DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 84/53

A PETROGRAPHIC DESCRIPTION OF TEN SAMPLES FROM MOUND SPRINGS OF THE GREAT ARTESIAN BASIN

GEOLOGICAL SURVEY

by

J. BEAL

and

A.F. WILLIAMS

JULY, 1984

DME.

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Photographs

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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A PETROGRAPHIC DESCRIPTION OF TEN SAMPLES FROM MOUND SPRINGS OF THE GREAT ARTESIAN BASIN

ABSTRACT

Ten samples of mound spring tufa were analysed by the Australian Mineral Development Laboratories (1977). Thin sections identified mineralogy, fossil fauna and flora and petrographic structure.

Mineralogy is mainly recrystallized calcite and detrital silica grains with calcareous silt, feldspar, silcrete pebbles and opaques; some of these constituents possibly have a windborne origin. Fauna is gastropod shells and flora, reed casts.

Formation of the tufa is generally considered to have originated by the nucleation of calcium carbonate upon gastropod shells, reeds, sand grains and opaque minerals.

INTRODUCTION

The purpose of this report is to present data resulting from field work (mid-1976) by the authors which has not previously appeared in report form.

The data is two reports (Appendix A) by AMDEL which describe in detail the composition of ten tufa samples taken from several mound springs visited for the purpose of collecting water samples.

DISCUSSION

The samples were collected from mound springs in the William Creek-Nilpinna-Peak and Denison Ranges area of northern South Australia while collecting samples of mound spring water for chemical analysis.

The tufa samples are mainly massive in texture with the exception of sample P414/76 which shows a fairly well developed layering and which could be described as travertine.

In one sample (P409/76) early layering has been disrupted by later crumpling followed by the further addition of material, in layers, followed by compaction.

In general the limestone has nucleated over an irregular surface and upon such objects as shells, reeds and windborne detritus. Layering is haphazard within several of the specimens, possibly due to the intermittent and varying nature of water flow and water-flow levels.

In several of the samples varying amounts of dissolution and recrystallization of the calcite has occurred in both mineral grains and in some of the gastropod shells.

J. C. Beal

JCB:DP

J.C. BEAL
SENIOR GEOLOGIST
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SECTION

REFERENCES

Dept. of Mines and Energy, Groundwater and Engineering Branch - working files 79-19; 79-21; 84-30

APPENDIX A

Report MP 993/77 and MP 994/77 from Amdel on the Petrographic description of ten Mound Springs Samples

A.F. Williams & J.C. Beal
7/2/77

amdel

The Australian Mineral Development Laboratories

Winner of Award for Outstanding Export Achievement, 1975

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Please address all correspondence to Frewville.
In reply quote: MP 1/17/0

4th February, 1977

The Director,
Department of Mines,
PO Box 151,
EASTWOOD, SA 5063.

Attention: Mr A.F. Williams

REPORT MP 993/77

YOUR REFERENCE:	Application for service work dated 27/9/76.
MATERIAL:	Six hand specimens
LOCALITY:	Beresford Hill (Out of Hundreds). Aerial Photo Location: Kewson/Run 1/07
IDENTIFICATION:	a to f, P406/76 to P411/76 respectively
DATE RECEIVED:	28/9/76
WORK REQUIRED:	Petrographic description

Investigation and Report by: R. Cooper

Officer in Charge, Mineralogy/Petrology Section: Dr K.J. Henley

for F.R. Hartley
Director

c.c. Department of Mines,
NARACOORTE, SA 5271.

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PETROGRAPHIC DESCRIPTION OF SIX MOUND-SPRING LIMESTONES (TUFAS) FROM THE VICINITY OF BERESFORD HILL

1. INTRODUCTION

Six samples, labelled P406/76 to P411/76, were submitted by the South Australian Department of Mines (Mr A.F. Williams, Hydrogeology Section) for petrographic description.

2. SUMMARY

These six samples of limestone (tufa) consist of finely crystalline calcite with minor to trace amounts of dolomite, quartz, clay and opaques. Varying amounts of dissolution and recrystallization of the calcite has occurred in the samples and in some gastropod shells and reed casts are preserved.

3. PETROGRAPHIC DESCRIPTIONS

Sample: a, P406/76; TS36634

Aerial Photograph Location: Kewson/Run 1/072/1a.

Rock Name:
Limestone (Tufa)

Hand Specimen:
The bulk of this sample is grey, weakly layered with the bands being up to 2 mm across and contains numerous lenticuluar friable patches up to 5 mm long some of which have largely leached away leaving behind pits and cavities. An irregular system of fractures is also present in the sample but no fossil remains or reed casts could be positively identified. On one surface there is a light coloured, finely crystalline and finely layered band which is up to 5 mm thick and on its exposed side has a botryoidal appearance. This layer is possibly flowstone (travertine).

