State of Lava Cave Research in Jordan

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The northeastern region of Jordan is volcanic terrain, part of a vast intracontinental lava plateau, called the Harrat Al-Shaam (Fig. 1). The centre is formed by young alkali olivine basaltic lava flows, the Harrat Al-Jabban volcanics, or Jordanian Harrat (Al-Malabeh, 2005). The top most and therefore youngest flows, collectively known as Bisriyya Formation, are ca. 400 000 years old (Tarawneh et al., 2000). We have explored, surveyed and studied a total of 14 lava caves since September 2003. Altogether 2,544 m of passages were surveyed until May 2006 (Table 1). Of this 1,486 m, or close to 59 % of the total, was surveyed in September 2005, among them the 923.5 m long Al-Fahda Cave (see Al-Malabeh et al., this volume). The caves represent six lava tunnels (one has two caves), five pressure ridges caves and two caves of doubtful origin.

Of the six lava tunnels (Abu Al-Kursi has two caves) so far investigated three are rather wide, Al-Fahda Cave, Al-Badia Cave (Beer Al-Hamam) (Fig. 2, 3), and the two Abu Al-Kursi Caves (Fig. 4), while Al-Howa (Fig. 5a, b), Hashemite University Cave (Fig. 6) and Dabie Cave (Fig. 7) are of smaller dimensions. All have very low gradient, in the case of Al-Fahda as low as ca. 0.7°. Lava falls, so often encountered in Hawaii, were not found in these caves. Benches and shelves marking older flow levels occur in Dabie Cave (Fig. 8), Al-Fahda and in one place in Hashemite University Cave. Branching is rare, apart from Al-Fahda Cave only Hashemite University Cave displays branching.

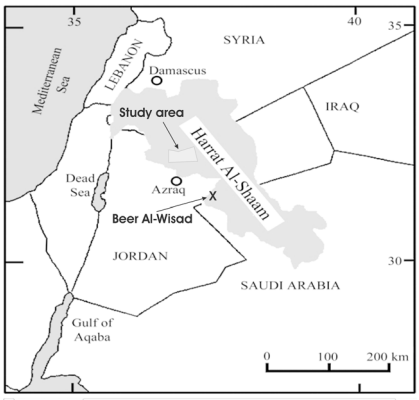

Figure 1. Study area and extent of Harrat Al-Shaam (altered after Al-Malabeh, 1994).

Apart from Al-Fahda Cave, speleologically, Hashemite University Cave is the most interesting. Hashemite University Cave is reached through a collapse hole at the crest of a ridge. There the primary 7 m thick roof is exposed consisting of only three pahoehoe layers (see Fig. 6). The mauka passage (uphill) apparently running NW is blocked by breakdown but from the north another low passage filled with sediment joins. The open tunnel leads makai (downhill) for about 180 m where the cave opens up to a nearly circular room of almost 20 m diameter and ends in a lava sump

Table 1. List of currently (May 2006) known and surveyed lava caves in Jordan, sorted by total passage length.

Name of Cave	Latitude	Longitude	Stations	Length m	Stations	Depth m	Direction	Altitude m	Type
Al-Fahda Cave	32°18'	37°07'	complex	**923.5**	2 to 54	6.7	SW-NE	832	Lava Tunnel
Al-Badia Cave	32°07'	36°49'	32 to 23	**445.0**	1 to 23	17.2	NW-SE		Lava Tunnel
Hashemite University Cave	32°14'	36°34'	21 to 35	**231.1**	1 to 23	10.0	NW-SE		Lava Tunnel
Al-Ameed Cave	32°13'	36°33'	complex	**208.0**	2 to 31	4.0	SW-NE		Pressure Ridge
Dabie Cave	32°10'	36°55'	0 to 14	**193.6**	0 1to 13	1.8	NW-SE	893	Lava Tunnel
Abu Al-Kursi East	32°15'	36°39'	20 to 34	**153.7**	1 to 34	12.2	W-E		Lava Tunnel
Al-Howa	32°18'	36°37'	complex	**97.1**	2 to 6	10.8	SW-NE		Lava Tunnel
Al-Hayya Cave	32°17'	36°34'	1 to 11	**81.3**	1to 9	4.2	NW-SE	911	Pressure Ridge
Abu Al-Kursi West	32°15'	36°39'	2 to 18	**77.1**	2 to 18	8.1	N-S		Lava Tunnel
Azzam Cave	32°17'	36°36'	13 to 25	**44.1**	1 to 25	4.2	NNW-SSE		Pressure Ridge
Al Ra'ye Cave	32°17'	36°34'	1 to 6	**42.0**	1 to 34	3.5	NW-SE	911	Pressure Ridge
Dahdal Cave	32°17'	36°35'	5 to 12	**28.9**	1 to 12	0.0	SW-NE		Pressure Ridge
Beer Al-Wisad	31°46'	37°28'	11-3-7	**11.4**	1-2-7	11.5	NE-SW	615	Pit (unknown)
Treasure Pit	30°51'	35°24'	Complex	**7.2**	2 to 11	5.8	NE-SW	960	Tunnel ?
Total				**2544**					

