Cataloguing Helictites
and other capillary-controlled speleothems

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Abstract:

In the 2nd Edition of Hill & Forti's book, "Cave Minerals of the World", helictites are described with three subtypes. Other capillary controlled speleothems described by Hill and Forti are Cave Shields and Welts.

This article suggests the addition of some other capillary controlled speleothems to the list, then attempts to sub-divide the speleothem type "helictite" into further sub-types.

The reason why is because there are several sub-types which can be recognised around the world as being of the same form, however there is no specific name given to them.

Possibly this consistency of form is due to a common chemical or biological influence, and cataloguing the forms is the first step in understanding what causes them.

Forms include ribbon helictites, saws, rods, butterflies and "hands". Influences include multiple canals, gravitation, possible chemical changes, and crystal twinning. Materials include calcite needle-form calcite and aragonite. Vaterite is touched-on however it generally occurs in caves as the result of human intervention (pollution).

Finally this article suggests that a better classification scheme could be done using a database rather than attempting to force a hierarchy onto disparate objects.

1. Project Aims

The short term aims of this project are to attempt to describe the varieties of helictites and related speleothem forms. The long term aims of this project are to:

- Determine the internal structure of each form
- Determine what the object is made of
- Determine what factors lead to the deposition of this form
- Develop a catalogue of helictites and related forms

2. What is a Helictite?

Helictites are a type of speleothem (cave decoration, spelean chemical sedimentary deposit) which are found in the limestone caves of most countries of the world.

Although usually described by many tourist cave guides as ``mysterious" and of ``unknown origin", the basic structure of helictites has been known for a long time, the earliest detailed description being by Olaus Worm in 1665 (Shaw, 1992).

A typical calcite helictite is a twisted, long cylindrical structure with a fine central capillary of about 0.2 - 0.35 mm diameter. Side micro-canals (``canalicules") result in a somewhat porous structure. Typically the helictite has radial symmetry.

A discussion of subaqueous helictites from Lechuguilla Cave, New Mexico by Davis, Palmer & Palmer (1991) showed a sectioned sample with its radial crystal growth and central canal.

3. What is a Related Form?

One of the key features of helictites is their capillary tube which can be straight or branched. Other speleothems have capillaries, too. Examples:

- Cave shields (capillary sheet)
- welts (capillary ring)
- anthodites (fibrous channels on surface)

Possibly popcorn and coralloids could be classified as a related form because of the effect of the surface capillarity.

4. Some additional forms of capillary-controlled speleothems

There are some additional speleothem types which appear to be capillary-controlled.

In Lucas Cave (Jenolan Caves, NSW) and Fig Tree Cave (Wombeyan Caves, NSW) there are hard white hemispherical deposits on the roof and walls of areas which have high air flow. They appear to be made of calcite. They deposit on bedrock, at joint intersections. Possibly they are made in the same way as are masses of helictites, ie by seepage along capillary channels, but due to the high air flow, precipitation of calcite occurs before the structure has a chance to develop a tube. Further investigation is required.

In Chifley Cave, Jenolan, there are some cauliflower-shaped deposits on the floor and walls. They are made of a mixture of calcite (including lublnite), silicates and phosphates (like a soil) however it could be argued that the form, as such, is the result of capillary action in a porous medium. It could also be argued that they form like cave caps (Hill & Forti, 1997) where new material is being deposited at the base of the deposit, locally raising the surface. More study needs to be done on these before deciding whether they are a capillary structure or not.

5. Present Classification System for Helictites

Hill & Forti (1997) have classified helictites as follows:

Type
: Helictites
Sub-types
: Subaerial, subaqueous
Varieties
: filiform, beaded, vermiform, antler

Heligmites are classified as simply helictites that grow upward from the cave floor. Helictites are further classified into varieties, again based on form (morphology) which can be identified in the field, as seen in Table 1.

6. Problems with the existing classification system

Just as there have been difficulties with cave classification schemes, there are difficulties with classifying speleothems, especially oddball things like helictites.

- The ``variety" classification gives no hint as to structure.
- Structural classifications are only in their infancy
- Helictites deposited from different materials may have different forms
- There are additional ``varieties" yet to be classified.

