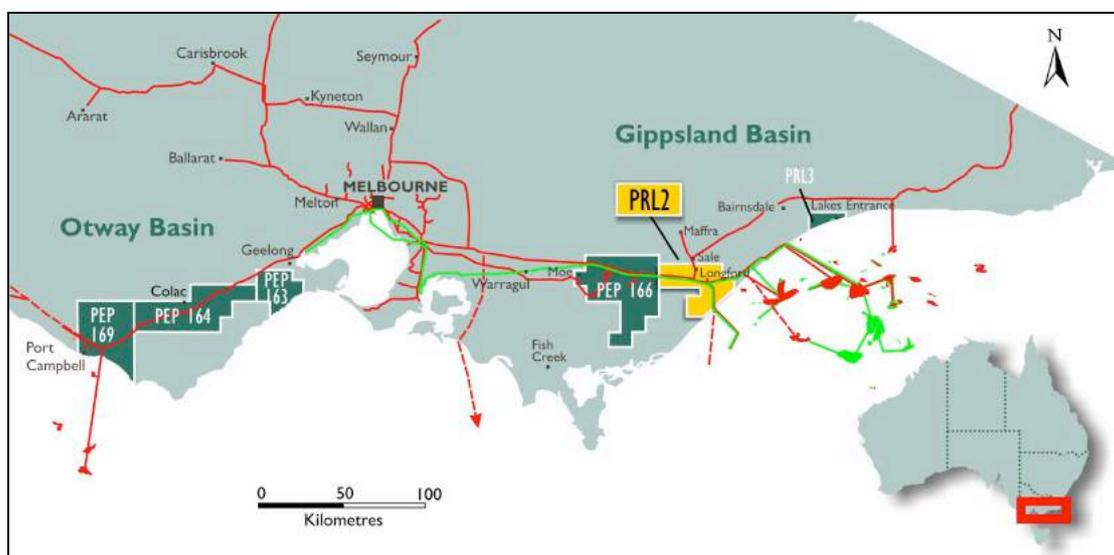


‘Mining for Oil in Victoria’: The Lakes Entrance Oil Shaft

By JIM ENEVER

The period leading up to the Second World War brought into focus once again Australia’s vulnerable situation regarding access to oil and petroleum products. This vulnerability had been realized at the time of the First World War, stimulating oil exploration activity in East Gippsland, after earlier interest had been aroused by the occurrence of what were thought to be oil slicks on the surface of stagnant water.¹ The level of activity escalated from 1920 following announcement by the Commonwealth Government of a reward of £50,000 for discovery of a commercial oil field. In 1924, the Lake Bunga No1 well located five kilometres East of Lakes Entrance (Figure. 1) struck traces of oil in an artesian water flow from a glauconite sand horizon at a depth of 326 metres, the first substantiated discovery of liquid ‘well oil’ in Australia.²

Figure 1: *Location of Lakes Entrance with respect to current oil and gas infrastructure in Victoria, circa 2010*



Source: Lakes Oil N.L

Over the 15 years following the 1924 discovery at Lake Bunga, some 40 wells were drilled, three quarters of them ‘producing oil in amounts varying from a few drops to about 130 gallons a day’.³ By 1938, an oil bearing basin of approximately 20 square kilometres had been defined, centred on the township of Lakes Entrance.⁴ The oil was

found within a glauconite sand unit of about 10 metres average thickness, and average depth of approximately 375 metres.⁵ Total production from the field was reported as 483,400 litres to 1938.⁶ The most productive part of the field was claimed to be a central core area of no greater than 10 square kilometres.⁷ The oil produced was a heavy asphaltic base type, suitable for producing fuel oil and lubricants, but deficient in lighter fractions.⁸ Oil recovered by bailing from a number of the wells was dehydrated and used to lubricate the wheels of Melbourne trams, as well as a local source of fuel oil.

In 1938, the Commonwealth Government's Oil Advisory Committee, consisting of Dr Keith Ward, Dr Arthur Wade and Dr George Woolnough, reported on the field. At this time the Lakes Entrance Oil Field was still the only known source of 'well oil' in Australia. The Committee estimated the oil in place at around 680 million litres, sufficient to warrant efforts at large scale production.⁹ Given the apparently low reservoir pressure, the Committee suggested that an alternative to standard vertical wells would most likely be necessary to achieve acceptable production rates.¹⁰ By 1940, the Oil Advisory Committee had been disbanded and replaced by Woolnough as Government Geological Advisor. In his capacity as Deputy Geological Advisor, Dr Harold Raggatt further reported on the field in 1940, concluding that:

It is impossible to view the prospects of the Lakes Entrance area very optimistically ... It has been suggested that oil might be produced from the Lakes Entrance area by "repressuring", unit pumping, *or by working from a vertical shaft*. [emphasis added] There are many enquiries which must be made before any idea can be formed as to the economics of these proposals ...¹¹

The concept of recovering viscous oil under low reservoir pressure by 'mining' has its origins in ancient history.¹² Versions of this concept have been documented from various locations throughout the world up to the present.¹³ A significant oil mining industry is recorded as having existed in the Alsace region of Europe from the early 1700s, a detailed account having been given by visiting US oil man, Lewis Emery Junior, in 1880.¹⁴ The process, as described, involved sinking a shaft to the producing horizon (typically at about 100m depth) and then excavating a network of tunnels into which the oil would seep over time, and from which the miners could remove it by shovelling. It was a derivative of this concept that Raggatt was referring to in his report.

1941, a pivotal year

Prior to 1939, the threat of war had pushed the Commonwealth Government to adopt a strategic policy to support the production of oil from oil shale at Glen Davis. By 1940, the Government found itself under pressure from various groups to further develop the

Lakes Entrance Oil Field as a second indigenous oil source.¹⁵ In a dilemma as to how to proceed with this technically challenging endeavour, and with no local experience to call on, the Government turned to the United States Bureau of Mines for advice.¹⁶ By this time, the concept of drilling horizontal holes into a producing horizon from the bottom of a vertical shaft had begun to emerge. This was seen as a possible solution to developing low pressure oil fields like Lakes Entrance, without the need for a network of tunnels such as practiced in Alsace. The Australian Minister in Washington was instructed to emphasise this technology in discussions with the Bureau¹⁷ and on their advice, the services of Leo Ranney were sought. After some consideration, Ranney accepted the brief as a contribution to the allied war effort.

An article in the *Bairnsdale Advertiser* during June 1941 described Ranney as being:

President and chief engineer of the Ranney Oil Mining Company New York City. ... The inventor of processes for mining oil from depleted fields, for the commercial recovery of natural gas from coal seams, for producing ground water and for the creation of underground gas reservoirs ... He has developed new methods of shaft sinking and horizontal drilling, and of obtaining commercial production from sands of very low saturation. He is the patentee of many improvements in obtaining production from low pressure fields.¹⁸

Ranney was undoubtedly one of the pioneers of horizontal drilling, being the author of a number of technical papers and the subject of many others.¹⁹ In a letter sent to the Australian Minister in Washington around the time of his engagement, Ranney summarised the development of the concept of oil recovery from horizontal wells.²⁰ As early as the 1920s, trials had been conducted in Texas in which a shaft was sunk through a producing sand, and tunnels excavated beneath the sand horizon from which short holes were drilled up into the sand to extract the oil. Attempts to produce oil by horizontal drilling followed on from the development of the technology for water extraction, and started in 1937, with drilling initially being into an outcrop, and then from the bottom of a vertical shaft. By drilling an array of holes radially from a work chamber at the base of the shaft, oil could be induced to flow into a collection point at the base of the shaft from where it could be elevated to the surface.

