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The SAIGUP Project – Sensitivity analysis of the impact of geological uncertainties on production forecasting in clastic hydrocarbon reservoirs

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Abstract

The principal purposes of the EU-Funded SAIGUP project are: i) to quantify objectively the sensitivity of geological complexity on production forecasts, as a function of generic aspects of both the sedimentological architecture and faulted structure of shallow marine hydrocarbon reservoirs, and ii) to validate these results using real-case reservoir and production data. Because of the case-specific nature of existing production forecasting sensitivity studies, links between geological and production uncertainty cannot be made at present. These links are a prerequisite for early recognition of the most significant geological parameters influencing production forecasting uncertainty and are a necessary basis for establishing optimal methods for including geological uncertainty in reservoir modelling studies.

Research partners in the SAIGUP project are: Norwegian Computing Centre (Norsk Regnesentral, Oslo), Heriot-Watt University; Imperial College London, TNO-NITG, Badley Earth Sciences, BG Group, ROXAR, Shell International Exploration and Production, University of Liverpool (Stratigraphy Group), Fault Analysis Group (University College Dublin).

Research programme

The SAIGUP project is a systematic assessment of uncertainty in reserves and production estimates within an objectively defined geological parameterisation encompassing the majority of European clastic oil reservoirs (Fig. 1). A suite of progradational shallow marine reservoir types are indexed to continuously varying 3D anisotropy and heterogeneity levels (e.g. Fig. 2). Each sedimentological model is placed in 28 structural models sharing a common overall form (i.e. an uplifted footwall reservoir; Fig. 3) but comprising three basic fault systems with variable fault density and fault sealing characteristics and a common unfaulted end-member. Flow simulation on the up-scaled, faulted models using four different production strategies results in production characteristics of ca. 10,000 full-field reservoir models. A parallel investigation using some of the models focuses on the uncertainty introduced as a function of up-scaling.

Production profiles and recovery factors from this suite of simulations are being combined with the geological and development plan parameters in a relational database. Interrogation of the database will permit the levels and origins of production and reserves uncertainty associated with geological complexity and methodological imprecision to be quantified as a function of the underlying geology. Existing and new static and dynamic heterogeneity measures and dimensionless parameters are being tested against production results for their ability to discriminate between geological architectures and to predict production characteristics.

Sensitivity analyses, performed using reservoir and production data from three geologically diverse shallow marine reservoirs (one each from the Central North Sea, the Viking Graben and the Niger delta), combined with results from the large suite of geological models, will test our principal technical findings.

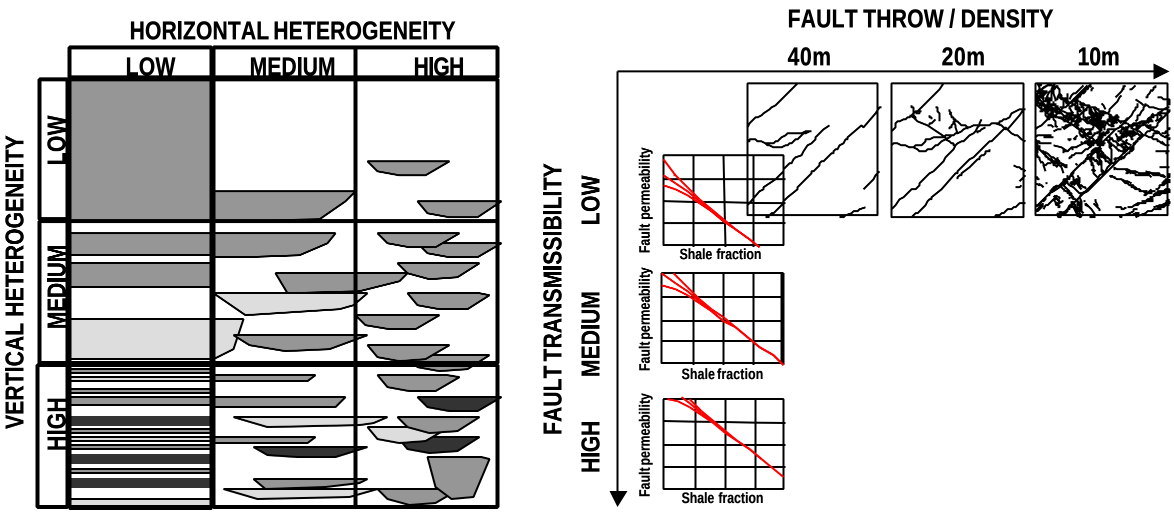

Figure 1. a) Matrix of sedimentological complexity(derived from Finalay and Tyler 1991 and from P.W.M. Corbett(pers comm.). b) Matrix of structural complexity: fault transmissibility vs. Lower limit of fault inclusion These 2D representations of continuously varying architecture provide the basis for a quantitative definition of geological parameter-space.

