Oral Presentation

Variations in carbonate reservoir quality through time

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A key characteristic of carbonate reservoirs is that the biological components constituting the sediment have evolved through geological time. This is a function not only of evolution, but also of 1st and 2nd order eustatic sea level variations, which is closely tied to climate and the chemistry of the seas (aragonite/calcite). As a result, Precambrian carbonates are considerably different to their modern counterparts, not only in facies, but also in their early diagenesis, reservoir stacking and pore systems.

Carbonate sediments are highly susceptible to diagenesis, which can modify a reservoir at any stage of its burial/uplift history. Diagenetic modification is not always negative for reservoir quality, with karstification (both meteoric and hypogenic), dolomitisation and fracturing creating dual and sometimes triple porosity systems for hydrocarbons to migrate into. Despite the almost ubiquitous propensity for diagenesis to modify the pore system in carbonates, temporal trends in reservoir quality can still be recognised.

Precambrian and Palaeozoic carbonate reservoirs occur mainly in Central Europe, the Former Soviet Union, Barents Sea, China and North America. Whilst the reservoirs typically have a reefal character (i.e. the Devonian build-ups of Western Canada), most of these reservoirs rely on later diagenesis (karstification, fracturing, hydrothermal/burial dolomitisation) to generate reservoir quality.

Permian and Triassic carbonate reservoirs have both organic and inorganic origins. For example, the reefal reservoirs of the Permian Basin in the USA are well-known, having been produced for many years. However, on the other side of the world, Permian to Early Triassic oolitic grainstones and dolomites are the reservoir to the largest gas field in the world, namely South Pars/North Field (on the Iran/Qatar border). Despite this, Permian and in particular, Triassic, reservoirs commonly have poor reservoir quality compared to some of their younger counterparts.

Jurassic carbonate reservoirs, and the Upper Jurassic in particular, are often world-class. These are distributed primarily in the Middle East/North Africa, Mexico/southern USA and to some extent Europe and Canada. Although Jurassic reefal reservoir systems do occur, the majority of reservoirs are characterised by laterally extensive and vertically stacked grainstones (oolitic/peloidal). Dolomitisation, and often late dissolution, commonly enhance reservoir quality.

The Cretaceous was a prolific geological period for carbonate deposition. The evolution and dominance of rudist reefal communities, and the shear diversity of platform types during this period, resulted in a vast array of carbonate reservoir types. These range from

- Shallow-water platformal reservoirs (prolific in Latin America/southern USA, and the Middle East and North Africa), where meteoric diagenesis is a common factor in the resultant reservoir quality
- Deep-water fractured carbonate reservoirs (Mexico, Middle East, southern Europe), which may have no effective matrix porosity, but produce through fractures

- Cretaceous chalks of the European North Sea (microporous fractured reservoirs)
- “Sub-salt” reservoirs of the South Atlantic margins.

Finally, Palaeogene and Neogene carbonate reservoirs predominate in SE Asia and the Middle East. These reservoirs are typically reefal in nature (i.e. Oligo-Miocene pinnacle reefs of Indonesia and Malaysia), and frequently these reservoirs can have very good matrix reservoir properties.

It is clear that reservoirs, of course, form only one element of the “reservoir-source-seal-trap-migration” story that is necessary for successful trapping of hydrocarbons. Early migration of hydrocarbons is often a key component in halting burial diagenesis (and thus preserving reservoir quality), and the close temporal association to world-class source rocks is often key to the success of carbonate reservoirs.