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Clues for stressed Australian explorers

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THE high stresses in the Australian continent can make life difficult for local petroleum explorers, but research led by the University of Sydney could improve the chances of discovery.

The research project was dubbed the Tectonic Reactivation and Paleo-Stress project, and conducted in collaboration with Shell, BHP Billiton, Woodside and Santos. Funding was also provided by the Australian Research Council.

The project produced a series of paleo stress maps, showing the direction and strength of maximum horizontal stress across the Australian plate at various points in time back to about 100 million years ago.

The pioneering work relied on expertise and modelling capability developed by the Earthbytes Group at the University of Sydney, led by Professor of Geophysics, Dietmar Muller.

The main results were published recently in the *Australian Journal of Earth Sciences* in a paper by Muller, ExxonMobil geophysicist Dr Scott Dyksterhuis and Associate Professor of Geology and Geophysics Patrice Rey.

Muller told *Energy News* that a great deal was known about existing stresses, but this did not tell petroleum explorers anything about past stresses and the likelihood of fault reactivation and trap leakage.

"What's different about what we have done is extrapolating the knowledge of current stresses into the geological past," he said.

"It's much more difficult and uncertain than mapping current day stress. The data constraining paleo stress are harder to come by. It depends on observations from combination of seismic profiles and well data, and building a computer model is not trivial at all."

Muller said Earthbyte was the only research group in Australia creating paleo-stress maps, and one of only a handful with such capability worldwide.

He said the Australian plate had been under high levels of stress since the Tertiary. This made fault reactivation a common feature of local sedimentary basins, including our most prolific petroleum provinces, the Carnarvon Basin and the Gippsland Basin.

"Most people think Australia is a stable continent," Muller said.

"It's true that we do not have mega earthquakes like California or Japan, but if you look at the map of smaller earthquakes, there are many happening here all the time.

"There is a lot of seismicity that's not very destructive, but the cumulative lower magnitude seismicity over geological time that expresses itself as fault reactiviation and fault movement."

Most of the structure reactivation around Australia has been almost entirely in the mid to late Tertiary.

"The Indo-Australia plate was in a tectonically quiet phase before the Tertiary, but since that time, it has experienced three continental collisions, which drive the intracontinental stress fields," Muller said.

"The first was the India-Eurasia collision, then the collision in New Zealand between the Pacific and the Australia plate, which created the Southern Alps, and then the last one was with Papua New Guinea, when the Australian plate collided with the Caroline plate.

"You can view Australia as being caught in a giant vice that has three jaws, with pressure sideways from New Zealand, Papua New Guinea and the Himalayas."

Muller said the likelihood of fault reactivation was determined by the paleo-stress field and its orientation to contemporary fault systems.

"It is the interaction between maximum horizontal stress and fault systems that determines the likelihood of fault reactivation.

"Explorers need to think about the likelihood of fault reactivation on the structural traps being examined.

"And if they were reactivated, what happens to the hydrocarbons? They could migrate all the way to surface, leaving a paleo oil column, but sometimes the hydrocarbons are trapped higher up in the stratigraphy, so that's where you have to look."

The research found a dramatic change in Australia's stress field from about 95 million years ago in the early Late Cretaceous, caused by the establishment of plate driving forces from mid-ocean ridges to the east and south of Australia.

This is thought to have led to reactivation of northeast-trending structural fabric on the North West Shelf, most likely as a strike-slip fault regime.

Stress magnitudes over the NWS then increased in the Early Miocene, suggesting the formation of northeast-trending anticlines occurred between 55 million and 23 million years ago, which is different to the time frames suggested by other research.

One of the highlights of the project was the explanation provide for reactivation of faults in the Timor Sea in the Miocene from 23 million to about 11 million years ago.

This time period was dominated by ridge push south of Australia and increased resisting forces north of India and east of Australia, leading to a severe increase in stress across the North West of Australia.

Stresses in the Australian plate can also work to the advantage of the energy industry, particularly in the search for shale gas and other unconventional resources.

Research groups and industry are looking closely at the distribution of faults and fracture systems in the Cooper Basin to understand how they can be exploited to enhance the permeability of fracced shales.

Muller said paleo-stress research could add much more value in this area.

"Our original models were quite simple and on a continent-wide scale without sophisticated depth layering," he said.

"If you are trying to understand local stresses as a function of depth, you need to put in much more detail and regional geology."

Muller said software was available to conduct these studies, along with high performance computing capability at the National Computational Infrastructure in Canberra.

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