Rock in Reservoir Rock-Typing – A Geological Perspective

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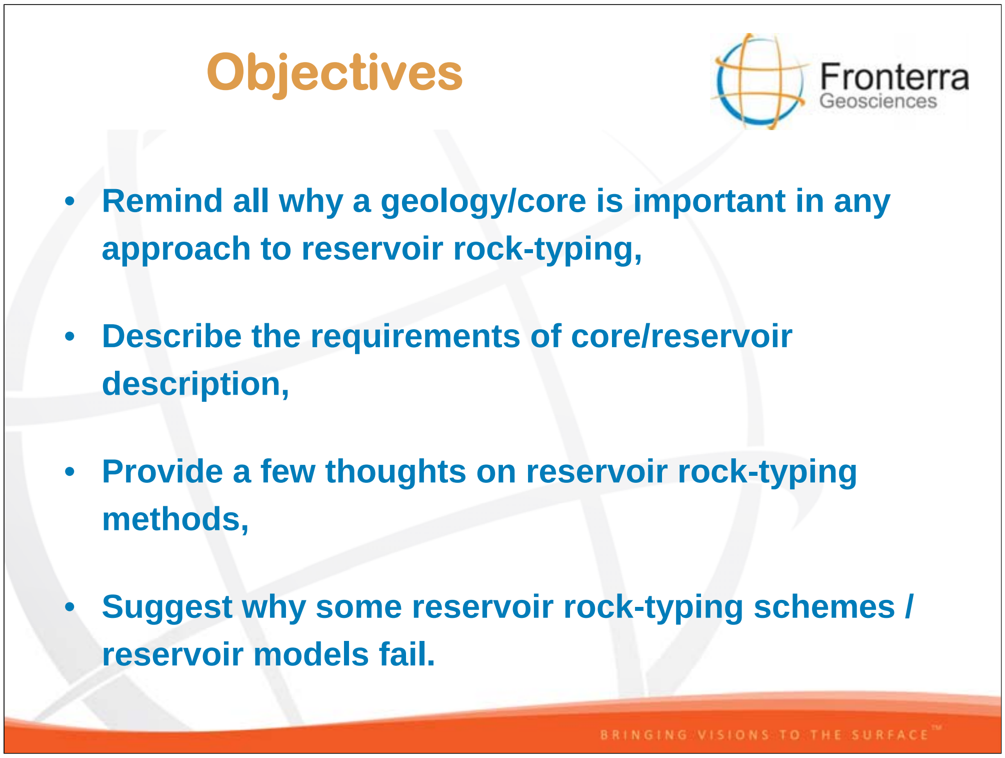
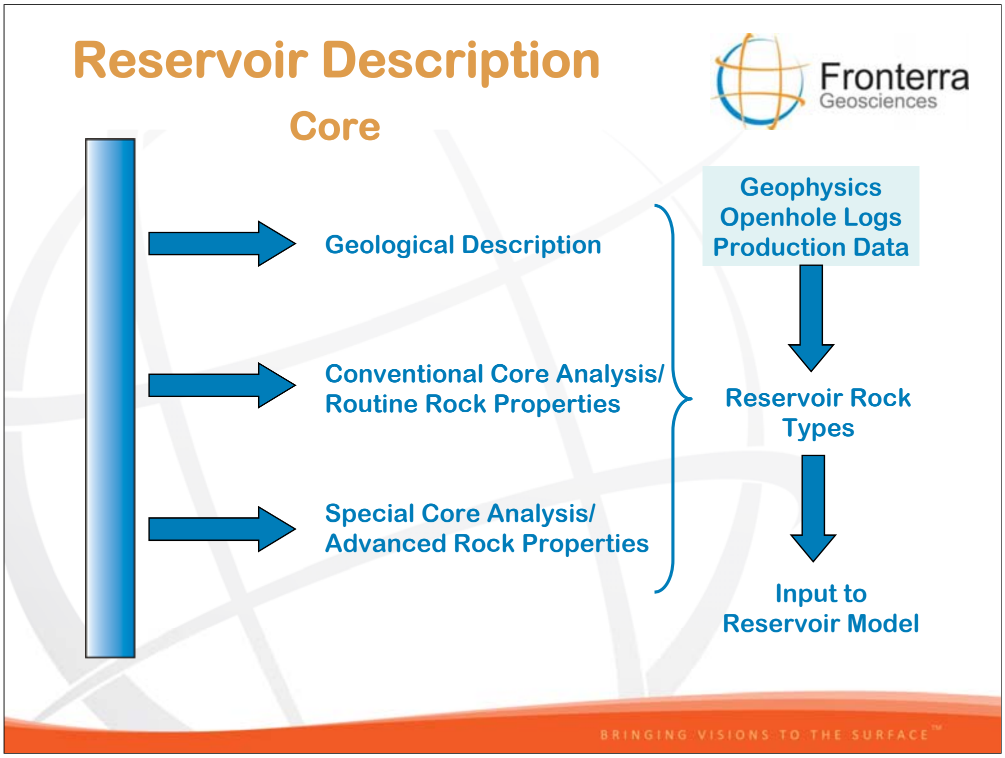


