# Structurally complex reservoirs programme
# Status reports

| PS 3062: ISF - Improved Simulation of Fractured and Faulted Reservoirs | |
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| **Status** | Ongoing |
| **Report date** | May 2003 |
| **Key contact** | Prof Martin Blunt Imperial College |
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| **Objective** | • To perform realistic numerical simulation of fractured and faulted reservoirs with discrete fracture and fault representations.<br>• To develop a physically-based mathematical model for reservoir-scale matrix-fracture transfer and fault transmissivity for a variety of different fault and fracture network geometries and stress states as observed in the field.<br>• To use findings from this research to extend the fast streamline-based simulation to fractured reservoirs.<br>• To compare the results to commercial finite-difference simulators.<br>• To make the new technology available in a commercially available streamline-based code and in a form that allows easy implementation into other existing simulation packages. |
| **Status, findings and plans** | The project has made excellent progress in its first six months. Specifically we have implemented a dual porosity formulation into a research streamline code. This represents one major achievement under the proposal. In addition we have implemented novel multiphase transport algorithms into CSP – our discrete fracture network code. We have studied different forms of the matrix/fracture transfer function and have found that a simple linear form matches the results of core-scale experiments and can be coded efficiently into a streamline simulator. The following research priorities have been agreed.<br><br>• A research dual porosity streamline code will be available to sponsors. This code will have been compared with a conventional grid-based dual porosity simulator to evaluate accuracy and runtime.<br>• A first commercial dual porosity version of 3DSL will be available to sponsors.<br>• To show multiphase flow simulations through geologically realistic three-dimensional fracture geometries using CSP.<br>• To demonstrate and test gridding capabilities using the new hybrid mesh-based gridding. |

| PS 3066: BMFFFS – Behaviour and Modelling of Fault/Fracture/Fluids Systems | |
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| **Status** | Ongoing |
| **Report date** | May 2003 |
| **Key contact** | Dr Gary Couples, Heriot-Watt University |
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| **Partners** | RDR University of Leeds; Texas A&M University |
| **Objective** | • Develop process-based understanding of the spatial and temporal variability of fault zone properties<br>• Improve our ability to assess the technical risks associated with fault-seal traps<br>• Creation of new tools for simulating flow in complex reservoirs that contain structural discontinuities<br>• Identification of characteristic scales and appropriate cross-scaling methods that capture sub-grid physics. |
| **Status, findings and plans** | Work is progressing well with both Heriot-Watt and RDR simulator developments. At RDR, the software has been extended to 3D with multiple solver options. At HW, the software is now being adapted to multi-phase flow. Petrophysical property measurements are underway. The Texas faultzone study is moving forward, now integrating small-scale features into the previous interpretation, with tomographic imaging of faulted materials. At HW, work is progressing to develop methods that use fault-rock images (from thin sections or other images) to create grains+pores models to be used as input for flow simulation studies. Geomechanical simulation work is progressing, but this is less advanced than planned due to the late appointment of staff. The RDR fault-rock property atlas is nearly complete.The work completed to this stage does not warrant major conclusions. Lab measurements suggest that fault-rock relative permeabilities may be extremely low. Planned work includes:<br>• Continuation of flow simulation software development, and application to example cases to build knowledge-base.<br>• Progress several geomechanical simulation threads, including grain-scale and for full faultzones.<br>• Start development of test cases, particularly focusing on the central Texas example via discussion visit to the UK by Texas A&M staff.<br>• Completion of property atlas and internal discussion; presentation of information to sponsors. |

| PS 3068: RFI - Robust Fracture Identification via Seismic Detection and Geomechanical Prediction £350,000 | |
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| **Status** | Ongoing |
| **Report date** | May 2003 |
| **Key contact** | Dr Helen Lewis, Heriot-Watt University |
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| **Partners** | University of Leeds |
| **Objective** | • To develop a general geomechanics-seismic modelling method for identifying open fractures.<br>• To develop the tools (e.g. seismic-geomechanics property transfer) necessary to achieve the seismic-geomechanics integration.<br>• To create open fracture array predictions for chosen field (Clair) for use in reservoir simulation.<br>• To create an RFI (open fracture identification) workflow designed to permit interfacing with standard industry tools (seismic packages, Eclipse etc.). |
| **Status, findings and plans** | Generally the project is on target.<br>• On-target on theoretical underpinning (note topic has expanded from initial expectations).<br>• On target for geomechanical modelling and associated vignettes.<br>• Behind on data acquisition for the Clair field but are catching up fast<br>• Seismic vignettes about to begin.<br>• Collaboration with Leeds University has started in earnest.<br><br>No milestones or conclusions were expected at this stage, however:<br>• We have a working demonstration of the RFI methodology.<br>• There is a wider audience, and scope of interest, than originally anticipated.<br><br>The next steps are:<br>• Identify likely structural evolution paths for the type reservoir (Clair) and use these to derive<br>• best-guess initial and loading conditions<br>• Develop suite of appropriate geomechanical vignettes.<br>• Use geomechanical vignette output to set up seismic forward models.<br>• Assess the Clair seismic (OBC) data for anisotropy analysis. |

