10.1071/PVv2013n163other

The Continental Drift Controversy

by Henry R. Frankel
Publisher: Cambridge University Press
2012, Vol. I 632 pp., Vol. II 544 pp.
RRP: $100.00 ea, $356.00 set of four (hardback)
ISBN: 978-0-521-87504-2 (Vol. I)
978-0-521-87505-9 (Vol. II)

The Continental Drift Controversy by Henry R. Frankel is a tetralogy beginning with Vol. I *Wegener and the Early Debate*, followed by Vol. II *Paleomagnetism and Confirmation of Drift*, Vol. III *Introduction of Seafloor Spreading* and concluding with Vol. IV *Evolution into Plate Tectonics*. These works document, as fully as possible for one individual, the trials and tribulations of Earth Scientists last century to synthesise geological information gleaned from earlier centuries and the more refined data as it became available through to the 1960s. Frankel's works cover the separate stages of the continental drift controversy, from the early suggestions by Wegener and others that the Atlantic continents, i.e. their continental shelves, fit together too well for it to be simply chance, to the truly amazingly rapid development and success of paleomagnetic methods in the 1950s, to the realisation that seafloor magnetic and seismic data were screaming out to be recognised as evidence of seafloor spreading (the missing sibling of continental drift) in the 1960s and the last volume tops off these developments with the crowning jewel of Plate Tectonics, every bit as consequential as Evolution, Relativity and Quantum Mechanics.

This astonishing saga by a few ringleaders is often compared with Darwin's and Wallace's contributions to Life Science and Planck's, Einstein's and others' contributions to the Physical and Chemical Sciences. It is on a par with these. The personal conflicts are similar in all these great revolutions, with typically elder stalwarts refusing to budge. Just as in the 19th century the natural philosophers were divided between 'Neptunists' and 'Plutonists', the early 20th century Earth Scientists were divided between 'Fixists' and 'Mobilists'. However, within a short period of few decades, a complete revolution occurred in favour of 'Mobilism' and newcomers to Earth Science late last century and later imagined it had never been different. The socio-philosophic interplay is filled with intrigue and enlightenment. The debates are exemplary of the scientific process reminiscent of the great experimentalists, Bacon, Boyle and Hooke who held peer review and reproducibility of results above all else. Frankel puts a microscope on the past, with the benefit of hindsight, and retrospective interviews with the surviving ringleaders of the revolution, he reconstructs the key tipping points that inexorably led to Plate Tectonics as we know it today. In this review I hope to give the reader a flavour (to attempt more would be foolhardy) of the contents of Vols I and II, and in a subsequent article I will review Vols III and IV.

Vol. I is divided into nine chapters covering (1) *The mobilism debate*, (2) *Wegener and Taylor*, (3) *Sub-controversies of drift: 1920s–1950s*, (4) *The mechanism: 1921–1951*, (5) *Arthur Holmes: 1915–1955*, (6) *Mobilism in South Africa, India and South America: 1920s to early 1950s*, (7) *Mobilism in North America: 1920s through 1950s*, (8) *Mobilism in Europe: 1920s through 1950s*, and (9) *Fixism in Australia: 1920s to the mid-1960s.* Alfred Wegener's evidence for continental 'displacement', as he referred to it, did not stop with congruency of continental shapes. He also amassed much palaeontological evidence, especially from land plant fossils and, unsurprisingly since he was a meteorologist, published much on palaeoclimates, particularly with his father-in-law, Wladimir Köppen. It was the translation of his books into English in the 1920s that threw down the gauntlet to the fixist orthodoxy. Harold Jeffrey's life-long objections to drift are well known, and stated early that drift was 'out of the question' because the sima is too strong. Vol. I p. 59 states that 'All these observations suggest that sima is plastic…… and that the sialic rind possesses a considerably greater strength without lacking plasticity altogether' (Wegener, 1912). Wegener also stated that 'the Mid-Atlantic Ridge ... zone in which the floor of the Atlantic, as it keeps spreading, is continuously tearing open and making space for fresh, relatively fluid and hot sima [rising] from depth' (Wegener, 1915), but while the majority was against drift, Wegener did not pursue seafloor spreading further. Wegener was clearly ahead of his time.

After the single American edition of Wegener's work was published in 1925, the American Association of Petroleum Geologists held a symposium to oppose the dangerous notion of continental drift. This strong negativism of US workers may play a part in their belated acceptance of drift, and the puzzling trouble John Graham, Carnegie Institution, took to trash his own work to which I'll return later.

