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Carbonate Integrated Reservoir Characterisation: A Unique Case Study

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SUMMARY

Over the years, one of the main discussion topics in most of the oil and gas conference is carbonates rock typing challenges. There were numerous publications on carbonate rock typing efforts since last seventy five (75) years of oil and gas era to date, be it by discipline i.e. geology – facies, petrophysics – rock types, reservoir engineers – flow units as well as cross disciplines effort. The ultimate goal is to come out with a fit for purpose carbonates reservoir characterisation for both three (3) dimensional geological (static) and simulation (dynamic) models, in other words a better resource and reserve formulation. Of course a great amount of man-hours were spent traditionally for above works.

Introduction

Over the years, one of the main discussion topics in most of the oil and gas conference is carbonates rock typing challenges. There were numerous publications on carbonate rock typing efforts since last seventy five (75) years of oil and gas era to date, be it by discipline i.e. geology – facies, petrophysics – rock types, reservoir engineers – flow units as well as cross disciplines effort. The ultimate goal is to come out with a fit for purpose carbonates reservoir characterisation for both three (3) dimensional geological (static) and simulation (dynamic) models, in other words a better resource and reserve formulation. Of course a great amount of man-hours were spent traditionally for above works.

With the latest development of technologies, significant improvement was observed in term of details scale of the reservoir characterisation versus the turnaround time. The presented study here is an unique attempt to formulate a fit for purpose integrated reservoir characterization on an oil bearing carbonates subject field utilizing the main inputs from advanced open hole well logs namely nuclear magnetic resonance (NMR) and resistivity based image in conjunction with digital rock analysis (DRA), apart from the conventional open hole well logs suite, conventional core laboratory analysis and other formation data such as mud logs, pressure and well tests. Fourteen (14) wells with different inclination types including horizontal were studied and tested.

Method

The main scopes conducted are advanced open hole well log processing and interpretation, DRA (from imaging to properties modelling) and integration of the two as well as other conventional formation dataset.

Since the two (2) main inputs i.e. advanced open hole well logs and DRA are acquired at two (2) distinct scales, each dataset were honoured formulating two (2) rock types namely electrotype (well log scale rock type) and petrotype (core plug scale rock type).

Several approaches were adopted in the rock typing exercise stage at both electrotype and petrotype levels, including but not limited to deterministic rock typing approach i.e. Flow Zone Indicator (FZI) or Reservoir Quality Indices (RQI), Lucia Rock Class, Clerke Pore Size technique from mercury injection capillary pressure (MICP), computer based automated rock typing i.e. multi-variate cluster analysis (with normalization and with biased), cluster analysis (without normalization and without biased) and self-organizing maps (without normalization and with biased).

It is important to note that prior to all of above rock typing exercises, a geological driven facies association were conducted. This alone is a considerable amount of work scopes which cover seismic facies (depositional), lithofacies (conventional core description), microfacies (thin section from each one foot interval of conventional core acquired) and image facies from the resistivity based image log processing and interpretation. This is of course any approach on above rock typing efforts will only be applicable across the subject field as long as it’s having similar digenetic changes.

All the methods were studied and compared in order to come out with an optimised number of rock types which yield high confident representation of the subject field carbonates subsurface architecture.

After the rock type finalisation, properties modelling were conducted whereby petrophysical parameters were assigned for each rock type accordingly. With ‘garbage in, garbage out’ in mind, a details effort on improving the robustness of the input dataset were undertaken which defaulting in the production of a fit for purpose properties prediction model.

Several sources of capillary pressure (Pc) measurements i.e. core laboratory centrifuge, core laboratory MICP, core laboratory porous plate (end point) as well as the DRA special core analysis (SCAL) Pc were discussed and filtered post quality assurance. Similar steps were taken as a whole comparison between core laboratory Routine core analysis (RCA) and (SCAL) with the DRA RCA and SCAL.