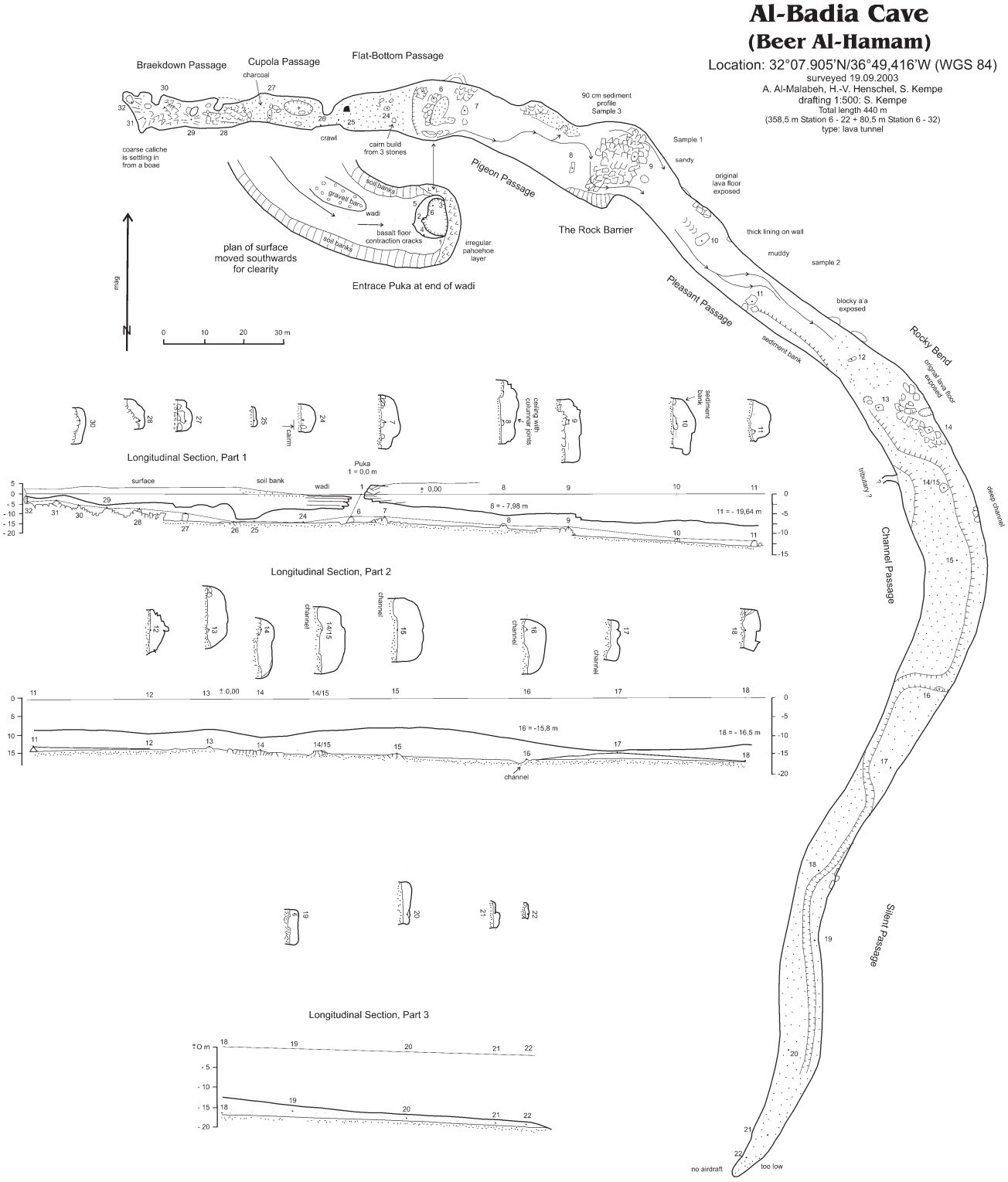

Figure 2. Map of Al-Badia Cave (by the authors). The cave is entered through a large breakdown hole, overhanging on all sides. This hole acts as a sink for a short wadi at times of heavy rains that has filled the cave with sediments.