Table 1: Hill & Forti classification of helictite varieties

Variety	**Further classifications**
filiform	thread
beaded	unbranched
	branched
	sea anemone
antler	antlers
	rod helictites
vermiform	worms
	corkscrew
	jag at right angles
	combined with straws
	butterfly
	bell
	tomahawk
	pigtail
	hook
	tangled masses
	unicorn horn

7. Some additional forms of helictite

In NSW caves and elsewhere I have noticed some helictite forms which aren't well described in the latest edition of Hill & Forti.

The same forms occur in several caves both in Australia and elsewhere in the world.

They have consistency of form: that is, if one looks for a particular shape of helictite (eg butterfly) one can find examples in other caves around the world. Often where they do occur, all the helictites in the one area are of the same form. Presumably the same set of influences occurs at each site for a given form.

Table 2: Some descriptive names

Name	**Location**	**Comment**
Saws	Orient Cave, Jenolan	Straight, gravity effect
Rods	Ribbon & Baal, Jenolan	Long, maybe fibrous
Butterflies, hands	Orient Cave, Jenolan	Twinning effect
Upturned helictites	Tantanoola Cave, SA	Gravity effect
``Peripatus"	Sigma Cave Wombeyan	Fractal appearance
Ribbon Helictite	Jubilee Cave, Jenolan	Needle form calcite
Intermediate forms	Cliefden Main Cave	Curved, flattened

Unfortunately, I have no way of telling (without a picture) whether the forms described above are actually the same as what other people have described. For example, are the ``rod'' and ``butterfly'' forms in Table 2 the same as those of the same name in Table 1? Is the "butterfly" form in Table 1 the twin version of the ``tomahawk'' form?

The helictite form taken by vaterite in carbide dumps is also unusual; it is an inverted horn shape (carbidimites) and is unstable: the form changes over months. Carbidimites are discussed in Hill & Forti (but not in the section on helictite forms).

Another form, again in Hill & Forti is the pseudo-helictite as photographed by V. Maltsev. This is a concentric tube of calcite over an aragonite core, with dolomite between the two: a triple layered speleothem.

Names may help to describe helictite forms. Some are described below. A better way of classifying these forms is discussed later.

7.1 Saw Helictites

Saw helictites are generally straight (see Figure 1). The lower edge appears to have a row of prototype straw stalactites along it. The cross section shows the helictite has a central canal and is symmetrical. Its development is influenced by gravity. Saw helictites appear to protrude from the wall at fixed angles, typically about 35 ° with respect to the wall. They have a central canal and appear to have minor side canals. If a laser pointer is used to light up the tip of one of the ``stalactites'', the light also appears to be conducted along a curving, cone-shaped portion of the main part of the helictite.

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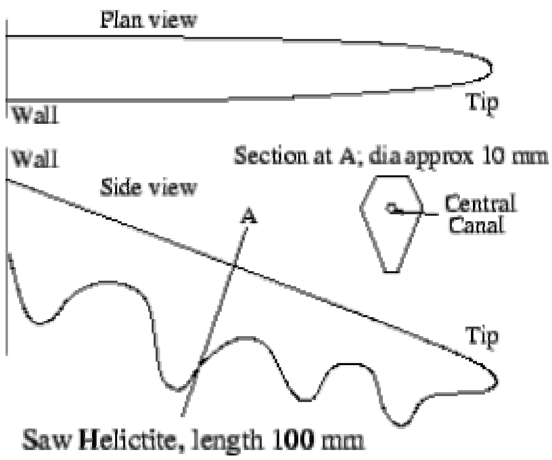

Figure 1: Saw Helictite

Some saw helictites appear to be composed of a series of half-butterfly helictites (see Figure 3) with well-developed ``wings'' and ``tails'' (ie the stalactites). More work needs to be done on saw helictites.

