Chapter 4

Discussion

Aragonite was found in most of the caves examined, but the conditions under which it was found varied from cave to cave, and within different areas of a cave. Table 4.1 lists some of the associations found between aragonite occurrence and variables such as humidity, elements and ions present in the cave minerals and the presence of steep beds, dykes, joints or faults.

4.1 Comparisons and contrasts between areas

Association with dolomite

Dolomite was found in the bedrock at all areas examined. Jenolan has by far the most dolomite, with possibly two episodes of dolomitisation. Aragonite at Jenolan is significantly affected by the amount of dolomitisation in the bedrock. At Wombeyan, dolomite is less significant as a source of calcite-inhibitors at aragonite sites compared to Jenolan. At Walli, dolomite is mainly associated with the chert nodules and this association occurred with aragonite at one site in Piano Cave. Exposure of pyritic chert to meteoric water may release calcite-inhibitors from the cherts and prevent calcite from depositing. Dolomite is significant in Flying Fortress Cave and is likely to be a factor at Wyanbene Cave.

Aragonite association with minerals containing Mg

Magnesium is a calcite-inhibitor (Morse 1983). Aragonite is associated with minerals containing Mg in all sites except for Walli, where Mg was only detected at some locations. In the case of Wyanbene Cave, Mg is present in the ironstones. In most cases, the most likely source of Mg is from weathering dolomite which is problematic as dolomite is usually slightly more resistant to chemical weathering compared to limestone. Many of the dolomite thin sections indicated pseudomorphs of goethite after pyrite, and in some cases intact pyrite was present. It is most likely that the slow weathering of this pyrite in oxygenated water is releasing strong acid which is chemically altering the dolomite, eroding the limestone, and releasing the Mg from the dolomite.

In the case of Wombeyan, an additional source of Mg appears to be from the weathering of ferromagnesian minerals from nearby igneous rocks.

Aragonite association with minerals containing Mn

Manganese is one of the calcite-inhibitors listed by Morse (1983) so it is not surprising to find Mn present where there is aragonite. Magnesium and manganese often appear to occur together. Mn-bearing minerals were detected at most sites (less so at Walli where sulfate is dominant). In one sample from Walli, manganese (as pyrolusite) was found to be the substrate of an aragonite speleothem coating.

The origin of Mn varied between areas. At Jenolan Caves, sources of Mn may include the weathering of ferroan dolomite, weathering of ferromagnesian minerals in dyke rocks, breakdown of ferromagnesian minerals in the "Jenolan Beds" and cobbles of dacitic tuff in stream beds. At Wombeyan Caves, sources of Mn include breakdown of local and regional igneous rock cobbles in stream beds, some weathering of ferromagnesian minerals in the filled joints, and weathering of ferroan dolomite. At Walli Caves, the main source of Mn appears to be from the breakdown of minerals in the cherts. Sources of Mn at Bungonia appear to be the weathering of ferroan dolomite, and mafic dykes. At Wyanbene, Mn appears mainly associated with the ironstones and ferroan dolomite.

Aragonite association with minerals containing SO_4

The sulfate ion is listed by Morse as a calcite-inhibitor. Sulfate-bearing minerals were found at most sites to some extent (less so at Wombeyan). The most common form encountered was gypsum. Gypsum at some sites appeared to be organically derived, being often encountered in areas with bat guano (e.g. Wiburds Lake Cave). Gypsum at Jenolan is also associated with pyritic weathering of limestone.

Gypsum is plentiful at Walli, forming white masses and long monocrystalline "hairs". Walli was the only site with large quantities of inorganically-derived gypsum and barite, thought to be emplaced by hydrothermal activity.

Aragonite association with minerals containing PO_4

In the sites examined, aragonite is less commonly associated with phosphatic minerals, although phosphate is one of the calcite-inhibiting ions. In most cases, the origin of phosphate appeared to be organic, derived from bat guano. Phosphate was significant at Aragonite Canyon in Sigma Cave and at The Loft in Wollondilly Cave.

Aragonite association with heavy metals

Heavy metals are only significant at Walli and in the ironstones at Wyanbene. At Walli, the most common heavy metal salts are barium (often as barite) and minor copper (as chalcopyrite in the cherts). More aragonite was present where the barium occurred as more soluble salts such as the carbonate. The source of barium is thought to be from hydrothermal fluids. Heavy metals at Wyanbene are present in the ironstones and gossans, which form dyke-like structures in the cave. Aragonite at Wyanbene is associated with eroding low-grade ore bodies. At Wyanbene, the significant heavy metals appear to be lead and possibly copper.

Aragonite association with ironstones

Ironstones were significant at some aragonite sites, mainly Jenolan, Jaunter and Wyanbene. Ironstones were present at most areas but did not appear to influence the presence of aragonite. At some sites, e.g. Neddys Knock, ochre appeared to form the substrate for the aragonite. The ironstones at Wyanbene are associated with low-grade ore bodies. At other locations, there appears to be two types of ironstone present: one which is rather dense and appears to be mainly highly ferruginised sandstones with stalactitic goethite vughs. The other type appears to be the result of weathering ferroan dolomite and is much more porous. It is the porous type which appears to be associated with aragonite.

Aragonite association with mafic intrusions

Mafic intrusions are associated with aragonite at Wiburds Lake Cave and Flying Fortress Cave. In Crystal Cave, the dyke-like structure has not been analysed so its origin remains speculative. In the case of Wombeyan, the “dykes” are filled grikes except near Sigma Cave where detrital material from a gabbro intrusion has weathered to release ferromagnesian minerals in Aragonite Canyon. Aragonite near the dyke in Wiburds Lake Cave appears to be associated more with weathering of ferroan dolomite replacement minerals in the dyke, than the dyke itself.

Association with steep bedding, jointing or faults

All caves examined were developed in steeply-bedded rock. For this study, the Wombeyan marble is considered to be steeply bedded as remnant bedding is visible in the marble. Steeply dipping joints are prominent in most caves. Faults were significant at Walli and Wiburds Lake Cave. Possibly the steep bedding and jointing allows fresh oxygenated water into the cave. In the case of Walli, faults may contain veins of hydrothermal minerals. In the case of Wyanbene, aragonite is mainly associated with a major N-S joint in the cave. Regional geological maps indicate N-S faults may cut the area as well.

Steep bedding, jointing or faulting is unlikely to be the sole reason for aragonite deposition, as these features also occur in caves with no aragonite. One possible exception would be where the feature is associated with a mineral vein (such as at Walli).

Aragonite association with low humidity

Low humidity was considered significant at several sites. In Contact Cave, it may be significant during winter, allowing the formation of a popcorn line where cool dry air pools in the cave during winter. In The Maze in Wiburds Lake Cave, and at the "Shale Beds" in Deep Hole, the closeness of the site to the cave entrance has allowed gypsum and aragonite to precipitate partly by evaporation. At Cow Pit, the site is close to external atmospheric conditions and this has allowed water to evaporate from mineral-laden solutions seeping from the cave fill and bone breccia, precipitating aragonite and other minerals. In Star Chamber and The Loft at Wollondilly Cave, low humidity associated with air movement appears to be causing evaporation, precipitating some of the minerals from solution. Piano Cave had areas with low humidity depending on the direction of air flow and the time of year. Some of the aragonite coatings appeared to be associated with evaporation, e.g. near site "S5". In Flying Fortress Cave, low humidity did not appear to be a factor during the site inspection as relatively warm moist air was flowing out of the cave. If the air flow was reversed, however, this may have a drying effect at certain times of the year. At Crystal Cave (Jaunter), the connecting passage between the aragonite area and the entrance has been dug out. Over about three visits (about 18 months), small gypsum and aragonite-like speleothems were noticed to have developed in an area near this passage and are possibly developing due to evaporation when dry air enters the cave.

The most common form taken by aragonite in low humidity conditions is as a fine crust with microscopic crystals. In contrast, aragonite deposited in caves under conditions of high humidity and little air movement usually has large crystals and often stalactitic forms.

Low humidity was never a solitary factor but was always associated with calcite-inhibitors. There are plenty of caves with low humidity which do not have aragonite present.

Aragonite association with air movement

Generally, anywhere where low humidity was considered a factor, air movement is also a feature of the area. In some cases, air movement was noticed without the low humidity. In Contact Cave and Glass Cave, air movement appears to be responsible for some of the directional aragonite speleothems. Air movement has been reported in "The World of Mud" near the aragonite areas. Air movement may be linked with periodic low humidity in The Maze (Wiburds) and in Spider Cave, especially where there are beaded helictites (alternating calcite and aragonite). Air movement was considered significant at Aragonite Canyon in Sigma Cave, where aragonite has deposited on projecting edges of passages. The "popcorn lines" in Caesars Hall in Wyanbene Cave may be due to barometric air movement concentrated along particular passages in the large cave, coupled with availability of calcite-inhibitors.

Aragonite precipitated under conditions of high air movement often has a skeletal appearance, with feathery “hopper” crystals and speleothems such as frostwork and coralloids. Under conditions of low air movement, the speleothems are often more dense and massive.

Air movement was never a solitary factor but was always associated with calcite-inhibitors. There are plenty of caves with air movement which do not have aragonite present.

Aragonite not associated with CO_2 levels

CO_2 was detectable at Aragonite Canyon, CO_2 Pit, Piano Cave and caves at Bungonia. The presence or absence of CO_2 appeared to have little effect on aragonite, as it can occur in caves with or without aragonite (and *vice versa*).

Association with Clay

Some of the best displays of aragonite in NSW caves are associated with the most unctuous clay. Examples of this include Sigma Cave (Wombeyan), Wyanbene Cave (Wyanbene), the Jenolan show cave Mud Tunnels, Wiburds Lake Cave and “The World of Mud” in Mammoth Cave (Jenolan). Clay is a common mineral found in nearly all caves in NSW whether they contain aragonite or not. Most likely the plasticity of the clay is due to the high humidity, and the size of the aragonite speleothems are due to the persistent conditions of calcite-inhibitors and bicarbonate availability.

