

## FORMATION AND LOCATIONS OF LAVA STALACTITES AND LAVA STALAGMITES IN THE VIÐGELMIR LAVA TUBE (ICELAND)

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**Abstract:** In the Icelandic Viðgelmir lava tube several types of lava dripstones can be found. Many lava stalagmites can evolve on the sidewalls as a result of their complexity with lava shelves, side walks and aprons. The floor's lava stalagmites situated near the sidewalls are in greater density. At the gradually narrowed ending of the lava tube the terminated lava flow piles up in bigger thickness. That is why the lava flow's cooling time was longer here than in the other areas of the cave. It results a greater number and size of lava stalactites and stalagmites at the cave's ending.

The aim of the study is to present that the type, the morphology, the occurrence and the numeral density of lava dripstones greatly depend on in which section of the lava tube (narrow or spacious) they formed, but they also depend on the morphological diversity or featurelessness of the tube's different sections (eg. complexity of the sidewalls with lava shelves, balconies). The author investigated and divided several types of lava stalactites and lava stalagmites of the Viðgelmir cave into groups according to the location of their formation sites in the lava tube.

**Keywords:** Iceland, Viðgelmir, lava tube cave, lava stalactite, lava stalagmite, ceiling, sidewall, floor

### 1. INTRODUCTION

The Hallmundarhraun lava field including the Viðgelmir lava tube is situated on the west side of Iceland to the north of the Langjökull ice cap (Fig. 1.). The area of the lava flow is about 200 km<sup>2</sup>, and the volume was estimated to be about 2–3 km<sup>3</sup> (Hróarsson & Jónsson, 1991). <sup>14</sup>C dating of the peat beneath the Hallmundarhraun lava flow gave the age of 1190±100 years BP. (Sæmundsson, 1966). Recent reinvestigations of the age of the lava flow using tephrochronological methods has verified the abovementioned data (Jóhannesson, 1989). The source crater row of the Hallmundarhraun lava flow is situated just off the edge of the Langjökull glacier, but the other rows and a possible eruptive fissure could be covered with ice (Hróarsson & Jónsson, 1991).

The entrance of the Viðgelmir lava tube can be found 33 kilometers southwest from the craters (Fig.1/b.). The cave presumably opened simultaneously with its formation as a result of the collapse of the former arched cave roof (Wood et al., 2003). These collapsed lava rise pits are 20–40 m in diameter. About 15 m lower down from here there is a narrow passage that takes us to the 1585 m long lava tube cave. The volume of the Viðgelmir lava tube has been estimated to be 148 000 m<sup>3</sup>. The average height of the cave is 9.2 m, maximum height 15.8 m, average width 16.5 m (Hróarsson, 2006). Until the near past the Viðgelmir's entrance was locked by an ice plug, which contemporaneously played an effective protective role for the vulnerable, fragile dripstones of the cave.

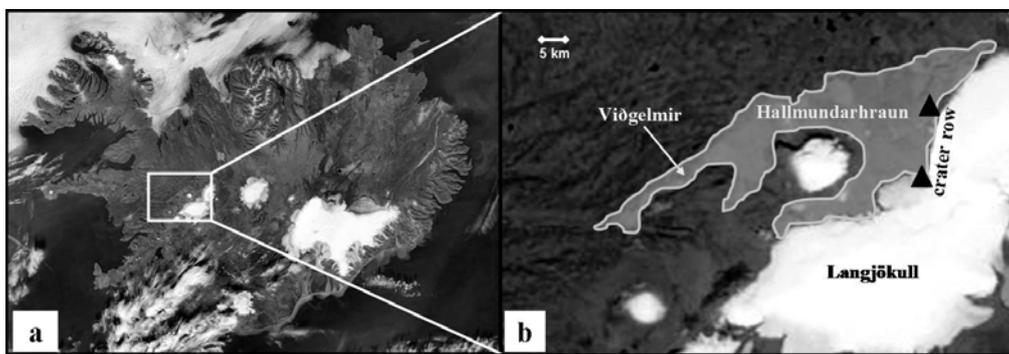


Fig. 1. a. Satellite image of Iceland. b. The Hallmundarhraun lava flow northwest of the Langjökull ice cap, and the entrance site of the Viðgelmir lava cave.

