PRELIMINARY SURVEY FOR CAVES IN THE HABAKAH REGION OF THE KINGDOM OF SAUDI ARABIA

By

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ABSTRACT

During 2001 and 2002, the Saudi Geological Survey cave unit made four field trips to the immediate vicinity of Habakah, a small settlement located 90 km west of Rafha, Saudi Arabia. Eleven caves were located, ranging in length from 1.5 to 390 m, all found in the Umm er Radhuma Formation, which consists of light gray to white foraminifera-bearing, fine-grained calcarenitic limestone, dolomitic limestone, and dolomite with chert scattered throughout the section. Calcarenitic and siliceous beds are common in the upper part of the formation and dolomitized fine-grained limestone in the lower. In the area of the Habakah caves, the succession includes beds of gypsum a few meters thick interbedded with the limestone. Whereas caves in the Umm er Radhuma Formation farther south often take the form of vertical shafts without speleothems, the caves studied in this report are often horizontal passages or collapses with gypsum or calcite formations.

Two examples of such caves were mapped and are geologically described in this report. Serdab al Aqrab al Aswad or Black Scorpion Cave is a horizontal cave with approximately 390 m of passages ranging in height from 60 cm to 17 m. Large rooms filled with breakdown are found as well as low crawlways. Gypsum speleothems in a variety of forms decorate many passages. Also found are large caches of bones, old and recent scat of foxes, hyenas, and wolves, bat guano and many bats. Kahf al Ramlah al Hamra, or Red Sand Cave, is a collapse with a 50-m steep slope covered with breakdown and terminating in a room 13 m in diameter and 4 m high. Fine-grained limestone is the host rock of this pit, at the bottom of which a stratum of dolomite can be seen interbedded with secondary gypsum and iron oxides, with no sign of speleothems. A brief description of four other caves is also given. It is noted that the dissolution of gypsum may have played a large role in the development of these caves and the authors speculate that this area may be part of the terrain affected by the Aba al Qur dissolution-collapse structure located in the eastern extremity of the Judayyidat 'Ar'ar quadrangle.

مسح أولي للكهوف في منطقة الهبكة
بالمملكة العربية السعودية

إعداد

محمود أ الشنطي وجون ج بنت وعبد الرحمن ج الجعيد وسعيد أ العمودي

الخلاصة

خلال عامي ٢٠٠١م و ٢٠٠٢م قام فريق وحدة استكشاف الكهوف بهيئة المساحة الجيولوجية السعودية بأربع زيارات حقلية إلى المنطقة المجاورة لقرية الهبكة وهي هجره صغيره تقع على بعد ٩٠ كيلو متراً غرب مدينة رفحة بالمملكة العربية السعودية . وتم اكتشاف أحد عشر كهفاً تتراوح أطوالها ما بين ١,٥متر إلى ٣٩ متراً تقع جميعها في متكون أم الرضمة الذي يتكون من حجر جيري كلكارينيتي ناعم الحبيبات حلوي المنخريات رمادي فاتح إلى ابيض اللون مع حجر جيري دولوميتي ودولوميت مع صوان منتشرة في كافة أرجاء المنطقة . كما تنتشر طبقات كلكارينيتية وسليسية في الجزء الأعلى من المتكون وحجر جيري متدلمت ناعم الحبيبات في الجزء الأسفل من المتكون . وفي منطقة كهوف الهبكة يشمل التتابع طبقات من الجبس تبلغ سماكتها عدة أمتار متعاقبة مع طبقات من الحجر الجيري .

وفي حين أن الكهوف الموجودة في متكون أم الرضمة الذي يوجد إلى درجة أبعد نحو الجنوب ، تتخذ أحياناً شكل ممرات رأسية عمودية لا تحتوي على رسابات كهفيه ، نجد أن الكهوف موضع هذا التقرير هي أحياناً ممرات أفقية أو انهيارات مع متكونات من الجبس أو الكالسيت .

تم رسم خرائط كهفين يمثلان الكهوف السائدة في هذه المنطقة ويحتوي هذا التقرير على الوصف الجيولوجي لهذين الكهفين وهما سرداب العقرب الأسود الذي يتكون من كهف أفقي يبلغ طول ممراته ٣٩٠ متراً تقريباً تتراوح ارتفاعاتها ما بين ٦٠سنتمتراً إلى ١٧ متراً ، وتم العثور على حجرات كبيرة مليئة بالركام الصخري وممرات أرضية ضيقة . وتزين رسابات الجبس المتعددة الأشكال العديد من هذه الممرات . كما تم العثور على أكوام كبيرة من العظام و فضلات قديمة و حديثة للثعالب و الضباع و الذئاب والخفافيش وأيضاً العديد من الخفافيش.

والكهف الثاني ، كهف الرمال الحمراء عبارة عن انهيار يتميز بانحدار حاد لمسافة ٥٠ متراً ويغطيه الركام الصخري وينتهي إلى غرفة يبلغ قطرها ١٣ متراً وارتفاعها ٤ أمتار . والصخر المستضيف لهذه الحفرة هو الحجر الجيري ناعم الحبيبات وتقع في قاعها طبقة من الدولوميت المتعاقب مع جبس ثانوي وأكسيد الحديد مع غياب الرسابات الكهفية (الصواعد والهوابط) .

يتضمن التقرير أيضاً وصفاً موجزاً لأربعة كهوف أخرى . ويلاحظ إن ذوبان الجبس قد يكون لعب دوراً كبيراً في تكوين هذه الكهوف ويعتقد المؤلفون أن هذه المنطقة قد تكون جزءاً من الإقليم الذي تأثر بتركيب ذوبان الهيثر أبا للغور الذي يقع في أقصى الجزء الشرقي لمربع جديدة عرعر .

INTRODUCTION

GEOLOGY OF THE HABAKAH REGION

The location of the region studied in this report is from lat 29°57′N. to 29°45′N., and from long 42°14′E. to 42°21′E. The authors are grateful to Mr. Faisal S. Al Zamil for directing our attention to the caves of Habakah. The latitude and longitude of individual caves are given in Pint, 2001 but omitted in this report to protect the caves from unnecessary human disturbance. The caves described here are found in the Umm er Radhuma formation (fig. 1). Karst dissolution caves farther south in this formation are described by Peters and others (1990), but the caves investigated in this report may differ in origin from classic karst structures because of the effect of the Aba al Qur dissolution-collapse structure.

The Umm er Radhuma Formation

The Umm er Radhuma Formation was first named by Henry and Brown (1935), for water wells in the Umm al Radhmah area. Steineke and Hoover (1936) could not follow a complete succession at that location and designated a reference section at Wadi al Batin. The name Umm er Radhuma Formation was first published in 1952 by Steineke and Bramkamp. A detailed reference section was published by Steineke and others (1958). Powers and others (1966) gave the formal name Umm er Radhuma Formation. More details and a correlation with subsurface data were provided by Powers (1968). El Khayal (1970, 1974a,b) studied foraminifers from subsurface Umm er Radhuma samples in the Gulf area, and Al Furaih (1977, 1983a,b, 1984) examined ostracods from subsurface samples. Hasson (1985) proposed a biostratigraphic revision of this formation. The geologic map of Bramkamp and Ramirez (1963) shows that the Habakah region occurs in the lower part of the Umm er Radhuma Formation.

