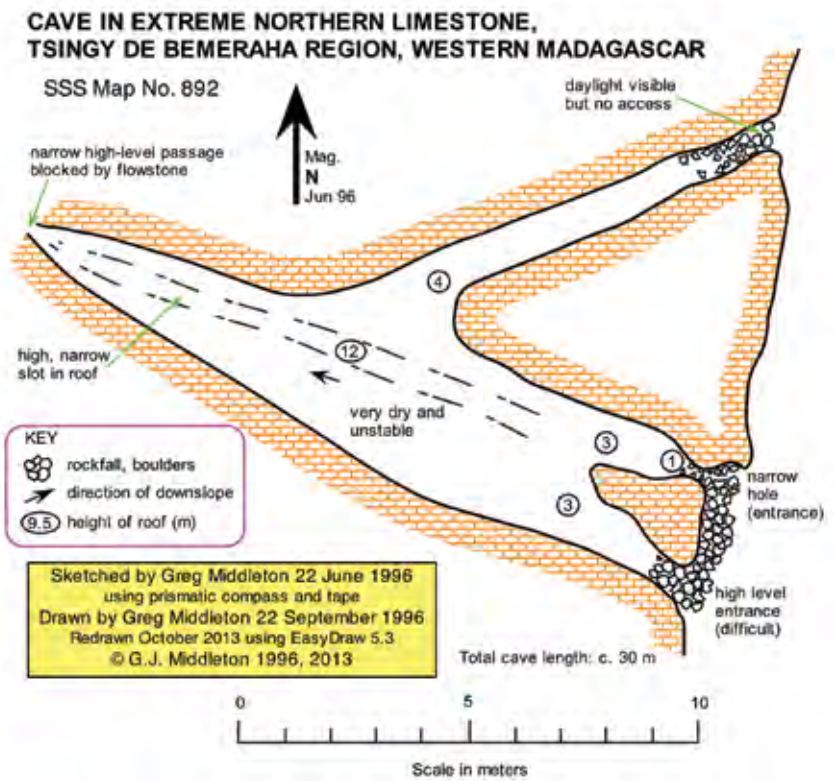


**Figure 3-3.** Plan of small cave in the eastern cliffs, found in June 1996.

A series of ongoing expeditions under the leadership of Owen Griffiths investigated many of the island's karst areas and it was ten years before they returned to this region. After examining some of the extensive karst in the vicinity of Antsingimavo (more than 60 km north of Beanka) in September 2006, a group returned to the northern Bemaraha karst for closer investigations (Middleton, 2007). It was on this occasion, noting the name 'Beanka' (meaning 'many owls') on the Ampasimena 1:100,000 map that it was decided to identify this as the Beanka karst area. Almost certainly, it is geologically contiguous with the Bemaraha karst but the access points are sufficiently far apart that it is convenient to treat them separately. A few more small caves were located and documented during the September 2006 trip, this time with the assistance of locals, but no significant caves were located.

Serious work on caves really started in 2009, following Owen Griffith's establishment of the Beanka Reserve, under a lease from the government of Madagascar. Investigations were facilitated by the appointment of Roger Randalana as the local manager and a team of locally-recruited rangers, together with the creation of a basic field station/ headquarters at Ambinda.

## Geology

The generalized geological map of Madagascar by Besairie, as reproduced by Du Puy & Moat (1996) clearly shows the Bemaraha area as "Mesozoic limestone and marls (inc. 'Tsingy')" and indicates that this extends, in a much narrower band, about 150 km north of the Bemaraha protected area. Rossi (1980) is more specific, describing the most northerly section, the Bemarivo karst, as being developed on mid-Jurassic limestone often partially hidden under clays of decalcification. This description may also be applied to the Beanka karst area.

The exposed limestone in the Beanka area generally does not stand out in as bold relief as is seen both to the south in the Bemaraha and to the north in the vicinity of Antsingimavo (the eastern cliffs shown in Figure 3-2 are an exception), nor are the characteristic giant grikes (vertical joints enlarged by

**Figure 3-4.** The thin, sharp blades of eroded limestone give the landscape its local name, *tsingy*. These are above the Ambinda Burial Cave.

solution) and jagged solution fluting, known locally as *tsingy*[a], as highly developed (Figure 3-4). The mode of formation of the Bemaraha *tsingy* has recently been studied, concluding that "the majority of grikes are created from caves formed under the karst water table and subsequently opened up to the surface" (Veress *et al.*, 2008). No doubt, the same processes are occurring at Beanka. Whatever their mode of formation, it has become evident that caves are at least as well developed in the Beanka area as in the rest of the Bemaraha karst.

## Documentation of caves at Beanka

In addition to the small cave found in 1996, some minor caves were located by the 2006 expedition members (Middleton, 2007) (locations of some of these caves, as well as later discoveries are shown on Figure 3-1). These were recorded as Beanka 1 (Figure 3-5), Beanka 2 (Figure 3-6), and Beanka 3 (Figures 3-7 & 3-8). A small (3 m long) cave was also found at the rising of a stream, which flows down to join the Kimanambolo River in the far southeast of the reserve. Its location was recorded (S 18°02.515', E 44°31.883' – shown as "tufa spring" on Figure 3-1), but it was not considered worth surveying. A short distance downstream, an unusual series of impressive tufa dams (Figure 3-9) testify to the very high concentration of calcium carbonate in the water from this spring.

More significant caves were identified following the establishment of the reserve and the employment of local men as rangers. In October 2009 (Middleton, 2010), we were conducted to, and surveyed: Ambinda Burial Cave (Ampasan' Ampagnito) (160+ m; Figure 3-10), Kimanambolo Bat Cave (Anjohin'i Kimanambolo) (160 m; Figures 3-11 & 3-12), Bokarano River Cave (Anjohin'i Bokarano) (only the first 220 m of which could be explored and surveyed at the time due to the river becoming too deep and filling the width of the passage) (Figure 3-13) and Kinahaingo River Cave (Anjohiben'i Kinahaingo), only about 200 m of which could be explored and surveyed in the time available (Figures 3-14 & 3-15).

[a] The word *tsingy* may be of onomatopoeic origin, being derived from the ringing sound emitted when a blade of the rock is struck – but other origins have been suggested, such as meaning "on the tip of the toes".