Thin Section:
An optical estimate of the constituents gives the following:-

	%
Calcite	>95
Quartz	1-4
Clay	2-6

An X-ray diffraction analysis of this sample indicates that dolomite is present in trace amounts but this could not be distinguished with certainty during the optical examination of the thin section. The X-ray diffraction analysis also indicated that the calcite was poorly crystalline and did not detect the clay that was present. Presumably the clay is very poorly crystalline or amorphous and gives either a very weak pattern or no pattern.

In the thin section the calcite appears as an interlocked mosaic of equant but irregularly shaped crystals which range in size from less than 0.03 mm up to at least 0.2 mm. The main features of the layering which is

visible in the hand specimen are the clay-filled patches/voids occurring between the layers and, in a few cases, distinct changes in the size of the calcite crystals. Only in a few places do the calcite crystals have a prismatic habit and appear to be orientated in a pattern relating to growth and/or the development of the faint layers visible in the hand specimen.

The quartz occurs as equant subrounded to angular (xenomorphic) grains/crystals which are typically about 0.04 mm across and rarely up to 0.06 mm across.

The clay in the patches/voids is pale brown, finely crystalline and in places stained with limonite.

There is some evidence that the calcite in the sample has recrystallized since deposition. There appears to have been reaction between some of the quartz grains and the calcite that surrounds them and the clay-filled patches or voids usually are surrounded by a band of finely crystalline calcite.

The light coloured layer on one surface of this sample is composed of calcite. However, this calcite has a distinctly different habit to that in the rest of the rock and occurs as aggregates/sprays of crystals of strongly prismatic habit. The aggregates which appear to have developed away from the bulk of the sample extend, in some cases, for several millimetres and contain individual crystals which are just as long. The only evidence of the fine banding visible in this layer in the hand specimen is the existence in some places of fine dislocations, these dislocations (the visible layering) being normal to the direction in which the crystals have developed.

This is a sample of limestone (tufa) which has recrystallized probably quite extensively since it was deposited. No fossil remains or reed casts could be distinguished in this sample and there is a layer of travertine/flowstone along one edge.

Sample: b, P407/76; TS36635

Aerial Photograph Location: Kewson/Run 1/072/1b

Rock Name:
Limestone (Tufa) containing pebbles of calcareous siltstone

Hand Specimen:
This sample is pale grey-pink, finely crystalline and largely featureless except for numerous cavities/pits up to 5 mm across and a number of pebbles the largest of which is several centimetres across. The pits are possibly weakly aligned but this is not a prominant feature. The pebbles are dark, finely crystalline and subrounded to well rounded. The external surface of this sample is rough, corroded and covered in places with lichens.

Thin Section:

An optical estimate of the constituents gives the following:-

	%
Host Rock	
Carbonate (mainly calcite)	>98
Opaques (goethite/limonite and ?carbonaceous material)	trace
Pebbles	
Quartz	4-8
Feldspar	1-3
Calcite	80-90
Clay/phyllosilicates	2-4
Opaques	1-3
Accessory: ?staurolite	trace

The pebbles constitute less than 10% of the sample.

The bulk of this sample consists of finely crystalline and turbid carbonate which is probably mainly calcite. The crystal size of this carbonate is less than 0.01 mm and it is probably mainly because of this fine crystallinity that the carbonate is semi-turbid and semi-opaque. A microchemical staining test for calcite was applied to this sample and much of the finely crystalline carbonate has stained although in some places the result is inconclusive. In the finely crystalline carbonate there are numerous cavities some of which are several millimetres across and about these there is normally a rim of calcite which is more coarsely crystalline to that in the rest of the rock. This calcite has a crystal size of up to 0.04 mm and unlike the more finely crystalline carbonate has responded very positively to the microchemical staining test.

Opaque material occurs in trace amounts in the host rock as small grains/patches which range in size up to 0.06 mm across. The bulk of this opaque material is thought to be geothite-limonite but there is also probably some carbonaceous material present.

The pebbles consist mainly of calcite through which is dispersed small grains of quartz, feldspar and opaques and small patches of clay/phyllosilicates. The calcite although more coarsely crystalline than the bulk of the carbonate in the host rock still has a crystal size of 0.06 mm or less. Unlike the carbonate/calcite in the host rock this calcite responded well to the microchemical staining test. The quartz grains are angular to sub-rounded in shape and range in size up to 0.1 mm across. There angularity may be a primary feature but could well have been enhanced through reaction with the calcite matrix. The quartz grains are dispersed throughout the sample although not particularly evenly and there are patches, often ovoid, up to at least 1 mm across of pure calcite. Feldspar occurs as grains of similar size and shape to those of quartz and because of the fine grainsize some are difficult to distinguish. Clay, or at least 'clay-like phases' occur in small patches up to 0.1 mm across which are thought to have formed through alteration of other detrital phases (possibly feldspar and mica) since the rock was deposited.

Opaques, mainly goethite and limonite occur as small grains up to 0.06 mm across throughout the pebbles and goethite-limonite staining is particularly

heavy at the margins of the pebbles in a zone up to 1 mm thick.