The Umm er Radhuma Formation is exposed in an area between lat 27°32′N., long. 44°52′E., and lat. 27°50′N., long. 45°20′E., the section being a composite of several intervals. It overlies the Aruma Formation and underlies the Rus Formation. The age of the Umm er Radhuma Formation is Paleocene to lower Eocene from subsurface data by Powers and others (1966), based on poorly preserved microfauna and the occurrence of echinoids, gastropods and bivalves (Powers, 1968). In the Eastern Province, Tleel (1973) found Paleogene (Early Eocene) planktonic foraminifers in subsurface samples, which was confirmed by El-Khayal (1974a, b) and Al-Furaih (1983a, b) from interpretation of ostracods in subsurface samples. However, Vaslet and others (1999) found Miocene (Chattian to Tortonian) fossils in the Umm er Radhuma Formation, which suggests that it is younger than proposed by Powers and others (1966) and that there is a major break in sedimentation (hiatus) between the Aruma and Umm er Radhuma Formations. Powers and others (1966) and Powers (1968) reported a disconformity with the underlying Aruma Formation. However, Vaslet and others (1988) described a conformable contact and Hasson (1985) reported a probable hiatus in the subsurface of eastern Saudi Arabia. The Umm er Radhuma Formation near the village of Linah overlies the Lina Member of the Aruma Formation on a conformable contact according to Lebret and others (1999) who also states that the Umm er Radhuma Formation is conformable below the Rus Formation in the eastern province.

The Umm er Radhuma Formation consists of light gray to white foraminifera-bearing, fine-grained, calcarenitic limestone, dolomitic limestone, and dolomite. Chert is scattered throughout the section. Calcarenitic and siliceous beds are common in the upper part of the formation and dolomitized fine-grained limestone in the lower. In the area of the Habakah caves, the succession includes beds of gypsum a few meters thick interbedded with the limestone.

Caves in the Umm er Radhuma Formation farther south

Peters and others (1990) states that the caves located near the village of Ma'aqala, south of the area described in this report, are typically dolines in the Umm er Radhuma formation, taking the form of vertical shafts with openings of two meters or less in diameter and reaching depths of 4 to 15 meters. Horizontal passages extending from these shafts are usually blind cul-de-sacs or are connected to other shafts only a few

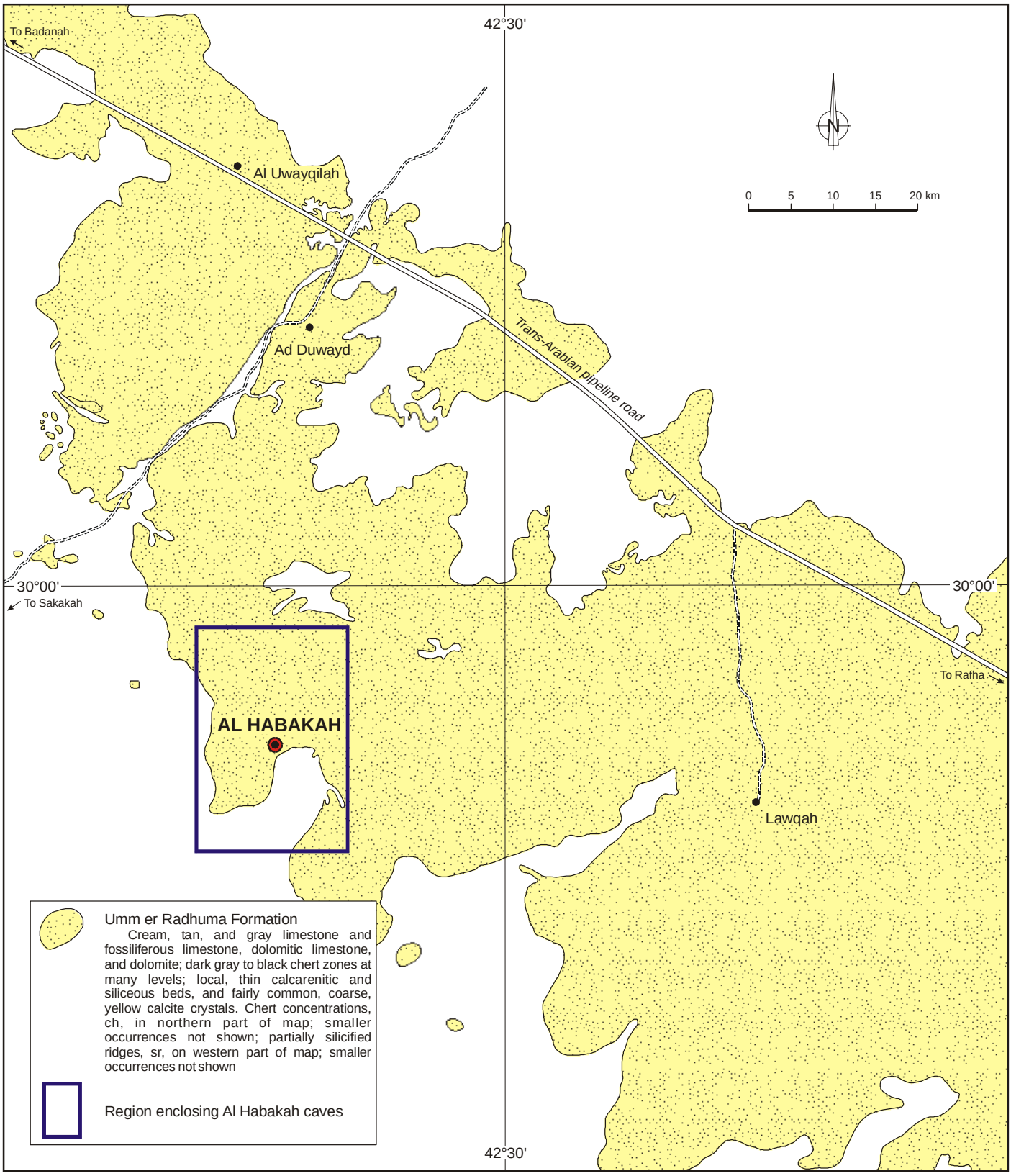

Figure 1. Geologic setting of Al Habakah

meters distant. A typical cave in the Umm er Radhuma formation is Dahl Abu Hashami, described by Benischke and others, 1986. This is a shaft 14.67 m deep with horizontal passages totaling 23.80 m in length. Neither stalactites nor stalagmites are found in this cave, although a small part of the wall in the horizontal passage was covered with flowstone.

Because the caves in the Habakah area are typically collapses or horizontal passages hundreds of meters long and frequently displaying gypsum or calcite formations, it is possible that the Umm er Radhuma formation as found in the Habakah area has been influenced by the terrain of the Aba al Qur dissolution-collapse structure.

The Aba al Qur Dissolution-Collapse Terrain

The Aba al Qur dissolution-collapse structure is located in the eastern extremity of the Judayyidat 'Ar'ar quadrangle area of approximately 650 square kilometers. It is developed in the Badanah Formation as an upland area characterized by sinkholes, disrupted drainage, and remnants of carbonate dissolution breccia. East of this upland area is a zone of disrupted drainage from 1 to 10 km wide, on the east side of which is an escarpment facing east, toward the dissolution crater floor. Near the escarpment is a region that is fully disrupted with no surface drainage but contains caves that break through to the surface. The rock is dissolution breccia. The escarpment dips toward the dissolution crater, which forms a flat area of poorly developed drainage punctuated by large and deep sinkholes, and dissolution breccia. The floor of the crater is mainly breccia and gypsum.