Even before the plans to bring Ranney to Australia had become public knowledge, rumblings started within Government regarding his suitability for the engagement.²¹ A claim was made that there was no evidence of any significant oil production from horizontal wells drilled using Ranney's methods, and that the applicability of this technique to Lakes Entrance was purely speculative. After some

discrete enquiries, these concerns appear to have been allayed and plans were advanced for his visit.²² Ranney arrived in Sydney on 11 July 1941, in company with Charles Fairbank, a Canadian petroleum engineer nominated by Ranney.²³ During July they toured the oil field and met with a number of relevant parties, including Charles Demaine, manager of the Austral Oil Drilling Syndicate, the major producing interest on the Field (Figure. 2).²⁴

Figure 2: Messrs *Fairbank, Raggatt, Ranney* (left to right in middle group at back) and *Demaine* (foreground) during visit to Lakes Entrance, July 1941.



Source: Victorian Mines Department Photo Collection.

The eagerly awaited report was presented on 24 July 1941, and, as might have been expected, was optimistic about the potential for development of the field by horizontal drilling. The authors recommended specifically:

a circular, vertical shaft of 8 feet inside diameter, lined with a concrete wall 1 foot thick extending down to the oil bearing horizon and ending in a circular chamber approximately 25 feet in diameter, from which horizontal wells [will be] drilled to great length in the oil-bearing formation.²⁵

The cost of the complete exercise, including the drilling, was estimated to be £100,000. A site was suggested near the centre of the most prospective area, within the township of Lakes Entrance. The probable oil recovery was estimated at '1,160,000 barrels for a 400 acre area' and assumed recovery of 25 percent.²⁶ This estimate was acknowledged as being based on scanty information, but served to suggest that production should be able to readily cover the costs of development and operation of the facility. What was not addressed was any prediction of the likely rate of recovery, the critical factor that was ultimately to decide the fate of the enterprise.

In August 1941, the Commonwealth Government convened a meeting with the Victorian Government to resolve how best to advance the project.²⁷ Charles Demaine was invited as a representative of the Austral Syndicate. The prospect of forming a stand alone authority similar to Commonwealth Oil Refineries was canvassed, but dismissed in favour of an entity involving both Governments with the Austral Syndicate. The meeting requested Demaine to come up with a scheme for further consideration.²⁸ After dismissing Demaine's initial equity based proposals, the Governments eventually settled on a cost sharing model, with Austral as operator. Verbal advice of this was conveyed to Austral in September 1941, but a change in the Commonwealth Government delayed progress until the arrangement could be ratified by the new Government in November 1941.²⁹ The main details of the proposed arrangement were:

That the Commonwealth should make available a sum of £33,333 and the Victorian Government £16,667, making £50,000 altogether by way of loan to the Company ... Horizontal drilling equipment and accessories required for the Lakes Entrance Field ... to be sought from the U.S.A. under Lease-Lend on high priority on the understanding that the Companies concerned will assume liability for such equipment or, alternatively, that the equipment will be leased to the Companies by the Commonwealth ... The services of Messrs Ranney and Fairbank to be retained involving total expenditure of about £A 1,800, £A1,200 to be borne by the Company ... The purchase, transport and assembly of electrical generating plant at a cost of approximately £10,000 on the understanding that this equipment and the liability will be taken over by the Company ... The acceptance of the offer of patent rights made by Mr Ranney subject to the processes being patentable in Australia.³⁰

The terms of the arrangement were made public in December 1941.³¹ An announcement in the press told of the formation of a new company to be spawned by the Austral Syndicate to undertake the trial.³²

By the end of 1941, interested parties were polarised in their views. Some, like the now Government Geological Advisor, Harold Raggatt, had become convinced of the project's merits, others saw the proposed trial as folly, despite the strategic context. *The Petroleum Times* made no secret of its views:

This is really the most surprising development of recent months. It would seem that an attempt is being made to bolster up a moribund company with political affiliations, which the public has steadfastly refused to support by buying shares. The latest holes in this area (all financed by the Government) were all duds.³³

The Austral Oil Drilling Syndicate

The Austral Oil Drilling Syndicate NL was formed in 1936 to undertake 'oil drilling operations at Lakes Entrance'.³⁴ Over the next few years a number of conventional wells were drilled and tested. By August 1941, the Syndicate felt in a position to state that 'the Company had to-day finally reached its objective ... proving that oil existed at Lakes Entrance in commercial quantities'.³⁵ While this might have been hotly contested, the affinity developed between the Syndicate and Governments through mutual participation in exploration activities had put the Company in an advantageous position with regard to the trial, as did the fact that they had been able to achieve a rationalisation of the exploration efforts of a number of groups, positioning themselves as the predominant operator on the field.³⁶

An impasse began to emerge even before the trial was announced publicly. Austral had indicated that it wanted to float a new company to raise the extra capital that would be required. The terms of the proposed contractual agreement between Austral and the Governments required the Company to raise capital to fund its portion of the on-going costs as a prerequisite, but to be able to go to the capital market the Company required a formal agreement to be in place. The terms of an arrangement proposed to circumvent this problem, involving the Governments advancing the Company funds to cover its component of the program until capital could be raised, were felt to be a disincentive to prospective investors.³⁷

While attempts were made to resolve the organisational issues, progress was made on the ground. Acting as an agent for the proposed consortium, Austral began to source some of the major equipment that would be required.³⁸ A diesel power plant of sufficient capacity to supply the electricity and compressed air for the operation was located and arrangements made for its procurement and transfer to Lakes Entrance. A suitable set of steel poppet legs, electric winder and ancillaries were located at Bendigo

and certified by the Mines Inspector as appropriate for the job. Preliminary designs were initiated for the shaft, and site work undertaken to prepare for installation of the surface facilities. Austral initiated, at its own expense, the drilling of a pilot bore adjacent to the selected shaft site to provide information to help with the on-going shaft sinking activities. Throughout the first half of 1942, up to 28 men were reported as being engaged on the site in preparatory work and the drilling of the pilot bore.³⁹

Direct action

During the early months of 1942, it became increasingly clear that Austral was not going to be able to raise the capital to consummate the arrangement with the Governments, despite their obvious on-going involvement with the project. At a meeting of Federal Cabinet held on 15 April 1942, it was decided to resume the site under National Security (Minerals) Regulations and develop it as a Government project, with the Commonwealth providing £112,500 and the State £37,500. Control of the project was to be delegated to the Controller of Mineral Production. A nominal allowance would be made to account for the residual equity of Austral which would be used to calculate a pro-rata profit for the Syndicate in the event of a net profit eventuating. A provision was included that would allow the Commonwealth to buy out Austral's equity at any time.⁴⁰

An administrative structure was set up within the Commonwealth Department of Supply and Development. A committee of three, The Lakes Entrance Oil Departmental Executive Committee, took overall control. This committee was made up of J. Malcolm Newman, Controller of Minerals Production for the Commonwealth Government, George Brown, Secretary Department of Mines Victoria, and A.C. Smith from the Department of Supply and Development. Detailed management of the project on a day-to-day basis was to be entrusted to a dedicated project supervisor responsible directly to the Executive Committee. In June 1942, an offer was made to Charles Demaine to take up that position, despite the obvious potential for a conflict of interests, but by September 1942, Demaine had not been able to give his unqualified commitment to the position and the offer was withdrawn.⁴¹ The Executive Committee had another candidate in mind. H.J. Cook was a mining engineer with a background in tin dredging⁴² and given his lack of experience with anything to do with petroleum, his appointment to the position of project supervisor appeared an anomaly at the time.⁴³ As much as anything else, it appears to have been a growing frustration with Demaine's

perceived obfuscation in their eyes that ultimately convinced the Committee to appoint Cook. Austral was not to have a direct role in the management of the project, and the financial details around the takeover were to be the basis for an on-going dispute.⁴⁴

A shaft at last

In September 1942, all surface facilities were essentially in hand.⁴⁵ By that time the shaft had acquired a life of its own, becoming synonymous with the project as a whole. The underlying feeling was that while the horizontal drilling activity might remain a black art to be dealt with by overseas specialists, Australia possessed ample shaft sinking expertise to undertake that task. In the report prepared by Ranney and Fairbank, a clear division of responsibility was built in between the shaft sinking (to be supervised by Australian engineers) and drilling (to be supervised directly by American engineers).⁴⁶