Unlike limestone dripstones, basalt dripstones can evolve in a few days or during a few hours. But in comparison, these features of different origin almost have the same appearance. Therefore basaltlava-dripstones are considered pseudokarst features.

Out of the several types of lava stalactites and lava stalagmites of the Viðgelmir cave, I investigated the types described below, where I divided them into groups according to their location of formation sites in the lava tube.

## 2. LAVA STALACTITES IN THE VIÐGELMIR LAVA TUBE

The several morphogenetic types of lava stalactites can be found on the ceiling and also on the sidewalls of the cave. Their occurrence in the lava tube and their shape varies depending on the height and width of the cave passage and the diversification of the sidewalls.

### 2.1. Lava stalactites on the cave's ceiling

In some sections of the Viðgelmir lava tube the cave narrows to 2–3 m in height and 2–4 m in width ( Fig. 2, 3, 4.). In these passage sections the arched ceiling is more resistant and has not collapsed. Therefore the lava glaze on it with the 1–4 cm long lava stalactites, which originates from the stretching of the former molten lava

glaze, have also remained (Fig. 5.). Here the lava stalactites could not grow longer because of the melting effect of the hot molten lava river that runs close to them on the floor of the narrow passages. In the narrow passage sections at a greater rate of the inner lava flow the hot fluid lava can reach and adhere to the cave's ceiling. If the rate of the lava flow decreases, similar lava stalactites can evolve on the ceiling by the disjunction from the lava flow.

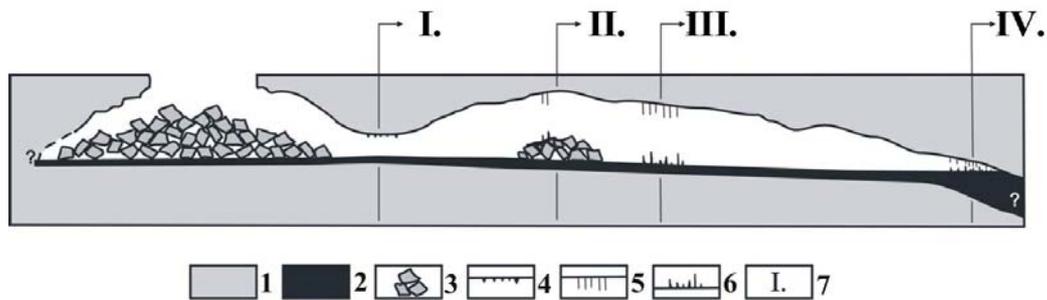


Fig. 2. Schematic longitudinal sectional view of the 1585 m long Viðgelmir lava tube in high vertical exaggeration. The evolution sites of the typical lava dripstones and the places of the cross sections (see Fig. 3, 5, 7.) shown by roman numbers. Legend: 1. The host rock, and the walls of the lava cave; 2. The terminal lava flow; 3. Breakdown blocks and boulders piled up by roof collapse(s); 4. Small size lava stalactites; 5. Lava straw-stalactites, and their tubular variations; 6. lava stalagmites on the floor; 7. The number of the cross sections (see Fig. 3, 5, 7.)

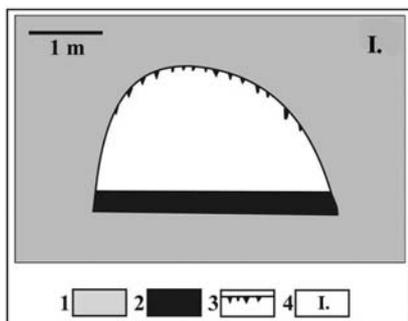


Fig. 3.

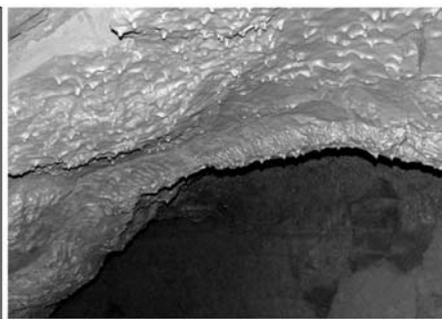


Fig. 4.

Fig. 3. Schematic cross sectional view of a low and narrow passage of the lava tube (see in Fig. 2, No I.), with the locations of the formation sites of the typical lava dripstones situated here. Legend: 1. The host rock and the walls of the lava cave 2. The terminal lava flow 3. Small size lava glaze stalactites 4. The number of the cross section (see in Fig 2.).