This is a sample of limestone (tufa) which contains pebbles of calcareous siltstone. The calcite in the pebbles appears to be a primary feature and not to have developed through replacement since the pebbles became incorporated in the tufa.

Sample: c, P408/76; TS36636

Aerial Photograph Location: Kewson/Run 1/072/2a

Rock Name:
Sandy limestone (Tufa) containing numerous gastropod shells

Hand Specimen:
This sample is pale yellow-gray and appears to consist of numerous quartzose grains and small gastropod shells in a matrix of finely crystalline carbonate The quartzose pebbles are up to 3 mm across and range in shape from angular to well rounded. The gastropod shells are up to 2 mm across and in terms of size and structure (appearance of the chambers) are most likely of one species. Fine pits/cavities occur throughout the sample but are concentrated near the margins and the fossil remains appear to be more susceptible to dissolution than the matrix carbonate.

Thin Section:
An optical estimate of the constituents gives the following:-

	%
Calcite (matrix)	60-70
Calcite (shells)	10-20
Quartz (and a few silcrete pebbles)	10-20
Feldspar	trace-2
Opaques	1-3

This sample consists essentially of grains of quartz and gastropod shells in a matrix of finely crystalline calcite. Also present are a few feldspar grains, some opaque grains and a few silcrete pebbles. There are also patches, possible small pebbles, of more coarsely crystalline calcite some of which are regular in shape whereas others are highly irregular.

The quartz grains range in size from 0.04 mm up to at least 0.3 mm and are angular to subrounded in shape. The quartz grains are randomly oriented and although present throughout the sample tend to be concentrated in patches. It is not clear why the quartz grains are so concentrated although possibly it is related to the way the finer detritus in the rock accumulated about the gastropod shells.

There are also a few feldspar grains present which are of similar size and shape to the quartz grains.

The gastropod shells are up to several millimetres long and have been variably preserved. In some cases the shells appear intact (as seen in (thin section) but there are also broken shell fragments and, in a few places, it appears that the shell has been replaced by matrix calcite. Only one type of shell appears to be present although other species could be included among the broken fragments.

The matrix calcite is so finely crystalline as to appear turbid and semi-opaque. It may have partially replaced the quartz grains but this is not a prominent feature. At the external margins of the sample there are numerous fine cracks running through the rock parallel to the surface and it appears as if the weathering of this rock is probably controlled largely by chemical alteration/leaching which is largely confined to the matrix calcite. That the matrix consists of calcite was confirmed with a micro-chemical staining test.

Opaques occur as small subangular to subrounded grains which range in size up to 0.1 mm across, as minute granules, as goethite-limonite staining along fractures, and, in a few places, in small irregularly patches up to 0.1 mm across. The bulk of the opaques appear to consist of goethite-limonite but the small irregularly shaped patches could, in some cases, contain carbonaceous material.

In the portion of the rock thin sectioned there are at least two silcrete pebbles. These are up to 3 mm across, are of somewhat irregular shape and consist of fairly angular quartz grains and a finely crystalline quartzose matrix which is sieved with minute opaque granules. Also present in the sample are a number of patches of ? calcite which have a crystal size of approximately 0.1 mm (considerably coarser than the matrix calcite) and which did not respond very well to the microchemical staining test for calcite. Some of these may be small pebbles, some may be recrystallized portions of shell fragments and some appear to be recrystallized areas of the matrix.

This is a sample of sandy limestone (tufa) which contains numerous gastropod shells and a few silcrete pebbles.

Sample: d, P409/76; TS36637

Aerial Photograph Location: Kewson/Run 1/072/2b

Rock Name:

Limestone (Tufa) which is relatively hard and contains numerous ? crumpled colloform layers/lenses

Hand Specimen:

This sample is pale yellow-brown, relatively hard even though it contains numerous cavities/pits and appears to be composed of finely crystalline carbonate. The carbonate occurs as numerous ? crumpled colloform layers/lenses which are up to 2 - 3 mm thick and can extend for 1 cm or more. Between the irregular layers/lenses there are cavities, the largest of which are up to 1 cm across, there are ? clay-filled patches up to 5 mm across and, in a few places, incorporated in the carbonate layers/lenses there are irregular shaped slightly lighter coloured patches.

Thin Section:

An optical estimate of the constituents gives the following:-

	%
Calcite	>95
Quartz	2-4
Opaques	1-2

This sample consists mainly of calcite with minor to trace amounts of quartz and opaques. The bulk of the calcite occurs in layers, lenses and less regularly shaped colloform structures which can extend for several millimetres although many are circular/ovoid (or at least appear so in thin section) with individual layers ranging in thickness from a fraction of a millimetre up to at least 0.2 millimetres. How the carbonate formed in this manner is not known for certain although the following are possibilities:

1. The calcite formed as layers which have subsequently been disrupted and crumpled with the addition of further layers/material and resultant compaction.

