

**"Summary and Reflections"**  
**delivered by F.E.M.(Ted) Lilley to the**  
**Third International Symposium on**  
**Three-Dimensional Electromagnetics,**  
**Adelaide, 21 February 2003.**

Ladies and Gentlemen,

In delivering the Summary and Reflections for this third 3DEM Workshop, let me first congratulate the trustees and organizers for the vision of this meeting, the sponsors for making it possible, and the contributors for making it happen, in such style! Also the students who have quietly and effectively run the sessions so smoothly. I think it is still a new experience to have a meeting totally "lap-top based" - no overheads, no slides, and no hassles at this meeting!

And while I am getting used to this microphone let me tell you that in Canberra we are very proud of our "wheelie bins", especially the big green and yellow ones for recyclables. One day a man was standing by the street when a truck came along, and the driver called out "Where's your bin?". The man replied, "I've been in the field, doing time-domain". And the driver said, "No, where's your wheelie bin?". And the man said "Well, I've really been in gaol, doing time. I just tell people I've been in the field, doing time-domain."

I have a theory that it is perhaps the convict background of Australia that has made time-domain such a success here. (Adelaide, of course, is proud of its free-settler origins.)

Australia has demonstrated strengths in geophysics, and at different times these have high-lighted IP, aeromagnetism, and now ground and airborne EM. ASEG meetings over more than twenty years have canvassed these strengths, including the five meetings held here in Adelaide. A paper by Greg Newman and Jerry Hohmann, for example, appears in the extended abstracts volume of Exploration Geophysics for the Adelaide ASEG/SEG meeting of 1988.

This year 2003 is the 75th anniversary of what can be regarded as the formal beginning of exploration geophysics in Australia, with the Imperial Geophysical Experimental Survey, or IGES, founded jointly by Britain and Australia in 1928. So this year we are 75 years on from then. The IGES tested geophysical exploration methods on suitable prospects in Australia over several years, and published the results in a book "The Principles and Practice of Geophysical Prospecting" by Broughton Edge and Laby, in 1931. Founded in 1928 they did well to operate all over Australia, and get the book out in 1931. They were probably helped by not having to type-set their equations themselves on a computer!

In the IGES the EM expertise came from Canada, and consisted of a large loop laid out on the ground (start to sound familiar?) in a square of side-length several hundred metres. It was a simple wire, and a 3 ampere current was alternated at 500 Hz. The secondary signal was detected by a roving coil system.

Well some things change little, some things change so much. And where are we today?

This workshop, juxtaposed with the ASEG conference, has brought together the Australian and international themes (dare I say the Australian and international clubs?) and in this Festival City we have had a festival week of geophysics. At this workshop we have had the following sessions : Minerals (4 papers), Minerals and novel techniques (3 papers), Environmental studies (6 papers), Crustal studies (5 papers), Petroleum exploration and borehole EM studies (5 papers), Minerals exploration and borehole EM studies (4 papers), Posters (some 20 papers): for a total of some 50 papers.

I think a remarkable thing about the papers at this meeting is their breadth. It is "3DEM At Work" indeed, and taken to every nook and cranny where it might be useful. Thus we have papers

- on theory, such as David Annetts' point on the insight offered by the mapping of actual electric current flow in a computed model; and George Jiracek's application of the Rayleigh scattering method;

- on the forward modelling of known 3D structures (ore-body and regional);

- on when 3D can be approximated by 2.5D, 2D and 1D models, and we have been presented by Niels Christensen with the temptation of being "kings in a 1D kingdom!" (That picture made me think of the Hobbits and the Middle Earth, to which I will return at the end);

- on the problem of anisotropic conductivity. On a larger scale in the Earth, anisotropic properties at depths of tens of km is a frontier topic, both in magnetotellurics and seismology, with important agreement between the results of the two methods;

- on down-hole methods, modelling and inversion;

- on case histories all over the globe from Australia to Alaska. This meeting has perhaps seen a shift to more natural-source magnetotellurics, for example in the study of geothermal prospects in Japan;

- on the frontier developments in seafloor MT, as in Kerry Key's paper, presenting recent work from the Marine EM Lab at Scripps Institution of Oceanography (one of our sponsors).

- on other methods, such Matthew Ludwig's investigation of magnetometric resistivity;

- on looking for orebodies; and studying impact crater structure.

The shift to environmental geophysics has meant a shift to smaller scales, and now suddenly ground-truthing is much more possible: as in Richard Lane's boreholes through saline regolith, and James Reid's planned sea-ice measurements.