Fig. 4. At the narrowed section of the lava tube between two spacious sections the ceiling did not collapse that is why the lava glaze of the ceiling and its lava-stalactites still exist.

The degassed outer lava glaze prevents the gas from escaping from the inner part of the semi-solidified cave's wall. This is the reason why the interior structure of the lava glaze stalactites is generally vesicular or hollow. In some cases the accumulated and overpressurized gases underneath the lava glaze erupted. As a result of this, the burst lava glaze after having cooled forms a peculiar „cicatrice” on the

cave's wall (Balázs, 1974).

In the spacious passage sections of the Viðgelmir lava tube cave the lava stalactites are longer, 5–50 cm on average, but thin in diameter, 0.5–1 cm. So, regarding their shape, the majority of them are lava straw stalactites.

In caves that are still hot the molten lava runs towards the ridge-shaped parts of the ceiling, therefore on these „lava collectors”, the lava straw stalactites develop in greater length and are more frequent in occurrence. In the high cave passages the hot lava flow was more distant from the ceiling. It results that here the lava straw stalactites can grow longer than in the narrow passage sections, where the melting effect of the closer hot lava stream prevents the longer lava stalactites from forming (Fig. 2, 4.).

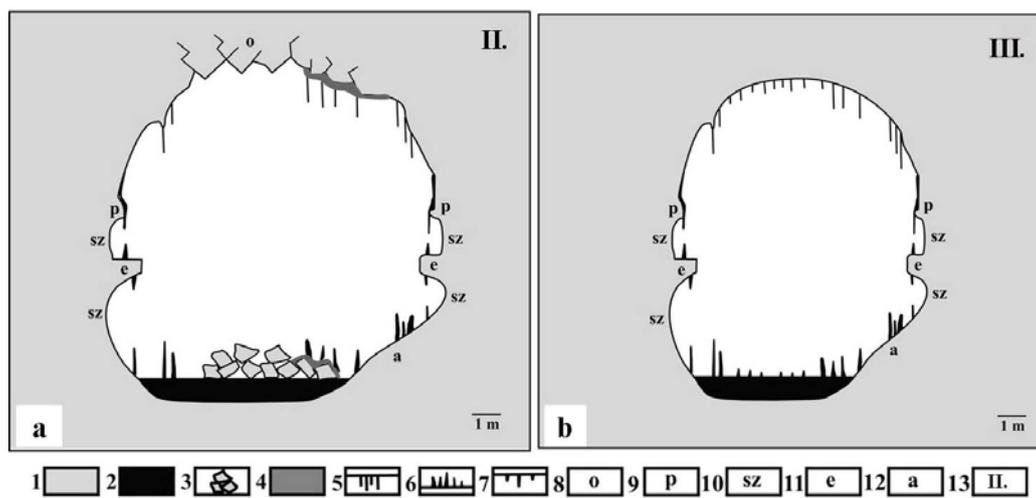


Fig. 5: a. Schematic cross sectional view of a high and wide and therefore partly collapsed passage section of the lava tube (see in Fig. 2, No II.) with the locations of the formation sites of the typical lava dripstones situated here. b. Schematic cross sectional view of a high and relative narrow passage of the lava tube (see in Fig. 2, No III.) with the locations of the formation sites of the typical lava dripstones situated here.

Legend: 1. The host rock and the walls of the lava cave, 2. The terminal lava flow, 3. Break-down blocks and boulders piled up by a roof collapse(s), 4. Lava glaze, 5. Lava straw-stalactites, and their tubular variations, 6. Lava stalagmites on the sidewalls and on the floor, 7. Lava stalactites in a combination with their corresponded runners on the sidewalls, 8. Collapsed section of the ceiling, 9. Lava shelf, 10. Horizontal sidewall trough (cutbank), 11. Lava balcony, 12. Apron (slipbank), 13. The number of the cross section (see in Fig 2.). The lava dripstones are illustrated in double size exaggeration.

The interior of some lava straw stalactites, called tubular lava stalactites, often constitutes an almost continuous tube. The material of the tubular lava stalactites is extruded residual parts of the cooling host rock, which segregated from it by partial crystallization (Allred & Allred, 1993). It means that these kinds of stalactites do not evolve by (re)melting, but cooling of the caves' host rock. A significant amount (about 0.5-3 dm<sup>3</sup>) of molten lava rushes along in the tube of the tubular lava straw stalactites

(Larson, 1993).