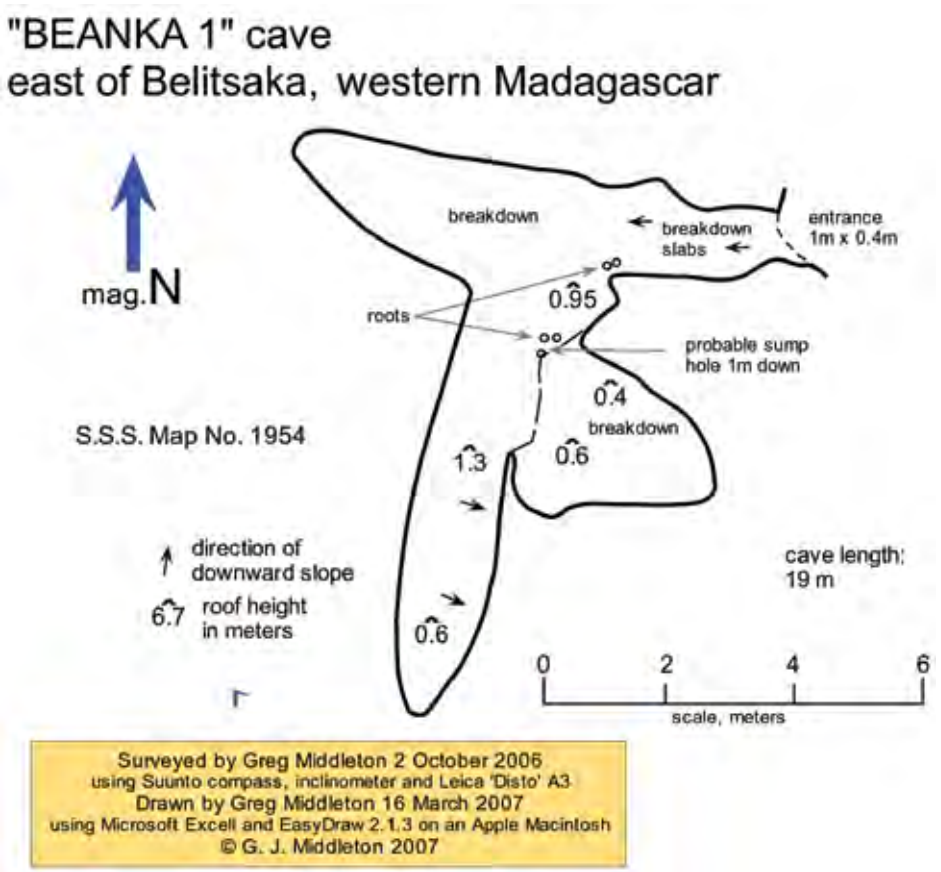


**Figure 3-5.** Plan of cave designated Beanka 1, found in October 2006.

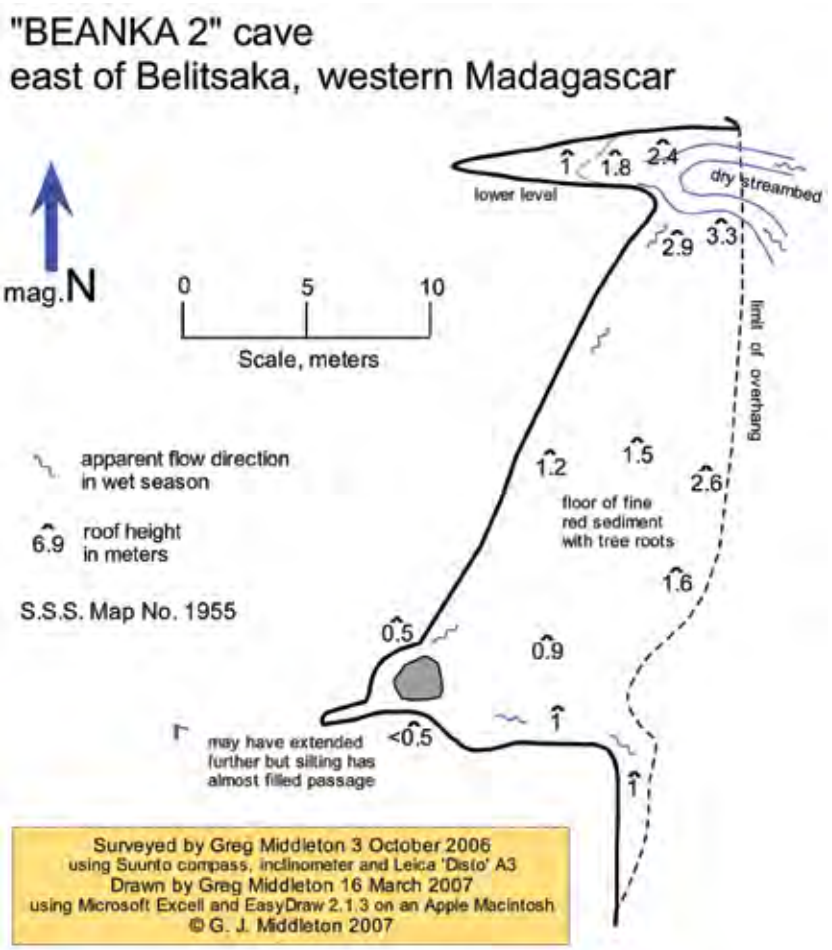


**Figure 3-6.** Plan of rock shelter, designated Beanka 2.

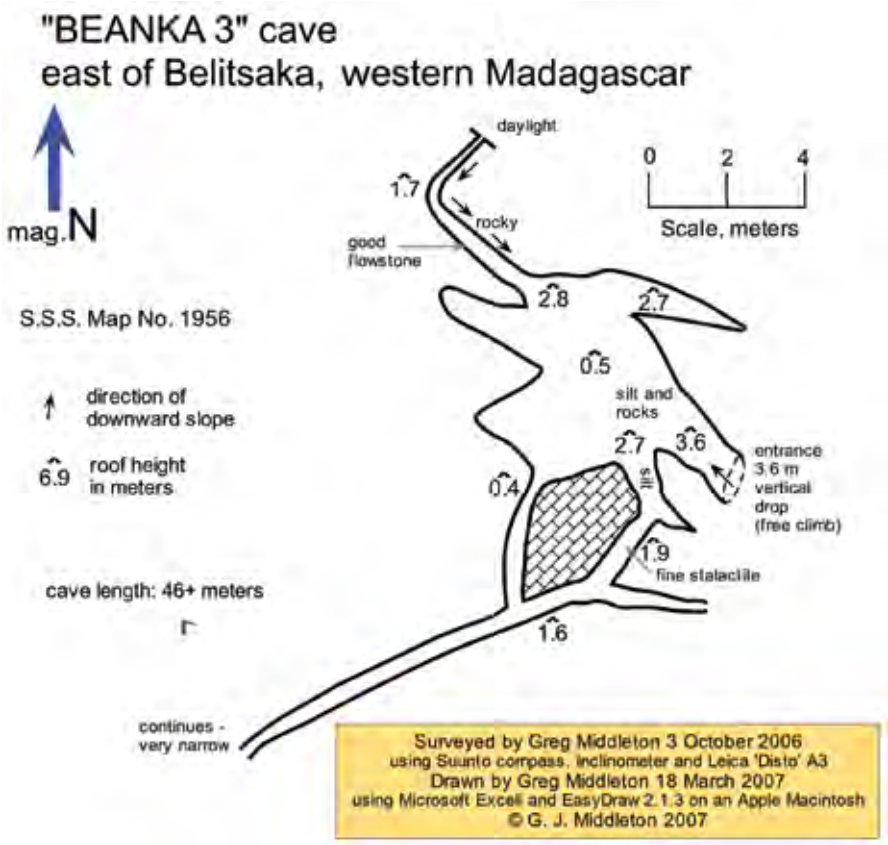


**Figure 3-7.** Plan of small cave designated Beanka 3.

**Figure 3-8.** Fine stalactites in Beanka 3.

**Figure 3-9.** One of a series of large tufa dams deposited from water from a karst spring saturated with calcium carbonate.

