## A tribute to Ron Green

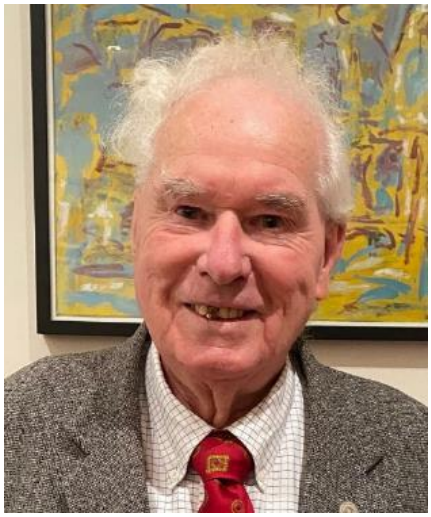

Photo caption: Ron Green

This year, 2020, we celebrate the 90th birthday of Ron Green, one of the Society's founding members, and a person who through lateral thinking and a unique approach made pioneering contributions to several facets of our science. Ron also mentored many geophysicists who have gone on to make their own careers in geophysics.

**Background: Pioneering continental drift**

Ron Green was born in Brisbane on 22 July, 1930. Following secondary school Ron was paid a Public Service salary by the Commonwealth (Department of Supply) to attend the University of Queensland (UQ). The federal government department selected all course work with emphasis on mathematics, physics, electronics and geology. No failures were tolerated. Ron did not fail, and on graduation was employed by the Commonwealth of Australia on a permanent basis. Ron graduated with a BSc (Hons Physics) in 1953 and his thesis was entitled: "The electron density in the F2 ionosphere layer".

Ron commenced his PhD studies in 1955 in the nascent Department of Geophysics in the Research School of Physical Sciences at the Australian National University (ANU). John Conrad Jaeger had been appointed the Foundation Professor of Geophysics in 1952. Previously Jaeger had lectured in mathematics at the University of Tasmania and had attended a series of lectures presented by Professor Sam Carey (1998 ASEG Gold medallist).

Jaeger was inspired by Carey to focus his new Department of Geophysics on "the physics of the crust and interior of the Earth". It is probably pertinent that at about this time (1952-1953) Carey was appointed Visiting Reader in Jaeger's new department. In late 1954 Jaeger also appointed Edward (Ted) Irving as a Research Fellow to commence a systematic study of rock magnetism in Australia

Ron was Ted Irving's first PhD student. Ron had worked on magnetic surveys in WA at the Bureau of Mineral Resources (BMR), Canberra, between 1953 and 1955. He recognised the heterogeneous magnetisation of rocks, and how this fact was not consistent with a simple induction model. Ron was, therefore, well placed to begin doctoral studies on rock magnetism. Ron's contacts in the BMR were very useful at times, with BMR field geologists generously providing oriented field specimens from remote localities. Their assistance was greatly appreciated and gladly acknowledged.

One of Ted and Ron's first findings was that at the time the Jurassic Tasmanian dolerite was intruded, Tasmania was very close to the South Pole. The opportunity to carry out research on the Tasmanian dolerites and to test the predictions of Wegener's continental drift hypothesis was one of the main reasons Ted had agreed to come to Australia. Their finding was opposed to the conventional polar wander interpretation of results from Europe and North America, and was probably one of the main factors behind Sam Carey's "Continental Drift Symposium" in Hobart in 1956. Earth science thinking in the southern hemisphere was well ahead of thinking elsewhere. It is hard to appreciate now just how ground-breaking this early work was and, although not as widely recognised as it should be, how very influential on research directions globally.

While Ted was a geologist and Ron a physicist/mathematician, they complemented each other perfectly and managed enormous progress in a very short time period. Ron also worked closely with Jaeger, especially on the cooling history of a massive Tasmanian dolerite sill, where they demonstrated geomagnetic secular variation during the Jurassic period. Jaeger was already well known for his work on heat flow and the cooling of solids.

