Carbonate Reservoir Characterisation Research Project

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Prepared for

Open Tender

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This research will determine a streamlined, minimum-cost process to exploit Lonoy's 21 carbonate poretypes (Lonoy 2006) to estimate reservoir properties in both cored and uncored wells including: saturation; permeability; relative and effective permeability; capillary entry height; irreducible water height and residual oil saturation. The research will identify and rank those logs which succeed in achieving optimal cost-benefit in terms of calculated HC and kh uncertainty for cored and uncored wells. This research seeks to minimise logging costs and be soundly tied to geological concepts to facilitate geological modelling. Research will be conducted by Mark Deakin (PhD, Petrophysics), Carbonate Petrophysics Course Instructor and Technical Consultant and Arve Lonoy (PhD, Carbonates), Carbonates Reservoir Modelling Consultant.

1.1. OBJECTIVES

To research and determine a streamlined, minimum-cost process to exploit Lonoy's 21 (Lonoy 2006) carbonate poretypes to estimate reservoir properties in both cored and uncored wells including: saturation; permeability; relative and effective permeability; capillary entry height; irreducible water height and residual oil saturation. The research will identify and rank those logs which succeed in achieving optimal cost-benefit in terms of calculated HC and kh uncertainty for cored and uncored wells. Unlike others this method will be aimed at minimising logging costs and founded upon and remain directly tied to, geological concepts which will facilitate geological modelling.

1.2. INTRODUCTION

Whilst clastics reservoir properties are largely controlled by total porosity and clay minerals carbonates are controlled by pore geometry. Clastics properties are therefore seen by conventional logs whereas carbonate properties are not. Further, carbonates are notoriously variable and unpredictable being subject to greater diagenesis, vugs and fracturing than clastics. Consequently rock typing, or more aptly pore typing, is typically employed to determine carbonate reservoir properties so that porosity, or some other easily determinable property, can be used to estimate reservoir properties through their relationship with that property, in that pore type. This process tends to be ad-hoc, expensive and time consuming and to occur largely within the core domain. However, it is logs that will finally be called upon to estimate reservoir properties and build geological models. A unified and more efficient core-log approach is needed.

This research seeks to unify and optimise the process of using Lonoy's 21 poretypes with logs to a) find those poretypes beyond rock samples and b) estimate reservoir properties within each poretype either from Lonoy's catalogued properties or the logs themselves properly calibrated to that pore type. Rather than running a diverse suite of expensive logs this research seeks to identify and rank the best logs to achieve these goals. The logs will be ranked for the best cost-benefit in reducing total EHC and kh error. This will result in a) the cheapest data set to achieve the most accurate results, and b) a streamlined and efficient process to determine foot by foot reservoir properties during exploration, appraisal and development.

Lonoy's 21 poretypes have been garnered from a diverse global database of carbonate reservoirs consisting of more than 3,000 core plug thin sections.

1.3. PROCESS

An expanded Process will be discussed with applicants.

Lonoy's experience in recognising and understanding poretypes in a geological context will be the starting point of this research. Deakin' s experience in using all logs, core and other data in a holistic manner, already implemented in the 28,000 core-plug PetroDB-Vault software, will allow Lonoy's geological knowledge to be effectively integrated with modern logs, carrying that information to the larger and more available log domain, and to geological models.

The final process will result from the research itself but may be, broadly:

1) Identify geologically based poretypes from rock samples

2) Identify optimal logs

3) Pre-process logs

4) Investigate statistical techniques

5) Determine each poretype's specific properties

6) Determine the minimum cost data set

7) Evaluate reservoir properties

8) Calibrate minimum cost log data set

In favourable intervals these answers may serve as reference answers for the subsequent calibration of cheap, standard log analysis such as the Archie cementation exponent m, saturation exponent n, Timur Coates permeability BFV, a, b and c constants. Interactive petrophysics software will be used to adjust the least certain input of m, n, IFT, contact angle, FWL etc. to determine the best fit to the poretyped answers above. Such interactive "what if" scenarios provide insight into spatial differences in those inputs, notably FWL or wettability.

1.4. DELIVERABLES

1) A step by step method which may be applied to any carbonate field to deliver continuous curves of porosity; Lonoy poretypes; saturation; permeability; relative and effective permeability; capillary entry height; irreducible water height and residual oil saturation at minimum cost and at maximum speed. This method may also be adapted to any complex conventional reservoir, such as tight gas.