Unfortunately Wegener did not live to see his work vindicated. Vol. I p.45 states Wegener 'died in Greenland leading a scientific exhibition' (obviously *expedition*, one of the few typographical errors I found). Frankel also discusses in some detail hypotheses of Frank Taylor (continental creep), Eduard Suess, James Dana (contractionism), Alex Du Toit (disjunct biota/glacial stratigraphy), John Joly (thermal cycles) and others beyond the scope of this review.

Like Wegener, Arthur Holmes (whose textbook that I bought in 1969 was the best valued book I ever purchased, 1288 pages @ 0.54c per page), was also aware that rocks could 'flow' under heat and pressure and developed his theory of *substratum convection*. Jeffreys 'grudgingly admitted that…. [it] moved mobilism from the impossible to the highly unlikely' (Vol. I p. 203). Holmes was instrumental in the development of the radiometric determination of rock ages. He clearly had a good grasp of radioactive decay and its thermal consequences on the behaviour of rocks deep in the Earth. Frankel devotes a whole chapter (5) to Holmes, such was his immense contributions to geology.

Chapters 6 to 8 of Vol. I discuss how mobilism was received around the world up to 1950s, when the game suddenly changed with the rise of paleomagnetism. In the last chapter (9) Frankel views

Australia as a nest of fixists. A brief (pp.497–502) section (9.2) headed 'Geologists working on Australia's geology favourable to mobilism' is followed by a long tract (pp.503–545) of sections 9.3 to 9.6 headed 'Geologists against mobilism', 'Paleontologists…. in Australia reject mobilism', 'Biologists.. in Australia disagree' and 'Regionalism in Australia'. Five pages 'for' and over 40 'against'. I do remember my first year structural geology class being taught geosynclines and the 'Steinmann Trinity' in first term. The lecturer came in after a good read over Easter and stated we would be taught plate tectonic in second term. This department was 'Geology & Geophysics' and the head of geophysics was none other than Ron Green and it was almost 1970 so, recalling the title of chapter 9 *Fixism in Australia: 1920s to the mid-1960s*, perhaps Frankel has a point!

In the (small) mobilist camp Edgeworth David receives singular treatment but others favouring mobilism were Leo Cotton (who inspired, some would say incited, Sam Carey) and Douglas Mawson (Antarctic expedition). Mawson went to Antarctica to examine the coastal geology to compare to that of South Australia, and while things went awry, he clearly took Wegener's ideas seriously. In a section (9.3) headed 'Geologists against mobilism' Frankel lists Ernest Andrews (of Broken Hill fame), as 'the most outspoken Australian anti-mobilist'. Andrews was an early student of David's, either before his teacher decided where he stood on the issue or strongly disagreeing with his teacher. The naysayers include Walter Bryan (of Mining and Geology Research Centre, UQ fame), Edwin Sherbon-Hills (University of Melbourne), William Browne, who laboured for years to finish David's *The Geology of the Commonwealth of Australia*, but disagreed with him on mobilism and Curt Teichert, who thought the lack of Permian land animals in Australia, so abundant in South Africa and South America, was a problem for mobilism. Browne also helped Ted Irving and Ron Green on fieldwork when in his late 70s, but did not accept their findings, even rejecting a manuscript of Irving's submitted to the Journal of the Geological Society of Australia.

Moving onto Vol. II, which describes the incredible discoveries of the 1950s, the reader is introduced to more quandaries, True Polar Wander (TPW) versus Apparent Polar Wander (APW), the latter inferring another cause for polar movements, such as drift, and Geomagnetic Reversals versus Self-reversal. Both these issues were shrouded in baffling ambiguities that were only fully unravelled after new evidence came to light. In both these debates Australian researchers were to play a central role. Vol. II is divided into eight chapters covering (1) *Geomagnetism and paleomagnetism*: *1946–1952*, (2) *British paleomagnetists: summer 1951 to fall 1953*, (3) *Global paleomagnetic test: 1954–1956*, (4) *Runcorn shifts to mobilism*, (5) *Refinement of paleomagnetic support: 1956–1960*, (6) *Earth expansion*, (7*) Criticism of paleomagnetism: late 1950s and early 1960s*, (8) *Reaction against the paleomagnetic case and the radiometric reversal timescale: 1958–1962*. Below I pick the eyes out of these juicy morsels.

