QUEENSLAND GEOLOGICAL RECORD 2008/01

A review of the geology and production of diatomite in Queensland

JSF Lam

Queensland **the Smart State**

Queensland Government
Department of Mines and Energy

ADDRESS FOR CORRESPONDENCE:

Geological Survey of Queensland
Department of Mines and Energy
Block A, 80 Meiers Road, Indooroopilly, QLD 4068
Telephone: (07) 3362 9364; International +61 7 3362 9364
Facsimile: (07) 3362 9343; International +61 7 3362 9343
Internet: www.dme.qld.gov.au

ISSN 1039-5547
ISBN 978-1-921489-56-3
Graphics by: JSF Lam
Issued: April, 2008

REFERENCE: LAM, J.S., 2008: A review of the geology and production of diatomite in Queensland. *Queensland Geological Record* **2008/01**.

CONTENTS

TABLE

SUMMARY

This report presents an update of the economic uses of diatomite focused on the properties of the Queensland deposits.

Queensland has several small diatomite deposits; however mining to date has been conducted only at the Mount Sylvia and Maidenwell deposits in south-east Queensland. The Conjuboy deposit in north Queensland is also being developed for mining in the near future. The average yearly production of ~5000t of diatomite is used in the agricultural and horticultural industries.

INTRODUCTION

DIATOMS

Diatoms are microscopic unicellular algae-like plants (usually ranging from 20–200µm diameter) that live as plankton in the benthic zone in lakes, rivers and oceans. They are primitive, free drifting aquatic algae that have no roots, stems, or leaves belonging to the phylum *Bacillariophyta*.

The name *diatom* comes from a Greek word *diatomos* that means *cut in half*, because the shells of diatoms have two symmetrical, interlocking box-like halves (*thecae*), one fractionally larger than the other. The shell or 'test' is commonly pennate (axial or elongate) or has a centric (radial or circular) form. It consists of opaline silica ($SiO_2.nH_2O$) that the diatom secrets from its silica-rich lacustrine, brackish or marine habitat. Each theca consists of an elaborated compartment called the valve (*frustule*) with multiple partitions (*girdle*) attached to it. The valves are connected by a seam-like ridge (*raphe*) between the two halves of bilaterally symmetrical valves (Figure 1).

Figure 1 illustrates the basic structure of a diatom, however, the thecae have a broad variety of delicate, lacy, perforated, honeycomb shapes varying from solid and perforated rods to needles, cylinders to discs, and spheres to hemispheres, crescents and polygons, and size from less than 1 micrometer (µm) to >1mm in diameter but are typically 10–200µm across.

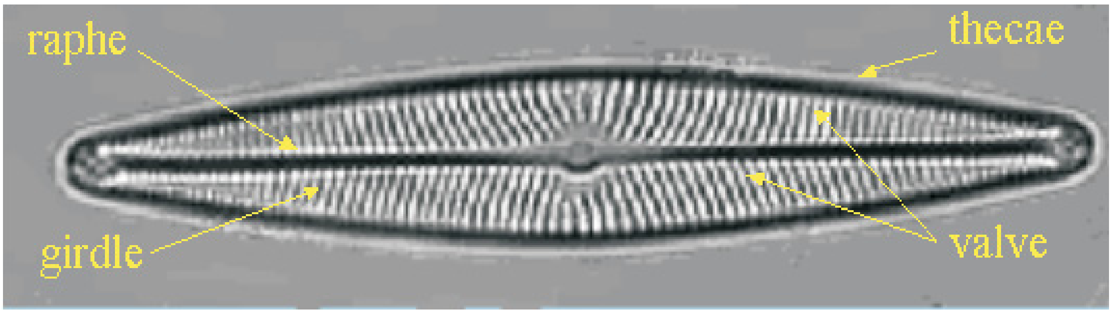


Figure 1. Naviculoid — these genera have a raphe on both valves and are symmetrical to both the longitudinal and transverse axis of the valve.

About 60 000 species of these algae have been identified. On the basis of morphological characteristics, the University of Michigan (USA) has illustrated 10 groupings of diatom genera, under the banners of Eucentric, Eccentric, Araphid, Eunotoid, Monoraphid, Naviculoid, Cymbelloid, Epithemioid, Nitzschioid and Surirelloid. Readers are referred to the following website for identification of genera (http://www.umich.edu/~phytolab/GreatLakesDiatomHomePage/groups/majorgroups.html).

Diatoms (*Bacillariophyceae*) live as individuals or in groups in lacustrine, brackish or marine water. Light is essential for the organisms to grow, as they are photosynthetic and hence restricted to the photic zone <100–200m deep. Most planktonic diatoms are centric in form and are the primary nutrient producers in the photic zone. Depending on the local environment such as nutrient supply, turbulence, and illumination in the photic zone, diatoms can occupy various benthic habitats in shallow ocean margins, but they are rare in deep-sea sediment (Bradbury & Krebs, 1995).

DIATOMITE

When diatoms die, their delicately constructed silica shells/tests sink and accumulate on the floor of the body of water in which they lived. The resultant sedimentary rock, diatomite, forms as a result of this accumulation and preservation of diatoms in fresh or marine water within the photic zone — i.e. in water depths from 100–200m. When consolidated it becomes a light weight rock (average SG<1) which floats in water until saturated and is white in colour when pure. Diatomite is also known as diatomaceous earth and kieselguhr, and as tripolite after a diatomite occurrence near Tripoli, Libya. In different countries it is known by names such as gaize, opoka, infusorial earth, kieselerde and bergmehl.

The amorphous silica that makes up the porous shell is resistant to acids and heat, but can be attacked by strong alkaline solution and hydrofluoric acid. Thick layers of these diatom shells are incorporated with organic matter and clays and accumulated in beds near continental margins, or in lakes or marshes. These beds are diatomite or diatomaceous earth. Diatomite is a soft, chalk-like, low density, highly absorbing sedimentary rock containing billions of loosely interlocking siliceous diatom skeletons in a random, three-dimensional framework. Rock outcrop is usually light in colour, white if pure, commonly buff to grey due to iron and black due to organic matter.

Marine diatomite deposits generally accumulated along continental margins with submerged coastal basins and shelves. They generally contain larger resources than continental deposits, but globally commercial deposits are mostly fresh water (lacustrine) deposits of Miocene to Pleistocene age. Lacustrine diatomite deposits are typically found in volcanic terrains commonly associated with volcanism. However, some recently formed lacustrine diatomite deposits show no association with volcanic activity.

MINING AND PROCESSING

Diatomite has a wide industrial application but is mainly used as an absorbent and filtration medium. The yearly world production is ~2Mt and known resource is ~2Bt.

Open pit mining is one of the low cost methods of recovering diatomite from near surface deposits, even though underground mining is also common. Explosives are not normally applied either at surface or in underground mines due to the soft, friable nature of the rock. Dredging is also used to recover diatomaceous mud from the bottom of modern lakes. Nowadays, diatomite is commonly mined by open-pit quarrying techniques using heavy-duty earth moving equipment, and the crude ore is then transferred to an onsite processing plant.

Diatomite is usually processed at or near the mine site to reduce the cost of hauling the crude ore, which can contain up to 65% water. The crude ore is milled, dried at low temperatures (300–500°C) and classified to remove impurities and to produce a variety of different particle-size grades. Processing typically involves a series of crushing to separate the diatomite ore from clays, shales and sands, drying to reduce inherent water content trapped in the diatomite shells, size reduction to separate individual frustules without destroying their delicate structure, and calcining (to 1000°C) and flux calcining (to 1200°C) to effect reduction in the content of free crystalline silica, iron and organic matters, and to sinter the shells into small clusters.

USAGE

The commercial use of diatomite can be traced back to Roman times. The Romans used diatomite for making fireproof tiles. Diatomite has an inherent hardness of about 5 on Moh's scale and the delicate structure of the diatom skeletons breaks down easily into very fine powders. It was used by the Greeks 2000 years ago as an abrasive in metal polishes and in making lightweight building bricks and blocks, and in ceramic pottery (Breese, 1994).

In the Middle Ages diatomite was added to grain meal for bread making because of its potential medicinal value in the human body digestive system.

In 1867, pulverized diatomite was used as the preferred absorbent and stabilizer of nitro-glycerine to make dynamite and the use has continued (Harben & Kuzvart, 1996; Harwood, 1999).

In modern times the application of diatomite usage has been greatly expanded. It is used as a filtration medium to filter impurities from beer, wines, oils, greases, sugars and syrups, and human blood plasma. Additionally, diatomite is used to filter impurities from water to produce drinkable (potable) water by removing bacteria and protozoa.

Diatomite is also used as a filler (a substance that increases the volume of a product and/or fills in space), as it is non-reactive. Products include paints, lacquers, rubber, plastic, agricultural chemicals, insulation, anti-caking agent, cement, concrete, pasteboard, animal feeds, fertilisers and catalyst carriers.

Other uses of diatomite include the manufacture of heat- and fire-resistant insulating material in furnaces and boilers, sound proofing insulating materials, polishing powder such as ‘Tripoli’, porcelain, drain pipes, tiles, non-conducting materials and artificial dimension stones.

The percentages of use by worldwide major users for diatomite in filtration and filler applications are approximately 73% and 14%, respectively. A large and growing application is its use as an absorbent for industrial spills (oil and toxic liquids) and for pet litter.

SPECIFICATION

A major specification for commercial diatomite is that it contains between 86% and 94% diatoms. The remnant minerals are alumina and alkaline earth and clay. A nominal composition for diatomite is silica (89.70%), alumina (3.72%), red iron oxide (1.09%), and loss on ignition (3.70%)

Commercial diatomite products are offered in a great variety of grades of calcined powders. Principal grading factors are fine size, shape, overall arrangement, and proportions of the various types of frustules, the content of silica, and various impurities, such as volcanic ash, quartz, mica, and feldspars and chemicals especially iron, clay, sand, and organic matters such as fossil leaves, fish and reptile bones and peat. Additional specialised application specifications are brightness/whiteness, low refractive index, mild abrasive hardness and low thermal conductivity with high fusion point (~1650°C).

Most filter grades are calcined. The calcining process removes the organic remains, increases filtration rate, oxidizes iron, increases specific gravity, increases particle hardness, and can lighten the colour of the finished product. Flux calcining improves the whiteness and filtration properties.

COMPETITORS

There are a number of synthetic and natural materials available for the substitution of diatomite. Expanded perlite and silica sand are competitive products for filtration. Synthetic filters, such as ceramic, polymeric, or carbon membrane and cellulose fibres, are becoming competitive as filter media. Talc, ground silica sand, ground mica, clay, perlite, vermiculite, and ground limestone have been used as filler substitutes for diatomite. For thermal insulation, materials such as clays, wool, expanded perlite, and exfoliated vermiculite have also been used.

Despite all these substitute products, diatomite is an abundant and low cost commodity ensuring its competitiveness. As a filtration medium, diatomite is a superior product and is cost effective when compared with other substitutes.

PRODUCTION

WORLD

For the past six years (2000–2005), total world production of diatomite has fluctuated between 1.9–2Mt (Table 1). With a less than 1% growth rate in the marketplace, diatomite is a mature market. In the diatomite market, the USA is the leading producer (with over 30% of world production), consumer, and exporter. The European Union's production peaked at almost 425 000t in 2006. World consumption of diatomite exceeds 2Mt in 2006 and is forecast to be worth almost US$620 million by 2007.

World resources of 2Bt of crude diatomite are adequate for the foreseeable future. The increase in production from 2000 to 2005 was small, and the diatomite market has grown only slightly since 2000. Much of the growth was due to increasing use of diatomite as a lightweight component and as a pozzolan in the cement industry. With the large domestic and world reserve bases and small change in demand, it appears that there will be adequate supplies of diatomite for the foreseeable future.

QUEENSLAND

The most recent on-site inspections of the deposits were in the 1930s, 1940s and 1950s, and the information was compiled in a report by Krosch (1976). Recent company exploration of the Conjuboy, Glen Eagle, Maidenwell, Mount Sylvia and West Haldon deposits has advanced the geological knowledge of these deposits.

As indicated in Table 1, total Australia production has been stagnant at 20 000 tonnes per annum for the past six years (2000 to 2005). Over the same period total Queensland production of diatomite has fluctuated between 2.6 to 6.7 thousand metric tonnes from 2000 to 2005 (Table 2) with a yearly average production of 4.5 thousand tonnes. The 2005 production figure represents a 7% growth rate of previous year and the growth rate for 2004 increased 21.5% from the 2003 figures. On the basis of this growth rate, the possible projection to 2010 is 7000t at a steady 10% yearly increase, as the current diatomite mines have planned to increase output meeting newly developed market demand from hygienic repellent and stockfeed products.

The trend of growth for Queensland diatomite production from the two deposits at Mount Sylvia (Black Duck Creek) and Maidenwell has a positive outlook. The Conjuboy deposit is being developed for mining and will add upward pressure of addition production. It is anticipated that Queensland will achieve as significant diatomite producer status in Australia in 2008.

Diatomite resources amount to many hundreds of millions tonnes in Queensland and the local resources will satisfy the production growth demand in Queensland horticultural and agricultural industries for many years to come. Although

Table 1: Diatomite: World production, by country

	Diatomite: World production (thousand tonnes)					
Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Algeria	3	3	3	3	3	3
Argentina	18	17	23	25	25	10
Australia	20	20	20	20	20	20
Brazil, marketable	13	13	13	13	13	8
Chile	13	23	30	26	25	30
China	350	350	370	380	390	410
Colombia	4	4	4	4	4	4
Commonwealth of Independent States	80	80	80	80	80	80
Costa Rica	35	26	26	26	26	27
Czech Republic	34	83	28	41	30	35
Denmark	234	231	230	232	233	234
France	75	75	75	75	75	75
Iceland	28	30	31	30	29	29
Iran	5	5	5	5	5	8
Italy	25	25	25	25	25	25
Japan	136	132	112	129	130	130
Kenya	<1	<1	<1	<1	<1	<1
Republic of Korea	34	28	21	16	16	2
Macedonia	5	5	5	5	5	5
Mexico	96	69	62	68	70	62
Mozambique	—	—	—	—	3	5
Peru	35	35	35	35	35	35
Poland	~1	~1	~1	~1	~1	~1
Portugal	2	2	2	2	2	1
Romania	9	10	20	31	30	30
Spain	35	35	35	35	35	35
Thailand	<1	1	1	1	1	1
United States	677	644	624	599	620	653
Total	1 970	1 950	1 880	1 910	1 930	2 020*

Source: http://minerals.usgs.gov/ United States Geological Survey Mineral Resources Program
*approximate total

Table 2: Queensland diatomite production from 2000 to 2006

	Queensland diatomite production (tonnes)						
Deposit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Maidenwell	1544	3716	5749	2532	3167	3517	3709
Black Duck	1076	911	1008	1209	1388	1313	*387
Total	**2620**	**4627**	**6757**	**3741**	**4555**	**4830**	**4096**

* January to June 2006 figure as a result of restructure of company

Queensland resources are guaranteed for the future years, new discovery and development of diatomite deposits close to market place remain a competitive edge to its potential substituted competitor products. Transportation cost, product quality and local industry demands will have a strong bearing on the long-term demand of diatomite.