2. The limestone has nucleated over an irregular surface and about objects such as shells, reeds and windborne detritus and, with a variable and possibly intermittent water/flow level has formed in a rather haphazard fashion.

As well as the calcite with colloform layering there are also patches which are finely crystalline and unstructured. These are the lighter-coloured patches visible in the hand specimen. Quartz grains tend to be concentrated within these patches and, to a lesser extent, opaque material. The carbonate in this sample was identified by a microchemical staining test.

Quartz occurs as angular to rounded grains which range in size from less than 0.02 mm up to at least 0.15 mm. The angularity of the quartz grains appears to have been enhanced in places through reaction with the matrix calcite.

There are also a few colourless prismatic crystals present, the largest of which are up to 0.2 mm long. Optically these crystals closely resemble quartz but their habit is somewhat unusual.

Opaques occur as subangular to subrounded grains which range in size up to 0.2 mm across and as less regularly shaped patches. Most of the opaques are thought to consist of goethite-limonite but trace amounts of carbonaceous material could also be present.

This is a limestone (tufa) which is relatively hard and contains numerous ? crumpled colloform layers/lenses. The rock is harder than normal for a tufa but the layering is not sufficiently regular for the sample to be called travertine. The development of the textures seen in this rock could be influenced by the regularity of the flow from the spring, the fauna and flora and possibly the periodic covering of the surface of the deposit with exotic detritus (possibly windborne).

Sample: e, P410/77; TS36638

Aerial Photograph Location: Kewson/Run 1/072/2c

Rock Name:

Limestone (Tufa) which is relatively hard, extensively recrystallized and contains abundant reed casts on one surface

Hand Specimen:

This sample is pale pink-brown, finely crystalline and is texturally irregular with numerous small cavities/pits, the largest of which are up to 5 mm across. On one of the weathered surfaces numerous tubular structures which are thought to be reed casts stand out in relief. These reed casts are tubular with a bore up to several millimetres and walls which are up to 1 mm thick and composed of finely crystalline carbonate which is slightly lighter in colour than the matrix carbonate. On the sawn surface ?pebble and reed-like structures are visible but the irregular 'mottling' suggests that the carbonate may have recrystallized to some extent.

Thin Section:

An optical estimate of the constituents gives the following:-

	%
Calcite	>95
Quartz	1-3
Goethite-limonite	1-3

This sample is composed essentially of calcite and is texturally highly variable due to recrystallization. Irregularly shaped patches of finely crystalline, turbid, semi-opaque calcite which range in size from a fraction of a millimetre up to several millimetres across and are semi-continuous through the rock are intergrown with more coarsely crystalline clear, limpid calcite which contains equant subidiomorphic crystals ranging in size up to 0.1 mm across. The proportions of turbid and clear calcite vary in different parts of the sample but overall clear calcite generally predominates slightly. In a few places it appears as if the finely crystalline calcite may have been brecciated and the coarser, clear calcite is filling the interstices formed.

Dispersed through the sample are grains of quartz and these are angular to subrounded in shape and up to 0.1 mm across. Some appear to have finely corroded margins and have probably reacted to some extent with the calcite in which they are embedded.

Goethite-limonite is associated with the clear, limpid calcite where it delineates growth bands within that calcite. Distinct opaque grains up to 0.2 mm across are also present and these occur in both the finely crystalline turbid calcite and the more coarsely crystalline clear calcite. These latter grains appear to consist of goethite.

This is a sample of limestone (tufa) which is relatively hard, extensively recrystallized and contains abundant reed casts on one surface. However, when viewed in thin section it is evident that recrystallization has occurred to the extent where original structures have been obliterated.

Sample: f, P411/76; TS36639

Aerial Photograph Location: Kewson/Run 1/072/1c

Rock Name:

Limestone (Tufa) of weathered, porous appearance which contains reed casts and a few gastropod shells.

Hand Specimen:

This sample is grey with lighter coloured patches, is porous and contains cavities up to 1 cm across and contains numerous tubular structures some of which are clearly reed casts as well as a few gastropod shells. The bore of the reed casts varies from less than 1 mm up to at least 4 mm and the ?walls of the reed casts vary from less than 1 mm up to about 1.5 mm. Some of the reed casts appear crumpled/flattened and many have been partially or wholly infilled with calcite. The gastropod shells are up to 3 mm long with chambers up to 1.5 mm across.

Thin Section:

An optical estimate of the constituents gives the following:-

	%
Carbonate (calcite with minor dolomite)	>98
Quartz	trace

In thin section this sample is seen to be composed essentially of finely crystalline carbonate and the rock to be extremely porous with cavities ranging in size from a fraction of a millimetre up to at least 1 cm across. In places the rock has a distinctly skeletal texture. The microchemical staining test for calcite when applied to this sample reacted patchily and irregularly and an X-ray diffractometer trace confirmed that calcite with accessory amounts of dolomite was present. Dolomite occurs as a thin lining about some of the cavities and as irregularly shaped patches within the larger masses of calcite. Shell structures are composed of finely crystalline calcite and the walls of the shells are typically between 0.03 and 0.07 mm across, are sometimes incomplete and broken and the chambers within the shells are up to at least 1 mm across. Some of the reed structures are quite well preserved and these are composed of finely crystalline calcite and can extend for several millimetres. The 'walls' of the reed casts are up to 0.1 mm across but many ?reed casts are partly or wholly infilled with calcite and their structure largely obliterated.