The dissolution crater is formed from dissolution of gypsum that was interbedded with limestone. The limestone shows prominent dissolution features and is fully recrystallized. The main dissolution event appears to have occurred during Miocene and Oligocene time.

S.M. Dini (oral communication, 2003) and C.W. Wallace (written communication, 2003), state that the area affected by this evaporite-collapse structure extends southeast into the Al Uwayqilah quadrangle, but that it is not known whether the area of the evaporite collapse reaches as far as the At Timayit quadrangle where the caves in this report are located. Because the dissolution of gypsum appears to have played an important role in the formation of the Habakah caves, it is thought likely that these caves lie within terrain affected by the Aba al Qur dissolution-collapse structure.

SERDAB AL AQRAB AL ASWAD / BLACK SCORPION CAVE

GEOLOGICAL DESCRIPTION OF THE CAVE

The Habakah area lies in sedimentary rock marked by a number of small hills. The cave, registered as No. 85 in Pint, 2001, is an opening in the southwest side of one of these hills, apparently the result of dissolution by running water of a layer of gypsum in limestone (figs. 2 and 3).

At the entrance of the cave, calcarenitic limestone can be seen on both sides and on the ceiling with different sizes of cracks and cavities filled with secondary gypsum and anhydrites. A stratum of gypsum was leached to make the entrance and rooms inside. A sample taken from the west wall, near station 1 is white on its weathered surface, light brown inside, and is fine-grained (Sample BLS_001). Another sample (BLS_002), taken from the wall 15 m west of station 2, is a chalky limestone, white on the surface, fine grained and there is a new growth of calcite due to leaking of water from the surface through cracks (fig. 4).

Sample BLS_003, taken from 5 m SW of station 3, shows a new growth of gypsum on the chalky limestone (figs. 5 and fig.6). This passage is full of broken, chalky limestone fallen from the roof and sidewalls (fig. 7).

Sample BLS_004 is taken from the NE wall near station 5, is a hard, massive rock marked by white and red bands of calcium carbonate, two meters above the floor (fig. 8).

South of station 8, 3 to 4-ton blocks of limestone lie one upon the other to a height of 10 m in the 17-m high Majlis ath Thiyab (Wolves Assembly Hall), filling most of the space for a distance of some 60 meters. A cache of bones, about 15 m long and 2 m wide, covers the floor along the western wall (fig. 9). Scat found here is similar to that seen in B7 Cave on the Summan Plateau. Toothmarks found on bones in B7 cave were proven to have been made by hyenas, which presumably brought the bones into the cave (Benischke and others 1988). Among the rocks are found openings large enough for animals to enter and to use for dens. The east trending alcove 20 m E of station 8 contains a great deal of scat, possibly from foxes as well as hyenas and wolves (fig. 10). A stratum of crystallized gypsum can be seen here (fig. 11) and both the ceiling and some walls of this passage are covered with gypsum flowers (fig. 12).

Passages in this cave vary in height and width in accordance with the size of the gypsum bed, which was dissolved. From time to time gypsum speleothems can be seen on the edges of the ceilings and walls, especially in the Ghorfat al Makarona (Macoroni Room) between stations 15 and 16. Here are found beautiful gypsum speleothems, in the form of flowers, swords, needles and cotton candy (figs. 13, 14, and 15).

At station 19, the roof is covered with calcite growth within the chalky limestone, due to cracks and leakage of water. A powder, white in color, lies on the floor and has been submitted for analysis (Sample BLS_005) (fig. 16).

At station 20 a yellow stain is visible on the chalky limestone ceiling, which reflects the light and exhibits a strong smell of bat urine. Bat guano is found below, on the floor.

Between stations 19 and 20, upward-trending openings are found on both sides of the main passage. The eastern opening leads to a passage too tight for investigation. The western opening leads to a drop of several meters, which was not entered.

SW of station 23 the size of the passage is reduced to less than 60 cm in diameter. The floor of this low, tight crawlway is covered with sharp-edged fragments of limestone as well as bones and fresh fox scat. The ceiling of this passage is spotted limestone in the form of shiny calcite crystals, which reflect light.

At station 25, on the NW side wall, sample BLS_006 was taken. Here the walls and ceiling consist of red iron-stained limestone caused by water leaking through the cracks from the surface cut by a clear mud stratum 50 cm thick. The Reddish color is pervasive on the walls, floor, and ceiling (fig. 17).

At station 28 the ceiling height reaches 4 m. At station 29 a large room opens, measuring 26 by 20 m. Guano beds at station 31 cover the floor causing a sharp odor, with hundreds of bats flying about the room. This layer is from 50 to 70 cm thick. Samples of this guano were collected from the top and the bottom of this layer. Some fallen or broken rocks can be seen in this room. These range in size from over ten tons to very small. Red sand, fallen from the ceiling, covers the breakdown and the floor. The temperature in this large room is 26°C and the humidity is 84 percent (fig. 18).

At the end of this cave, at station 33, there is a 3 x 3 m room. To reach it, one must pass through very soft powder, which rises and causes breathing problems. This room is full of red sand. The limestone ceiling and walls are also red in color. It has a dome ceiling and thousands of bats roost here.

In summary, this cave consists of two units; the lower unit is chalky limestone overlain by a calcarenite unit more than 20 m thick. Calcite and gypsum speleothems precipitated on the walls of the cavity created in this unit take a variety of forms. This is evidence of frequent leaching and dissolution of these sediments. As mentioned above, large pieces of fallen rocks lie on the floor of this cave, due to dissolution and possibly earthquakes. We also note the use of cavities as dens of wild animals, as evidenced by their scat and the remains of their prey. Moving deep inside the cave one observes the changing of the color of the limestone from white to red, the effect of iron oxide. The presence of powdery dust in the air causes serious breathing problems for visitors and their numbers should be limited.

KAHF AL RAMLAH AL HAMRA / RED SAND CAVE

GEOLOGICAL DESCRIPTION OF THE CAVE

The cave, registered as number 175 in Pint, 2001 and shown in Figure 19, is located in a channel surrounded by small hills of limestone. The cause of this cave is the dissolving action of water on the limestone, causing a pit of almost 20 meters in diameter with 70 meters of sloping passages below (figs. 20, 21).

Fine-grained limestone is the host rock on the walls of this pit (fig.22). Samples were collected to show its composition. One to three ton blocks of rock are found at station 1 (fig. 23) and cover the west slope all the way to station three. These blocks were caused by the movement of water down the slope, breaking down the walls and ceiling (fig. 24).

At station 3, a stratum of dolomite can be seen, interbedded with secondary gypsum (figs. 25, 26, 27) and at the end of this cave, a room 13 by 13 meters is found, with a sandy floor. Secondary gypsum can be seen on the ceiling, with iron-oxides stain on the walls interbedded with the fine-grained limestone. This bed of iron oxide is friable and soft. Samples were collected from this room (fig. 28).

OTHER CAVES LOCATED IN THE REGION

Serdab Tayib al Issim

The cave is registered as number 84 in Pint, 2001 and is shown in Figure 29. The entrance is found at the bottom end of a low depression measuring 8 m in diameter (fig. 30). The entrance, defaced with grafitti, measures 6 m wide and 2 m high and opens on to two separate passages. The passage on the south side of the entrance is walkable and the floor is covered with black bat guano, which gives off a strong smell, and some bones including the complete body of a dead fox (fig. 31). The passage ends after approximately 30 m, and was not surveyed.

