

## Reflection on Ted's career

### Introduction

Penny, Matthew and Elizabeth, Jo and Josh, Jim and Jane, and your families, it is a privilege to be able to bring to today's celebration of Ted's life some reflections from his professional friends and, through them, convey to you the utmost esteem and affection in which Ted is held by us all. In doing so, we recognise that you all are very much joint partners in all that Ted achieved.

### Career

Ted's career was in the field of geomagnetism - the Earth's magnetic field. For many of us the closest we might come to geomagnetism is using a compass to find magnetic north. For Ted, its subtle changes from moment to moment and place to place were a source of fascination that sustained his entire research career because they enabled his wonder, as he said himself, of being able to measure geophysical processes in the Earth.

Ted's interest in science was well formed by the time he graduated from Hutchins School in Hobart. He undertook a BSc (Honours) degree at the University of Sydney between 1957 and 1960.

After his undergraduate studies, Ted joined the Bureau of Mineral Resources Airborne Group which was then pioneering in Australia airborne magnetic-field measurements, using a World War II-era DC3 aircraft and old, cumbersome submarine-detection magnetometers. Ted helped to modernise the program by field testing the use of newer and lighter proton-precession magnetometers in a smaller, more-maneuvrable Cessna aircraft.

In the early 1960s Ted began an MSc and PhD program at the University of Western Ontario. Here he initially continued working in aeromagnetism, investigating the practical problem of how flight direction affected the detection of magnetic anomalies on the ground. In his later doctoral research he turned his attention to the mathematically challenging issue of how earthquake waves travelling through the core of the earth would be affected by the intense and highly variable magnetic fields there.

This interest in core studies was further fuelled by Sir Edward Bullard during postdoctoral research at the University of Cambridge. Here his investigation of models of fluid flow in the earth's core were sufficiently demanding to require the use of the recently built IBM 360/model 91 computer at the NASA Goddard Space Flight Center, at that time the most powerful in operation!

Ted and Penny returned to Australia to the Australian National University Department of Geophysics and Geochemistry in 1968, later the Research School of Earth Sciences. While at RSES, Ted supervised 10 PhD graduates and 3 Honours graduates.

His research there took a major new direction - studying the electrical structure of the Australian continent. Initially Ted and his first students used instruments they had built themselves, and then a sabbatical by Professor Ian Gough from the University of Alberta gave access to a pool of 25 instruments, which he later permitted RSES to copy. These magnetometers could be buried at field sites and left to record for weeks or months at a time. Analysis of the subtle differences between the magnetic-field changes from site to site, permitted estimates of the electrical conductivity of the geology.

These magnetometers were not without their challenges. They were housed in an aluminium tube standing more than 1.5 m tall, cumbersome to transport in numbers, and very hard to dig vertically into the ground. Visiting colleagues, students, pilots, Matthew, Jo and Jim, and station managers - particularly those with tractor-mounted augurs - were key collaborators in this fieldwork. After a survey, each instrument had weeks or months' worth of photographic film that needed to be developed, measured and transcribed to useful numbers for analysis. Ted's Research Assistant Merren Sloane managed this process meticulously.

Ted and his early students Hans Tammemagi, Dave Bennett and Dennis Woods deployed arrays of these instruments in central and southern Australia. They collected magnetic-field data across the south of the Northern Territory and western Queensland, extending to much of South Australia, western and southern New South Wales, all of Victoria, and northern Tasmania. That must add up to about a quarter of the country! These studies found large electrical conductivity anomalies in the Flinders Ranges of South Australia, the Eromanga Basin in southwest Queensland and the Otway Ranges of southern Victoria. They also found evidence of the "coast effect" in which magnetic-field changes are affected by the strong contrast in electrical conductivity between the continent and the ocean.