7.2 Rod Helictites

Rod Helictites (see Figure 2) are generally straight, similar to saw helictites but without the saw edge. They are often found protruding upwards from walls or columns, making an angle of about 30 or 60 degrees to the vertical. Their cross section is almost the inverse of that of the Saw helictite. They appear to be made of en-echelon stacks of calcite crystals, although this could be just the surface coatings. Rod helictites can be quite large, with a total length of about 1 metre and a diameter of about 20 mm. They can be seen in the Temple of Baal, the Orient Cave and the Ribbon Cave, Jenolan Caves, NSW. They are often associated with deposits of aragonite and hydromagnesite, however they are also

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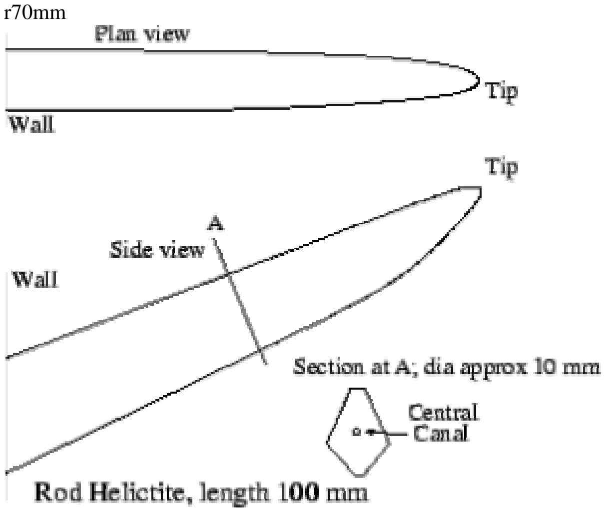

Figure 2: Rod Helictite

sometimes found partially engulfed in flowstone. Although rod helictites are usually straight, both bent and branched ones occur. This may well be the ``rod" variety described in Hill & Forti.

7.3 Butterfly Helictites

Butterfly shapes can occur either singly (imagine a resting butterfly with its wings folded together) (see Figure 3) or twinned to form a pair of open wing shapes. The single wing shape may be the "tomahawk" as mentioned in Hill & Forti. Close inspection of this type of helictite shows that it appears to be made of a number of segments, each optically continuous but with optical discontinuities at the segment boundaries. This can be seen using a laser pointer. The segments appear to be recrystallised. They appear to have a number of micro-channels rather than the usual single canal that most helictites have. Possibly what happens is the micro channels may fork, so the speleothem develops a broad wedge shape. Growth seems to occur predominately in one plane. It is clearly influenced by gravity (the stalactitic deposit forming the butterfly ``tail"). The open butterfly shape appears to be due to crystal twinning,where each half shares a common attachment point to the wall, and whatever influences one side will influence the other side. They occur in Orient Cave, Jenolan Caves, Wyanbene Cave, NSW, and numerous other caves around the world.

