Seismic window

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Faults

How far will a fracture propagate during hydraulic stimulation? I was investigating this topic following the Western Australian Government's moratorium on 'fracking' when I came across some notes on fault deformation (I will provide the answer later). Around the same time a colleague decided to go back to university and to begin researching the structural evolution of the Carnarvon Basin. These two events led me to my *Atlas of Analogue Modelling of Extensional Fault Systems* for a quick brush up on extensional tectonics. This Atlas was produced by the National Centre for Petroleum Geology and Geophysics at Adelaide University and documented several sand box models of different structural settings found on the NW shelf. With its sand box modelling of the Mermaid Fault this book would be a good place for my colleague to start his research.

Early in my career, when I began interpreting seismic, I had access to several useful atlases that contained example seismic sections from various structural and stratigraphic settings. I still have eight of these books. They are large format; maybe 60 × 30 cm and a few centimetres thick, covering topics such as Australian and New Zealand basins, Seismic Stratigraphy, Rocky Mountain Region, Modern Convergent Structures, three volumes of Structural Styles, and, my favourite, the 'Fault Atlas'. They are a useful reference but use more shelf space than I would like. Today we have the internet.

This got me thinking about the importance of having a good fault interpretation as a foundation for prospect mapping. I'm not a structural geologist, but I think I know most of the rules; such as individual faults are not very long, and even long ones are actually several short faults that have amalgamated. There is an empirical relationship between fault throw and fault length with outcrop and mine studies suggesting the length is 50 to 100 times the throw. Using this ratio would suggest the fault shown in Figure 1 should be 5–10 km long because its displacement is about 100 m. But it appears to extend for over 25 km. A closer examination of the similarity attribute (Figure 2) reveals several shorter segments about 6 km long (B and C), which are linked by faulted relays. Further to the west, there are some examples of relay ramps. As an interpreter is it better to pick each fault segment separately, or pick the entire length as a single fault? In my experience both have problems but generally it is better to pick each separate segment.

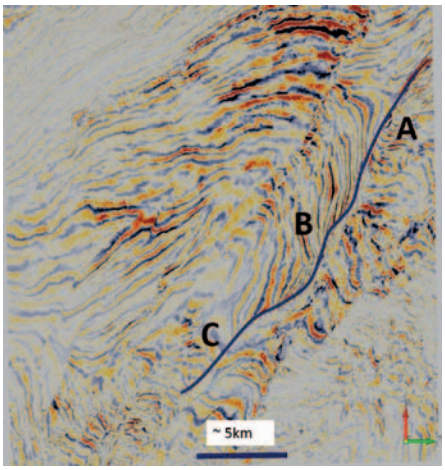

Figure 1. *Seismic timeslice at 1800 ms. Several faults can be identified with Fault ABC appearing to be over 25 km long. On closer examination it consists of a number of linked faults (A, B and C) each about 6 km long and connected by relay faults which form kinks along the fault trace.*

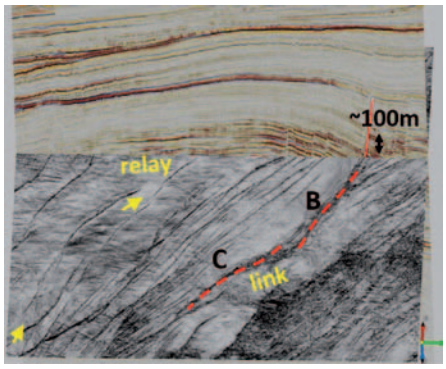

Figure 2. *Vertical seismic with similarity attribute on 1800 ms timeslice. Similarity helps to identify the 6–8 km long segments of the red fault which is consistent with the 100 m throw. The relay ramps have failed and faults link the segments. Yellow arrows indicate relay ramps that have not yet failed.*

Back to hydraulic stimulation. Researchers at Durham University have built a database of the results of thousands of fracture stimulation projects around the world. The longest vertical fracture created is 588 m, and statistically the chance of a vertical fracture exceeding 350 m is only 1%. This puts a safety buffer of more than a thousand metres between deep reservoirs and shallow aquifers. Another interesting snippet of information – a 1 m displacement along a fault results in/from a magnitude 6 earthquake so a 100 m fault requires either a huge earthquake or dozens of smaller ones.

For those who really want to get into the details of fault modelling, structural restoration and validating geometries I suggest taking a look at Structure Solver (www.structuresolver.com). The website for this neat piece of software has several examples of different fault regimes and a large gallery of informative videos.

Reference

ATLAS: 3D Analogue Modelling of Extensional Fault Systems plus Field Applications, NCPGG Adelaide University, 1995.