ASEG Oral History – Lindsay Thomas

This file contains a transcribed copy of an oral history interview of Lindsay Thomas conducted by Bob Smith and Joe Cucuzza on March 25, 2020.

The interview aimed to record some of Lindsay's recollections as a geophysicist and his observations of developments in geophysics during his working life.

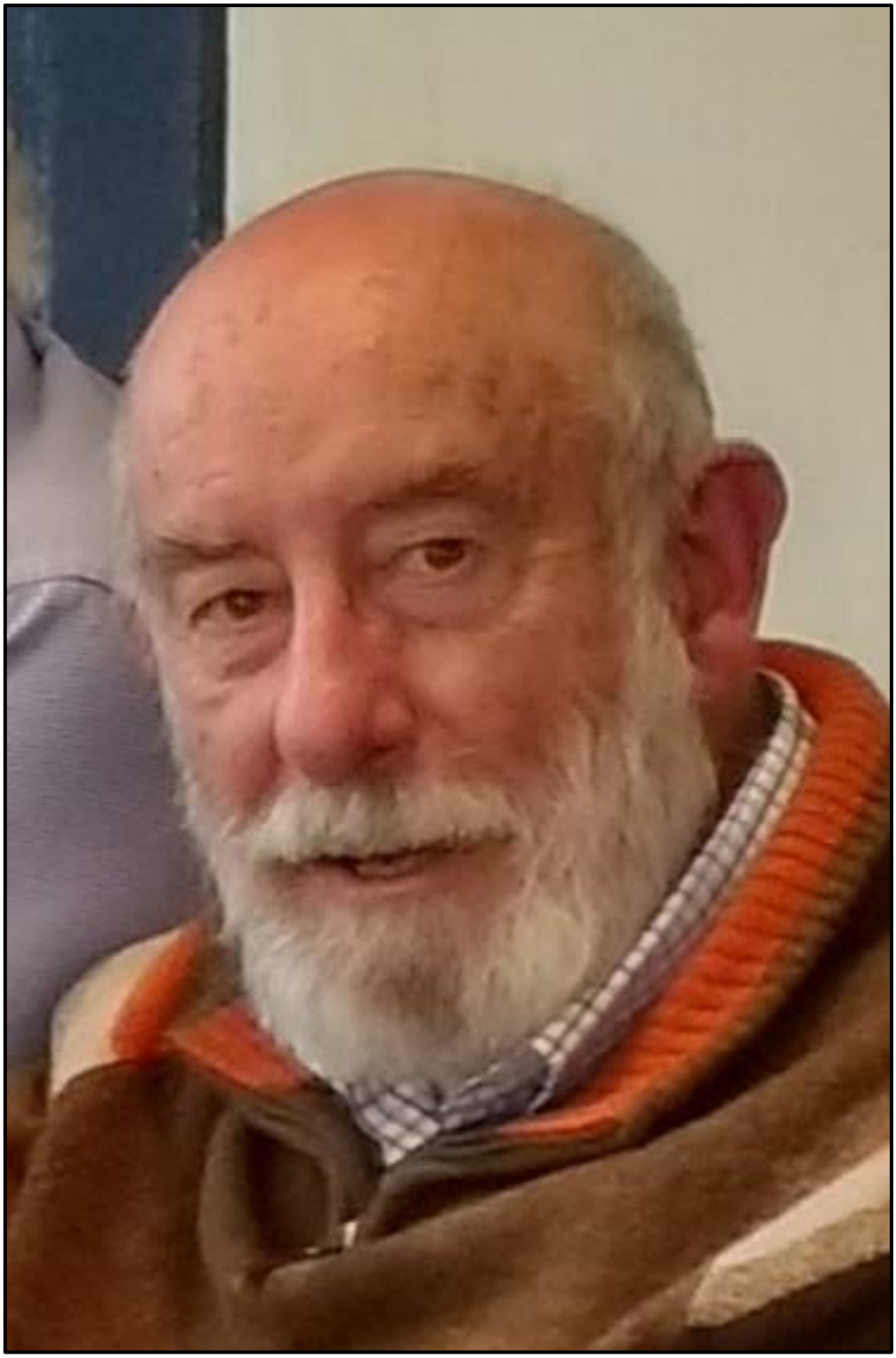
Lindsay has been a member and supporter of the ASEG since its inception in 1970 - he was present at the Sydney ICOGEO (and voted for ASEG to be independent of SEG). For several years thereafter he joined with Pat Hillsdon and Ian Lilly as the "Northern Suburbs (of Melbourne) Branch" of the ASEG, in some attempts to get a local branch operating, but without success. When Melbourne meetings did eventually get under way, Lindsay was the "token member" of the Kelvin Club to enable our meetings to be held there. Later, the ASEG executive eventually moved to Melbourne and Lindsay was enlisted as Treasurer (1992-1995), and subsequently as Editor of Exploration Geophysics (2001-2008). He was honoured and humbled to be awarded one of the first ASEG Service Certificates in 1998, and Honorary Membership in 2006.

A structured series of questions were prepared before the interview and forwarded to the interviewee to allow the interviewee an opportunity to prepare his responses.

The interview was conducted via ZOOM and transcribed by Microsoft Word. Subsequently, both interviewers and the interviewee were able to edit the final document before its' release.

A list of Lindsay's Honours students is included as Appendix A, and Lindsay's

publications as Appendix B, at the end of the interview.



Lindsay Thomas - 2017

Bob

Question 1 (including Question 3)

Can you tell us a bit about your background, where you were born and educated, and how you became a geophysicist?

Lindsay

I'm an Adelaide person, and was educated in Adelaide at St Peter's College and the University of Adelaide in the 1950s and 1960s, and became a geophysicist almost by inertia. I was a good student at college and the University and set out on a Physics/Maths double major. When I came to the end of my undergraduate career, I went straight onto the Honours degree. I did an experimental project in semiconductor physics with a supervisor that I did not really get on with.

The best lecturer in the Department (Physics), as far as I was concerned, was David Sutton. So, at the end of my Honours year, I went and offered myself to David. David had taken a PhD in Adelaide in ionospheric physics, I think, but had spent time with Patrick Blackett at Imperial College, London, when Blackett was following his interests in geophysics and palaeomagnetism. When David returned to Adelaide he set up a paleomagnetic lab, and later when the World Wide Standard Seismograph Network (WWSSN) installed a seismograph system in Adelaide, David took responsibility for that. He later published several papers on Australian seismicity and seismology.