COMMERCIAL VALUES

WORLD

Prices per metric tonne depend greatly on the end uses of a diatomite product, from relatively low values for insulation and absorbent uses to significantly higher values for its use as filler and in filtration. Table 3 provides a general guide of diatomite values in the USA market for the years 2003 to 2005. The weighted average values range from $US 265.00 to $US 285.00 per tonne.

Table 3: Indicative commercial values of diatomite in the USA market

	AVERAGE VALUE PER METRIC TONNE OF DIATOMITE, BY MAJOR USE IN USA		
	2003	**2004**	**2005**
Absorbents	95.59	72.94	30.68
Fillers	371.08	360.65	382.27
Filtration	246.94	269.25	261.79
Insulation	35.27	43.41	44.09
Other	970.12	1020.00	652.34
Weighted average	264.77	285.72	274.02*

Source: http://minerals.usgs.gov/ United States Geological Survey Mineral Resources Program
*$US

QUEENSLAND

The major users of Queensland diatomite are the agricultural and horticultural industries, mainly as an absorbent in soil conditioners. Other usages are as industrial spillage absorbent, kitty litter and as an additive in stockfeed. All commercial enquiries may be directed to Maidenwell Holdings Pty Ltd, 39 Jones Road, Carina, Brisbane, Qld 4152 and to Mount Sylvia Mining Pty Ltd, 40 Lowes Road, Gatton, Qld 4343. Samples of diatomite are available upon request.

The average price for horticulture diatomite is about $A185.00 per tonne.

QUEENSLAND DIATOMITE DEPOSITS

The distribution of selected diatomite deposits in Queensland is shown in Figure 2. Reported deposits extend from inland of Ingham in the north to the Gold

Coast hinterland in the south-east near the Queensland and New South Wales State border. They are mainly a lacustrine style deposit associated with hot springs, creeks and lakes, occurring as thin seams (averaging ~2–3m thick) interbedded with basalt lava flows of the Late Oligocene to Early Miocene. The cylindrical *Melosira* appears to be the most common identified species.

Most of the Queensland diatomite deposits were discovered in the early 1900s. No mining was carried out for many years as there was little local demand for diatomite at the time. The Mount Sylvia deposit was mined in the 1920s. The Maidenwell deposit probably was discovered soon after 1900 but was not mined until the mid 1990s. These two deposits continue to produce in 2006 with a small annual production of 5 to 6 thousand tonnes meeting the local market in the agricultural and horticultural industries.

The Conjuboy and Planet Downs deposits were among the early discoveries, and the Conjuboy deposit is being developed as the third diatomite mine in Queensland. Very little is known about the Planet Downs deposit. Other early discoveries include Mount Meerschaum (1889), Beechmont (1908), Mount Tambourine (1908), Numinbah Valley (1907) in the Gold Coast hinterland but none of them has been assessed to any extent.

The Cashmere, Gleneagle (Glen Eagle), Walters Plains Lake (Lake Walters), and Flaggy Creek (Princess Hills) deposits were discovered by government geologists during mapping in the Herbert River area in 1958 (White & Crespin, 1959). In 1970, two leases were applied over the Cashmere deposits and a number of leases were applied for mining diatomite 4km east of Gleneagle homestead, covering a distance over 6km south of the track to Glen Ruth homestead. However, no evidence of mining was found during field inspection in 2006.

NORTH QUEENSLAND DEPOSITS

The north Queensland deposits (Figure 3) are inland from Innisfail, and include the Pozzolan, Cashmere, Glen Eagle, Walters Plains Lake, Flaggy Creek and Conjuboy deposits. The Cashmere deposit was discovered around 1958 and the Rosetta Creek deposit around 1990 by geologists of the Geological Survey of Queensland mapping in the Herbert River and Mount Coolon areas. Shallow quarry development work (Photo P 1) is evidenced at the Pozzolan deposit; however, no sign of recent mining or excavation is recognised. The Glen Eagle and Cashmere deposits were explored from 2002 to 2005 as a result of mining lease applications over prospective areas. The Conjuboy deposit was explored in the 1970s and 1980s, and Australian Diatomaceous Earth Pty Ltd reported that a high grade diatomite test result has been obtained for this deposit. The Flaggy Creek deposit appears to have development potential but as it lies entirely within the Girringun National Park no exploration has been conducted over this deposit.

The north Queensland deposits are interbedded with vesicular basalt flows of the McBride and Wallaroo Basalt Provinces, which dammed palaeo-streams, -springs and -lakes providing a quiescent environment for the growth of diatoms. Most of the deposits are finely-laminated and flat-lying, and contain clay and organic

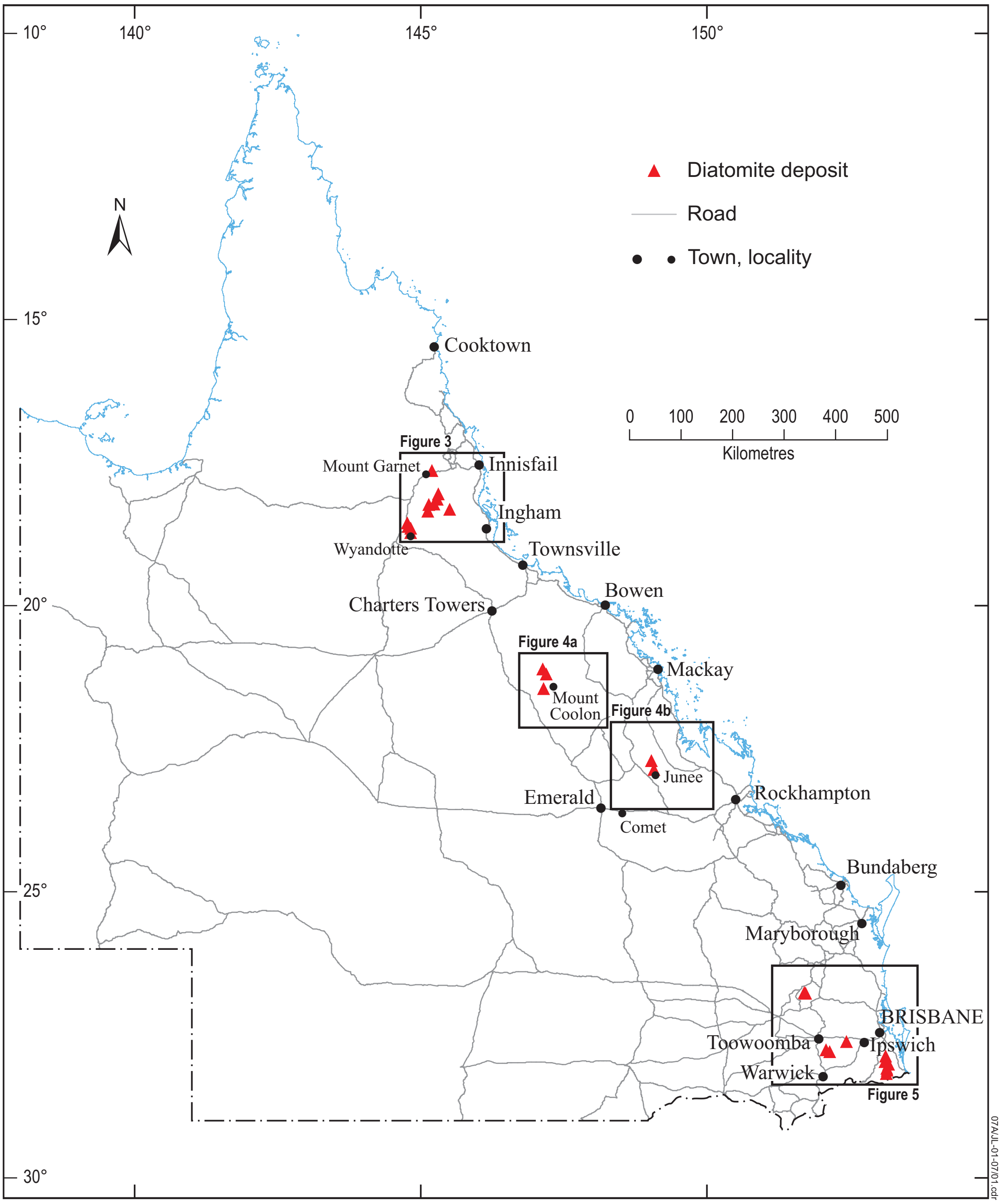


Figure 2: Distribution of diatomite deposits in Queensland

matter reflecting the local environment and seasonal change at the time of deposition. Sections of the deposits are preserved between basalt flows that periodically filled the lakes and streams. Nowadays, the diatomite outcrops are generally exposed on creek banks.

Pozzolan/Nettle Creek/Innot Hot Springs (MGA 94, Zone 55, 0312415E, 8046077N)

The Pozzolan diatomite deposit is ~13km east of Mount Garnet (96km west-south-west of Innisfail) and is ~500m west of a thermal hot springs spa pool at Innot Hot Springs. This spa pool appears to be a present day setting conducive

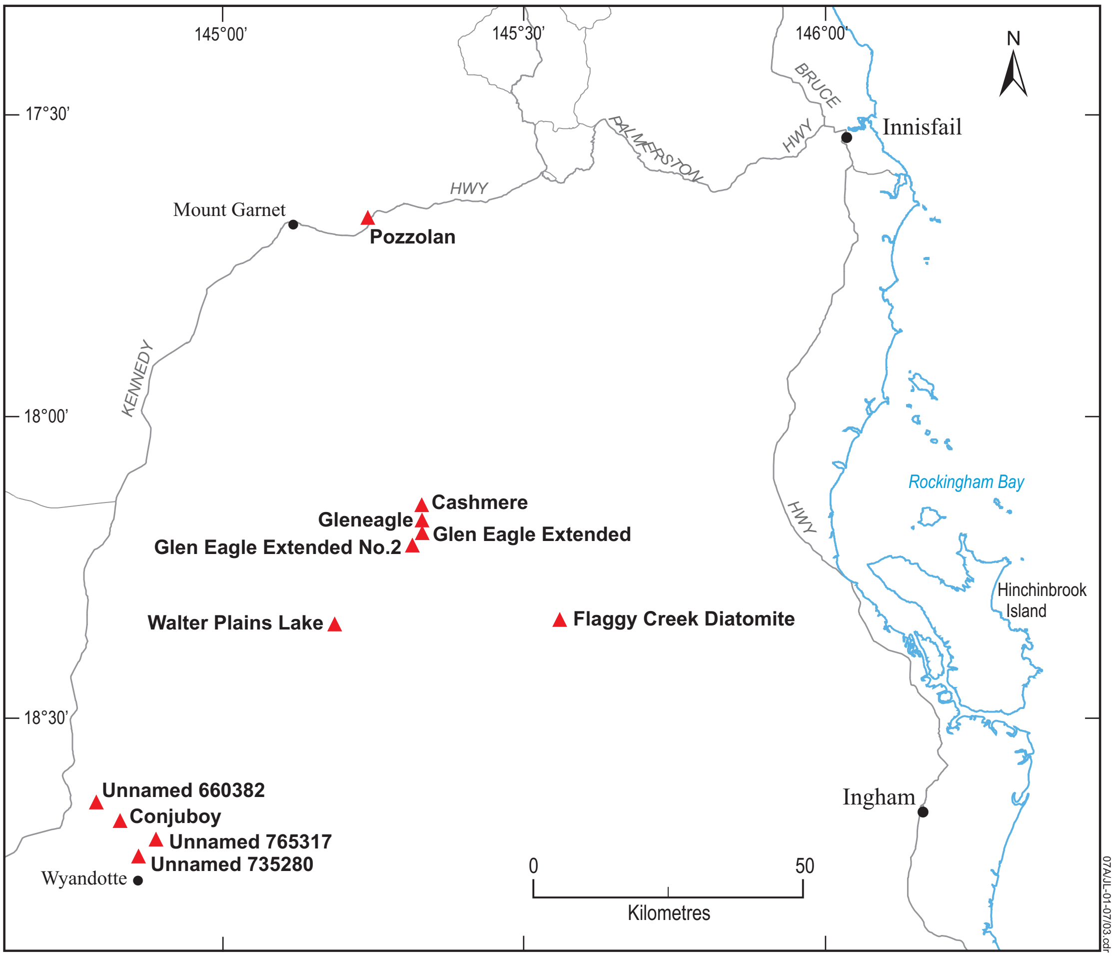


Figure 3: Distribution of diatomite deposits in north Queensland

for growing of diatoms. The deposit occurs within the Atherton Basalt Province, a thick unit of Tertiary volcanic rock consisting of vesicular to massive olivine basalt flows and thin bedded sediments unconformably overlain granite of the Middle to Late Carboniferous Pinnacle Granite. Ferricrete, duricrust, silcrete, residual sand, and alluvial silt, and sand cover most of the area. The deposit has been exposed by weathering of the overlying basalt.

In the area, diatomite crops out over an area ~300m in diameter and 1m thick. The diatomite bed rests on weathered granite and is covered by a thin layer of black soil (up to 0.5m thick) and basalt rubble. A small shallow quarry 100m by 100m (Photo P1) was excavated on a flat-lying diatomite comprising two distinct seams; a 1m thick finely-laminated off white diatomite overlying a 0.3m thick greyish white diatomite (Photo P2). At site (MGA 94, Zone 55, 0312597E, 8046032N) is an exposure of pitted, mud-crack greyish white diatomite (Photo P3).

On the basis of the diatom genera, Crespin (1943) reported that the diatom assemblage of this deposit is similar to those recorded from swamp and lake deposits of similar age in Western Australia. This deposit contains no *Melosira* so commonly found in many other Queensland occurrences, but largely comprises rod-like *Epithema*, both the broad and narrow rectangular *Diatomella*, the filiform *Synedra*, and the naviculoid *Navicula* and *Cymbella*, and *Diatoma, Pinnularia, Amphora*. Sponge spicules are also common.