The passage on the northern side of the entrance leads east for 15 m and has a height of 1.5 m. This passage smells strongly of animals such as wolves and foxes. The passage then forks and becomes two NE-trending parallel passages about 30 m in length and 0.5 to 2 m in height. The southeast of these parallel passages contains two natural bridges east of stations 5 and 6 and, between stations 6 and 8, a room ten meters long whose walls are covered with sausage-shaped formations tipped with spikes (figs. 32 and 33). The parallel passages lead to rooms filled with breakdown and contain some bones (fig. 34). Here, at station 10, are found stalagmites of gypsum, which had been broken by local people to collect the gypsum powder inside (fig. 35). Stalactites and sausage-shaped formations can be seen on the walls, breakdown (fig. 36), and ceiling around this station and the remains (bottom) of a water bag or ghurba was found here, suggesting that this cave may have held water in the past. A naturally preserved bat was found in the easternmost room of the cave and was identified as *Asellia tridens* in a personal communication by Dr. Ian Nader of the King Khalid Wildlife Commission, Riyadh (fig. 37). A living bat was found inhabiting a small hole from which bat urine had produced a brown stain. Several other such holes with stains were seen nearby, but uninhabited.

Dahl al Maqlab / Practical Joke Cave

The cave, registered as No. 174 in Pint, 2001 and shown in Figure 38 is located 900 m northwest of Kahf al Ramlah al Hamra on top of a small hill. This dahl is found in fine-grained limestone with a small bed of boxwork texture on the surface. This pit was formed by water flowing from the peak down the slope, perhaps dissolving a small bed of gypsum. Gypsum and mud are visible on the cave walls, and the entrance to the cave is filled with piles of rocks in the entrance (fig. 39). The rocks and steep slope prevent easy entrance to the cave. Twenty-two meters below the surface, the cave ends in a small that contains a sand and mud floor (fig. 40). Secondary gypsum is pervasive on the ceiling of this room. Cracks can be seen in the ceiling with breakdown below, on the floor. No horizontal passages, nor speleothems were observed in this

cave, which gave rise to the name Practical Joke Cave because, from the surface, it appears to be the entrance to large horizontal cave.

Dahl Abu Rijl Maksura

The cave, registered as No. 86 in Pint, 2001, is a collapse, which has produced a nearly round entrance hole 5.85 m by 4.5 m (fig. 41). From this hole there is a vertical drop of 6.98 m to the top of a mound composed of sand, dirt, breakdown and trash. This mound slopes radially for a distance of 13 to 20 meters and is covered by breakdown. At one point at the base of the mound, calcite stalactites and stalagmites were observed in great numbers and in many sizes and shapes (fig. 42). These speleothems appear similar to the calcite formations found in B-32 Cave and Kahf al Rutuwbah, described in Pint and others, 2003, and occurring in the Tsm of the Summan Plateau.

Six months after the initial visit to this cave, sections of the roof at the base of the mound were found to have collapsed, leaving a space of 30-100 cm where walking had previously been possible.

Dahl Saad

The cave, which lies north of Habakah, is registered as No. 91 in Pint, 2001. This cave is located north of Habakah. It is a pit, roughly 14 m wide by 16 m long, created by the dissolution of limestone by water (fig. 43). At the east and west ends of the pit are crawlways less than 70 cm high. The western passage terminates after roughly ten meters, but the eastern passage may continue a longer distance. This passage contained pools of water when visited in March 2002 and further exploration of it would require wriggling through such puddles, beneath a ceiling only 50 cm high. No speleothems were seen, but tumuli of rock-dove guano were found. The pit contains dead goats, which cause a bad smell.

Five other caves were located in the Habakah region. Four of these, designated No. 88, 89, 90 and 92 in Pint, 2001, are less than two meters long, and lack speleothems, artifacts, etc. The fifth cave, No. 87, was not investigated due to fresh wolf tracks found outside the entrance.

CONCLUSIONS AND RECOMMENDATIONS

The findings in this report suggest that the Habakah region may be an important site for speleological investigations in Saudi Arabia. The possible influence of the Aba al Qur dissolution-collapse structure on the limestones of this area, suggest that many other caves, not yet discovered, occur northwest of Habakah. Some caves in this general area may present hazards to the local people due to instability caused by speleogenesis based on the dissolution of gypsum layers. Other caves, such as Serdab al Aqrab al Aswad contain beautiful gypsum formations, which should be protected from human damage, perhaps through the use of gates and/or fences. In addition, the many bones found in these caves may provide valuable information on animals that lived in this area in the past. Finally, it should be noted that many of these caves are horizontal, with walk-in entrances and may have been visited or even inhabited in ancient times. It is recommended that archeologists and historians visit the caves to determine their possible importance to these fields.

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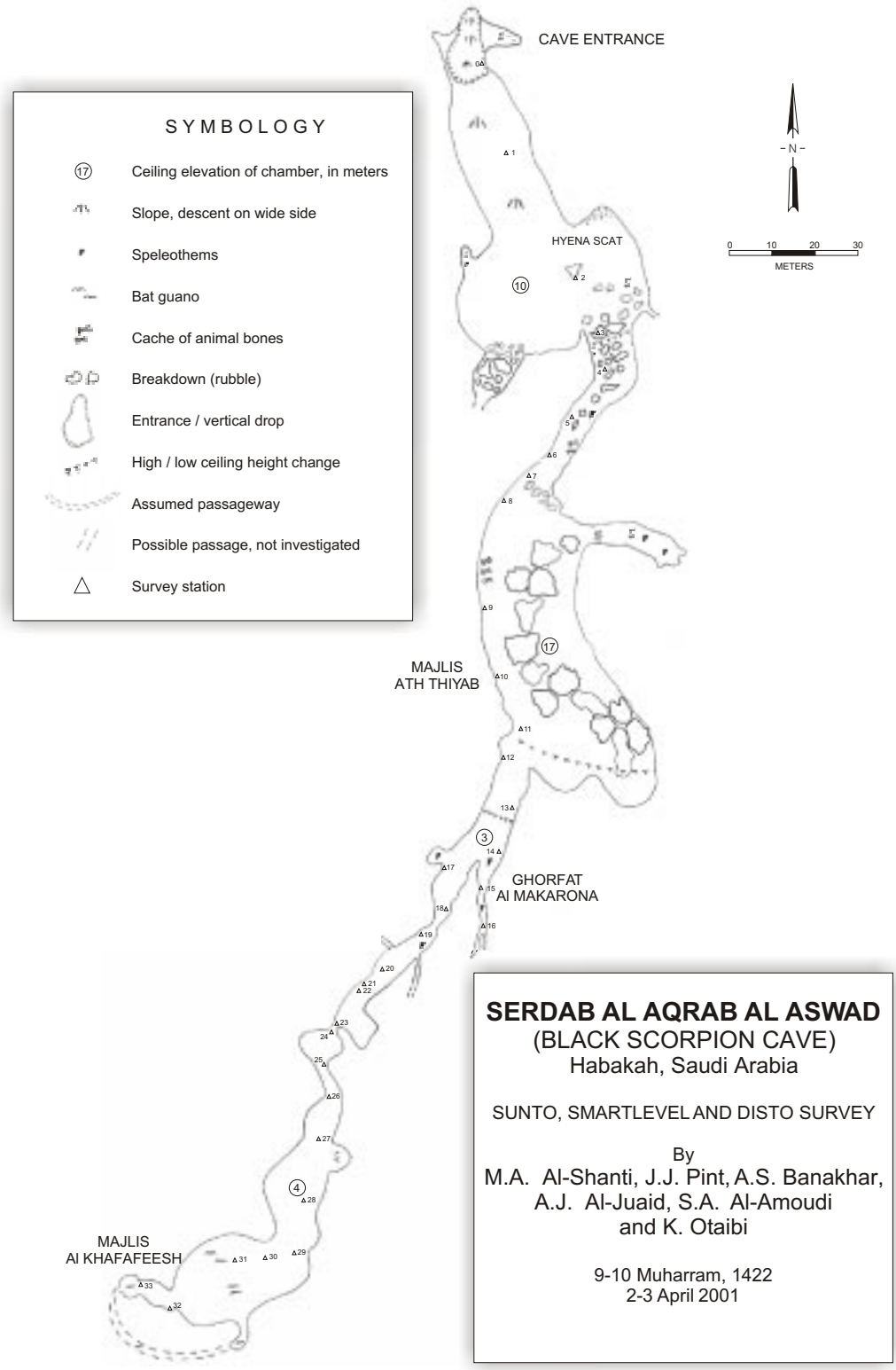