In preparing for this summary I scanned through the abstract volumes of the two previous 3DEM workshops, in Connecticut, and in Utah. Please join me in raising your hand if you have now been to all three. I also looked through the conference on Airborne EM, held in Sydney in 1998, at Manly Beach, and who could ever forget that meeting! Again could we have a show of hands of who was there. Do you remember that pesky in-your-face Senator from Tasmania who kept criticising government spending on basic science? Even today just the thought of him is enough to raise the hackles. (No matter that he was actually a comedian, planted by the conference organisers to stir us up; it is bad enough that there are some out there just like him.)

Looking back over three workshops there is a lot of common material, and one cannot say that all the problems have been solved. 3DEM is not an easy subject - that is why it challenges us. But it is my judgement that impressive progress is steadily being made, the constant chipping at the frontier is wearing it away, and sometimes large blocks are dislodged; these events are exciting and satisfying for us all.

And so where to in the future?

Last week I saw a production of the musical "Joseph and the Amazing Technicolor Dreamcoat" which I expect many of you will know. The dreamcoat looked, in fact, quite like some of the 3D models we have seen this week, and perhaps the phrase "This is my 3D model" sometimes means "This is my 3D dreamcoat!" In the musical, Joseph is an interpreter of dreams, and what would an interpreter of dreams say of the dreams of this meeting? I think clearly the dreams would be these:

1. The dream of clearer theoretical analysis. Some further flashes of insight, the next steps up the ladder, in front of which some mathematical barrier crumbles. Art Raiche described this morning the benefits of introducing a potential into the treatment of a problem; on a different scale we have had the GILD method espoused to us with enthusiasm; Richard Smith has advocated a new approach to the use of impulsive moments.
2. The dream of faster, bigger computers. One dream we can be optimistic about. Especially in inversion are these needed, to compute more detailed models faster. This dream can be backed to come true.
3. The dream of clearer Earth structure, and the technology to image it. Even this week this dream is being increasingly realized in the tomographic images presented. Such imaging is a speciality of two of our sponsors, Electromagnetic Imaging Technologies, and Encom Technology.

4. The dream of finding rich orebodies, both as a commercial goal, and for the more altruistic reason of supplying resources for society. (We await with excitement the drilling of Louise Pellerin's structure in Alaska.)
5. The dream of solving Australia's salinity problem. And what could be a more basic contribution to that task than the monitoring of salinity loads, which several contributions have addressed.

I said I would return at the end to the Hobbit, and for those who saw the film "The Fellowship of the Ring" what would be a great help in this subject would be for us to have "One Ring to Rule Them All". Perhaps that ring started with the 1928 IGES loop of wire, and we have seen it develop through SIROTEM, TEMPEST and many others. The EM Loop is perhaps "The Ring to Rule Them All".

For magnetotelluric analysis, however, where we do not have loops of wire, it is clear to me that "One Ring to Rule Them All" will be John Weaver's new Mohr circle for the phase tensor. This ring, brought red-hot from the forge especially for this meeting, is no doubt still glinting and glowering on the posterboards in the next room. We will have to be careful when we take that poster down.

In conclusion I wish everyone safe travel home, and a return someday to witness the further progress of 3DEM in Australia.

Thank you.

*(Ted Lilley).*

### **Bibliography:**

The abstracts and presentations of the 3DEM-3 Symposium

Broughton Edge, A.B. and Laby, T.H. The Principles and Practice of Geophysical Prospecting, being the Report of the Imperial Geophysical Experimental Survey. Cambridge University Press, 1931.

Newman, G.A and Hohmann, G.W. Transient electromagnetic responses of high-contrast prisms in a layered Earth. Exploration Geophysics, 19, 322-324, 1988.

Oristaglio, M. and Spies, B. International Symposium on Three-Dimensional Electromagnetics, Abstract volume, 642 pp. Schlumberger-Doll Research, Ridgefield, Connecticut, USA, 4-6 October, 1995.

Spies, B., Fitterman, D. and Liu, G. Proceedings of the International Conference on Airborne Electromagnetics (AEM 98), Exploration Geophysics, 29, 1-271, 1998.

Wannamaker, P. and Zhdanov, M. The Second International Symposium on Three-Dimensional Electromagnetics (3DEM-2), Abstract volume, 341 pp. University of Utah, Salt Lake City, Utah, USA, 26-29 October, 1999.