Photo P 1: Pozzolan diatomite quarry — shallow surface scrapping of diatomite (2006)

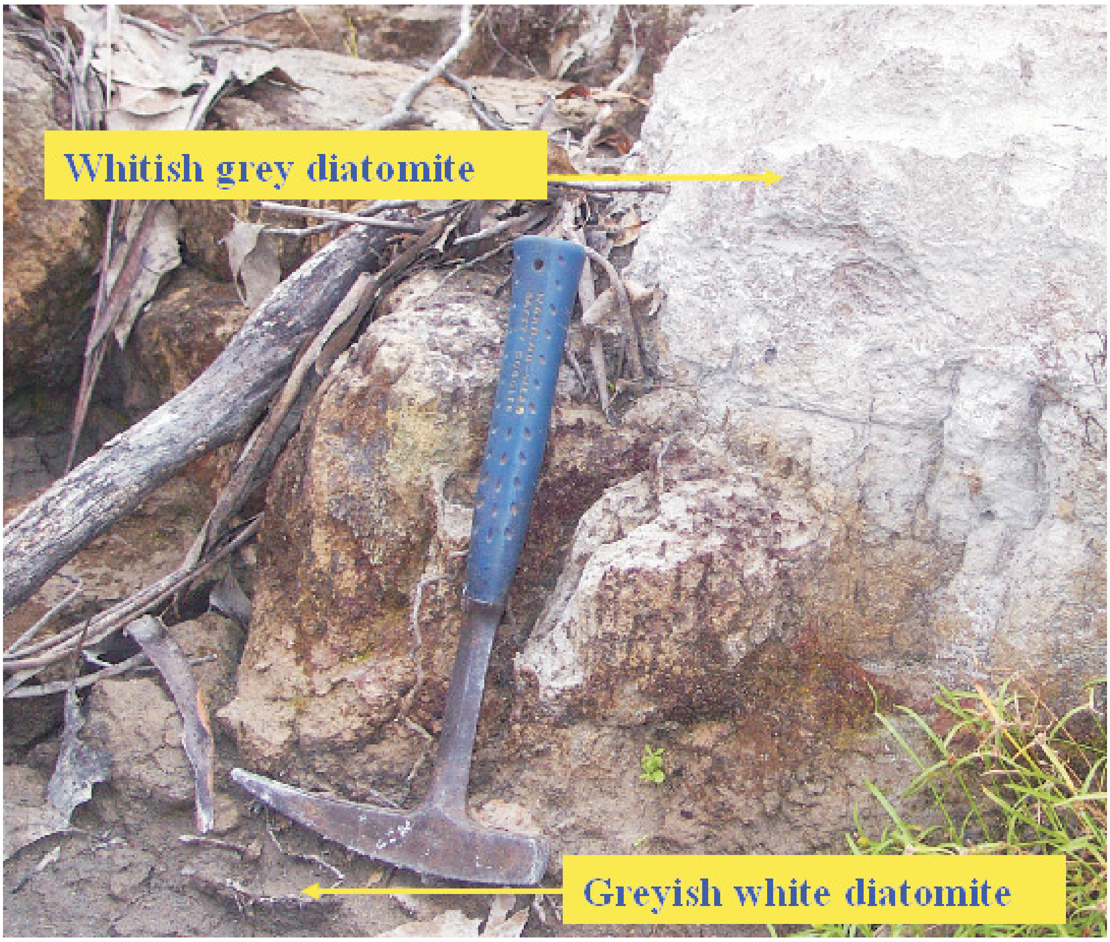


Photo P 2: Pozzolan diatomite deposit — 1–1.5m thick bed of white diatomite lying on a bed of 0.3m thick mud cracked grey diatomite adjacent to unconsolidated sandy sediment on top of decomposed granite (2006).

Photo P 3: Pozzolan diatomite deposit — pitted, mud crack diatomite (2006)

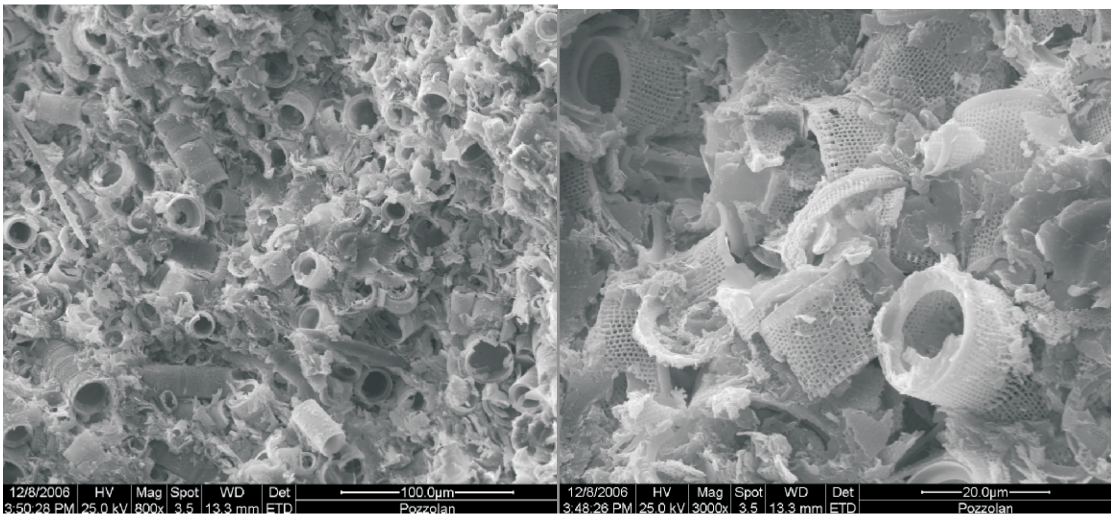


Photo P 4: Photomicrograph at 3000x and 6000x of the Pozzolan diatoms (Photo taken by L Duong of QUT, 2006)

However, a grab sample of diatomite from the Pozzolan deposit shows the main genera is *Melosira* (Photo P 4).

Cashmere (MGA 94, Zone 55, 0322315E, 79933777N)

The Cashmere diatomite deposit is ~3.5km north-north-west of Gleneagle homestead (100km south-west of Innisfail). The deposit occurs within the Wallaroo Basalt Province, a thick unit of Tertiary volcanic rock consisting of vesicular to massive olivine basalt flows overlain granite of the Permo-Carboniferous Herbert River Granite. The outcrop on the north side of the track to Gleneagle homestead has been exposed by weathering of the overlying basalt.

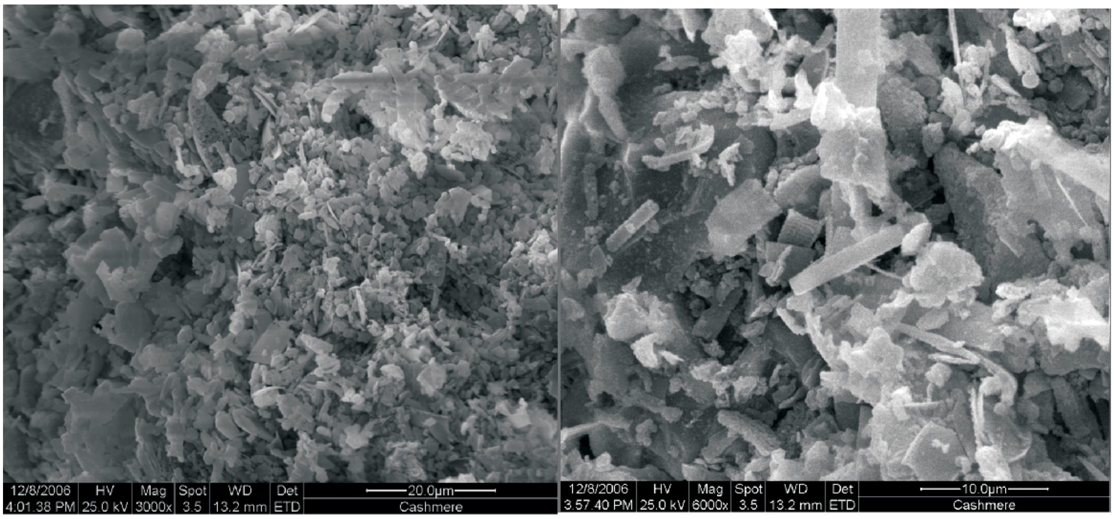


Photo C 1: Photomicrograph at 3000x and 6000x of the Cashmere diatoms (Photo taken by L Duong of QUT 2006)

A narrow seam of diatomite up to 1m thick overlain by 0.5–1m of black soil is located on the bank of a small creek. White & Crespin (1959) described this occurrence 100m long by 18m wide and 3m thick, overlain by basalt. The diatomite is chalky-white, consisting of cylindrical *Melosira* (Photo C 1). Past laboratory tests indicated this deposit consists of high grade diatomite; it has a porosity of 73–75%, a bulk dry density of 0.72g/cm^3 and a grain density of 2.74g/cm^3).

At sample site (MGA 94, Zone 55, 0322326E, 7993842N), diatomite exposed on shallow bank of a small creek is under a blanket of 0.5m thick black soils (Photos C 2 and C 3). Vesicular basalt crops out prominently on hilltop to the north.

Historically there was an application for a mining lease application over this occurrence and another area 1km to the south-west. This suggests that there is a lower resource potential than the diatomite deposit at Glen Eagle.

Glen Eagle/Gleneagle (MGA 94, Zone 55, 0322515E, 7991363N)

The Gleneagle deposit is ~2.5km south of the Cashmere occurrence. Here a seam of diatomite up to 3m thick is overlain by black soil/basalt and is exposed on a high creek bank (Photo GE 1). It is chalky white, and where exposed the seam dips to the south-west beneath a hill of vesicular basalt flows up to 20m thick. White & Crespin (1959) reported *Melosira* as the predominant diatom (Photo GE 2). The diatomite has a porosity of 72.17%, a dry bulk density of 0.74g/cm^3 and grain density of 2.67g/cm^3. Recent Company exploration outlined a resource potential of many million tonnes of amorphous diatomaceous earth with a base grade of 70% SiO_2 (Adams & West, 2003).

In 2006, this deposit was covered by one mining lease ML 20341, Glen Eagle (2001 to 2026) and two mining lease applications (ML 20407, Glen Eagle Extended, and ML 20471, Glen Eagle Extended No 2) over the prospective areas including ~20km^2 extending south from the track to Glen Eagle homestead. This

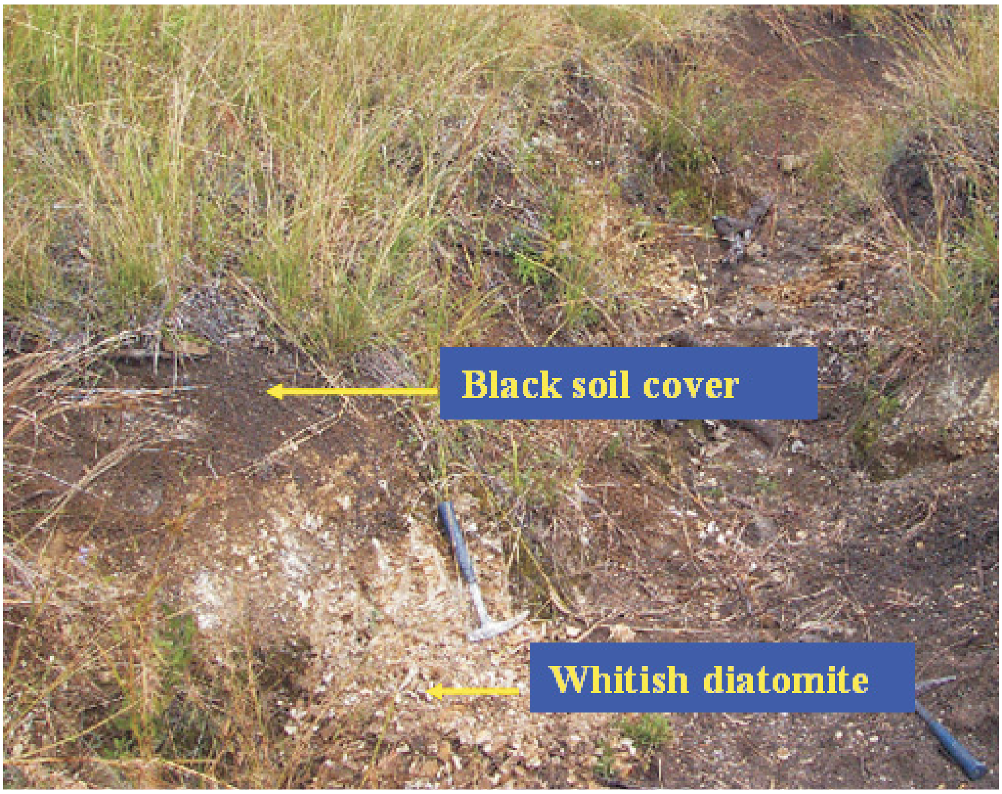


Photo C 2: Cashmere diatomite (MGA 94, Zone 55, 0322326E, 7993842N), exposure on shallow bank of a narrow creek (2006)