David took one of the early physics PhD degrees in Australia, in the late 1940s. He talked to us about Observatory seismology during my Honours year, and at the end of the year, I thought I had a notion about why microseisms were so evident and suggested that I might work on that as a PhD project. David sent me off to talk to an engineer who swiftly demolished my project premise. I went back to the rest of the seismology group in Adelaide, and David eventually assigned me a task, to report on surface wave propagation as essentially a term paper, something to present to the seismology group. While working on that I got quite intrigued by the proposition of surface waves as a method for studying the properties of the upper crust. So, from learning about surface wave dispersion I took that as a project, to study surface wave dispersion In Australia.

As an aside here I remark that this was back in the days when students could, and very often did, choose their projects. Supervisors then would take up research work like that and therefore it was quite natural for me to expect that I would be supported in my project by my supervisor, without necessarily having to work on a project that he defined. So, I continued with my PhD and completed that in 1967 and started looking around for work.

Bob

You said on the way through, Lindsay, but I missed it – what was your PhD topic?

Lindsay

Surface wave Dispersion in Australia. If you are familiar with the Skippy project that was run out of Canberra in the 1990s, by Brian Kennett, professor of geophysics in Canberra – that particular project was my PhD thesis on steroids. I was impressed by what they did.

The next step in me becoming a geophysicist was finding a job. In what seems like an aside at this time is that I had got to know the former Professor of Physics in Adelaide on a personal level; that was Professor Sir Kerr Grant. A position came up in Melbourne for which I applied – and was interviewed at my desk in Adelaide by Prof Sir Kerr's son Colin Kerr Grant, who had been Reader in Geophysics at Melbourne since 1958. It turned out that Colin and I had been at the same school

albeit a generation apart, (and this was Adelaide, remember) so I found myself invited to go to Melbourne to take up a lectureship in the Geology Department of the University of Melbourne.

Bob

Could I just interrupt to say that Colin Kerr Grant was also my introduction to geophysics! I was doing a physics degree at Melbourne and he lectured for one unit of that in 3rd year, on geophysics, but he got sick halfway through and Maurice Tattam came in and read his notes, so it was a fairly rough introduction to geophysics.

Joe

I can say something here also: Colin was my initial lecturer as well substituting for Lindsay, who was on study leave, and so we all have a connection.

Lindsay

You were a bit early, Bob, because I was a compulsive lecture-notes writer so when I was giving classes I just about always had notes which were printed and distributed; Colin was even more old school than I was I think in that respect at least.

Bob

Well, I enjoyed the lectures that he managed to give and got to know him a bit more later, and certainly, he was my introduction to geophysics – there were lots of things that I missed so I thought I must follow this to find out more about it.

Joe

Lindsay, it was only when you entered the job of a lecturer at Melbourne Uni that you considered yourself entering into geophysics proper – is that correct?

Lindsay

Yes, that's correct Joe. Before that I was aware of geophysical activities that went on, including in the State Mines Department; we had been out in the field with Bernie Milton a couple of times, doing engineering seismic exercises, but I went as an observer [an observatory seismologist rather than an exploration seismologist]. When I put myself into the job market, I was initially looking at, and interviewed for, places like Esso and BMR in oil search (but I was also interviewed by Roy Woodall and Anton Triglavcanin for WMC. But we went our separate ways…)

Around about that time, the industry dropped away and I was fortunate to have found a job in Melbourne. One of the first things I had to do was buy a copy of Dobrin's Introduction to Geophysical Prospecting, as that was the textbook; I did not have a copy of that yet. I still have that copy on the shelf behind me! For the first several years now, I think I was pretty much operating within Colin Kerr Grant and the Melbourne department's orbit. I guess almost unconsciously by this time, I was becoming a lecturer and researcher – a lecturer primarily. There wasn't much else in Melbourne that I knew about at that time to broaden my outlook, I might say, but it was at the International Conference on the Chemistry and Physics of the Earth's Mantle in Canberra in 1969, which I attended with a couple of my geochemistry colleagues from Melbourne that I met several other geophysicists and started to think a bit more about geophysics itself, as opposed to a physics sub-field.

[Reflecting while editing these notes, I don't think I hesitated at all about taking on the lectureship in Melbourne – even though I had virtually no direct exposure to exploration geophysics. I have always

held that a lecturer in any field should be able to give undergraduate classes in his or her field with sufficient notice, but I think I took myself for granted in 1968].

Bob

Lindsay, I think you've probably answered **Question 3** on the list here which is what attracted you to a career in geophysics, and did it meet your expectations, but if you haven't answered fully is there anything you'd like to add to that point?

Lindsay

I would add that it was not so much what attracted me – I had a position! — as what kept me in it. I found that the classical physics level was something that I could keep up with. Another thing that was a positive throughout my career was fieldwork with the students (and occasionally staff). I have never completed a geology course as a student but was well supported by colleagues throughout my career. By contrast, my Honours class in physics numbered ten of us and I think only two of the others had jobs that took them "outside the building". There may have been something in the water at the time because of the ten of us nine did PhDs eventually, one way or another, and the 10th one was the deputy Hydrographer of the Navy. Even though they were shut up inside, of the others, seven became Department Heads or Chiefs of Division or things like that in the Australian education and scientific scene. So, I was part of a strong group in Honours and PhD. So, working in Geophysics met my expectations and as I say the continual refreshment of being out in the field and getting out and talking to people who were not academics for that matter was a Good Thing.

Another belated memory is attending the first and second Geophysics of the Earth and Oceans, in 1970 and 1973, where I made several social contacts; people working in the various fields who were willing to share their understanding. I think I was at the inaugural ASEG meeting; I certainly remember voting for us to take a separate identity rather than a local branch of SEG.

I was principally a teacher – I have very few publications; a half dozen or so, I will claim. That was one of the reasons for looking out my list of honours students. I did teach in just about every year a full third-year class (i.e., a Geophysics major) plus one or two service courses, and between one and six Honours students too.

Question 2

Bob

We can probably move on to question two, which was on the list but skipped over. Before we do that anything from you, Joe?

Joe

Not at this stage, thanks.

Bob

Lindsay, was your education background appropriate and helpful, and how does it compare with current education and training in geophysics?

Lindsay

I'll hedge on that — I've been out of the (education) business for 20 years now and I now refer to myself as a "social geophysicist". Certainly, in education as far as I can tell it was "appropriate". I never recall thinking another kind of education would have been better – until very late in my career.

I do have doubts about some standard features of our system, however; for instance, a graduate can exit the university with a complete misunderstanding of one aspect of the discipline, but that is obscured by the aggregation of marks in the various assessment processes, so I'm not sure how in other words to put that now, do you, Joe?

Joe

I guess one of the issues that we face today is that the nature of geophysicist's job is, arguably, different to that of the 60s and 70s and 80s. Some say that the job of today doesn't require the sort of background that perhaps the three of us would have considered necessary, i.e. a thorough understanding of fundamental physics. Can you comment on this?