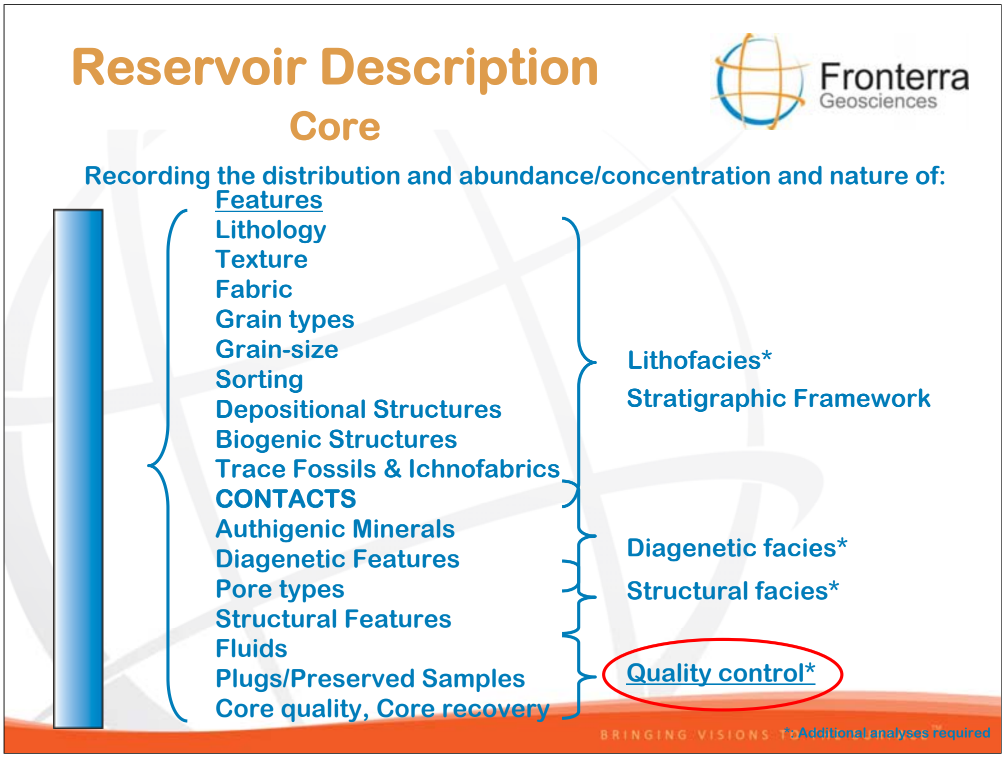
This presentation is based personal experience. Procedures for building reservoir models have been published and many have similar work flows (Martin *et al.* 1997). Reservoir rock types are the fundamental building blocks of a reservoir model, but they require a geological framework to populate the model. If most people agree on the work flow and perform the work to the highest standards, the question becomes, Why do reservoir models fail? Geology is an important and often under-appreciated component.

Geophysics, wire-line logs, production logs and petrophysical data are all involved in the result, but the basic framework has to be geological, even if the petrophysical rock types do not match geological reservoir rock types in detail, they will be constrained by geological layering and, to a lesser extent, by the various facies types.

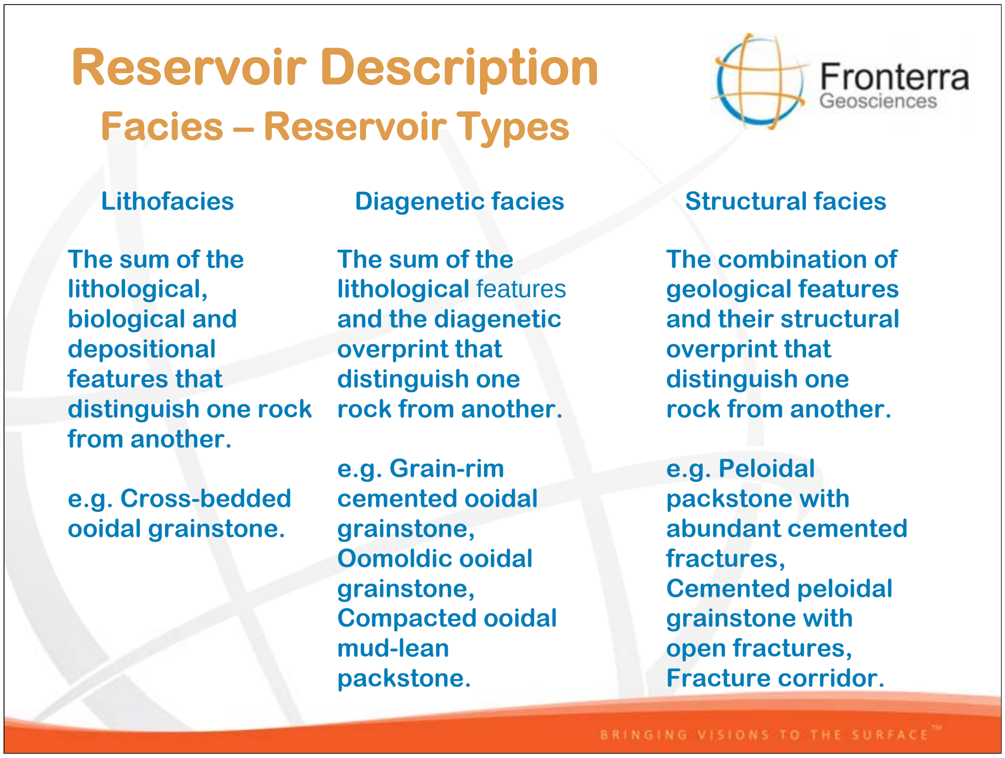


Core is the only direct control on the geological and physical properties of the material that forms the framework in which the resources reside. Core description can provide some information on the nature and distribution of fluids but is mainly concerned with the distribution of solids and spaces. AS the talk progresses, the brackets will remain and collapse to the left leaving room for more data.