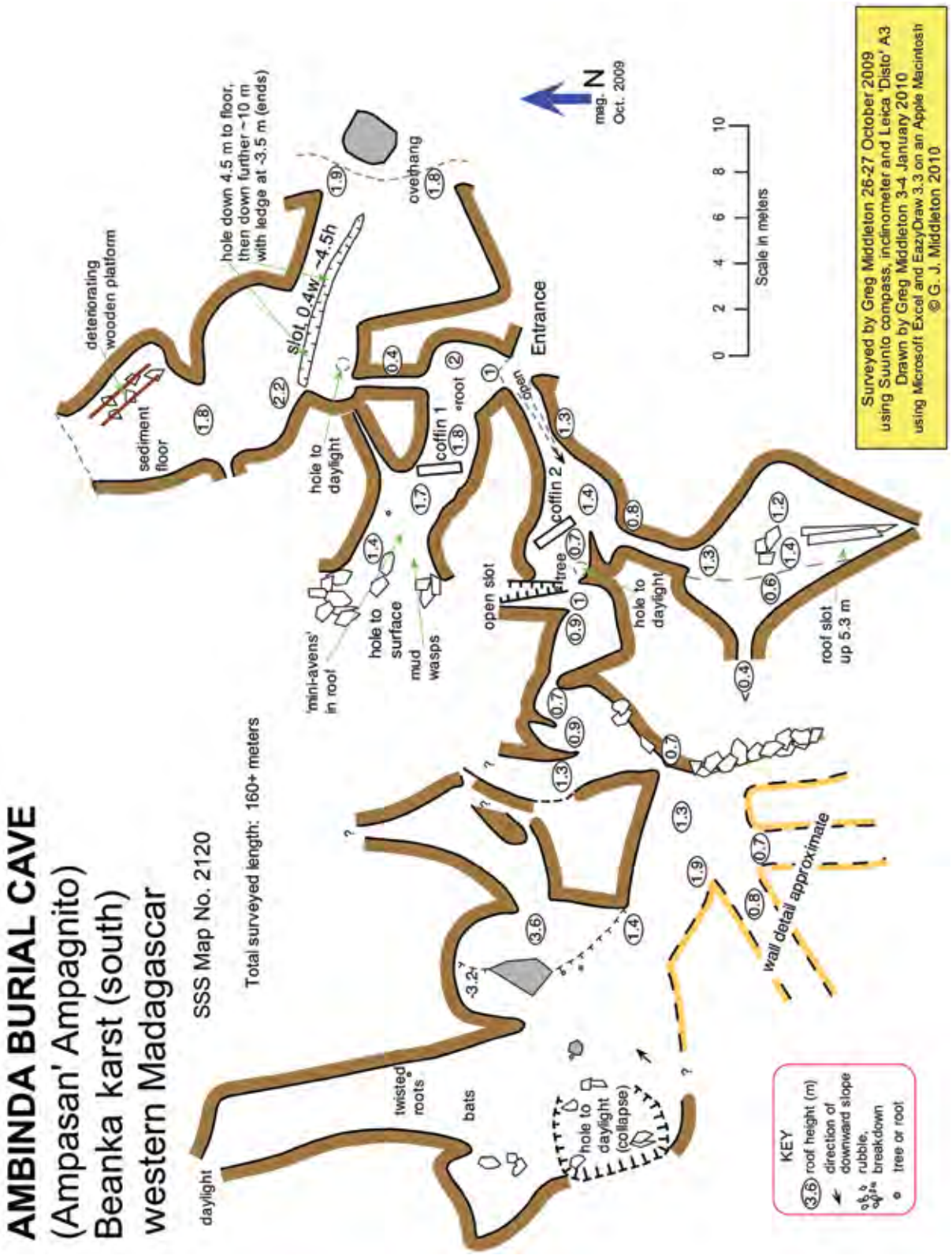


**Figure 3-10.** Plan of Ambinda Burial Cave, surveyed 2009.

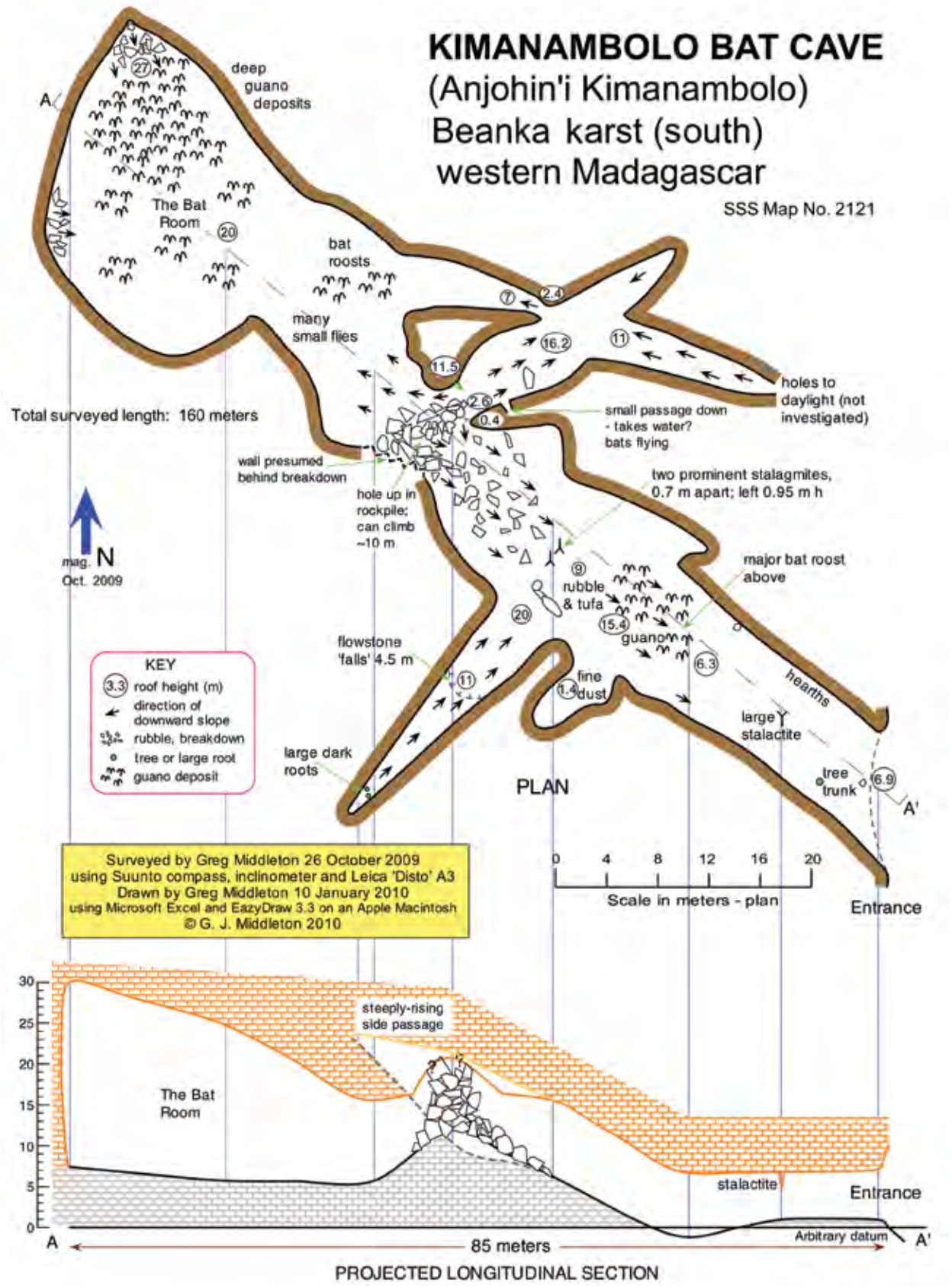


**Figure 3-11.** Plan and section, Kimanambolo Bat Cave.

**Figure 3-12.** Kimanambolo Bat Cave has a large entrance chamber with a huge central stalagtite.

On the 2010 expedition (Middleton, 2012), using inflatable boats, the survey of Kinahaingo River Cave was completed (Figure 3-14) and its length was determined to be 1200 m. The cave has cut deep into the limestone and attained a vertical range (lowest to highest points) of over 45 m. The cave was found to contain a significant bat colony (*Hipposideros commersoni*) and, in the daylight-lit upper level (Figure 3-15), a former occupation site indicated by lots of potsherds and charcoal remnants. Exploration of the Bokarano River Cave was also made possible with inflatable boats, revealing a remarkable sinuous stream passage some 1575 m in length (Figures 3-16 & 3-17) and with a vertical range of more than 47 m. Beyond the stream way, was a large breakdown chamber with roof heights reaching 24 m. From the back of this chamber a lower passage, carrying the stream, was explored by John Wylie for an estimated 100 m to the probable end. A nearby (dry) cave, opening onto the Bokarano River, Andrakaraka Cave, was surveyed to 620 m (Figure 3-18).

On a follow-up trip in 2012, the author confirmed the most remote section of Bokarano River Cave, and surveyed the passage from an upper entrance (Figure 3-19) to the stream way (about 50 m). Further caves have been noted opening onto the Bokarano Gorge but have not yet been surveyed. Also on this same trip, we were shown a large open cave, “Anjohibe” (a name found elsewhere in Madagascar and simply meaning ‘place of the big cave’) northwest of Vohimiary (Figure 3-20). In earlier historical periods, this cave was clearly inhabited or