By 1957 the “polar wandering” path of Australia from Early Proterozoic times to the Late Tertiary had been constructed. Laughably (now) Ted and Ron’s manuscript was rejected by the *Journal of Geophysical Research* (JGR). Their paper “Polar movement relative to Australia”, was published in the first issue of the *Geophysical Journal of the Royal Astronomical Society* (Irving and Green, 1958). To reconcile the European, American and Australian paths, relative motion between the continents must have occurred. With remarkable accuracy a rate of 50 mm/year was determined for the northward drift of Australia. See also a review by one of us (PWS) of "The Continental Drift Controversy" by Henry R. Frankel (*Preview* **163** p. 29). It is also noteworthy that Sam Carey had a manuscript rejected by *JGR* at about this time.

In the late 1950s, while still pursuing his PhD research, Ron took up a lecturing position in Carey’s department at the University of Tasmania. Ron graduated with a PhD in geophysics from ANU in 1961. The title of his thesis was “The Palaeomagnetism of some Kainozoic & Palaeozoic rocks”. Also in 1961, the year Ron joined the SEG, he participated in the voyage of the *R.V.Argo* from Fremantle to Hobart. The cruise established that there was no continuation of the Darling Fault through the oceanic floor, and that there were mirror-image magnetic anomaly stripes paralleling the ‘50°S degree’ ridge. All these findings supported continental drift.

In 1967 Ron was appointed to the UNE at Associate Professor level, and tasked with establishing an independent Department of Geophysics. Some students remember that Ron began his lecture on continental drift warning that the theory was controversial, and that the student should ask him/herself, the question "Do I agree with that statement or do I disagree with it? If you agree you will remember it, and if you disagree make a note to check it out - get some numbers you can rely upon”. Also, Ron liked questions from students. If a student asked a silly question, his standard reply was "I am glad that you asked that, it gives me an opportunity to clear up a common misunderstanding”.

With hindsight, and now knowing all the facts, Ron’s students are quite rightly dismayed he never received the recognition he deserved and made a full professor while at UNE! However, in 1980 Ron was awarded DSc from UQ for “Geophysical Investigations”. He is

now a retired FIEAust, CPEng, College ITEE and a committee member of Engineering Heritage of SA.

**The focus of the new Department of Geophysics at UNE.**

What ambitions did Ron have for his new department? In 1967 there was an emerging boom in mineral exploration in Australia, but geophysical technologies to assist in near-surface exploration for minerals were all being developed in the formerly "glaciated environments" of Canada and Sweden. They were failing in our ancient, deeply weathered, ferruginous and highly conductive crustal environments. ANU had already established pre-eminence in crustal geophysics and continental drift. So Ron identified different priorities. These were directed towards producing graduates that were equipped to become geophysical "problem solvers", capable of advancing any branch of geophysics. He would establish the first specialised department in Australia to encompass both global and applied geophysics, with an emphasis on applied.

The department Ron established primarily targeted post graduate activities. While geophysical subjects, including crustal and inner Earth physics and near surface exploration and mapping, were taught at 3rd year undergraduate level, Ron focussed his attention upon an Honours year course, complemented by Masters and PhD programmes. He recognised that to solve future problems in geophysics, students primarily had to have a solid understanding of physics and mathematics. While the application of geophysics may well have been to assist geological investigations for which a knowledge of geological subjects was an advantage, knowledge and understanding of maths/physics was imperative. For most students it was not practical to major in physics, mathematics and geology, and while learning physics and maths was best facilitated in a university environment, geological insights could be acquired through work experience and fieldwork. So, Ron made the call, the pre-requisite for his Honours Geophysics degree was maths and physics with geological subjects listed as optional.

Ron's Honours degree course had four main components:

- Graduates in physics were to be given bridging coursework specifically in the application of their undergraduate studies to a crustal/geological environment,

- Their undergraduate studies were to be supplemented with an intensive course in the Fourier transform and its data and signal processing applications,
- Students were to write up a geophysical topic researched from published literature, and
- Students were to conduct applied research into a geophysical problem.