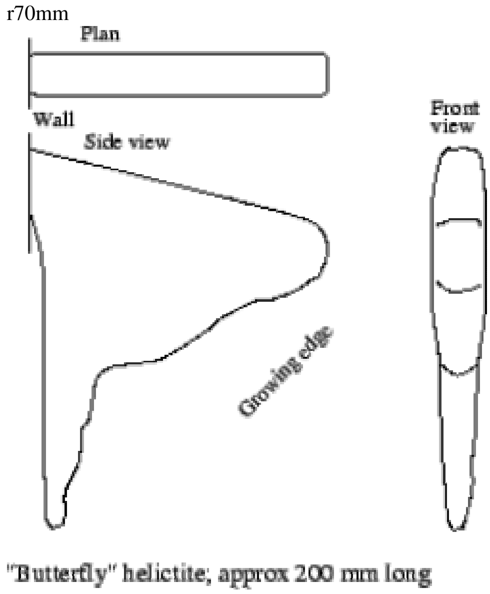

Figure 3: Butterfly Helictite

7.4 Hand or Shell Helictites

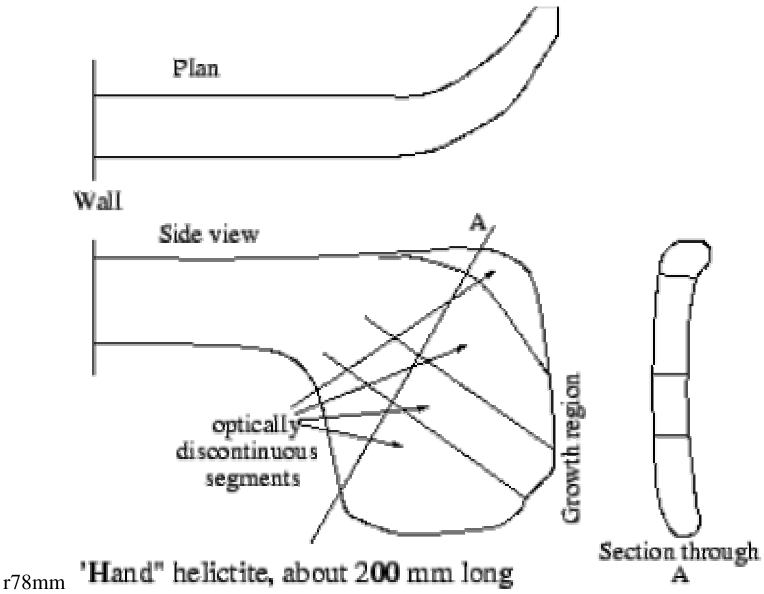

Figure 4: Hand Helictite

Similar to the Butterfly Helictites, Hand (or Shell) Helictites are planar structures. They generally lack the stalactitic ``tail" that the Butterfly Helictites have. They also occur as twinned pairs. They are made of segments, as can be seen with a laser pointer. Hand helictites look like a pair of hands in mittens; there is a distinct ``wrist" and the ``hand" section is translucent. It can be curved. One hand helictite is show in Figure 4. They occur in Orient Cave, Jenolan.

7.5 Intermediate forms

Some other intermediate forms are like a ribbon helictite but with diagonal spikes (like aragonite) leading to a saw edge. These can get fairly large. They occur in between Orient Cave and Ribbon Cave, Jenolan Caves, NSW. Another intermediate form is like the saw helictite, but with a smaller zigzag edge. They curved regularly forming loops and occasionally a spiral, with a diameter of about 10 cm. This form is fairly common at Cliefden Caves, NSW, forming large clumps of similar helictites.

7.6 Ribbon Helictites

Ribbon Helictites are flattened helictites. They are generally fairly small, typically 5 mm wide, 1 mm thick and 20 mm long. The type locality is Jubilee Cave, Jenolan Caves NSW Australia. See Figure 5.

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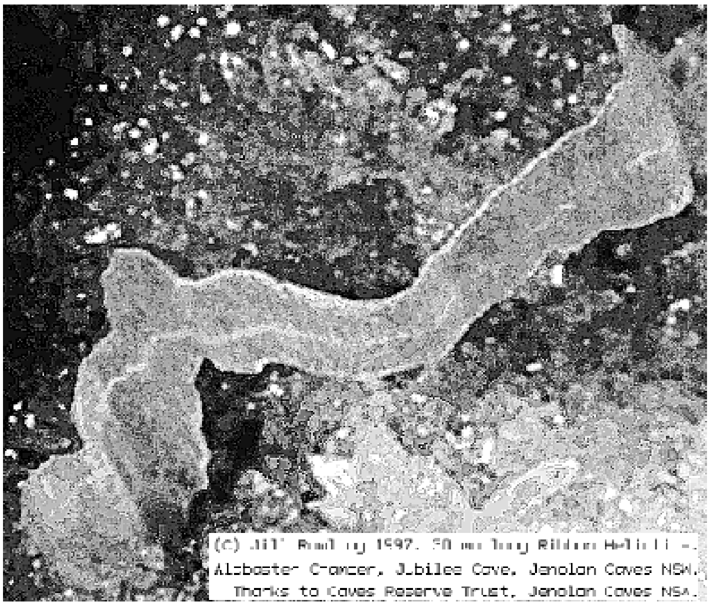

Figure 5: Ribbon Helictite

They appear to be made of calcite in the lublinite form, although individual crystallites appear to be an order of magnitude larger than those of lublinite. A detailed description of Ribbon Helictites is in Rowling (1998). Basically, they have a short stem made up of a twinned pair of crystallites with the central canal developed between the pair. Crystallites are made of pseudo-hexagonal columns of calcite in the lublinite form. At the end of the stem, the ribbon develops. This is a flattened structure made of twinned sets of crystallites, aligned with those of the stem. The central canal is usually visible in the centre of the ribbon as a thin white line. At Jenolan Caves, they are usually associated with ancient gravel beds which appear to have reacted with the limestone.