Figure 2. Map of Serdab al Aqrab al Aswad (Black Scorpion Cave).

Figure 3. The entrance to Serdab al Aqrab al Aswad.

Figure 4. Calcarenite on the west wall of the entrance room.

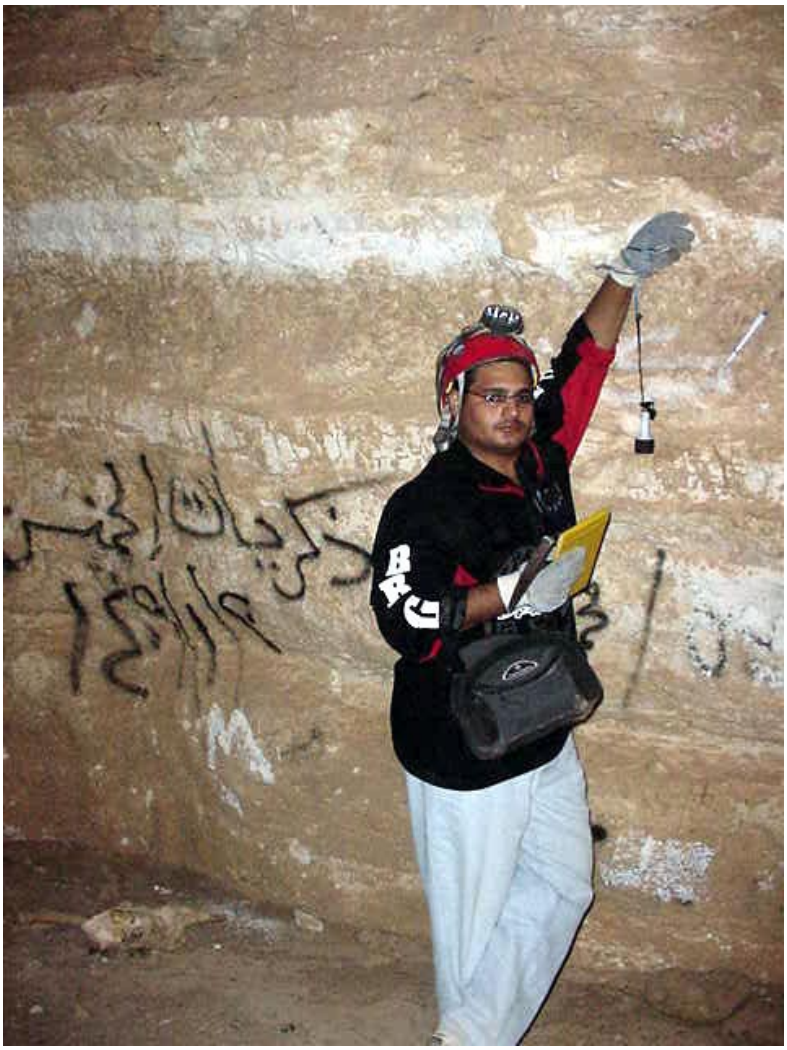

Figure 5. Bands of gypsum on the wall S of station 3.

Figure 6. Weathered surface of the chalky limestone near station 3.

Figure 7. Breakdown from the ceiling seen near station 5.

Figure 8. Small layers of new gypsum and yellowish soil due to leakage of water.

Figure 9. The biggest of several caches of bones found in the cave. These are in the Majlis ath Thiyab room.

Figure 10. Fresh and old scat is found among bones on the floor in the alcove of the Majlis ath Thiyab room.

Figure 11. Layer of gypsum crystals on the ceiling of the Majlis ath Thiyab alcove.

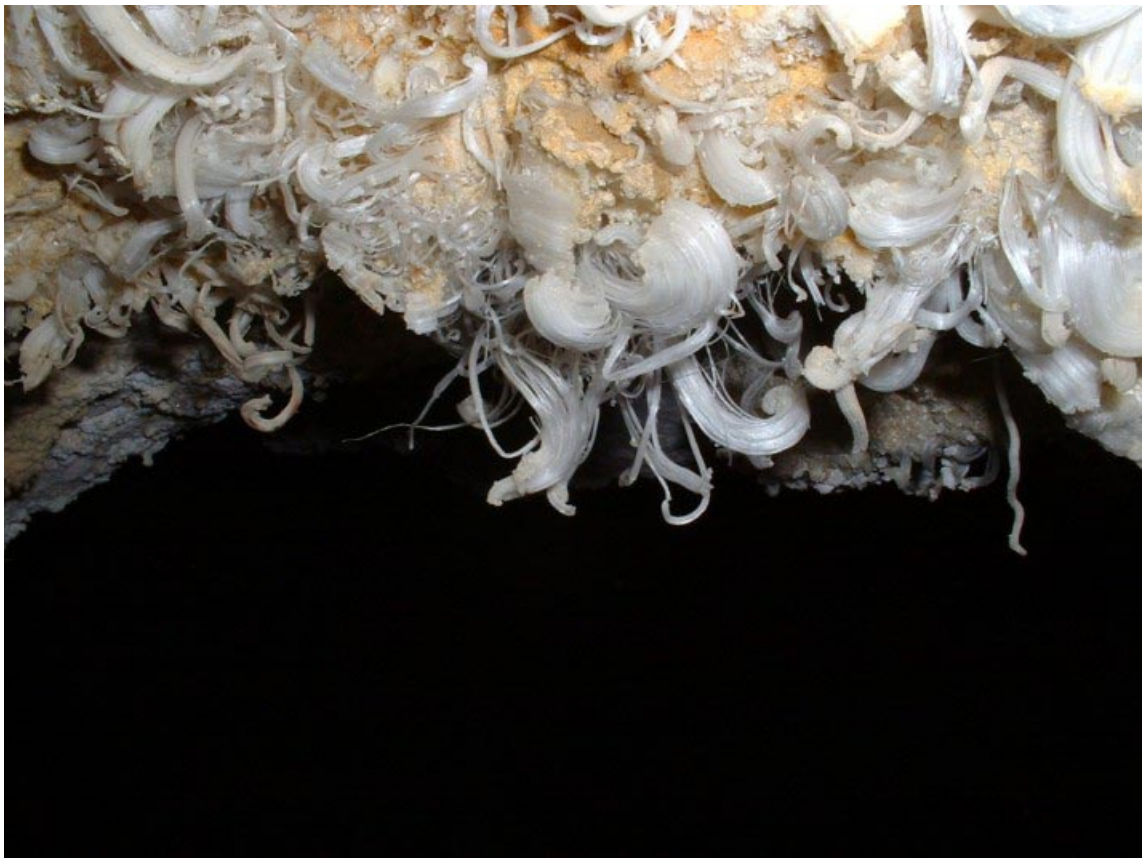

Figure 12. Gypsum flowers on the ceiling of the Majlis ath Thiyab alcove.