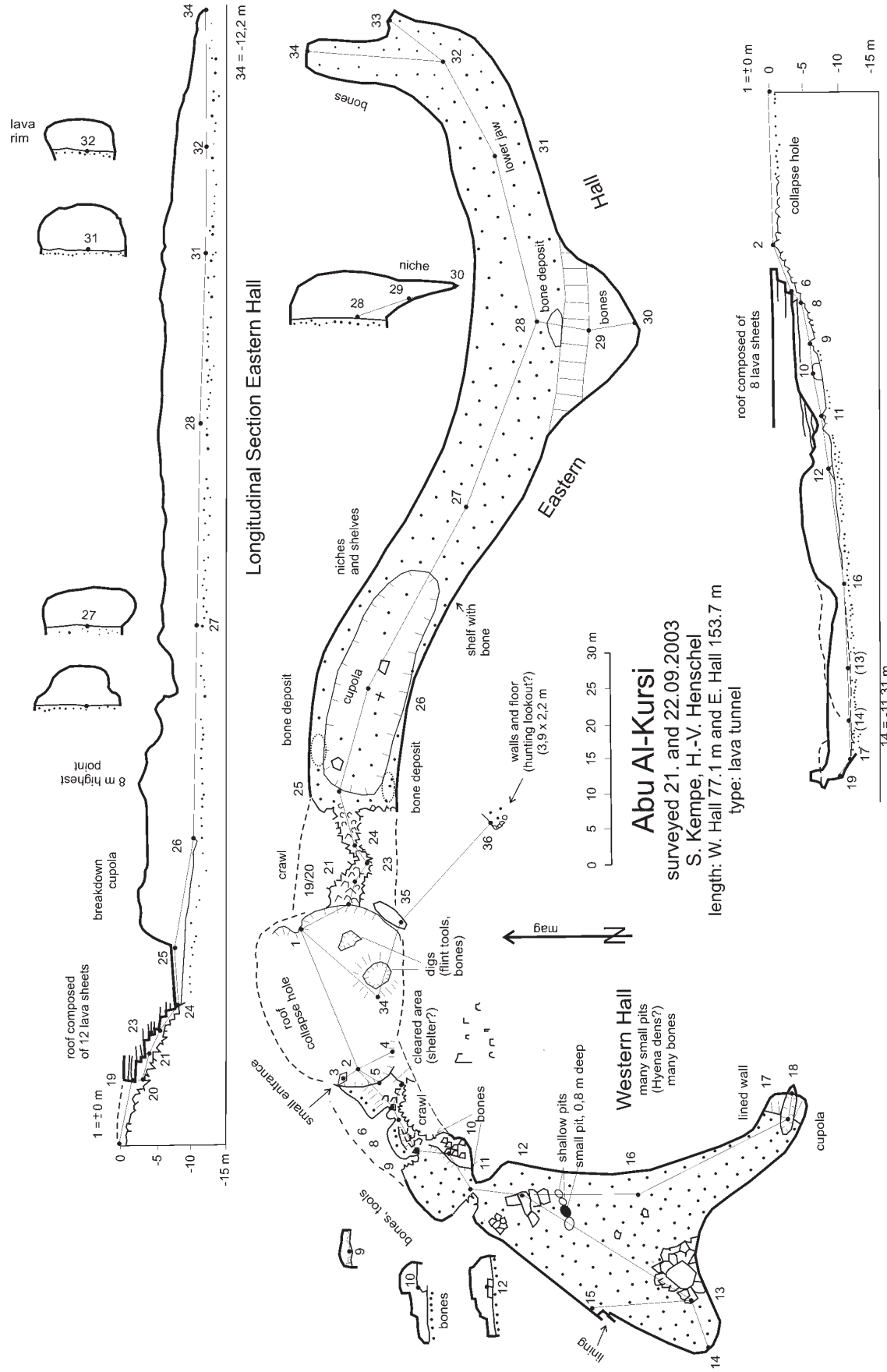

Figure 4. Map of Abu Al-Kursi (by the authors). Abu Al-Kursi has two separate caves (East and West) separated by a breakdown depression.