Small grains of quartz, less than 0.1 mm across are present in trace amounts in this sample.

This is a sample of limestone (tufa) of weathered, porous appearance which contains reed casts and a few gastropod shells. It differs from the preceding three samples P408/76 to P410/76, in being considerable softer, more porous and less recrystallized.

DESCRIPTION OF PHOTOMICROGRAPHS

(a) P409/76; TS36637; Magnification ∿40x,
Field of view 1.75 mm x 2.5 mm

In this photomicrograph there is an ovoid structure composed of concentric layers of finely crystalline calcite. This structure and others in this sample appear to have nucleated about small areas where quartz grains are concentrated.

(b) P410/76; TS36638; Magnification ∿40x,
Field of view 1.75 mm x 2.5 mm

In this sample there has been considerable recrystallization of the calcite. Early-formed, finely crystalline and turbid calcite has been irregularly replaced by more coarsely crystalline limpid calcite.

(c) P411/76; TS36639; Magnification ∿40x,
Field of view 1.75 mm x 2.5 mm

In this field of view several gastropod shells in various states of preservation are visible. The matrix is finely crystalline, semi-opaque calcite.

(d) P408/76; TS36636; Magnification ∿40x,
Field of view 1.75 mm x 2.5 mm

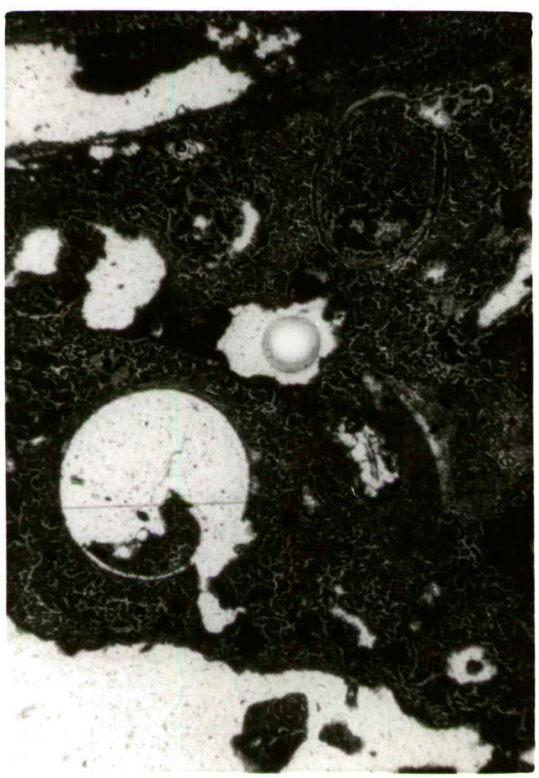
This is a particularly well-preserved gastropod shell which has been only partially infilled. The matrix is finely crystalline turbid calcite.

a

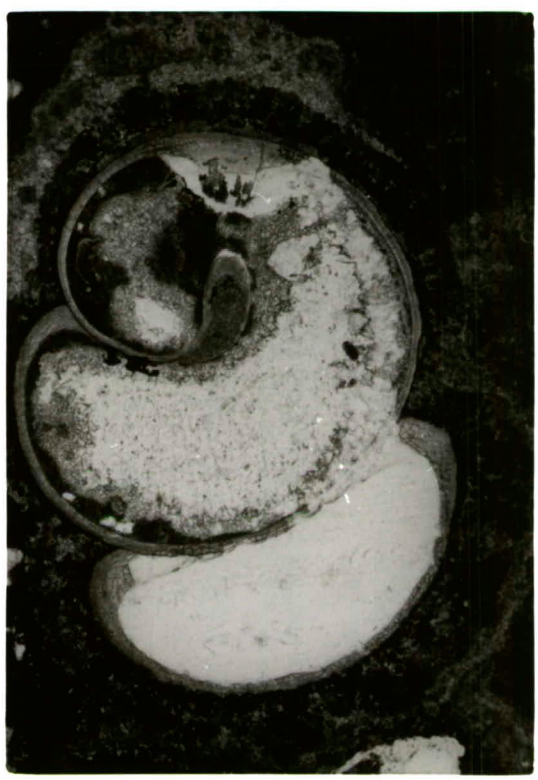
b

1·0 mm

PLATE 1



c



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A.F. Williams & J.C. Beal

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In reply quote: MP 1/17/0

21st January, 1977

The Director,
Department of Mines,
P.O. Box 151,
EASTWOOD, S.A. 5063.