Much of the early discussion about the project revolved around the best way to construct the shaft. As early as mid 1940, when the possibility of recovering oil via a shaft was being mooted prior to the visit by Ranney and Fairbank, the Victorian Mines Department suggested that a '12 foot by 4 foot timbered shaft' would be the best option.⁴⁷ This was undoubtedly based on accumulated experience, rather than on the likely prevailing conditions. During Ranney's visit, discussions were held with engineers from Gold Mines of Australia to obtain their views and possibly engage their services.⁴⁸ They proposed a scheme whereby a temporary rectangular timbered shaft would first be sunk to the required depth, and then re-excavated from the bottom up to produce a circular, concrete lined, permanent shaft. Over the next few months, Gold Mines of Australia became increasingly wary about the difficulties that might have to be faced, and in October 1941, reluctantly informed the Commonwealth Government that it would not undertake the work.⁴⁹

While calling on a well established mining company for the shaft sinking appeared to provide comfort to the Governments, Austral was not so fixated. By the end of 1941, Austral had engaged the Snider Construction Company, a Melbourne based concrete construction group, to carry out the surface works preparatory to shaft sinking. In November 1941, Snider provided to Austral a quote for shaft sinking against a general specification for a circular concrete lined shaft as proposed by Ranney.⁵⁰ Their quote was for a shaft of '10 foot' internal diameter, the minimum likely to be allowed by the Mines Department, to be constructed from the top down.⁵¹ In their proposal, Snider claimed their approach was based on modern coal mine shaft sinking in the UK,

a situation considered analogous to the geological environment at Lakes Entrance. After the Government takeover of the project in May 1942, the Executive Committee sought advice on the suitability of the proposal that had been developed by Austral and Snider. A shaft sinking engineer from Zinc Corporation was brought to Melbourne for discussions, and expressed general satisfaction with the proposed scheme.⁵²

A call for tenders for the first 60 metres of the shaft was placed in the major Melbourne newspapers on 14 September, closing on 28 September 1942. It came as no surprise when the only tender received was from the Snider Construction Company, and in essence was a re-run of their earlier proposal to Austral, at a cost of '£35 per foot for the first 200 feet'.⁵³ The Committee considered this price to be excessive, and entered into negotiations with Snider to reduce the price to no more than '£30 per foot'.⁵⁴ An accommodation was finally reached on the price, and Snider were engaged to conduct the first stage of sinking.

At the outset of activities, day-to-day site management for Snider had been the responsibility of Albert Clarke, a qualified and practical mine manager from Bendigo. After the Government takeover, Clarke was appointed formally as the site manager for the project.⁵⁵ Through his contacts, skilled men from Bendigo were recruited to fill critical roles. Other labour requirements were met locally. Finally, by October 1942, all arrangements were in place for shaft sinking to commence in earnest (Figure 3).

Figure 3: *Surface installation showing headframe, winder house, and drilling derrick for pilot bore.*



Source: Victorian Mines Department Photo Collection.

Progress is made

In December 1942, progress was reported to be about 6 metres per week.⁵⁶ Excavation was without recourse to blasting and the shaft was being advanced in stages of around 3.5 metres. After each stage of excavation, timber formwork was erected and the concrete lining poured. Holes were left in the concrete to allow any ground water to escape until the concrete had cured. These holes were subsequently blocked off, and the gaps between the segments of lining sealed, to form a nominally watertight lining. The shaft was arranged for twin compartment winding with steel work, and fitted with timber guides.⁵⁷

The pilot bore, which was being advanced in conjunction with shaft sinking, indicated the possibility of significant water inflows below about 60 metres depth. As a precaution, a decision was made to install permanent pumping stations at a number of points down the shaft. By March 1943, however, the shaft had reached a depth near 90 metres, with no major water handling issues reported.⁵⁸

In April 1943, it was decided to recommend to the Commonwealth and State Governments that the Snider Construction Company be given a further contract for an additional 60 metres of sinking, with a provision for extension to the final depth.⁵⁹ This was approved. In anticipation of harder going, moves were made to acquire a number of pneumatic spades and borers, as well as shot firing equipment.⁶⁰

At about this time consideration was given to the thickness of the concrete lining. Further advice was sought from Zinc Corporation and a design eventually adopted that called for the lining thickness to vary from 'one foot at the top to three foot six inches at the bottom'.⁶¹ Experiments were also initiated into the potential impact of the ground water on the long term durability of the concrete.⁶² The aggressive nature of the sulphate charged ground water was to remain a concern throughout the construction program.⁶³

In August 1943, shaft sinking was temporarily suspended at 140 metres while a permanent pumping chamber was excavated. This chamber was 12.5 metres long and provided enough space for a pump and water storage cistern. The ground conditions encountered during this operation required that substantial timbering be installed.⁶⁴

By the end of 1943, the shaft had reached a depth of 188 metres.⁶⁵ Further work was suspended at this depth pending installation of an adequate ventilation system. According to the Mines Inspector:

This was deemed necessary due to quantities of methane gas met with in the pilot bore. While this installation was proceeding, the opportunity was taken to send the shift leaders and manager to Wonthaggi, where ... they were enabled to receive some instruction in gas testing and safety lamp work. The men are now carrying out gas examinations in the shaft.⁶⁶

By January 1944, the ventilation system had been installed, and shaft sinking was underway again.⁶⁷

In accordance with the plan being followed, another pump chamber of similar dimensions to the previous was excavated at a depth of 200 metres. During this operation, two men were injured in a rock fall on 20 March 1944, the accident being attributed to the miners' inexperience with this type of work.⁶⁸ The accident depleted the ranks of miners available and prompted an attempt to recruit suitably experienced men from Ballarat.⁶⁹

On reaching a depth of 203 metres, a major inrush of water occurred, that according to one account involved 'water at a pressure of 270 p.s.i. ... breaking through sixteen feet of sediments into the base of the shaft during sinking operations'.⁷⁰ An attempt was made to seal off the water bearing zone by pressure grouting, reducing the flow to about 5,500 litres per hour. The operation was apparently successful enough to allow shaft sinking to continue, reaching a depth of 225 metres by mid June 1944. By this time, heaving of the soft sediments in the shaft bottom and caving of the walls, requiring removal of excess material, slowed progress.⁷¹ In one account it was claimed that at one point 'the men excavated for some days without making any progress. What they took away one day was pushed upward to the same level the next'.⁷² Consideration was given to changing the procedures being employed, including the use of cast iron 'Tubbing' to replace the concrete lining (at a substantial extra cost), but eventually it was decided to persevere with the system that had been developed.⁷³

By September 1944, the shaft had reached 255 metres and conditions had improved, it being reported that 'no surplus ground was at present being dug'.⁷⁴ The mechanism that had caused the ground to heave was debated, with an eye to the future. Some thought that the problem was due to the competency of the ground, while others believed the root cause to be water and/or gas pressure. A program of advance boring into the shaft bottom had been instigated after the water inrush at 203 metres, and the advantages and disadvantages of continuing this program were now discussed. It was decided to continue to drill ahead in 3 metre increments as a precaution against possible high-pressure gas being encountered.⁷⁵ In the event, no gas flows that could not be handled by the ventilation system were encountered.⁷⁶

By the end of 1944 the shaft had reached 280 metres and another pumping station had been excavated at 275 metres.⁷⁷ Around this time, it looked like an acute shortage of skilled winder drivers might bring operations to a halt.⁷⁸ An emergency recruitment

campaign in Bendigo managed to secure extra qualified drivers, coaxed to Lakes Entrance by the offer of a living away from home allowance above normal salary.⁷⁹