The shape of the tubular lava stalactites might be almost straight, but often twisted and tortuous (Fig. 5.). The varied look of the semi-solidified straw stalactites is also modified by the violent currents of hot gases in the cave's interior (Balázs, 1974). If the lower side of the tubular lava stalactite solidifies, it can block the molten lava oozing in the tube. In that case the molten lava has to change its way, generally with 90 degrees, and so, it appears on the side of the stalactites. The process described before might take place several more times forming tortuous, twisted-shaped tubular lava straw stalactites (Fig. 6.).

On the relatively featureless parts of the caves' ceiling, where the ridge-like forms („lava collectors”) are almost absent, the lava straw stalactites occur in greater density, but in shorter average length.

On the ceiling of the cave's narrowed ending passage the tubular lava straw stalactites can reach the length of 30–50 cm (Fig.6, Fig. 2, 7.)

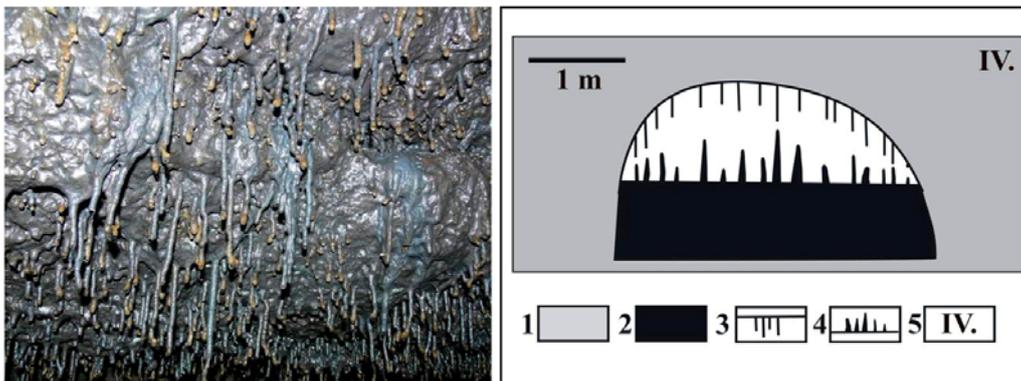


Fig. 6.

Fig. 7.

Fig. 6. Tubular lava stalactites on the ceiling at the gradually narrowed ending of the lava tube (see in Fig 2, 7.).

Fig. 7. Schematic cross sectional view of a low and narrow ending passage of the lava tube (see in Fig. 2, No IV.), with the locations of the formation sites of the typical lava dripstones situated here. Legend: 1. The host rock and the walls of the lava cave, 2. The terminal lava flow, 3. Lava straw-stalactites, and their tubular variations, 4. Lava stalagmites on the floor, 5. The number of the cross section (see in Fig 2.)

## 2.2. Lava runners and lava stalactites on the cave's sidewalls

Lava runners similar in shape to the bulged human veins are characteristic features on the lava tube sidewalls. These elongated, solidified lava rills are situated in parallel with the directions of the largest dip angles of the sidewalls, and in many places they piled up on each other. (Fig. 8.). The lava runners are 1–5 cm in diameter on average, and their length varies from a few decimeters up to several meters. Many of the lava runners have the same interior tube structure as the lava straw stalactites, forming a tubular lava stalactite which lies along the surface (Larson, 1993).

On the ledges of the sidewalls (e.g. lava shelves, lava balconies) the lava

runners often continue as a lava stalactite in straw shape with a tubular inner structure or also in a bulbous form (Fig. 5, 8, 9).

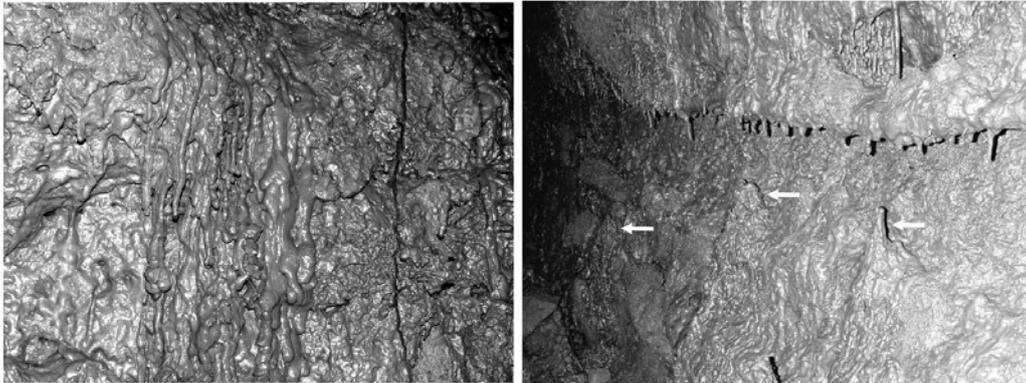


Fig. 8.