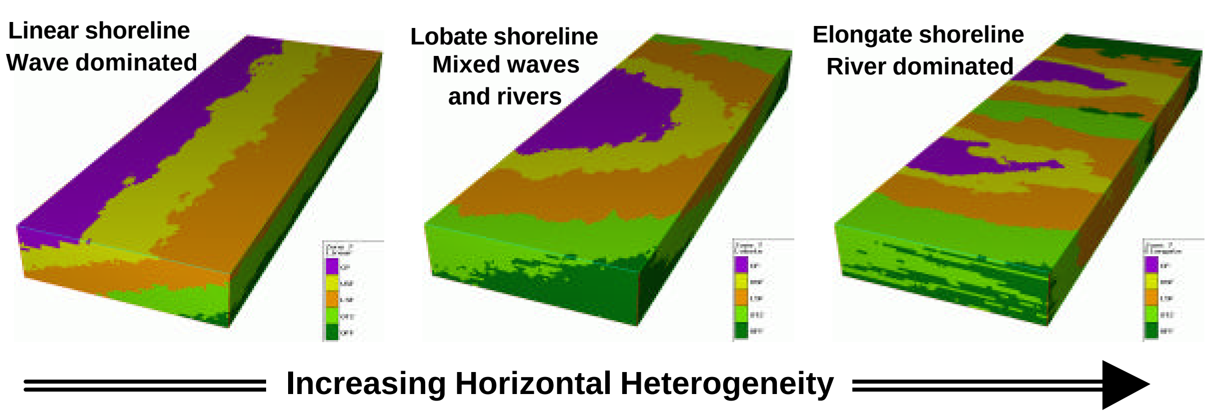

Figure 2: Models of shallow marine sediments showing changing architecture for wave through to river-dominated systems. Facies types are: coastal plain - blue; upper shoreface - yellow; lower shoreface - red; offshore transition zone – light green, offshore mudstone – dark green.

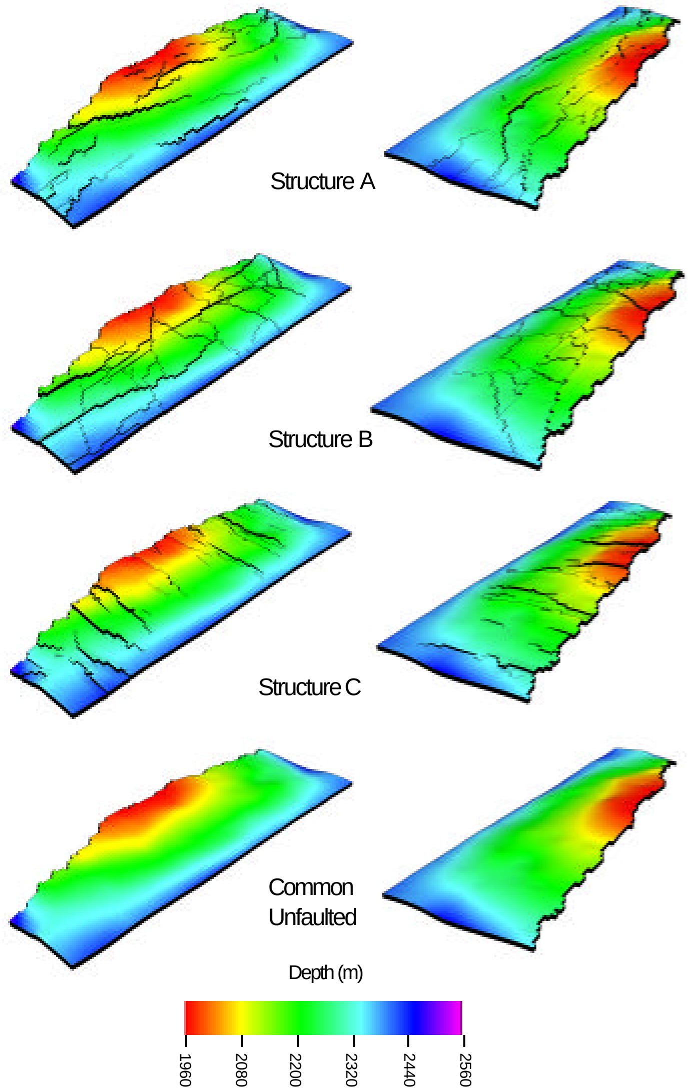

Figure 3: Views of the three most faulted systems and of the common, unfaulted reservoir. All faulted models have the same gross-rock volume and the same fault-related shear strain.

Expected results

The expected project results are i) quantification of the relative and absolute influences of sedimentology, structure and up-scaling on reserves estimation and production forecasting from reservoirs with different sedimentological and structural properties, and ii) definition of geologically relevant dynamic and static heterogeneity measures and dimensionless groups for improved production forecasting in faulted clastic reservoirs. Project results will be tested and implemented through the consulting and software roles of the two service companies and through the practical implementation of the methods developed on the case studies of three real reservoirs. We expect the project results and methods to contribute towards an improvement in the planning and execution of geological reservoir modelling programs, and towards a reduction of the economic risk associated with field development.