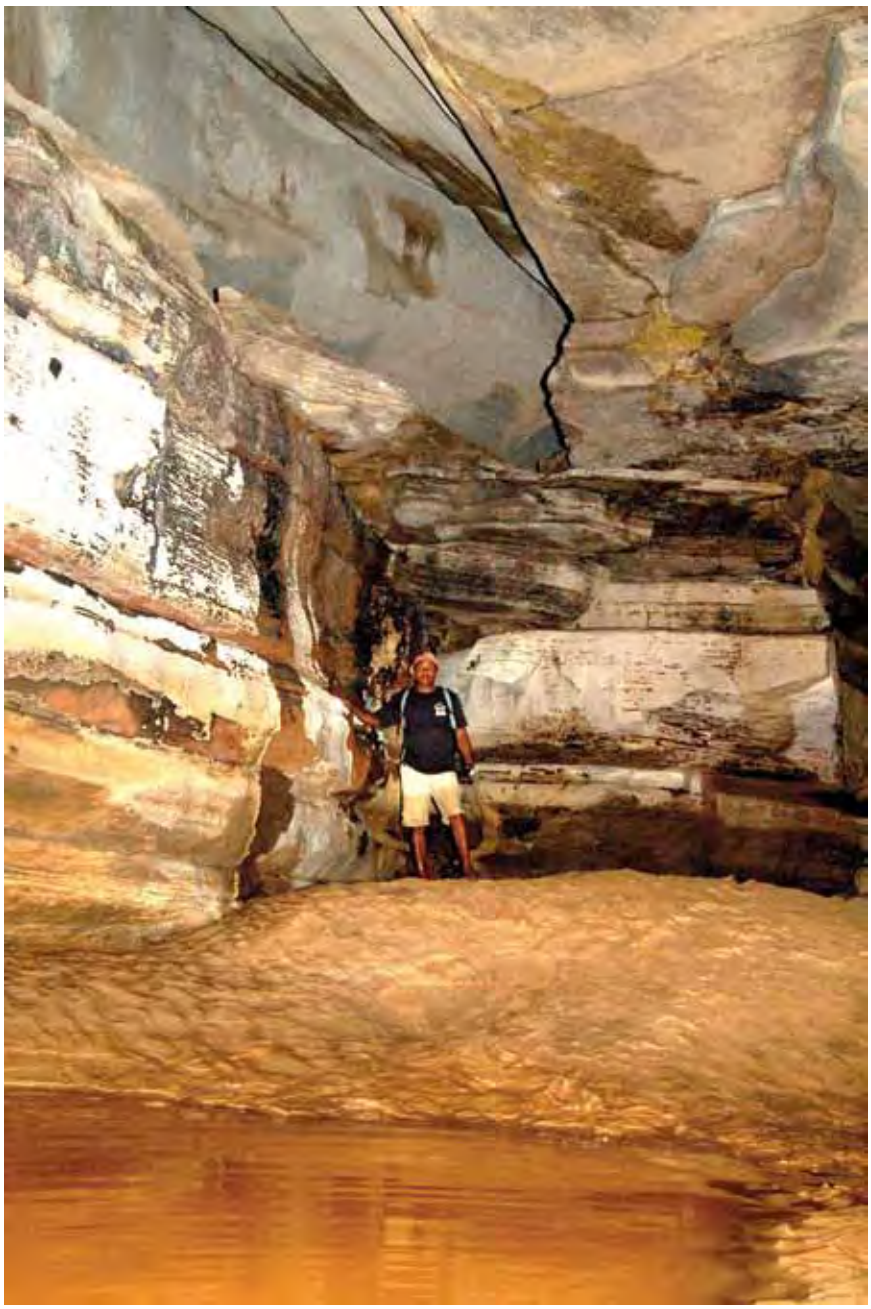

**Figure 3-13.** Beyond this sandbar in Bokarano River Cave water fills the passage and becomes too deep for wading. Roger Randalana figured in photo.

used for ceremonial purposes. It contained two old intact round pots and fallen slabs of rock had clearly been arranged to create a number of relatively level platforms. This cave is also notable for its external 'fringe' of very large stalactites.

A visit to the far north of the reserve, via the village of Anahidrano, in September 2012, resulted in our locating a further spring from a small flooded cave (Figure 3-21) and two caves comprising networks of joint-controlled narrow passages – Anahidrano Cave (Figure 3-22) and Andriamamelo Cave (Figure 3-23). Other caves are reported in this vicinity by local villagers.

## Discussion

The caves documented to date in the Beanka karst vary in extent from a few meters to over 1.5 km and comprise a range of types such as might be expected in a region of this size. While some are little more than rock shelters and slots, others are extensive networks of intersecting passages or long sinuous active stream passages. Frequently the pattern of cave passages reflects the natural jointing in the rock, presumably because meteoric water is able to preferentially penetrate limestone along joints, which become enlarged in the process. Such patterns are

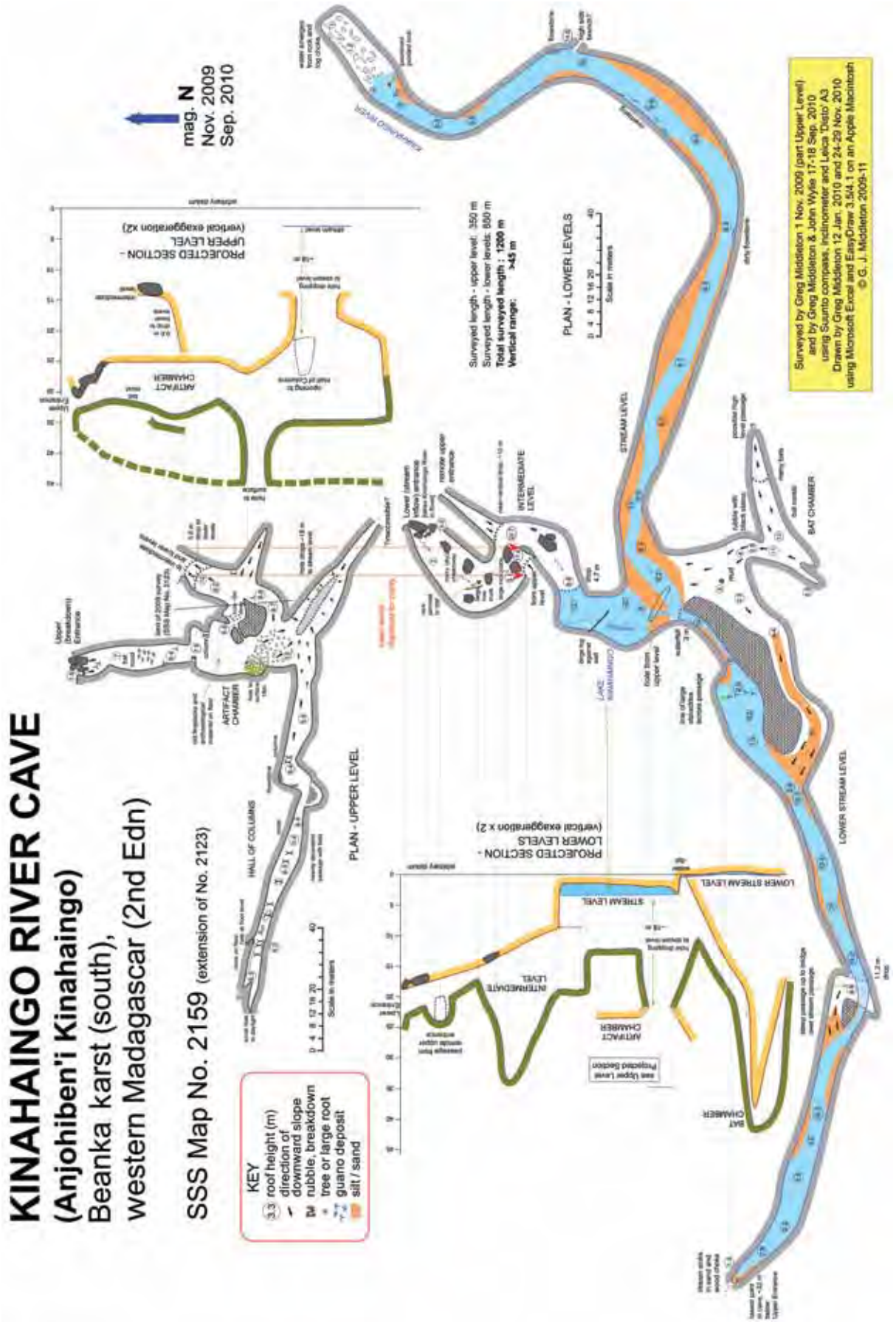


**Figure 3-14.** Plan and sections of Kinahaingo River Cave, surveyed length 1.2 km.

**Figure 3-15.** The large daylight hole in upper level, Kinahaingo River Cave, appears to have made this an attractive site for occupation.