Fig. 9.

Fig. 8. Lava runners piled up in a great density on the sidewall. From these forms lava stalactites developed at the hollowing sections of the sidewalls (e.g. below the lava shelves). On the right side of the picture a contraction crack can be seen that evolved when the sidewall of the cave was cooling.

Fig. 9. Typical lava dripstone forms on the Viðgelmir lava tube's sidewall. Narrow and wide runners can combine with tubular stalactites and soda straw stalactites and, finally, a row of 10–20 cm high lava stalagmites (shown by the white arrows) can develop on the lava shelves from the droplets dripping from the stalactites.

### 3. LAVA STALAGMITES IN THE VIÐGELMIR LAVA TUBE

Lava stalagmites can develop on the sidewalls as well, but they built up in the greatest number on the cave's floor.

#### 3.1. Lava stalagmites on the sidewalls

The droplets derived from the trickling molten lava runners and their corresponding lava stalactites on the overhanging sidewall sections create lava stalagmites on the sidewalls as well. In the Viðgelmir cave the height of the sidewalls' lava stalagmites varies from 1–2 cm up to 30–40 cm. These stalagmites are usually built up on the surface of the lava shelves, on the balconies, and on the aprons (Fig. 5., 9.).

In the meandering lava tube, the convex banks of the curves form slip banks (Larson, 1993), which slope down inward from the lava tube wall. On the top of the surface of these sidewall sections lava stalagmites can be built up by lava droplets dripping from the ceiling and from the overhanging sections of the sidewall, even from a few meters distant from the active lava stream (Fig. 5.). Lava stalagmites can also form on the lower side of the concave meander bend walls, on the so-termed cutbanks (Larson, 1993).

### 3.2. Lava stalagmites on the floor

The lava stalagmites are rarely built on a slowly moving floor with hot creeping lava underneath (Balázs, 1974). However, the rest of the molten lava derived from the ceiling and from the sidewalls of the cooling cave still being hot drops on the floor after the moving lava flow has come to a stop. The evidence of the abovementioned assertion is provided by the tubular lava stalactites (evolved by the cooling of the host rock – see above) which hang on the ceiling right above their corresponding lava stalagmites on the floor.

The floor lava stalagmites deposited onto the solidified crust cover of the still molten but gradually cooling lava. It is proved by the contraction cracks, resulted from cooling, which, in some cases, cleave the floor lava stalagmites (Fig. 11, 10.).

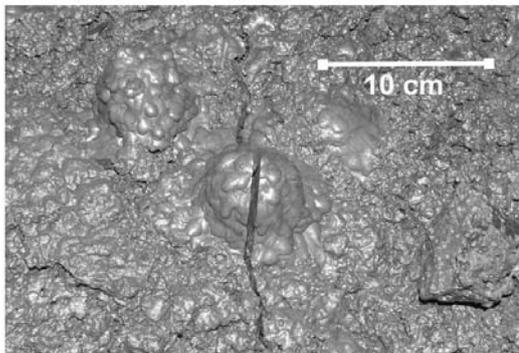


Fig. 10.

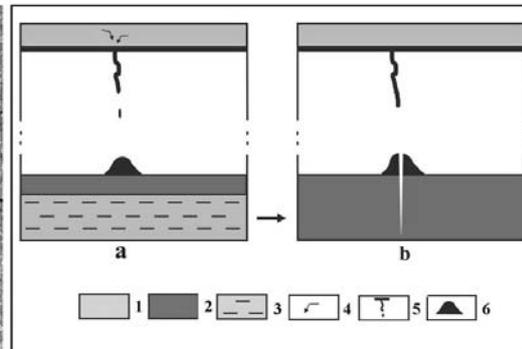


Fig. 11.

