

MAYDENA SANDS PTY LTD

ACN 111 938 428

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RETENTION LICENCE NO. 2/2003

MAYDENA, TASMANIA

ANNUAL REPORT

TO

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ABSTRACT

The diverse glass industry in China in general continued to experience difficult times due to subdued demand and downward pressure on prices, creating a climate not favourable for investment. However, the niche sector of display glass and specialty glass, as represented by Corning Inc., showed low digit growth though some sectors suffered price declines. This indicates continuing demand for high purity silica sand products. Of note also is growth in demand for quartz crucibles used to grow silicon ingots for the production of chips and semiconductors. This segment uses ultra high purity quartz sand which currently remains in short supply.

The enormous demand for photovoltaic modules will fuel large volume demand for low-iron cover glass for which Maydena Sands silica flour and sand would be suitable.

Thus the future for high purity silica flour and sand remains encouraging, but off-take at this time will largely be determined by price. In this price sensitive context, capex/opex updates for the proposed Maydena Sands Project become more urgent. Furthermore, any processing plant revision should include provisions for the production of silica powder, if pending research proves successful.

Discussions with 3 Crosses Energy Pty Ltd progressed to the point where a “Heads of Agreement” document is ready for signature, which may lead to an application for a mining lease and development permit in due course, following some additional bulk tests.

A test survey to gauge the suitability of Passive Seismic to determine additional resources of mainly red sand at depth was deemed unsuccessful for the intended purpose and further use of this method was discontinued. Drilling remains the most viable option.

Keywords:

Maydena; Silica flour; Silica sand;
Passive Seismic; Marketing; Logistics.

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1. INTRODUCTION

This Annual Report outlines activities by Maydena Sands Pty. Ltd. during calendar year 2017 in this Tenement.

Retention Licence No: 2/2003 Area: 3sq.km

Tenement Holder: Maydena Sands Pty. Ltd.

Ownership: 100% owned and operated by Maydena Sands Pty. Ltd.

Location: Pine Hill, 4km south west of Maydena, 90kms by road, west of Hobart.

Infrastructure: The Tenement is located just south of the sealed Gordon River road on the eastern slopes of Pine Hill, approximately 4km west south west of Maydena (pop. 250 approx.) and about 90km by road from Hobart (Fig.1).

There is good access to and within the prospect area. Power, water, housing and basic facilities are readily available within a short radius of the prospect. The last few years saw the progressive upgrade of the narrow gauge New Norfolk-Maydena rail line to passenger standard but only as far as the entrance to the Mt Field National Park. After a recent assets review, TasRail resolved to hand over the Derwent Valley Railway line west of Boyer to tourist and heritage operators in a deal yet to be finalised. In this context, mooted upgrades to freight standard of the entire stretch are now highly unlikely. An alternative rail loading facility, a major freight hub at Brighton, approx. 65km by road east of Maydena has been completed and is now fully operational. A 700m long gravel airstrip is located 3 km north west of the silica sand deposit.

Objectives: The primary target for investigation, assessment and eventual exploitation remains the deposit of silica sand and its silica flour matrix located largely to the west of the Eastern Quarry, about 1 km south east of Pine Hill (Fig.2).

The overall aim of the investigations and activities is to determine if a commercially viable operation can be established, based on products derived from the silica flour, silica sand and silica rock resource in the tenement and on various, changing economic and market factors.

In view of the growing use of solar power locally and overseas, interest was also maintained in the silica rock potential of the tenement. This raw material, if of sufficiently high quality, is used in the production of high purity silicon metal, an essential component for the manufacture of computer chips and photovoltaic solar cells. Also of potential interest is the coarser, higher purity sand fraction for use in the manufacture of technical glass, optical glass and solar cell cover glass with high light transmissivity characteristics.

2. PREVIOUS WORK

2.1 By Previous Holders

For a Summary See Krummei, 2016.

2.2 By Current Tenement Holder

This tenement has its origins in EL 17/1998 of 7sq.km previously held and operated by J.J. McDonald & Sons Mining Pty. Ltd., the precursor of Maydena Sands Pty. Ltd. (See below).

During its tenure of EL 17/1998, which contained these deposits, J.J. McDonald & Sons Pty. Ltd., using the air core drill sampling method, completed 43 drill holes totalling 553 m which outlined a global raw material resource of about 6 million tonnes of loose, unsorted silica material, ranging in size from very coarse to very fine.

The drilling also demonstrated that the deposit is more variable, complex and higher in iron oxides and other impurities than previous data suggested.

Laboratory sizing determinations indicated that the deposit is a possible source of silica flour as well as glass sand, while geological mapping and interpretation also pointed to a small resource potential for hard rock silica.

Preliminary bench scale beneficiation and bulk sample processing tests, including acid wash tests showed that the +45 -250 micron silica flour fraction could be upgraded to a high quality product containing only about 50ppm Fe₂O₃ or less without major environmental impact, with levels of iron as low as 10ppm a

possibility for a premium product. Results for the coarser +250-600 micron sand fraction were similar.

Sources of good quality limestone and dolomite were noted in relative proximity to the silica sand deposit for eventual acid neutralization, if needed.

The company's activities in the marketplace identified the natural silica flour as potentially the deposit's most important component economically. This material provided the major focus for ongoing geological, processing and marketing activities, though the coarser size sand fractions and the hard-rock silica potential, as well as any silica powder, remain of interest for future attention under the appropriate market conditions.

In early 2004, EL tenure over the area was converted to a Retention Licence.

In late 2004, Directors of J.J. McDonald & Sons Mining Pty. Ltd. formed a new holding and operating company, Maydena Sands Pty. Ltd., to which the Retention Licence and all of the former company's interests in the Maydena area were transferred in April 2005.

Since then, all activities are being conducted under the new Company name.

These included additional shallow AirCore/RC drilling, deep, 4x50m RC drilling into silica bedrock, various further beneficiation tests, extensive company promotion, product marketing and logistics monitoring.

Details of past activities and outcomes are provided in reports listed in Sections 8 and 9 below.

3. ACTIVITIES FOR PERIOD

These included:

3.1 Work Done

- Geophysics:

- Passive Seismic scoping test.

- Market related activities:

- Ongoing market monitoring – silica sand, silica flour, quartz sand, display panels, technical glass, quartz glass crucibles and PV silicon/polysilicon.

- Company and product promotion via MRT at PDAC, Toronto, Canada; China Mining Conference, TianJin, and Beijing Investment Seminar, China.

- Attendance and promotion at several significant events including:

- Semicon/FPD 2017 Exhibition – Shanghai, China
 - China Glass 2017 Exhibition – Beijing, China

- In addition, Contacts or Meetings with a number of companies summarised in Section 4.3.4.

- Project Planning and Feasibility:

- Engaged Consultant towards year end to initiate Project Capex/Opex Revue/update.
 - Discussions with Forestry Tasmania (Now Sustainable Timber Tasmania) re road haulage charges and compensation.
 - Discussion with Derwent Valley Shire re Silica Project.
 - Discussion with MRT and SEMF re Mining Lease Application procedures.
 - Site visit familiarisation with potential investor.
 - Permit for bulk sample collection and excavation contractor engagement.
 - Further discussions and update with Swire Shipping re container shipping ex Hobart to overseas destinations via mainland trans-shipment.
 - General monitoring of transport logistics.
 - Monitoring of a new Tourist Development Proposal for Maydena area.