Attention: Mr. J.C. Beal

REPORT MP 994/77

YOUR REFERENCE:	Application of 27/9/76.
MATERIAL:	4 Mound Spring samples.
LOCALITY:	Warrina 1:250,000 sheet.
IDENTIFICATION:	P412 - P415/76.
DATE RECEIVED:	28/9/76.
WORK REQUIRED:	Petrography.

Investigation and Report by: Dr. B.G. Steveson

Officer in Charge, Mineralogy/Petrology Section: Dr. K.J. Henley

for F.R. Hartley
Director

grs

EXAMINATION OF MOUND SPRING SAMPLES FROM WARRINA 1:250,000 SHEET

1. PETROGRAPHY

Sample: P412/76; TS36647

Location:

Tarlton Springs on Warrina 1:250,000 sheet (east of Wilpinna).

Rock Name:

Tufa.

Hand Specimen:

The sample is fairly compact and has an overall rather pale cream colour. To some extent the rock contains irregular cavities and some of these are exceptionally 1 cm in size. The cavities are essentially randomly distributed throughout the rock although in the surfaces of the sample there is some tendency for an irregular foliation defined by long axes of small cavities several millimetres in length and less than 2 mm wide. The rock contains pale green material some of which tends to line the larger cavities.

X-ray diffraction results:

Dolomite	Dominant
Sepiolite	Accessory
Quartz	Trace
Gypsum	Trace

Thin Section:

The bulk of the sample consists of extremely fine grained dolomite which forms a random uniform mosaic with an average crystal size of <0.005 mm. In most of the thin section individual crystals can barely be identified. There are elongate and equant cavities in the dolomite and those intersected in the thin section range in size up to about 2 mm. Some of the cavities are distinctly elongate. There is a tendency for slightly coarser grained dolomite to line some of these cavities but this is by no means a well defined textural feature.

Quartz occurs as widely distributed crystals which range in size generally up to about 0.05 mm. The crystals of quartz are slightly more concentrated in one place in the thin section where they comprise 10% of the rock but in general quartz only comprises less than 5% of the total volume of the tufa. That part of the rock where quartz is relatively abundant contains a concentration of gypsum. Gypsum and dolomite are intergrown together and aggregates of gypsum are no more than 0.1 mm in size. The gypsum is extremely fine grained and individual crystals cannot be positively identified in the thin section. The aggregate of gypsum-rich material has a gradational contact with the adjacent dolomitic material and there is no well defined shape to the aggregate of gypsum.

No sepiolite was positively identified in the thin section. The sample contains in addition traces of opaque material and of muscovite.

The characteristic feature of this tufa is the presence of the magnesium minerals, dolomite and sepiolite (none of the latter was identified in the thin section). Both these minerals occur in a natural environment in water in which there has been an increase of magnesium concentration. In the case of sepiolite such concentration is likely to have occurred in essentially siliceous solutions, whereas this is not a necessary condition for the crystalisation of dolomite.

Plate 1a shows an aggregate of gypsum and ?sepiolite in this sample.

Sample: P413/76; TS36648

Location:

Brinkley Springs on Warrina 1:250,000 sheet (east side of Peak and Denison Ranges).

Rock Name:

Tufa.

Hand Specimen:

Although this sample is fairly strong and compact it is distinctly more cavernous than Sample P412/76. The cut surface of the sample appears to consist of at least 30% of void space generally organised either as small, discrete cavities or as part of a system of curved and distorted elongate cavities.

The cut surface appears to contain a few cross-sections of fossils and these are approximately 3 to 5 mm in size and consist of from 2 to 4 cells (?gastropods). The sample is a brown colour overall and appears to be partly ferruginous.

Thin Section:

The sample consists very largely of calcite with small amounts of quartz, goethite and ?jarosite.

The bulk of the sample consists of calcite which is extremely fine grained and appears to be dark in plane polarised light in the thin section. In some places in the tufa the calcite is somewhat coarser grained, but even so crystals do not exceed 0.04 mm in size. Coarser grained calcite appears to be associated with particular parts of the tufa. It occurs, for example, in shell and fossil fragments and, in some places, forms a rim around the actual shell remnant. The largest fossil intersected in the thin section shows 2 or 3 cells and is 0.5 mm in length. Coarser grained calcite is also associated with films of goethitic material. Some of these films lie in cavities and others simply transect the finer grained calcite and are associated, particularly on one side, with coarse grained calcite. In some places the texture suggests that the coarser grained calcite has developed into a cavity away from the finer grained calcite rimmed with a thin layer of goethitic material. Such a goethitic layer is shown in Plate 1b where dark fine grained calcite can be seen on one side of the goethitic material and lighter, coarser grained calcite is present on the other side.

In other places in the thin section the rock has a distinctly banded appearance due to the presence of aggregates of dark material which are of the order of 0.03 mm in width and several tenths of a millimetre in length. To some extent, these aggregates of dark material could be plant remains which have been partly compressed but it is difficult to make a positive identification in the thin section.