Location	Cave and site	Dolomite	Mg	Mn	SO_4	PO_4	Heavy metals	Ironstones	Mafic intrusions	Steep bedding	Joints	Faults	humidity	Air movement	CO_2	Substrate	Arag ID
Jenolan	Contact Cave	Yes	Yes	Yes	Yes	Yes	na	Yes	na	Yes	Yes	na	LH	poss.	na	B	X
Jenolan	Wiburds Lake Cave, Neddys Knock	Yes	Yes	Yes	Yes	Minor	na	Yes	Yes	Yes	Yes	Yes	H	na	na	IB	X
Jenolan	Wiburds Lake Cave, The Maze	poss.	Yes	Yes	Yes	na	na	na	na	Yes	Yes	Yes	L	Yes	na	B	X
Jenolan	Glass Cave	Yes	Yes	Yes	Yes	Minor	na	Yes	na	Yes	Yes	na	H	Yes	na	BS	XM
Jenolan	Mammoth Cave	Yes	poss.	poss.	poss.	na	na	Yes	na	Yes	Yes	na	H	Yes	na	D	M
Jenolan	Spider Cave	Yes	poss.	poss.	na	na	na	Yes	poss.	Yes	Yes	na	H	Yes	na	D	M
Jenolan	Orient Cave	Yes	Yes	poss.	poss.	na	na	Yes	na	Yes	poss.	na	H	na	na	I	M
Jenolan	Ribbon Cave	Yes	Yes	poss.	poss.	na	na	Yes	na	Yes	poss.	na	H	na	na	I	X
Jenolan	River Cave, Mud Tunnels	Yes	poss.	poss.	poss.	na	na	na	na	Yes	poss.	na	H	na	na	D	M
Jenolan	Pool of Cerberus	poss.	poss.	poss.	poss.	na	na	na	na	Yes	poss.	na	H	na	na	D	M
Wombeyan	Sigma Cave: Aragonite Canyon	Yes	Yes	Yes	Yes	Yes	na	na	detrital	Yes	Yes	na	H	Yes	minor	BCF	X
Wombeyan	Sigma Cave: Iota Grotto	na	poss.	Yes	Yes	Yes	na	na	na	Yes	Yes	na	H	Yes	na	B	X
Wombeyan	Wollondilly Cave: Star Chamber	poss.	Yes	Yes	Yes	na	na	na	na	Yes	na	na	L	Yes	na	FS	X

Associations between aragonite, mineralogical and geological features in NSW caves.

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Location	Cave	Dolomite	Mg	Mn	SO_4	PO_4	Heavy metals	Ironstones	Mafic intrusions	Steep bedding	Joints	Faults	humidity	Air movement	CO_2	Substrate	Arag ID
Wombeyan	Wollondilly Cave: The Loft	poss.	Yes	Yes	na	Yes	na	na	detrital	Yes	na	na	L	Yes	na	F	X
Wombeyan	Cow Pit white coating	na	Yes	na	na	na	na	na	na	Yes	Yes	na	L	Yes	na	F	X
Wombeyan	Cow Pit red breccia	na	Yes	Yes	na	Yes	na	minor	detrital	Yes	poss.	na	L	Yes	na	F	X
Wombeyan	CO_2 Pit	Yes	Yes	na	na	na	na	Yes	na	Yes	Yes	na	L	na	Yes	S	R
Walli	Deep Hole, near “Shale Beds”	na	Yes	Yes	Yes	Yes	Yes	na	na	Yes	Yes	na	L	Yes	na	B	X
Walli	Deep Hole, near “Z”	na	Yes	Yes	Yes	na	Yes	na	na	Yes	Yes	Minor	H	poss.	na	B	X
Walli	Deep Hole, near “S1”	na	na	Yes	Yes	minor	Yes	na	na	Yes	Yes	Yes	H	na	na	B	X
Walli	Piano Cave, near “S2”	na	na	na	Yes	Yes	Yes	na	na	Yes	Yes	Yes	HL	Yes	varies	B	X
Walli	Piano Cave, near “S3”	na	Yes	na	Yes	Yes	Yes	na	na	Yes	Yes	poss.	HL	poss.	yes	B	X
Walli	Piano Cave, near “S4”	na	Yes	na	Yes	na	na	na	na	Yes	Yes	poss.	HL	na	yes	B	X
Walli	Piano Cave, near “S5”	na	Yes	Yes	Yes	na	Yes	na	na	Yes	Yes	Yes	L	Yes	na	F	X
Bungonia	Flying Fortress Cave near dyke	Yes	Yes	Yes	Yes	na	na	na	Yes	Yes	Yes	na	HL	Yes	varies	Dd	X
Jaunter	Crystal Cave	Yes	poss.	poss.	poss.	na	na	Yes	poss.	Yes	Yes	poss.	H	Yes	na	D	M
Wyanbene	Wyanbene Cave near Frustration Lake	poss.	poss.	poss.	poss.	na	poss.	Yes	na	Yes	Yes	poss.	H	na	na	I	X

Associations between aragonite, mineralogical and geological features in NSW caves.

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Location	Cave	Dolomite	Mg	Mn	SO_4	PO_4	Heavy metals	Ironstones	Mafic intrusions	Steep bedding	Joints	Faults	humidity	Air movement	CO_2	Substrate	Arag ID
Wyanbene	Wyanbene Cave near Caesars Hall	poss.	poss.	poss.	poss.	na	poss.	Yes	na	Yes	Yes	poss.	H	poss.	na	I	M

Table 4.1: Associations between caves, aragonite, calcite-inhibitors, geological structures and weather. Key: "Yes": there was an association; "na": no association noted; "H": high humidity; "L": low humidity; "HL": both high and low humidity; Substrates indicated by "C": clay, "B": bedrock, "I": Ironstone, "D": dolomite, "d": dyke, "M": manganese oxides, "S": other speleothems, "F": fill (detrital); aragonite identification (ID) by "X": XRD, "R" Raman spectroscopy, "M": morphology

4.2 Possible mechanisms leading to deposition of calcite-inhibitors

The main calcite-inhibitors noted during this study were minerals containing Mg, Mn, SO_4, PO_4 and heavy metals.

Geological Setting

All areas were formed in Late Silurian limestones except for Walli which is Ordovician (Eastonian). The Wombeyan Limestone has been metamorphosed to marble. All areas are located in the Lachlan Fold Belt tectonic unit. Most areas, with the exception of Walli, are located near the edge of the Sydney Basin. Possibly deep burial of the sediments has allowed basinal fluid to circulate past the limestones. Additionally, at Jenolan, some of the dolomitisation may be early diagenetic, especially along the eastern side of the valley.

In contrast, Walli is not particularly close to the Sydney Basin, but the presence of a warm spring and the coatings on the cave walls suggest that hydrothermal minerals have been precipitated in the cave at some stage. What is not clear is how the ferroan dolomite was introduced to the cherts. If it was introduced at an early diagenetic stage, it is unclear how the material deposited as ferroan dolomite with chalcopyrite in the dolomite rhombs. Another possibility is the dolomite was introduced during a period when sulfide mineralisation occurred in the region. The barite and sulfate coatings have been emplaced much later, after (or during) the formation of the present cave passages.

Dedolomitisation at Jenolan Caves

The process of dedolomitisation at Jenolan appears to be initiated by exposure of the rock to air or groundwater through karstic processes. Dolomitised rock exposed at the surface, such as on the hillside near Contact Cave, has a ferruginised "limonite" surface as all the magnesium has been removed from the first few millimetres of the surface. Deeper in the rock, ferroan dolomite is preserved. These ferroan dolomite zones also contain small quantities of pyrite, and exposure of these pyrites to oxygenated water further accelerates the weathering process.

Underground, oxygenated water penetrates joints in the limestone and weathers the pyritic, ferroan dolomite. This results in a porous "rotten rock" with high moisture content, low calcite content and high proportion of iron and manganese oxides. The original rock structure, opaque cubes (from weathered pyrite) and zoned dolomitic patterns are preserved although the original minerals are not.

Usually, not far from these areas of dedolomitisation, one can find some of the migrated minerals redeposited as speleothems. These often occur together as aragonite, huntite and / or hydromagnesite and sometimes gypsum. Depending on the amount of magnesium ions available, some of the aragonite speleothems revert to calcite if continued dripping removes the calcite-inhibitors from the speleothem. Thus aragonite at Jenolan is a transient speleothem, only lasting while protected by coatings.

If conditions are suitably dry, gypsum may be deposited although care should be taken in generalising the origin of gypsum at Jenolan caves as bat guano is also a source of sulfates.

As dolomitised bedrock is exposed, it weathers to a series of minerals depending on the initial constituents. At Jenolan, the dolomitised zones contain ferroan dolomite, pyrite, manganese minerals such as todorokite and calcite. As these zones oxidise, the pyrite releases strong acids which remove the calcite and release manganese, iron and magnesium ions. Sulfate minerals may be deposited or may dissolve in the ground water. Iron may further oxidise from II to III resulting in reddish deposits. Manganese may redeposit through the porous matrix as dendrites on the microscopic scale and liesegang rings on the macroscopic scale.

Chapter 5

Conclusions

Calcite is the most common polymorph of calcium carbonate encountered in NSW caves. Calcium carbonate is depositing in NSW caves in the aragonite form wherever it cannot deposit in the calcite form due to the chemical and physical environment at the location. The conditions under which this occurs vary from cave to cave and between locations within a given cave.