- Community relations:

Occasional contact with Maydena Development Association representative.

- Environmental

No impact. No action required.

3.2 Statistical Summary

Test Samples for Quality Assessment sent to:

APT Asia Pacific - Vic	:	1 x 0.5Kg Silica Sand - processed
APT Asia Pacific - Vic	:	1 x 0.5Kg Silica Flour - processed
GPC Co. Ltd - Japan	:	2Kg Silica Flour – unprocessed
Modern Olives Laboratory Services - Vic	:	1Kg Silica Sand - processed

Geophysics

No. of Passive Seismic Stations : 7

4. RESULTS

4.1 Geophysics

4.1.1 Passive Seismic Scoping Survey

Situated in the redox zone below the base of the white silica sand and above bedrock is a layer of unknown, probably variable, thickness of heavily iron-stained sand. This material was previously discounted as waste because of perceived processing difficulties using conventional methods and costly to upgrade to high purity product and, therefore, not fully explored by drilling.

Results of acid leach tests conducted in 2013 and 2014 (Krummei 2013 and 2014) suggested that this contaminated material could potentially represent an additional resource to generate second grade, or possibly even premium high purity silica flour and silica sand. At worst, it may have value as construction or filler sand. Various low cost, low impact methods were considered to quantify this resource potential, including the use of available drill hole information.

After discussion with geophysical consultants, Passive Seismic methods emerged as a possible cost effective, low impact, logistically simple geophysical method to address this problem. A proposal from Hobart-based PassiveX Pty Ltd., for two trial lines was reduced to a short, non-intrusive scoping survey using several existing drill hole sites and stations on haulage tracks. Details of the method and results are presented in the consultant's report in Appendix 1.

Despite the positive tone of the latter's report and in view of the inherent margins of error in the interpretation of the results, it was decided that the method was not fit-for-purpose in the case of what was likely to be a relatively thin layer of sand. It was concluded that drilling was the only viable method to provide the accurate information required. Further use of the passive seismic survey method was discontinued, thereby also avoiding the cost of a deposit-wide coverage.

4.2 Project Planning

4.2.1 General

In the light of developments with 3 Crosses Energy Pty, Ltd., (See below p. 12) SEMF of Hobart was approached to provide advice and guidance in regard to mine lease and development permit applications. This resulted in a proposal to be fully evaluated and, if deemed fit, to be implemented at the appropriate time.

Allied with this, a meeting was held in Hobart with a representative of Forestry Tasmania (now Sustainable Forests Tasmania) to discuss compensation for tree removal, road ownership in the immediate area of the deposit and standard road toll charges applicable within the area of the eventual mining lease.

Similarly, the new Development Officer of the Derwent Shire Council was informed about Maydena Sands' proposed activities going forward. It emerged that a new Shire Planning Scheme was put in place at the end of 2015, replacing that of 1993. It appears that Extractive Industry (i.e. quarrying and mining) remains an approved activity.

A new tourist operation is being established at Maydena for sport and recreation based on mountain bike trails using established infrastructure on the slopes of the Maydena Range, south of the township of Maydena. The main haulage roads within RL2/2003 may occasionally be used in connection with these activities. At this stage, these tourist activities are unlikely to have a significant impact on Maydena Sands' operations in the area. However, safety issues and concerns remain.

The important and hotly debated issue of reliable power availability in Tasmania is being addressed by State Government. After the shock and difficulties experienced with electric power supply in Tasmania after the Basslink failure in 2015, the State Government has been taking steps to ensure reliable power supply to the State in the future. This is being done in part by HydroTas investing in expanding its generating capacity and by providing additional, clean, reliable power via large wind farms being constructed at Cattle Hill, Granville Harbour on Robbins Island in the north and west of the State.

4.2.2 Logistics

Road:

Minor road works around Bushy Park on the Maydena to New Norfolk Road caused only slight delays to traffic movement.

Elsewhere, major road upgrades to sections of the Midland Highway continued between the Brighton Freight Hub and Launceston.

Rail:

TasRail has recovered from the severe damage inflicted on the rail network during the 2016 winter floods and continues to show significant on-going improvements to the point where it is now efficient and cost competitive. Total freight transported in 2016/2017 was in excess of 3 million tonnes. During the same period TasRail notes a 7% increase in container units transported and a 20% increase in container revenue.

Standardisation of the locomotive and wagon fleet has been achieved. There were no main-line derailments affecting freight movement in either 2016 or 2017.

TasRail continues to operate 4 seaside freight terminals to facilitate the handling of goods: one each at the ports of Burnie, Devonport, Bell Bay and Brighton. The latter two are of prime significance to the Maydena Sands Project.

Ports:

Tasmanian Ports appear to show signs of increased freight activity. With the advent of the Searoad Mersey II ferry, freight and container shipment capacity and frequency ex Devonport has increased. The latter port represents a stand-by option for shipments of containerised Maydena Sands silica product in the event of unavailability of services from Bell Bay or Burnie.

Discussions earlier in the year with representatives of Swire Shipping indicated the possibility of monthly shipping schedules from the port of Bell Bay.

Its schedules ex Hobart would be increased to 15 days from March 2017 for trans-shipment to Asia and other overseas destinations via Melbourne or Sydney.

During 2017, Bell Bay has become the exit point for bulk shipments of bauxite accumulated on the wharf. This presents a contamination risk for any bulk shipments of low iron, high purity silica and, possibly to a lesser extent, for containerised high purity silica flour.

4.3 Marketing

The main focus remained again on TFT-LCD and other display and touch-screen glass, optical, technical, speciality and solar cell cover glass, with some attention to the low grade semi-conductor industry.

Also monitored was the PV polysilicon industry in the light of recent positive developments as a result of the growing adoption of “clean”, renewable energy production globally and, particularly, in China. This opens up the possibility of greater demand for clear, low-iron cover glass for solar cells and presents a marketing opportunity for Maydena Sands.

4.3.1 Overview – Polysilicon

Thanks to a global surge in the adoption of photovoltaic systems for electricity generation, the polysilicon supply deficit experienced in China during 2016 is narrowing. This turn-around is occurring ahead of previous predictions. Unused production capacity is being ramped up and shuttered facilities are reopening, altering the supply dynamics in China. Within this scenario, polysilicon prices in China have regained lost ground, hovering at around US\$20/kg towards year end 2017, up from a mid-year low of US\$13/kg.

The arrival of perovskites on the photovoltaic scene as a potential, lower cost competitor to polysilicon is noted in Krummei, 2016. The issue of degradation under normal operating conditions remains an obstacle to the commercialisation of perovskite cells.

Considerable research effort is directed to deal with this problem, including Australian institutions, such as the Australian National University and Monash University in the hope that perovskites can be stabilised so they may be used in, or added to, traditional solar applications. If that aim can be achieved, solar efficiencies from 25% - 30% are in sight. Elsewhere, researchers have achieved perovskite solar cells which have delivered a constant 11.2% efficiency for more than 10,000 hours, with no loss in performance under standard conditions.