Throughout the remainder of the thin section, very fine grained and slightly coarser grained calcite is arranged into more or less irregular structures with a tendency towards the formation of films of coarser grained material and more or less equant patches with a concentric structure defined by the presence of goethite or variations in the crystal size of the calcite.

Although this sample shows a simple mineralogy there is considerable evidence of a relatively complex history of the deposition of calcite and goethite. Possibly fine grained calcite represents relatively rapid deposition and in many places in the thin section there is evidence to suggest that this was followed by the deposition of a thin layer of goethitic material and (?slower) deposition of coarser grained calcite subsequently. The sample contains fossil remnants and these are filled with calcite.

Sample: P414/76; TS36649

Location:

South Hawker Springs on Warrina 1:250,000 sheet (east side of Peak and Denison Ranges).

Rock Name:

Tufa-travertine.

Hand Specimen:

This sample is denser and less cavernous than the two tufas described above and hence it is possible that the sample is better defined as travertine. The rock is massive and compact and has a pale buff to cream colour. Cavities are of the order of several millimetres in size but appear not to comprise more than about 10% of the volume of the rock.

Thin Section:

The sample consists essentially of calcite with a minor amount of detrital quartz. There are small amounts of ferruginous material but these are present in trace amounts only.

The bulk of the sample consists of a homogeneous aggregate of calcite which forms granular material with a crystal size which is too small to be identified in thin section. Approximately 10 to 15% of the volume of the rock is occupied by calcite which has a distinctly larger crystal size than the bulk of the material. These patches of coarse grained calcite have an average crystal size of about 0.04 mm. The coarser grained material occurs in films, atoll-like structures and in discrete blebs. The atoll structures and blebs range in size from about 0.2 mm to 1 mm and most have a granular texture with some tendency towards a comb texture at the periphery of the aggregate of coarse grained calcite. Where the comb texture is well developed elongate calcite crystals appear to have grown inwards from the margin of the cavity

and such crystals are sometimes as much as 0.15 mm in length. The films of coarse grained calcite are extremely irregular in shape and many extend from slightly elongate patches. Some more equant patches have extremely irregular shapes and several lobate and elongate irregular protrusions from the bulk of the patch. The origin of these features is rather difficult to determine but presumably the coarser grained calcite is later than the fine grained material and has partially filled in cavities. Some of the larger cavities in the rock are rimmed with this coarser grained calcite although this is by no means the case with all of the cavities.

In some places in the thin section coarse grained calcite forms elongate tabular features which are typically 0.1 to 0.15 mm in length and about 0.05 mm in width; these appear to be pseudomorphs after some pre-existing mineral phase but there is no evidence apart from the shape, to suggest what that phase was. Many of these ?pseudomorphs are rather ill-defined and they comprise <1% of the volume of this sample.

Quartz and a trace of potassium feldspar form equant anhedral crystals up to about 0.2 mm in size. These are widely distributed throughout the fine grained calcite and appear to represent a sparse detrital phase.

This is a calcite-rich tufa or travertine which contains a sparse phase of detrital quartz and potassium feldspar. Most of the calcite is extremely fine grained but there is some coarse grained material which occurs particularly in discrete patches; it is possible that these were originally cavities and that the later and coarser grained calcite has filled these cavities during a period of calcite deposition which followed the formation of the bulk of this tufa. Examples of patches of coarse grained calcite and irregular films of this material are shown in Plate 1c.

Sample: P415/76; TS36650

Location:
Near Warrangarrana Bore (west of Wilpinna) on Warrina 1:250,000 sheet.

Rock Name:
Banded tufa.

Hand Specimen:
This is a fairly compact rock but it has a distinct banding on a scale which ranges up to several millimetres. Bands consist of hard white material with cavities and softer, fine grained brown material which appears to have a clastic texture.

X-ray diffraction results:

Calcite	Dominant
Quartz	Accessory
Potassium feldspar	Accessory
Kaolinite	Accessory
Gypsum	Trace

Thin Section:

The rock consists largely of calcite with approximately 10% of detrital silicate and only very small amounts of gypsum. The texture of the sample varies from place to place in the thin section, and hence the proportions given are mean values only.

The calcite which comprises the bulk of this sample has a crystal size which ranges up to about 0.2 mm but there are places where elongate calcite crystals occur and these are as much as 0.4 mm in length. As in other samples in this collection there are aggregates of extremely fine grained calcite which has a crystal size so small that individual crystals cannot be seen under the microscope. In general the calcite forms coherent aggregates which have a consistent crystal size and such aggregates range from 0.2 mm to several millimetres. Characteristic features are the presence of radial aggregates of elongate calcite crystals particularly between relatively large blocks which have an equigranular texture. In some places there is a tendency for the formation of bulbous aggregates of calcite particularly draped around compact aggregates of extremely fine grained material. These, more unusual textures generally occur in those parts of the rock. which are free from detrital silicate material. Where this is present it forms commonly as much as 50% of the rock. The quartz and feldspar do not generally form a strong framework but are separated from each other by a relatively coarse grained granular calcite. The quartz and feldspar grains are angular in shape and commonly range in size from 0.1 mm to about 0.3 mm. There is, however, a wide crystal size range, particularly of quartz and there are some crystals as much as 2 mm in size. These large crystals do not appear to be veins but are genuine detrital crystals or crystal aggregates. The detrital grains occur in those parts of the hand specimen which are brown and slightly friable and it can be seen in the thin section that the brown colour is due to a thin film of ferruginous material which occurs on both the detrital silicates and the cementing calcite in these bands.