Fig. 10. Contraction crack that cleaved this lava stalagmite in two. It means this lava stalagmite evolved right after the moving lava flow had come to a stop, but just before the interior of the lava flow cooled down.

Fig. 11. a. The development of a lava stalagmite (see fig. 10) on a stationary crust of the terminal lava flow. b. The formation of a contraction crack in the cooled down lava flow that continues even into the lava stalagmite situated on its surface. Legend: 1. The ceiling of the lava tube, 2. The solid crust of the lava flow, 3. Hot fluid lava, 4. The extrusion course of the liquid segment of the ceiling material separated by fractional crystallization, 5. Tubular lava-stalactite, 6. Lava stalagmite (cleaved by a contraction crack in section b.)

On the floor of the Viðgelmir-cave, lava stalagmites evolved in various range of size and appearance (Fig. 10, 12, 13.).

The solid core of the lava flow, which resulted from cooling and forms the floor, finally came to a stop close to the medial current line zone of the former streaming lava flow. In this zone the average size of the lava stalagmites is smaller (2–10 cm high), in consequence of the relatively shorter time they had to build up. In some places of the middle sections of the floor another reason for the smaller average sized lava stalagmites might be the featurelessness of the ceiling above them with no „lava collectors” where greater amount of molten lava dripped from. In these areas of the floor the small sized lava stalagmites occur in greater frequency (Fig. 5/b and 12.).

At the sidewalls, the solid core of the lava flow, which resulted from cooling and forms the floor, earlier came to a stop. It results that in this zone of the floor bigger lava stalagmites (20–70 cm high) occur in greater frequency, because of the relatively longer time they had to build up (Fig. 5. and 13.). The accretion of the molten or semi solidified lava droplets derived from the overhanging sections of the sidewalls and the ceiling also contributed to the greater average size of the lava stalagmites of these floor sections.

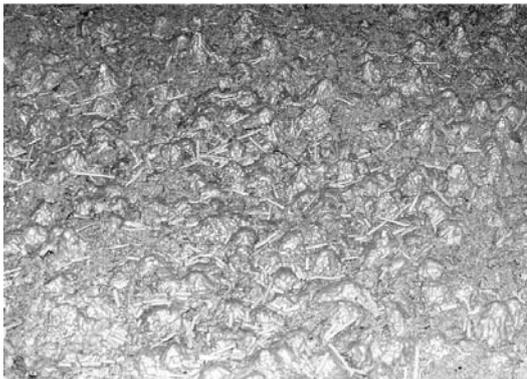


Fig. 12.



Fig. 13.

Fig. 12. In the middle section of the cave floor the average size of the lava stalagmites is smaller (4–6 cm), but they occur in greater density. The material of the droplets that the stalagmites are built up from derived from the lava straw stalactites of the relatively featureless section of the ceiling without “lava collector” ridges. Around the lava stalagmites the broken pieces of the abovementioned lava straw stalactites can be seen.

Fig. 13. A cluster of lava stalagmites on the floor near the lava tube sidewall. Their height is 20 cm on average, but some of them can be as high as 60–70 cm.

#### 4. CONCLUSIONS

In the spacious, high sections of the Viðgelmir lava tube cave, the sidewalls are characterized by many types of lava stalactites and lava stalagmites because the complexity of the sidewalls with lava shelves, balconies and aprons enabled the stalactites and stalagmites to form.

In the narrow cave sections where the sidewalls are relatively featureless, lava stalactites and lava stalagmites are almost absent.

Between the spacious cave sections, the ceiling of the narrowed passages — unlike the high passages — longer tubular lava straw stalactites are less common because of the closeness of the former hot lava stream, which blocked their growth with its (re)melting effect from below.

However, on the contrary, at the narrow ending passage, where the terminal lava flow plugged up the cave, the lava stalactites of the ceiling grew much longer (30–50 cm) and in greater density, along with their corresponding lava stalagmites on the floor. In this ending section of the passage the lava ponded up in greater thickness, so it

transmitted a greater quantity of heat for the cave walls in a relatively longer duration, in comparison with the thinner, stagnant lava flow in the other passage sections of the cave. Moreover, the ponded, thick and therefore slowly cooling lava flow mass melted the growing tubular lava straw stalactites to a gradually smaller extent, so they could grow longer, together with their corresponding lava stalagmites below them on the floor.

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