In the meantime, polysilicon remains the preferred material of PV cells while the problems of stability, performance and longevity of perovskite cells continue to be addressed.

4.3.2 Overview - Display Glass

Market signals in 2017 for display glass were somewhat mixed. LCD glass remains a very competitive environment. According to Corning Inc's Annual Report for 2016, the market for LCD televisions is maturing, though still growing, accompanied by price declines. There is also weakness in the PC, smart phone and tablet markets, all of which impact negatively on the demand growth rate for display glass. But, on a more positive note, demand for 'advanced glass' such as the tough 'Gorilla' glass family products is predicted to grow. This glass group also finds applications in automotives such as console fixtures, windshields, sunroof, etc. Ultra thin and high performance display glass is also expected to show growth in demand. Corning also notes strong demand for fibreglass used in optoelectronics and optical cable. Going forward, Corning estimated demand for glass products in the mid single % digits, while specialty materials (eg Gorilla glass) sales growth is expected to be in the high teen %. However, funding for research was cut back across all areas, positive trends notwithstanding.

However, despite a current, somewhat sober outlook for display glass, China is projected to surpass South Korea as the world's largest supplier of LCD panels for TVs and is likely to emerge as the world's LCD production centre with production from Japan, Taiwan and South Korea moving to China. Leading LCD materials businesses, such as JSR, Sumitomo Chemical, Nitto Denko and Asahi Glass plan to invest in production there, followed by Chinese investment.

In Japan, production capacity seems to have been rationalised and possibly increased by the merger of the small-sized display units by Hitachi, Toshiba and Sony into a new unit, Japan Display Inc. which seeks Chinese funding.

This lends a degree of confidence in the future of this business sector and future demand for Maydena Sands' low iron, high purity silica flour and sands.

4.3.3 Ultra High Purity Quartz

The demand for ultra high purity (6N or better) quartz sand and silica flour in China continues to grow in the face of diminishing resources and growth in the PV cell sector in line with demand for polysilicon and synthetic sapphire products. This is also supported by an increase in the number of specialist companies focused on supplying quartz crucibles to grow silicon ingots for the production of computer chips, wafers for semiconductor or PV applications and for sapphire ingots to produce sturdy, more durable cover glass and slabs for cell phones, watches etc. Sapphire covers are finding increasing use despite substantially higher costs compared to toughened glass and other glass types.

4.3.4 Marketing Activities

Semicon/FPD China 2017 - Shanghai

As in past years, this large trade exhibition showcased the broad range of products, producers, production equipment and innovations in the semiconductor and TFT-LCD display industries. Of note was the drop in the number of new TV units displayed which are now being noticeably replaced by more advanced, larger OLED and AMOLED flat or curved screens. These technologies are also gaining a strong foothold in such applications as GPS systems, mobiles, phablets, etc. There was also a larger presence of producers of quartz crucibles used to grow silicon and sapphire "boules" under high temperatures. This segment, which uses IOTA standard, ultra high purity quartz sand and flour, is poised for strong growth due to surging demand for semi-conductors and silicon chips. This latter demand is fuelled by the ever increasing use of chips in smart phones, AI devices, virtual personal assistants (VPA's), electric vehicles, autonomous cars, computing and medical devices. Discussions with several producers of crucibles indicated a current market in China of at least 27,000 tonnes per annum of 6N quartz sand. Demand is estimated to reach 160,000 tpa

by 2021, with no new production capacity of this high value quartz sand coming on-stream or announced.

China Glass 2017 – Shanghai, China

The Chinese flat glass industry does not appear to have recovered significantly from difficulties experienced in 2016, as attested by the noticeably lower numbers of attendees at this trade show. However, according to Asian Glass, *the specialist segment of LCD substrate manufacturing is growing at a dizzying speed. China is emerging as the world's LCD production centre and is expected to overtake South Korea as the world's largest supplier of LCD panels for TVs in 2018 and 2019.*

This is good news for Maydena Sands high purity silica flour and sand. Equally positive for the latter products is the growth of photovoltaic cells which will continue to support demand for low iron photovoltaic cover glass. For Australian products to be competitive production, land transport and shipping costs need to be lowered so as to gain an edge on suppliers from China and near-by countries.

Other

Significant contacts in progress are:

- *3 Crosses Energy Pty Ltd*

Continuing interest was shown by this company in sourcing raw material silica sand from the Pine Hill deposit for its planned processing plant to be established in Tasmania and using its new proprietary processing technology. Intermittent discussions and negotiations during the year culminated in the formulation of a basic "Heads of Agreement" document. This is ready for signing early in 2018 by Maydena Sands Pty Ltd and newly established 3 Tas Mining Pty Ltd (3TM) a 100% owned subsidiary of 3 Crosses Energy Pty Ltd. This will open the path for more detailed negotiations for 3TM to acquire all the rights, title, shares and interests in Maydena Sands Pty Ltd. A bulk sample of up to 1.000 tonnes was requested for process testing in due course. Consent for this work was obtained from MRT. To minimise environmental impact, this sample will be extracted from the floor of the existing quarry. A quote for this excavation and delivery to the processing site was obtained from a local contractor. All up, this programme is expected to take 7-10 days to complete.

- *APT Asia Pacific Pty Ltd*

This Company is a synthetic surface specialist based in Dandenong, Victoria. Out of a 0.5kg sample each of silica flour and silica sand, the latter material was deemed suitable for their use based on visual inspection. Their requirement of about 9 tonnes per month, small but immediate and for a few months, could not be satisfied, as there is no production yet at the Pine Hill deposit.

- *SAC Corporation – South Korea*

Samples of raw material silica flour and silica sand processed last year by SAC Corporation yielded end products judged by that company to be “very good quality” (Krummei 2016). Based on these results, a meeting was held in Brisbane with a company marketing executive to determine a way forward. The latter executive left the company unexpectedly and further discussions were suspended until a replacement is appointed. There are also reservations about dealing with the company in the light of the current geopolitical tensions on the Korean Peninsula. Low-key, low priority follow-up.

- *Havelock Mining Investments – Perth and Hong Kong*

This contact eventuated as a result of MRT promotions at Beijing Investment Seminar run by Austrade and also at the China Mining Conference at Tianjin. Further project information was supplied to Havelock on request and a response is awaited. To be followed up in 2018.

- *Shield Resources Pty Ltd - Sydney*

Last year samples of silica flour, silica sand and rock were forwarded for inspection and tests. These were passed on to an end user in China for confirmation and comments which have not yet eventuated. To be followed up in 2018.

- *Mountsharp International Pty Ltd - Brisbane*

The marketing efforts of this company in China produced no results.

Consequently, the marketing agreement with this company was terminated.

Furthermore, approximately 30 product enquiries were dealt with from end users, marketing agents and individuals during the year. Most were for supply to China, but the spread also included Japan, India, Indonesia, Thailand, South Korea, Germany, USA and Australia. Applications included material for “sand play therapy”, filter sand for agricultural research purposes, electric cars, foundry use, and production of various types of glass. All were low value applications. Quality specs were mostly well below those for the Maydena Sands’ materials and volumes required were well above those that Maydena Sands was likely to be able to supply. Apart from the supply of a number of small test samples sent to several parties, no off-take arrangements eventuated.