The photomicrograph of Plate 1d shows, at the top, part of the rock which is rich in detrital silicate grains and on the bottom there is an aggregate of fine grained calcite surrounded by coarser grained material which has a tendency towards a radial structure.

In general, this tufa is distinctly different from others in this collection in that it contains more detrital material and has a more complex texture. Some aggregates of calcite were clearly deposited and lithified before being cemented by relatively large areas of calcite which is organised into radial and similar aggregates. In general the textures of the sample reflect a complex history involving periods with considerable deposition of detrital material and possibly also periods of compaction of the material and some evidence of slumping and movement of partly consolidated calcite.

2. COMPARISON

Sample P412/76 is significantly different from the three other tufas in that it contains abundant magnesium, both in dolomite and sepiolite. There is some evidence in P413/76 of several stages of calcite deposition but P415/76 shows the most complex history in this respect; in this sample there are bands and patches of fine-grained calcite with large proportions of detrital quartz and potassium feldspar whereas other bands contain only coarse grained calcite.

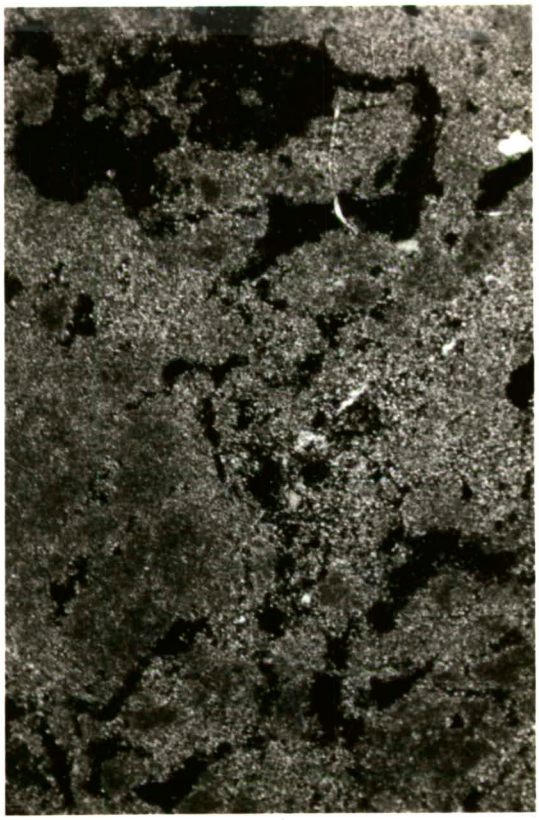
PLATE 1

Plates 1a and 1d - crossed nicols.

1b and 1c - plane polarised light.

For all plates, the magnification is 45x.

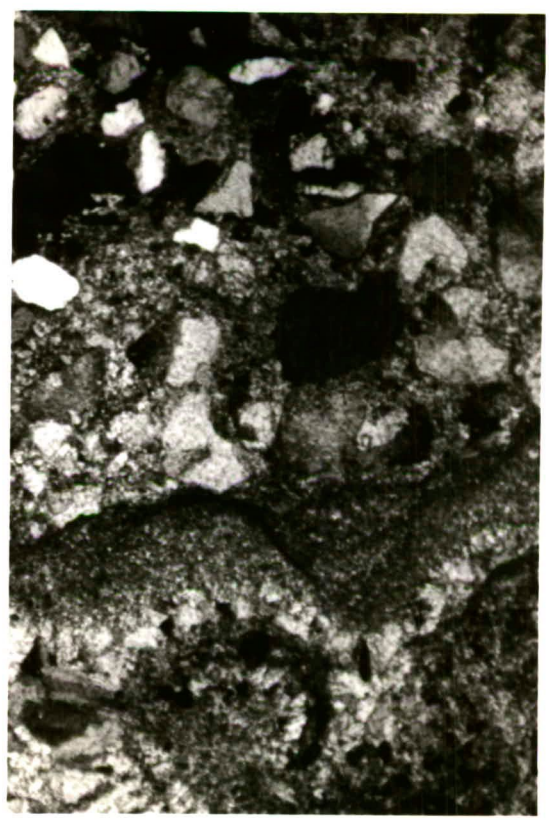
Descriptions of the plates are given in the text.



1a.

1b.

1c.



1d.