Some may be surprised to learn that the first group to study paleomagnetism was at the Department of Terrestrial Magnetism, Carnegie Institute in Washington, DC, in the late 1930s. John Graham is best remembered for devising the fold test and conglomerate test, which before the advent of laboratory 'cleaning' techniques were essential to demonstrate reliability. It is truly ironic that Graham found directions strongly oblique to the local geomagnetic field direction in folded strata that satisfied his fold test but dismissed them, preferring directions from flat lying strata aligned with the field. The director of Terrestrial Magnetism was a fixist and did not believe in geomagnetic reversals. It seems that to keep his job Graham had to spirit away his perfectly reliable results. Graham tortured himself for the remainder of his career bringing forth all kinds of spurious reasons why rocks can show oblique magnetisation direction, even reversals. To further confound matters, in 1951 Japanese workers, Seiya Uyeda and Takesi Nagata, published results from the Haruna dacite demonstrating self-reversal. This dacite begins cooling with its (net) magnetisation aligned with the field, but after cooling further the previously subordinate sub-lattice becomes dominant and the (net) magnetisation is reversed. One can imagine how this set a cat among the pigeons!

Meanwhile, Jan Hospers in Cambridge was accumulating results from Iceland that showed normal and reverse basaltic layers held a consistent stratigraphic relationship. Evidence for geomagnetic reversals became stronger as various groups began systematic studies of young piles of volcanics. Hospers was fortunate to have Ron Fisher in Cambridge to show him how to apply statistics to his results. Fisher statistics introduced order and consistency to the reporting of paleomagnetic results.

In 1950 Keith Runcorn was in Manchester, studying under Patrick Blackett, who had developed a magnetometer to test his theory about the fundamental origin of magnetism. Although his experiment proved negative, Runcorn realised the magnetometer could measure the weak remanence of rocks. Runcorn was interested in secular variation of the geomagnetic field, as a means to study the mechanism behind it. Runcorn thought a thick sedimentary sequence would be ideal to record such variations. In 1951 Runcorn moved to Cambridge and hired Ted Irving to give him the geological guidance he needed. Ted was a mobilist and interested in palaeomagnetism to detect polar motions. Ken Creer also joined this group and 1952 to 1954 was such a prolific period of determining basic paleomagnetic results their full interpretation and meaning was not immediately appreciated, certainly not by Runcorn. Irving and Creer knew their results better than anyone else, they knew that the armchair critics were fooling themselves. But Irving failed his PhD, only because his examiners would not fully appreciate his results. Creer had a better run, with Blackett as one of his examiners. This did not concern John Jaeger, who was setting up geophysics at ANU, and when offered Irving jumped at the chance to test drift using Australian rocks. Irving was sent a few samples of Deccan Traps for his Ph D and he realised the secret to differentiating between TPW and APW lay in studying the magnetisation of Gondwana continents. By 1956/57 Irving, with his student Ron Green, had proved the point and although the fixists still outnumbered the mobilists the latter camp was growing, even Runcorn switched camps.

In a twist of fate Irving's results from the Deccan Traps caused Allan Cox at the USGS Berkeley labs to reject mobilism and concentrate on the study of reversals. John Clegg from Blackett's group confirmed Irving's result so the Deccan Traps pole position could not be spirited away as Graham had sought to do to his results. Cox had sampled the Eocene Siletz River Volcanics in Oregon

and found a similar pole to that of the Deccan Traps. Although Irving suggested that Oregon may be rotated, which in fact turned out to be correct, Cox was unconvinced, his mind closed. Irving and Cox did not always enjoy a convivial relationship, especially when Irving and another of his students, Don Tarling, began working on reversal stratigraphy of Pacific islands, including Hawaii, with Ian McDougall as geochronologist. Irving never saw this as a competition but Cox apparently did, claiming that the USGS would only allow them to work on the Hawaiian Islands. It was years later when Irving was awarded AGU's 1979 Bucher Medal that Cox made amends with a conciliatory citation. Vol. II ends with a postscript describing latter-born mobilists justifying their early recalcitrance on various grounds, dissembling and revising history to suit. Clearly this was not confined to the US and Australia.

