Four-dimensional fracture distribution in the Cooper Basin using image logs

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Abstract

An understanding of four-dimensional fracture distribution in the Cooper Basin can be used to optimise the development of well placements and fracture stimulation treatments used in tight gas and shale gas reservoirs. Comprehension of the paleo-stress, current stress, natural fractures and tectonic history of the basin can facilitate the exploitation of hydrocarbon resources in the basin.

Natural fracture distribution and orientation were analysed using borehole image logs of 13 wells in the NW of the Cooper Basin. Additionally, in situ stress was evaluated in these locations, and paleo-stress evolution was interpreted based on the structures analysed.

Through drilling-induced tensiles fracture and breakouts observed in the image logs, the maximum horizontal stress is oriented WNW-ESE in Patchawarra Trough and Sub-Patchawarra Trough. It has been observed that older and deeper buried formations have a higher number of fractures per thickness ratio (fracture density) than shallow formations. Stress history is recorded in ancient formations; therefore, the age of the formation may affect the number of fractures per thickness. However, the contribution of lithology must be taken into consideration. Rocks with low tensile strength have a more common rock failure than stiffer lithologies. Correspondingly, fine-grained lithologies such as siltstone, shale and mudstone have more natural fractures than sandy lithologies.

Various fracture sets were determined in the analysed wells. The NW-SE extension fracture sets of Adelaidean rifting were observed in two wells. This was followed by a compression of Kanimblan/Alice Springs, which is proposed to accompany the WNW-ESE strike-slip regime. The NW-SE compression fracture sets of Permian formations were related to the Sakmarian uplift. The Daralingie uplift is also proposed to be evident in the analysed image logs. Local heterogeneous kinematics are suggested to affect the Daralingie uplift, and it is associated with an extension event. The Hunter Bowen Orogeny ended the deposition of Cooper Basin formations. It has been suggested that E-W compression events affected the basin during the Late Cretaceous. During the Cenozoic Era, E-W to N-S compression might have affected the basin, as shown by the N-S and NE-SW compression fracture system in the analysed image logs. Present-day maximum horizontal stress is attributed to the NW-SE compression and extension fracture sets of the Eromanga Formations.
## Contents

**Acknowledgments** .................................................................................................................. ii

**Abstract** .................................................................................................................................. iii

**Contents** .................................................................................................................................... v

**List of Tables** ............................................................................................................................ vii

**List of Figures** ........................................................................................................................... viii

**List of Abbreviations** ................................................................................................................. xi

1. **Introduction** ......................................................................................................................... 1  
   1.1. Aim ................................................................................................................................. 2  
   1.2. Objectives ...................................................................................................................... 2  
   1.3. Geomechanical Setting of the Australian Plate .................................................................. 4  
   1.4. Tectonic and Geological Setting ..................................................................................... 5  
      1.4.1. Cooper Basin structural style .................................................................................... 7  
      1.4.2. Basin stratigraphy and structural evolution .............................................................. 9  
      1.4.3. Basin in situ stress field ........................................................................................... 14

2. **Literature Review** .................................................................................................................. 16  
   2.1. Stress ............................................................................................................................. 16  
   2.2. Fracture ......................................................................................................................... 17  
   2.3. Fracture Development (Rock Failure) .......................................................................... 19  
   2.4. Borehole imaging Tools .................................................................................................. 21

3. **Methodology** ......................................................................................................................... 22  
   3.1. Image Log Generation ..................................................................................................... 22  
   3.2. Determination of Deformations from Borehole Image Logs ........................................... 22  
      3.2.1. Defining in situ stress ............................................................................................. 23  
      3.2.2. Natural fracture and fault analysis .......................................................................... 24  
   3.3. Defining Principle Stress Axis ....................................................................................... 25  
   3.4. Natural Fractures vs. Depth and Lithology .................................................................... 26  
   3.5. Tectonic Phases Succession ............................................................................................ 26  
   3.6. Tectonic Phases Chronology ........................................................................................... 27

4. **Results** ................................................................................................................................... 29  
   4.1. In Situ Stress .................................................................................................................. 29  
   4.2. Natural Fractures ........................................................................................................... 29  
      4.2.1. Natural fracture systems from image logs .............................................................. 29  
      4.2.2. Natural fractures vs. lithology and depth ................................................................. 37  
      4.2.3. Natural fracture distribution through time and space ............................................ 44  
      4.2.4. Natural fracture chronology ................................................................................... 45  
   4.3. Fault analysis ................................................................................................................... 45

5. **Discussion** ............................................................................................................................. 50  
   5.1. In Situ Stress .................................................................................................................. 50  
   5.2. Natural Fractures .......................................................................................................... 50  
      5.2.1. Fracture system from image logs ........................................................................... 50  
      5.2.2. Natural fractures density vs. lithology and depth .................................................... 51
5.2.3. Tectonic events succession ........................................................................ 52
6. Conclusions ................................................................................................... 69
7. Recommendations .......................................................................................... 71
8. References ..................................................................................................... 72
9. Appendix 1 ..................................................................................................... 77