5.1 Factors associated with aragonite deposition

Calcite-inhibitors

All aragonite-bearing sites examined have minerals containing ions known to be calcite-inhibitors. These were considered the main factor associated with aragonite. The main calcite-inhibitor associations with aragonite were minerals containing the magnesium ion. This was often found together with other ions, the particular substance varying from site to site.

- Magnesium;
- Manganese;
- Sulfate;
- Phosphate;
- Heavy metals.

Some of the minerals found were double salts.

Association with magnesium

Magnesium was present at most sites examined, and in many cases was due to pyritic weathering of ferroan dolomite. Aragonite was associated with the following minerals which contain Mg: huntite, hydromagnesite, epsomite, dolomite, magnesian calcite, nesquehonite, lansfordite, hexahydrite.

Association with manganese

Manganese was also present at most sites examined. In some cases, its presence was ascribed to the weathering of ferroan dolomite. In other cases, the weathering of ferromagnesian minerals from nearby mafic rocks was the suggested source. Aragonite was associated with the following minerals containing the Mn ion: rhodochrosite, todorokite, pyrolusite, braunite, manganocalcite, manganoan calcite, rabbittite, birnessite, hausmannite.

Association with sulfate

Sulfate was present in many aragonite sites examined. Three origins were suggested, one biological (bat guano) and two mineralogical (weathering pyrite and hydrothermal minerals). The biogenic sulfate minerals were often associated with phosphates and vaterite. The following sulfate-bearing minerals occurred with aragonite: gypsum, letovicite, epsomite, bassanite, natron, hexahydrite.

Association with phosphate

Phosphate was present in some aragonite sites, and a bat guano origin was suggested. The following phosphatic minerals were associated with aragonite: diadochite, vauxite, koninckite, leucophosphite, arrojadite, variscite, collinsite, hydroxyapatite, ardealite, cacoxenite, heneuite.

Association with vaterite

Calcium carbonate was present in the form of vaterite, aragonite and needle-form calcite ("lublinite") at some sites examined. It was suggested that the minerals were associated with old bat guano deposits, and that the aragonite in this case may be forming by inversion of vaterite to aragonite. Other minerals present contained ions of Mg, Mn, SO_4 and PO_4.

Tectonic Region

The caves examined were all situated in the Lachlan Fold Belt tectonic region. Possibly something in the region's geological history has emplaced more dolomite and pyrite than in other regions.

Steeply-dipping beds, joints or faults

At all sites, there were steeply-dipping beds, joints or faults. These may allow meteoric water to penetrate the site, as seepage (not flowing). These structures may also host minerals containing calcite-inhibitors, e.g. at Walli Caves and Wyanbene Cave. The presence of these structures alone does not infer that aragonite will be deposited, as steeply-dipping joints and beds are common in all caves examined.

Mafic rocks, intrusives and extrusives

Mafic rocks host minerals containing calcite-inhibitors, however in many cases, these are not active unless the minerals are weathered. For example, vesuvianite in the rocks at Wombeyan Caves is unlikely to be effective as a calcite-inhibitor, but its weathering products include various hydrated minerals containing Mg and Mn, which are effective calcite-inhibitors. The weathering of pyrite in some of these rocks assists in the release of these ions to the environment. In other cases, it was suggested that the corrosive effect of bat guano had released ions from detrital mafic rocks. Dykes may also host dolomite by mineral replacement during deep burial, e.g. the dyke in Wiburds Lake Cave, which can weather to release Mg, Mn and SO_4.

Association with ochres and gossans

Aragonite was found to be associated with ochres and gossans in many sites examined, although not all such sites contained aragonite. Aragonite was associated with ochres where the ochre appeared to be made of highly weathered ferroan dolomite. Aragonite is associated with gossans at Wyanbene Cave. In both cases, calcite-inhibitors present in the ochres and gossans appear to have the most influence on whether aragonite is present or not.

Low Humidity

Aragonite was found in sites with high humidity and low humidity. In both cases, calcite-inhibitors were also present. Low humidity affects evaporation rate, which concentrates minerals containing calcite-inhibitors.

Air Movement

Aragonite was found both in sites with little air movement and sites with perceptible air movement. In the sites examined, air movement alone was not considered to be the primary reason for the polymorph deposited, as calcite-inhibitors were present as well. One effect of air movement is to increase the rate of exchange of CO_2 between the speleothem and the air, allowing a higher rate of deposition than with still air. In areas with low humidity and perceptible air movement, evaporation rate is increased. In areas with high humidity and perceptible air movement, aragonite speleothems form filigree patterns such as frostwork. Supersaturation and rate of deposition were discussed in Chapter 1, Introduction. It is possible that the rate of deposition only affects the form taken by the speleothem, and the mineralogy is dependent on the presence or absence of calcite-inhibitors such as Mg.

5.2 Factors contributing to speleothem form

Some factors contribute more to the form taken by the speleothem and less to the polymorph.

Low Humidity

In the case of low humidity:

- Crystal size, which is smaller for low humidity areas.
- Crystal orientation is more random as rate of deposition is faster.
- Forms taken by aragonite speleothems may be irregular masses, very small helictites or simple coatings.

High Humidity

In the case of high humidity:

- Crystal size is generally larger for high humidity areas.
- Crystal orientation tends to follow that of the substrate as rate of deposition is slow.
- Forms taken by aragonite speleothems may be anthodites, large helictites and spherulites.

5.3 Factors not associated with aragonite deposition in caves

Temperature

The temperature ranges at the aragonite sites examined were not extreme, and ranged from 12.2°C to 18.8°C. There was no correlation between temperature and the presence or absence of aragonite at any of the sites examined.

CO_2

In all aragonite sites examined, some had relatively fresh air and others had medium levels of CO_2. There was no difference in the CO_2 levels in the areas with aragonite compared with the areas with calcite.

Pressure

In the near-surface environment, pressure is not considered a factor on the presence or absence of aragonite. Pressure was not a factor in any of the sites examined.

Presence of clay

Aragonite was found in areas both with and without clay. As calcite speleothems were also found in areas both with and without clay, clay is not considered to be a factor.

Strontium

Strontium was present at only one site, in conjunction with strontium barite. As the mineral has very low solubility, it was not considered to be a factor.

5.4 Implications for site management in show caves

Aragonite occurs in some show caves in NSW. As the polymorph is highly dependent on the availability of often soluble calcite-inhibitors, it is worthwhile preserving these minerals in order to preserve the aragonite speleothems in-situ. Cave cleaning often involves the use of water sprays; this method is not advisable in areas with aragonite, as without the calcite-inhibitors the material may revert to calcite. Other cleaning methods should be investigated.

5.5 Further Work Required

This study has uncovered several problems which could be examined by future studies.

At Jenolan Caves

1. Investigate the pasty material in the gours in the Dreamdust section of Chevalier Extension, Glass Cave. Does the material have a biological component?

2. Continue to study the detailed mineralogy for caves at Jenolan.

3. Groundwater isotope analysis during a wetter period (not a drought).

4. Given the history of flooding of Wiburds Lake Cave, it would be interesting to see what are the hydrological relationships between the water levels in the creek and the cave passages, and compare that with speleothem and bat guano deposits in the cave.

5. Samples from the World of Mud should be obtained; check for aragonite, heavy metals, strontium.

6. The Palaeozoic fauna at Jenolan could be further examined as it appears to be different near Caves House compared to Wiburds Lake Cave and Mammoth Cave.

7. The large helictites and recrystallised speleothems in Orient Cave should be further examined.

8. The geological structure of Wiburds Lake Cave and the Big Rift could be further examined.

9. What is the origin of "native sulfur" in Jubilee Cave? Is it biological? What is its relationship with the black deposits in the area?

10. The western boundary of the Jenolan Caves Limestone could be better mapped; also the karst area could be extended further westwards to include isolated limestone lenses.

11. Examine the geology in the northern end of the Jenolan valley, about 600 m north of Wiburds Lake Cave.

At Wombeyan Caves

1. Further study could be done on hollow hemispheroidal speleothems - "cave turnips".

2. Mineralogy in detail could be done for caves at Wombeyan.

3. The stratigraphy of Wombeyan Caves marble deposit needs further work.

4. The origin of the crystal vughs at Wombeyan Caves needs further study.

5. Cavers estimate that the presently depositing calcite rimstone dams in Junction Cave will block the spring in about 200 years. This will cause the Junction Cave creek to back up and most likely re-activate the Grants Cave spring. If so, is there a cyclic cave chemistry that blocks and unblocks this spring? Several caves have both eroded and active calcite dams.

At Walli Caves

1. Mineralogy in detail could be performed for caves at Walli.

2. Geological structure needs further work at Walli. There appears to be a bedding dip and strike change in the vicinity of WA13 and Piano Cave. There may be other features like this near the caves.

General

1. Origin of subaqueous helictites at Mullamullang cave, Nullarbor Plains (Rowling 2004).

2. The mineralogy of other caves would be a worthwhile study. For example, the data from Mullamullang Cave (Nullarbor, Western Australia) shows a high proportion of silica and strontium, and the Colong cave sample seems to have less aragonite than a similar material from Wiburds Lake Cave.

3. It could be worthwhile comparing the microbial activity on aragonite speleothems compared with calcite ones in the vicinity.

4. Given the rich mineralogy of the bat guano deposits at Jenolan and Wombeyan, it would be interesting to trace the origin of some of these minerals, in particular the trace heavy metals and rare earths associated with bat guano deposits such as lead, arsenic, lutetium. These elements are not common elsewhere in the bedrock, so it is assumed that they are incorporated into the life cycle of bats as a result of an insectivorous diet.

5. It would also be interesting to compare the heavy metals present in modern bat guano deposits and compare them to pre-colonial deposits in NSW. This would indicate whether or not the heavy metals were present in the pre-colonial insects or whether they are present as a result of agricultural or industrial activity.