| PS 3082: Project FIFT: Quantitative Characteristics of Faults and Fault Zones and their Impact on Flow within Deep Water Turbidites, Onshore New Zealand | |
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| **Status** | Ongoing |
| **Report date** | May 2003 |
| **Key contact** | Dr John Walsh, Fault Analysis Group, University College Dublin |
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| **Partners** | Institute of Geological & Nuclear Sciences (GNS), New Zealand; Marine and Petroleum Group, University College Dublin |
| **Objective** | Few constraints are available on the geometric and hydraulic properties of faults within turbidite sequences. Of particular interest is the impact of faults of different size on the geometric and hydraulic connectivity of turbidite beds and sandbodies, and the inter-relationships of lithology/lithofacies with fault system architecture and fault zone permeabilities. The classic turbidite succession of the Taranaki Basin, New Zealand is exposed along 25 km long cliffs, hosts two producing reservoirs and is mappable from seismic and well data. Quantitative analysis and modelling of a population of normal faults within this area, combined with geological and flow modelling of a representative suite of faulted turbidite reservoir architectures will provide a basis for addressing recurring issues related to fluid flow in faulted turbidite reservoirs, such as reservoir compartmentalisation on production time scales and the distribution of unswept oil in older fields.<br><br>This project will provide quantitative constraints on the geometry and hydraulic properties of faults in turbidite sequences from outcrop and seismic data. Combined with sedimentological constraints from the main study area and from a selection of classic turbidite sequences, a suite of faulted turbidite models (ca 500) will be constructed for a range of turbidite reservoir and fault architectures. Flow modelling of these high resolution models (500,000 cells) will provide a basis for establishing the sensitivity of flow results to different combinations of both the sedimentological and fault architectures. The combined effects of generic turbidite and fault architectures on fluid flow will be quantified by identifying links between sedimentological and fault system parameters, on the one hand, and the flow response, on the other. This methodology will identify the most important geological parameters controlling flow within a range of faulted turbidite reservoir architectures. |
| **Status, findings and plans** | The project has been in progress for only six months. Our two main field seasons have, nevertheless, been completed, although our analysis of outcrop data is ongoing. The available exposures provide constraints on faults in turbidite sequences that have exceeded expectations. Numerous faults, defining a rhombohedral fault pattern, have been mapped and analysed. Fault zone geometries and fault rock content can be defined for faults with mm to ca 50m throws within a range of turbidite facies. |

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| | These faults provide excellent constraints on the distribution of clay-rich and sandstone derived fault rocks and a basis for defining models for fault zone growth and fault rock distributions. Combined with forthcoming poro-perm data, the project findings will provide a means of estimating the impact of faults on flow within different turbidite facies. Our sedimentological studies are also progressing well, with the available exposures and previous studies by GNS providing excellent quantitative constraints on sedimentological architectures and related parameters. Interpretation of available 3-D seismic, from both a structural and sedimentological perspective, is well advanced, and the development of links between outcrop and seismic is looking very promising. Strategies for sedimentological and structural modelling have been defined and the work of constructing models is soon to begin. All work items are on schedule.<br><br>Continued research will follow the planned work programme and schedule. Our research into mid- 2003 will involve continued analysis of outcrop and subsurface data and the start of the main phase of sedimentological and structural modelling. |

| PS 3090: Calibration of Faults and Fractures Extracted by Rate Statistics (COFFERS) | |
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| **Status** | Ongoing |
| **Report date** | May 2003 |
| **Key contact** | Prof Ian Main, The University of Edinburgh |
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| **Partners** | Reservoir Dynamics Ltd; VIPS Ltd; Roxar Ltd |
| **Objective** | • To evaluate the predictive capability of production/injection rate data on a whole oilfield as a test case<br>• To relate these correlations to the known system of faults, fractures and stress state in the field<br>• To build a finite element geomechanical model for directional, long-range correlations, and apply it to injection /production data from the test case oilfield |
| **Status, findings and plans** | So far we have completed the following tasks:<br>• Reviewed thirty papers published in SPE on the application of production data to reservoir engineering to provide an appropriate background and context for the project.<br>• Written a report on improving oil recovery using statistical analysis techniques used in China.<br>• Held a meeting to explore the techniques for using production data to identify reservoir characteristics and dynamic behavior.<br>• Redeveloped the exploratory statistical method from a previous project i.e. a multiple linear model to identify significant correlations of the pressures between wells using forward selection regression. A Bayesian information criterion and the coefficient of determination is used in a targeted search for an optimal statistical reservoir model.<br>• Reproduced a research code in the analysis package 'R' for more rapid computation.<br>• Reproduced some significant results using real oilfield data, and presented these to sponsors in a separate report.<br><br>We conclude that:<br>• Production data is a source of integrated information about reservoir characteristics and the dynamic flow process in the reservoir. Results show that production data could be used to identify significant correlations of the pressures between wells.<br>• The study has shown that the initial developed method is proper and feasible, and long-range correlations have been detected.<br>• R' is the most approprioate statistical language. It has a parallel interface that makes it a good candidate for extending the analysis to a whole test case oilfield. |