NEW IDEAS ON RIFTING HISTORY, STRUCTURAL REACTIVATION, AND HYDROCARBON ENTRAPMENT IN THE TIMOR SEA

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Objectives of program

Over the last two and a half years, the Australian Geological Survey Organisation (formerly BMR) has, as part of its ongoing Continental Margins Program, been carrying out a major research program into the structural setting and evolution of the Vulcan Sub-Basin and Bonaparte Basin. The principal scientific objective of this program is to understand the deep crustal architecture and the principal basin-forming processes in the Timor Sea and thereby to understand the control that the deep crustal architecture has on structural reactivation in the shallow (< 4km), hydrocarbon prospective sedimentary section.

To this end, approximately 1900 km of deep crustal (14 sec) seismic and 20,000km of aeromagnetic data have been acquired in the Vulcan Sub-Basin, while 2180km of deep crustal data were collected over the Bonaparte Basin (i.e. the Sahul Syncline, Malita Sub-Basin and the Petrel Sub-Basin). Another 6100km of high resolution seismic and water column geochemical ('sniffer'-type) data were also acquired in the region.

Fundamental Architecture Revealed

Interpretation of the deep crustal data has revealed the fundamental architecture of the Timor Sea for the first time. Rifting in the Timor Sea began in the NW-trending Bonaparte Basin in the late Devonian and continued until the early Carboniferous. Crustal extension was extreme in the central Petrel Sub-Basin, where about 9 sec of thermal subsidence phase sediments are present. In fact, virtually the entire drilled section in the offshore Bonaparte Basin belongs to the thermal subsidence or sag phase.

Reactivation is the key process controlling the development of structures within the Bonaparte Basin, with most of the major structures actually being due to Mesozoic inversion of the primary, deep-seated late Devonian/early Carboniferous rift faults, rather than to salt tectonism, as previously believed. Our data actually show that most of the salt diapirism is of Tertiary age and hence post-dates the Mesozoic inversion. Salt diapirism is in fact localised by the same primary rift faults which controlled the inversion structures in the shallow sedimentary section, leading to a close spatial (but not genetic) relationship between the inversion anticlines and the salt diapirs.

Late Carboniferous to Early Permian Rifting

Integration of image processed aeromagnetic data with deep crustal seismic, Landsat and gravity data has revealed that the principal rifting/extension event in the Vulcan Sub-Basin occurred during the late Carboniferous to early Permian (Westralian Super-basin rifting), rather than during the Jurassic, as has been previously proposed. This rift was oriented NE, and overprinted the older NW-trending Bonaparte Basin rift north-west of the Malita Graben. The top of this rift can now be seen as a strong seismic event which is present between approximately 7-8 sec TWT on the deep crustal seismic lines. This rifting was characterised by large amounts of crustal extension, with the development of a linked array of NE-trending normal and NW-trending transfer faults. The seismic data are most consistent with the Vulcan Sub-Basin having developed over an upper plate margin.

The fundamental architecture of the Timor Sea was established during this Westralian Super-basin rifting phase, though the architecture of the rift itself was strongly influenced by pre-existing NW- and NS-trending Proterozoic lineaments. This episode of rifting was followed by a significant thermal subsidence phase, with the attendant deposition of a thick sequence of largely unstructured Permian and Triassic sediments.

Prime Locations for Hydrocarbons

Mesozoic structural reactivation of the deep-seated Permo-Carboniferous Westralian Super-basin fault architecture resulted in the formation of the complex NE- to ENE-trending structural elements which now comprise the Vulcan Sub-Basin. The intersection of the reactivated NW-trending Permo-Carboniferous transfer faults and/or the N-S trending (Proterozoic) faults with the NE-trending, reactivated Westralian Super-basin normal faults are prime locations for both

enhanced structural complexity and hydrocarbon entrapment within the Vulcan Sub-Basin. Indeed, all of the major discoveries lie at or near such intersections and it appears likely that the majority of the hydrocarbon-bearing structures within the sub-basin are either closed, or induced by, NW-trending reactivated transfer faults. These intersections and trends provide exploration "fairways" along which structural reactivation is greatest, and therefore the chances of exploration success are highest.

A Powerful Tool

AGSO's work in the Timor Sea has demonstrated that virtually all of the significant hydrocarbon-bearing structures so far discovered in the region have been formed by Mesozoic reactivation of major Palaeozoic rift faults. Indeed, the locations of the major transfer faults within the rift(s) were in turn themselves controlled by the pre-existing Proterozoic structural grain. The fact that none of these critical relationships could have been established using available conventional seismic data highlights the value of deep crustal seismic data, particularly when used in conjunction with modern, image processed aeromagnetics. It is a powerful tool which, until now, has been largely overlooked by the exploration industry.

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