most clearly demonstrated in the caves at the far north, near Anahidrano (Figures 3-22 & 3-23), but the same tendency is evident in the first documented cave (Figure 3-3), as well as those shown in Figures 3-7 and 3-11. The active stream caves (Kinahaingo, Figure 3-14 – lower level, and Bokarano, Figure 3-16) are on a much larger scale. While the streams may seem to follow meandering courses rather like those adopted by surface streams, if one looks carefully at the orientations of the passage sectors, it is evident that some alignments are favored over others, indicating joint influence over the passage development. In some caves there are extensive rock falls, notably Kimanambolo Bat Cave (Figure

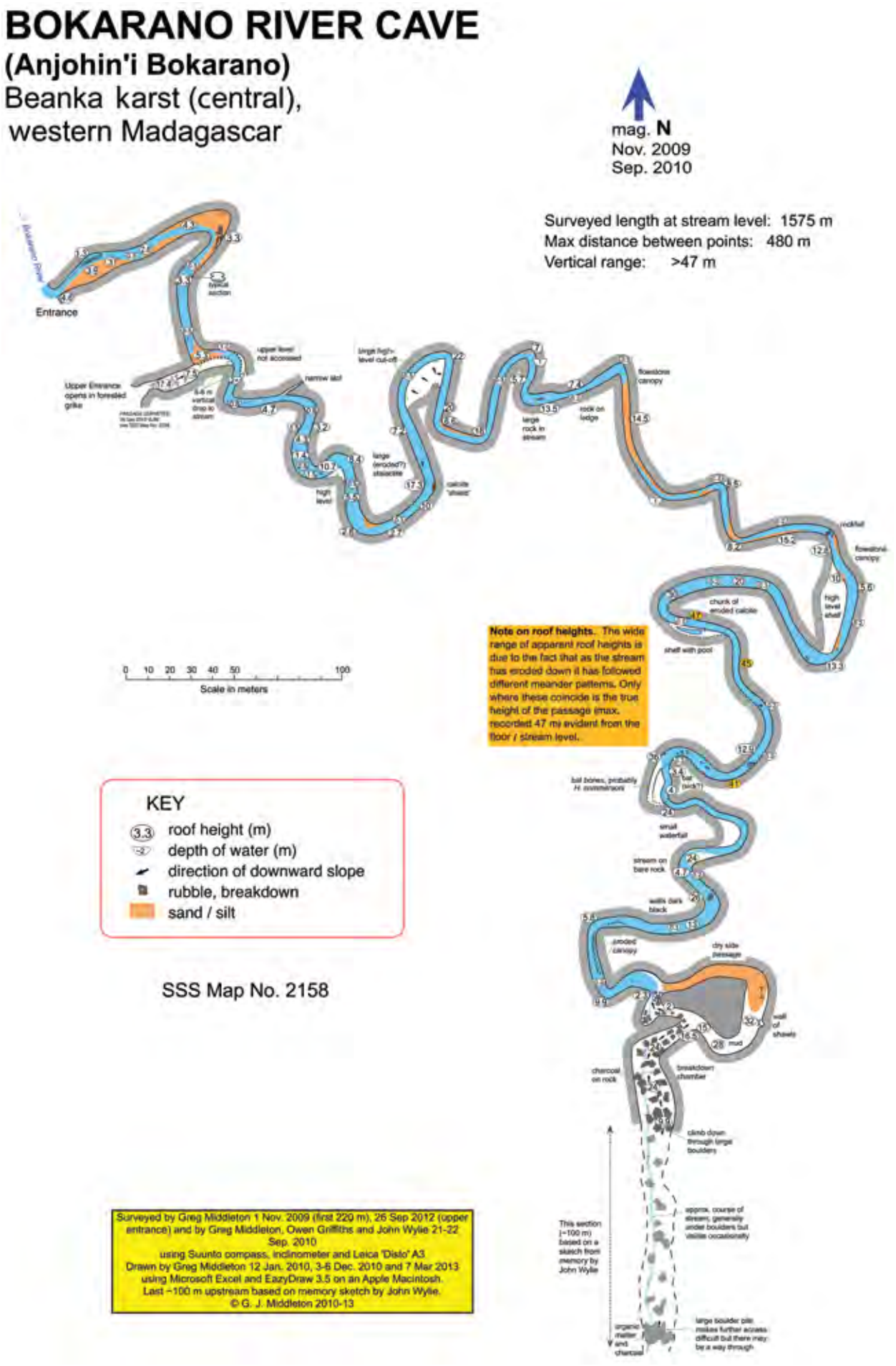


**Figure 3-16.** Plan of Bokarano River Cave, surveyed length nearly 1.6 km.

**Figure 3-17.** The impressive sinuous river passage in Bokarano River Cave.

3-12) and Anjohibe (Figure 3-20), while in others rock falls are uncommon. Most of the caves, especially the stream caves, contain varied collections of calcite speleothems (stalagmites, stalactites, columns, shawls, flowstone, etc). In places along the stream courses in the two river caves, it is evident that speleothems are being re-dissolved, indicating that the streams at times remain at elevated levels for extended periods.

Many of the caves show some evidence of phreatic (i.e. below the water table) formation – particularly indicated by roof pendants and half-tubes – but the stream caves are classic cases of active vadose (above the water table, with free air space at least most of the time) formation. Most caves experience periods under both types of formation and thus display evidence of each.