Lindsay

I suppose when I think about that now I came into science and then physics and then geophysics from what I would now think of as a very narrow and conservative background. My school subjects and my undergraduate degree were all in what would now be called "hard" STEM subjects. I only did physics, chemistry, and maths after giving up English and German at school so that and the kind of geophysics then I think was suited by that kind of background. Today, or recently, it seems to me that students are better prepared in geology, which is very good, but this is often at the expense of (in particular) maths. I have no Geology, but being in a geology Department I had a fair injection of it from year after year after year and my science background meant that I could follow an argument. But it is something that today the kind of maths background (which was certainly second-year maths for most of my career) is quite unusual for students as far as I can tell. And I think that picking up geology from a STEM background will be more likely than becoming handy in maths with only first year (or VCE) to start from.

Question 4 (1960's)

Bob

Okay well the next question then: Can we go through your observations of the history of exploration geophysics, decade by decade and we could start with the 1960s.

Lindsay

My general recollection, or hindsight, is that the 60s and 70s were a time when geophysics – mining geophysics, was dominated by a small number of individuals who made advances, often developed into startups, which became standard practice after a while. [John Webb in Adelaide grumbled to me about a proton precession magnetometer that he had built and sold to BMR – who he said promptly disassembled it and reverse-engineered it.]

So in the 1960s and 1970s, I have the feeling that the people who were leading the way were solo operators in some sense. Then as the 1980s and 1990s came in, geophysics became more dominated by large scale operators, either resource companies or contractors; and the students that I was turning out were trying to find work as components of a larger organization.

Bob

Well, let's not get ahead of ourselves we are just on the 60s at the moment.

Any comments Joe, before we move to the 70s.

Joe

Not yet

Question 5 (1970's)

Bob

Well, the 70s; 1968 is when you started as a lecturer I guess, so after a couple of years you got into the 70s and that's also a time when things were moving in the area of mineral exploration so let's go to your comments. What changes took place in geophysics and I guess in terms of jobs, in geophysical methods and geophysical activities in general. Over to you Lindsay.

Lindsay

A very important event in my life occurred in the middle of the 1970s when I was given an invitation by Stan Ward to spend most of the year (my sabbatical) as a researcher at the University of Utah, an opportunity which I took to go there and spend time both in the field and also in the lab with the people there.

Bob

You and I first met when I visited the University of Utah while you were there, and I think we spent a bit of time together.

Lindsay

I apologise, Bob, although we must have gone out for a beer at some time, then. I do remember being met and settled in by Don Pridmore, who was doing his PhD at that time.

Bob

I think we did

Lindsay

Did you come out in the field down to the Mineral Mountains? Stan Ward had a multi-technique project operating in the Mineral Mountains setting – it was a geothermal project, and he also was developing an EM technique with his super-14 frequency domain system, which I spent a bit of time with in the field. When I said I had the feeling that 60s and 70s were the province of a person here and a person there at the head of small groups, I was thinking of Stan in Utah, and Frank Morrison down in California, with whom I also spent a bit of time with. In other words, you could identify people who were key to the advances. An anecdote essentially in and around that particular time was the informal discussion after work in the field, about this guy, Ken Zonge, who had the "weird idea" that time-domain EM would do better than FDEM; Stan seemed to think it was a weird idea and was quite dismissive of it when we talked about it out in the field. [The Utah group had a significant "investment" in FDEM, exemplified by the Super 14 system, and could be expected to defend their approach if challenged.]

Bob

Well, certainly that was a time when there was a lot of debate between the frequency domain experts and the time domain experts. I think the time domain movement was really pioneered in Russia, but then in North America, it was McLaughlin (who was the "M" in McPhar originally). He was working for Newmont at that time and they started developing time-domain EM but yes there was a lot of argument back and forth about which was the best way to go, time domain or frequency domain.

Lindsay

I probably feel Stan and his group convinced me about frequency domain so when I came back from Utah it took a while before I embraced the substance of the time domain method. Another anecdote also from those times: I think it was after 1975 when the Russian MPPO method became available. One of my predecessors, Les Starkey (Senior Demonstrator 1960–1963), came into the Department one day with an MPPO, trying to get me to buy one "for teaching". I, in turn, asked him where around Melbourne we might use it because he was certainly pushing for it to be part of the Department's kit. "Oh, you can use it all over the place – it will find anomalies everywhere!" said Les. I didn't think that was a very good way to proceed [I wasn't keen on the "bump-hunting" approach to exploration, feeling that we should try to explain if not predict what might result from an experiment.]

However, we didn't buy the MPPO – no money!

Joe

It was in 1975 that AMIRA first got involved with EM research.

Bob

I joined CRAE in the late 70s and that's when I got involved with the AMIRA too on the SIROTEM project. Will we move onto the 80s, do you have anything to add to the 70s Joe?

Joe

I finished Uni in 1975, so it wasn't until the late 70s and 80s that I became involved.

Question 6 (1980s)

Lindsay

In the late 80s, I went back to Utah for six months at the invitation of Jerry Hohmann. I don't think I can recall anything specific about that but it seemed to me there that one of the new things in mining geophysics was the use of graphics, colour and the like.

Bob

Lindsay, I think it was in the 80s that you came and spent one of your summer vacations working with CRAE, but I don't remember the exact date. I think was the late 80s, it could have been early 90s, but I don't think so.

Lindsay

I think it was at the end of the 80s – after 1988 because I've been touched by the graphics advances that had happened in Utah. I remember working on projects with CRAE during the summer in Canberra which had to do with model display, a possible outcome being a library of (magnetic) model responses. It may not have made much of an impression on geophysics, I think, as interpretation moved on swiftly from look-up model images. It certainly did my confidence a lot of good to come and mix with the CRAE people, and as far as I was concerned to understand the things that the people at CRAE were trying to do at that time in geophysics and also in graphics.

[I should make clear that, because I was largely self-taught, particularly in field geophysics, the time spent in the field with Stan Ward and later CRAE was invaluable to me, largely confirming that I did know what I was doing.]

Bob

I think you would have met Kerry O'Sullivan in Canberra; he was doing quite a lot in graphic displays at that time.

Lindsay

yes

Joe

I suppose one of the things that distinguished the late 80s more than anything else, was the geophysical research capacity that was available, with people like Bruce Dixon, Dave Clark, Art Raiche, Jock Buselli, Phil Schmidt etc. These guys started work on software, instrumentation, and interpretation. What involvement did you have with this early research?

Bob

I think that in the 80s, there were a couple of significant developments which changed our profession.

I think that was the era of the emergence of small computers; we could have our own computer on a desktop.