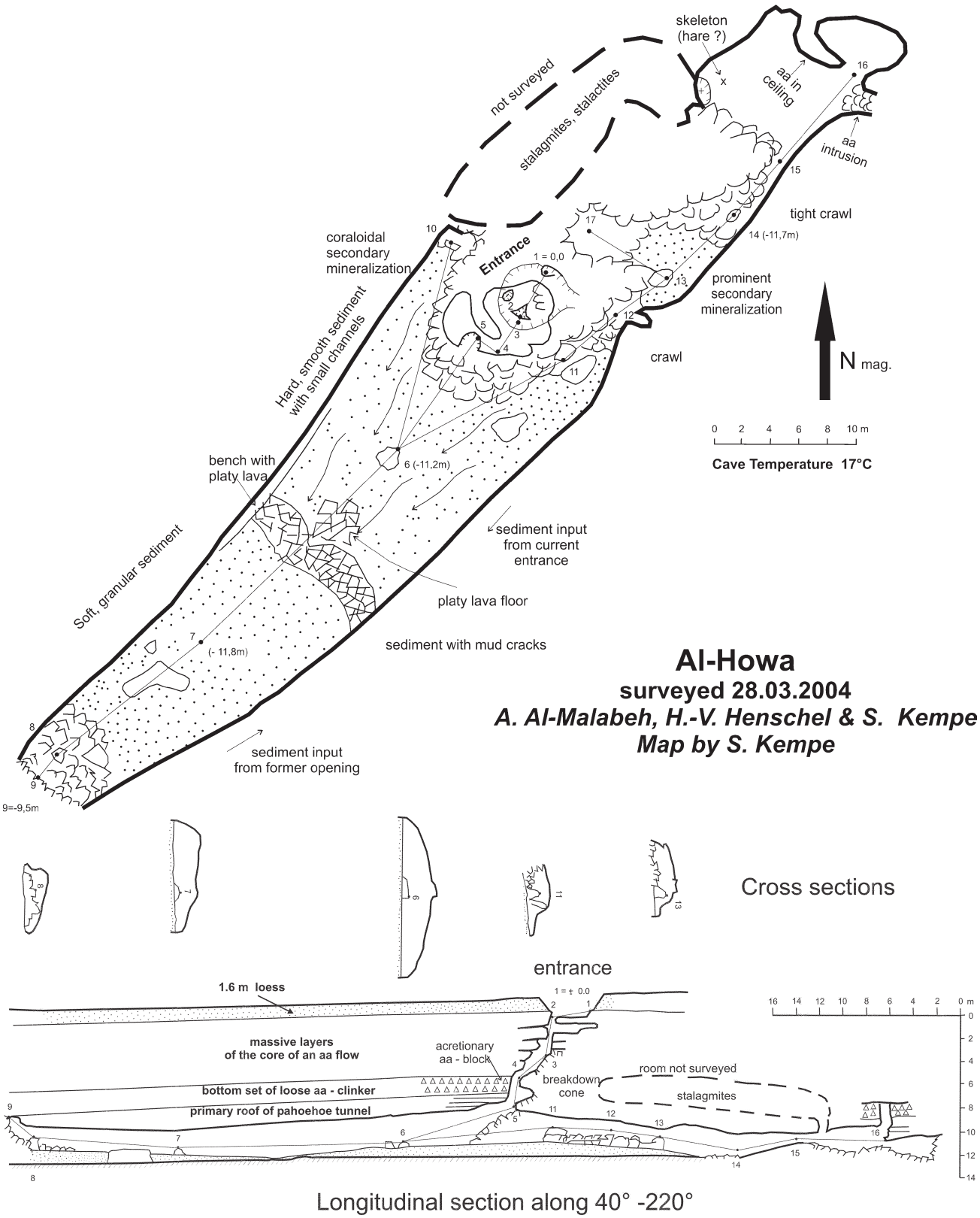

Figure 5. Map and longitudinal section of Al-Howa (by the authors). Note that the cave containing pahoehoe flow has been overridden by a later a'a flow. This flow has broken through the roof at both ends of the cave, closing it off. The current entrance is through a later breakdown hole in the center of the cave.

Figure 3. Entrance of Al-Badia Cave. It forms a sink in a small wadi. It is ca. 5 m deep and overhanging on all sides, exposing the uninterrupted lava sheets of the primary ceiling.

Figure 8. Panorama of Dabie Cave with prominent benches on both sides of the passage.

Figure 9. Panorama view of the terminal hall of Hashemite University Cave. The floor consists of thick ropy pahoehoe.