Contact maintained with:

- Shanghai Dawnlite Electronics Tech.Co.Ltd – Shanghai,China – Silica Flour, Silica Sand, Silica Rock
- Innoceram Co. Ltd – Suzhou, China – Fused Silica & Ceramics
- Wuxi Ding Long Co. Ltd. – Wuxi, China – Silica Flour & Sand

4.4 Environmental

This year’s activities had no environmental impacts.

4.5 Rehabilitation

No rehabilitation was necessary, including on area relinquished.

4.6 Community Relations

Occasional contacts with members of the Maydena Development Association were maintained.

5. CONCLUSIONS

- A brief scoping test using Passive Seismic to determine depth to bedrock, and hence estimate the thickness of overlying iron-stained sand, lacked the accuracy required. The method was deemed unfit-for-purpose on this occasion, with no further work planned.
- Progress achieved in discussions between Maydena Sands Pty Ltd and 3 Crosses Energy has resulted in a final draft of a “Heads of Agreement” type document which is now ready for signature by the two parties. Execution of this document will open the path to the negotiation of a more formal, detailed, binding agreement.
- Successful outcomes of these negotiations will lead to an application for a mining lease and development permit over the Pine Hill Silica Sand deposit.
- Delayed beneficiation tests by 3 Crosses Energy on a bulk sample of silica sand raw material using that company’s proprietary new processing technology to be progressed as soon as possible.
- Contacts with SAC Corporation of South Korea, interrupted due to their in-house issues, to be pursued.
- There were no major changes to the transport infrastructure relative to this project except that rail transport facilities and reliability in Tasmania show impressive on-going improvements.
- Problems of electricity supply to industry as a result of the recent Basslink failure appear to have been largely resolved, with the State Government investigating measures to avoid a repeat of this supply crisis.
- Based on available information, the proposed tourist activities for the Maydena area are likely to have only very minor impact on Maydena Sands activities in RL 2/2003, if any.

6. PROPOSED FUTURE ACTIVITIES

- Initiate laboratory scale investigations into the possibility of producing high purity silica powder from the -45 micron “waste” fraction.
- Initiate and progress revision of flow sheet design and capex/opex estimates including both high purity silica flour and high purity silica sands product and also, possibly, silica powder.
- Continue work towards determining a reliable minegate, FOB and CIF product price for the high purity silica flour and silica sand product.
- Continue on-going engagement with 3 Crosses Energy Pty Ltd and its investigations into a new processing method to upgrade the raw material sand and flour into ultra high purity silica products.
- Follow up on 2017 and prior market contacts, enquiries and product sale opportunities, with attempts to lock in off-take agreements.
- Respond to any product enquiries in 2018.
- Continue with product awareness and marketing activities, including attendance at SEMICON/FPD China 2018 and China Glass 2018 Trade Shows.
- Continue monitoring developments in logistics support systems in Tasmania, including road, rail and shipping.
- Maintain contact with State and Local Regulatory Authorities, and other relevant parties on project related matters.

7. EXPENDITUREFor Reporting Period:

Geology	\$1,085
Geophysics	\$2,858
Feasibility incl. Marketing	\$37,674
Other	\$13,293
Admin	\$5,911
Total for Period	\$60,821

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APPENDIX 1
REPORT
PASSIVE SEISMIC SCOPING SURVEY

Gerhard Krummei

From: "Nicholas Smith" <nick@passivex.com>
To: "Gerhard Krummei" <gkrummei@ozemail.com.au>
Sent: Friday, 10 March 2017 3:13 PM
Subject: Re: Scoping Tests- Passive Seismic
Hi Gerhard,

Thanks for the drilling information.

I will complete my interpretation and report through next week, most likely by Wednesday.

Regarding "H/V" - this is what we are extracting from the passive seismic data. The term H/V means the horizontal to vertical ratio of motion, at the measurement location, as induced by seismic energy.

The important concepts to understand are as follows:

- Seismic motion is three-dimensional (i.e. for a given measurement point a seismic wave induces motion in the x, y, and z directions)
- Ambient seismic energy is "equipped-partitioned", meaning that all types of seismic waves exist with equal energies and propagate in all directions
- For an equipartitioned wave field, a layered geology with a soft upper layer overlying a hard bedrock induced a horizontal "resonance" in the seismic motion around a certain frequency (hence a peak in the horizontal to vertical ratio of motion)
- The frequency of horizontal resonance induced by the layered geology is proportional to the average seismic velocity and thickness of the overlying "soft" geology
 - If we know the depth of the bedrock at a given location we can calculate the average velocity,
 - or vice-versa, if we know the average velocity of the overlying material we can calculate the depth to the bedrock interface
- The amplitude and width of the measured H/V peak carries information on the characteristics of the soft rock / hard rock interface

Regarding the "frequency to depth conversion" If we can measure the H/V peak frequency at a location with known depth to bedrock we can define a relationship that converts frequency to depth and which can be applied to other measurements throughout a project area. Alternately, if we can measure the average seismic velocity of the "soft" layer overlying the bedrock we can use this information to directly calculate the bedrock depth from the measured H/V peak frequency (without using drilling for a priori depth calibration). There are several methods to estimate the seismic velocity from passive seismic data, the best of which required at least two seismometers to be deployed at the same time and employ "array processing" methods. I was able to use the data from our scoping survey from two seismometers deployed at the same time and estimate the seismic velocity profile of the geology, and the result is well constrained. All in all, there are several methods to employ to convert the H/V results to bedrock depth estimates. When the different methods give the same answer a high confidence in the result is achieved. This is the objective for next week.

Cheers,
Nick

11/12/2017

Report for
PASSIVE SEISMIC SCOPING SURVEY

At the
MAYDENA SANDS PROJECT

On behalf of
**MAYDENA SANDS PTY. LTD.
GERHARD KRUMMEI**

Submitted by

Nick Smith
Mar 16, 2017

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1. INTRODUCTION

On Tuesday March 7th 2017, passive seismic data were collected at seven locations on the Maydena Sands Pty. Ltd. project in Maydena, Tasmania. These data were collected at locations with ground truth established through previous drilling (Figure 1). The objectives of the survey was to trial the Horizontal to Vertical spectral ratio (H/V) passive seismic method and to establish *a)* characteristics of the ambient seismic wavefield, and *b)* the nature and acoustic properties of the bedrock contact beneath a silica sand resource, as manifested in the passive seismic data.

This report addresses the scoping survey objectives and provides a summary of the passive seismic data, acoustic properties of the geology of interest, and an interpretation of the passive seismic data in terms of cover thickness.

2. METHOD OVERVIEW

Passive seismic methods are a cost-effective and logistically simple geophysical method for characterising and mapping the principal sub-horizontal geological boundaries from the near-surface to 100's of metres depth. The methods use the background vertical- and horizontal-component seismic energy, recorded using high-fidelity portable broadband seismometers, and modern data processing methods.