Figure 13. Accumulation og gypsum growth on the ceiling of Ghorfat al Makarona due to leakage of water.

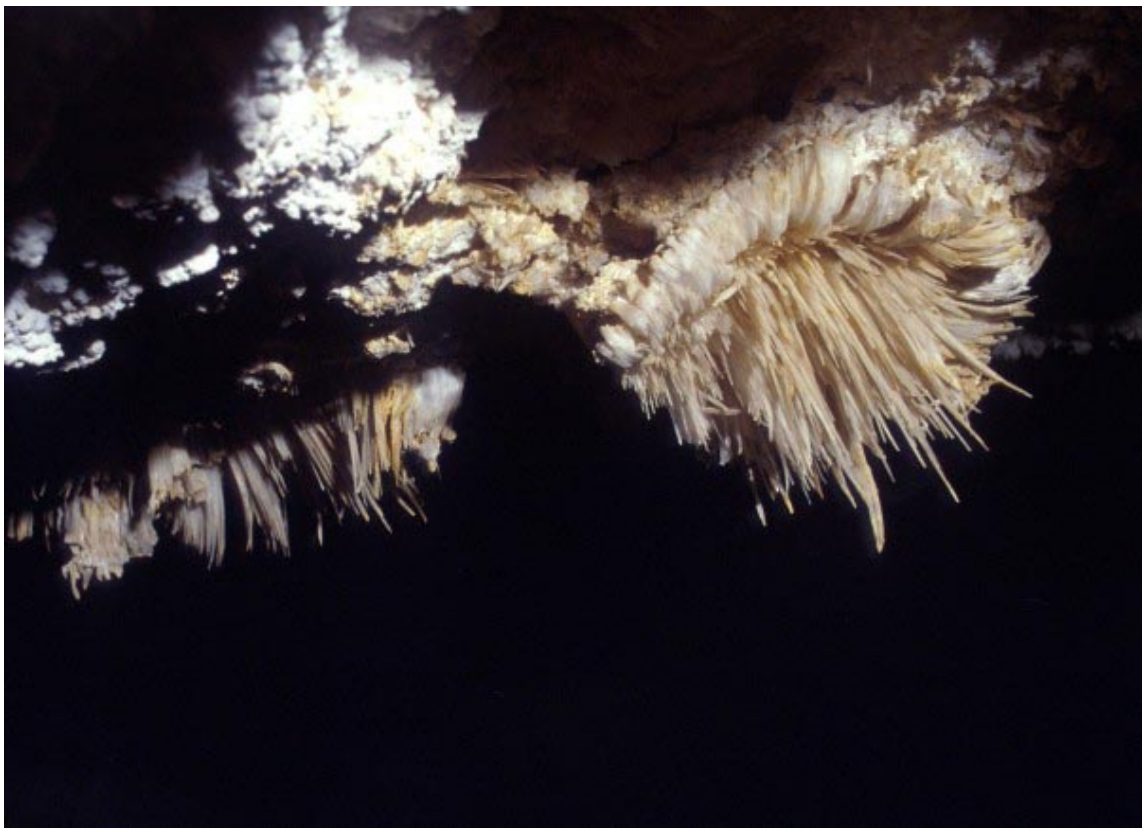

Figure 14. Gypsum growth on the wall at station 14.

Figure 15. Gypsum needles less than 3 cm long on the ceiling of Ghorfat al Makarona.

Figure 16. Close-up of calcite growth on the ceiling at station 19.

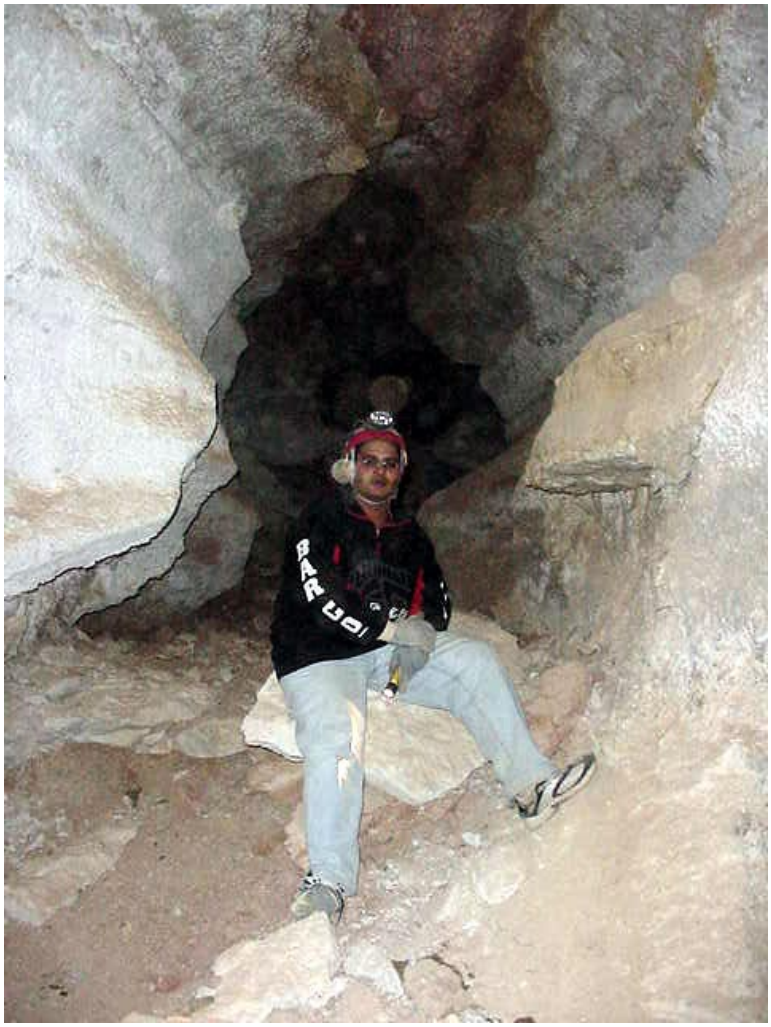

Figure 17. This passage had been formed by the action of water moving through the cave. Note the iron-oxide stain.

Figure 18. Disturbed bats at the end of the cave. The yellow color of bat urine can be seen on the wall.