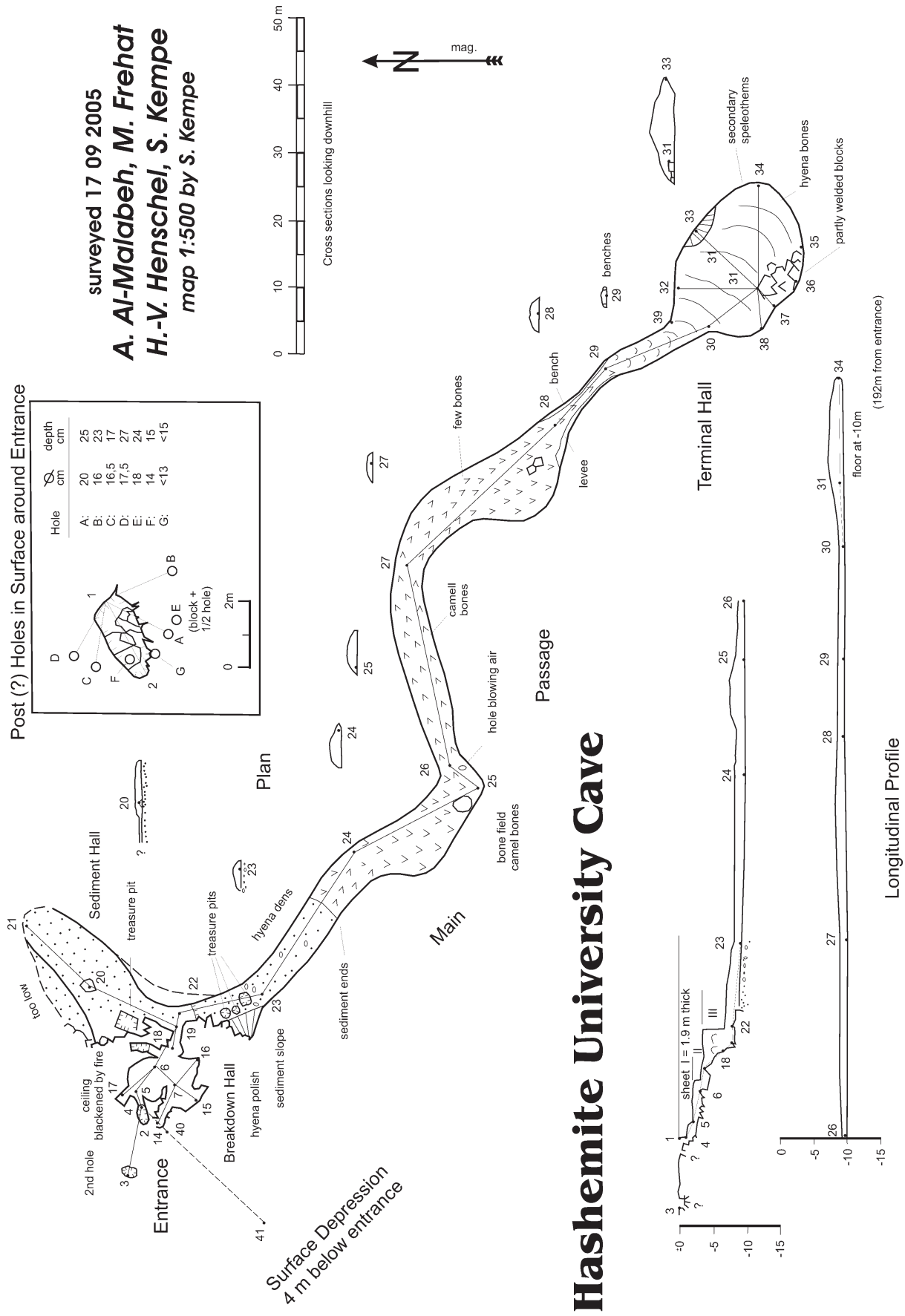

Figure 6. Map of Hashemite University Cave (by the authors). Entrance is through a breakdown hole.