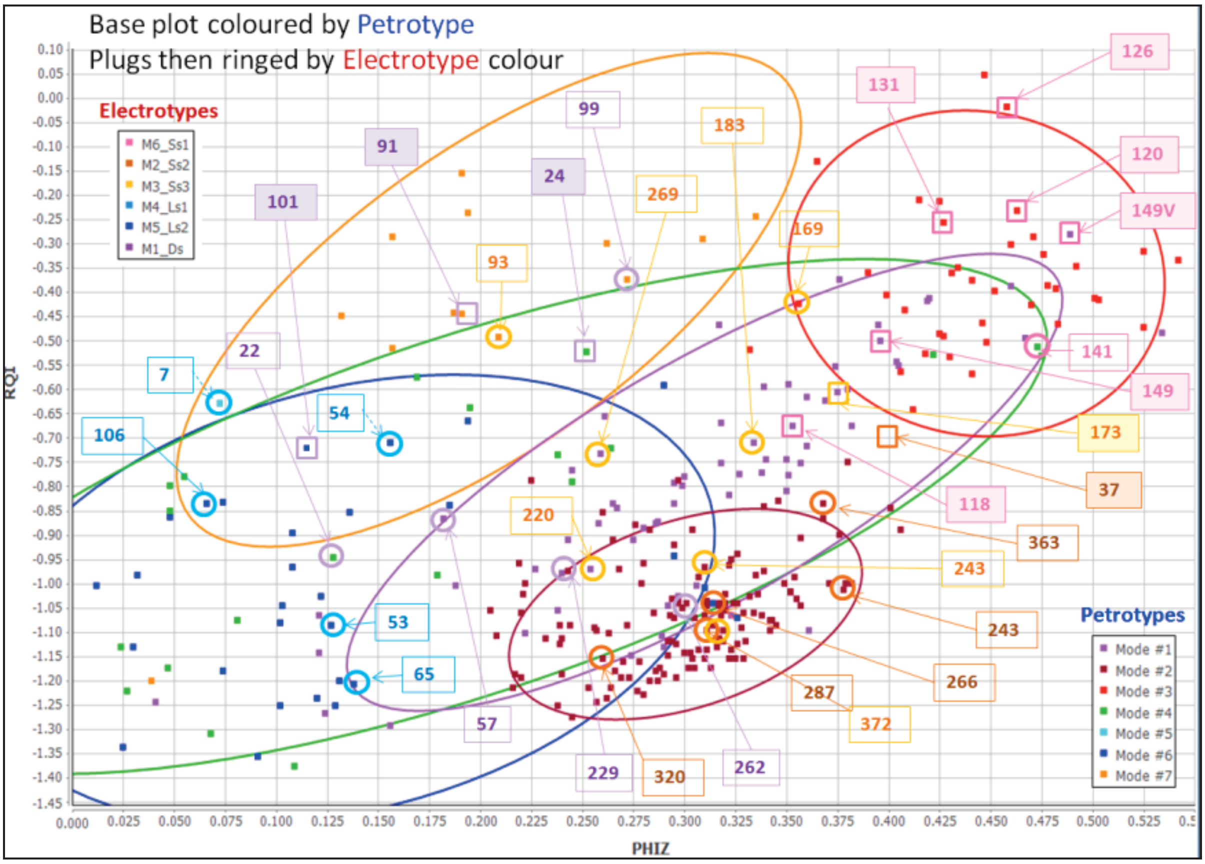

Figure 1 The presentation of core plug sample selection criteria for DRA with overlapping of electrotype and petrotype in a FZI cross plot.

Conclusions

As the first conclusion, the main objectives were successfully achieved i.e. to honor all formation dataset input in formulating a fit for purpose integrated carbonates reservoir characterisation for both three (3) dimensional static and dynamic models. Secondly, a thorough data quality assurance and quality control were performed scrutinizing a valid comparison which resulted in the optimum number of rock types, which is insensitive of any approach described above undertaken, but as a factor of similar digenetic changes. The study also remarkably maximised the value of information extracted from the wide range of dataset. One of the important note is the study does not demonstrate a group of data is more accurate than other (which contradicting in concluding anything), but rather complementing each other, which definitely will show a different path if any of them were not acquired in the first place. Finally, data preference and user bias was well controlled thus conclude a robust integrated carbonates rock typing approach for internal replication to other ventures.

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