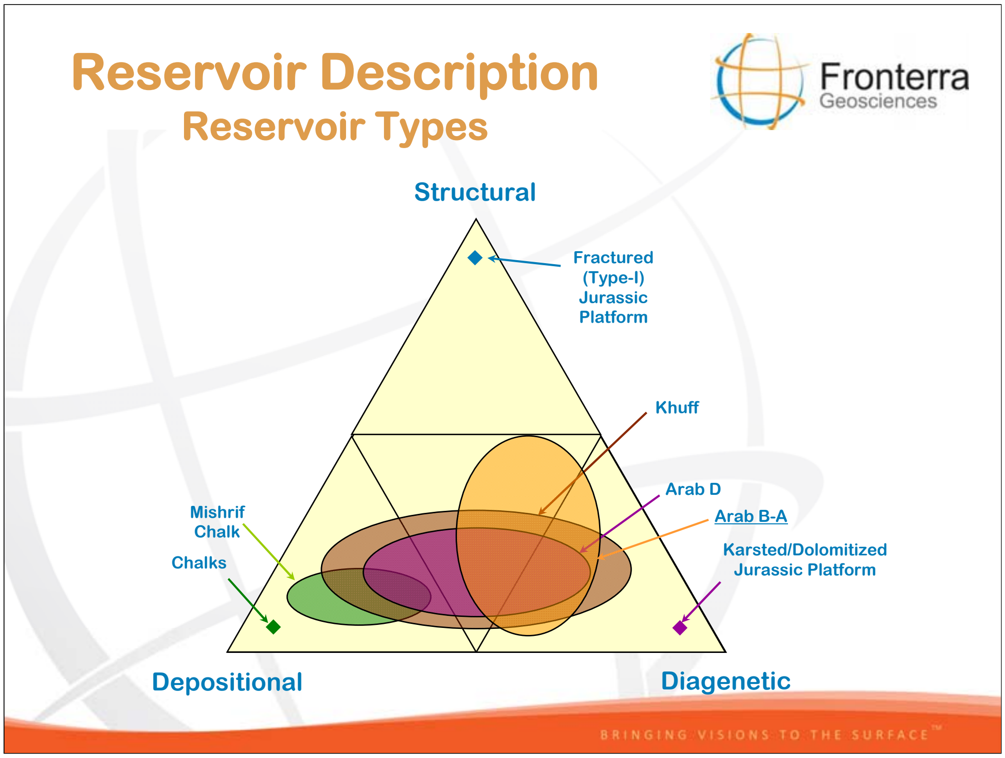
The amount of data to be recorded in a core description is large. Not only does the composition but the variations in composition, abundance and their distribution have to be recorded. Comments on the possible causes of features should also be recorded. The only efficient way to record this data is using core description software. Paper description of all the data is only possible with a lot of columns to fill and takes away time from interpretation and integration. Quality control as part of the core description is often absent or inadequate.



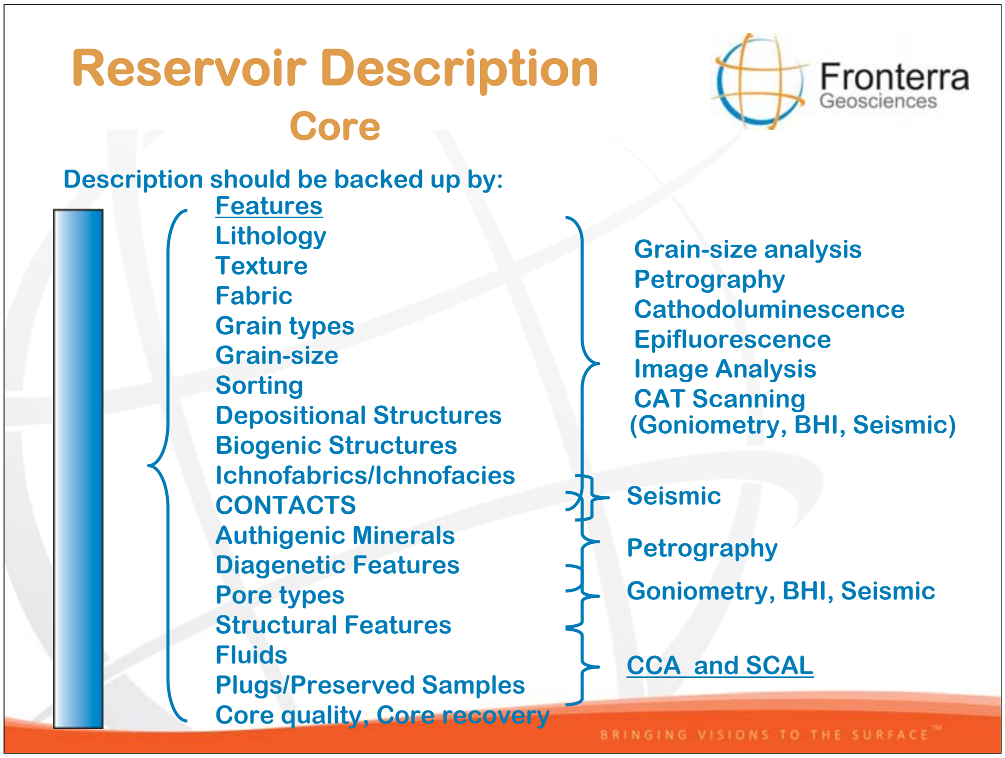
Core description has often been described as more of an art than a science. This is especially true in the past when it was done on a sheet of paper and the description was often more interpretive than descriptive. You can't fit all the data onto a convenient sheet of paper. Computer-aided logging has reduced/removed the limitations. All data is important, but some is more important. I would like the opportunity to re-log **<u>all</u>** my previous studies to improve them.