As if the profusion of quotes and citations throughout the text are not enough to support Frankel's reconstruction of events, each chapter is followed by copious and detailed notes carefully written to explain arcane scientific concepts and interesting asides that put various ideas into their societal and scientific context. Read and studied cover to cover the reader is assured of a solid grounding in historical geology and geophysics. The new word I learnt from Frankel is *consilience*, which I could not find in my 1690 page Collins English Dictionary. However, from Wikipedia all becomes clear – 'consilience (also convergence of evidence or concordance of evidence) refers to the principle that evidence from independent, unrelated sources can 'converge' to strong conclusions.' Most apt.

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Remote geophysical consulting

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With the skyrocketing cost of Perth office space, and the global trend of remote staffing, I thought I would try an experiment and work remotely from head office within my humble abode.

The technology available for working remotely is really very good. I thought that aside from a few technical hurdles, it would be easy to work from home so that I could see my kids off to school in the morning and help pick them up at the end of the day – maybe take some pressure off of my wife? In between, I could get in a full day of uninterrupted work – and start to eat regular meals (win–win).

I am a person that does not work well with interruption. I tend to end up working on the last thing I was asked to do and my priorities go out the window. Working from home would allow me to shut out office distractions and focus more on the priority tasks – plus I could leave NHL.com open on my second screen all day and keep track of the ice hockey scores without fear of anyone seeing me use the internet inappropriately.

When working at the office, I used to get in early, check my mail and then complete as much as possible before the 'Good morning's' of staff arriving and the sound of the grinder on the espresso machine distracted me from my duties.

In my line of work, technology is a big essential to being productive. Internet access, a solid connection to my virtual private network back at the office, printing capabilities, voice and video communication and good coffee simply go hand in hand. With any one element missing, my entire ability to work is marginal at best.

For voice and video I use Skype mainly because it is ubiquitous, and free. With Skype, I can still stay in touch with everyone at the office, attend meetings, plus you get the added upside of emoticons to express dissatisfaction or do the odd breakdance, followed by a beer, martini and a headache (or regurgitate – love that one): 🕺🍺🍸🤢. I also discovered that Skype allows me, free of guilt, to interrupt anyone at head office, while making it near impossible for them to deny they are there.

So off I went to start the experiment. My cardboard box (with the bottom that always falls out) of desk essentials under one arm, and my laptop and 'Don't Mess with Texas' coffee mug in the other.

Game plan

1. Get up early.
2. Knock out a bit of work and some communications before kids get up.
3. Feed kids and get them to school.
4. Return to desk with third cup of coffee and check NHL.com over breakfast.
5. Work until lunch.
6. Attend regular management meetings during the day via Skype.
7. Then help pick up kids from school.

Obstacle 1: five kids in four schools

I forgot that I have five kids in four different schools. Their school days start within 15 minutes of each other, so the race to get everyone to their schools on time is fairly demanding (let's not lie – it is impossible). The kissing my wife on the cheek and heading out of the driveway to the office in the morning has been replaced with two nappy changes, three kids showers, five bowls of cereal, four school lunches, four episodes of *SpongeBob*, 10 pairs of shoe laces to tie, the occasional extra nappy change, and a lost shoe or hockey stick, or swimming goggles that MUST be located.

In the first few weeks, I don't think anyone in the office missed me. We had five key data management projects on in three different countries so my schedule was quite busy and staying on top of my duties was not easy, but I managed. Then it happened…

Obstacle 2: school holidays

Did I mention that I have five kids?

The two nappy changes, three kids showers, five bowls of cereal, four school lunches, four episodes of *SpongeBob*, 10 pairs of shoe laces to tie, the occasional extra nappy change, and a lost shoe or hockey stick, or swimming goggles was replaced with a living hell like I have never known.

I never knew that an 8 year old could eat his bodyweight in corn flakes and still manage to utter the words, 'what do we have to eat?'. And now, by 8:00 am (when I should be about to get stuck into my day), the voices start. At first I thought they were in my head, but no they were at my feet: 'What are we going to do today?; 'Can I have XYZ over for a play date?; 'Have you seen my Lego Batman Bat Mobile service station?'. By 8:30 am, when I would normally be working so hard that veins would stick out of my neck, I hear 'I'm bored, I'm hungry, Lucy took my Lego Batman Bat Mobile service station', and of course, the mildly entertaining *SpongeBob* theme song as the sultry tones underpinning all of the banter (how many episodes did they make of that show!?).