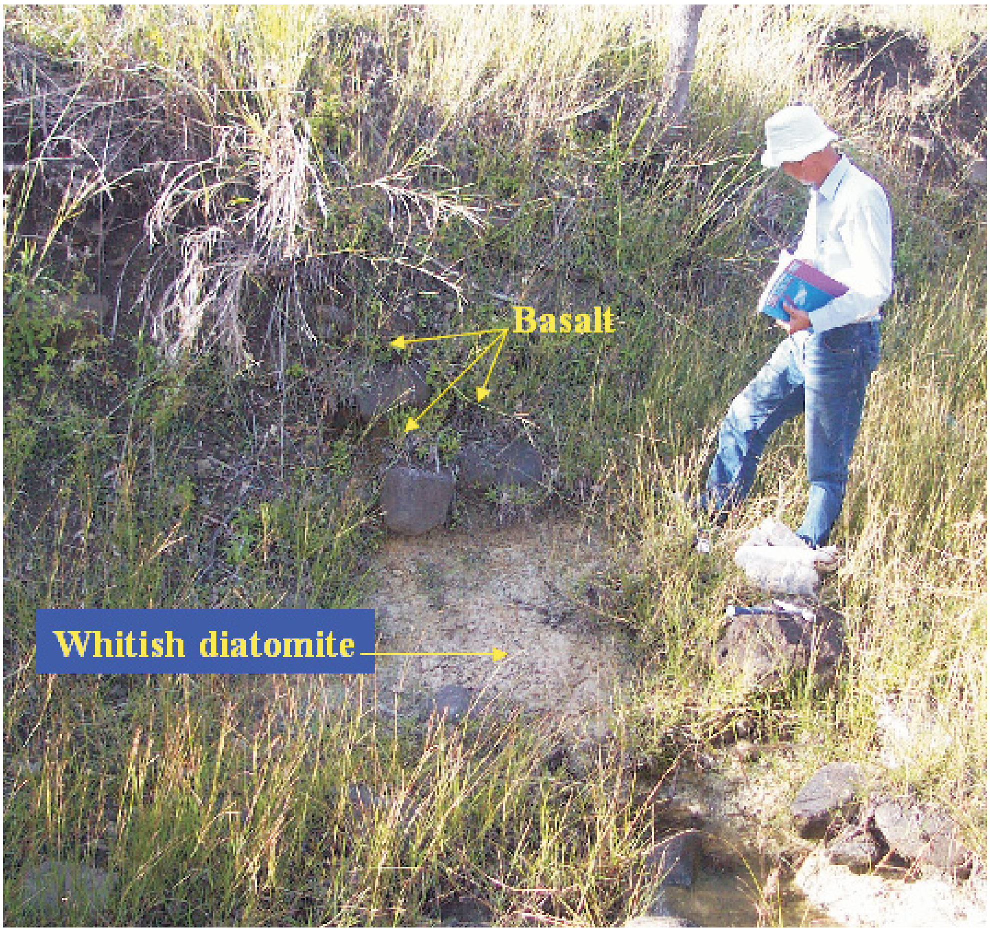


Photo C 3: Cashmere diatomite, another exposure on shallow bank of a small creek (2006)

Photo GE 1: High creek bank of Glen Eagle diatomite deposit (MGA 94, Zone 55, 0322404E, 7990072N)

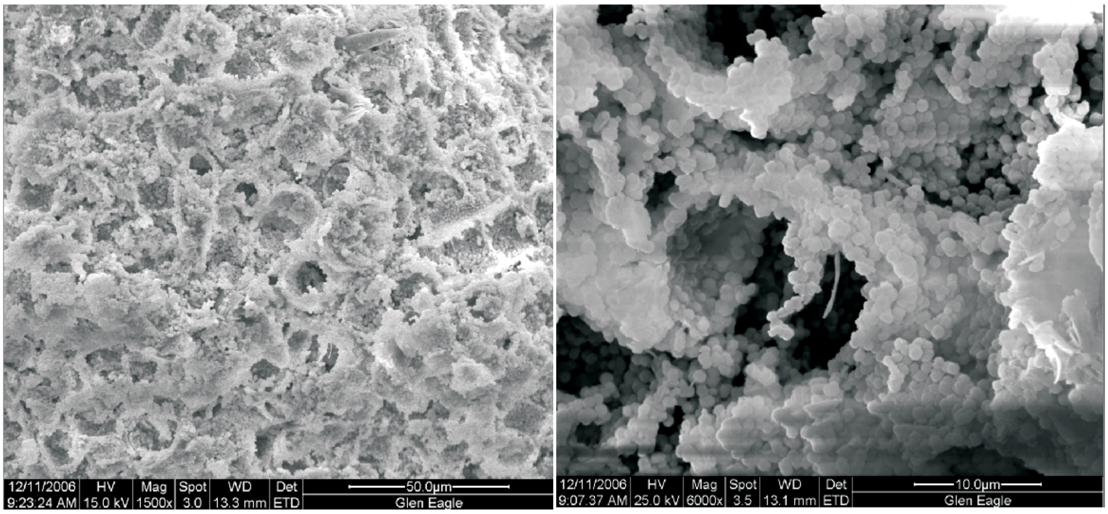


Photo GE 2: Photomicrograph 3000x and 6000x of the Gleneagle diatoms showing dense overgrowths of opaline silica (Photo taken by L Duong of QUT 2006)

Glen Eagle deposit has the potential to be developed as one of the most significant diatomite mines in Queensland.

Other outcrops were reported in the vicinity of sites at Grid Reference MGA 94, Zone 55, 0320708E, 7985979N and Grid Reference MGA 94, Zone 55, 0322025E, 7988669N.

Walters Plains Lake (MGA 94, Zone 55, 0307115E, 7971377N)

The Walters Plains Lake deposit is 5km west of the Walters Plains Lake and 27km south-west of the Cashmere deposit. White & Crespin (1959) reported that

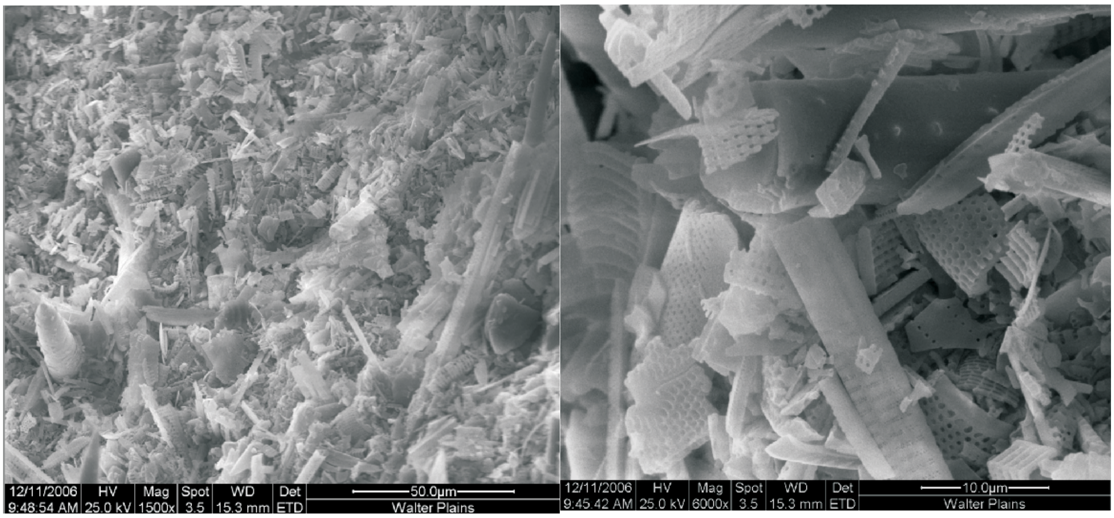


Photo WPL 1: Photomicrograph at 3000x and 6000x of the Walters Plains diatoms (Photo taken by L Duong of QUT 2006)

outcrops in a small tributary of Leichardt Creek (in Dam Creek, a small tributary of Anthill Creek) consist of well-laminated, impure diatomite (Photo WPL 1) with intercalations of coarse-grained, clayey sandstone. It is part of the freshwater deposits formed relatively recently when Walters Plains Lake was somewhat larger than at present. The diatoms identified are *Cymbella, Epithema, Navicula* and broken fragments of *Synedra*. The diatomite has a porosity of 68.93%, a dry bulk density of 0.91g/cm^3 and grain density of 2.92g/cm^3.

An extensive area of outcrop is exposed across the width of the creek. It consists of up to 1m thick seam of off white diatomite and 0.5m clayey diatomite underlain by decomposed granite of the Permo-Carboniferous Princess Hill Granite (Photo WPL 2). The overall size of this deposit is not known as the diatomite seam is concealed beneath a cover of black soil. Recent mapping by the Geological Survey of Queensland outlined other outcrops in the area and further exploration is necessary to delineate the extent of this deposit. The Walters Plains Lake deposit is believed to be of Holocene in age (Withnall, Lang & Warnick, 1985).

Flaggy Creek/Princess Hill (MGA 94, Zone 55, 0346815E, 7972477N)

The Flaggy Creek deposit is 32.5km south-west of the Cashmere occurrence, and lies within the Girringun Nation Park (NP 727). The deposit is exposed on low ground and appears to be extensive with a surface area over 100m by 100m. An outcrop of water-sculptured/polished diatomite forms a rock bar across Flaggy Creek (Photo FC 1) and at one exposure the diatomite shows an upward fining of grain size. The diatomite overlies duricrust developed on decomposed granite of the Permo-Carboniferous Princess Hills Granite. There is no direct evidence of basalt flows at the deposit outcrop site. White (1959) reported this deposit contains broken frustules of *Melosira* (FC 2). The diatomite has a porosity of 90.47%, a dry bulk density of 0.62g/cm^3 and grain density of 3.15g/cm^3.

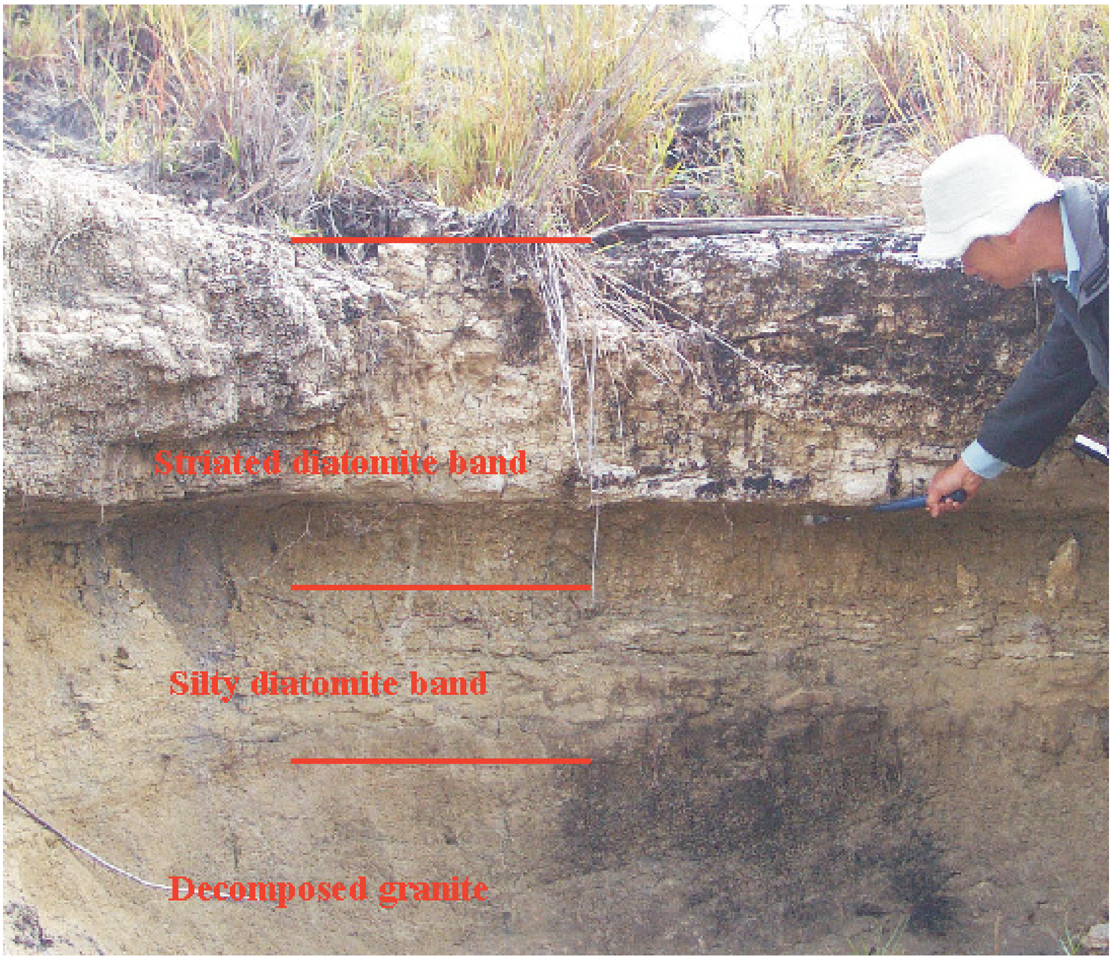


Photo WPL 2. Walters Plains Lake diatomite deposit (MGA 94, Zone 55, 0307215E, 7971480N), creek bank exposure shows a 0.6m thick wave-cut platform of diatomite overhanging 0.3m thick of silty diatomite underlain by decomposed granite (2006).

Photo FC 1: Flaggy Creek diatomite deposit, creek bed exposure shows 1m tall rock bar of white diatomite overlying duricrust and decomposed granite (MGA 94, Zone 55, 0347253E, 7972823N).

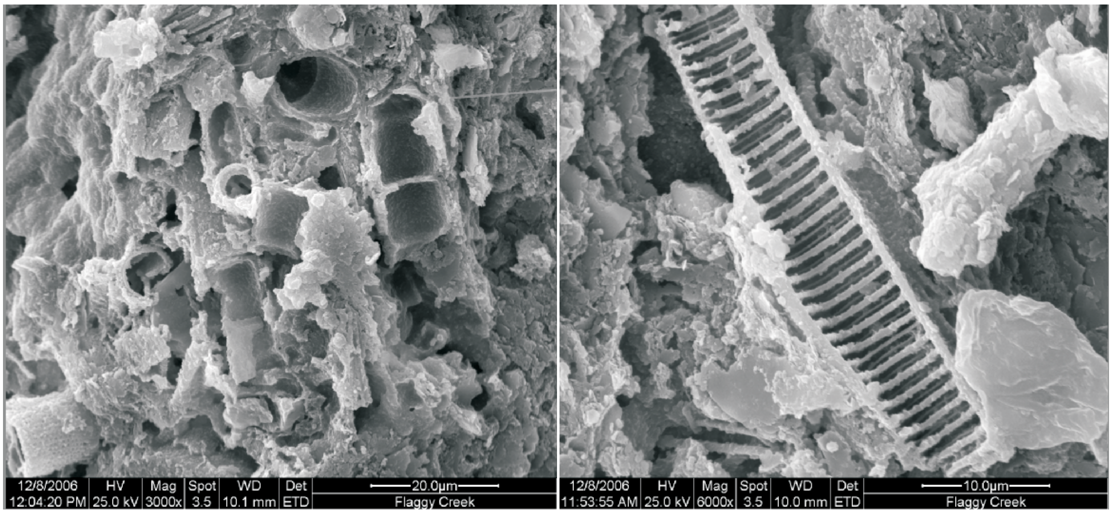


Photo FC 2: Photomicrograph at 3000x and 6000x of the Flaggy Creek diatoms showing growth of secondary opaline silica infilling between the diatoms (Photo taken by L Duong of Queensland University of Technology 2006).

Conjuboy (MGA 94, Zone 55, 0269547E, 7935100N)

The Conjuboy deposit on Spring Creek is probably the same as that described by Dunstan (1913) at 3km west of Spring Creek homestead, which is about 45.5km north-west of Greenvale on Wyandotte station. The deposit is exposed in Wyandotte Creek near its junction with Fig Tree Spring.