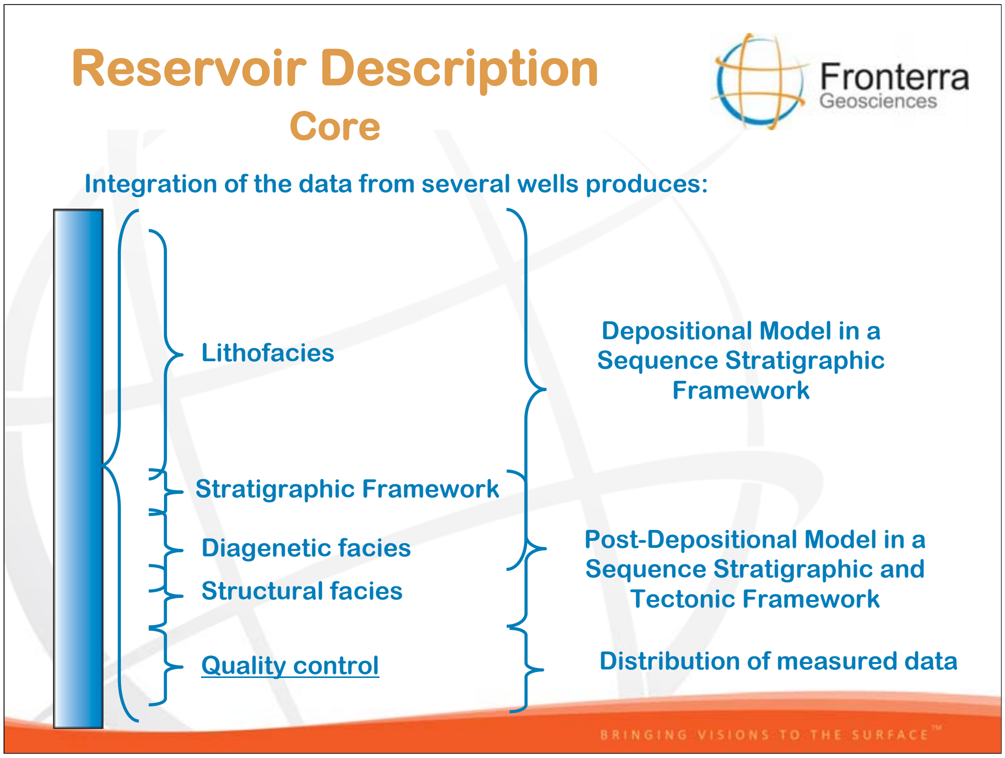
Although lithofacies should incorporate diagenetic and structural features, it is useful to separate them in your mind before synthesis. Each facies type has the potential to affect the reservoir behaviour in different ways. Depositional facies should be identified wherever possible, even though replacement is extensive. Understanding the distribution original facies (even when gobbled up by "pacman anhydrite") is essential to understanding the depositional **AND** diagenetic controls on the distribution geological reservoir rock types.



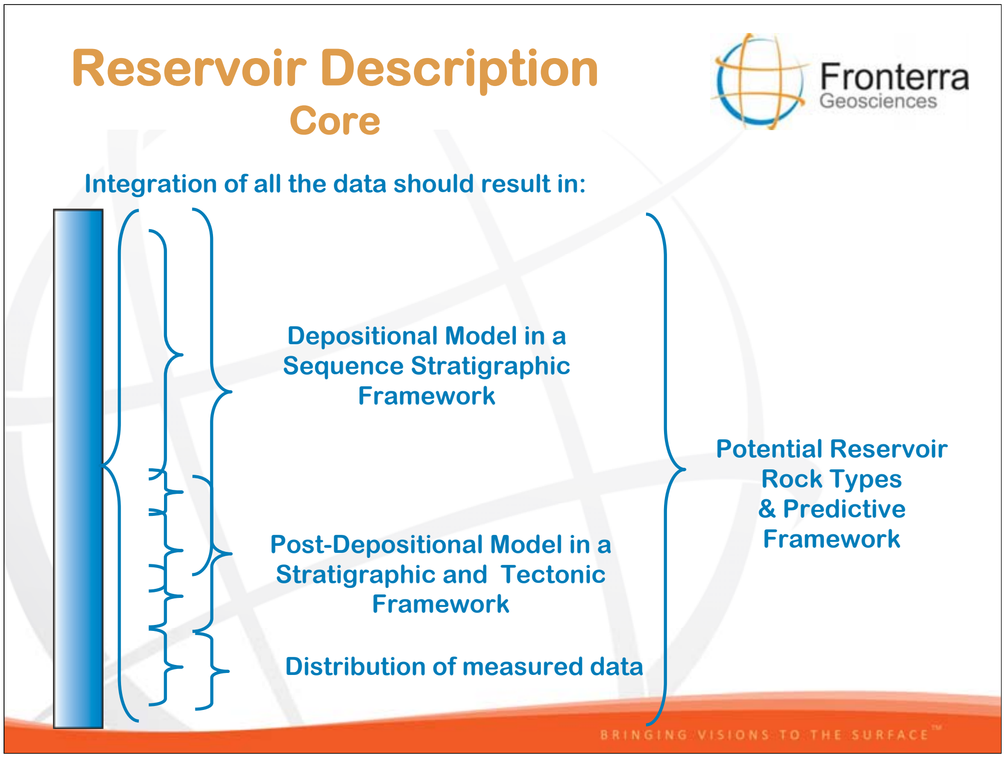
This diagram assumes that the original rock is sediment, but that the dominant controls on reservoir properties are either the original depositional fabric, diagenetic modification or structural modification. Not all parts of a reservoir will fall into the same category, some areas will be better cemented; others are more leached or more compacted; fractures are often clustered (heterogeneity). Although this diagram resembles that published by Ahr *et al.* 2005, this was generated independently