The results

1. Technology: performed well and was in no way linked to a downturn in productivity.
2. Meetings: I attended 100% less.
3. Time management: I learned skills that would not have been possible at the office (like building a Lego castle with a 6 year old while talking to the exploration manager of a large multinational oil company).
4. Sales skills: I picked up new sales skills like getting five kids into one car without arguments by offering (or 'selling them on') a choice of ice cream or icy pole when they get home from school).
5. Pseudo-geophysical skills: I learnt that dirty nappy odours are non-linear – steeply logarithmic over time and also omnidirectional irrespective of wind direction or speed of infant travel.

Conclusion

The overall desired outcome of helping my wife out by being at home during the day while still being productive – an impossibility.

The demise of ASEG polarity

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I would like to dispatch to the annals of history the term ASEG polarity or Australian SEG polarity when referring to seismic data displays. There is no ASEG polarity standard.

Seismic data polarity is a common source of confusion for many interpreting geophysicists (Simm and White 2002), including me. As a joint venture representative I attend meetings and presentations with several companies and to fully understand the presentation material it is necessary to confirm the display polarity because it determines how an increase (e.g. intrusives) or decrease (e.g. gas sand) in acoustic impedance appears.

The only definition of normal or standard polarity I know is given in the SEG *Encyclopedic Dictionary of Applied Geophysics* (Sheriff 2002) – here is an excerpt from the online version (http://wiki.seg.org/index.php/Dictionary:Polarity_standard):

'…for a zero phase wavelet, a positive reflection coefficient is represented by a central peak, normally plotted black on a variable area or variable density display. This convention is called **positive standard polarity**…' (an increase in acoustic impedance produces a positive reflection coefficient). There is also a definition for minimum phase wavelets but I will stay with zero phase because most seismic processing aims to output a zero phase wavelet – a symmetrical wavelet with a maximum value at zero time.

The SEG Dictionary also describes dual polarity displays as 'Troughs may be colored red and peaks blue or black, or some other combination of colors may be used.' This is more like a suggestion but is an extension of the polarity definition – if the peaks are coloured black a contrasting colour, commonly red, was used to colour troughs.

The SEG Positive polarity definition makes sense because an increase in impedance produces a positive reflection coefficient which is displayed by a positive number or black peak. With this definition the mathematics is consistent and AVO analysis and seismic inversion is simpler with no need to swap sign.

But in Australia and Europe the opposite convention is often used. The correct name for this convention is SEG Negative standard polarity, not ASEG polarity. The SEG polarity standard is quite clear and is illustrated below (Figure 1) along with the polarity conventions used by an Australian operator, an international operator working in Australia and a European service provider. To confuse interpreters even further Operator A displays AVO (Figure 2) and inversion results with the opposite polarity to their display of standard seismic data. They do this to avoid the situation shown in Figure 3. Even industry leaders Schlumberger (2013) have no consistent usage, with their excellent web-based Oilfield Glossary correctly describing Positive polarity while their Petrel software defaults to something else.

Figure 3 is an example of AVO modelling from a recent prospect presentation that I attended. This company displays seismic data as SEG Negative polarity (an increase in impedance is displayed as a trough) while their seismic modelling results are displayed with SEG Positive polarity. To enable the modelled and actual curves to be compared directly one of the displays has been flipped. In this case the model display was flipped and the curves can be compared but the text and labels are difficult to read.

So what has brought about this confusion?

We can blame it on computers – the introduction of digital recording brought about the need to define polarity and this led to the SEG polarity standard published in 1975 (Thigpen *et al*. 1975).

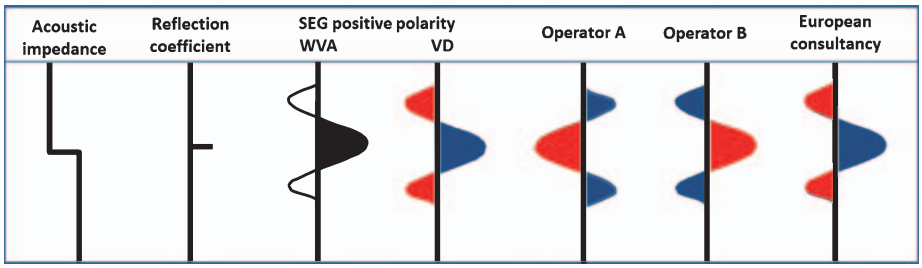

Fig. 1. *The SEG positive polarity standard for zero phase wavelets. From left, an increase in acoustic impedance ptroduces a positive reflection coefficient that is displayed on wiggle variable area displays as a black peak or blue on a variable density colour display. The three right wavelets illustrate the variety of conventions used by three companies operating in Australia. Only one uses the SEG standard.*