It was also about that time that GPS became available so we knew where we were, or we could find out where we worked within a few metres and that made a big difference to our work practices.

Lindsay

I was certainly conscious of the GPS side of things not least because one of my projects with colleagues at Melbourne was using boats for offshore shallow marine seismic, and a big problem for work in the early 80s was positioning offshore, and when GPS became available its value was immediately grasped – I remember Graham Boyd showing me a little system that he had built so that his helicopter pilots could "follow the bouncing ball" in doing helicopter magnetics. This was something that I certainly wish we had had in the early 80s … climbing the Sabine Tower in the Otways in the middle of the night to put up a navigation reference beacon is not something I recommend to anybody.

Bob

I understand that one of your activities is orienteering, surely GPS would have made quite a difference there wouldn't it?

Lindsay

It certainly does but only in support activities. A runner must navigate through the bush, avoiding thick bush or stony ground, which is not information that GPS delivers. So, we do use GPS but to locate where the runners are for the people back at the arena to follow on the screen. It's somewhat daunting how fast people can run through the bush and read a map at the same time.

Joe

I guess with the coming of computers, and other technologies like GPS changed exploration forever. Another important technology was the application of technologies that NASA developed in its imagery of planetary exploration to the image-processing of geophysical data. How did these developments affect your career and your teaching at the time?

Lindsay

The use of imagery techniques was something that, as I said, I came to see when I was spending some time with CRAE in the late 80s [although I think the breakthrough work was done by CSIRO perhaps a decade earlier, but the geological imaging from NASA data relied on geochemistry rather than geophysics]. The effect on my teaching perhaps came a little later when the precision airborne mapping of magnetics and radiometrics, and later EM and gravity became available. I think I retreated into the basic (geo)physics so that forward solutions would not be a weakness in inversion. I recall Nick Sheard forcefully arguing that without quantitative analysis, the images that we were generating were almost wallpaper.

Joe

Did image-processing of geophysics make geophysics more attractive, i.e. attracted more people to consider geophysics as a career?

Lindsay

I don't know about expecting more people but attract more use. Thinking in particular of airborne radiometrics and the vast changes in the perception of the earth that comes from having that kind of broad bandwidth view. The struggle was that it seemed that people would be still quite happy to regard the image as a colour picture and forgo the opportunities for getting quantified results out of the magnetics, radiometrics, and then later gravity maps that we were not taking advantage of. One of my long-held interests was indeed modelling (the core of my thesis) but I didn't go anywhere with that in research, but I did try to get people – my students – to see that the images weren't simply images of surface conditions, but records that contain three- dimensional information which could be prised out of the image. Mark Jessell's Noddy software was an example of the direction that could be taken. (I think Noddy itself dates from the early 80s, but its use for geophysical/structural geology modelling developed in the 90s.)

Bob

Okay that covers the 80s, I think. I might just mention, on that topic that sometime in 1984 a group of geophysicists went to China on a government arranged mission. It was led by Dave Tucker from Geoscience Australia (or was it AGSO then?) with Jock Buselli, Dave Johnson, Reg Nelson from Adelaide and me. I had some of Kerry O'Sullivan's images of air mag, radiometrics and things like that in colour and the Chinese were absolutely fascinated by them. They were still drawing contours at that stage and that was the only way they displayed such things, as contour maps. When I went

back a few years later and visited them again a lady who had shown interest was now head of the Department and she had colour images everywhere you looked.

I also attended the Exploration 87 decadal conference in Toronto in 1987 and presented a radiometric tertiary colour image (one of Kerry O'Sullivan's) of an area around Mary Kathleen where you could match it with the geology. It was a beautiful image, one that attracted a lot of interest and I think the head of the Geological Survey of Canada used the same image in some of his presentations at the same conference, ten years later. These images took off in the 80s

Question 7 (1990s)

I think we can move on to the 90s. If we have missed anything in the 80's or have any new suggestions we can put them in the transcript later. Okay, Lindsay what happened in the 90's.

Lindsay

There is not a lot that I think I have to say. For me, internal politics dominated the 90s; that was when we had Ian Plimer as Departmental Head (I was his Deputy). It wasn't so much that there was an impact on geophysics directly (although he did cancel the presentation of geophysics subjects at one point, a decision overturned by Faculty) as an ongoing distraction. So, sorry I'm afraid I don't have much to add unless you can prompt something out of my memory.

Joe

One of the things that happened in the early 90s was an increased emphasis on understanding the geophysical properties of rocks and ores, including of course magnetics, how important was this?

Lindsay

I was always trying to recognise things of value that should be part of my teaching materials, which could not be confined to mining geophysics. One of the things I was quite curious about was the lithological interpretation of large-scale seismic data, which certainly I think during the 90s became more of "a thing" in oil exploration. It seems to be a topic of a lot of work even now.

Bob

One thing I would mention, I guess it originally started more in the 80s, but that was inversions. During the 80's we were developing a lot of forward modelling software for various methods. Jerry Hohmann was doing a lot of work at Utah, Art Raiche was doing it in CSIRO and several other people were developing forward models. In the late 80s and then into the 90s people started doing inversion modelling. Some of this was kicked off by presentations at the Toronto conference in 87 but then a lot of people started developing inversions, particularly led by Doug Oldenburg at UBC. So, inversion became popular. Of course, it is still going and still developing. I don't think we have mastered it yet. We've certainly moved on since then but the 90s were when it really started.

Lindsay

I had a long interest in inversion – the title of my PhD thesis is "Surface Wave Inversion in Australia" And I believe that I was the first person to actually publish an inversion of seismic surface wave data to crustal structure, using the Marquardt algorithm to stabilize the inversion process (in the late 60s).

Bob

I guess we missed this in the 60s

Lindsay

It seems to me that the late 1960s could be marked as a bit of a turning point, not because of my inversion studies themselves, but because that's when modelling and inversion first started to appear as a possibility. We were able to run forward modelling, which is imperative of course, and we started to learn about the vagaries of inversion and model construction. Now, in recent times, the last 10 or 20 years or so, society overall has been asked to react to predictions of climate change which are essentially based on modelling. Now it's my social thesis that most of the people who are deniers are people who were born or did their science before the late 60s when modelling as we now understand it became possible, and of the people who accept the value of modelling are people who grew up in times after the 60s and 70s and so are more accepting of the value of modelling. I think that one of the problems even as a society today with the COVID-19 virus is that people won't accept the modelling because it's "numerical" and not "real" observation – but we need to accept the modelling. Sorry – that became a rant.

Bob

Well seeing into the future has always been tricky, with or without models.