The single-instrument H/V technique measures the frequency of ground resonance where a layered sequence (cover) overlies a hard bedrock, and an acoustic impedance contrast of several factors exists between the cover and bedrock. Where a suitable impedance contrast exists, horizontal-component seismic motion is amplified relative to vertical-component motion and a horizontal resonance is produced at a resonance frequency which is proportional to the cover thickness. The frequency of ground resonance is calibrated to thickness when the average shear-wave velocity or the thickness of the cover at calibration points (e.g. drill holes) is known. When multiple measurements are made, the H/V technique is used to map the variation in cover thickness and basement topography.

An accuracy of <10% for the cover thickness is routinely achieved for the H/V technique. Where particularly high-quality data are recorded, further qualitative inference of the nature of the cover and the cover-bedrock interface can be made.

3. PASSIVE SEISMIC DATA CHARACTERISTICS

Time-series' of recorded data are characterised by a consistent and uniform low-amplitude signal with occasional superimposed "spikes" of high-amplitude transient signal (Figure 1). The low-amplitude signal is representative of the background ambient energy (utilised for H/V processing) and its uniformity through time indicates a high-quality wavefield. The high-amplitude transient signals are due to impulsive sources such as footsteps and tree-falls. The exact source of the transient signal cannot be determined in this case, but the low rate of occurrence and rapid decay preserves the ambient signal.

For such high-quality passive seismic data, acquisition times for a production survey can safely be reduced to the recommended minimum of 20 minutes. In practice, for a production survey using 8 instruments and a 2-person field crew, acquisition times of 1 hour are maintained due to the field crews rate of instrument deployment and uplift, therefore providing additional data redundancy.

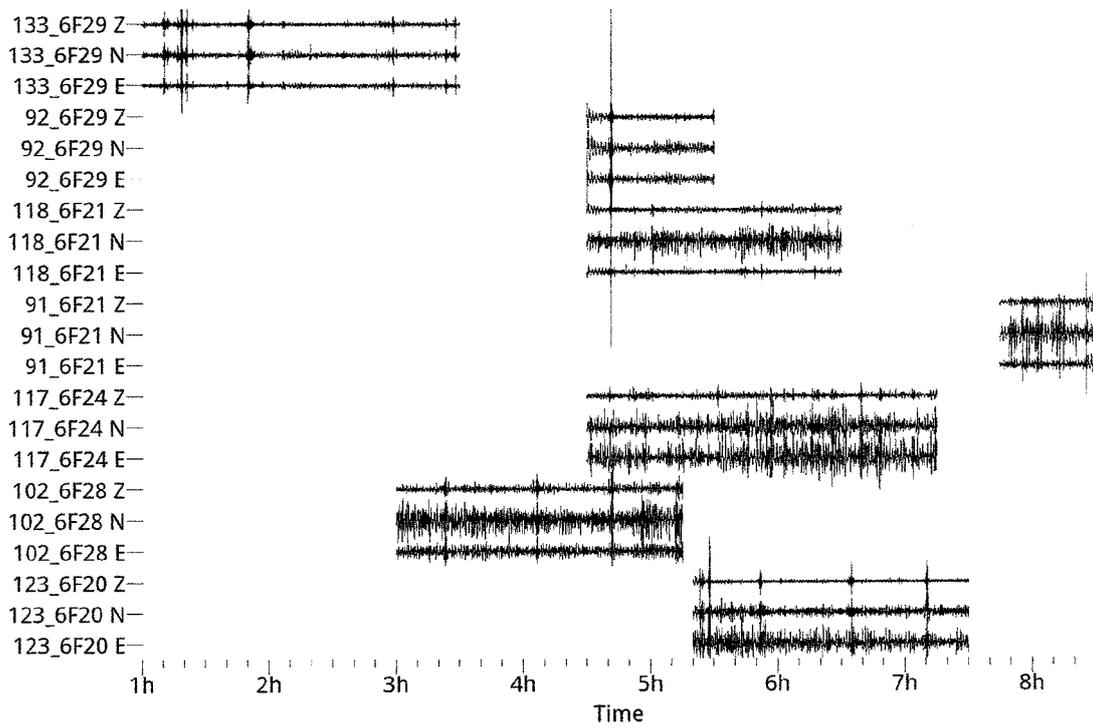


Figure 1: Seismic time-series for acquired data.

For data pre-processing, the recorded time-series were high-pass filtered above 0.1 Hz to remove the signal from the settling of the concrete seismometer plinth, and cut and tapered at the start and finish of the recording to remove the signal of deployment/uplift activities.

For computation of the H/V curves, pre-processed time-series were cut into 20 second windows and the ratios of horizontal to vertical energy estimated. The ratios for each window were then averaged to estimate the H/V curve along with the ensemble variances. Review of the H/V ratio for each window and the average H/V ratio shows a high stability through time.

Results for H/V directionality analysis, whereby directional horizontal-component energy at 5 degree increments (as opposed from the total horizontal-component energy) is used to compute the H/V curve, show a dominant resonance peak irrespective of horizontal component orientation and the emergence of low amplitude subsidiary resonance peaks for several measurement locations. The lack of strong H/V directionality phenomena indicates a relatively flat cover/bedrock contact with low aspect-ratio, and validates the isotropic and equi-partitioned wavefield assumptions fundamental to the H/V method. The emergence of subsidiary resonance peaks may qualitatively indicate an increase in geological complexity, but is inconclusive. For locations where subsidiary peaks are present, a dominant peak remains and it interpreted to represent the acoustic impedance contrast of the main cover/bedrock interface.