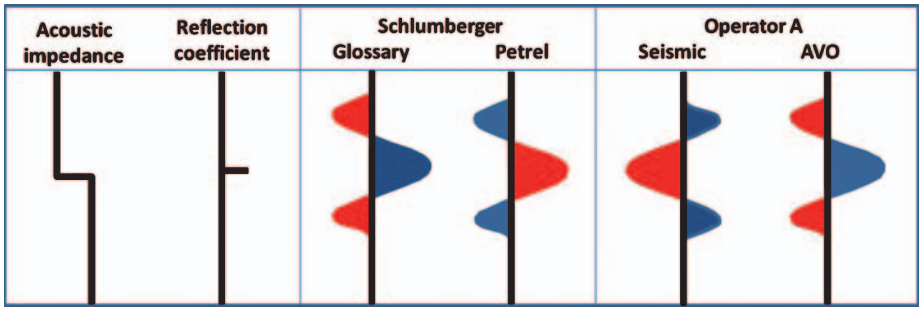

Fig. 2. *Even companies with well-defined standards have internal variation. The Schlumberger glossary of oil field terms (internet) correctly describes the SEG standard, but their interpretation software (Petrel) defaults to something else. A major operator uses SEG Negative polarity for seismic displays but reverts to SEG Positive polarity for QI and AVO displays.*

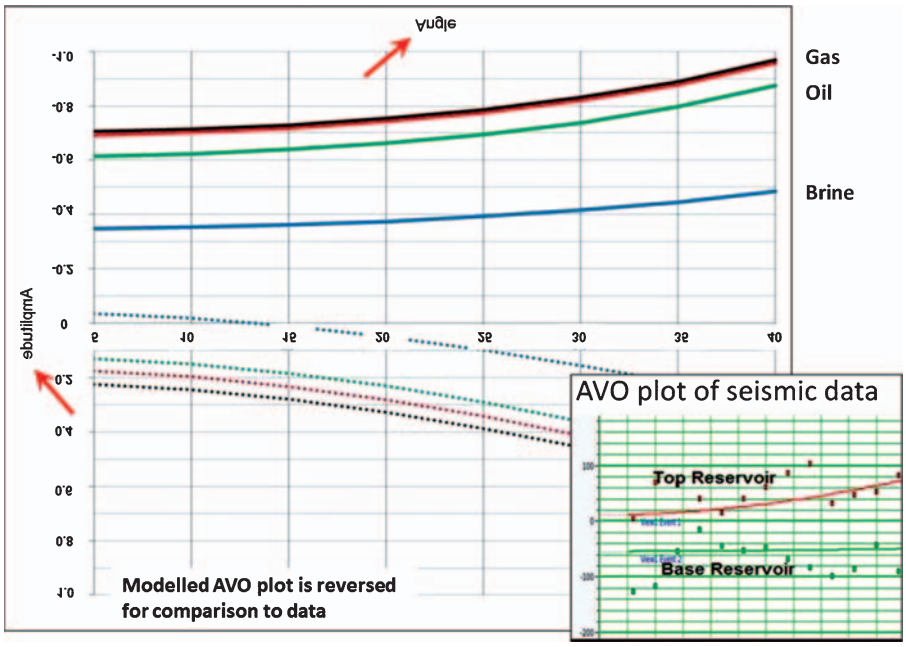

Fig. 3. *Example of AVO modelling results presented by an Australian operator. For comparison the display of modelled results has been inverted to account for the negative polarity convention of the seismic data (lower right). Inverting the graphical display to match the measured seismic response results in unreadable text (arrows).*

This document provided details of tests and standards for seismic acquisition and included this text '… An increase in acoustic impedance … recorded as a negative number on tape…'. I understand this was a pragmatic decision because most manufacturers at the time wired their sensors in this way. But the standard was for acquisition standards and did not contain a definition for displaying the data on paper or computer screens. About 1988 John Denham (Chief Geophysicist BHP) queried the authors of the 1975 standard and they replied confirming that the standard did not include displaying the recorded data for interpretation. It was not until the mid-90s that the later editions of the SEG *Encyclopedic Dictionary* defined polarity without any fanfare – the definition just appeared. The intervening gap of approximately 20 years was plenty of time for various companies to implement their own polarity definition. Generally, the US went for SEG positive and Europe and Australia went negative or reverse polarity.