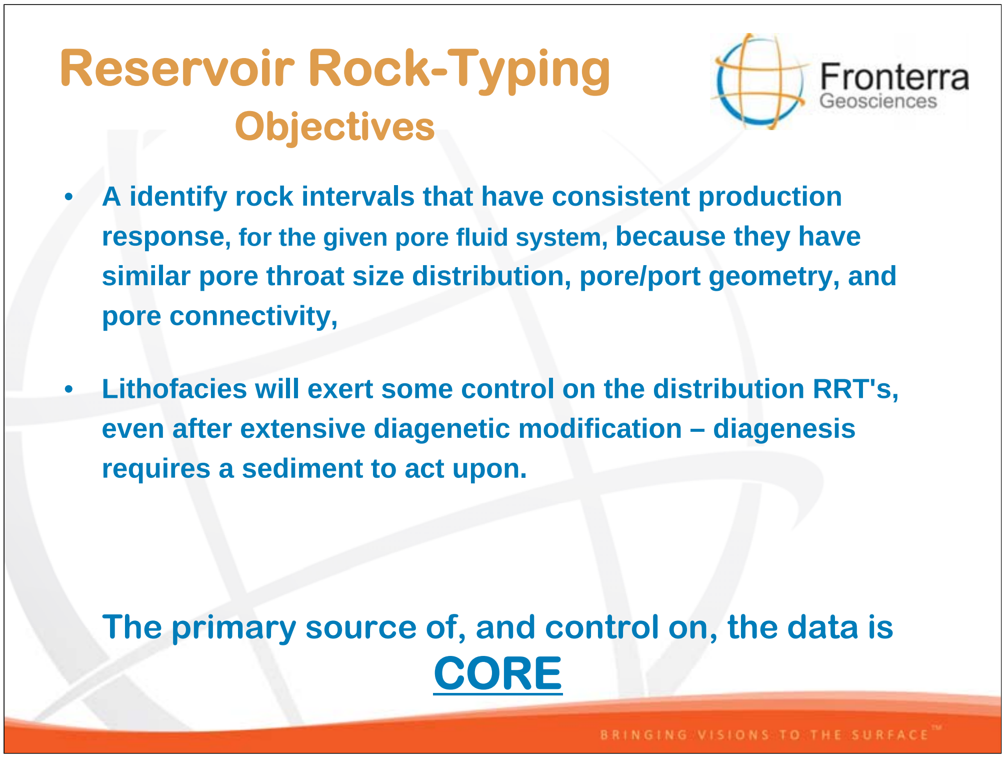
Examples of additional analyses that might be appropriate, based on the complexity of the reservoir and the information required to understand the reservoir. Petrography is often used to aid in sample selection and to provide quality control for HPMICP analyses. The list is not exhaustive; new techniques are always being developed.