7.7 Heligmites

Heligmites are generally classified as helictites which simply develop on the ground rather than on a wall or roof. However there are some exceptions where the heligmite should be classified separately.

In this case, the heligmite is a fairly large structure resembling a stalagmite. They have a central canal. In large heligmites (say 30 cm tall and 5 cm diameter), the central canal can be about 5 mm diameter in the main part of the heligmite but microscopic at the tip.

In this type of heligmite, the central canal appears to be filled with a sticky, fine mud. Large examples can be seen at Tantanoola Cave, South Australia, where they have

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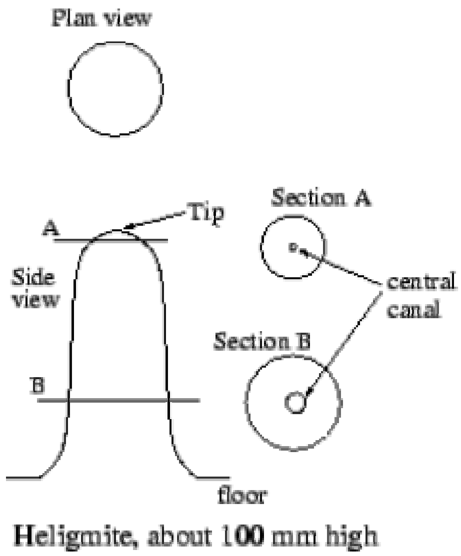

Figure 6: Heligmite

developed in a dolomite cave. Lesser examples can be seen at Jenolan Caves. They can have side branches.

One of the Jenolan Caves heligmites (Dwyers Cave) appears to have dark material deposited along with the clear calcite; possibly this is manganese dioxide. The Tantanoola heligmites also seem to have this dark material.

One could argue that these large heligmites are actually geysermites, however the definition of geysermites in Hill & Forti specifies that geysermites have thin walled sides and a crater-like central hole whereas these heligmites have very thick sides and no apparent central hole at the tip, ie they are more like a normal helictite

In both these sites, the speleothems are developed in an area which does not have geysers or thermal springs. Swelling clay, however, may be a contibuting factor.

7.8 Upturned Helictites

Upturned helictites are usually vermiform helictites which initially develop with a horizontal orientation, then they develop in a vertical (upward) orientation. The horizontal development is usually only about 5 cm length, however the vertical development can be metres long.

Some of the best examples can be seen at Tantanoola Cave SA, where they can be seen attached to stalactites and columns; they resemble electrical wiring in some places. A smaller version can be seen in the Wollondily Cave, Wombeyan Caves, NSW, where they appear to be associate with magnesium deposits.

At the bend, the central canal appears to be enlarged. More work needs to be done on this type of helictite.

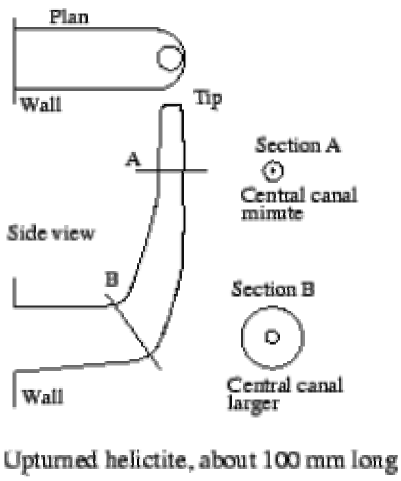

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Figure 7: Upturned Helictite

There is a similar form of upturned helictite which appears to be common in caves all round the world. This form however rarely reaches the size of the Tantanoola helictites and may either stop developing once a certain size is reached, or may become engulfed with flowstone.

7.9 More forms - subaqueous

After the ASF conference, I was alerted to some more new forms of helictite, this time underwater in Nurina Cave on the Nullarbor. Paul Boler (pers. comm.) has shown finger shaped heligmites, as well as a crested form and a conical form. Again, these are not one-off; where they occur there are a lot of similar ones nearby. They appear to be actively depositing.

In McCavity, Limekiln Cave, Wellington Caves, NSW the divers have found large helictites underwater however these appear to have been deposited originally in air and the cave has subsequently filled with water. The helictites in this case have a clear crystalline core (possibly aragonite?) and a thick dark coating (possibly a mixture of calcite and manganese dioxide). They may be still active.