6. Cleaning aragonite speleothems in show caves is problematic. Not only are the speleothems delicate in many cases, but the action of cleaning may wash away calcite-inhibitors, causing the speleothem surface to invert to calcite. Methods should be investigated to assist the cleaning of show cave aragonite and preserve the calcite-inhibitors on the speleothems.

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Appendices

Appendix A

Glossary of Terms

Some terms used in speleology may be unfamiliar to the general geologist. Most speleothem terms used in this document are those defined by Hill & Forti (1997) and are recognised internationally. Other terms are used in Australian caving.

anthodite: Type of speleothem, usually made of aragonite, which has an acicular and often branching appearance. Usually, anthodites develop from the cave's ceiling, and may have a branching appearance. Anthodites often have a solid core of aragonite, and may have huntite or hydromagnesite deposited near the ends of their branches. Anthodites vary in size from a few millimetres to about a metre.

cave: A natural cavity in rock that a person can enter, that has an opening to the outside. Some show caves used to be subdivided into convenient sections, each of which was called a "cave". Although this terminology is not encouraged, the names of the cave tours are often kept. Thus one could refer to the whole of the Jenolan show caves as one "cave" as they are all interconnected via underground passages, including the Grand Arch.

chamber: A cavity that a person can stand in, varies from about 4 m diameter to about 20 m diameter.

column: When a stalactite and a stalagmite join, the resulting speleothem is called a column. Development may continue to increase the diameter of the deposit.

coral, cave: Type of speleothem characterised by hemispherical to globular appearance. Cave coral is often calcite, deposited on surfaces where there is some air movement. Deposition is mostly by capillary movement across the surface, with the main deposit occurring at the outside edge of the speleothem. Sizes usually vary from a few millimetres to a couple of centimetres diameter.

coralloid: Resembling coral. A speleothem which resembles coral but has not been sufficiently analysed to determine exactly what it is. Examples of coralloids can be seen near the entrance areas of caves where there is a mixture of deposits and deposition mechanisms at work, resulting in speleothems with a mixture of characteristics and mineral content. The term is also used to describe the transition form taken by some aragonite speleothems which alternate in appearance between anthodite-like and coral-like depending on the growth conditions at the time.

crawlway: Low cave passage. To negotiate a crawlway, a caver has to crawl.

deckenkarren: Solutional bedrock feature in cave ceiling forming an array of protrusions. Each protrusion has sinusoidal to square vertical cross section, about 30 cm long, and often has round to oval horizontal cross section, with base diameters about 20 cm. Often formed at the top of water-filled chambers where there is little flow.

false floor: Flowstone deposited on gravels which are later excavated, leaving the flowstone standing well above the present substrate.

flowstone: A deposit of (usually) calcite as a surface coating on any substrate in a cave resulting in a mass of calcite with the appearance of melted wax. The overall shape of flowstone is controlled by gravity and the surface tension of water. Surface textures range from completely smooth to deeply pocketed depending on carbonate concentration, flow rate and other factors which are not well-understood. Flowstone is usually built up from thin layers of calcite, caused by seepage or dripping water containing HCO_3 outgassing CO_2 into the cave to precipitate $CaCO_3$. Depending on where the source of water is physically located, flowstone can grade into stalagmites. Where flowstone builds up over steep drops, furled shapes may occur which resemble draperies.

flos ferri: Type of helictite characterised by slender tightly twisted forms. Usually aragonite. There appear to be three different usages of this term. According to Shaw (1992), the term was first described in 1748 by John Hill to describe a twisting variety of speleothem from mines and some Mendip (UK) caves. Hurlbut (1970) used a similar definition for aragonite associated with iron ore mines in Austria. Hill & Forti (1997) define flos ferri as a quill-like variety of anthodite, and define the earlier usage of the word to be “an ancient word for aragonite and for frostwork and helictites growing in the cavities of iron deposits”. In this thesis, where flos ferri is used, it is assumed to mean the tightly twisted form of aragonite helictite associated with iron ores.

furze bush Type of combination helictite, stalagmite and anthodite characterised by a vertical carbonate deposit (stalagmite/tite or column), usually of aragonite, together with finely twisting helictites. The helictites are also usually of aragonite. Their diameter is typically about 1 to 5 mm and the radius of curvature ranges from about 10 mm to 100 mm. The name was given by Jenolan Caves guides on account of the fancied resemblance to a fir tree, and because they needed a name for the ones in the show caves.

helictite: Type of speleothem characterised by a fine capillary tube surrounded by usually either calcite or aragonite. Helictites often have a worm-like appearance, with typical diameter of a few millimetres and typical length of a few centimetres. Development is usually outwards from a wall. Beaded helictites have alternating deposits of calcite and aragonite giving the speleothem a pipe-cleaner appearance. Ribbon helictites are flattened calcite helictites.

heligmite: Type of helictite that develops from the floor of a cave. They may resemble small stalagmites, but they retain a fine capillary tube and develop by mineral-rich water flowing gradually through the capillary and onto the surface of the heligmite where it can outgas CO_2.

moonmilk: Speleothem with a pasty appearance, with a texture like cottage cheese when rubbed in the fingers. This material has a high water content. Most moonmilk is made of needle-fibre calcite. Some deposits have been shown to contain hydromagnesite and other minerals. Moonmilk may be biogenic. According to Fischer (1988), true moonmilk has to be at least 90% calcite.

oolite: A loose spherical concretion, often pea-sized but can be larger. Usually found in pools or underground creeks where calcite is precipitating. May be calcite or aragonite. Oolites are rarely cube shaped. The term is specific to speleothems. Outside of speleology, the conventional term for similar concretions is "pisolites". Oöids are defined as smaller concretions (of any material) with a diameter of 0.2 to 0.5 mm.

passage: Part of a cave which is much longer than it is wide, so that it resembles a corridor in a building. Passages are generally of walk-through dimensions. In Australian speleology, a passage with reduced width would be called a "rift", and one with reduced height would be called a "crawlway" or a "flattener" depending on the way a person moved through it.

popcorn: A speleothem which vaguely resembles the snack, popcorn. Similar to "coralloid". A "popcorn line" is a horizontal deposit of popcorn in a cave passage at a particular height where there is a humidity change or layer. Hydromagnesite and huntite may be deposited along with aragonite or calcite in a popcorn line.

shield, cave: Speleothem developed as two plates joined together with a fine crack between them. This crack acts as a capillary channel to bring carbonate-rich water to the edges of the shield where it is deposited either side of the crack. The name is derived from the resemblance of some cave shields to war-shields. A shield developed vertically is called a "stegamite" after the resemblance to the back of a stegosaurus. A shield developed in the middle of a stalactite or straw is called a "welt".

spathite: A stalactite made of aragonite may have a wider central tube than the conventional calcite stalactite. This is caused by the flaring of the aragonite crystal compared to calcite.

Sometimes the tube comprises a series of aragonite “petals” overlapping each other to form a wide (2 or 3 cm) tube, called a spathite.

speleothem: Secondary mineral deposit in a cave. May be subaerial or subaqueous. Speleothems are classified according to mineral and shape, for example, a calcite stalactite. The material is most commonly calcite, but can also be other carbonates, sulfates, phosphates, oxy-hydroxides, etc. Most carbonate speleothems are formed by bicarbonate-rich water outgassing CO_2 and depositing calcium carbonate either as calcite or aragonite.

SRT: Single Rope Techniques. This is a method of rigging, descending and ascending a single rope using mechanical devices which grip the rope. Most cavers are instructed in the use of SRT for safely exploring vertical caves.

stalactite: Speleothem, usually of calcite, deposited on the ceiling of a cave. Characterised by general conical shape. Stalactites usually have a central hollow tube of calcite with the C-axis pointing downwards. This is surrounded by layers of calcite with the C-axis pointing at 90° to the surface.

stalactite, straw: Also known as “soda straws”, straw stalactites are just the central hollow tubes of stalactites without surrounding deposits. They usually occur in areas where the bicarbonate-rich water is coming from a single point of crack, rather than running across the ceiling. Diameters are typically 4 or 5 mm and lengths vary from a few cm to metres.

stalagmite: Speleothem deposited on the floor of a cave under a drip point, resulting in a pile of (usually calcite) that is often higher than it is wide. Stalagmites often have roughly cylindrical symmetry. Size varies from a flat disc about 4 cm diameter to massive deposits that are tens of metres high. The calcite C-axis is always directed at 90° to the stalagmite surface.

tray: Trays are a type of speleothem, often developed in gypsum. They are a type of stalactite in which the lower edge is relatively flat. Hill & Forti (1997) suggest the shape is influenced by evaporation.

turnip, cave: Cave turnips are a type of speleothem which has not been well-studied. They occur on the walls and ceilings of some caves. They appear to comprise a hollow sphere of calcite, with acicular minerals on the inside (either needle-form calcite or aragonite) together with clay and hydromagnesite or huntite. They may have a stalactite developed on the underside. They are sometimes found in a naturally burst or damaged state, so it is assumed that the material inside may swell when wet and crack the sides of the sphere. Hill & Forti (1997) suggest they may be a type of vertical welt, i.e. a speleothem related to cave shields.

Appendix B

Sample Catalogue

This section contains tables of all samples and thin sections which were used in this thesis.

B.1 Samples

Samples could be subjected to several tests. Codes used in the tables below are as follows:

Raman If Raman spectroscopy was performed on the sample, ‘A’ = Analysed, ‘X’ = checked but not useful (fluorescence too high).

SEM ‘Yes’ means scanning electron microscopy was performed on the sample.

XRD ‘Yes’ means X-ray diffraction was performed on the sample.

Photo If there is a photograph of the sample, ‘S’ = specimen photo, ‘A’ = area photo.

TS ‘Yes’ means there is a thin section of the sample. All samples with thin sections have thin section photos.