KAHF AL RAMLAH AL HAMRA
HABAKAH, SAUDI ARABIA

Disto, Smartlevel
and Suunto Compass
Survey
by

M.A. Al-Shanti
A.J. Al-Jouid
S.A. Al-Amoudi

8 Ramadan, 1423
13 November, 2002

Map by
M.A. Al-Shanti and J.J. Pint

Symbology as in Fig. 2

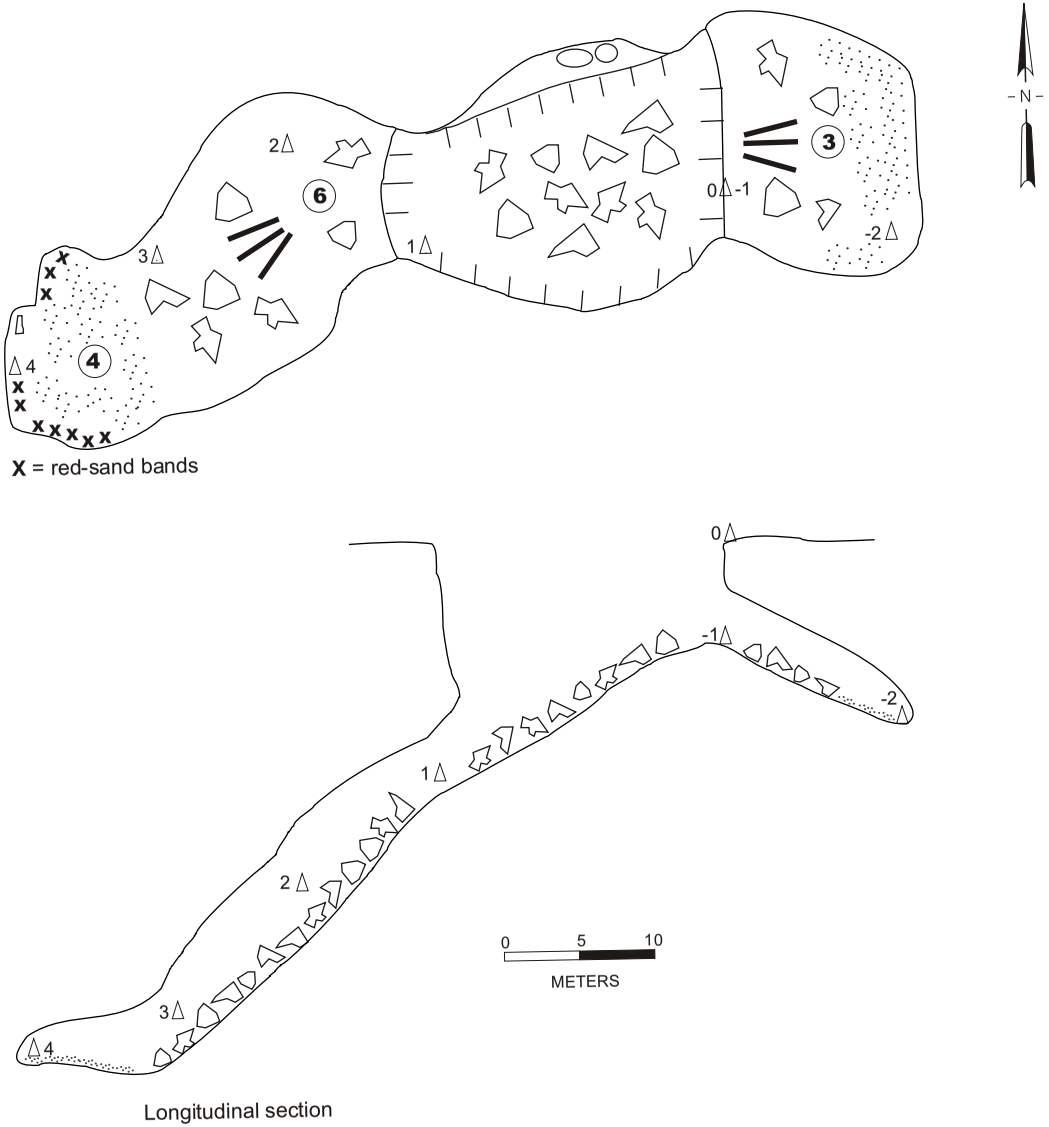

Fig. 19. Map of Kahf al Ramlah al Hamra (Red Sand Cave)

Figure 20. The cave was formed because of the water channel shown here between limestone hills.

Figure 21. Entrance of Kahf al Ramlah al Hamra seen from below.

Figure 22. The fine-grained limestone strata can be seen on the ceiling of the entrance pit.

Figure 23. Mapping and describing the geology of the cave at station1.

Figure 24. The top of the slope seen from the mouth of the cave.

Figure 25. Red sand in the lowest room of the cave.

Figure 26. Fine-grained limestone interbedded with red sand.

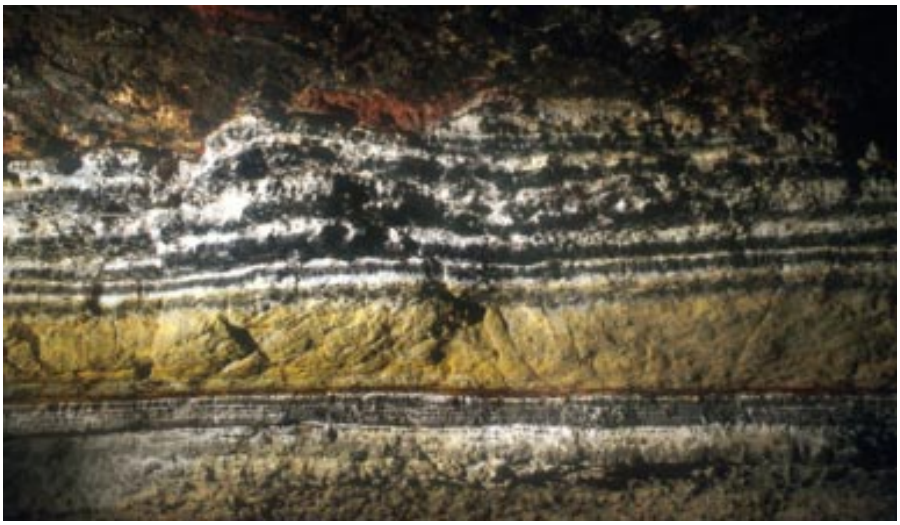

Figure 27. Bands of different colors in the limestone due to the effect of water.

Figure 28. Iron oxides interbedded with limestone on the ceiling near station 4.