As sinking pressed on during the early part of 1945, the attention of all those involved turned to the critical question of the depth at which to terminate the shaft. Throughout the construction period, and even before, the overriding issue in the back of everyone's mind had been the potential for a catastrophic inflow of high pressure water into the shaft from the artesian zone known to immediately underlie the weak oil sand horizon. The experience of the inrush that had occurred at 203 metres only accentuated this concern.⁸⁰ While most, including the Mines Inspector, expressed a conservative view to stop the shaft about 30 metres above the top of the sands, Ranney, who had been consulted on the issue, apparently favoured continuing the shaft to the top of the sands at approximately 365 metres, with the possible precaution of pre-grouting the sands.⁸¹ The Committee pondered the trade off between the safety offered by leaving a substantial buffer of rock above the sand, and the impact this might have on being able to effectively drill holes into the sand to collect any oil, recognising that the project might in fact be fatally compromised.⁸²

While the Committee continued to agonise over this question, shaft sinking proceeded, reaching a depth of 340 metres by June 1945.⁸³ With the shaft held at this depth, a diamond drill was brought in to core down from the bottom of the shaft to the sand horizon to allow more definitive information to be obtained on the nature of the rock overlying the sand.⁸⁴ A technical sub-committee was formed to evaluate the information obtained and recommend the appropriate course of action.⁸⁵ The sub-committee reported on 3 July 1945, that it thought it safe to continue shaft sinking a further 12 metres to a total depth of about 352 metres, but that any further consideration would have to await additional information.⁸⁶ At a meeting of the Executive Committee held on 28 August 1945, there was still some equivocation among the members of the sub-committee, but the Mines Inspector was adamant that the main shaft should not be continued beyond its present depth of 352 metres.⁸⁷ As a fallback, it was decided to sink a timbered winze, approximately '5 foot by 4 foot clear', from the bottom of the shaft to penetrate the top of the sand horizon.⁸⁸ It was believed that an excavation of this size would be relatively safe. By October 1945, the winze had been completed to a total depth of 367 metres, and the excavation of short drives to the north and south from the winze commenced.⁸⁹ It was reported that 'no serious difficulties were being met with'.⁹⁰ By November 1945, the drives were completed and a further 2.5 metres of winzing

undertaken from the north drive to form a 'pot hole' extending to a depth of 4.3 metres into the sand.⁹¹

Two holes were drilled approximately 9 metres horizontally from each end of the north-south drive to test the oil flow, and a further hole was drilled in an easterly direction. The flows of water and oil into these holes, as well as into the 'pot hole', were monitored over a period of 20 days during November and December 1945. Maximum flow rates equivalent to approximately '50 gallons per 1000 foot of hole length per day of dry oil' were recorded, generally depleting to a much lower rate over the monitoring period.⁹² The relatively poor flow rates obtained during these trials compounded the air of pessimism now surrounding the project arising from the multitude of difficulties that had had to be overcome.

With the benefit of hindsight

As cores of the producing sand became available from the pilot bore, detailed examination of the nature of the oil content led to some sobering conclusions. In January 1945, the project supervisor produced a report concluding that:

The Ranney estimate of oil production at Lakes Entrance was based on assumptions now known to be unfounded and the actual production will probably be less than one tenth part of the estimate.⁹³

This realisation was compounded by ambiguous feedback from the USA regarding the outcome of the parallel trial of Ranney's scheme being pursued in Pennsylvania at the time. In March 1945, it was decided that Cook and Newman should visit the USA as a matter of urgency to resolve some of the critical issues.⁹⁴

In the event, Cook made the trip on his own, but was able to meet up with Raggatt who was already in the USA. Cook's visit extended from May to July, during which time he met with a number of authorities and commissioned a well credentialed petroleum geologist, John Pemberton, to provide an opinion on the prospects for the Lakes Entrance Oil Field.⁹⁵ Cook's report on his findings was to the point and unequivocal, concluding, among other things, that:

- There is no successful application of the Ranney method for oil recovery in America
- There is no evidence that controlled horizontal drilling is possible by using the Ranney equipment ... All indications are there is no control particularly when holes are more than 1000 feet long ...

- The pressure injection of cement, referred to as “cement grouting”, into unconsolidated sands has not been developed sufficiently to warrant forecasts that it can be done with successful results ...
- The report prepared by oil geologist Pemberton ... states clearly what has been hinted at by so many of the authorities contacted in the U.S.A. that there is no chance of a successful outcome to the work now in hand at Lakes Entrance, simply because there is not sufficient oil present there.⁹⁶

Cook also found that the promised specialised drilling equipment was not going to be supplied in the foreseeable future. Cook expressed disappointment that the Bureau of Mines had recommended Ranney when there was a widespread feeling among the experts he had met that Ranney was held in low esteem. This view was certainly held by at least one senior member of the American Institute of Mining and Metallurgy, who claimed that they did not accept Ranney’s credentials, and that it was a pity that ‘instead of putting ourselves in the hands of a consultant, we fell into the hands of a promoter’.⁹⁷ Cook’s strong recommendation was that ‘all expenditure at Lakes Entrance cease forthwith, and that the plant be realised and the monies obtained be offset against past expenditure’.⁹⁸

Cook’s report was presented to the Executive Committee at the end of July 1945. The Committee, in turn, passed on the conclusions and recommendations verbatim to the Governments for their instructions.⁹⁹ As the wheels of government turned, work on the shaft continued as described and more detailed evaluation of the cores from the shaft and pilot bores was undertaken.¹⁰⁰ Based on this more detailed information, Raggatt reported that it might be expected that 20,000 barrels of oil could be recovered from an area of 300 metres radius within which control over drilling might be maintained.¹⁰¹ At a realistic price on the market, this might yield a return of about £20,000, far less than required to make the project viable. Raggatt conceded that if work was to be continued, it would be primarily to obtain further information on the field.

The Commonwealth Cabinet finally considered the situation in November 1945, by which time the war had ended, removing the strategic driver that had largely led to the project in the first place. The Government’s considerations were based essentially on the commercial credentials of the project.¹⁰² It was decided to consult further with the State Government before making a final decision. The State Government clarified its position in December 1945, suggesting that the project be abandoned, subject to Austral being offered the opportunity to make a proposal to take over. A recommendation was made that the operation be placed on a caretaker basis until this possibility had been evaluated.¹⁰³ The Commonwealth Cabinet subsequently ratified

this position, just in time to be able to digest the relatively disappointing results obtained from the initial flow trials. The project had been placed on a care and maintenance basis by the end of 1945, bringing to an end three years of struggle.

Back to the future

In December 1945, the Department of Supply and Shipping formally notified Austral of its desire to enter into negotiations about the future of the site. At a meeting held in January 1946, it was agreed that a detailed inventory of the realisable assets would be obtained as a basis for any offer that Austral might make.¹⁰⁴ It was made clear to the Syndicate that the Governments would not consider a loan to them on any basis, as this would imply Government endorsement of the project contrary to their position.¹⁰⁵ Austral turned to an earlier plan to float a new company to obtain the capital necessary to pursue dealings with the Governments and continue operations. At this point, wartime restrictions on capital raising were still in place, so Austral applied to the Capital Issues Board for their permission to float a new company with a nominal capital of £200,000, with the intention of immediately calling up approximately £100,000 to:

purchase the plant from the Commonwealth and State Governments, obtain horizontal drilling equipment, complete the work chamber ..., obtain the services of experts from abroad, drill four holes, each approximately 1,000 feet long, to test the application of the Ranney system.¹⁰⁶

This application was refused on the grounds of the negative view of the project held by the Governments.¹⁰⁷

At the end of March 1946, the Commonwealth Government notified Austral that it was now 'willing to revoke the order made under National Security Regulations, and [would] offer the Company the opportunity to acquire all plant and machinery ... for the sum of £16,620/16/4'.¹⁰⁸ This was the amount determined as the residual value of the installation by the auditors appointed by the Government, a substantial discount from the £150,000 already invested.¹⁰⁹ A condition of the Government's offer was that Austral should drop any claims they had made for compensation resulting from the compulsory acquisition. In an apparent case of pushing their luck, Austral held out on this point, and eventually received a settlement totalling £2,100.¹¹⁰ Austral re-applied to the Capital Issues Board presenting new information.¹¹¹ This application was approved, although there is no clear explanation for the changed reasoning of the Board.