Lindsay

I became involved with Art Raiche and Freddie Sugeng and the modelling team at CSIRO partly because we've done a little bit of physical modelling, and I had seen a paper about the process of creating models which drew attention to the fact that validation of models is a very fraught procedure. If you have a mathematical model, on one hand, it requires one transformation to become a numerical model and then there's another translation to a physical model (and another translation between the physical model and the real world; and we tend to think that we can jump from the mathematical model directly to the physical model without paying much regard for the steps in between. So, I tried to do some work on the subject of validation of models at about that time.

Joe

If I recollect correctly, I think you were involved in stress testing some of Art Raiche's software at that time

Lindsay

Yes, one of the projects that we ran – I'd have to look it up to see who it was – there were two or three little projects with scaled sized targets and Sirotem technology to see whether we could reproduce the responses that Samaya and other programs predicted. Which was valuable for the students involved but I don't think it made a lot of difference to the progress of geophysics.

Bob

I would like to add to that I think, for quite simple models, you know the usual thing is a cube or a sphere or something like that, with a particular physical property, the forward modelling should be correct provided we've got the right physical properties. Unfortunately, the temptation is to press a button and spit out a model, and we regard that as being the truth, so inversion modelling is extremely dangerous in the wrong hands.

Joe

In the case of simple geometry, were able to calculate the response because analytical solutions existed, however for more complex geometries, we had to revert to numerical approaches and thus the importance of computers. Indeed, the software evolved as fast as the computer's speed improved.

Bob

I well remember the first "International Symposium 0n 3D Electromagnetics", held in Ridgefield, Connecticut in 1995. It was held in honour of Jerry Hohmann and similar symposia have been held at four-year intervals since. I attended and presented a paper jointly submitted by John Paine and myself which compared calculated EM responses to a simple 3D model, using several different modelling codes available to us at the time. The calculated responses were widely divergent and emphasised the limitations of our methods at that time. Jerry had always been open to testing his models against other methods. Some people in the audience did not agree with this approach as they "knew that their methods were correct so what was the point of the test"? If you then use any of these forward modelling codes in an inversion, you can imagine the result is somewhat uncertain.

Lindsay

[To return briefly to the modelling/validation topic – if we discretize the subsurface for a gravity model, the forward model values are simply the sum of the contributions from each element. However, if magnetic properties are assigned for a magnetic response, then the contribution from the shape/size of the elements must be moderated by the possibility of self-demagnetisation and a simple sum is not necessarily adequate. So in an EM model, the total response will be some aggregation of the currents flowing in the discrete elements – and their interactions – which may not be independent of the size or shape of the elements. Validation against physical models might then be the only way of choosing between alternative forward modelling schemas.]

Those parallel tests quite often draw some interesting outcomes. I remember arguments over seismic processing alternatives that John Denham commissioned; it surprised me that it didn't seem to happen more often (at least, with results in the public domain).

Bob

coming up to the 2000s anything to add before we go beyond that

Lindsay

No.

Question 8 (2000s)

Bob

I know you said you have been out of geophysics for 20 years Lindsay but I am sure you've been aware of what's going on. Any comments on what has happened since 2000? We can group the 2000s with the 2010s right up to now.

Lindsay

I just can't think of anything to say!

Joe

It is probably fair to say that in the late 2000s the geophysical research capacity in CSIRO started to decline when people like Art Raiche and others finished projects and retired. We, therefore, started to lose the capacity for research in geophysics, but it was not just in CSIRO. In my view, there was a general decline in universities in the 2000s and onwards. It was also a time when geophysics and geology departments started to decline. Have you any comments on this?

Lindsay

Yes, I can see something I could go back and review there, because like you, I thought that research both inside and outside the University was declining. On the other hand, looking around now I think I see people like Graham Heinson in Adelaide and James Reid in Hobart, and James Macnae here, leading groups operating that are sometimes bigger and better resourced than what they replaced. I'm not sure how true that is in Sydney and Brisbane because at this stage it's just my observation from outside the tent. And I don't know anything recent about UWA and Curtin.

The problem that we had in Melbourne up till after I left was that there simply weren't enough students, undergraduate or postgraduate, who wanted to do science! Departments were fighting over what there was to pick from, and in order to get extra people into courses, things like mathematical prerequisites were cast away, which made it more difficult to get people who could work with the kind of projects that we've just been talking about.

One of the changes in recent times which is quite intriguing to me is that there seem to be many more students particularly from East and South East Asia showing interest in Earth Sciences in its various forms. Back in the year 2000, there was, I think, simply no interest. At that time universities were mounting campaigns trying to inveigle students to come to Australia to come into the Graduate School, but few were interested in postgraduate geophysics - but now there is interest.

[During my career I can recall only a handful of students who came up to the university with the intention of doing Geophysics. Commonly students would encounter earth sciences as the "fourth subject" in the first year, and see (Geology or) Geophysics as an interesting alternative to a Physics, Geology, or Math major; but if their course adviser was in Geology, Physics, or Maths departments the advice would often be to stick to the main pathway.]

Anyway, the position is now much better than I expected that it would be 20 years ago – or perhaps much better is an overstatement but there is some positivity, I think. [In saying that – there are no undergraduate courses in Geophysics in the Melbourne calendar now, and only two or three available through the MSc program. I don't know if a minimum-enrolment requirement for undergrad subjects still holds – it was 16 at one time – but that is a disincentive to even considering offering a specialist subject.]

Bob

I might just remind you, I think was in the late 70s or 80s when we first started using SIROTEM and similar instruments like that in Australia, we began to realise that there was something going on that we didn't understand. We noticed that when we inverted EM data to get a resistivity section, that very often the earth appeared to become more conductive at depth. We knew this was quite unusual because things were usually the other way around, the earth became more resistive at depth with the near-surface being relatively conductive due to salinity. Jock Buselli was the one who found the reason, it was due to Superparamagnetism on the surface.

Another thing we often found was that the TEM signal, which was meant to be a simple decrease, from a positive start down to approaching zero, often went negative which seemed inconsistent with the physics. I think it was Art Raiche and Jerry Hohmann who, about the same time published on the fact that these were probably IP effects. It is interesting to note now one of the big topics in airborne EM in the last few years has been the IP effects in AEM. It has been known for about 30 years but only became remarkably interesting in the last decade or so.

Now there is a lot of effort, particularly by people like Graham Heinsen, in trying to see deeper and using MT. 2D and particularly 3D inversion modelling of MT is difficult and often fraught with danger. It often requires huge computer resources to do the modelling and I think the models often cover quite large volumes of the earth where a lot of things not as simple as we would like them to be. However, that is where we are now, I guess.

Joe

If I can just add to that a little bit, it was the MT modelling of Olympic Dam that resulted in the famous “hands of God” results.