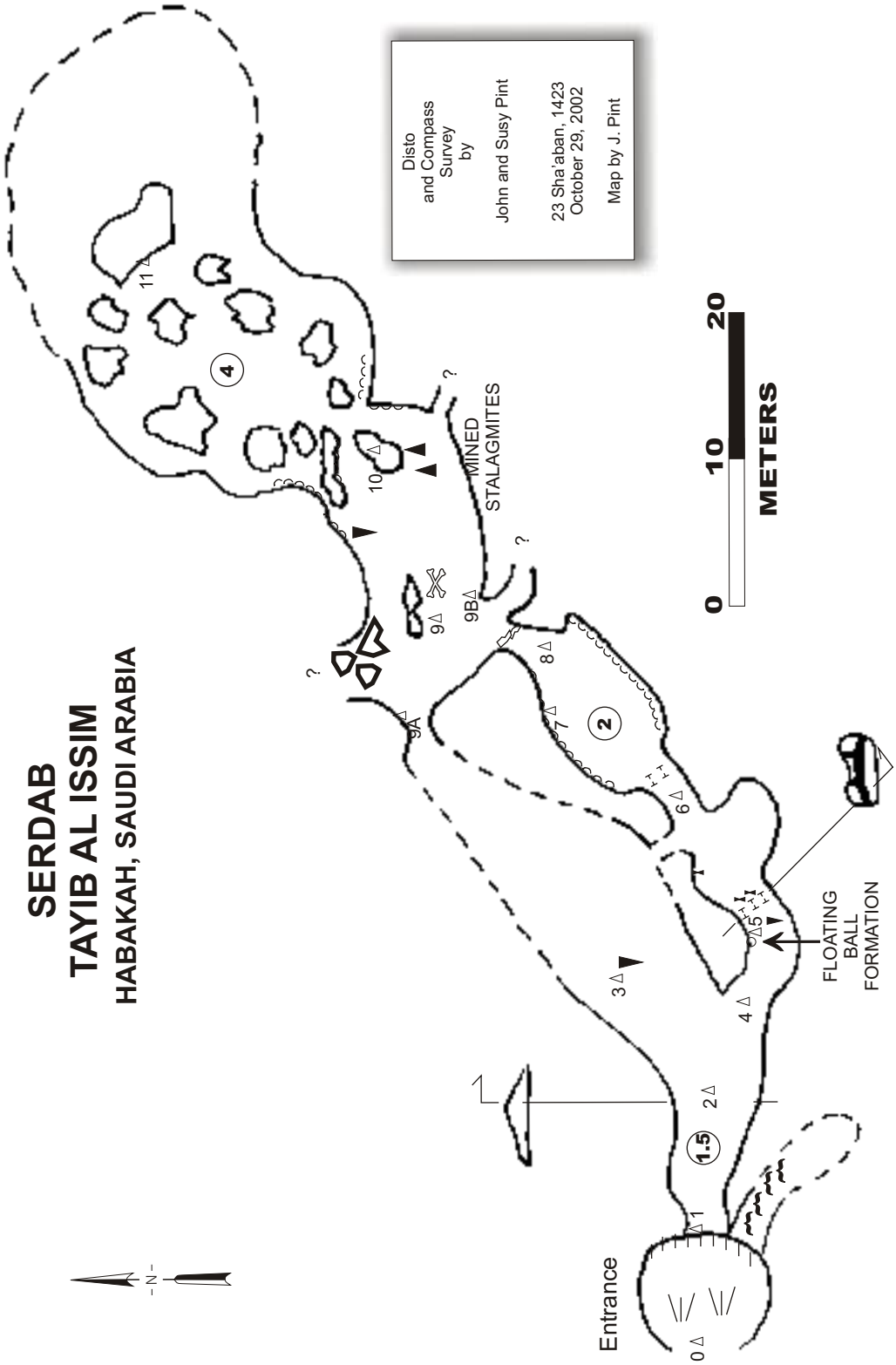

Fig. 29 Map of Serdab Tayib al Issm (That's-a-Nice-Name Cave)

Figure 30. Entrance to Serdab Tayib al Issim. The opening on the left leads to over 100 m of passages.

Figure. 31 Flat, naturally preserved body of a fox, found near the cave entrance.

Figure 32. Irregular ceiling near station 7. Sausage formations can be seen on the walls.

Figure 33. Close-up of sausage formations.

Figure 34. Bones found at station 9.

Figure 35. One of several stalagmites from which soft white gypsum powder had been extracted.

Figure 36. Sausage formations on the breakdown near station 10.

Figure 37. A well preserved *Asellia tridens* bat was removed from the cave and sent to experts for identification.

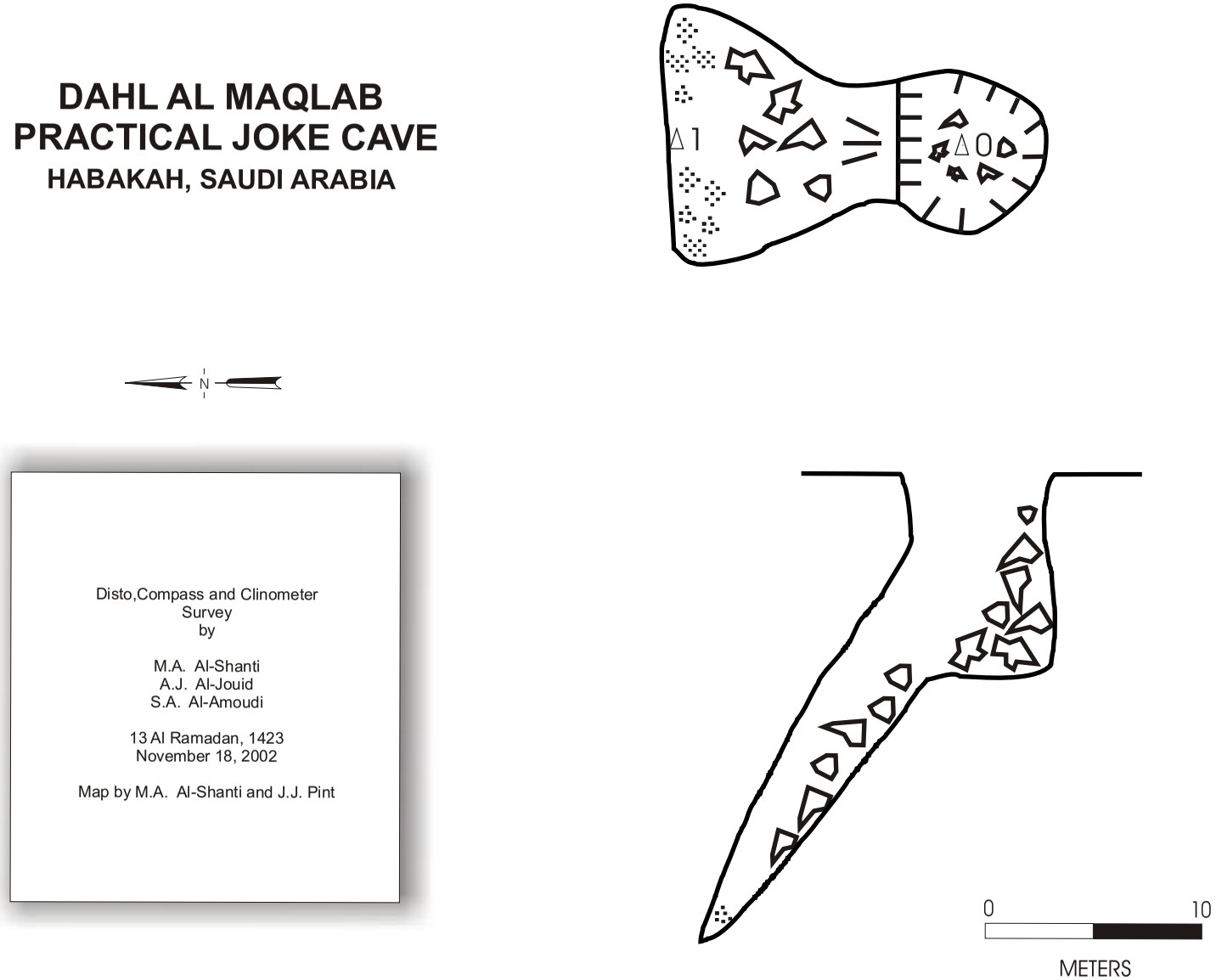

Fig. 38. Map of Dahl al Maqlab

Figure 39. Steep entrance to the cave.

Figure 40. Photo taken from the very end of the cave and showing some of the breakdown.

Figure 41. Entrance to Dahl Abu Rijl Maksura or "Pit of the Man with a Broken Leg" named after a local man who tried to enter it via a ladder made of bedsprings wired together.

Figure 42. Calcite stalactites at the base of the mound inside the cave. Several months later this part of the cave collpased.

Figure 43. The entrance to Dahl Saad with tea-drinkers for scale.
Al-Shanti and others, 2003