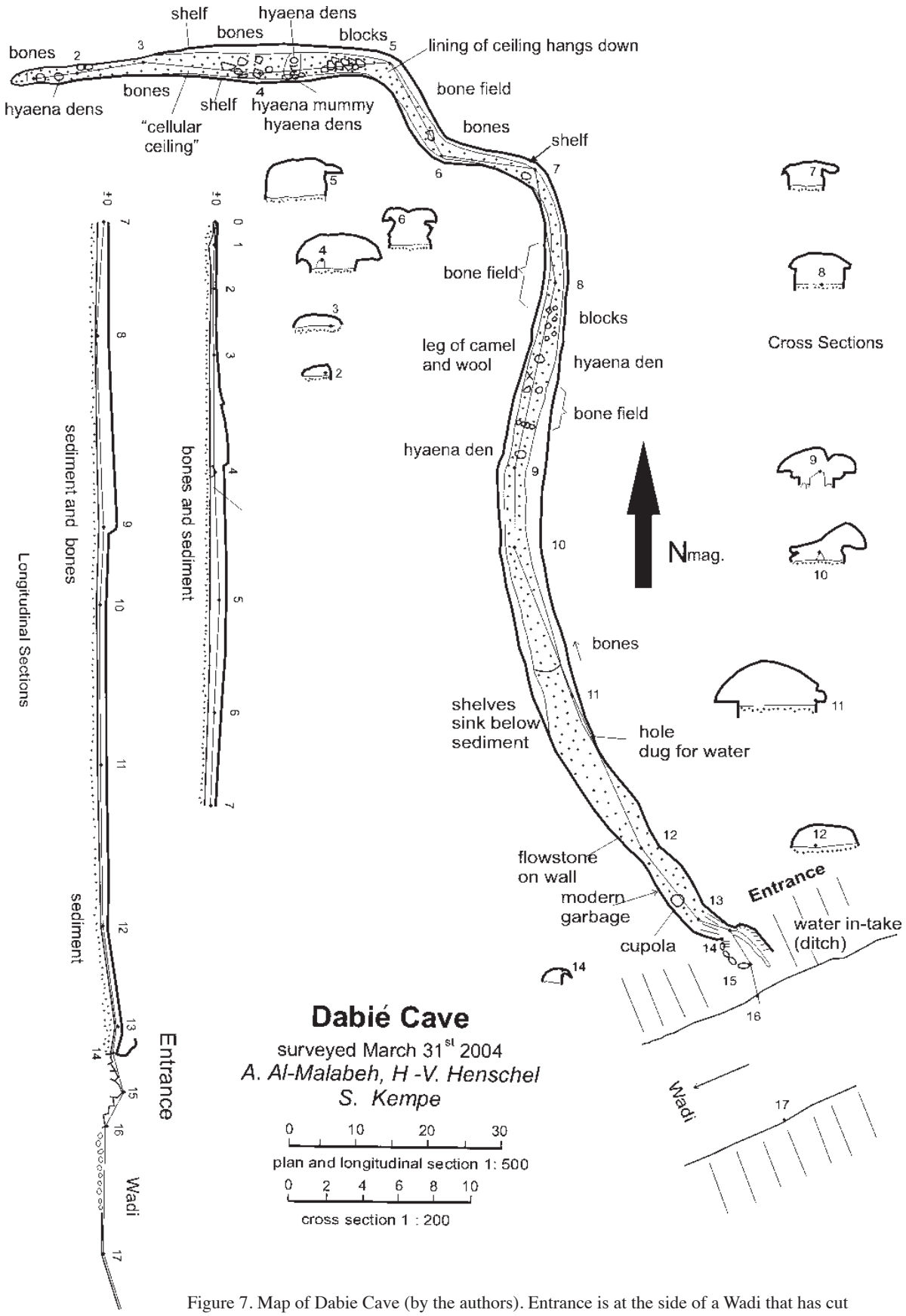

Figure 7. Map of Dabie Cave (by the authors). Entrance is at the side of a Wadi that has cut through the lava flow. A small channel used to divert water into the cave.