2) The Lonoy poretypes which are most crucial to delineate and the means of that delineation

3) The identification and ranking of cheap and special logs which achieve the best cost-benefit in terms of the final evaluated EHC, kh and uncertainty for the well track.

4) The complete evaluation of TWO fields or 100 wells with this research projects final methodology

5) a Weekly Project Brief sent each Friday at 4pm during the project. Briefs aid collaboration, serve as a useful technical reference and ensure timely deliverables.

1.5. TIMING

The research project as laid out above is anticipated to take from 6-12 months. Guaranteed deliverables and end date may be discussed.

1.6. PROTAGONISTS

All research will be conducted by Mark Deakin (PhD, Petrophysics, Imperial College London) and Arve Lonoy (PhD, Carbonates, Bergen University). Both are established, highly regarded technical experts in their fields each with over 25 years mainstream industry experience.

SHORT CV Dr Mark Deakin is a Course Instructor in Petrophysical Data Integration and Carbonate and Fracture Petrophysics, active technical consultant/advisor and author. He holds a Ph.D. in 'Integrated Petrophysics' from London's Imperial College, is an ex Amoco petrophysicist, and has 25 years' experience, including 12 as a lecturer and director of PETROPHYSICS Pty Ltd. He has performed over 50 detailed reservoir studies, primarily in Southeast Asia's difficult carbonate and stacked 'low-contrast-pay' reservoirs, keeping abreast of new technologies by operations work, attending short courses, technical reading and updating lecture courses. Deakin' s proven approach is to identify and rank reserves uncertainties then guide companies toward defensible reserves via a process of targeted data acquisition, Data Hierarchy and systematic integration. After his PhD Deakin authored the first public Integrated Petrophysics course in 1989 which has evolved into the industry benchmark course for mainstream petrophysics. In 2005 Deakin developed "Carbonates & Fracture Petrophysics – A Roadmap" and the powerful PetroDB-Vault core-log-test linked database evaluation for complex reservoirs. Deakin is a member of SPWLA with offices in Perth, Australia.

OVERVIEW Arve Lonoy. More than 30 years of experience as a carbonate geologist within exploration, production/field development, and research. Main specialty is sedimentology and diagenesis with special emphasis on reservoir characterization. Extensive experience on core description, thin-section analyses, pore typing, characterization of flow units, reservoir zonation, well correlation, integration with

petrophysics and reservoir engineering, prediction of pore types and reservoir properties from wireline logs using neural network, field work studies, interdisciplinary integration etc. Extensive experience from carbonates in the Barents Sea (Palaeozoic), North Sea (chalks), Russia (Palaeozoic), Gabon (post-salt), Angola (pre- and post-salt), Iran (Cretaceous) and Iraq (Tertiary, Cretaceous and Jurassic). Some experience from carbonates in the Norwegian Sea, Oman, Philippines, Cuba, Canada, Congo, Namibia, Spain and Greece.
Specialties: Carbonate reservoir characterization and integration with petrophysics and reservoir engineering. Development of pore-type based prediction tools for permeability, porosity cut-off, effective PHI, fluid contacts, saturation, HC volumes and more. Predicted data are applied in reservoir geological modelling and reservoir simulation, and represents a new methodology for reservoir characterization. The methodology is applied to uncored wells using artificial neural network.

1.7. INTELLECTUAL PROPERTY

Research results and process remain the Intellectual Property of the Mark Deakin and Arve Lonoy. However, the method and results of this research as herein may be applied directly to the field and data supplied by the company for this research free of charge up to a maximum of TWO fields or 100 wells, whichever comes first.

1.8. FINANCE

Budget 250,000 USD.

1.9. PREFERRED ATTRIBUTES OF SPONSOR

The preferred attributes of the sponsoring company may be summarised as:

- have a wide range of carbonate conventional core spanning different poretypes (rocktypes, facies) of different porosity with adequate core data to be set aside for blind testing.

- have a good log data range including modern image logs, NMR, compressional, shear and Stoneley wave sonic

- a pressing commercial need and interest in a carbonate reservoir or reservoirs

- a co-operative approach from geological / engineering staff which should encourage but not stifle innovation towards a practical solution

- funds available and set aside for the project

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