I have seen what appears to be a subaqueous helictite under a baldacchino canopy in Croeseus Cave, Tasmania. This was not an unusual form, though, and would be normally classified as tthe Vermiform variety.

Possibly there are more of these around if we look for them.

7.10 Peripatus Helictites

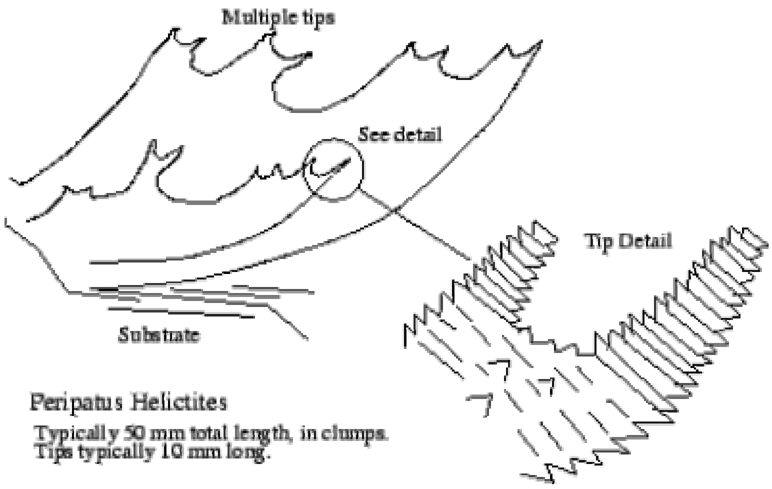

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Figure 8: Peripatus Helictites

Peripatus helictites were discovered in Sigma Cave, Wombeyan Caves, NSW during a cave survey. At first, they were thought to be simply corroded helictites. After developing the photographs, it was apparent that they were yet another undescribed form.

They have a very rough surface, composed of small crystal terminations. This makes them difficult to photograph as they tend to absorb light.

They appear to form horn shapes, where each horn forms part of a larger horn (see Figure 8). The angle that the horn axes make with each other is similar to the angle at which aragonite tends to develop (split).

They occur on flowstone (as shown) and in a stalactitic form, associated with a white deposit (possibly hydromagnesite).

The general form is fractal in nature, in that the closer you look, you still see similar shapes (paired horns).

The name "Peripatus" is after a fancied resemblance of the fine structure to the rough skin of the velvet worm, Peripatus.

8. Proposed Classification System for Helictites

The system being proposed should take into account the various factors involved in the development of helictites and other capillary-controlled speleothems.

Unfortunately for the general caving community, it does not classify helictites into neat ``pigeonholes".

One of the interesting things about helictites is that there are indeed consistent types. They are not just random aggregates. Ribbon helictites, for instance, are fairly rare throughout the world but locally common where they do occur.

Helictites of a particular form often occur in groups of all one sort, inferring that there is something that has caused the helictites to take on the particular form.

Here are some of the factors that should be taken into account:

8.1 Gravitational effects

Gravity may affect the alignment of the helictite. It may affect the long section or the cross section.

- Is the helictite aligned with respect to gravity? This may occur if the helictite has a large central canal where capillarity is balanced by gravitational force (eg drips or density of

liquid / mud). In the case of subaqueous helictites, there may be a difference in the density of the liquid within the helictite compared to the water in which it has developed.
- Does it develop at a specific angle with respect to gravity? This can occur if calcite polysynthetic twinning is involved. This is a feature of calcite whereby sufficient pressure along cleavage planes causes the calcite to move along the planes in a regular way (like a deck of cards) without breaking.
- Is its cross section aligned at a specific angle with respect to gravity? If a cross-section is meaningful, one may notice that it is always aligned one way. Again, this infers that there is a density effect or water may gather at one end of the helictite.

Examples include rods, saws and hands in Orient Cave, Jenolan; heligmites; stegamites; helictites in Tantanoola Cave (SA).

8.2 Crystal twinning effects

- Does the helictite display any symmetry either by itself or as an aggregate? Ribbon helictites are highly symmetrical. They have four fold symmetry.
- Are there any identifiable repeat patterns in the form? For example, with some branched helictites, one notices that every branch occurs at a certain angle and at every branch there is only on fork.
- Does the form appear to be fractal in nature? That is, is the helictite made up of miniatures of the same shape? Does it look as though it is made of repeat patterns?