Metals Exploration Ltd (AP 2630M & 2808M, 1980) mapped the area and reported that the diatomite seam has a thickness of 20 to 30m and is interbedded with, and underlain by claystone developed in a fresh water lake on the surface of a basalt flow. The diatomaceous earth is poorly cemented, and contains lenses of clay and beds of coarse sandstone. Where exposed in creek cuttings the diatomite seams are 10–15m thick with a cover of 0–5m of sandy clay, diatomite rubble, basalt rubble and soil. Past drilling by Metals Exploration Ltd has shown that the diatomite-bearing horizon comprises two main zones of material, a 'low grade' diatomite which is pale orange in colour or grey-white with increasing clay content, and a 'high grade' diatomite which tends to be white to slightly-tinted (Photo CJ 1).

The 'low grade' material comprises approximately 50% diatomite and 50% clay on a volumetric basis, whilst the 'high grade' material comprised approximately 90% diatomite and 10% clay. Microscopic examination indicated that the majority of the diatomite frustules were intact. This lacustrine deposit consists mainly of the cylindrical diatom *Melosira* with *Synedra*, *Stauroneis, Pinnularia, Navicula* and *Eunotia* (White & Crespin, 1959). Some sponge spicules are also present (Photo CJ 2).

Australian Diatomaceous Earth Pty Ltd was granted ML 10279 “Conjuboy”(2004 to 2054) over the deposit and their tests indicated the diatomite could be treated to improve its application as a filtration medium. The calculated resource figure was given as 3.55Mt (Border, 2001).

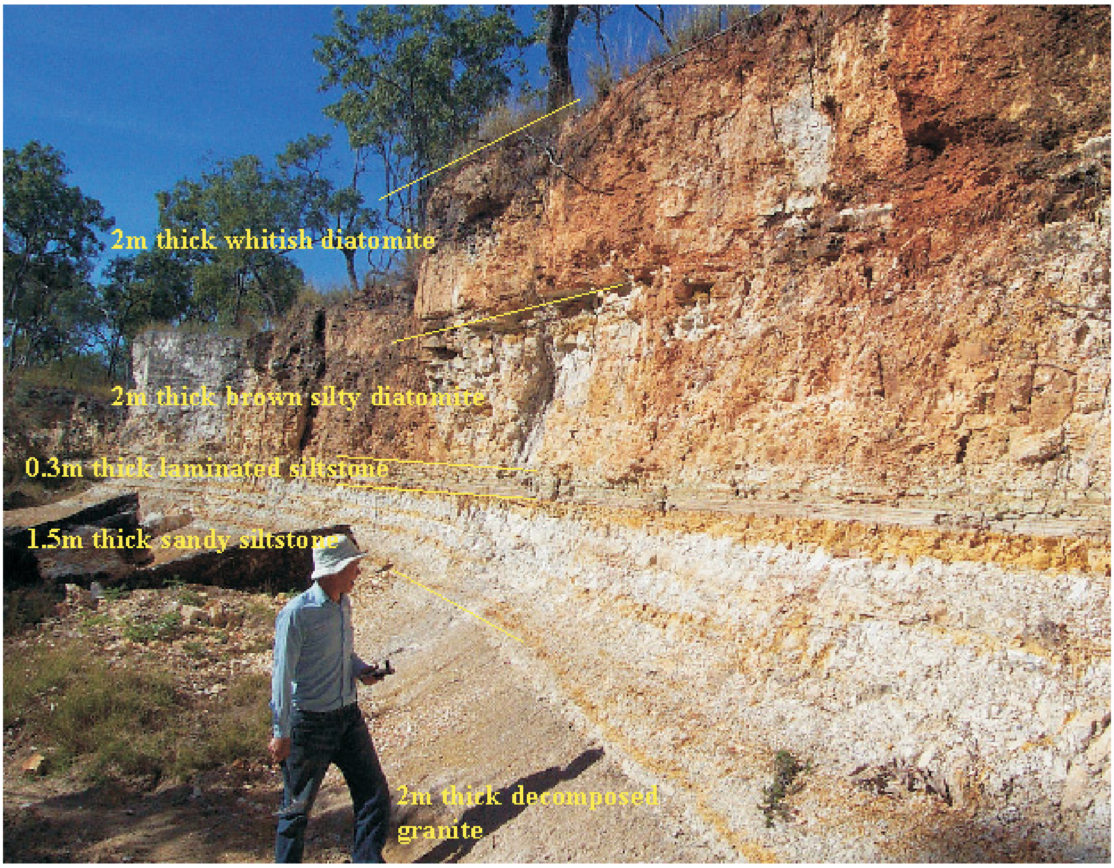


Photo CJ 1: Conjuboy diatomite deposit creek bank exposure of massive diatomite beds overlying siltstone and decomposed granite. No basalt was identified towards the base at this outcrop (2006)

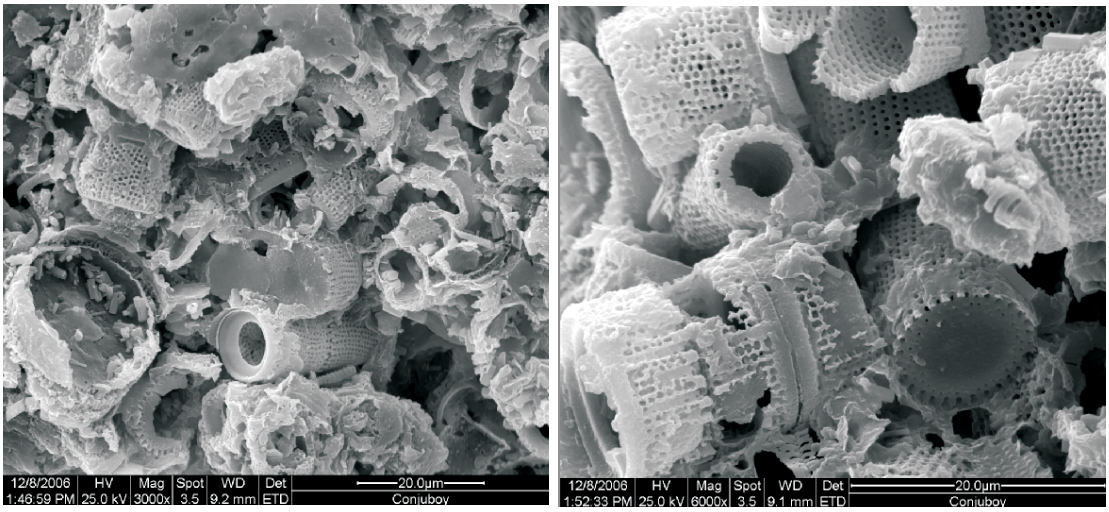
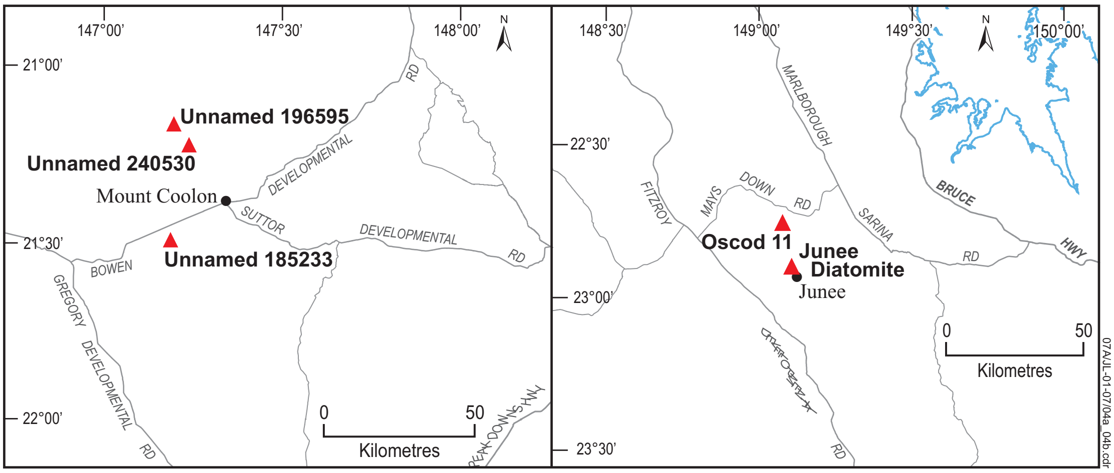


Photo CJ 2: Photomicrograph at 3000x and 6000x of the Conjuboy diatoms (Photo taken by L Duong of QUT 2006)

Similar, though generally smaller, deposits at Unnamed-660382 (MGA 94, Zone 55, 0266174E, 7938437N) Unnamed-735280 (MGA 94, Zone 55, 0273615E, 7928178N) and Unnamed-765317 (MGA 94, Zone 55, 0276615E, 7931878N) south-east of the main Conjuboy deposit, were mapped by Withnall & others (1994).

CENTRAL QUEENSLAND

The central Queensland deposits (Figures 4a,b) include the Rosetta Creek occurrence ~21.5km north-north-west of Mount Coolon, the Planet Downs occurrences near Planet Downs homestead and the Junee occurrences ~81km west-south-west of Marlborough. None of these deposits have been explored.



Figures 4a,b: Central Queensland diatomite deposits

Rosetta Creek/Mount Coolon/Unnamed 240530 (MGA 94, Zone 55, 0524113E, 7653179N)

This deposit occurs in the north branch of Myall Creek, an eastern tributary of Rosetta Creek. Mapping by the Geological Survey of Queensland in the 1990s located a number of small diatomite occurrences ~22km north-north-west of Mount Coolon. The diatomite is hosted by the Tertiary Suttor Formation consisting of sandstone, siltstone and minor interbedded basalt. They occur as rubble at the base of the section at Grid Reference MGA 94, Zone 55, 0518613E, 7623480N, as float on a dam wall at Grid Reference MGA 94, Zone 55, 0519713E, 7659679N, and as a thin bed at Grid Reference MGA 94, Zone 55, 0524113E, 7653179N. No analyses have been carried out and the potential of these deposits is uncertain (Hutton & others, 1991).

At site MGA 94, Zone 55, 0524207E, 7653571N (Photo RC 1) exposure of a flat-lying bed of diatomite consists of 0.6m of white diatomite on 0.5m creamy brown diatomite. This outcrop extends discontinuously over 300m as a wave cut platform along the creek bank (personal communication, D. Purdy of the Geological Survey of Queensland, 2006). There is no evidence of basalt in the vicinity and the nearest sandstone outcrop is 1.5km to the east. The diatomite appears to contain *Melosira*. A photomicrograph image of the diatom species is shown in Photo RC 2.

Junee (MGA 94, Zone 55, 0715912E, 7465481N)

The Junee diatomite deposit was discovered prior to 1939. Outcrop up to 10m thick was exposed along creek bank.

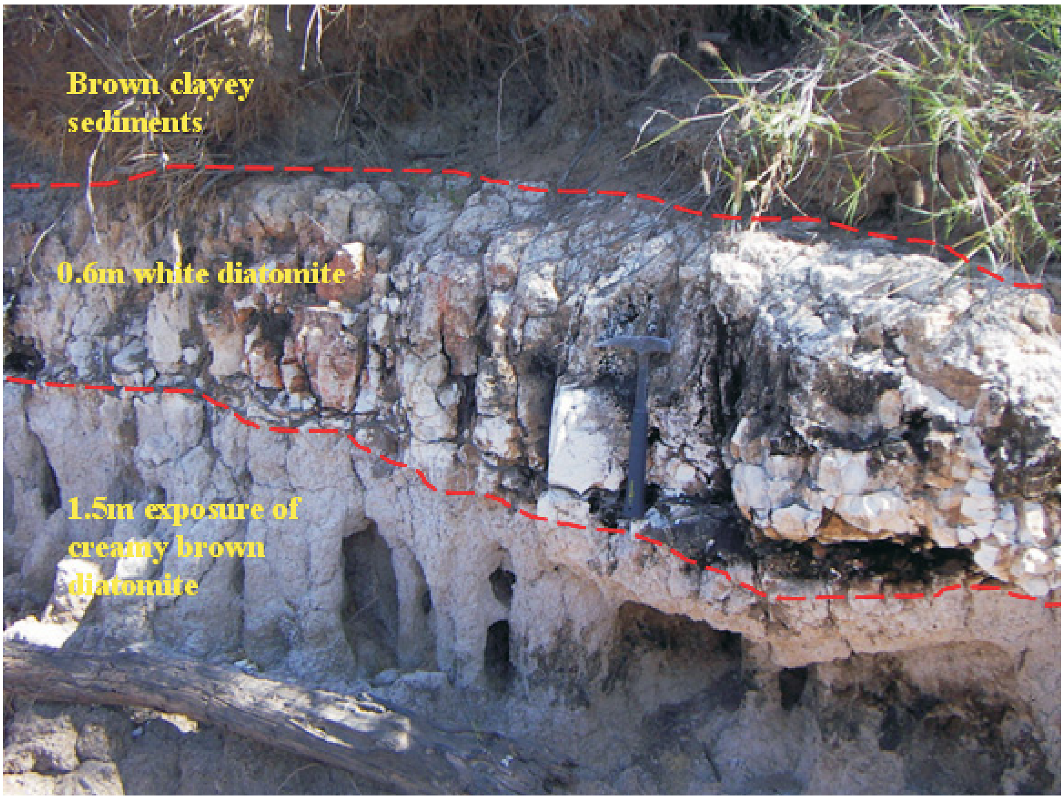


Photo RC 1: Rosetta Creek diatomite deposit: creek bank exposure of massive diatomite beds and overlying brown clayey sediments (Photo taken by D. Purdy of Geological Survey of Queensland, 2006).