Slab If there is a cut slab of the sample or a polished section, ‘P’ = polished for optical work, ‘U’ = unpolished.

Acid If HCl was applied to the sample, ‘0’ = no reaction, ‘1’ = some material dissolved but no fizz. ‘F’ = Fizzes; carbonate. ‘S’ = Slow fizz rate (reduced carbonate) ‘B’ = Brief fizzing, majority of sample unaffected. A colour name refers to a colour change in the solution.

In all cases, ‘na’ means the test was not applied.

Samples from Jenolan Caves

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
surface	J105/1	near Contact Cave, pt. 8	dolomitised limestone	na	na	na	S	Yes	P	F
surface	J105/2	near Contact Cave, pt. 8	dolomitised limestone	na	na	na	S	Yes	P	F
surface	J105/3	near Contact Cave, pt. 8	dolomitised limestone	na	na	na	S	Yes	P	F
surface	J105/4	near Contact Cave, pt. 8	zoned, dolomitised limestone	na	na	na	S	Yes	P	F
surface	J105/5surf	near Contact Cave, pt. 8	dolomitised limestone	na	na	Yes	S	na	P	F
Contact	J105/5ug	eastern side of cave	zoned, dolomitised limestone	na	na	na	S	Yes	P	S
surface	J105/6	near Contact Cave, pt. 8	dolomitised thinly bedded limestone	na	na	Yes	S	na	P	F
Contact	J105/7	site S1	cave coralloid	X	Yes	S	na	na	na	na
Contact	J105/8	site S2	cave coralloid	na	na	Yes	S	na	na	na
Contact	J105/9	site S3	speleothem coating (shard)	X	Yes	S	na	na	P	na
Contact	J105/10	site S4	pink pasty speleothem	na	na	Yes	S	na	na	na
Contact	J105/11	site S5	dolomitised wackestone	na	na	na	S	Yes	P	F
surface	J105/12	north of Contact Cave	dolomitised limestone	na	na	na	S	na	na	na
surface	J105/13	about 70 m east of Contact Cave	dacitic crystal tuff	na	na	Yes	S	Yes	P	0
surface	J105/14	near Contact Cave, pt. 52	welded tuff	na	na	Yes	S	Yes	U	1
surface	J105/15	near Contact Cave, pt. 53	lava	na	na	Yes	S	Yes	P	S
surface	J105/16	near Contact Cave, pt. 54	lava	na	na	Yes	S	Yes	P	S
surface	J105/17	near Contact Cave, pt. 55	rhyolite	na	na	na	S	na	na	0
surface	J105/18	near Contact Cave, pt. 56	rhyolite	na	na	na	S	na	na	0
surface	J105/19	near Contact Cave, pt. 56	rhyolite	na	na	na	S	Yes	U	0
surface	J105/20	pt. 57 north of Contact Cave	Dolomitised limestone	na	na	na	S	na	P	F
surface	J105/21	near Contact Cave, pt. 58	rhyolite	na	na	na	S	Yes	U	1

Register of Samples, Jenolan Caves

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from previous page

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
surface	J105/22	near Contact Cave, pts 7-10	quartz porphyry	na	na	na	S	na	na	0
surface	J105/23	near Contact Cave, pts 7-10	quartz porphyry	na	na	na	S	na	na	0
surface	J105/24	near Contact Cave, pts 7-10	quartz porphyry	na	na	na	S	Yes	U	1
surface	J105/25	near Contact Cave, pts 7-10	quartz porphyry	na	na	na	S	na	na	1
Wiburds	J58/1	Neddys Knock	Aragonite speleothem fragments	na	na	Yes	S	na	na	na
Wiburds	J58/2	Neddys Knock site S1	weathered dyke	na	na	na	S	Yes	P	F
Wiburds	J58/3	Neddys Knock site S1	weathered dyke	na	na	Yes	S	Yes	P	F
Wiburds	J58/4	Neddys Knock site S1	dolomitised fault zone breccia	na	na	na	S	na	na	F, 0
Wiburds	J58/5	Neddys Knock site S1	dolomitised fault zone breccia	na	na	Yes	S	Yes	P	F, 0
Wiburds	J58/6	Neddys Knock site S1	dolomitised lime mudstone	na	na	Yes	S	Yes	na	F
Wiburds	J58/7	Neddys Knock site S1	unlithified sediment with carbonate coating	na	na	Yes	S	na	na	B
Wiburds	J58/8	Neddys Knock site S1	weathered dyke	na	na	Yes	S	Yes	P	F, 0
Wiburds	J58/9	Neddys Knock site S2	dense vugh with speleothem coating	na	na	Yes	S	Yes	P	F
Wiburds	J58/10	Neddys Knock site S2	ochre with aragonite spherulites	na	na	Yes	S	na	na	F
Wiburds	J58/11	Neddys Knock site S2	red bat guano minerals	na	na	Yes	S	na	na	1
Wiburds	J58/12	Neddys Knock site S2	dense vugh with speleothem coating	na	na	Yes	S	Yes	P	F
surface	J58/13	hillside south of Wiburds	qz sandstone	na	na	na	S	na	na	0
Wiburds	J58/14	Neddys Knock site S2	dyke	na	na	Yes	S, A	Yes	U	1
Wiburds	J58/15	Neddys Knock site S3	speleothem coating	A	na	Yes	S, A	na	na	F
Wiburds	J58/16	Neddys Knock site S3	contact metamorphosed limestone	na	na	na	S, A	Yes	P	F
Wiburds	J58/17	Neddys Knock site S4	dyke	na	na	na	S	Yes	U	B

Register of Samples, Jenolan Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Wiburds	J58/18	Neddys Knock site S5	red bat guano minerals	na	na	Yes	na	na	na	S
Wiburds	J58/19	Neddys Knock site S5	dolomitised wackestone, white coating	na	na	na	S	Yes	P	F
Wiburds	J58/20	Neddys Knock site S5	fault breccia	na	na	na	S	na	na	F
Wiburds	J58/21	Neddys Knock site S5	weathered breccia	na	na	na	S, A	Yes	U	F
Wiburds	J58/22	near J92 entrance	sheared argillite	na	na	Yes	S	Yes	P	0
Wiburds	J58/23	near J92 entrance	sheared, thinly bedded limestone	na	na	Yes	na	na	na	F
Wiburds	J58/24	Dyke Passage	fault breccia	na	na	na	S	Yes	P	1
Wiburds	J58/25	Neddys Knock, site S2	fault zone breccia	na	na	Yes	S	Yes	P	F
Wiburds	J58/26	Neddys Knock, site S2	weathered dyke	na	na	Yes	S	Yes	P	B
Wiburds	J58/27	Neddys Knock, site S6	speleothem coating	na	na	Yes	na	na	na	na
Wiburds	J58/28	Neddys Knock, site S2	aragonite coating	na	na	Yes	na	na	na	na
Wiburds	J58/29	Neddys Knock, site S2	rusty illite substrate	na	na	Yes	na	na	na	na
Wiburds	J58/30	Neddys Knock, site S1	fault zone breccia	na	na	Yes	S	Yes	P	B
Wiburds	J58/31	in The Maze	speleothem coating	na	na	Yes	S, A	na	na	na
surface	J58/32	top of Wiburds Bluff	chert breccia	na	na	na	S, A	Yes	U	na
surface	J58/33	top of Wiburds Bluff	chert breccia	na	na	na	S, A	Yes	U	na
surface	J58/34	creek at base of Wiburds Bluff	ironstone	na	na	na	A	na	na	na
surface	J58/35	creek south of Wiburds Bluff	ferruginised chert breccia	na	na	na	na	na	na	na
Glass	J17/1	"Dreamdust" area	coralloid	na	na	Yes	A, S	na	na	na
Glass	J17/2	"dreamdust" area	moonmilk	na	na	Yes	A, S	na	na	F

Register of Samples, Jenolan Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Mammoth	J13/1	Railway Tunnel	paramorph of calcite after aragonite	X	na	Yes	S	na	na	na
Mammoth	J13/2	Railway Tunnel	powder	na	na	Yes	na	na	na	na
Jubilee	Ribnhel	near the Pincushion	ribbon helictite, coll. 1996	na	Yes	EDAX	S, A	na	na	na
surface	JEN-1	Lucas Rocks	ironstone concretion	na	na	na	S	Yes	U	na
surface	JEN-2	near Twin Shafts Cave	ironstone concretion	na	na	na	S	na	na	na
surface	JEN-3	behind cottage 2, Burma Rd	ironstone	na	na	na	S	na	na	na
surface	JEN-4	behind cottage 2, Burma Rd	ironstone	na	na	na	S	na	na	na
surface	JEN-5	behind cottage 2, Burma Rd	pyritic radiolarian chert	na	na	na	S	Yes	U	na
surface	JEN-6	behind cottage 2, Burma Rd	ironstone	na	na	na	S	na	na	na
surface	JEN-7	behind cottage 2, Burma Rd	limestone	na	na	na	S	Yes	U	na
surface	JEN-8	behind cottage 2, Burma Rd	ironstone	na	na	na	S	na	na	na
surface	JEN-9	base of north Mammoth Bluff	limestone	na	na	na	S	Yes	U	na
surface	JEN-10	base of north Mammoth Bluff	limestone	na	na	na	S	Yes	U	na
surface	JEN-11	S end of Hennings Flat	micromonzonite dyke	na	na	na	S	Yes	U	na
surface	JEN-12	6 foot track east of DCH	purple shale	na	na	na	na	na	na	na
surface	JEN-13	600 m nth of Wiburds	slate	na	na	na	na	na	na	na
surface	JEN-14	600 m nth of Wiburds	phyllite	na	na	na	na	na	na	na

Table B.1: Register of Samples, Jenolan Caves.

Wombeyan Caves

Samples W111 and W114 were collected by Osborne.