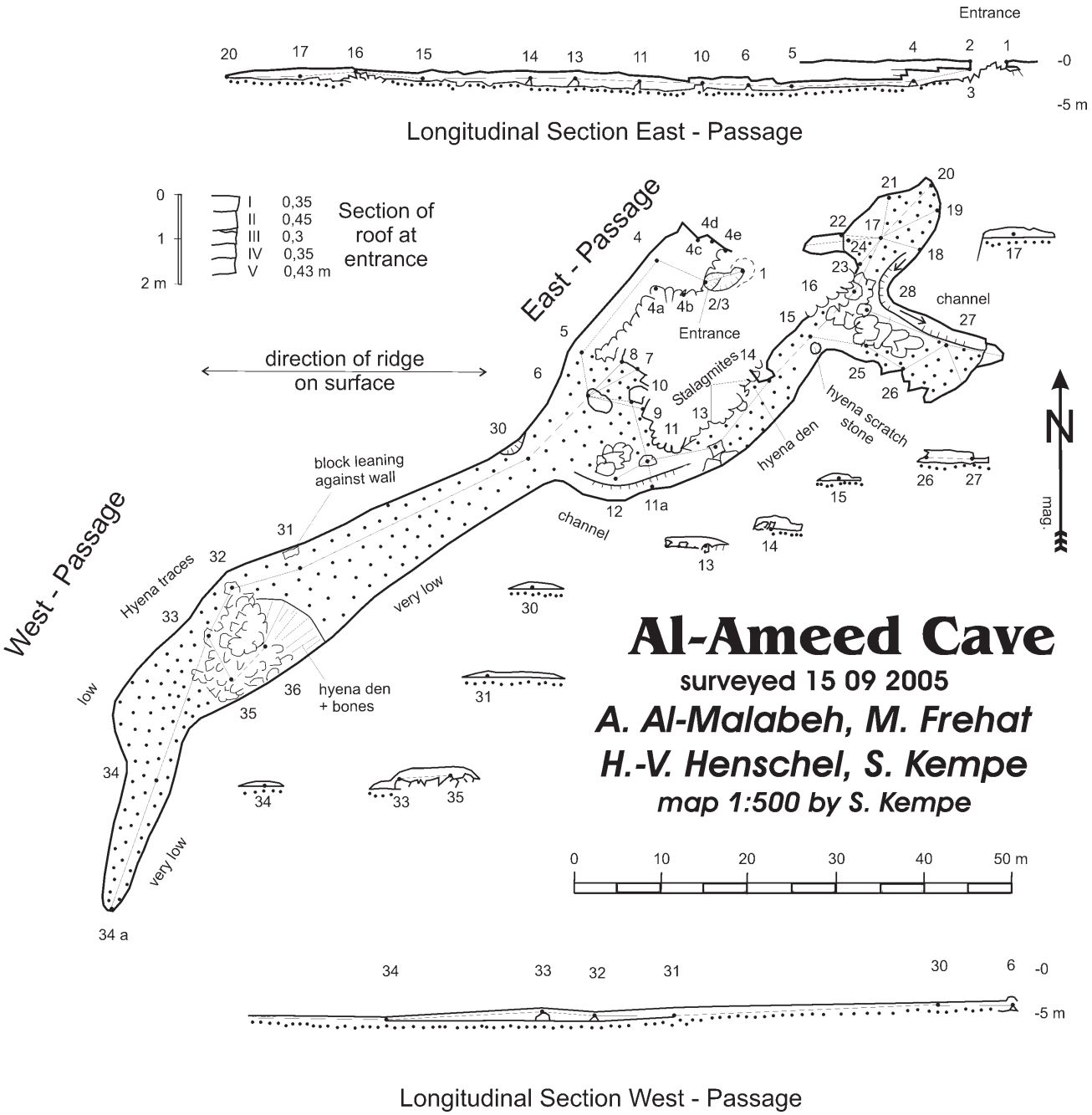

Figure 10. Map of Al-Ameed Cave (by the authors). Entrance is through centrally collapsed low and wide hall below up-domed lava sheets.

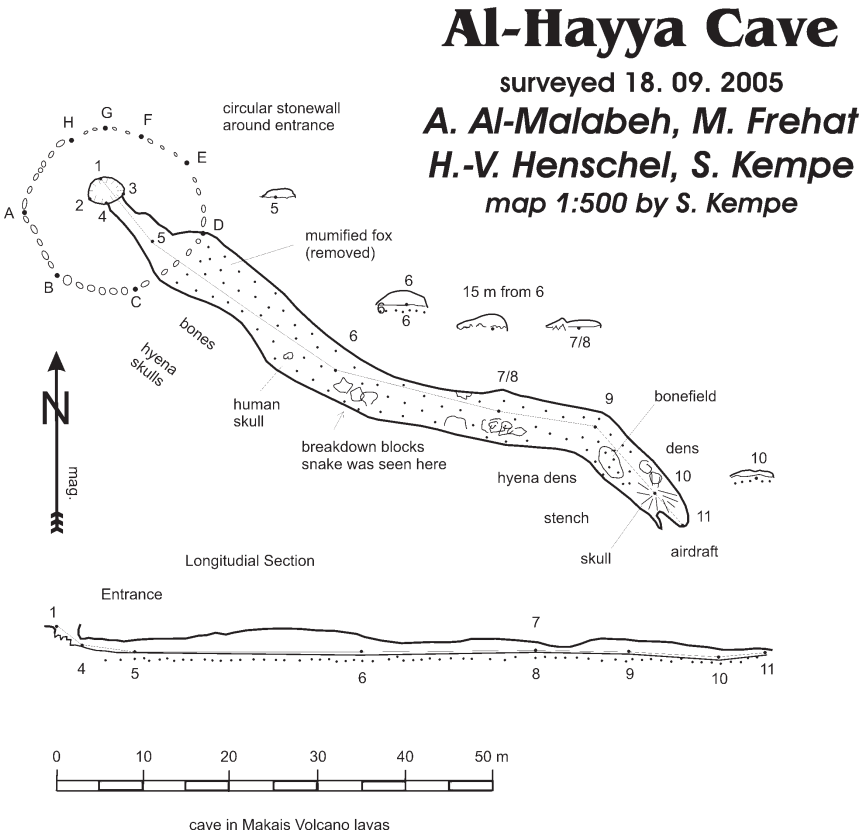

Figure 11. Map of Al-Hayya Cave (by the authors). Entrance is through a collapse hole which possibly dissects the cave in to two parts. The western part is yet unknown.

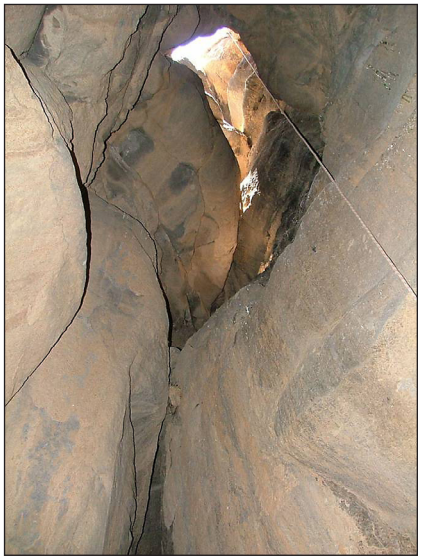

Figure 14. Pit of Beer Al-Wisad.