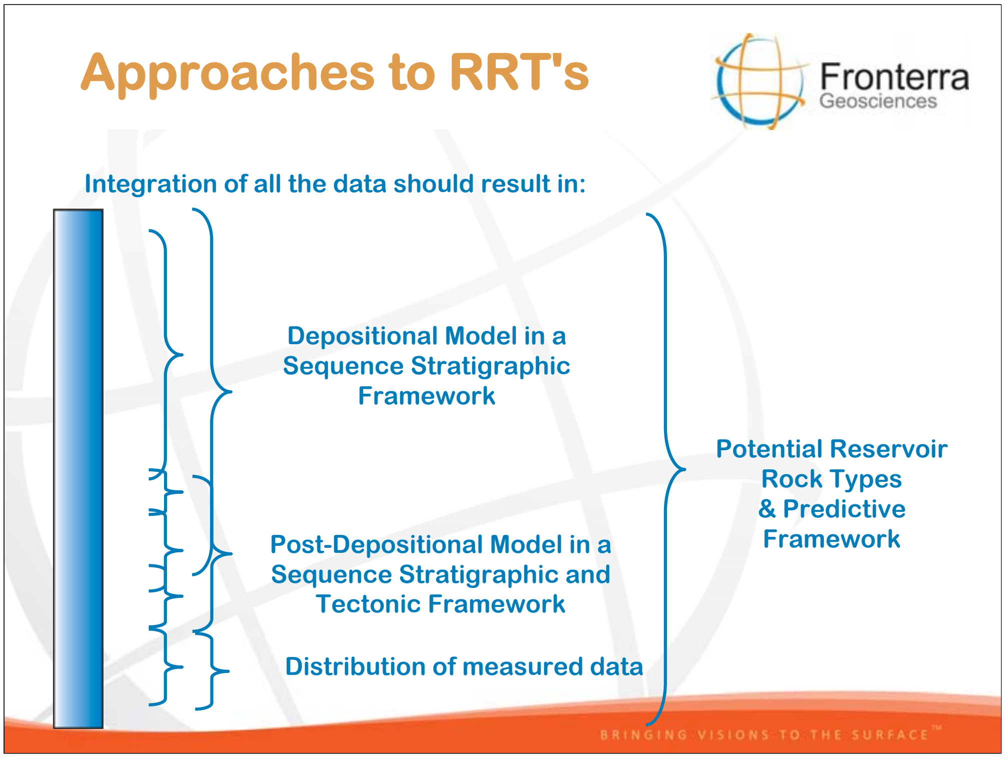
Integration of the data from the core description and subsequent analysis should give the depositional model, a model for the diagenesis by stratigraphic layer and the structural evolution and how that affected the depositional history and diagenesis. Although much of the data in individual wells should be in digital format, this does not mean that it can be given directly to the reservoir engineer or petrophysicist; simplification to a reservoir grid block scale is essential. Nor does it mean that the data will provide precise limits for facies.



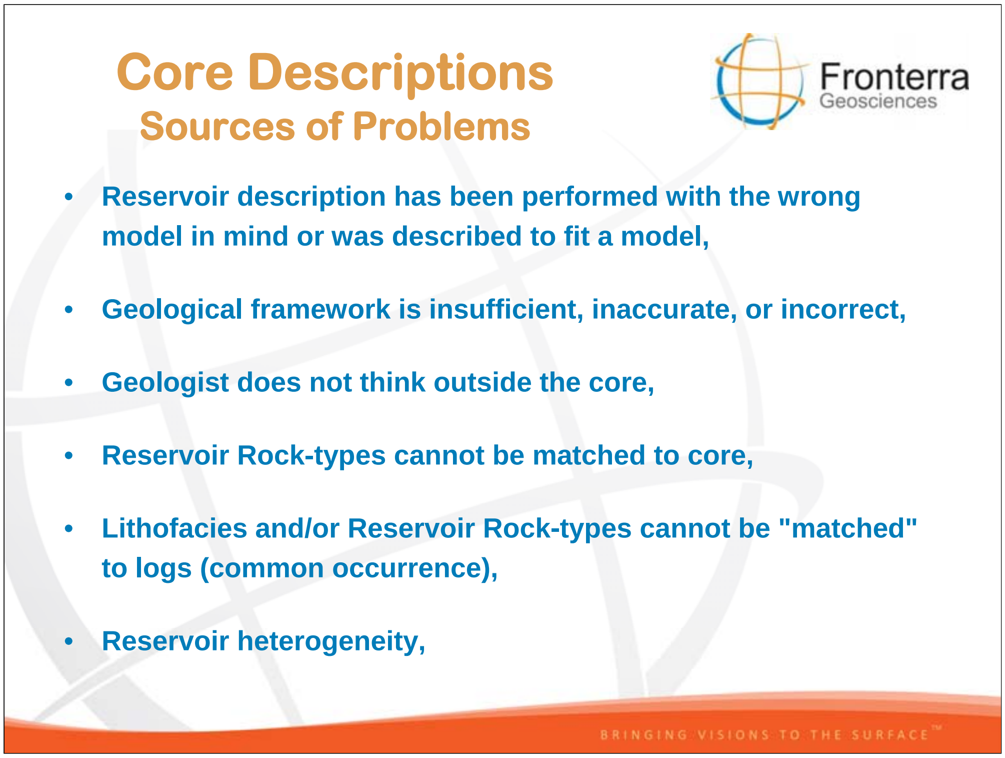
Having an understanding of the geological processes and their effects on the reservoir provides the initial indication for potential reservoir rock types and their distribution. The number of Reservoir Rock-types has to be small ; simplification is important. Using incorrect reservoir rock types or incorrect grouping of reservoir rock types is likely to lead to problems. Confirmation of reservoir rock types from Pc Purcell measurements; petrography should ensure the correct grouping and help detect heterogeneities. Accurate plug locations on a core description are also important.



Geological Reservoir Rock-types should incorporate depositional, diagenetic and structural facies. These should allow grouping for up-scaling and be capable of sufficient prediction potential for populating a reservoir model.



The number and nature of potential RRT's should fall out as a natural consequence of building the geological model. Similarly the reservoir model should honour the geological model, at least in terms of layering; the big questions for compatibility of the geological and reservoir modal arise from questions of scale.



Why do some reservoir models fail? My favourite answer is people. Douglas Adams wrote that "People are a problem". David Eddings wrote that "Many people are more firmly wed to their ideas than they are to their spouses." The rocks are just rocks and the fluids that flow through them are subject to physical laws. People often look at things from one perspective or get carried away with one set of features and forget the rest. Sometimes people lump the wrong data because they look at it from the wrong perspective.