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
W43	W43/1	base of entrance climb	coralloid	A	na	Yes	S	na	na	na
surface	W43/2	near cave W43	marble	na	na	na	S	Yes	U	na
surface	W43/3	near cave W43	marble	na	na	na	S	Yes	U	na
surface	W43/4	near cave W43	marble	na	na	na	S	Yes	U	na
Cow Pit	W52/1	floor, Cow Pit	cave turnip speleothem	A	na	Yes	S, A	na	na	na
Cow Pit	W52/2	floor, Cow Pit	cave turnip speleothem	na	na	na	A	na	na	na
Cow Pit	W52/3	wall, Cow Pit	cave turnip speleothem interior	na	na	na	A	na	na	na
Cow Pit	W52/4	wall, Cow Pit	white speleothem coating	na	na	Yes	A	na	na	F
Cow Pit	W52/5	wall, Cow Pit	lithified red sediment	na	na	Yes	A	na	na	na
Cow Pit	W52/6	wall, Cow Pit	unconsolidated red sediment	na	na	Yes	S	na	na	F
surface	W52/7	near Cow Pit	marble	na	na	na	S	Yes	U	na
surface	W52/8	near Cow Pit	weathered speleothem	na	na	na	S	Yes	U	na
surface	W52/9	near Cow Pit	Broom breccia	na	na	na	S	Yes	U	na
Sigma	Σ/1	wall of Aragonite Canyon, east	aragonite splinters	na	na	Yes	A	na	na	na
Sigma	Σ/2	Psi Pit	carbonated grike fill	na	na	Yes	S	Yes	U	F
surface	Σ/3	near Sigma upper entrance	marble	na	na	Yes	S	Yes	U	F
Sigma	Σ/4	wall, Iota Grotto	gypsum coating	na	na	Yes	S, A	na	na	na
Sigma	Σ/5	floor, Iota Grotto	calc-silicate coralloid	na	na	Yes	S	na	na	na
Sigma	Σ/6	ceiling, Iota Grotto	helictite	na	na	na	S	na	na	na

Register of Samples, Wombeyan Caves

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from previous page

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Sigma	Σ/6a	ceiling, Iota Grotto	helictite substrate	na	na	na	na	na	na	na
Sigma	Σ/7	Aragonite Canyon, east, near floor	aragonite hemispheres	na	Yes	na	S, A	na	na	na
Sigma	Σ/8	Aragonite Canyon, south, wall vein	vein	na	na	Yes	S	na	na	na
Sigma	Σ/9	Aragonite Canyon, floor	aragonite coralloids	na	Yes	Yes	S	na	na	na
Sigma	Σ/10	Aragonite Canyon, north, wall	anthodite fragments	na	Yes	Yes	S	na	na	na
Sigma	Σ/11a	east of Aragonite Canyon, nth wall	vein	na	na	Yes	S	na	na	na
Sigma	Σ/11b	east of Aragonite Canyon, nth wall	speleothem	na	na	Yes	S	na	na	na
Sigma	Σ/11c	east of Aragonite Canyon, nth wall	clay	na	na	Yes	S	na	na	na
Sigma	Σ/12	ceiling, Iota Grotto	straw stalactite	na	na	Yes	S	na	na	na
Sigma	W111a	Aragonite Canyon, floor	clear part, stalagmite fragment	na	na	Yes	S	Yes	na	na
Sigma	W111b	Aragonite Canyon, floor	chalky part, stalagmite fragment	na	na	Yes	S	Yes	na	na
Sigma	W111c	Aragonite Canyon, floor	sediment, stalagmite fragment	na	na	na	S	na	na	na
Sigma	W114	Aragonite Canyon, wall	prickles, anthodite	na	na	Yes	S	na	na	na
Guineacor	W121/1	western wall in cave	part of speleothem	na	na	na	A	na	na	na
Guineacor	W121/2	western wall in cave	part of speleothem	na	na	na	S	na	na	na
Guineacor	W121/3	helictite wall in cave	part of speleothem	na	na	na	S	na	na	na
Guineacor	W121/4	helictite wall in cave	part of speleothem	na	na	Yes	na	na	na	na
surface	W121/5	near Guineacor entrance	marble	na	na	na	S	Yes	U	na
surface	W121/6	near Guineacor entrance	Broom breccia	na	na	na	S	Yes	U	na
surface	W121/7	near Guineacor entrance	weathered speleothem	na	na	na	S	Yes	U	na
Wollondilly	W144/1a	Star Chamber	coralloid speleothem	na	na	na	A	na	na	na
Wollondilly	W144/1b	Star Chamber	coralloid speleothem	na	na	Yes	A	na	na	na

Register of Samples, Wombeyan Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Wollondilly	W144/2	Star Chamber	speleothem coating	na	na	Yes	A	na	na	na
Wollondilly	W144/3	Star Chamber, pendant	recrystallised speleothem	A	na	Yes	S, A	na	na	na
Wollondilly	W144/4	Star Chamber, wall	recrystallised speleothem	A	na	Yes	A	na	na	na
Wollondilly	W144/5	The Loft	fluffy speleothem	na	na	Yes	A	na	na	na
Wollondilly	W144/6a	Jacobs Ladder	recrystallised speleothem	na	na	Yes	A	na	na	na
Wollondilly	W144/6b	Jacobs Ladder	recrystallised speleothem	na	na	Yes	A	na	na	na
Wollondilly	W144/7	Jacobs Ladder	mud and sediment substrate	na	na	Yes	S	na	na	B
Wollondilly	W144/8	The Pantheon	hopper coralloid	na	na	Yes	A	na	na	na
Wollondilly	W144/9	The Loft	speleothem, grey crust	na	na	Yes	S, A	na	na	na
Wollondilly	W144/10	The Loft	white fluffy speleothem	na	Yes	na	S, A	na	na	na
Wollondilly	W144/11	The Loft	pale orange fluffy speleothem	na	Yes	Yes	S, A	na	na	na
Wollondilly	W144/12	The Loft	substrate to white fluffy speleothem	na	na	Yes	S, A	na	na	na
surface	W144/13a	near Wollondilly upper entrance	marble	na	na	na	S	Yes	U	na
surface	W144/13b	near Wollondilly upper entrance	marble	na	na	na	S	Yes	U	na
Tattered Shawl	W161/1	side chambers past base of main pitch	clay	na	na	Yes	na	na	na	na
Tattered Shawl	W161/2	side chambers past base of main pitch	clay	na	na	na	na	na	na	F
surface	W161/3	above Ohno Drop	weathered porphyry	na	na	Yes	S, A	Yes	U	na
surface	W161/4a	Sigma creek	gabbro	na	na	Yes	S	Yes	U	na
surface	W161/4b	Sigma creek	hypersthene porphyry	na	na	Yes	na	Yes	U	na
surface	W161/5	Sigma creek	marble	na	na	na	S	Yes	U	na

Register of Samples, Wombeyan Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
surface	W161/6a	Sigma creek	marble	na	na	na	S	Yes	U	na
surface	W161/6b	Sigma creek	marble	na	na	na	S	Yes	U	na
surface	W161/7	Sigma creek	gabbro	na	na	Yes	S	Yes	U	na
surface	WOM-1	Wombeyan Creek	Columba Granite	na	na	Yes	na	Yes	P	na
surface	W203/1	near Lone Shoe Cave	Ironstone	na	na	Yes	S	na	na	na
surface	W203/2	near road	goethite	na	na	Yes	S	na	na	na
surface	WOM-2	near Igneous Fingers Spring	chert	na	na	na	S	Yes	U	na
Bullio	W2	Dog chamber	gypsum coated grike fill	na	na	Yes	S	na	na	na
surface	WOM-4a	east of Victoria Arch	hypersthene porphyry	na	na	na	na	Yes	U	na
surface	WOM-4b	east of Victoria Arch	hypersthene porphyry	na	na	na	na	na	na	na
surface	WOM-4c	east of Victoria Arch	hypersthene porphyry	na	na	na	na	na	na	na
surface	WOM-5	centre of park	phonolite	na	na	na	na	Yes	U	na
surface	WOM-6	centre of park	tuff	na	na	na	na	Yes	U	na
surface	WOM-7	White Bend	dacitic tuff	na	na	na	na	Yes	U	na
surface	WOM-8	roadside, NW corner of reserve	Columba Granite	na	na	na	na	na	na	na
surface	WOM-9	250 m SW of Glass Cave	gabbro	na	na	na	na	Yes	U	na

Table B.2: Register of Samples, Wombeyan Caves.