Because of their unusual mode of formation from the solution of solid rock, karst caves at times exhibit somewhat enigmatic structures. An example is bellholes – “symmetrical, circular, vertical cavities found in the ceilings of caves … with diameters of 50-500 mm, extending from a few millimeters to two meters in height” (James, 2011). Particularly good examples of bellholes can be seen in the ‘coffin chamber’ of Ambinda Burial Cave (where bats roost in them), in the main stream passage of Kinahaingo River Cave and in Andrakaraka Cave (Figure 3-24). It has been suggested that the formation of bellholes may be due to, or at least facilitated by, roosting bats. However, it is much more likely that they result from condensation erosion – though once initiated, their use as roosts by bats may expedite their upward development (James, 2011). Bellholes are most

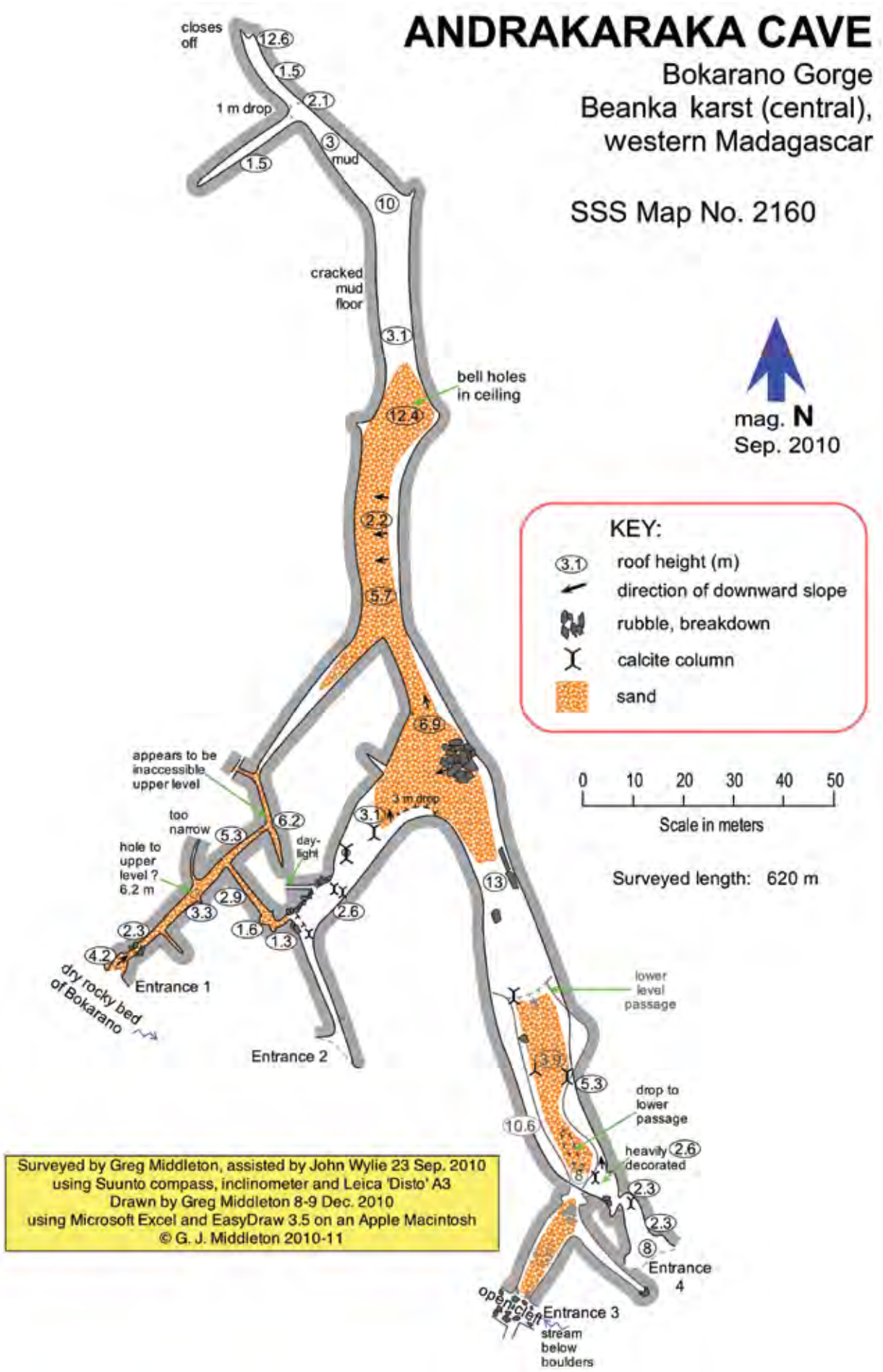


**Figure 3-18.** Plan of Andrakaraka Cave in Bokarano Gorge.

**Figure 3-19.** The large, well-decorated upper entrance to Bokarano River Cave.

common and best developed in caves in tropical zones.

It might be expected that suitable caves would have been used by humans as shelters in earlier times. This is clearly the case at Anjohibe (Figure 3-20); not only have ancient pots been left *in situ,* but it is evident that significant rearrangement of fallen slabs has taken place to form stone platforms. This might have been for ceremonial purposes or as sleeping sites within the shelter. Considerable quantities of pottery shards, charcoal, and broken bones were found in the upper level of Kinahaingo River Cave (particularly below its convenient skylight), indicating past human occupation. The special case of Ambinda Burial Cave with its (now empty) coffins highlights the former practice of using some caves for disposal of the deceased. It is unusual to find artwork of any kind on the walls of the caves, but the Andriamamelo Cave in the far north has such drawings. Nothing is known at this time of their age or origin but a study has commenced.