The new company, Lakes Oil Limited, was formed in Melbourne soon after, and on 6 May 1946 acquired the rights and assets of Austral relating to the Lakes Entrance

project.¹¹² Meanwhile, on 24 April 1946, Austral wrote to the Commonwealth Government indicating that it had held talks with the Victorian Mines Department regarding its plans for further activity and had received the Department's blessing.¹¹³ At the same time, Austral indicated that it would make payment of the amount requested on 9 May 1946. On 15 May 1946, the Lakes Entrance oil lease was handed back to Austral, and as a result of the arrangement between Austral and Lakes Oil, the Lakes Entrance project was taken over by Lakes Oil.¹¹⁴

The decision by Austral to carry on activities in light of the pervasive negative sentiment around the project can be attributed largely to the unrelenting personality of Charles Demaine. Demaine's fractious relationship with the Committee during the years that the Governments managed the project had made him *persona non grata*, but after the hand back he emerged once again as the main driving force. Demaine's unwavering belief in the Lakes Entrance Oil Field is encapsulated in his appeal to Austral shareholders at the time of the hand back:

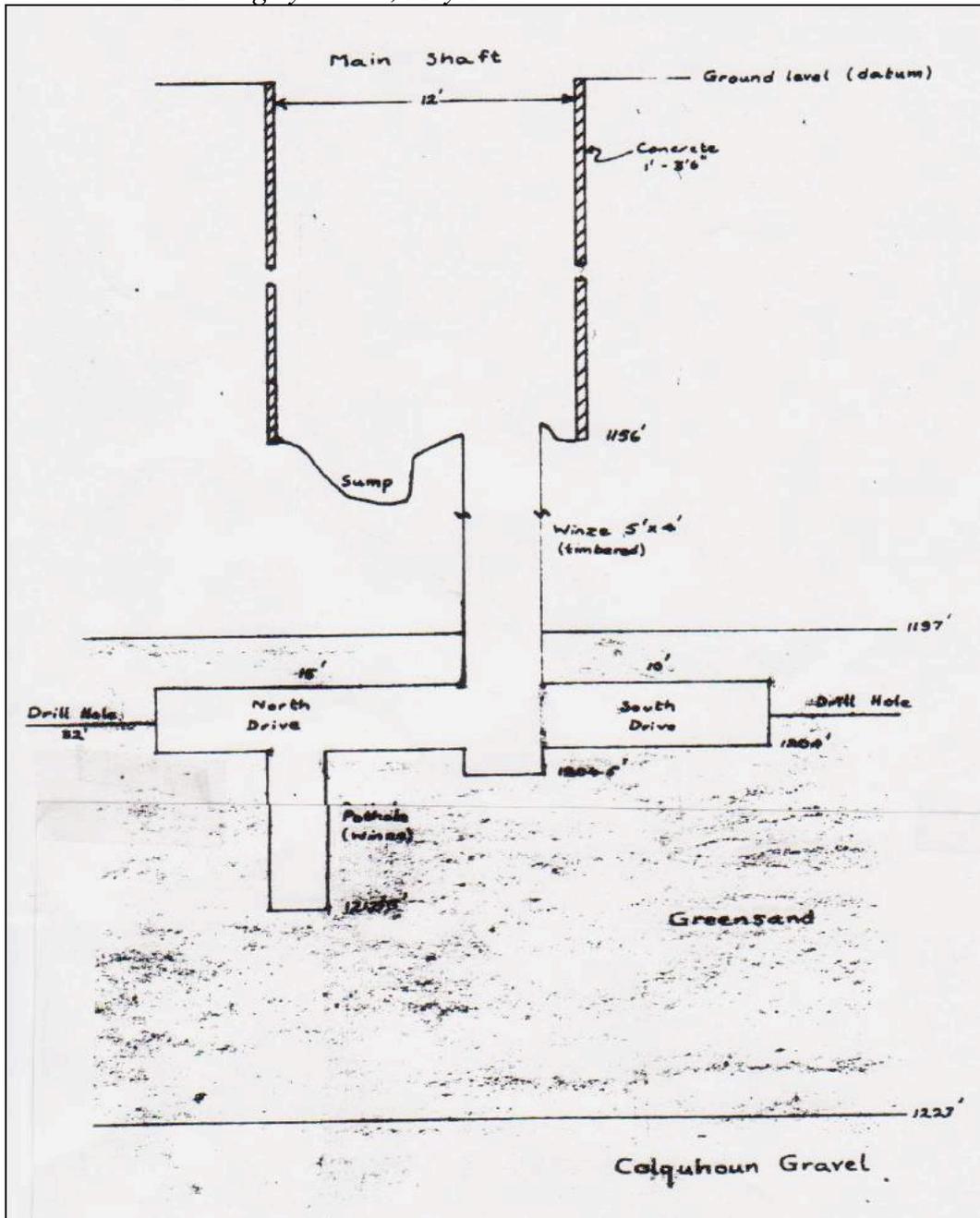
The making of estimates of the oil content ... is not a question to be determined as a result of a geological or geophysical examination of one core 16 feet long and one and a quarter inches in diameter ... Actual yields of oil obtained by your Company have conclusively shown that far and away the greater portion of the oil that has so far been recovered ... has been obtained after a depth of something more than 25 feet below the top surface of the glauconite has been drilled. For anyone to have made an estimate of the total content of oil in 400 acres [as Raggatt had done in October 1945], but to have excluded entirely from the calculation the oil in the bottom half of the glauconite, is entirely unjustified.¹¹⁵

A re-start

The approximate configuration of the shaft at the time of the hand back is shown in Figure 4. During the period of Government management, John Laing, a noted civil engineer, conducted a detailed evaluation of the problem of ensuring the integrity of a work chamber.¹¹⁶ In Laing's view, three alternatives presented themselves: to rely on the inherent strength of the rock in which the chamber would be located; to augment this strength by a process such as cement injection; or to design the chamber itself to be able to largely resist any forces that might be mobilised. Laing favoured the latter approach, proposing a design incorporating radial buttress walls to help support the floor and outer walls of the chamber. Whether as an act of faith, or an educated gamble based on the absence of major problems when the trial excavations were made, Lakes decided to stick essentially with the original concept proposed by Ranney and construct a circular chamber with an internal diameter of 6 metres and a height of 9 metres, to be

located immediately above the north-south drive that had been excavated previously. The chamber was designed with reinforced concrete walls 1.2 metres thick, and a reinforced concrete floor, without any additional strengthening features such as had been suggested by Laing.¹¹⁷ The prospect of installing two floors in the work chamber was considered but not adopted.

Figure 4: *Sketch of shaft configuration at time of hand back to Austral Oil Drilling Syndicate, May 1946*



Source: P.R. Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft for testing explosives', Unpublished Report July 1966, Mines Department of Victoria.