Examples: ``Peripatus" helictites in Sigma Cave (Wombeyan, NSW); ribbon helictites; ``butterflies".

8.3 Environmental effects

- Does air or water flow appear to have influenced the helictite's growth?
- Carbon dioxide levels in air, water and substrate?
- Humidity in both air and substrate?
- Temperature of air, water and substrate?
- Presence of water (subaqueous or subaerial helictites)?
- Groundwater (rainfall), climatic changes?
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8.4 Trace element effects

- Presence of metals such as magnesium, iron, copper, lead in helictite or in water? Ribbon helictites, for example, contain about 0.5% Fe. This does not colour them (they are clear) however it may influence the crystal growth by causing regular crystal lattice defects.
- Presence of sulphate and phosphate in helictite or in water

8.5 Crystal system effects

Is the helictite composed of all one type of material or are there influences from different minerals and their polymorphs?
- $CaCO_3$ polymorphs: Calcite / aragonite / vaterite
- Halides and sulphates
- Crystal and crystallite alignment with respect to helictite development
- Crystal size ranges

Example: Vaterite helictites associated with carbide dumps; beaded helictites.

8.6 Biological effects

- Presence of calcite as needle-form calcite (lublinite)
- Association with sulfuretums (sulphur cycles)

8.7 Substrate effects

The porosity of the substrate may affect the development of helictites.

- Gravel substrate
- Clay substrates
- Ochre substrates

8.8 Canal effects

- Single central canal
- Multiple central canals
- Side-branching canals (canalicules)
- Surface capillary channels
- Shape of canal: Circular, flat, U-channel, hexagonal, spherical etc?
- Size of canals

For example, most vermiform helictites have circular central canals whereas the capillary channel in a cave shield is a flat sheet. Welts and ``turnips" have spherical hollows. Some of the helictites described in this article have branching canals.

8.9 Activity

Is the helictite active or ``dead"?

- If ``dead", when was it formed and under what conditions (U-Th dating, etc)?
- If ``live", what is its growth rate?

8.10 Development habits

Additional information may be useful in describing the helictite.

- Presence of active / inactive drip points at regular or irregular intervals
- Straight habit (like a rod)?
- Curved habit, spiral habit, radius of curvature?
- Shape of cross section(s)
- Overall length and widths
- Fracture habit
- Colour
- Surface texture and pattern
- Forking habit and angles of forks
- Bending habit and angles of bends

9. Summary

There is really no way we could give individual names to each of the combinations and permutations of influences as listed above.

Although the classification scheme by Hill and Forti serves well for the general caver, a more comprehensive classification scheme is needed if we want to explain what causes the development of helictites.

Possibly this could be addressed by developing a catalogue of helictite types rather like a smaller version of ``Cave Minerals of the World''.

This would be huge undertaking however it could be started as a set of tables, at least defining those influences relevant to helictites and lead to a useful, publically accessable database of helictite forms.

One of the nicer features of databases is the information is not stored in a hierarchy, so one is not forced into classifying things first. Rather, that becomes the responsibility of the *application* rather than the database itself.

One could query the database for all helictite forms which were found underwater. Or all helictite forms containing aragonite. Or all helictite forms at Jenolan Caves. Or those that had single central canals. Or whatever.

It also makes it possible to visualise the helictite without having a photograph of it. Possibly the shape could be described in terms of parameters to an equation, which could then be displayed by an application.

If and when an exact explanation can be found for the development of a particular helictite form, that can be added to the database (or at least a reference to it).

The concept can also be used for conservation. For example, if it is found that a particular helictite only occurs with certain bacterial colonies, then it would be inadvisable to clean up a tourist cave containing such helictites using an antibacterial cleaning agent.

Also if a particular helictite form is known to have small water reservoirs as part of its make-up, then it would not be advisable for a tourist cave operator to put strong, high powered lights on the speleothem otherwise the water can boil and fracture the helictites (cave photographers take note!).

10. References

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Arthur Clarke

Helictites in Orient Cave, at Jenolan