Walli Caves

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Deep Hole	WA17/1	site S1	water	na	na	na	A	na	na	na
Deep Hole	WA17/2a	site S2	gypsum	na	na	Yes	A, S	na	na	0
Deep Hole	WA17/2b	site S2	limestone	na	na	na	A, S	Yes	P	F
Deep Hole	WA17/2c	site S2	mixture gypsum and barite	na	na	Yes	A, S	na	na	B
Deep Hole	WA17/3a	site S3	coated limestone nodule	na	na	na	A, S	Yes	na	S
Deep Hole	WA17/3b	site S3	crystal coating	na	na	Yes	A, S	na	na	F
Deep Hole	WA17/4	site S4	ochreous chert nodule	na	na	Yes	S	Yes	P	F
Deep Hole	WA17/8	“Shale Beds”	thinly bedded limestone	na	na	na	A, S	Yes	U	na
Deep Hole	WA17/9a	“Shale Beds”	speleothem coating	na	na	Yes	A, S	na	na	na
Deep Hole	WA17/9b	“Shale Beds”	thinly bedded limestone	na	na	na	A, S	na	na	na
Deep Hole	WA17/9c	“Shale Beds”	clay	na	na	na	A, S	na	na	na
Deep Hole	WA17/10	site X	limestone fragment	na	na	na	A, S	na	na	na
Deep Hole	WA17/10a	site X	coating on limestone	na	na	Yes	A, S	na	na	na
Deep Hole	WA17/11	site Y	vein	na	na	Yes	A, S	na	na	na
Deep Hole	WA17/12	site Z	vein	na	na	Yes	A, S	na	na	na
Deep Hole	WA17/13	site Z	aragonite spheroid	na	na	Yes	A, S	na	na	na
Deep Hole	WA17/14a	site S4	limestone	na	na	na	A, S	na	na	na
Deep Hole	WA17/14b	site S4	crystal coating	na	na	na	A, S	na	na	na
Deep Hole	WA17/15	site S4	crystal coating	na	na	Yes	A, S	na	na	na

Register of Samples, Walli Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Piano	WA12/1	site S1	gypsum extrusion	na	na	na	A, S	na	na	na
Piano	WA12/2	site S1	gypsum transistors	na	na	na	A, S	na	na	na
Piano	WA12/3	site S1 ceiling	gypsum flake	na	na	na	A, S	na	na	na
Piano	WA12/4	site S2	gypsum and aragonite	na	na	Yes	S	na	na	na
Piano	WA12/5	site S2	small speleothem	na	na	na	S	na	na	na
Piano	WA12/6	site S2	“rotten” rock	na	na	na	S	na	na	0
Piano	WA12/7	site S2	small white sphere	na	na	na	S	na	na	na
Piano	WA12/8	site S3	small speleothem	na	na	Yes	A	na	na	na
Piano	WA12/9	site S3	powdery speleothem	na	na	Yes	A	na	na	na
Piano	WA12/10	site S4	pink speleothem	na	na	Yes	A, S	na	na	na
Piano	WA12/11	site S4	small crystals	na	na	na	A, S	na	na	na
Piano	WA12/12	site S1	gypsum (selenite)	na	na	na	S	na	na	na
Piano	WA12/13	site S1	chert nodule	na	na	Yes	A, S	na	na	F, 0
Piano	WA12/14	site S5	small “tray” speleothem	na	na	Yes	S	na	na	S
Piano	WA12/15	site S5	calcite scales	na	na	Yes	A, S	na	na	na
Piano	WA12/16	site U	vein	na	na	Yes	S	na	na	na
Piano	WA12/17	site W	speleothem coating	na	na	na	S	na	na	na
Piano	WA12/18	site W	coated chert nodule	na	na	Yes	S	na	na	na

Register of Samples, Walli Caves

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Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
surface	WA17/5a	above Deep Hole	pink coating on limestone	na	na	Yes	A, S	na	na	F
surface	WA17/5b	above Deep Hole	vein in limestone	na	na	Yes	A, S	Yes	U	F
surface	WA17/5c	above Deep Hole	limestone	na	na	na	A, S	Yes	U	na
surface	WA17/6a	above Deep Hole	vein in limestone	A	na	na	A, S	Yes	U	0
surface	WA17/6b	above Deep Hole	limestone	A	na	na	A, S	Yes	U	na
surface	WA17/7a	above Deep Hole	chert in limestone	na	na	na	S	Yes	U	0
surface	WA17/7b	above Deep Hole	limestone	na	na	Yes	S	Yes	U	na

Table B.3: Register of Samples, Walli Caves.

Other Caves

Samples B69, LC26 and IA2 were collected by Osborne.

Cave	Sample No.	Location	Description	Raman	SEM	XRD	Photo	TS	Slab	Acid
Flying Fortress, Bungonia	B17/1 (B69)	near dyke	top of aragonite spheroid	A	na	na	na	na	na	na
Flying Fortress, Bungonia	B17/2 (B69)	near dyke	base of aragonite spheroid	A	na	Yes	S	na	na	na
Lannigans Cave, Colong	LC26a	near dyke in cave	white coating	na	na	Yes	S	na	na	na
Lannigans Cave, Colong	LC26b	near dyke in cave	brown coating	na	na	na	S	na	na	na
Phosphate Mine	IA2	mine	phosphatic nodule	na	na	na	S	Yes	U	na
Phosphate Mine	IA2a	IA2	spar from nodule	na	na	Yes	na	na	na	na
Phosphate Mine	IA2b	IA2	phos. from nodule	na	na	Yes	na	na	na	na

Table B.4: Register of Samples, Other Caves.

B.2 Thin sections

Thin sections numbered N... and '-' were prepared by the School of Geosciences Thin Section Technician, George Navratil.

Cave	Rowling ref.	Navratil ref.	Material
Sigma Cave, Ohno Drop	Σ2	N35768	filled grike
Surface at Sigma Cave	W45/3, Σ3	N35766	marble
Surface at Wollondilly Cave	W144/13A	N35929	marble
Surface at Wollondilly Cave	W144/13B	N35930	marble
Surface near CO_2 Pit	W43/2	N36084	marble
Surface near CO_2 Pit	W43/3	N35937	marble
Surface near CO_2 Pit	W43/4	N35938	marble
Surface near Cow Pit	W52/7	N36085	marble
Surface near Cow Pit	W52/8	N35939	weathered speleothem
Surface near Cow Pit	W52/9	N35940	broom breccia
Surface near Guineacor Cave	W121/5	N35941	marble
Surface near Guineacor Cave	W121/6	N35942	Broom breccia
Surface near Guineacor Cave	W121/7	N35944	weathered speleothem
Surface near Tattered Shawl Cave	W161/3A	N35931	weathered porphyry
Surface near Sigma creek	W161/4A	N35932	gabbro
Surface near Sigma creek	W161/4B	N35933	hypersthene porphyry
Surface near Sigma creek	W161/5A	N35934	marble
Surface near Sigma creek	W161/6A	N35943	impure marble
Surface near Sigma creek	W161/6B	N36086	impure marble
Surface near Sigma creek	W161/7A	N35935	gabbro
Wombeyan Creek	WOM-1	N35850	Columba Granite
Igneous Fingers spring	WOM-2	N35936	siltstone
Surface E of Victoria Arch	WOM-4	N36886	hypersthene porphyry
Surface, centre of park	WOM-5	N36887	phonolite
Surface, centre of park	WOM-6	N36888	tuff
Surface, White Bend	WOM-7	N36889	dacitic tuff
Surface, SW of Glass Cave	WOM-9	N36890	gabbro

Table B.5: Rock thin sections, Wombeyan Caves.

Cave	Rowling ref.	Navratil ref.	Material
Surface near Contact Cave	J105/1	N35858	dolomitic limestone
Surface near Contact Cave	J105/2	N35859	dolomitic limestone
Surface near Contact Cave	J105/3	N35860	dolomitic limestone
Surface near Contact Cave	J105/4	-	dolomitised limestone
Contact Cave	J105/5ug	-	weathered dolomitic limestone
Contact Cave	J105/11	-	dolomitised limestone
Surface near Contact Cave	J105/13	-	dacitic crystal tuff
Surface near Contact Cave	J105/14	-	welded tuff
Surface near Contact Cave	J105/15	-	mafic lava
Surface near Contact Cave	J105/16	-	mafic lava
Surface near Contact Cave	J105/19	-	qz porphyry
Surface near Contact Cave	J105/20	-	dolomitised limestone
Surface near Contact Cave	J105/21	-	rhyolite porphyry
Surface near Contact Cave	J105/24	-	qz porphyry
Wiburds Lake Cave	J58/2	-	weathered dyke
Wiburds Lake Cave	J58/3	-	weathered dyke
Wiburds Lake Cave	J58/5	-	weathered dolomitic material
Wiburds Lake Cave	J58/6	N35851	limestone
Wiburds Lake Cave	J58/8	-	weathered dyke
Wiburds Lake Cave	J58/9	-	base of dense vugh
Wiburds Lake Cave	J58/12	-	base of dense vugh
Wiburds Lake Cave	J58/14	N35852	dyke
Wiburds Lake Cave	J58/16	N35853	light wackestone
Wiburds Lake Cave	J58/17	N35854	dyke
Wiburds Lake Cave	J58/19	N35855	limestone
Wiburds Lake Cave	J58/21	N35856	weathered breccia
Wiburds Lake Cave	J58/22	N35754	sheared argillite
Wiburds Lake Cave	J58/24	N35755	fault zone breccia
Wiburds Lake Cave	J58/25	N35756	fault zone breccia
Wiburds Lake Cave	J58/26	N35857	carbonated dyke
Wiburds Lake Cave	J58/30	N36515	fault zone breccia
Wiburds Lake Cave	J58/32	N36516	fault zone breccia
Wiburds Lake Cave	J58/33	N36517	fault zone breccia
Surface, Lucas Rocks	JEN/1	N36370	goethite concretion
Surface, near Burma Rd	JEN/5	N36371	radiolarian chert
Surface, near Burma Rd	JEN/7	N36372	ferruginised wackestone
Surface near Nth. Mammoth	JEN/9A	N36450	wackestone
Surface near Nth. Mammoth	JEN/9B	N36450	wackestone
Surface near Nth. Mammoth	JEN/10A	N36451	wackestone
Surface near Nth. Mammoth	JEN/10B	N36451	wackestone
Surface near Hennings	JEN/11	N36518	micromonzonite dyke

Table B.6: Rock thin sections, Jenolan Caves.

Cave	Rowling ref.	Navratil ref.	Material
Deep Hole	WA17/2	N35757	limestone with speleothem coating
Deep Hole	WA17/3	N35767	limestone with speleothem coating
Deep Hole	WA17/4	N35758	altered chert
Surface near Deep Hole	WA17/5A	N35717	limestone
Surface near Deep Hole	WA17/5B	N35718	limestone
Surface near Deep Hole	WA17/6	N35647	limestone
Surface near Deep Hole	WA17/7A	N35719	limestone with chert
Surface near Deep Hole	WA17/7B	N35720	limestone with chert
Deep Hole “Shale Beds”	WA17/8	N36083	thinly bedded limestone

Table B.7: Rock thin sections, Walli Caves.