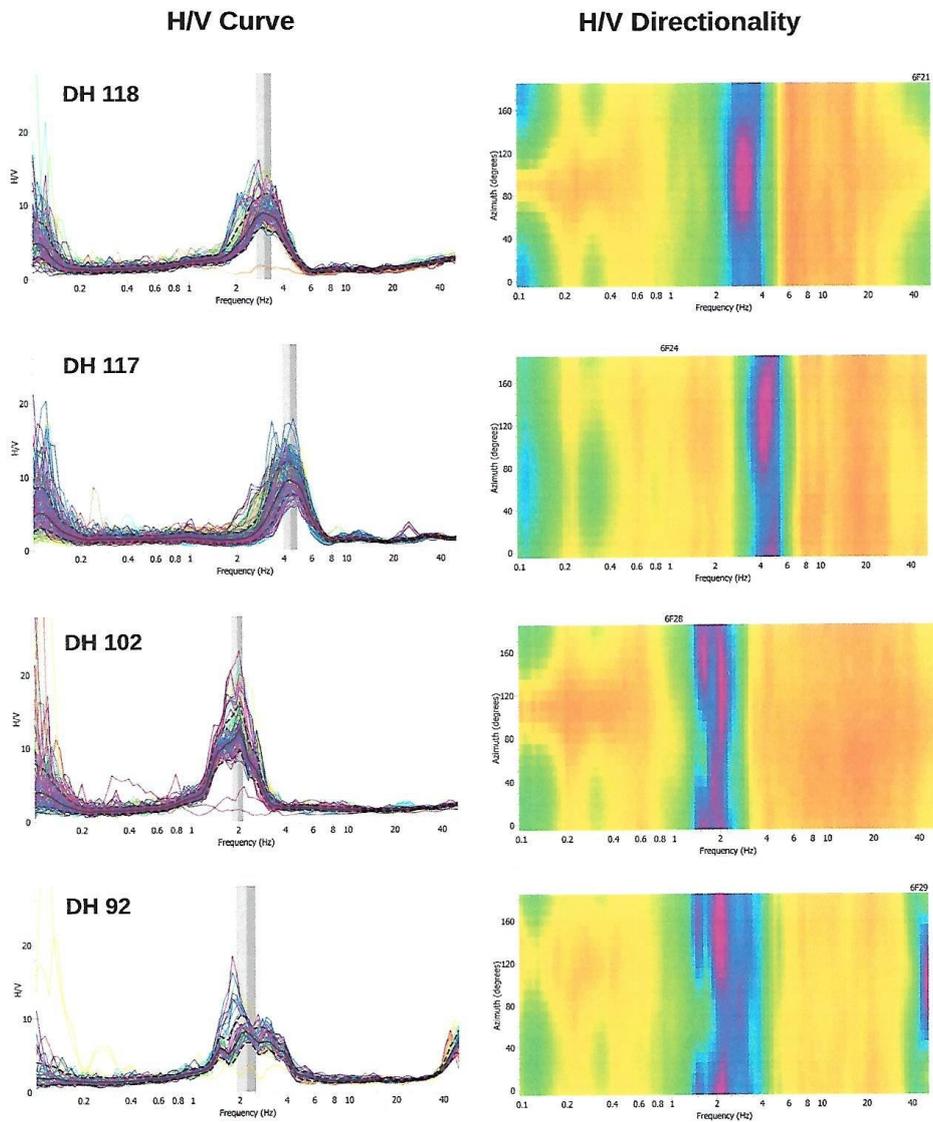


Figure 2: H/V curves and directionality analysis for representative measurement locations. The left column shows the H/V versus frequency curve, with coloured lines showing the H/V curve for successive 20 sec duration time-series windows, and black solid line showing the average H/V. The right column shows the average H/V amplitude computed with directional horizontal-component energy at 5 deg intervals.

4. INTERPRETATION

Following data processing, the frequency of H/V peak maximum for each measurement location was picked from the average H/V curve. Estimated cover thicknesses (from drilling) were then plotted against the picked H/V peak frequencies and a power law of the form $\text{Thickness} = A * \text{HV_freq}^b$ was then fit to the data cross-plot (Figure 3). The power law parameters A and b were adjusted using a non-linear solver algorithm to minimise the RMS difference between cover thicknesses estimated from drilling, and those predicted from the H/V peak frequency calibrated to thickness using the power law equation (Table 1).

The cover thicknesses predicted using the thickness-calibrated H/V frequencies were cross-checked against several alternate methods for thickness calibration. These alternate methods use a) the average velocity measured for the cover using seismic methods, or b) estimated velocities from empirical and laboratory measured velocity-pressure relationships for unconsolidated silica sand, as published in the relevant literature. All three methods produced consistent a consistent result, and as such the alternate thickness-calibration methods and results are not discussed further in this report.

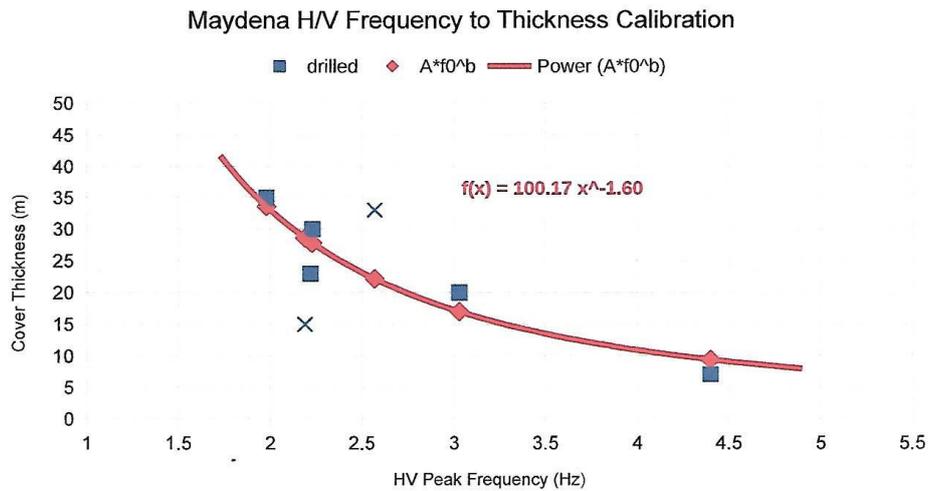


Figure 3: Frequency to thickness calibration. Blue squares show cross-plot data of known cover thickness vs. measured H/V frequency. Orange diamonds and solid line show the power law fit to the data for frequency to thickness calibration. Blue crosses show outlier measured data where the cover thicknesses estimated from drilling are inconsistent with the general data trend.

Thicknesses estimated from drill holes 118, 117, 102, 123 and 92 were used for the thickness calibration. Thicknesses estimated from drill holes 133 and 91 were inconsistent with the data trend, and as such were not used for the frequency to thickness calibration procedure. For drill holes 133 and 91, the cover thickness predicted from the H/V resonance frequencies were under and over estimated respectively by >20%. The main reason why this has happened is likely due to a high uncertainty in the cover thickness for the drill holes used in the calibration procedure.

Geological sections showing surveyed drill holes and H/V cover thickness interpretations are included in *Appendix A* of this report.

DH #	Easting (AGD66)	Northing (AGD66)	INST #	Start (local)	End (local)	HV Frq (Hz)	HV Dpth (m)	DH Dpth (m)
133	465666	5263933	29	12:00	14:30	2.57	22.1	33
118	465654	5263892	21	12:30	14:30	3.03	17.0	20
117	465655	5263853	24	12:45	15:45	4.40	9.4	7
102	465990	5263834	28	14:00	16:15	1.98	33.6	35
123	465932	5263846	20	13:45	16:15	2.23	27.8	30
92	465926	5263790	29	15:30	16:30	2.22	28.0	23
91	465983	5263757	21	15:45	16:30	2.19	28.6	15

A = 100.17	B = -1.6	RMS = 6.8m
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Table 1: Frequency to thickness calibration and survey metadata. Note – Cover thicknesses estimated for drill holes 133 and 91 (red font) are inconsistent with the general data trend, and as such, are rejected from the frequency to thickness calibration procedure.

5. SUMMARY

A passive seismic scoping study was completed in March 2017 at the Maydena Sands Pty. Ltd. project at Maydena, Tasmania to assess the ability of the single station H/V passive seismic method to detect the bedrock beneath a silica sand deposit at the project. One day of field work was carried out, during which data were recorded at seven locations with drill hole ground truth.

Review of the collected data indicated a high-quality passive seismic wavefield and a strong acoustic impedance contrast in the earth. Processed H/V waveforms were diagnostic of a relatively simple geology with a dominant acoustic impedance contrast, and were stable over time and wavefield direction.

Interpretation of processed H/V waveform indicated cover thicknesses consistent with the depths estimated from the drill hole ground truth for five of the seven measurement locations. The two inconsistent locations are interpreted to represent a bad thickness estimate from the drill hole data.