Because of the remoteness of these surveys, the equipment was usually deployed by aircraft. Dennis recounts stories of pilots Peter Smith and Jan Styles flying Ted, his students, and the equipment to remote landing strips on cattle stations and clay pans in the middle of the Simpson Desert, sometimes having to make a first pass bouncing the wheels on the surface to see if it was hard enough to land on. Jan later won an award for her bush piloting skills on these surveys. Dennis tracked Jan down last week. She remembers "what a kind, thoughtful gentleman Ted was", and still recalls the large "FEM Lilley" that he used to mark his baggage.

One of Jan's photos shows Ted and Dennis installing a magnetometer at a desert site, Ted in a white lab coat over shorts and a singlet, Dennis in shorts, and both wearing bucket hats and thongs. In these days of high-vis and toe-capped boots - it's amazing what sufficed for PPE back then!

In the early 1980s, Ted, Baldev Arora and other Indian collaborators used the ANU magnetometers to investigate electrical conductivity anomalies in India. This work identified a major conductor running from the Himalayan foothills southwest towards Delhi, and another running between the southern coast of India and Sri Lanka. Ted always remembered fondly the wonderful hospitality he enjoyed in India, and the chai breaks on trips through the mountains.

The 1980s also brought new students - Ian Ferguson, Nathan Bindoff, Richard Kellett and Graham Heinson. With them, and in collaboration with Jean Filloux, Phil Mulhearn, and Tony White, Ted's research began to focus more offshore. Seafloor instruments were deployed off the New South Wales coast using the *HMAS Cook*, the *RV Franklin*, and a lobster boat out of Ulladulla. They provided the opportunity to study the electrical conductivity of oceanic crust, the electrical and pressure signatures of ocean tides and currents, and the "coast effect" from the ocean side. This new data permitted the first computer models of the electrical structure of the Tasman Sea to be developed using the "thin-sheet" modelling method developed by John Weaver's group at the University of Victoria, British Columbia. Nathan recalls he, Ian and Ted desperately trying to test one of the magnetometers near a boat ramp in Ulladulla to make sure it was working correctly before deploying it, essentially in their underwear. Maybe so their clothes didn't get too wet? Anyway, apparently the instrument gave very mixed results in that deployment, which was a real shame given the effort that went into testing it.

Into the 1990s, with his final students Robert Corkery, Liejun Wang and me, Ted's research began to bring together some of his work of the past two decades. Rob and Liejun worked with Ted to amalgamate data from all the Australian array studies, including by Francois Chamalaun, Charlie Barton, Tony White and Peter Milligan, to build the first conductivity model of the entire continent. With me, Ted investigated how all this electrical structure might affect aeromagnetic survey data.

Through the 2000s, Ted worked with John Weaver on the inventive use of Mohr circles in the analysis of magnetotelluric data, and authored book chapters, review papers, and, increasingly, articles about boats and yachting – a lifelong passion.

## Reflections

Ted considered himself very fortunate in the colleagues with whom he shared the pleasures and satisfaction of making geophysical studies in Australia. At this point, I would like to share with you an additional selection of short reflections from them.

### **Dave Bennett**

Ted and I were returning from fieldwork on a flight from Adelaide to Sydney, years ago. Before we took off he was regaling me with his memories of airborne magnetic surveys when he was in BMR, and how they had a nerveless pilot, called Darkie Dangerfield, who would land the old DC3 on salt pans and the like, out in the bush; when the pre-flight announcement came on... 'ladies and gentlemen, this is Captain Dangerfield speaking.....'

Ted pressed the attention button and asked the steward whether the captain was indeed Darkie Dangerfield. After being assured he was, Ted said 'please tell him Ted Lilley is in the plane'. Back came the message – Captain Dangerfield invites you to join him in the cockpit – where they reminisced happily as we flew to Sydney.

### **Dennis Woods**

We didn't always camp out. Some cattle station owners and managers insisted that we stay with them at the station house. It didn't take too much of this hospitality to convince Ted it was better than camping out every night. So we loaded up on good wine as hospitality gifts, and Ted organized toys and children's books to give to the station kids that always seemed to be around. I heard later from these station folk, when carrying out my own follow-up study, that they looked forward to these visits from Professor Ted even more than we looked forward to them.