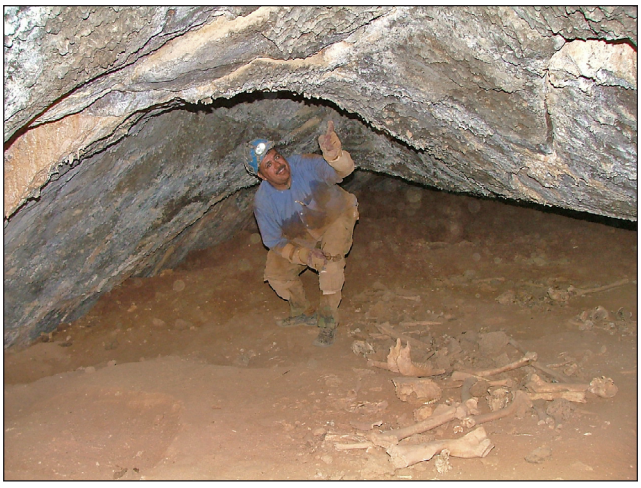

Fig 12. Passage view of Al-Hayya Cave. Bones (mostly from camel) in foreground are "left-overs" of hyenas.

Figure 13. Pillow basalts of Miocene age near Beer Al-Wisad.

(Fig. 9). In a way, this is similar to the lava sump at the end of Thurston Lava Tube (see Kempe et al., this volume). It poses a geological riddle since one would expect that the back-up of the residual flow in the tunnel might close the cave at a narrow point but not at a wide passage. One possible solution of the riddle could be the assumption that we are standing on top of a secondary ceiling. A blowhole, situated near station 26, indicates that there is an open passage underneath, giving some credibility to this hypothesis.

The proportion of pressure ridge caves and their length are an interesting finding. When compared to the population of lava caves on Hawaii, we find lava tunnels to be in majority. Here we use the term "pressure ridge cave" collective for a class of caves which does not show signs of lava flowing gravitationally through them. These cavities rather seem to have been created by doming the lava surface sheet either by lateral compression or by lifting them up through lava injection with consecutive drainage of the lava. This upward doming often occurs with axes perpendicular to the direction of pressure (Ibrahim & Al-Malabeh, 2006). Considering that the lava in Jordan forms rather thick sheets, low, but wide and astonishingly long caves may result.

The longest pressure ridge cave we surveyed up to date is Al-Ameed Cave (Fig. 10), with over 200 m in length. Actually, the cave seems to consist of two caves under two different tumuli connected by an over 30 m long, low, but wide passage. The tumulus with the entrance collapsed centrally, so that the cave leads around the breakdown almost in full circle. One can stand at only a very few places, the rest of the cave is too low and the north-eastern and south-western ends of the cave sink in the sediment fill.

The newly surveyed pressure ridge cave of Al-Hayya Cave (Snake Cave) and Al Ra'ye Cave (Sheep Cave) are of a different nature. They are elongated cavities which are comfortably high at their centres and of moderate width. Al-Hayya averages ca. 1 m high and 4.6 m wide (Fig. 11, 12). Al-Ra'ye Cave has been used as a free-of-charge sheep pen for the winter. Al-Hayya opens in the centre of a tumulus, but then leads away from the tumulus without giving access to the interior cavity below the tumulus, if there is any, while the collapse entrance to Al-Ra'ye is not bound to a tumulus. Several other tumuli nearby have central collapses, but stones need to be removed to access their caves. These stones have been placed in the past to prevent hyenas from using the caves as hiding places.

Beer Al-Wisad (Arabian for Pillow Pit) in one of the most outstanding features in the Jordanian Harrat. It is a pit located in pillow lava. This lava is one of the oldest exposed flows in the Harrat (Miocene). The pillows are spheroidal and have about 40 – 70 cm in diameter (Fig. 13). The entrance of the pit is not wider than 1 m and bellows out downward (Fig. 14). At a depth of 9 m the massive, melanocratic basalt ends and is underlain by a ca. 50 cm thick sheet of layered basalt. This is followed downwards by vesicular basalt; its vesicles are filled with secondary minerals. Along this layer a chamber of about 11 m length and 5 m width is developed. Here we also find at two or there places peck marks made by a very slender tool. The floor is partly covered by a pile of sand, shifted-in down the entrance and partly covered with pigeon dirt (dung, eggshells, twigs). The pit appears not to be anthropogenic, it is not a man-made well or quanat and the peck marks seem to be of a more recent age (treasure hunters?). It remains a riddle how it could have formed naturally within a layer of massive pillow basalts and even extending into underlying strata. Due to the high age of the lavas, one would expect that the pit – if it would have formed during the deposition of the lavas - would be filled either with playa or aeolian sediments. It is hoped that further petrological investigations might give clues about the pit's genesis.

All in all, we are still at the beginning of lava cave research in Jordan, and when we began detailed work three years ago we would not have thought that we would encounter such a variety of caves. We are even more astonished that these caves are still partly accessible considering their great age.

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