There are a number of reasons for the negative polarity convention becoming common place. Here are three.

Probably the simplest is that a negative number on tape is simply displayed as a trough on paper.

The second reason harks back to seismic refraction records. Refraction seismic uses first arrivals which are refracted along a boundary across which the seismic velocity (impedance) increases and commonly refraction instruments were wired to display first arrivals as a deflection downwards. This convention carried over into seismic reflection records.

All very technical but my favourite explanation is an anecdote from the days when seismic interpretation was drawn on paper sections using coloured pencils to pick reflectors which were most commonly at major increases in acoustic impedance. If the increase in impedance was displayed as a trough (an unfilled wiggle deflecting to the left) the coloured pencil line was easier to see. This convention also had the added bonus that the coals (common in the Gippsland and Cooper Basins) were displayed as black peaks and hence looked 'coally'.

This brings me back to my opening – for consistency we should all be using the SEG Positive polarity standard and terms such as ASEG or Australian polarity should be replaced with the correct term SEG Negative polarity. Unfortunately I haven't seen any evidence of willingness in the industry to move in this direction and there will be more confusion when 4D seismic and shear wave data becomes more commonplace.

Finally I'll finish with an extract from a Schlumberger Petrel users guide . The Polarity and colour conventions described in Petrel manuals are '…the default color scale displays troughs as 'cold' blue colors and peaks as 'hot' red and yellow colors. This appears to be against another popular convention used, whereby positive amplitudes are usually displayed in blue tones…. Whatever convention is chosen, it is up to each user to make this clear in any resulting map or display showing amplitude related information.' Thanks for that – this is exactly why the confusion continues.

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May			**2013**
10–13 May	SEG/AAPG African Geosciences Student Conference http://www.agsc2013.org/	Lagos	Nigeria
13–16 May	Geoinformatics 2013: XIIth International Conference 'Geoinformatics: Theoretical and Applied Aspects' http://www.eage.org	Kiev	Ukraine
June			**2013**
10–13 Jun	London 2013: 75th EAGE Conference & Exhibition incorporating SPE EUROPEC2013 http://www.eage.org	London	UK
August			**2013**
11–14 Aug	ASEG-PESA 2013: 23rd International Geophysical Conference and Exhibition http://www.aseg-pesa2013.com.au/	Melbourne	Australia
September			**2013**
8–11 Sep	Near Surface Geoscience 2013 http://www.eage.org	Bochum	Germany
30 Sep–4 Oct	Sustainable Earth Sciences 2013: Technologies for Sustainable Use of the Deep Sub-surface http://www.eage.org/events/index.php?eventid=960&Opendivs=s3	Pau	France
October			**2013**
6–11 Oct	SAGA 13th Biennial Conference and 6th international AEM 2013 http://www.saga-aem2013.co.za/	Mpumalanga	South Africa
7–10 Oct	7th Congress of the Balkan Geophysical Society http://www.eage.org	Tirana	Albania
November			**2013**
18–20 Nov	The 11th SEGJ International Symposium: Geophysics for establishing a sustainable secure society http://www.segj.org/is/11th/	Yokohama	Japan
24–27 Nov	Second International Conference on Engineering Geophysics http://www.eage.org	Al Ain	UAE
January			**2014**
20–22 Jan	The 7th International Petroleum Technology Conference (IPTC) http://www.iptcnet.org/2014/doha/	Doha	Qatar
February			**2014**
25–27 Feb	SPE/EAGE European Unconventional Resources Conference and Exhibition http://www.eage.org/index.php?evp=1979	Vienna	Austria
March			**2014**
9–12 Mar	GEO 2014 – 11th Middle East Geosciences Conference and Exhibition http://www.geo2014.com/	Manama	Kingdom of Bahrain
April			**2014**
7–10 Apr	The 6th Saint Petersburg International Conference and Exhibition http://www.eage.org/index.php?evp=1979	Saint Petersburg	Russia
June			**2014**
16–19 Jun	76th EAGE Conference and Exhibition incorporating SPE EUROPEC 2014 http://www.eage.org	Amsterdam	The Netherlands

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Preview is published bi-monthly in February, April, June, August, October and December. The deadline for submission of material to the Editor is usually before the 15th of the month prior to the issue date. The deadline for the June 2013 issue is 9 May 2013. For the advertising copy deadline please contact Wendy Wild on (03) 9662 7606 or wendy.wild@csiro.au.