Lakes entered into a further contract with the Snider Construction Company, and with essentially the same work force, set about extending the shaft and constructing the work chamber in January 1947.¹¹⁸ The earlier winzes and drives were filled with concrete prior to excavation commencing.¹¹⁹ Progress was made in increments, with concrete being poured after each stage of excavation, as had been the previous practice. The floor of the chamber was reported as having been poured at midnight on 4 September 1947, marking a significant milestone for the project.¹²⁰ Apart from progress being slowed by the intersection of some 'hard bands', no particular problems were reported during construction.¹²¹ Forty eight 'portholes' to facilitate later drilling were cast into the walls of the chamber during construction, at various radial locations. Some of these were 15 cm in diameter, others 20 cm. Some were set horizontally, and others at a slight downward angle.¹²²

Drilling gets underway

An early decision by Lakes had been to use Australian supplied drilling equipment and in early 1947 an order was placed on Mineral Drillers Pty Ltd for the supply of the equipment.¹²³ After trial of the equipment on the surface, it was put into action in October 1947.¹²⁴ Drilling was conducted through 'stuffing glands' installed in the 'portholes' to facilitate control of any water inflows that might occur during drilling.¹²⁵ Permanent casing was inserted for some distance into each hole and pressure grouted in place to ensure a seal against the inherent reservoir pressure. Problems began to occur when the men conducting the grouting operation started to suffer from cement burns (dermatitis).¹²⁶ This was exacerbated by the high humidity in the work chamber. To alleviate this, the ventilation system was improved and the methods being used for grouting were reviewed and altered to minimise the risk of cement burns.¹²⁷ Despite these problems, 1947 ended on a positive note, with the Board being able to report to shareholders at the annual meeting that drilling had commenced and oil was being produced.¹²⁸

By the end of 1947, a number of short holes had been drilled, six at a dip of nine degrees and several more at a dip of 30 degrees. These nine holes were reported to have intersected the top of the producing horizon approximately 18 metres from the work chamber. Some of these holes had been cased to the top of the producing horizon and drilled on for a further distance of approximately 9 metres into the upper zone of the producing sand. All of these latter holes were reported to have been producing 'small quantities of oil'. No problems arising from excess water flows from the sand were

reported.¹²⁹ It was, however, already becoming evident that due to the natural tendency for holes drilled near horizontal to sag, the lateral coverage that could be expected before holes penetrated through the complete sand section would most likely be less than planned.¹³⁰

By May 1948, it was reported that the yield being obtained from the holes so far drilled was only about one half of what would be required for commercial viability and that the oil content of the produced fluid produced varied between '60 and 200 gallons of dry oil per one million gallons of water'.¹³¹ Holes of larger diameter were considered, and a trial hole drilled for the first time into the lower zone thought to have higher oil content.¹³² When a somewhat higher yield was indicated from this hole, nine additional holes were planned to go into the lower zone, 'spaced to tap the full 360 degrees'. It was thought that if a yield of around 115 litres per day per hole could be achieved from these holes, the Board might be able to make a decision on the prospects for further development.¹³³

By August, the financial situation was becoming critical, with only enough funds left to support another 10 weeks of activity.¹³⁴ At a special meeting of the Board held on 11 September 1948, it was suggested that based on the results from the nine trial holes, development of an area of around '300 acres by an array of holes might yield about 150 barrels per day'.¹³⁵ In October it was agreed to recommend to shareholders that activity be continued, and that the nominal capital of the Company be increased from £200,000 to £1,000,000 by an issue of shares to current shareholders.¹³⁶ Temporary finance was arranged when one of the directors guaranteed the Company's bank overdraft.

In an impassioned presentation to the second annual meeting on 15 December 1948, the Chairman described how oil was flowing, particularly from the lower zone, under the inherent reservoir pressure of about '520 pounds per square inch, without recourse to the use of explosives or the application of a vacuum'.¹³⁷ The chairman also dwelt on the fact that the Company had sold about 136,000 litres of oil to that date. At the time of the meeting, the longest hole drilled was about 60 metres. Most holes were 38 mm in diameter, with one being 64 mm. Production was stated to be around '2.5 barrels per day per acre developed, with 3 acres having been developed'. The chairman set out the plans for future development of a '60 acre area, followed by a 300 or 400 acre area if the 60 acres proved commercial'.¹³⁸ His presentation culminated in the proposal to increase the Company's capital, by which time those present must have been ready to sign up, for that is what they mainly did.

As noted in *The Age*, 15 holes had been drilled by February 1849. Impressed by what he saw, the correspondent described a visit to the project in dramatic terms:

The journey down in a lift that descends at the rate of 500 feet a minute through blackness is an eerie experience for the uninitiated. The cage itself is oozing oil: the shaft is as wet as a shower, and the working chamber is humid and slippery. It is no place for anyone with claustrophobic tendencies ... The working chamber resembles somewhat the fire room of an oil burning ship without the fire ... The oil drains through the drilled holes into a sump beneath the working chamber, and is brought to the surface in bailers.¹³⁹

In anticipation of a bright future, attempts were made to improve the ventilation and further seal the shaft lining to overcome the oppressive conditions in the work chamber. Storage and separation tanks were installed. Plans were made to install a pump capable of pumping from shaft bottom to the surface directly, to circumvent the need for bailing. A laboratory was established at the shaft site and a chemist employed to monitor the quality of the oil produced. Experiments were conducted into the best way to dehydrate the oil.

In all publicity about the project at this time, the Company stressed the experimental nature of the enterprise and fell back on motherhood statements such as, 'from seeps and dribbles you get cups, then pints and gallons. They build to barrels, drums then tons'.¹⁴⁰ This cautionary approach by the Company to its image was in contrast to the expectation of shareholders, who began to default on calls made on shares.¹⁴¹ The mood of the local public was buoyed by reports such as that in the *Bairnsdale Advertiser* of 18 February 1949, in which a claim was made of production of '10,000 gallons per month'.¹⁴² The more cynical of oilmen, however, were not convinced. A report in *The Petroleum Times* on March 25 1949 was to the point:

A report issued by the directors of Lakes Oil Ltd., refers to progress being made at the so-called Lakes Entrance Oil Field. This appears to consist of recovering the 7,000 to 10,000 gallons of oil and water, especially the latter, which have seeped into the bottom of the hole from the horizontal shafts drilled on the experimental system a couple of years ago.¹⁴³

Full scale production development of the larger area was scheduled to start in May 1949, for which it was intended to drill much longer holes than previously, to implement the use of hole surveying technology and to utilise a hole trajectory control system called a whipstock.¹⁴⁴ It was not until September 1949, however, that any real progress seems to have been made.¹⁴⁵ At this time, plans were revealed to drill a 300 metre long hole parallel to the bottom of the sand horizon in the higher producing lower

zone. It was estimated that this operation might take about two months.¹⁴⁶ By the time of the annual meeting in December, the chairman was able to report that after overcoming a number of teething problems, this hole had reached a depth of '650 feet and was producing 100 gallons of dry oil per day'.¹⁴⁷

Long hole drilling continued throughout 1950 at an agonisingly slow rate, this being attributed to the shortage of critical supplies. By the time of the annual meeting in December 1950, a small number of holes had been drilled out around 300 metres, and in some cases had produced encouraging flows.¹⁴⁸ One hole was reported to have produced '629 gallons in 16 tests extending over 7 hours and 20 minutes between December 19 and December 21, 1950'. It was noted, however, that the flow rate dropped off rapidly from the first to the last test period, suggesting a severe problem of water invasion.¹⁴⁹ Demaine calculated that the average production rate would have to be increased by a factor of about 10 if the project was going to produce a net profit for the Company.¹⁵⁰

In January 1951, Lakes wrote to the Victorian Mines Department seeking their support for an approach to the Commonwealth Government for a grant of up to £30,000 per year for two years to continue the project. While recognising the commercial reality, the Mines Department saw value in further experimentation and supported the application with a letter from the Premier. This was to no avail.¹⁵¹ In the annual report of the Mines Department for 1951, the entry under Oil simply read, 'oil production ceased toward the end of the year when Lakes Oil Ltd suspended operations at the Lakes Entrance shaft after ten years of work'.¹⁵²

In the final analysis, approximately '5,000 barrels of poor quality oil had been produced, with a total value of about £10,000'.¹⁵³ The annual report of Lakes Oil for 1951 stated that due to lack of finance, all 26 horizontal holes had been cemented, all valuable equipment removed from the shaft, and the shaft allowed to fill with water.¹⁵⁴ The Chairman's report to the meeting ended with a lament that it was 'unfortunate that Government policy had been directed to aiding the search for oil, but not to helping the actual production of oil'.¹⁵⁵

Epilogue.

After cessation of activities, the shaft was left to become progressively derelict. In 1966 a proposal was made by Imperial Chemical Industries Ltd. to use the chamber to test explosives. This never eventuated. Over time, the surface facilities were progressively removed and the shaft sealed. Today, only a few remnants are left to bear witness to this

ground breaking, if quixotic, chapter in Australia's mining history. Recent attempts to establish a tourist centre around the site have so far not come to fruition.