Question 9

Bob

Yes, well we have covered the first eight questions. Some of these probably overlap. Lindsay what do you consider were the main steps forward in either instrument, software tools or applications, in your lifetime, and what had the most impact on you or on your ability to do your job?

Lindsay

Undoubtedly, the digital revolution and the ramifications of that in just about every direction you look. We were just talking about inversion; initially, doing inversion in my initial studies involved numerically inverting matrices, and I was doing those calculations with a Brunsviga mechanical calculator – our group bought the first electronic calculator in the Physics Department, to use in earthquake location calculations.

Now what we're looking at here is another one of the benefits: you can have people out in the field, people back in the office, and people in the lab communicating with each other there and then without having to wait for the night and return from the field. So, my step forward is the use of digital techniques.

Question 10

Bob

What do you think are the most probable and useful further developments in the next decade or two?

Lindsay

Distributed sensors! I’m thinking of seismic exploration, already perhaps using a million sensors in actual projects. Eventually, I'm sure that will be adapted to mineral exploration, perhaps not with a million sensors (but resistivity projects with many electrodes have been carried out for many years already). That will be adapted to mineral exploration as well which address one of the problems which is still around with digital – which is aliasing. I would also submit, mischievously, that we have for a long time been running with “million sensor” operations – every pixel in an image can be thought of as being the response of a magnetic or radiometric sensor, so with many, many pixels we

are seeing the benefits, and that's the sort of thing people are trying to reproduce with multiple sensors.

Bob

Yes, I notice Lindsay, in the seismic world they often use hundreds of sensors at least and the expectation is that, if you average them out or somehow process them, you will get about the right result. Now, if it is a normal distribution, I suppose that is reasonable. If you try to do the same thing in EM or IP, the electrical methods, it doesn't seem to work that well because you can have quite a regular level of noise then in unpredictable moments you get huge spikes of signal coming from the natural fields and you can average them for a week if you want. You are unlikely to end up with the right result because there will be more spikes. Simply having lots and lots of sensors and then expecting the average to be a meaningful result does not seem to work quite as well with electrical measurements as it does in seismic.

Lindsay

I'm not content to say that we will stay where we are with the problem of how to deal with noise in EM. I don't think anybody in the business would say the problem is solved (or even defined) but when you ask the question about what's the most useful field likely to be, I think I would underline the development of the practices that we have. I think that multiple sensors in seismic is the response to a quest for efficiency more than new geophysics, but in electrical methods are we not still flying lines and interpolating between them?

I think that we'll probably get a solution eventually to the lightning noise problem – it may have to wait until some other process pushes the need for a solution.

Bob

I agree there is great potential in better signal processing and some people are trying to do it but it is not being done on the scale that I would like it to be.

Question 11

What would you like to change in our present methods of education, research development and usage?

Lindsay

Well, in the big picture I would like to make it easier for groups of researchers to get together than it has been; the CRCs have been terrific.

I will cut a little bit closer to the chase then, Universities should stop trying to be all things to all people. The "Australian model" has been that if you want to study something at tertiary level, you have a right to expect that you can be taught that through the University at the end of the street [as opposed to the US practice of moving to an appropriate school]. This doesn't help groups like CRCs to concentrate on other problems when some of their research staff might be expected to teach in a local University if that is where the salary comes from. We should be encouraging people to do science and to see career opportunities with their degrees, but the opportunity to do geophysics or genomics doesn't have to be in every University.

[This is a situation that must have changed in the last quarter-century, as university education has been reframed from a national benefit to a product traded in global markets.]

Bob

Yes, I thoroughly agree with that. I think at one stage a decade or 2 or 3 ago the ASEG did a survey of Tertiary institutions in Australia. There were, I think, somewhere between 15 and 20 that were teaching geophysics. I do not think any of them had more than one geophysicist and they were often teaching exploration geophysics. Most of them had had never actually done it or done anything other than teach, and they did not want to do anything other than teach. We did think it might have been better if they could consolidate a bit and have less Tertiary institutions teaching geophysics but having a staff of more than one with a range of experience.

[Lindsay: I think I'll answer to that description, Bob, it does fit. Incidentally, at about the same time or in the 90s anyway, there was a time when more than half of our university earth-science departments were actually being run by geophysicists…]

Lindsay

It's quite a long time ago now that I argued with Keeva Vozoff against the "chicken in every pot" theory (i.e., geophysics in every university).

An anecdote about the possibility of change back then: the Earth Sciences department in Melbourne was reviewed in 1984 by a panel led by Geoff Loftus Hills with Bob Carter from Townsville. They handed down their results and recommendations, and one of those was that my position, trying to teach half of the 3rd year plus some honours students each year, was untenable. I hoped to take this and argue for some additional support. However, as soon as the recommendation was read, my colleagues in the Department passed a motion expressing their deep support for me in that what I was doing was great and should continue! Which was entirely wrong; at least their hearts were in the right place even if their heads weren't.

Bob

Okay, anything to add there Joe?

Joe

I think that in last 20 years the nature of universities has changed and this has manifested itself in many ways: for example departments making decisions based on the cost of delivering a course and for disciplines such as geophysics, making decisions on the basis of the number of students. It is a different world, there is a decline in demand for geophysics courses at universities and Michael Aston would tell you that that is why doing physics (as part of a geophysics degree) has basically died at Monash for example. In some universities, geophysics is simply an adjunct elective. The result is the consolidation of geophysics in several Universities - in Hobart, Curtin University, a little bit at UWA, even at Adelaide uni it is only a shadow of what it used to be.

Bob

I think it is a great pity that we cannot somehow spread the knowledge of how much fun geophysics can be. When we look back on our careers and things we have done and were actually paid to do, I'm sure we can all recall great memories of places, people and events that we would not have experienced in a more mundane job. We were applying the science we had been taught, but having a great time doing it.

Lindsay

That's a reflection of my comment about being out of the office.

Bob

Yes, we went to interesting places, which we would never have chosen to go to, but they turned out to be better than we expected and we met a lot of interesting, colourful people along the way. I think nowadays the students more often go into finance or something like that; they will get rich and they can afford big cars and expensive holidays, but they're missing out on the fun we had.

Joe

And the other thing that young people today ask is "I don't really want to go out in the Bush but can I do that at home on my desktop?"

Bob

In the next few months, we probably will be all be doing that to avoid COVID-19. Well, I guess the second last question on our list is, what do you see as the most critical challenges for geophysics and geophysicists currently and in the future?