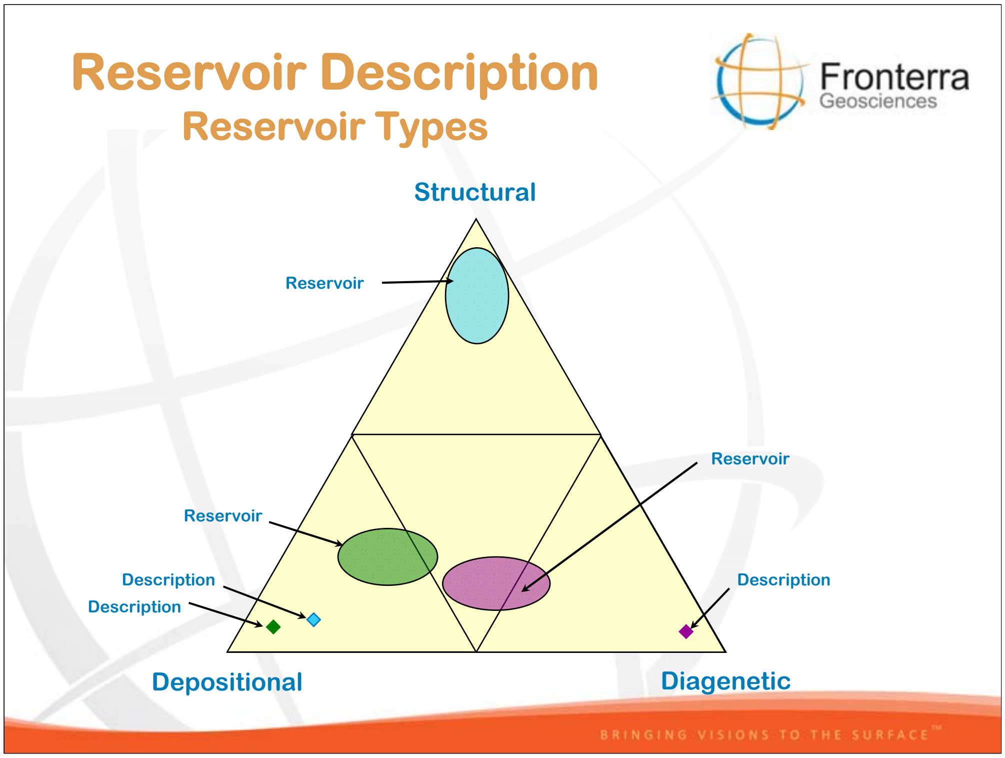
Reservoir models are built on a foundation of stone, but the model is not carved in stone. If a model does not work, the model should be analyzed to determine why, and then be upgraded. Revision and upgrading should be a continuous process.

Not fit for purpose would include descriptions that focused on single aspects to the detriment of the reservoir description.

Sample locations and comments on core recovery **and** quality are often missing.

Descriptions can be made with a model already in mind; it is easy to fall into the trap of describing those things that fit the model and ignore those that do not fit the model.

Ideas change, new techniques evolve, so descriptions and models should be updated periodically to ensure that the best quality and most up-to-date description is available; core logging software makes this easier.



Reservoir descriptions do not always match the described reservoir. These are examples of where I think descriptions plot as points, and where I believe the described reservoirs "plot" as ovals. Such differences can result from inexperience, from using a preconceived idea of the reservoir, and for becoming absorbed in one aspect of the reservoir to the exclusion of other aspects. Note different parts of a reservoir can have different reservoir types.

Reservoir Model
Sources of Problems

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- Problems CCA (QC, type of data, age of data),
- Problems SCAL (QC, type of data, age of data),
- Reservoir Rock Types are wrong or distribution is wrong,
- Reservoir Heterogeneity,
- Problems of scale (dataset is too complex, or too simple).

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Note that geological reservoir rock types might not match petrophysical rock types and even those might not fit with the reservoir engineer's reservoir rock types. However, the geological layering should control the reservoir layering and aspects of the depositional and diagenetic facies should help reduce uncertainty in the reservoir model.