Termination of the project in 1951 spelt the effective end to development of the Lakes Entrance Oil Field for a period, but interest in the area has never completely disappeared, resurfacing from time to time.

Long hole horizontal drilling from shafts into thin oil producing horizons never took on, although a near relative of the concept is today being widely used to extract methane from coal seams. The progressive development of technology allowing horizontal wells to be drilled from the surface has led to the position where this is now taken as the norm in the oil patch.

Of the main players in the project, Leo Ranney failed to get his concept for horizontal wells drilled from shafts generally excepted. Harold Raggatt was to become the founding director of the Bureau of Mineral Resources, Geology and Geophysics and went on to a distinguished career as the head of the Commonwealth Department of National Development. Charles Demaine, who had been the persistent champion of the project, died in 1952, never to see his dream of a forest of oil shafts around Lakes Entrance realised.

Acknowledgement.

The author sincerely thanks Lakes Oil Ltd for their generous help in providing access to the historic documents in their possession.

Endnotes

¹ In fact, these slicks were later shown to be iron oxide films known colloquially as 'Fool's Oil'.

² G. Brown, 'Gippsland East; Its Geology and Mining Development (including the Lakes Entrance Oil Field)', *Mines Department Victoria*, Victorian Government Printer, 1936, p. 14. Although Lake Bunga is generally acknowledged as the first location where true liquid oil was produced in Australia, liquid condensate had previously been found associated with gas flows at Roma in Queensland.

³ *Victorian Year Book, 1937-38*, Victorian Government Printer, 1938, p. 504.

⁴ H. Raggatt, 'Oil Possibilities, Lakes Entrance Area, East Gippsland, Victoria', Unpublished Report, *Commonwealth Department of Supply*, August 1940, A659 1940/1/7428, National Archives of Australia [hereafter NAA].

⁵ *Victorian Year Book, 1937-38*, p. 504.

⁶ *Ibid.*

⁷ Raggatt, 'Oil Possibilities, Lakes Entrance Area, East Gippsland, Victoria'.

⁸ *Victorian Year Book, 1937-38*, p. 504.

⁹ *Bairnsdale Advertiser*, 6 December 1938.

¹⁰ *Ibid.*, 24 February 1939.

¹¹ Raggatt, 'Oil Possibilities, Lakes Entrance Area, East Gippsland, Victoria'.

¹² See for example, H Hoover and L Hoover (trans.), *DE RE METALLICA, The Mining Magazine*, London, 1912.

¹³ A notable example of current activity is the extraction of oil from the Athabasca tar sands of western Canada.

¹⁴ *New York Times*, 23 February 1880.

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- ¹⁵ See for example, articles throughout 1939 and 1940 in the *Bairnsdale Advertiser*; Records of debates in Federal Parliament, 1939-40, *Hansard*; Representations by T. Paterson, 1939, MP99/3 88, NAA.
- ¹⁶ Memorandum for Federal Cabinet, 20 August 1941, CP12/3 23, NAA.
- ¹⁷ *Ibid.*
- ¹⁸ *Bairnsdale Advertiser*, 3 June 1941.
- ¹⁹ L. Ranney, 'Horizontal drilling through outcrop brings results', *The Oil and Gas Journal*, 20 April, 1939; *ibid.*, 'Drilling horizontal wells from a vertical shaft', 23 January 1941; H. Schultheis, 'Horizontal drilling from bottom of shaft in Pennsylvania field', *The Oil and Gas Journal*, 14 October, 1943.
- ²⁰ Letter from Ranney to Australian Minister in Washington, 26 August 1941, A1145 M6/3, Part 1, NAA.
- ²¹ Memorandum for Federal Cabinet, 20 August 1941, CP12/3 23, NAA.
- ²² *Ibid.*
- ²³ *The Argus*, 11 July 1941.
- ²⁴ See for example, articles in the *Bairnsdale Advertiser*, July 1941.
- ²⁵ Leo Ranney and Charles Fairbank, 'Lakes Entrance Oil Field', Report to Commonwealth Government, July 1941, A659 1940/1/7428, NAA.
- ²⁶ *Ibid.*
- ²⁷ *Bairnsdale Advertiser*, 5 August 1941.
- ²⁸ Letter by Demaine to Commonwealth Government, October 1941, A1145 M6/3, Part 1, NAA.
- ²⁹ Memorandum for Federal Cabinet, 17 November 1941, A2700 112, NAA.
- ³⁰ *Ibid.*
- ³¹ *Bairnsdale Advertiser*, 9 December 1941.
- ³² *Ibid.*, 19 December 1941.
- ³³ *The Petroleum Times*, 23 August 1941.
- ³⁴ *Articles of Association, Austral Oil Drilling Syndicate NL*, 1936, VPRS 567, Unit P0001, File 825, Public Records Office Victoria [hereafter PROV].
- ³⁵ Minutes of general meeting of shareholders, Austral Oil Drilling Syndicate NL, 6 August 1941, VPRS 567, Unit P0001, File 825, PROV.
- ³⁶ Petroleum Mineral Lease Files, VPRS 6809, Unit P0001, PROV; *Bairnsdale Advertiser*, 23 January 1940; Minutes of general meeting of shareholders, Austral Oil Drilling Syndicate NL, 22 December 1941.
- ³⁷ Representation by T. Paterson, 10 September 1941, A1145 M6/3, Part 1, NAA.
- ³⁸ Letter from Demaine to Commonwealth Government, 30 January 1942, A1145 M6/3, Part 2, NAA.
- ³⁹ Monthly reports of activities to Mines Department by Austral Oil Drilling Syndicate, January to June 1942, VPRS 567, Unit P0001, File 825, PROV.
- ⁴⁰ Letter to Austral from the Commonwealth Government, 14 May 1942, A432 1942/793, NAA.
- ⁴¹ Letter to Demaine from Newman, 3 September 1942, A1145 M6/25, NAA.
- ⁴² *The Argus*, 9 September 1942.
- ⁴³ *Ibid.*
- ⁴⁴ *Annual report of Austral Oil Drilling Syndicate NL*, 27 August 1942, VPRS 567 Unit P0001, File 825, PROV.
- ⁴⁵ Report by Snider Construction Company regarding status of surface facilities, 4 September 1942, A1145 M6/25, NAA.
- ⁴⁶ Ranney and Fairbank, 'Lakes Entrance Oil Field'.
- ⁴⁷ Letter from Victorian Mines Department to Austral Oil Drilling Syndicate, 13 June 1940, A1145 M6/3, Part 2, NAA.
- ⁴⁸ Letter from Raggatt to Commonwealth Government, 11 November 1941, A1145 M6/3, Part 2, NAA.
- ⁴⁹ Record of communications between Commonwealth Government and Sir Walter Massey-Green for Gold Mines of Australia, A1145 M6/3, Part 2, NAA.
- ⁵⁰ Letter to Austral Oil Drilling Syndicate from Snider Construction Company, 5 November 1941, A1145 M6/3, Part 1, NAA.
- ⁵¹ *Ibid.*
- ⁵² Zinc Corporation was at the time constructing a circular concrete lined shaft at Broken Hill; *Minutes of the third meeting of the Lakes Entrance Departmental Executive Committee [Committee]*, 21 August 1942, A1145 M6/34, NAA.
- ⁵³ Minutes of the fifth meeting of the Committee, 6 October 1942, A1145 M6/34, NAA.
- ⁵⁴ *Ibid.*
- ⁵⁵ Telegram to Raggatt from Smith, A1145 M6/3, Part 2, NAA.
- ⁵⁶ *Minutes of Committee meeting*, 2 December 1942, A1145 M6/34, NAA.
- ⁵⁷ Personal recollections of Albert Clarke in *Where God Never Trod*, Rick Wilkinson, Christopher Beck Books, Windsor, Queensland, 1991, p. 96.
- ⁵⁸ *Minutes of Committee meeting*, 4 March 1943, A1145 M6/34, NAA.
- ⁵⁹ *Ibid.*, 15 April 1943.