Lindsay

Well, I'll leave out the one that we just discussed. Probably about when I retired there was some concern that geophysics was dying out – but we're still going. Something is happening that is keeping a little bit of geophysics going. But the most critical challenge that I think of is the relevance of geophysics in a "sustainable" world. I've got a real grouse about the use of the word "sustainability", particularly in the topic of resources. I can't understand how it is that we have gone for centuries with the underlying premise that the economy has to grow unilaterally or monotonically – it's just not sustainable to do that. Mining is not sustainable – there are mined-out or pumped-out mines all over the world that attest to that, and yet that's something which every economist seems to have written on the inside of their hat that "we need 2% growth". 2% growth from 2020 to 2050 means doubling the size of the economy, effectively, so pick anything that you like that supports the economy, say water, there was something about water in the last Preview, I think. So if our economy grows by 2% a year between now and 2050 we will need twice as much water in 2050 as we are using now (and just change 2050 to 2070 and 2080 and then we will need four times as much water as we are using now).

[To go back to the critical challenges question: exploration geophysics has had about a century of growth and innovation because it, apparently, provided a service that made the recovery of economically useful materials more efficient. Where that case can be made (oil and gas exploration, for example) I would expect geophysics to attract continued support. Where geophysics doesn't add value (renewable energy, iron ore) it won't be used. And, if we do transition to a sustainable economy, with recycle, reuse, renew replacing search and mine, the "exploration" tag becomes moot.]

OK, anyway I have stopped my second rant.

I'm observing the change in the profession now (referencing the last question) and I am happily surprised to see that it's got younger. I think there was a time when I didn't think that was going to happen.

Bob

Do you think it's got younger or was it just from our perspective?

Lindsay

There are people who are coming into the ASEG; there are not many people who attend our meetings but there are people who attend the meetings who are relatively young. [For example, look at the photographs in the latest Preview, and at the incoming committee members.]

[Thirty or so years ago, the SEG was vocal about what they termed the Great Crew Change, in which geophysicists who reached retirement status had to be replaced by … what? The SEG transformed itself, and I have read little of the Great Crew Change in recent years.

Bob

The whole population looks young to me these days.

Lindsay

I remember saying when I was given life membership of the ASEG that it had been a privilege to work with people who are indeed almost universally optimists. (I include geologists in that band, by the way) It's not something that's changed over the last several decades, but something I think that has been constant is that I've worked in a profession which is notably optimistic.

Joe

As I said previously, the business of exploration has changed in many ways: how do you see this change manifesting in the role of geophysics and the geophysicist in companies?

As an example, I have discovered that geophysicists, in the majors, in particular, tend to be more project managers and there are few specialists in companies. Companies are relying more on consultants to do specialist jobs when in the past they were done in house.

Lindsay

It does seem to me that the efficiency which you gain by keeping say all the mineral explorationists in the same office, on the same floor and just throwing projects in there for them to work on. That's very efficient but it doesn't seem to have a long life. [The alternative, which is pretty much the status quo, seems to me to have resource companies supported by geophysical service companies. If the resource companies see an advantage in deploying geophysics, they will quantify the cost/benefit in their risk analyses.]

Bob

The geophysicist can tell an accountant what is technically worth doing but the accountant is the one who holds the purse strings, he may not understand anything about geophysics, but he decides whether it goes ahead or not.

Lindsay

Other questions come to the same problems. We were talking about the University teaching of geophysics, whether it is a one-person operation or whether it is a (small) group it's going to be seen by the rest of the Department as some kind of service or consultative operation.

[For what it is worth – it is difficult to do a “mystery shop” of possible course structures, but it appears that the only exploration geophysics coursework available within the BSc is a 2-hr lecture, 3-hr lab per week subject called Applied Geophysics. A similar subject with similar load (but not content!) has been offered ever since I began in 1968! But there is no longer a major in Geophysics.]

Perhaps the eventual home will be in something like Geoscience Australia.

Bob

Well, only quite large companies can afford to have an in-house geophysicist these days and the smaller companies rely on consultants as Joe pointed out. I think that works reasonably well but you still have the final decisions being made by people who do not understand what you are talking about.

Lindsay

[I taught for some years a service subject called Geology for (Civil) Engineers. My goal in that course was to give the students enough of the language and values of geologists that they could and would ask questions of their consultant geologists. Perhaps we should pitch for a service course in the Accountancy degree!]

Joe

I think that there is an underlying problem here, and that is that one assumes that the expertise currently in consulting firms will be available in the future. I am not convinced that that is necessarily going to be the case and if my prediction bears out, how is the geophysicist is going to be able to do his job or her job in the future and when they do not have access to specialists?

Bob

I think one thing that will change is that instead of having to buy expensive software you will be able to just rent it, and some people are doing that already. There will still be specialists, I do not expect that anyone geophysicist can sit down and run all the forward modelling and inversion programs and get sensible results. So, there will (hopefully) be specialists to do this for us. They can rent the software and pass on those rental charges to their clients. But yes, I agree, we are going to need these specialists because, with these more complex software tools, you must be using them frequently to be competent.

Joe

I think one solution is in the application of machine learning and AI. Perhaps you will not need any specialists at all because given enough data, these tools will be able to tell you where to drill and then, of course, it's a matter of finding the money to drill.

Bob

Well, perhaps it might be good if you had a tool like that to back up your opinion when you are heading into the accountant. If he will not believe what you say he might believe what the computer tells him.

Lindsay

[much after the interview comment:

I am concerned about the implications of Bob's concern in a wider sense. I have assumed that a procedure that adds value to a property (in either a positive or a negative sense) would be applied by a properly educated manager. But, in an environment where truth can be successfully denied on "policy" grounds, and objectivity is a refuge for lack of cogent analysis, perhaps that is a bold assumption. I guess it would be cheaper to go without geophysics, so leaving more of the capital raising to be shared amongst the principals.

Lindsay

I am thinking of something which is not exactly parallel with that, but geophysicists might perhaps usefully – or perhaps necessarily – have to do is to look at situations in which geophysics is actually necessary [as in hydrocarbon search]. As well as identifying the person that needs to be shown that we can do something which is almost literally invaluable, we should have relevant case histories for the pitch, which show successes or similar from the application of geophysics. It seems to me quite often that discovery is almost a side issue; at least in some cases we proudly say to each other that we could have found this with our latest tools – but what we have to do is demonstrate places where geophysics *will* at least reduce the risk of proceeding with the project – before discovery.