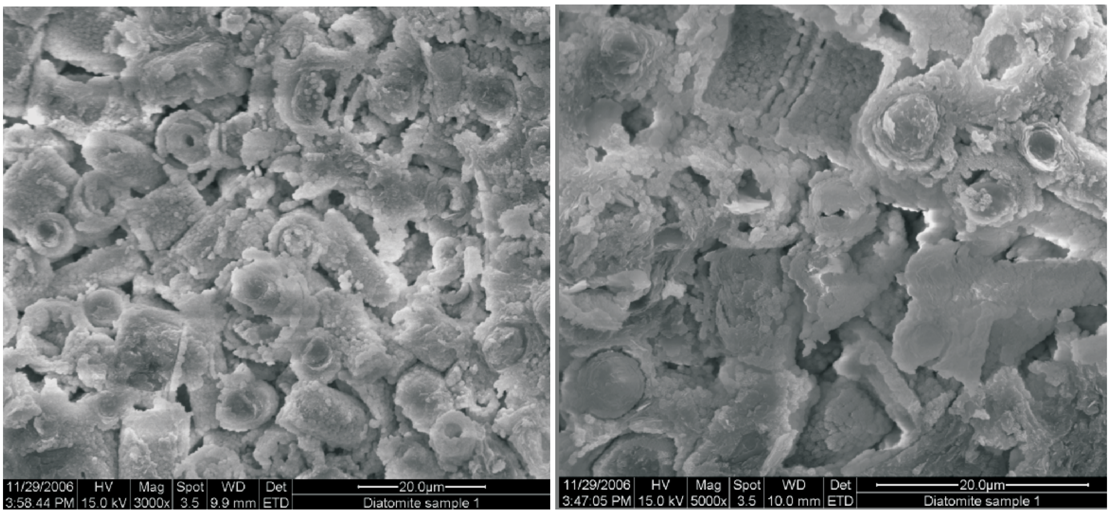


Photo RC 2: Photomicrograph at 3000x and 6000x of the Rosetta Creek/Mount Coolon diatoms showing dense overgrowths of opaline silica (Photo taken by L Duong of QUT, 2006)

Reid (1939) reported a thickness of 10m of diatomaceous earth occurs on the flank of a tableland area. He considered the diatomite to be of good quality and of a pure white colour. The deposit appears to be extensive and contains mainly *Melosira* (Photo J 1).

A small occurrence known as Oscod 11 is located 20km north-north-west of Junee homestead at Grid Reference ((MGA 94, Zone 55, 0713032E, 7481215N). Thick bed of white to cream coloured diatomite is exposed in gully erosion along the flank of laterite capped plateau.

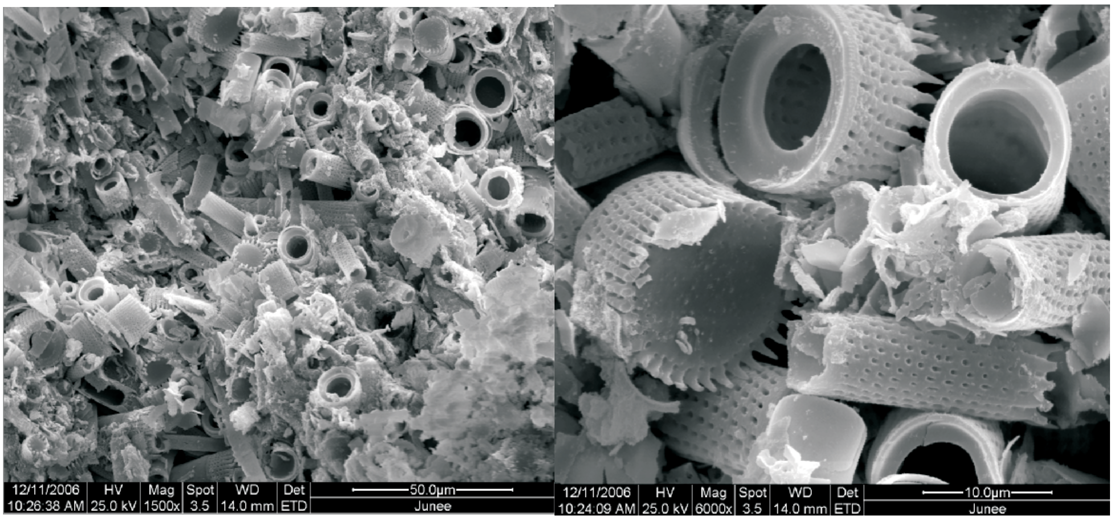


Photo J 1: Photomicrograph at 3000x and 6000x of the Junee diatoms (Photo taken by L Duong of QUT 2006)

Planet Downs

This occurrence, situated 28km east-south-east of Rolleston near Planet Downs homestead, was reported to have been discovered around 1910 (Dunstan, 1913). The diatomite seam is 1m thick with a chalky white to buff colour and of medium quality. It consists of cylindrical *Melosira* and *Stauroneis*, the short, stout form of *Pinnularia*, and frustules of *Navicula* and *Eunotia* (Crespin, 1947).

SOUTH QUEENSLAND

The southern Queensland deposits include Maidenwell, Portion 29, Mount Sylvia (Black Duck Creek), West Haldon (Hellhole) and Rosewood (Figure 5). Company exploration reported that the Portion 29, West Haldon and Rosewood deposits are inferior in quality and quantity when compared with those at Maidenwell and Mount Sylvia. The Portion 29 and West Haldon deposits tend to have a high percent of clay component and iron content. The Rosewood deposit is opalised.

The Maidenwell and Mount Sylvia deposits are producing diatomite adequately meeting local market demand in the agricultural and horticultural industries.

Maidenwell (MGA 94, Zone 56, 0378318E, 7035399N)

The Maidenwell diatomite deposit is ~29km south of Kingaroy (210km north-west of Brisbane). The ore is being mined by Maidenwell Holdings Pty Ltd from two shallow open pits to 5m deep at Brooklands Road, Maidenwell. The diatomite from this deposit is marketed mainly as a soil conditioner in the local grape and nursery industries.

The deposit occurs within the Main Range Volcanics, a thick unit of Tertiary volcanic rocks consisting almost entirely of basalt flows and thin bedded sediments that unconformably overlie granite of the Permo-Triassic Boondooma

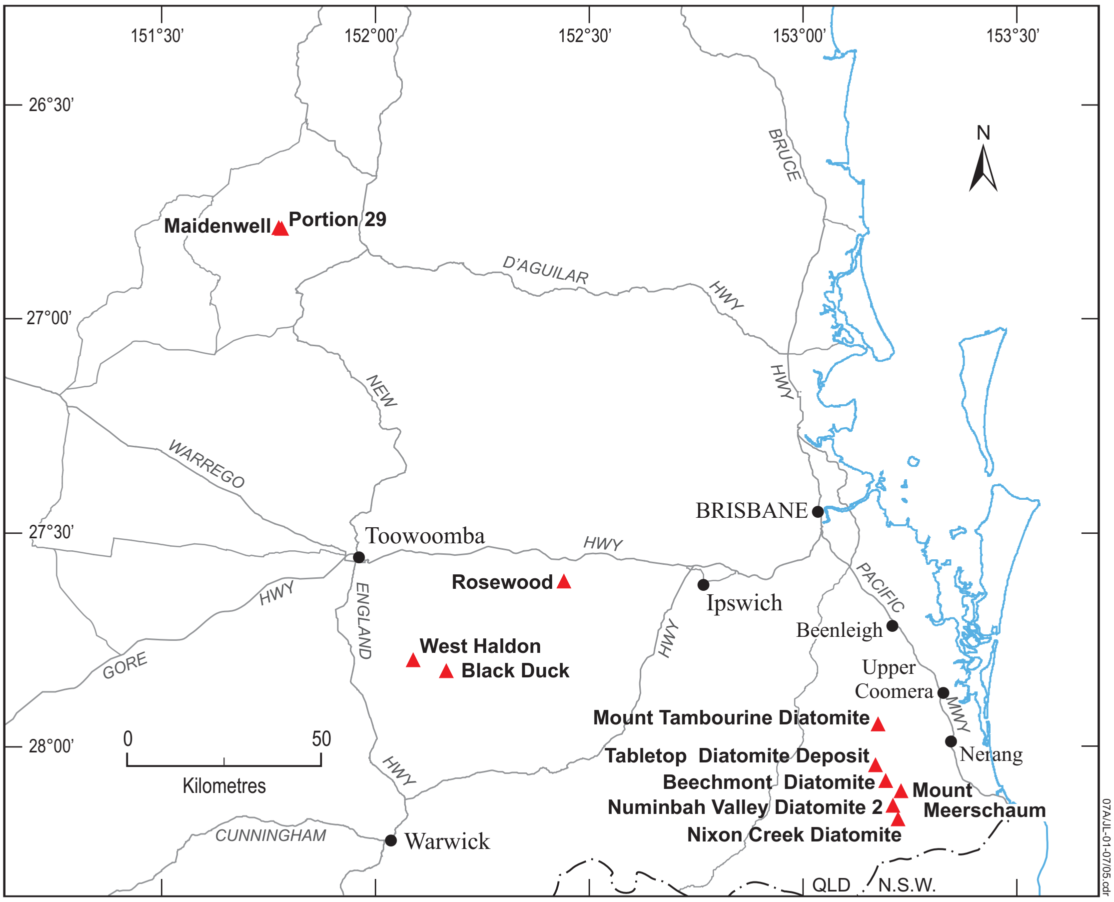


Figure 5: South and south-east Queensland diatomite deposits

Igneous Complex. The deposit has been exposed by weathering of the overlying basalt on a small plateau ~1km in diameter. The diatomite is well laminated and horizontally bedded. In one pit wall face a band of diatomite is interbedded with re-sedimented rhyolitic pyroclastic ash, and shale and sandstone. Fossil leaves and branches have been observed in the underlying sediments (Photo M 1).

The early discovery history of this deposit is not known but the deposit was first mentioned by Dunstan (1913). In 1980, Barrier Exploration NL conducted Air-Track rotary percussion drilling to test the deposit to a depth up to 9m. Results indicated that the diatomite apparently occurs as a single, continuous flat-lying seam ranging from 2.1–2.9m in thickness. This diatomaceous seam (Photo M 2) includes thin bands of bright yellow-brown ferruginous, clayey diatomite and thin bands of greyish-brown to dark brown clay. However, moderately pure off-white to fawn to pale yellow-brown diatomite usually makes up 60–80% of the seam (Drake & Edney, 1981). This lacustrine diatomite is inferred to occur ~1–3m above the base of a sedimentary unit which overlies a basaltic lava flow. The sediments are strongly weathered and comprise very fine- to fine-grained, poorly-sorted arkosic sandstone, argillaceous sandstone, siltstone, re-sedimented pyroclastic ash and clay.

Microscopic examination of diatom species indicated that they are almost wholly composed of *Melosira* granulate with average dimensions ~0.01mm (Photo M 3). Chains of *Melosira* up to six units in length are fairly common. Also present are

Photo M 1: Maidenwell diatomite deposit: woody plant remains buried in re-sedimentary pyroclastic ash, 2006.

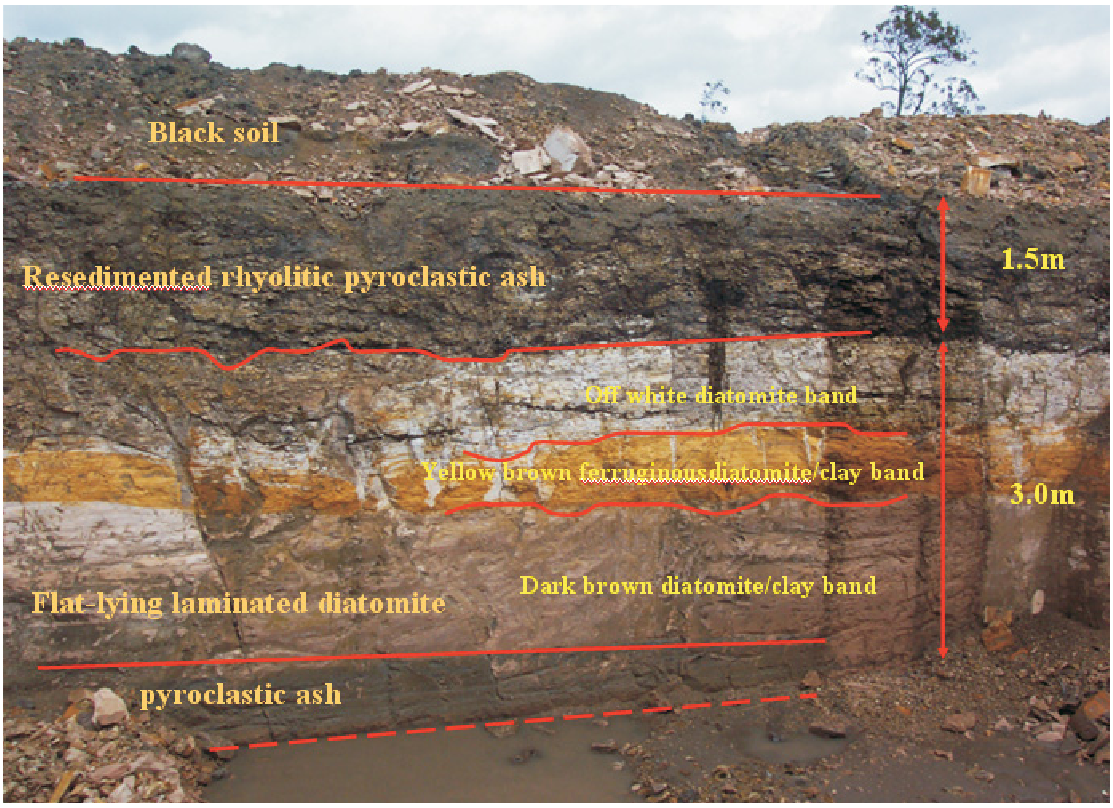


Photo M 2: Maidenwell diatomite deposit: one of the working open pits at MGA 94, Zone 56, 0378318E, 7035240N (Photo taken looking towards south 11/9/2006).

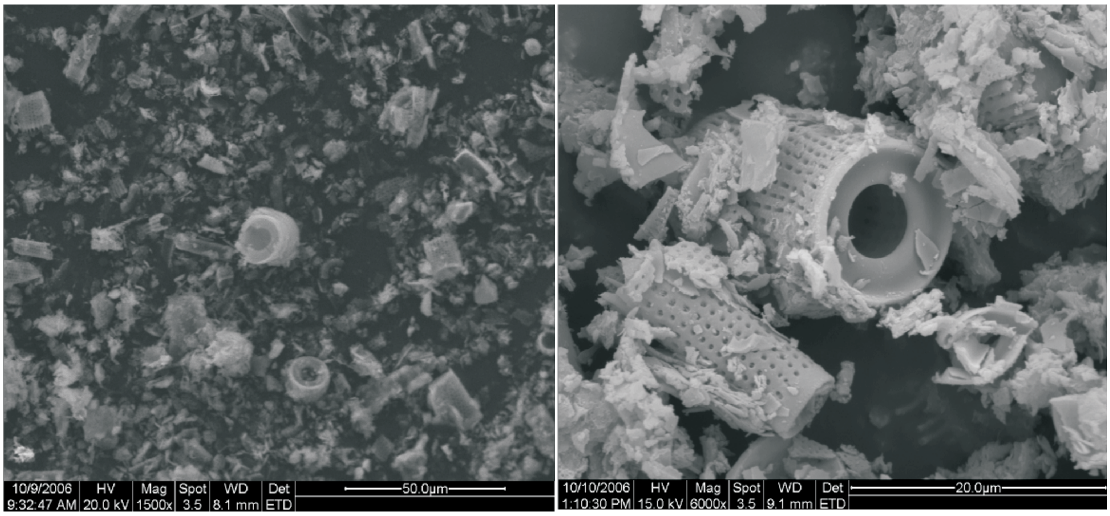


Photo M 3: Photomicrograph at 3000x and 6000x of the Maidenwell diatoms (Photo taken by W. Kwiecien of QUT, 2006)

traces of spicules, generally <0.03mm in length. The quartz content is low and clay is the main impurity. Variation in the diatom content is essentially linked to the relative proportions of intact and fragmented skeletons. Approximately half the diatomaceous material is in the form of intact skeletons, the balance being fine fragments (Ware, Spencer & Steveson, 1980).