### **Baldev Arora**

In 1989, while traveling to attend an IAGA meeting, I boarded a train from London for Exeter. To quench my thirst, I rushed to the cafeteria on-board and asked for a drink. While trying to pay for it with coins that I had carried from my last visit, I was surprised by the smile on the face of the serving staff, not realizing that the coins I offered were not operational currency anymore. From an unknown angle two hands came forward and paid the bill. This was none other than Ted Lilley.

### **Phil Schmidt**

I guess Ted was just following his curiosity but it turns out he was ahead of his time. Deeper exploration has sparked interest in the deep crust/mantle interface. As far as State surveys go South Australia is now at the forefront of magnetotellurics, maybe because most of Ted's work was in South Australia. Ted's legacy is more significant than many realise.

### **Alan Jones**

Ted came from a generation of gentleman and gentlewoman scientists. When I think of those who showed me what a wonderful and positive life academic magnetotellurics could be, I think of Ulrich Schmucker, of Peter Weidelt, of John Weaver, of Rosemary Hutton, and of Ted.

### **Ron Hackney**

Many of us are geophysicists, so we know many geophysicists. But of all the geophysicists that we know, Ted would be up there as one of our favourites.

### **Ian Ferguson**

Working with Ted was very much a great adventure. The adventure came from academic aspects – being involved in the earlier times of seafloor MT, being encouraged to try new processing approaches, and being supported in presenting the results. It was also an adventure in the classical sense – installing and servicing Gough-Reitzel instruments on long road trips to locations north of Ivanhoe and near Cobar, two cruises on the *HMAS Cook*, deployment of Tony White's continental-shelf instruments using a lobster fishing boat from Ulladulla, and, much later, scouting MT sites in Northern Saskatchewan during one of Ted's visits to

Canada. The hospitality from Ted, Penny and their family over more than four decades is also a very valued memory.

### **Nathan Bindoff**

The other thing that was larger than life is Ted's care of his students and their future. He introduced us to famous (and infamous) researchers and made it his life practise to open doors to us. I remember vividly meeting all those wonderful scientists at RSES.

I also remember those rather lovely lunches and dinners at 19 Araba St Aranda and what wonderful hosts Ted and Penny were. Those were exceedingly pleasant and wonderful occasions.

### **Ann Milligan**

Ted was very influential in my husband Peter's PhD work in the late 1970s and early 1980s. His findings guided some of Peter's thinking as he planned his own arrays and built his own magnetometers with Antony White at Flinders University. When we moved to Canberra in 1985, Ted and Penny invited us to their house to welcome us – as they have done for so many others over the years. Our three children warmly remember the Lilleys for their friendship to us all, and the fun of Ted's playfulness during our visits.

### **George Jiracek**

I'll never forget in November 1986 when Ted invited me to visit Canberra. As much as I enjoyed discussing geophysics with Ted and his students, it was a party at Ted and Penny's home that I have never forgotten and have reminisced about it many times since.

Ted knew that that day was Thanksgiving Day in the United States, so it was the theme for the evening. I don't remember the exact menu except that there was pumpkin pie. Pumpkin pie at Thanksgiving was what I grew up with and it was a huge a treat then. I'll simply never forget how thoughtful Ted and Penny were back then, over 35 years ago.

### Ending

So, what may be even longer-lived than Ted's research is the influence he has had on the lives of his colleagues. Influence that will be perpetuated through the generations, perhaps in ways that will not necessarily always be attributed to Ted but will nevertheless have him as their source – the "Ted Lilley" ripple effect.

Ted's colleagues have described him as famously patient, utterly kind, generous and gentlemanly, a mentor and champion, a supreme communicator, always generous with wise counsel, encouragement and carefully considered comment, a scientist to emulate, a strong influence not only on careers but on lives.

We are all enriched by having had Ted in our lives.

May he rest in peace.

Adrian Hitchman

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