The End

Lindsay Thomas: 27 July 2020/2020-09-02

Bob Smith

Joe Cucuzza

Appendix A

List of Honours Degrees Supervised by Lindsay Thomas

Geophysics Honours Students				
Year	Name	Topic		
2001	Steve Bos	An investigation of the geophysical anomalies in Western Victoria, Camperdown		LT
2001	Richard Griffin	Groundwater geophysics at Honeysuckle Creek, Victoria		LT
2000	Lee Platek	Hydrocarbon prospectivity of the pre-tertiary intra-basins underlying the Murray Basin in Northwest Victoria		LT
1999	Peter Corrie	Groundwater application of shallow subsurface geophysics		LT
1999	Lucy Kirwan	Statistical studies of seismic noise		LT
1998	Tom Forrest	The application of direct current resistivity to the study of Mitre Lake, Western Victoria		LT
1998	Trudi Hoogenboom	Total magnetic intensity zonation of the Mount Cole granite		LT
1998	Roger Hurren	The Lateral Variation of Magnetisation in Tertiary Near Surface Basalts, Victoria		LT
1997	Robert Pipunic	Gravity interpretation of Birch's Bald Hill, Creswick		LT
1995	Rebecca Allen	The problem of near surface basalts in Western Victoria: their complicated magnetic signal, and its removal from magnetic surveys		LT
1994	Andrew Boyd	The modelling of a transient electromagnetic system		LT
1994	Gordon Rouse	Potential field features near Olary and their interpretation		LT
1993	Suzanne Haydon	Gravity survey of the Ararat sheet		LT
1992	Jarrod Dunne	The T-P transform and multiple suppression		GBS
1991	Blair Sands	Transient electromagnetic scale modelling of aquifers and conductive bodies in a conductive host		LT
1991	Kevin Tucknott	A regional gravity survey around the Heathcote area, Central Victoria		LT
1990	Tony Howell	Physical TDEM modelling		LT
1990	Dylan Mair	review of the multiple suppression techniques, classical and current. Integrating pre-stack time shifts and post-stack migration for seismic data recorded over irregular seafloor topographies		GBS
1989	David Johnson	Numerical TDEM modelling		LT
1989	Chris McCauley	Geology and geophysics of the Mt Carrington area, Drake mineral field, NSW		LT
1989	Peter Stickland	A shallow seismic investigation at Lakes Entrance. Improving velocity analysis beneath a submarine canyon using velocity datuming.		LT
1988	Bob Harms	Seismic reflection data from near-surface reefs		LT
1988	(Study Leave)			LT
1987	Justin Costelloe	Reynolds Ranges Magnetics Interpretation		LT
1987	David Heislers	Murray Basin Magnetics Interpretation		LT
1987	Margery Perkins	Northern Victorian Gravity Interpretation		LT
1986	Colin Moorhead	Velocity Anomalies in NW Shelf Seismic Data		LT
1986	Andrew Smelic	Physical Modelling of downhole TDEM **m**		LT
1985	Russell Kneebone	Physical Modelling of downhole TDEM **n**		LT
1985	Earl O'Callaghan	Well ties to Bass Strait Seismic Data		LT
1985	Paul Odgers	Tasmanian IP data processing and interpretation		LT
1985	David Ormerod	Interpretation of BMR magnetic data on the Melbourne sheet		LT
1985	Greg Spillane	Reinterpretation of Otway Basin Seismic Data		LT
1985	Peter Thomas	Gippsland Gravity Surveys for Coal II		LT
1984	John Brett	Thickness of near-surface basalts from magnetics		LT
1984	Mike Bucknill	Reinterpretation of CRA deep lead gravity data		LT
1984	Rob Parums	Physical Modelling of downhole TDEM		LT

1983	Richard Lane	Test range for Electrical and EM equipment		LT
1983	Michael Morse	Gippsland Gravity Surveys for Coal		LT
1983	Helen Ormiston-Smith	Interpretation of magnetic surveys near Ararat		LT
1983	Franco Scalzo	Seismic Stratigraphy in Recent Sediments		LT
1983	Andrew Williams	Geophysical investigation of the Lake Bolac magnetic anomaly		LT
1982	Mark Lackie	Magnetic signatures of Victorian granites		LT
1982	Michael Moore	Gravity studies near Cobar		LT
1981	Barry Chalmers	Geophysical studies of deep leads		LT
1981	Rob Hewson	Seismic refraction studies in groundwater		LT
1980	Goh Sock Suan	The Gippsland Basin (offshore)		LT
1979	Simon Harris	Gravity studies on Tower Hill		CKG
1979	Peter Nicholls	Magnetic studies on Tower Hill		LT
1978	Rowan Walsh	Subbottom Profiling in Pt Phillip Bay		CKG
1977	Russell Cuthbertson	Earthquake magnitude determinations		LT
1977	Geoff Speedy	Yarra Hills Upper Crustal Survey		CKG
1976	Peter Elliott	Coal Geophysics, Otway Ranges		CKG
1975	Kerry Black	Rip Currents		LT
1975	Guiseppe Cucuzza	Geophysical Study of the Cobaw Granite		LT
1975	(study leave)			LT
1975	Nick Wirubov	Geothermal Potential of the Otway Basin		LT
1974	David Isles	Gravity studies of the Westernport Sunkland		CKG
1974	Arthur Koelle	Dipole Resistivity Transformations		LT
1973	Wolfgang Fischer	Gravity studies on Mt Kororoit		CKG
1973	Heather McCracken	Resistivity modelling of volcanic features		LT
1973	Mike Sexton	Frequency-domain filtering of aeromagnetic data		LT
1972	Graham Boyd	Telluric Currents		CKG
1972	Victor Hodor	Spectral analysis		LT
1972	Chris McKee	Gravity studies on Mt Porndon		LT
1972	Peter Wood	Seismic Refraction Studies at Dartmouth		CKG
1971	Gerry Barr	Analysis of Katherine Radiometric Survey		LT
1971	Ian Bishop	The Moon and Seismic Activity		LT
1971	Clive Collins	Seismic survey west of Melbourne		LT
1971	Lockie Cresswell	Seismic survey of Bass Plain		LT
1971	Rhonda Jones	Heat flow in lakes		LT
1971	Brian Sanaghan	Gravity studies on the Colbinabbin Range		LT
1970	Greg Clarke	Geophysical studies of the Cerberean Cauldron		LT
1970	Peter Edwards	Geophysical studies of the Cerberean Cauldron		LT
1970	Darryl Eyles	Geophysical studies of the Cerberean Cauldron		LT
1970	Adrian Power	Geophysical studies of the Cerberean Cauldron		LT
1970	Tom Wood	Geophysical studies of the Cerberean Cauldron		LT

Appendix B

Publications by Lindsay Thomas

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Larsen, L.H., R.W. Sternberg, N.C. Shi, M.A.H. Marsden, and L. Thomas, 1981, Field investigations of the threshold of grain motion by ocean waves and currents. (Book Chapter) in: Developments in Sedimentology 32, “Sedimentary Dynamics of Continental Shelves”, 105-132.

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