Reservoir Model

Summary

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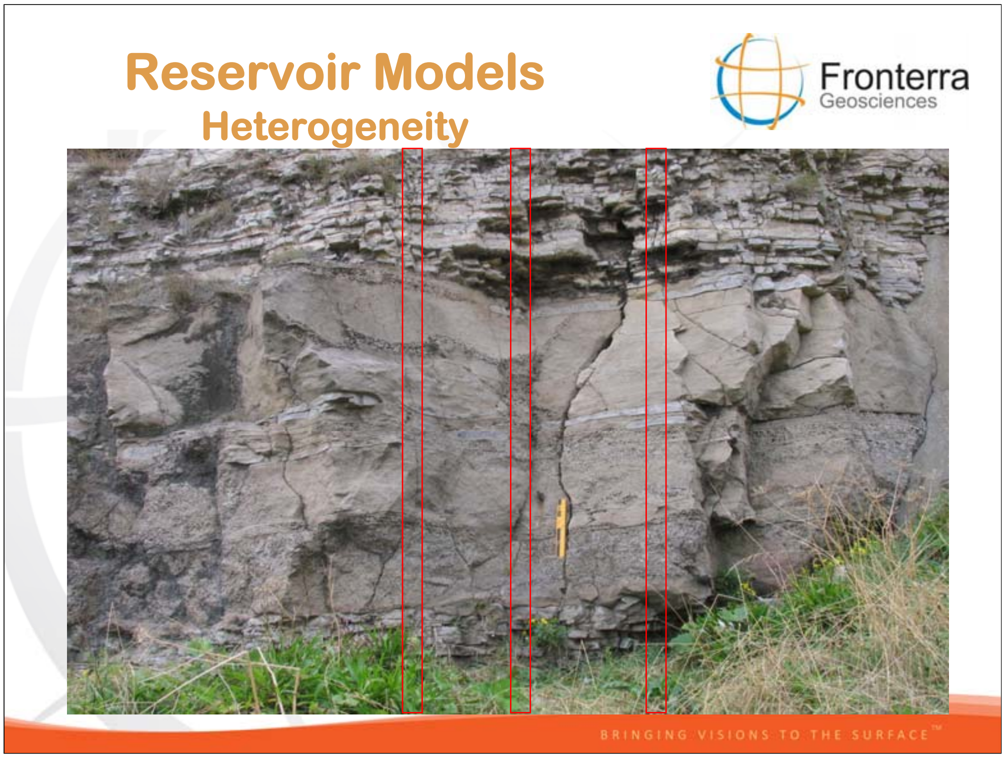
- Geological description and interpretation is required to help define a reservoir,
- Core description (and cuttings) data need to be analyzed carefully and used to provide quality control on samples, analytical data (CCA and SCAL), wireline logs and models,
- Geological reservoir rock types result from the core description and allied analyses; these aid in sample selection for SCAL,
- Reservoir layering results from the geological layering,
- Geological description helps understand aspects of reservoir heterogeneity.



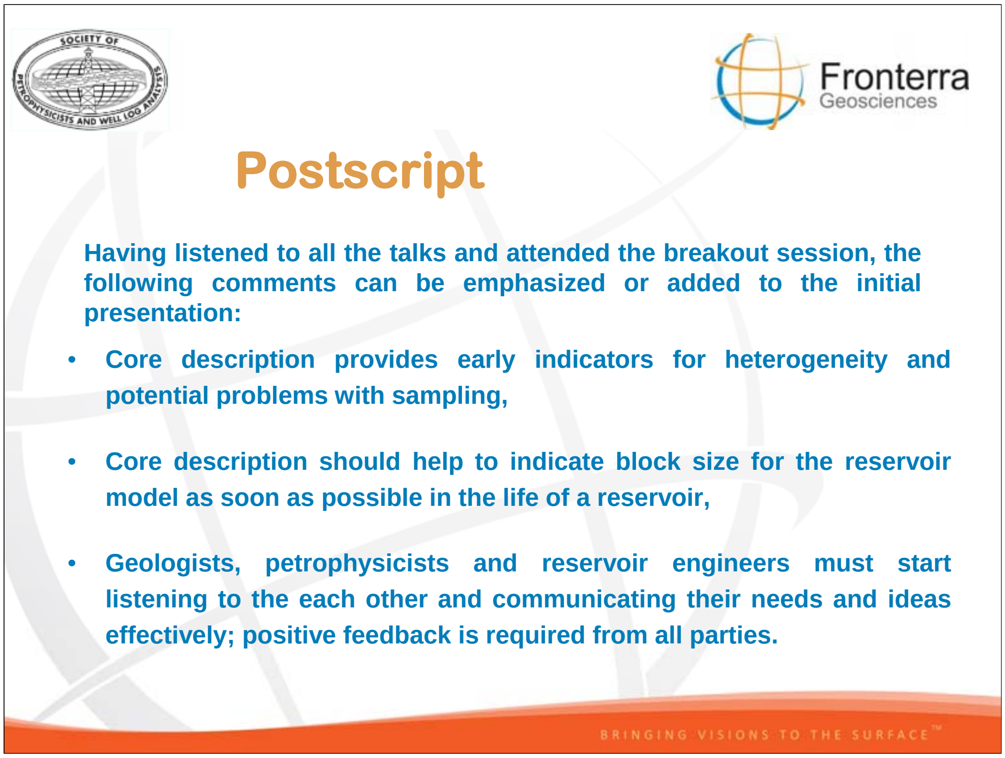
Core might be the ultimate control on the nature of the rock, but core and core descriptions do not yield unique solutions to the distribution of reservoir properties. Reservoir heterogeneity in this example is controlled by diagenesis within a depositional layering, but recognition of that fact can aid in reducing uncertainty.

Being a consultant is not a one way street. My favourite studies have been those where interaction with the clients has been greatest. These same studies are those that gave the greatest amount of useful information to the client.

References:

Ahr, W.M., Allen, D., Boyd, D., Bachman. N.H., Smithson, A., Gzara, K.B.M., Hassall, J.K., Murty, C.R.K., Zubari, H., and Ramamoorthy, R., (2005) Confronting the carbonate conundrum. *Oil Field Review*. Spring 2005, 18–29.

Martin, J.A., Solomon, S.T., and Hartman, (1997) Characterization of petrophysical flow units in carbonate reservoirs. *American Association of Petroleum Geologists Bulletin*, 81, 734–759**.**



Being a geologist, petrophysicists, or reservoir engineer is not a one way street. Geological data is vital, it needs to be supplied promptly at all stages of exploration and development and it must be in a format that can be used, incorporated into the model and updated as needed. Wireline logs of an interval are run once and the people that use them often forget the limitations. Core can be looked at reviewed and re-sampled repeatedly if it has been taken correctly and curated correctly.