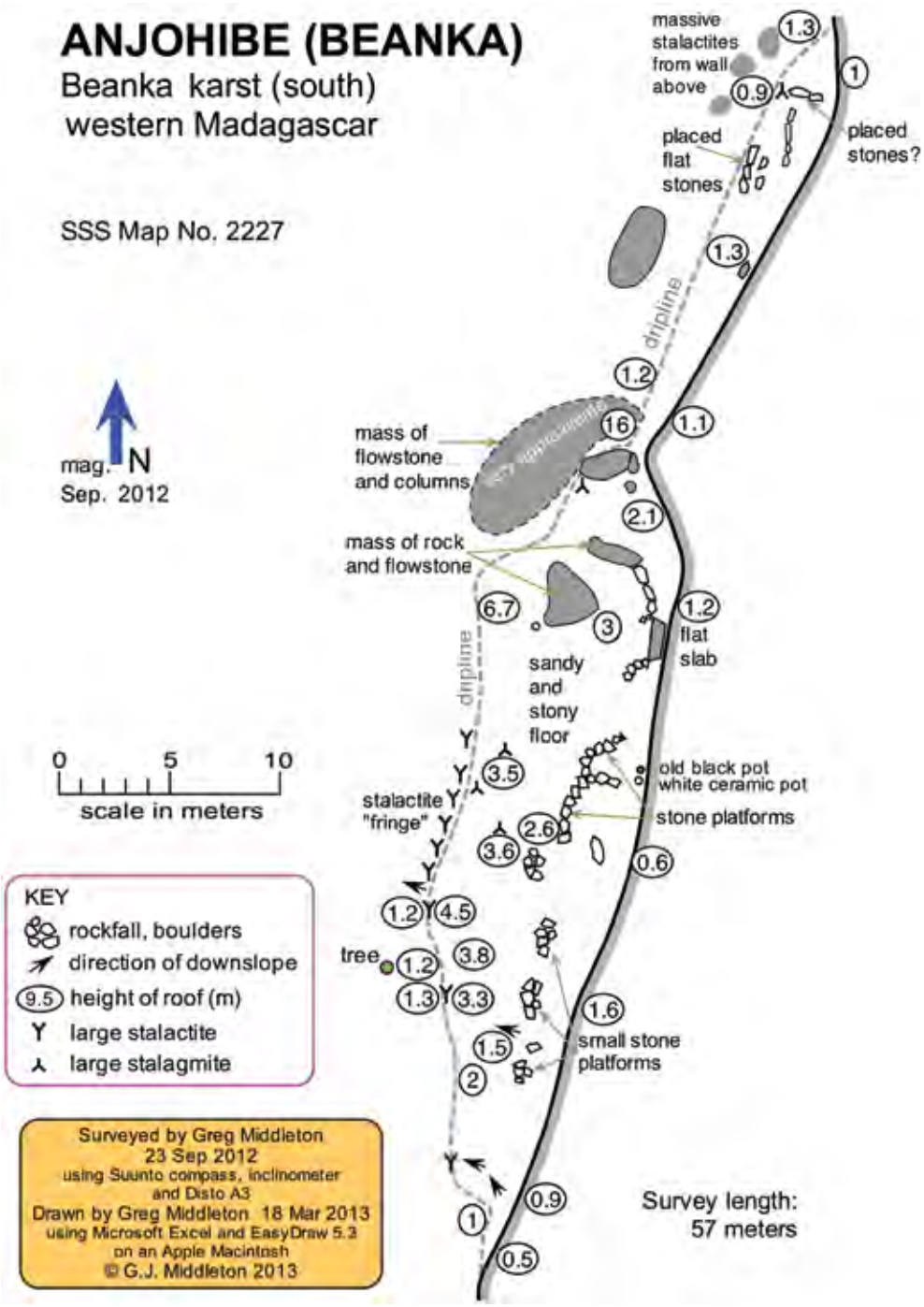


**Figure 3-20.** Plan of Anjohibe (Beanka), a 57 m long rock shelter.

The caves provide habitat for a range of animals (invertebrates and vertebrates) but little fieldwork has been undertaken. The most obvious cave dwellers are bats; the region is known to hold at least 12 species (Ramasindrazana & Goodman, 2011). Birds frequently use caves for shelter; owls have been observed in a number of Beanka caves. Only one significant paleontological site has so far been identified in the area – in a small cave near Bokarano River Cave – preliminary investigations have commenced.

## Conclusion

The Beanka Reserve is entirely comprised of forested karst. This encompasses a wealth of solution features typical of strongly jointed high-grade limestone in humid climates, including caves, riverine gorges, springs (some with tufa deposits), solution fluting (karren), and giant grikes. While the outcropping limestone at Beanka is less dramatic than in the more southerly Tsingy du Bemaraha and the more northerly Bemarivo karst, its caves are no

**Figure 3-21.** A stream emerges from this small 'slot' cave above the village of Anahidrano in the far north of the Beanka Reserve. Owen Griffiths figured in photo.

less significant than at these better-known areas. The fact that the karst areas are generally unsuitable for agriculture or human settlement has meant that they have been much less modified for human use and remain as viable habitat for the plants and animals that can adapt to their particular environments. The protection and management of the reserve should ensure the future conservation of the caves, their biological and non-living contents, and the overlying and upstream environments on which all of these depend.

## Acknowledgements

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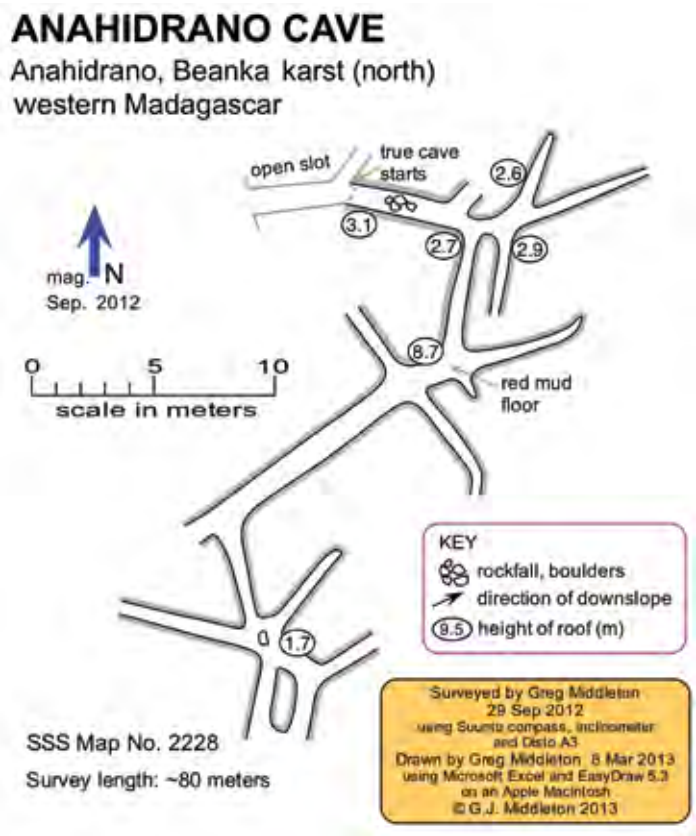


**Figure 3-22.** Plan of Anahidrano Cave, near the village of the same name.


**Figure 3-23.** Plan of Andriamamelo Cave, a few meters south of Anahidrano Cave.

**Figure 3-24.** Large bellholes in the high (> 12 m) roof of Andrakaraka Cave.

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