Portion 29 (MGA 94, Zone 56, 0378709E, 7034880N)

A small outcrop of diatomite about one tenth the size of Maidenwell occurs ~0.5km south-south-west of the Maidenwell deposit. Past exploration indicated this deposit is fresh water in origin and contains diatoms similar to those at Maidenwell.

Mount Sylvia (Black Duck Creek deposit) (MGA 94, Zone 56, 0417528E, 6921873N)

The Mount Sylvia deposit located near Gatton, 35km south-east of Toowoomba, is a lacustrine style deposit and diatomite here occurs as thin seams (averaging ~2m thick) interbedded with basalt lava flows of the Late Oligocene to Early Miocene Main Range Volcanics. The deposit has been known since 1907. In the past the Cardile's adit was cut 70m into the bank of Rocky Scrub Creek and 356t diatomite was mined in 1936.

The diatomite seam is successively overlain by thin beds of clay and carbonaceous shale. The overlying clay is grey, pale grey to grey-green varying thickness from 0.15–0.5m. The carbonaceous shale has the appearance of crumbly lignitic material, and varies in thickness from 0.15–0.3m (Photo MS 1). The basalt forming the floor of the deposit consists of fine-grained plagioclase laths with some augite and olivine phenocrysts. The flow succeeding the roof basalt of the deposit is vesicular (I'Ons, 2004).

The diatomite is largely massive with little bedding and is generally uniform in appearance and purity. Jointing is apparent only in localised sections, where it

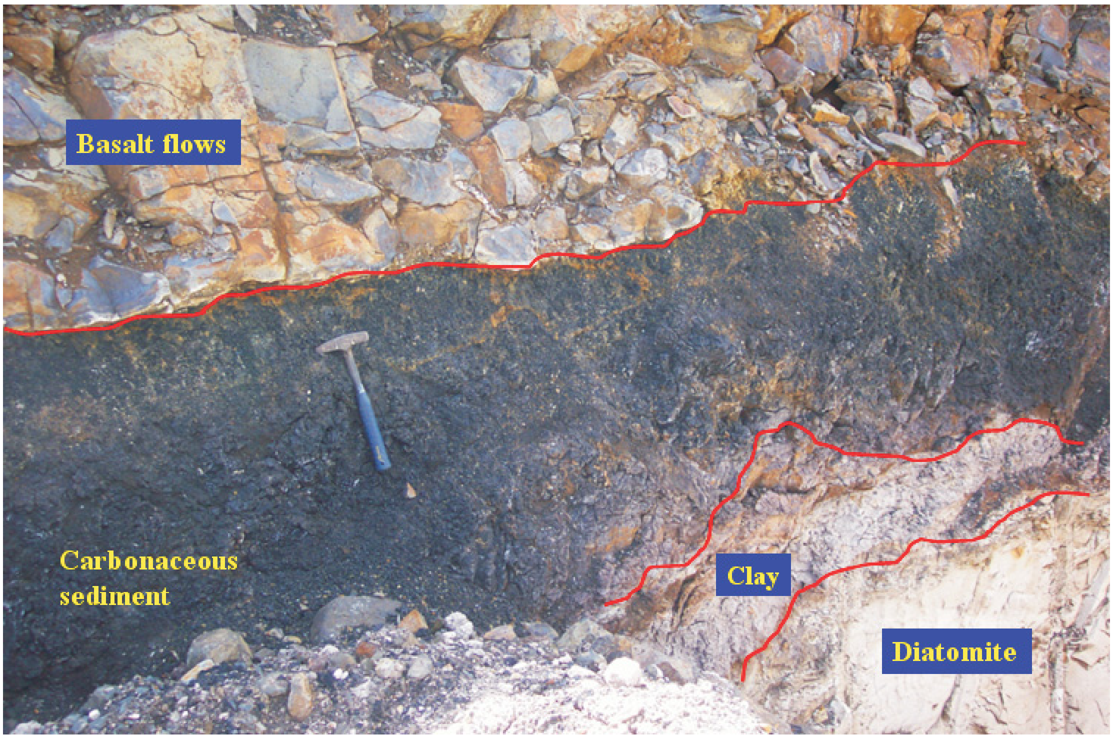


Photo MS 1: Mount Sylvia Diatomite Mine: the carbonaceous shale has the appearance of crumbly lignitic material, and varies in thickness from 0.15 to 0.3m. (Photo taken 2006).

occurs on either near horizontal or vertical patters. Secondary silica as veins and lenses and disseminations occur in sections of the diatomite seam. Minor opalisation of diatomite also occurs (Photo MS 2).

The diatomite comprises mainly of cylindrical *Melosira* plus some colloidal fines and occasional sponge spicules (Photo MS 3) in a white dense rock containing minor opaline material.

I'Ons (2004) reported that the Tertiary basaltic sequence that hosts the diatomite horizon at the Mount Sylvia mine (Black Duck Creek) rests unconformably on the Jurassic Walloon Coal Measures. The basal lava flows have a characteristic flaggy appearance in outcrop and have predominantly sub-horizontal fractures (Photo MS 4).

Commonly the overlying lava sank into the still soft diatomite and it has either partially or completely displaced the diatomite (Photo MS 5). In many parts of the deposit basaltic lava has intruded between the diatomite and underlying basalt. This intrusion has an irregular upper surface and in places invades the diatomite where it is surrounded by peperite breccias (Photo MS 6).

West Haldon/Hellhole (MGA 94, Zone 56, 0408426E, 6925578N)

The West Haldon deposit is situated ~2.8km west-south-west of West Haldon township, on Portions 109V and 92, Parish of East Haldon. It is 8.8km west-north-west of the Mount Sylvia (Black Duck Creek) deposit.

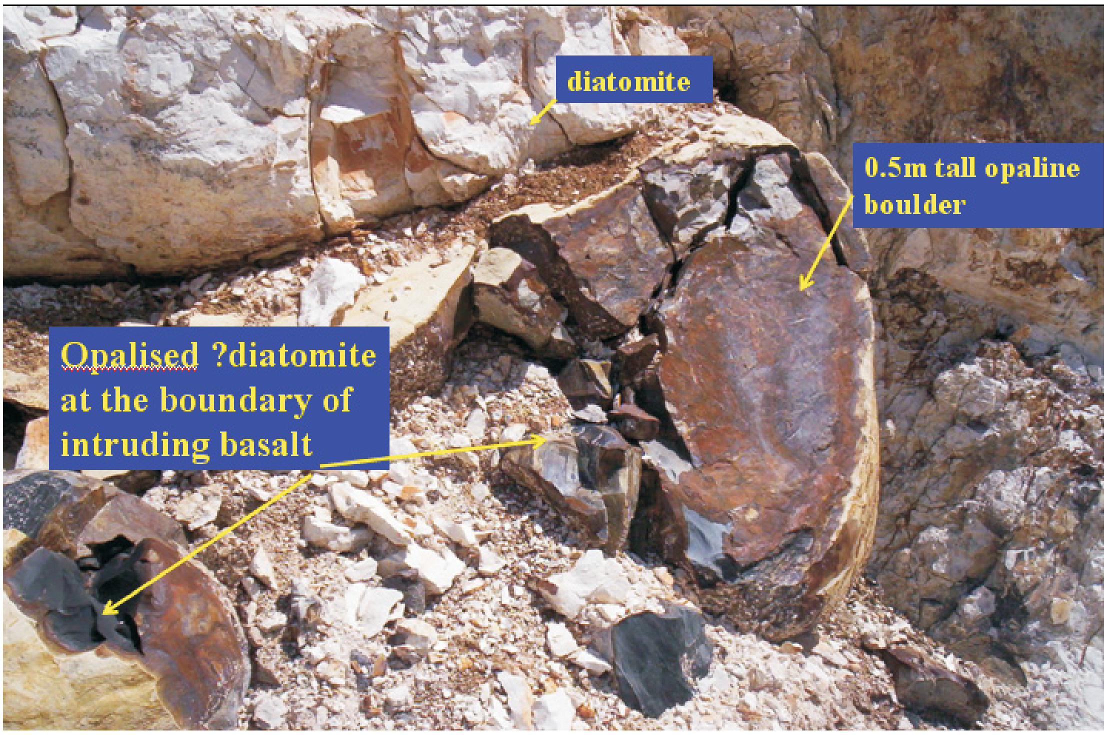


Photo MS 2: Mount Sylvia Diatomite Mine: opaline material near the boundary of diatomite and intruding basalt (Photo taken 2006 MGA 94, Zone 56, 0416759E, 6922066N).

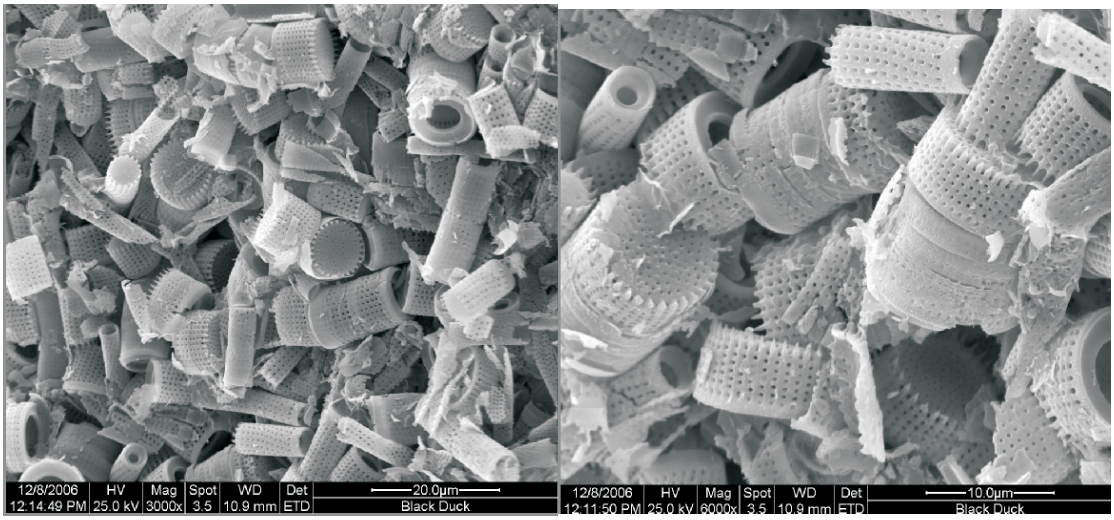


Photo MS 3: Photomicrograph at 3000x and 6000x of the Mount Sylvia/Black Duck diatoms (Photo by L. Duong of QUT 2006).

The geological setting of this deposit is similar to the Mount Sylvia occurrence where seams of diatomite are interbedded with Tertiary basalt overlying the Jurassic Walloon Coal Measures. The diatomite seam is exposed near the base of a steep hill just above the bank of Sandy Creek. The seam dips towards east-south-east.

The diatomite is finely laminated and yellowish near the surface but pure white at depth. It consists almost entirely of elliptical *Cymbella* and *Navicula*, with a few long ovate *Pinnularia*, cylindrical *Melosira*, and sponge spicules. Two short adits into the deposit have indicated that the thickness of diatomite exceeds 5.5m. Up to 1952, the deposit produced ~10–12t of diatomite (Bonner, 1952b).

Photo MS 4: Mount Sylvia Diatomite Mine: basalt flows with sub-horizontal fractures (Photo taken 2006).

Photo MS 5: Mount Sylvia Diatomite Mine: overlying lava sunk into the still soft diatomite (Photo taken 2006).

Photo MS 6: Mount Sylvia Diatomite Mine: peperite breccia with globular clasts of basalt, volcanic glass and opaline vugh (Photo taken 2006).

Recent company exploration indicated the deposit at Sandy Creek has a low commercial value because of its inherent high salt content and friable nature of the diatomite. The diatomite seam is laterally discontinuous.

Rosewood (MGA 94, Zone 56, 0444981E, 6942966N)

The Rosewood deposit, located on Portion 16V, Parish of Grandchester, is ~7.6km west-north-west of Rosewood township. The diatomite is greyish-white in colour and has been largely altered to an opaline form. It is wholly composed of *Melosira* (Bonner, 1952c). This deposit is small comparing with the Mount Sylvia deposit.

SOUTH-EAST QUEENSLAND/GOLD COAST HINTERLAND

The south-east Queensland diatomite deposits (Figure 5) in the Canungra–Beechmont–Nerang areas apparently include the earliest discovery made in the Queensland. The Mount Meerschaum deposit was mentioned in 1889 (Rands, 1989) and the Tabletop, Numinbah Valley and Mount Tambourine deposits were discovered in 1907 and 1908 respectively (Dunstan, 1913). Samples from these deposits were analysed for impurities, but none of them had been explored further as there was little demand for diatomite at the time. Most of the deposits appear to be thin-bedded and occurred between flows in the Tertiary

Beechmont Basalt that are currently overlying the Jurassic Gatton Sandstone on elevation high above ground level. The exact location of some of the deposits is difficult to find in heavily-timbered and hilly country that has been encroached by Government reserve or private residential subdivision lands. The generalised locations included in this report are approximately only.

Tabletop Diatomite Deposit (MGA 94, Zone 56, 0515809E, 6897264N)

This deposit is situated at the southern end of Subdivision 32, Portion 15, Parish of Witheren. At one exposure, the seam was 2.3m thick. Other exposures were found at elevation 290m, 335m and 365m. Outcrop was exposed between an overlying decomposed basalt and massive unweathered basalt beneath. The diatomite is of medium grade, dense, dark cream in colour, and laminated. It is composed of cylindrical diatom *Melosira* granulata, minor clay particles and numerous broken sponge spicules (Bonner, 1952e).