- ⁶⁰ *Ibid.*, 4 March 1943.
- ⁶¹ *Ibid.*, 15 April 1943; P.R. Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft for testing explosives', Unpublished Report July 1966, Mines Department of Victoria.
- ⁶² *Minutes of Committee meeting*, 4 March 1943, A1145 M6/34, NAA.
- ⁶³ Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft ...'.
- ⁶⁴ Report by Cook to Committee re progress, 24 August 1943, A1145 M6/34, NAA.
- ⁶⁵ *Minutes of Committee meeting*, 17 November 1943, A1145 M6/34, NAA.
- ⁶⁶ Mines Inspector's report, Gippsland District', *Annual Report of the Victorian Mines Department*, Victorian Government Printer, 1943.
- ⁶⁷ *Minutes of Committee meeting*, 20 January 1944, A1145 M6/34, NAA.
- ⁶⁸ *Ibid.*, 30 March 1944.
- ⁶⁹ *Ibid.*
- ⁷⁰ Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft ...'.
- ⁷¹ Mines inspector's report, Gippsland District', *Annual Report of the Victorian Mines Department*, Victorian Government Printer, 1944.
- ⁷² D.J. Binning, 'In Search of Liquid Gold', *The Record*, April 1949.
- ⁷³ *Minutes of Committee meeting*, 13 July 1944, A1145 M6/34, NAA; Note Tubbing, is the name given to a support system based on interlocking segments of cast iron lining.
- ⁷⁴ *Minutes of Committee meeting*, 13 September 1944, A1145 M6/34, NAA.
- ⁷⁵ *Ibid.*
- ⁷⁶ Mines inspector's report, Gippsland District', *Annual Report of the Victorian Mines Department*, Victorian Government Printer, 1944.
- ⁷⁷ *Ibid.*'; *Minutes of Committee meeting*, 29 November 1944, A1145 M6/34, NAA.
- ⁷⁸ *Ibid.*
- ⁷⁹ Letter to Committee from Snider Construction Company re procurement of engine drivers, 23 November 1944, A1145 M6/25, NAA.
- ⁸⁰ *Minutes of Committee meeting*, 1 March 1945, A1145 M6/34, NAA.
- ⁸¹ *Ibid.*
- ⁸² *Ibid.*
- ⁸³ *Ibid.*, 27-28 June 1945.
- ⁸⁴ *Ibid.*
- ⁸⁵ *Ibid.*
- ⁸⁶ Report of technical sub-committee, 3 July 1945, A1145 M6/34, NAA.
- ⁸⁷ *Minutes of Committee meeting*, 28 August 1945, A1145 M6/34, NAA.
- ⁸⁸ *Ibid.*
- ⁸⁹ *Ibid.*, 24 October 1945.
- ⁹⁰ *Ibid.*
- ⁹¹ *Ibid.*, 21 November 1945.
- ⁹² Results of initial monitoring trials, A1145 M6/37, Part 1, NAA.
- ⁹³ *Minutes of Committee meeting*, 26 January 1945, A1145 M6/34, NAA.
- ⁹⁴ *Ibid.*, 1 March 1945.
- ⁹⁵ Diary of Cook's visit to the USA, A1145 M6/37, Part 1, NAA; Report by J. Pemberton on the Lakes Entrance Oil Project, 5 July 1945, with accompanying CV, A1145 M6/37, Part 1, NAA.
- ⁹⁶ Report by Cook on findings in the USA, 31 July 1945, A1145 M6/37, Part 1, NAA.
- ⁹⁷ *Ibid.*
- ⁹⁸ *Ibid.*
- ⁹⁹ Letter from Committee to Commonwealth Government with Cook's findings, 31 July 1945, A1145 M6/37, Part 1, NAA.
- ¹⁰⁰ Extract from draft report by Thyer and Noakes, 'Drill Core from the Shaft Bore Lakes Entrance', 16 October 1945, A1145 M6/37, Part 1, NAA.
- ¹⁰¹ Letter from Raggatt to Department of Supply and Shipping, 17 October 1945, A1145 M6/37, Part 1, NAA.
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- ¹⁰⁸ Report by Austral Oil Drilling Syndicate NL to shareholders on the circumstances surrounding the proposed transfer of the project, 9 April 1946, VPRS 567, Unit P0001, File 825, PROV.
- ¹⁰⁹ J.H. Curnow and Son, 'Valuation of Machinery, Plant, Buildings and Equipment at the Oil Project Lakes Entrance' 30 January 1946, A1145 M6/31, NAA.
- ¹¹⁰ Report by Austral Oil Drilling Syndicate NL to shareholders on the circumstances surrounding the proposed transfer of the project, 9 April 1946, VPRS 567, Unit P0001, File 825, PROV.
- ¹¹¹ *Ibid.*
- ¹¹² R. Wilkinson, 'History of Lakes Oil NL', Unpublished Document for Lakes Oil Ltd, Date Unknown.
- ¹¹³ Letter from Austral Oil Drilling Syndicate NL to Department of Supply and Shipping, 24 April 1946, A1145 M6/37, Part 2, NAA.
- ¹¹⁴ Wilkinson, 'History of Lakes Oil NL'.
- ¹¹⁵ Report by Austral Oil Drilling Syndicate NL to shareholders on the circumstances surrounding the proposed transfer of the project, 9 April 1946, VPRS 567, Unit P0001, File 825, PROV.
- ¹¹⁶ Report by J. Laing to Committee, 2 September 1943, A1145 M6/34, NAA.
- ¹¹⁷ Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft ...'.
- ¹¹⁸ *Minutes of Board Meetings*, 12 February and 12 March 1947, Lakes Oil.
- ¹¹⁹ Kenley, 'Notes on the proposed use of the Lakes Entrance Oil Shaft ...'.
- ¹²⁰ *Minutes of Board Meeting*, 10 September 1947, Lakes Oil.
- ¹²¹ *Ibid.*, 11 June 1947.
- ¹²² *Ibid.*
- ¹²³ *Minutes of Board Meeting*, 12 March 1947, Lakes Oil.
- ¹²⁴ *Ibid.*, 8 October 1947.
- ¹²⁵ 'Mines inspector's report, Gippsland District', *Annual Report of the Victorian Mines Department*, Victorian Government Printer, 1947.
- ¹²⁶ *Bairnsdale Advertiser*, 22 February 1949.
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- ¹²⁸ *Annual report of Lakes Oil Ltd.*, 10 December 1947, Lakes Oil.
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- ¹³¹ *Ibid.*, 19 May 1948.
- ¹³² *Ibid.*, 14 July 1948; *ibid.*, 11 August 1948.
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- ¹³⁴ *Ibid.*
- ¹³⁵ *Ibid.*, 11 September 1948, Lakes Oil.
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- ¹³⁸ *Ibid.*
- ¹³⁹ *The Age*, 22 February 1949.
- ¹⁴⁰ *Ibid.*
- ¹⁴¹ Wilkinson, 'History of Lakes Oil NL',
- ¹⁴² *Bairnsdale Advertiser*, 18 February 1949.
- ¹⁴³ *The Petroleum Times*, 25 March 1949.
- ¹⁴⁴ The Whipstock was a wedging mechanism that could be inserted into boreholes to deflect a drill string from its previous trajectory.
- ¹⁴⁵ *Minutes of Board Meeting*, 17 September 1949, Lakes Oil.
- ¹⁴⁶ *Ibid.*
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- ¹⁵⁰ 'Report on the Advisability of a Grant to Lakes Oil Ltd.' Unpublished Report, 1951/33, Mines Department of Victoria, 1951.
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- ¹⁵³ Wilkinson, 'History of Lakes Oil NL'.
- ¹⁵⁴ *Annual report of Lakes Oil Ltd.*, 19 December 1951, Lakes Oil.
- ¹⁵⁵ *Ibid.*