Those students who may have done the bridging geophysical coursework as an undergraduate were encouraged to replace this component with geological subjects. Many of the applied research topics undertaken by his students were exploration and instrumentation oriented. But Ron recognised that the New England environment also presented a unique opportunity, and that was to develop a geophysical observatory for crustal studies, deep underground in a nearby disused gold mine at Hillgrove. Within three years of establishing his department, Ron had negotiated access to a suitable mine tunnel and was developing a laboratory for the measurement of crustal tilt and strain.

As the mineral exploration boom accelerated in the 1970s, industry required graduates capable of applying geophysical methods to exploration. Earth science schools that included a geophysics capability were soon established in other universities, while existing schools where geophysical subjects were being taught became more oriented towards meeting this demand. In contrast to Ron's model, this demand was generally perceived to be most readily met by offering geophysical exploration courses to students majoring in geology. Both models were successful! There was a place in the exploration industry for geologists knowledgeable about, and familiar with, geophysical tools. But with few exceptions, these staff were constrained to a textbook application of off-the-shelf technologies with limited opportunity to advance these technologies when shortcomings were encountered. And, in the Australian environment, there were many challenges encountered. Ron's students, in fact, excelled in exploration as they were invariably part of a team effort that benefitted from the input of a strong physics-based understanding of the geophysical response from complex geological structures. No real-world geological environment can be represented by simplified models taught from textbooks. As Ron's students subsequently proved, a training in problem solving with a sound grounding in the fundamentals of the physical sciences was a base from which almost anything could be achieved. Those of his students working in

mineral or oil exploration very quickly rose to high and successful positions. Others excelled in the application of geophysics to regional, environmental and archaeological mapping, palaeomagnetic and global crustal studies, instrumentation development, geomechanics, project and resource management, education and even resource industry stock broking. In the first ten years, Ron's department saw 30 students graduate with Honours.

In the 1970s the exploration industry was hampered by the lack of instrumentation capable of exploring through ferruginous and highly conductive regolith. Indeed, this very Australian problem was the driving force behind the establishment of the CSIRO Division of Mineral Physics under Dr Ken McCracken (1989 ASEG Gold Medallist) in 1972. At the same time it was recognised that the per-capita cost of educating the relatively small number of post-graduate students in Ron's department, of giving them training access to the latest exploration equipment and of funding their research projects, was quite high. To address both these problems, a proposal for a "Geophysical Research Institute" (GRI) was put to Ron. The concept behind this proposal recognised that the department had students capable of problem solving in the exploration and instrumentation arena. It also recognised that the industry had specific problems it wanted solved, and they had field sites where these problems were being encountered. In addition, industry had state-of-the-art commercial instrumentation that was unaffordable for teaching purposes. If industry and the university were to work together exploration technologies could be advanced, and useful graduates familiar with the latest technologies could be produced, most economically, with the research and field work funded by industry. Moreover, none of Ron's small staff of two had had exploration experience in industry, and by working on collaborative projects the industry sponsor could provide invaluable co-supervision. The proposed GRI would be a benefit to all parties, and Ron recognised this instantly, giving it his full support. Within four years, Ron's department had 20 well-funded and fully supported post graduate students. During this time Ron had independently established a wonderful relationship with the Indonesian Resources Ministry, and many outstanding students came from this Indonesian source.

Sadly, Australian universities were not as engaged with industry in 1978 as they are today, and the GRI was condemned within the university as "a threat to academic freedom".

Conveniently, Ron's 20 post-graduate students were attractive bait to an overstaffed Geology Department next door. In business parlance a "takeover" was inevitable, and an Earth Sciences Department resulted. The GRI was permitted to continue independently, but was to be self-sufficient and, at least initially, not to be involved with students. It was a strange transition period, and soon afterwards the UNE was to boast that it had led the way in integrating academic and industry needs. After just 15 years Ron's department was taken away from him, but in that time he had achieved a lot, and the accomplishments of his students speak for themselves.

In 1986 the ASEG inaugurated the Grahame Sands Award for "Innovation in Applied Geoscience". Nearly half (six) of the first 14 Grahame Sands Award recipients were graduates of Ron's department.

Ron's students respected him, called him their "Prof", and are forever grateful for the guidance he gave them in their education. Thanks Ron and congratulations on your longevity and great contributions to Australian and global geophysics!

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