The single station H/V passive seismic methods is well suited to the wavefield and geological conditions at the Maydena project site. Passive seismic surveys for the purpose of mapping the bedrock topography are expected to be successful if undertaken.

APPENDIX A

GEOLOGICAL SECTIONS WITH THICKNESS- CALIBRATED H/V MEASUREMENTS

Section 465660mE – Drill holes: 117, 118 & 133

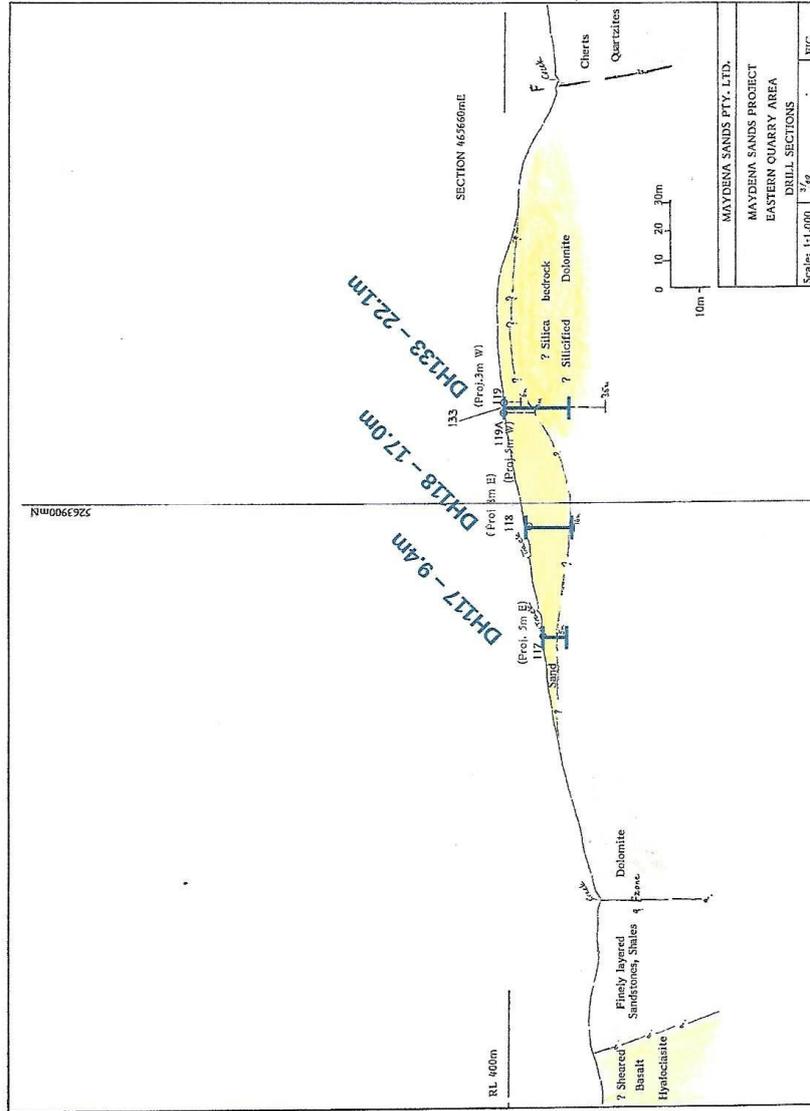


Figure A1: Geological section 465660mE. Blue lines show cover thicknesses from calibrated HVV measurements.

