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The Use and Abuse of Geological Fieldwork

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Summary

Geology is one of those wonderful subjects where nature has provided us with a laboratory right on our doorstep. This allows both geologists and specialists from other disciplines to examine outcrops and to learn from them, as well as providing a fascinating playground for amateur and non geologists alike. In some cases the rocks exposed at surface may act as direct equivalents to the same formations in the subsurface, as in many parts of Alberta, while in other cases it may be necessary to seek less direct analogues to those rocks from which hydrocarbons are being produced.

Introduction

The best way to learn about geology is to get out there and look at the rocks. Every outcrop is unique, and every outcrop provides a chance to learn. Dedicated field trip leaders can impart a wealth of knowledge to the participants, on a gamut of geological aspects that may run from structural, sedimentological, petrographical to palaeontological and beyond. Both geologists and non geologists can learn from careful observation of rocks in outcrop.

Theory and/or Method

Fieldwork can take on a variety of forms, but three styles stand out:

1. Dedicated fieldwork undertaken by geologists on a carefully chosen series of outcrops to elucidate the structural or sedimentary character of a particular formation or type of sedimentary deposit. The fieldwork is typically styled to answer a series of questions posed by uncertainties in subsurface data.
2. Geological field trip run by an expert in the geology of the selected region, with the aim of educating geologists through giving them access to world class exposures. The better the observation of the participants, the more they will learn. Discussion is to be encouraged at all times to maximize the sharing of learnings.
3. Multidisciplinary geological field trips allow non geologists to gain a huge amount of knowledge and understanding of geology in a short time. Fieldwork may be interspersed with lectures on selected geological topics to maximize the learnings. Field trips may include other subsurface technical disciplines, where discussion may focus on the suitability of outcrops as analogues to hydrocarbon fields in the subsurface on which integrated teams are working. Where the field trip is made up primarily of non geologists the level of science may be somewhat lower but the learning gradient extremely rapid. Such field trips work best in proven hydrocarbon provinces.

Examples

There are many aspects to the geological knowledge that can be gleaned from outcrop data, which relate to the different play elements required to fuel a working hydrocarbon system. Oil and gas may accumulate in structural or stratigraphic traps. In the former case the folding and faulting of sedimentary rocks creates large scale features which can be observed in areas like the Rocky Mountains. Here the behavior of rocks which have been subjected to enormous stresses can be explored and mapped, and models developed to explain their rheology and structural character. Many of these structural features are fractal, so even small outcrops can yield information on the largest folds. In addition the fracturing of the rocks is often well exposed, which is of particular relevance in brittle, fine grained reservoirs such as limestone and mudstone. Fracture patterns may be extremely difficult to understand from subsurface data alone. Stratigraphic traps generally form where large scale sedimentary features are encased in sealing rocks.

Almost all reservoirs are sedimentary deposits, and examination of these rocks allows a picture to be built up of the reservoir architecture at a variety of scales. At the large scale in clastic settings are features like coastal shoreface systems which may stretch for tens of kilometres, and deltas that prograde into seas or lakes. An oil or gas field may comprise a single one of these features. At the next scale down are mouth bars, channels and other features which, when stacked or in communication, may form one element of a field. All of these sand bodies are made up of beds, cross-beds, ripples and other sedimentary structures, which may provide critical data on the depositional setting in which the rocks were deposited. There is a similar scaling relating to carbonate deposits. Carbonate ramps or shelves may extend for tens of kilometres, while reefal build ups, bars and banks may make up reservoir elements with their attendant sedimentary structures. These deposits usually comprise chemical deposits and often a high proportion of framework building and other fossil material.

Many of these features can be traced out in outcrop, and the individual elements examined and compared to log and core data. This allows a detailed picture to be built up of the subsurface. The sedimentary structures, fossil and trace fossil elements can be recognized from different depositional settings in outcrop, and this knowledge applied to reservoirs. At the next scale down the composition, provenance and diagenesis can be characterized in the field, or through petrography, and models developed that can predict reservoir behavior in the subsurface.

Conclusions

The geologist can look at all of the above features in outcrop, using whatever detail is required as part of his or her work, while representatives of associated technical disciplines, such as geophysicists, petrophysicists and reservoir engineers can gain an improved idea of the scale and character of diverse reservoirs, seals, source rocks and traps. On any given field trip the different disciplines can share their knowledge and observations so that all can learn. In addition rock outcrops also provide the opportunity for non geologists to get out into the field to learn about how oil and gas are generated, trapped and eventually produced from the subsurface. In my opinion you can never see too many rocks, whether you are a geologist or not.

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