Mount Meerschaum (MGA 94, Zone 56, 0517994E, 6893889N)

This deposit is 22km east-south-east of the Beaudesert Railway Station on Portions 62V and 69V, Parish of Witheren. Field inspection located a small outcrop on the western side of a section of a north-trending fence track about 150m from the crest of a steep basalt hill. The diatomite is greyish white and the seam has orthogonal joints/partings (Photo MM 1). The dimension of the seam is not known as it dips flatly towards south-south-east under a thick cover of black soil and basalt rubble. Rands (1889) described this diatomite deposit composed of *Melosira arenaria* (Photo MM 2).

Photo MM 1: Mount Meerschaum diatomite outcrop showing orthogonal joints/partings (photo taken 2006).

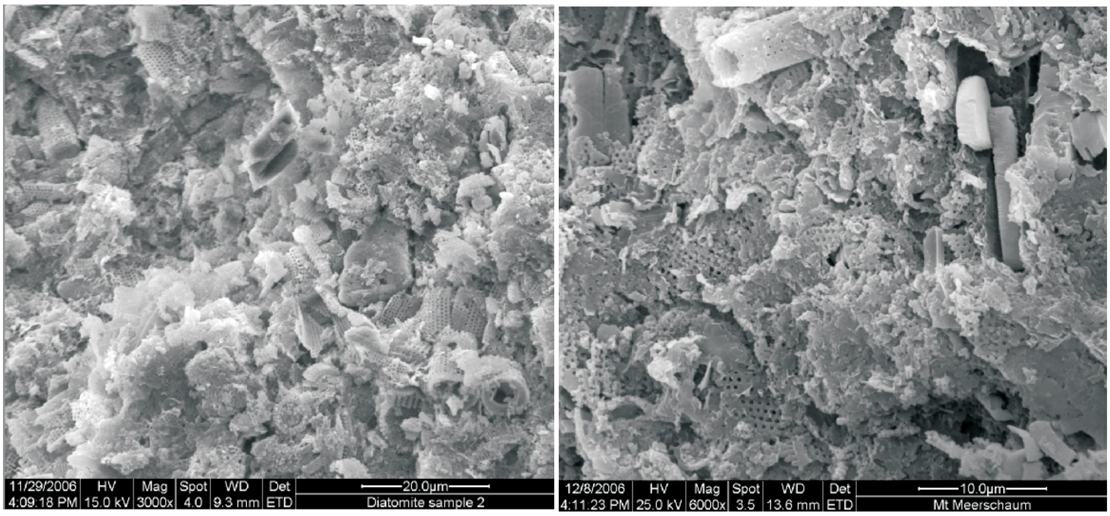


Photo MM 2: Photomicrograph at 3000x and 6000x of the Mount Meerschaum diatoms (Photo taken by L Duong of QUT 2006)

Numinbah Valley

Several diatomite occurrences were recorded in the Numinbah Valley. Their exact location is not known. The diatomite is generally white coloured, hard, and of poor quality. It is composed predominantly of *Melosira* with several forms represented in the deposits at 335m. Outcrops at 290m elevation are mostly composed of small, fragmentary *Melosira* crenulata (?) and the diatomite is frequently altered to the opaline form (Bonner, 1952c). Some of the recorded occurrences are:

- On the road between Portions 42 and 43, Parish of Numinbah, are two deposits at elevations of 290m and 365m.
- About 800m south of the south-west corner of Portion 17V, Parish of Numinbah within Reserve 362, at an elevation of 290m
- Two exposures at about 290m elevation in the south-west of Reserve 362 and in the eastern part of Portion 71, Parish of Numinbah. The diatoms appear to be fairly broken up (Photo NV 1).
- On Portion 4, Parish of Numinbah at elevations of 290m and 335m.
- On Horse Pocket Spur, east of Beechmont and 14.5km south-west of Nerang.
- In the vicinity of Egg Rock (Nixon Creek) and the headwaters of Nerang Creek.

Mount Tambourine

Diatomite is reported to occur at the base of Tamborine Mountain, ~6.4km north of Canungra Railway Station. The general location falls within residential land.

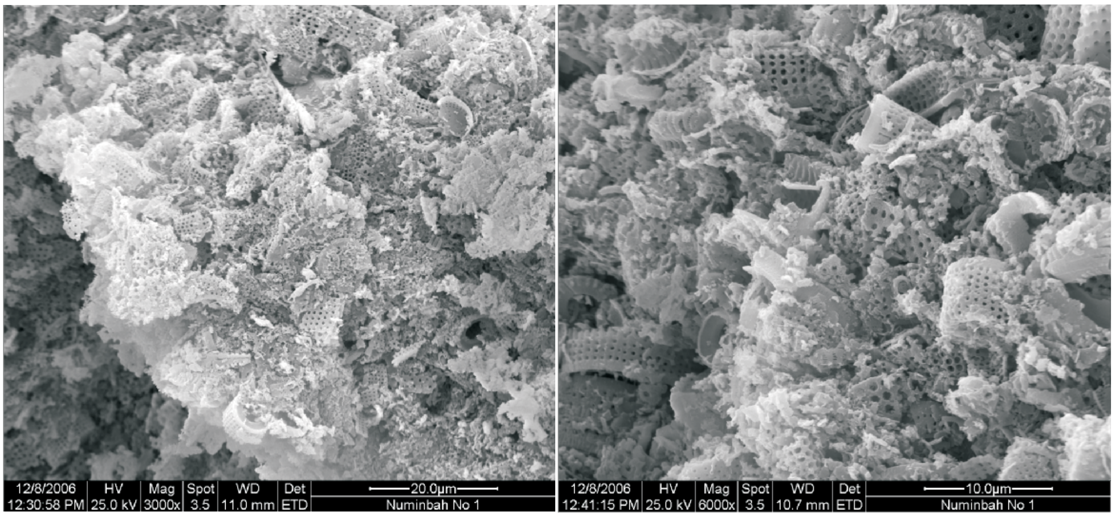


Photo NV 1: Photomicrograph 3000x and 6000x of selected sample of the Mount Numinbah diatoms (Photo taken by L. Duong of QUT, 2006)

CONCLUSIONS

Most of the world diatomite production comes from mining of continental deposits associated with palaeo-springs, -lakes and -streams. Marine deposits are far more extensive than the continental deposits but they are not commercially viable for mining unless uplift post-dates deposition and preservation of the diatomite.

Apart form those diatomite occurrences mentioned in this report, there are many other diatomite occurrences associated with various basalt provinces in the eastern part of Queensland which offer opportunity for exploration and assessment. The diatomite deposits described in this report are generally interbedded with Tertiary basalt lava flows on high elevation. The diatomite contains abundant *Melosira* diatom, suggesting the depositing environment is not dissimilar for each deposit despite their geographic distance spreading over 1000km.

The main uses of diatomite are as an absorbent and filtering medium, and as a filler. Synthetic filters are becoming competitive as filter media. Talc, ground silica sand, ground mica, clay, perlite, vermiculite, and ground limestone have been used as filler substitutes for diatomite. Despite all these substitute products, diatomite is abundant and low cost ensuring its competitiveness.

The yearly world production averages 2Mt per year. World resource amounts to 2 billion tonnes which ensures adequate supply of diatomite to satisfy industrial demands and guarantees no shortage in the near future.

Queensland has two operating mines (Mount Sylvia–Black Duck Creek and Maidenwell) producing ~5 000t a year for use in local agricultural and horticultural industries. A third mine (Conjuboy) is being developed in north Queensland and the diatomite from this deposit is believed to be suitable for use as a filtering medium. These mines, together with other occurrences at Glen Eagle homestead and Rosetta Creek, contain many million tonnes of diatomite resource. The projected increased production from these mines will propel Queensland forward as a significant producer in Australia.

The future outlook of diatomite in Queensland is steady and remains competitive provided the cost of mining can be kept within commercial stability.

ACKNOWLEDGEMENTS

Most of the technical information for this article has been compiled from literature research and from field inspections in 2006. Electron microscope scan images of grab samples of diatomite from various Queensland deposits were processed by technical staff of the School of Natural Resource Sciences, Queensland University of Technology, Brisbane.

BIBLIOGRAPHY

ADAMS, R. & WEST, S., 2003: EPM 13167, diatomaceous earth project, annual report for period ending 21/3/02. Company report held by the Department of Mines and Energy Library as CR34601

BALL, L.C., 1927: Diatomite at Black Duck. *Queensland Government Mining Journal*, **28**, 308–310.

BALL, L.C., 1934: Diatomite. *Queensland Government Mining Journal*, **35**,4.

BALL, L.C., 1937: Diatomite, Index to Localities on Queensland. *Queensland Government Mining Journal*, **38**, 396–397.

BONNER, M.H., 1950: West Haldon Diatomite Deposit — Cymbella Lease. *Queensland Government Mining Journal*, **51**, 984–986.

BONNER, M.H., 1951: Diatomite — Black Duck Creek — Gatton. *Queensland Government Mining Journal*, **52**, 533–538.

BONNER, M.H., 1952a: Diatomite — Black Duck Creek. Report held by the Department of Mines and Energy Library.

BONNER, M.H., 1952b: Diatomite — West Haldon. Report held by the Department of Mines and Energy Library.

BONNER, M.H., 1952c: Diatomite — Rosewood district. Report held by the Department of Mines and Energy Library.

BONNER, M.H., 1952d: Diatomite — Nixon Creek. Report held by the Department of Mines and Energy Library.

BONNER, M.H., 1952e: Diatomite in S.E. Queensland. Report held by the Department of Mines and Energy Library.

BONNER, M.H., 1953: Diatomite — West Haldon. *Queensland Government Mining Journal*, **54**, 657–658.

BORDER, A., 2001: EPM 4436, Conjuboy Area, Annual And Final Report For Period Ending 1/5/01. Company report held by the Department of Mines and Energy Library as CR11568.

BRADBURY, J.P. & KREBS, W.N., 1995: Fossil continental diatoms; palaeolimnology, evolution, and biochronology. *In* Blome, C.D., Whalen, P.M. & Reed, K.M., (Convenors): Siliceous microfossils (Short Courses in Palaeontology): Knoxville, Tennessee. *Palaeontological Society*, **8**, 119–138.

BREESE, R.O.Y., 1994: Diatomite. *In* Carr, D.D., Editor: *Industrial minerals and rocks (6th ed.)*. New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, 397–412.

BRUVEL, F., 1999: Diatomite — Mineral Information Leaflet No. 30. Report held by the Department of Mines and Energy Library.

COOPER, W., 1998: Minerals processing in Queensland (part 2). *Queensland Government Mining Journal*, **99**, 13–21.

CRESPIN, I., 1943: Report on diatomite from Nettle Creek. *Bureau of Mineral Resources Record* **1943/62**.

CRESPIN, I., 1946: Diatomite. *Bureau of Mineral Resources, Geology, Geophysics. Australia*, *Summary Report* **12**.

DOLLEY, T.P., and MOYLE, P.R., 2003: History and overview of the U.S. diatomite mining industry, with emphasis on the Western United States. *U.S. Geological Survey Bulletin* **2209–E**. [URL http://pubs.usgs.gov/bul/b2209-e/].

DRAKE, G. & EDNEY, J., 1981: ATP 2372M, Maidenwell diatomite geological report No 2. Company report held by the Department of Mines and Energy Library as CR9009.

DUNSTAN, B., 1911: Diatomaceous earth, Nerang. *Queensland Government Mining Journal*, **12**, 367.

DUNSTAN, B., 1913: Queensland Mineral Index. *Publications of Geological Survey of Queensland*, **241**.

DUNSTAN, B., 1916: Queensland Mineral Deposits. A Review of Occurrences, Production, Values and Prospects. *Queensland Government Mining Journal*, **17**, 585–588.

HARBEN, P.W. & KUZVART, M., 1996: Diatomite. *In Industrial minerals - a global geology*, London, Industrial Minerals Information Ltd, 161–167.

HARWOOD, D.M., 1999: Diatomite. *In* Stoermer, E.F. & Smol, J.P., Editors: *The diatom; applications for the environmental and earth sciences*, Cambridge, U.K., Cambridge University Press, 436–443.

HUTTON, L.J., GRIMES, K.G., LAW, S.R. & McLENNAN, T.P.T., 1991: Geology of the Mount Coolon 1:250 000 Sheet Area. *Queensland Resource Industries Record* **1991/19**.

I'ONS, M.E., 2004: EPM 13500, Mount Sylvia, partial relinquishment report for period 2/1/03 to 2/1/04. Company report held by the Department of Mines and Energy Library as CR37050

KROSCH, N.J., 1976: Summary report: diatomite. Serials - Geological Survey of Queensland.

METALS EXPLORATION LTD, 1983: A-P 2630M Conjuboy West Final Report. Company report held by the Department of Mines and Energy Library as CR11568.

RANDS, W.H., 1889: Albert and Logan district. *Geological Survey of Queensland, Publication* **51**.

REID, J.H., 1939: Merrion and Junee, MacKenzie River. *Queensland Government Mining Journal*, **40**, 221.

SHENK, J.D. 1991: Lacustrine diatomite. *In* Orris, G.J. & Bliss, J.D., Editors: Some Industrial Mineral Deposit models: descriptive deposit models. United States Geological Survey, Open File Report 91-0011-A, 26–29.

WARE, M.D., SPENCER, W.G. & STEVESON, B.G., 1980: In Goodall, D.K. ATP 2372M, (A) geological report no. 1 on Maidenwell diatomite deposit, Qld, (B) Identification and testing of diatomaceous materials. Company report held by the Department of Mines and Energy Library as CR8204.

WHITE, D.A. & CRESPIN, I., 1959: Some diatomite deposits, north Queensland. *Queensland Government Mining Journal*, **60**, 191–193.

WHITE, D.A., 1959: Cashmere Diatomite Deposits, Herbert River. Report held by the Department of Mines and Energy Library as Commodity file 2-1-44.

WITHNALL, I.W., LANG, S.C. & WARNICK, J.V. (Compilers), 1985: Summary of Results from the 1984 Field Season in the Einasleigh and Clarke River 1:250000 sheet areas, RGMP Progress report. *Geological Survey of Queensland Record* **1985/30**.

WITHNALL, I.W., HUTTON, L.J., GRIMES, K.G., WARNICK, J.V., OVERSBY, B.S. & RAPKINS, R.J. (Compilers), 1994: Australia 1:250 000 Geological Series, Einasleigh, Sheet SE55-9, Second Edition, 1994. *Department of Minerals and Energy, Queensland*.