Cave	Rowling ref.	Navratil ref.	Material
Phosphate Mine	IA2a	N36449	phosphatic nodule
Phosphate Mine	IA2b	N36449	phosphatic nodule
Phosphate Mine	IA2c	N36449	phosphatic nodule

Table B.8: Rock thin sections, Wellington Caves. Osborne sample IA2.

Cave	Bauer ref.	UoW ref.	Other ref	Material (Bauer/Rowling)
Flying Fortress Cave	TS11453	R14327	02B17	dolomitised biomicrudite
Flying Fortress Cave	TS11447	R14321	017B17	dolostone
Argyle Hole	TS11428	R14303	02B31	carbonated dolostone
Argyle Hole	TS11438	R14313	011B31	dolomitised pelmicrite
Argyle Hole	TS11426	R14301	00B31	dolomitised intramicrite
Argyle Hole	TS11441	R14315	012B31	anhydrite with qz. and calcite
surface	TS11457	R14328		dolomitised pelloidal micrite
surface	TS11468	R14337		dolomitised biolithite

Table B.9: Bauer’s rock thin sections, Bungonia caves. UoW = University of Wollongong.

Appendix C

List of Caves Reported as Containing Aragonite in NSW

Cave Area	Tag No.	Cave Name	JR Visited	Confirmed aragonite?	Ease of physical access	Comments
Bungonia	B-4, 5	Extension	12-7-92	-	CO_2	Xref B17. Julie and Peter Bauer said ceiling of Coffin Chamber contains arag.; Joe Sydney reports arag from deep in the Extension just before the “Lavatory Pan Squeeze.”

Caves in NSW reported to contain aragonite

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Cave Area	**Tag No.**	**Cave Name**	**JR Visited**	**Confirmed aragonite?**	**Ease of physical access**	**Comments**
	B-17	Flying Fortress	19-5-01	Yes	One short handline drop, rigging for lower section only	Bauer's thesis, RAO's sample. Near the dyke there are interesting deposits. Flos ferri and arag in ceiling of Magnathea chamber at other end to dyke, i.e. up the flowstone; associated with dolomitised limestone.
Cliefden	CL-2	Murder	20-7-96	-	rel. easy	A number of interesting sites. The blue stal is discussed in Turner (2002).
	CL-3	Boonderoo	-	Yes	Very muddy	The Aust. Museum sampled site. Substrate of the blue stal. unknown but OSS did not allow access to cave.
	CL-5	Taplow Maze	-	-	Maze	G.K. Smith sampled site reported as aragonite. Has blue stals.
Colong	CG-1	Colong	1997	trace	long walk in	Alan and Megan Pryke are preparing a much better map. Alan Pryke's photo looks like arag. RAO's sampled material from dyke is mostly calcite but contains traces of arag.
Jaunter	JA-?	Crystal	2-9-95	-	relatively easy	Particularly good displays of arag anthodites. However Tarakuanna property owner does not allow any visits.

Caves in NSW reported to contain aragonite

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Cave Area	Tag No.	Cave Name	JR Visited	Confirmed aragonite?	Ease of physical access	Comments
	JA-32, 33, 34, 35	Tugellella		-	long wet crawl	Hills C. C. reports aragonite associated with a dyke or zone of recrystallised calcite.
Jenolan	J-2	Chifley	31-12-00	-	Easy via Imperial	Show cave. Moonmilk, surface coatings. Trickets “mystery”; cauliflower and potato shaped speleothems.
	J-7	Lucas	12-9-98	-	Easy	Show cave. Moonmilk, surface coatings, “potatoes”. Iain McCulloch reported arag in rockpile between Lucas and River. Ladder req’d. to access the area in rockpile.
	J-8	Orient + Ribbon	31-12-00	Yes	Easy	Show cave. Long helictites, twinned butterfly helictites, white hemispheres on red infill. Aust. Museum samples of aragonite “stars”.
	J-9	Temple of Baal	3-5-98	-	Easy	Show cave. Large round masses of helictites and maybe arag.
	J-11	Cerberus (Skeleton)	27-4-96	-	Easy	Show cave. Arag. stalactites, straws, furze bushes.
	J-??	River (Mud Tunnels)	?	Yes	Easy	Show cave. Arag. furze bush.

Caves in NSW reported to contain aragonite

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Cave Area	Tag No.	Cave Name	JR Visited	Confirmed aragonite?	Ease of physical access	Comments
	J-13	Mammoth	3-11-02	-	varies	Area called “The World of Mud” and associated areas were investigated. The leads off Horseshoe Cavern look tight but apparently lead to an area containing aragonite. See also Dunkley & Anderson (1978) p14,15, 19: Upper Oolite.
	J-17	Glass	2-5-98	Yes	rigging req’d	Altogether a very interesting cave. A fair bit of arag. in Chevalier extension. Similar to Orient and Ribbon Caves.
	J-18, 25	Frenchmans	23-5-93	-	rigging req’d	Interesting because of the dyke. Some unusual calcite deposits near it.
	J-35, 36, 37, 58, 60, 61, 72	Serpentine - Little Canyon - Diggins Diggins - Nostrils	20-4-92	-	rigging req’d	Cavers may be confusing small acicular calcite helictite clusters with aragonite.
	J-39, 76, 77	Hennings	12-5-01	-	easy	arag as reported by cavers may be just helictites. Maybe arag under canopy in main chamber. Phil Maynard said it juts out of the wall on the south side of the cave. It is rather odd. Someone has sampled part of it.

Caves in NSW reported to contain aragonite

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Cave Area	**Tag No.**	**Cave Name**	**JR Visited**	**Confirmed aragonite?**	**Ease of physical access**	**Comments**
	J-41, 42	Dwyers	19-11-94	-	varies	Upper section relatively easy. However lower section where arag is reported by cavers requires 15+ hour trip with scaling poles and "carnivorous" mud.
	J-58 etc.	Wiburds Lake Cave	12-7-02	Yes	varies	The Maze, Neddys Knock and up in Western Passage. Eureka Track is apparently good but requires some rigging and rockclimbing.
	J-105	Contact	12-7-02	Yes	short pitch	Anthodites, arag. coated with hydromagnesite
	J-174	Spider	9-11-97	-	grunter	Moonmilk in ent area; Striped wall in ent area; shishkebab arag. 'tites in Helitite Hall.
	J-240	?	-	-	ladder + sqz	Arag. reported in Welch (1976).
Timor	TR-7,8	Hill	24-7-94	-	tight	Haven't seen all; cave turnips reported by Gary Smith
Walli	WA-12	Piano , Long	18-8-2002	Yes	easy	Historical aragonite observations (Wilkinson).
	WA-17	Deep Hole	-	Yes	vertical	Arag. reported by Geoff McDonnell and Frank (1974).
Wee Jasper	WJ-1	Dip	15-3-98	Yes	Vertical access to some parts	Popular adventure cave. Arag. reported to R.A. Osborne.

Caves in NSW reported to contain aragonite

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Cave Area	**Tag No.**	**Cave Name**	**JR Visited**	**Confirmed aragonite?**	**Ease of physical access**	**Comments**
	WJ-8	Punchbowl	14-3-98	Yes	Vertical access to most parts	Popular adventure cave. Arag in Australian Museum D44628 looks like a mass of brown aragonite popcorn. Could be from either Edies Grotto or from the dry crystal pools below the Laundry Chute.
	WJ-13	Dogleg	-	-	Arag. area often cut off by sumps	Popular adventure cave. Arag reported by SUSS, photos, anthodites. Discovered by digging and climbing during dry spell in 2004. Said to be associated with dyke.
	WJ-100	Careys	25-10-92	Yes	easy	Well decorated show cave.
	?	Nice	-	-	Special permission	Nice cave; may have arag heligmites.
Wombeyan	W-12	Shawl	?	-	Ladder req'd	Listed in Wombeyan Book as having arag but the actual material looks like fine calcite helictites.
	W-45, 415	Sigma	6-4-02	Yes	8 hr trips	Extensive system; aragonite canyon in particular.
	W-52	Cow Pit	7-8-99	trace	Easy	"Turnips" - Hemispherical speleothems, hollow, with spiky calcite? interiors. Associated with Pleistocene? fill. Some are naturally broken, poss. due to pressure inside.

Caves in NSW reported to contain aragonite

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Cave Area	Tag No.	Cave Name	JR Visited	Confirmed aragonite?	Ease of physical access	Comments
	W-121	Guineacor	26-8-00	No	Easy.	West wall is covered in interesting helictites, some which look spiky like arag. but XRD calcite. Flowst. near ent. has flat laths that may be aragonite.
	W-144	Wollondilly	7-4-02	-	Easy	Xref Mulwaree; Show cave; Cathedral area in particular.
	W-146	Kooringa	18-12-99	-	Easy	Show cave. Spiky white coating on ceiling near bend in staircase. Also folia and ceiling corrosion. Also “turnips”.
	W-182	Lantern	21-6-98	-	Rigging difficulties	A crumbly entrance leads straight onto a pitch. Apparently the ceiling has something interesting.
	W-384	Blackberry Hole (Dutchmans)	7-8-99	-	Easy	In the lower SW corner, there’s a complex stalactite which may have arag. hairs. Has helictites and may be developed on infill.
Wyanbene	WY-1	Wyanbene Main	25-3-00	Yes	Wet and rigging	Good examples of anthodites and flos ferri, popcorn, etc. Complicated geomorphology.
Yarrangobilly	Y-25	North Glory Hole	-	-	easy	Show cave
	Y-1	West Eagles Nest	-	-	?	Arag. reported by Geoff McDonnell on 30-4-2000

Table C.1: Caves in NSW reported to contain aragonite