Section 465890mE – Drill holes: 123 & 92

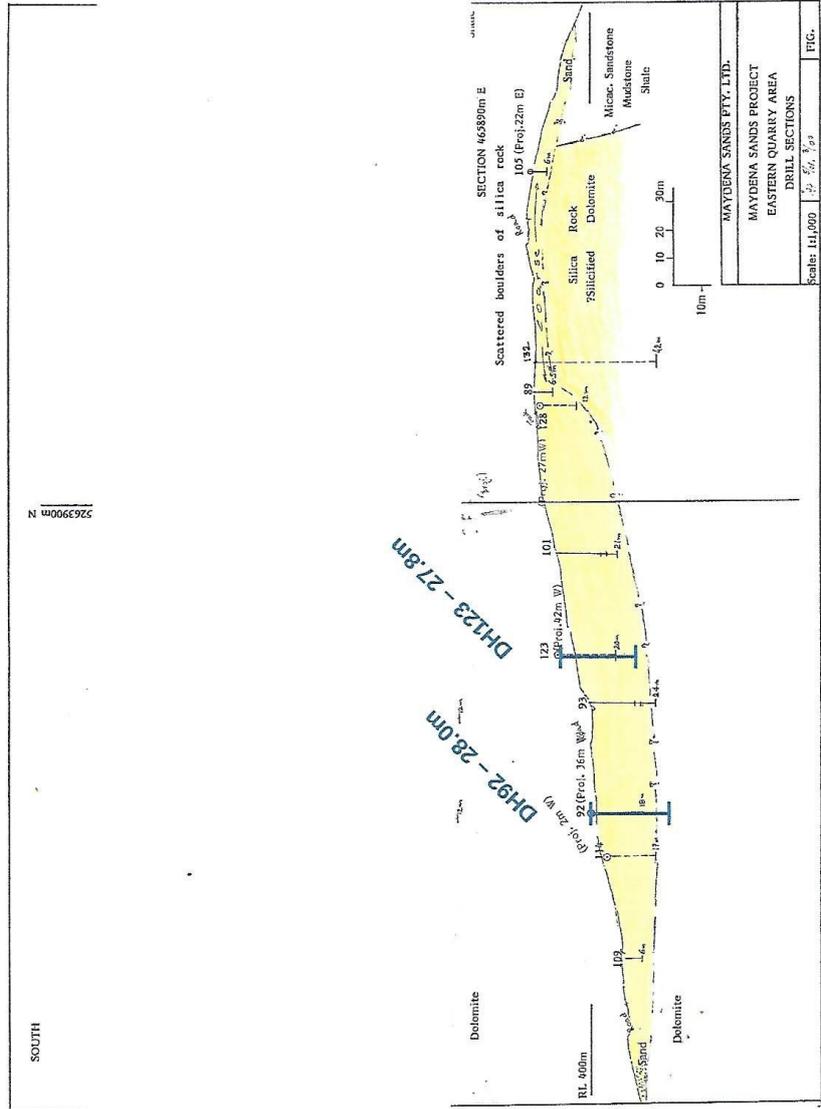
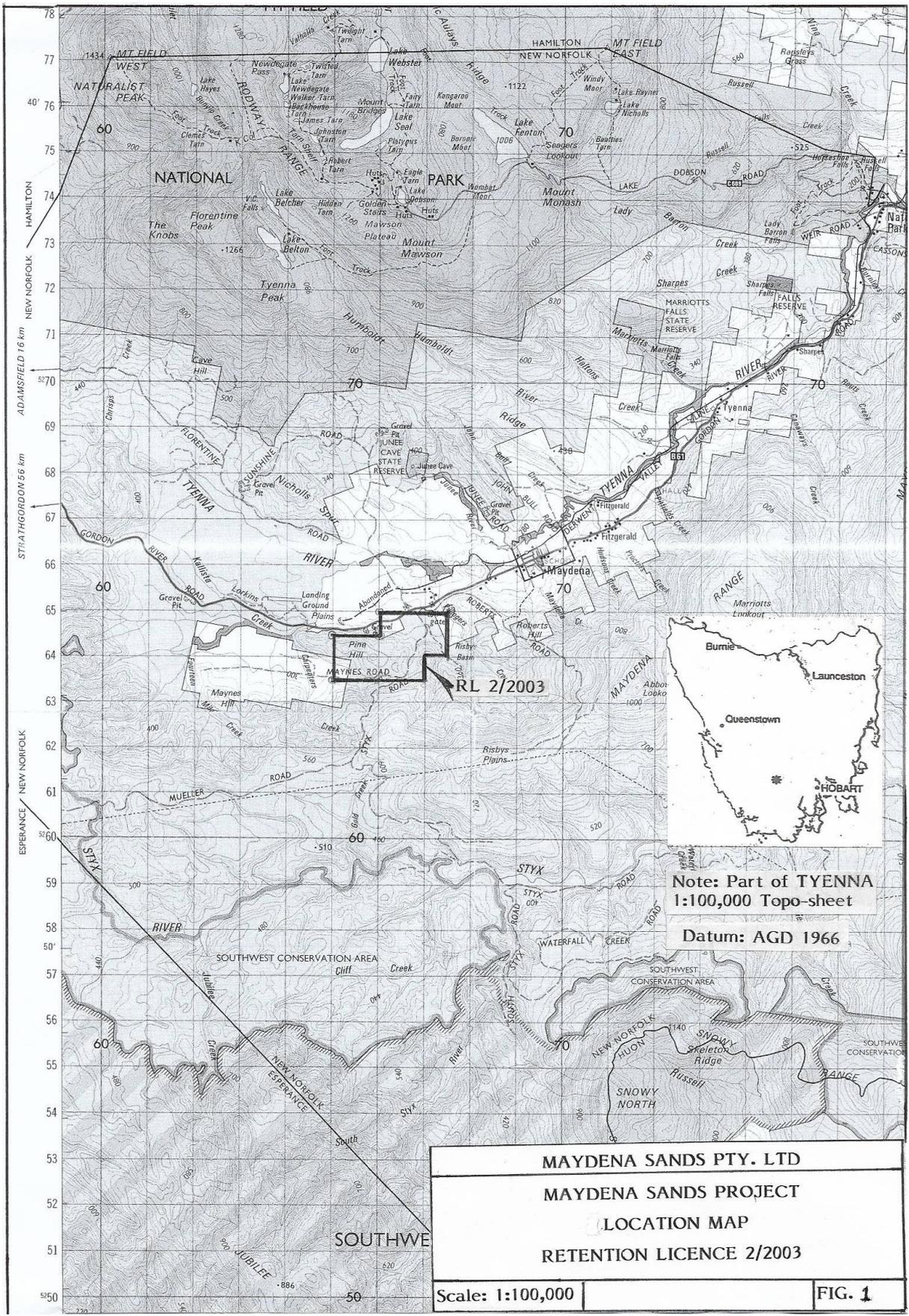
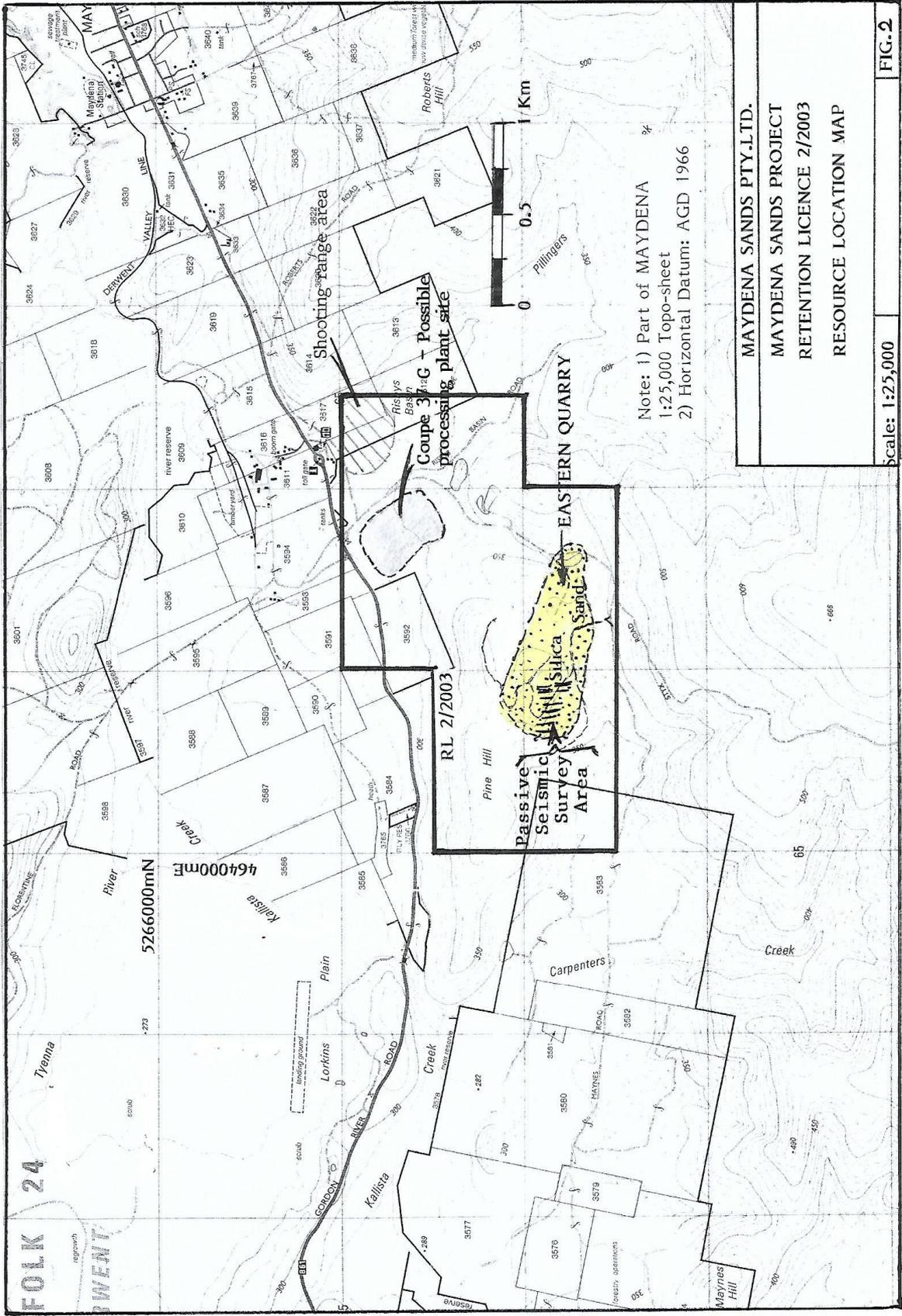


Figure A2: Geological section 465890mE. Caption as for Figure A1.

ILLUSTRATIONS





MAYDENA SANDS PTY.LTD.
MAYDENA SANDS PROJECT
RETENTION LICENCE 2/2003
RESOURCE LOCATION MAP

FIG.2