Historic drilling and production data can be used to enhance exploration strategies focused on stratigraphic and subtle combination traps.

Searching for Stratigraphic Traps

Stratigraphic and subtle combination traps are those which cannot be defined by structural closure alone. They have a well-documented track record as significant contributors to global hydrocarbon resources.

“These types of traps tend to lack obvious four-way closure and are not usually discovered using the standard exploration strategies designed for structural traps,” Robert Trice, Exploration Director and co-founder of Hurricane Exploration explains, a UK operator.

“If associated with a major structure, they often occur in an unexpected place such as in a down-flank position. However, many giant fields are the result of stratigraphic or combination traps, including, for example, Prudhoe Bay, which has more than 12 billion barrels of oil in a combined subconformity dip and fault closure trap.”

Global Analogues

Robert believes that through evaluating key global statistics related to stratigraphic and subtle combination traps it is possible to demonstrate that these traps have historically represented an important hydrocarbon resource.

“The most commonly encountered stratigraphic trapping mechanisms are the ones which should offer the greatest potential as exploration targets, so these can be applied as analogues in the development of strategies for exploration. This is particularly pertinent to exploration on the North-west European Continental Shelf (NECS) and the UK Continental Shelf area in particular.”

In 2006 Robert, together with J. R. Allen and S. Q. Sun, published a paper entitled ‘The deliberate search for stratigraphic and subtle combination traps: where are we now?’ In this study they analysed more than 170 stratigraphic and subtle combination traps, discovered between 1885 and 1996. They attempted to classify them into a number of categories and discovered that nearly 70% of discoveries were to be found in lateral depositional pinchout, channel and valley fill and lateral facies change traps, all of which tend to be associated with deepwater facies.

“Using the analogue approach documented in the 2006 paper it can be concluded that significant exploration opportunities exist on the Northwest European Continental Shelf (NECS), where at least 48 producing fields have resulted from stratigraphic and subtle combination traps. In this area palaeostructural subcrop traps have historically dominated to the extent that they form 73% of the stratigraphic or combination traps in the area.
Robert points out that “the UKCS statistics are complicated by the fact that they include the major early discoveries, such as Brent, Dunlin and Statfjord, which, although trapped by stratigraphic means, were drilled due to their association with significant structures. Therefore, although palaeostructural subcrop is an effective trapping mechanism, for future exploration of the NECS the search should be focused on synclinal areas, as the bulk of the significant highs have now been explored. In such settings trapping mechanisms like lateral depositional pinchout, lateral facies change, clastic macroform and channel-fill offer promising future exploration opportunities, particularly for deeper water facies, such as those associated with submarine fan and slope environments.”

**Case studies are key**

“When we looked at significant commercial discoveries on the NECS, they appear to have resulted from both serendipitous and planned exploration of stratigraphic and subtle combination traps,” Robert says. “For example, the opportune discoveries of the Halfdan and Alba fields were stratigraphic trap discoveries resulting from extended reach horizontal drilling and drilling for a deeper target respectively.”

“By contrast, the Buzzard Field is a good example of a discovery which resulted from the development of stratigraphic play concepts, drilling after new seismic surveys had reduced risk to an acceptable level.” This field, discovered in 2001 and one of the largest field developments in the North Sea for more than a decade, came onto production in January this year. It is estimated to hold 500 million barrels recoverable (80 million cubic metres) of oil equivalent within a stratigraphic trap in an Upper Jurassic deep water play (GEO ExPro Vol. 2, No. 2/3).

Robert explains the exploration concept behind this discovery. “It was thought that basin depocentres could contain thick successions of well-bedded, reservoir quality sandstones, coincident with oil mature source rock. The original well, drilled in 1986, had a thin oil column and thick sands, which supported the concept, but it targeted Upper Jurassic submarine fan sandstones on a small structural closure. Regional 2D seismic data, however, indicated that the stratigraphic potential up-dip of this well had not been tested. Reprocessing of 3D data in 2000 highlighted abundant minor faulting at reservoir level and imaged both base reservoir and intra-reservoir surfaces. The trap is now known to comprise pinchout against a graben slope, with lateral onlaps to intra-basinal, and fault-related bathymetry with a local fault seal.”

A further analogue that demonstrates how preliminary drilling results led to a change in the exploration paradigm and resulted in a stratigraphic trap discovery is the Everest Field. This is a good example of a stratigraphic trap, which was only successfully explored after the first wells had targeted older Jurassic structures. These initial wells, drilled in 1970, penetrated chalk unconformably overlying Triassic shales and tight Permian and Devonian sandstone. The presence of oil shows in Lower Paleocene sandstones in 22/9-1, downdip of stratigraphically equivalent mudstones in 22/10-1, raised the possibility of an intervening stratigraphic trap. Further seismic confirmed the presence of a Paleocene stratigraphic trap, with updip regional pinchout or shaleout and downdip closure beneath intraformational shales. The field was discovered in 1982 but only came on production in 1993, and is estimated to contain 699 Bcfg (20Bm3) recoverable.

“It is important to look at known discoveries carefully,” Robert adds. “By analysing NECS case studies we can demonstrate the key elements of how and why specific stratigraphic traps have resulted in commercial discoveries.”

**UKCS and NECS exploration potential**

After reviewing individual field case studies from the UKCS and NECS, Robert
suggests that an overview of the overall exploration potential for the UKCS can be used as an analogue to infer which geological settings are likely to provide significant opportunities for stratigraphic trap exploration in the NECS.

Such an overview is summarised by the DTI 2004 (UK Department of Trade and Industry) figures which indicate that, of the up to 21.3 billion barrels (3,4Bm) of recoverable oil equivalent forecasted as the yet-to-find resource of the UKCS, at least 50% is located within stratigraphic traps,” Robert explains. “Of this 50%, 5% are anticipated to be found in primarily Carboniferous and Lower Permian reservoirs, 17.5% in Upper Jurassic deep water plays and 33% in post-rift Palaeogene and Lower Cretaceous deep water reservoirs.

It is these Lower Cretaceous deepwater reservoirs that are of particular interest to Robert and Hurricane Exploration in their evaluation of their West of Shetlands (WOS) acreage.

“Hurricane Exploration and its 50% partner Sunshine Oil plc are working a 14 block licence and believe that the WOS offers a significant opportunity for the explorationist who is willing to try new concepts and apply different thinking,” Robert says.

The West of Shetlands is a proven oil province, well covered by 3D seismic and yet underdrilled in comparison to the North Sea. Drilling results demonstrate that many of the early exploration ideas were focused on drilling significant structural targets that we now know to have been “bald highs” and therefore devoid of reservoir. The opportunity remains to apply current thinking and new technology to locate and drill features in structural lows that have the potential to enclose stratigraphically trapped opportunities.

**Structural traps still preferred**

“Despite the key learning gained from evaluating global analogues, and the remaining upside in the exploration for stratigraphic and subtle combination traps, structural traps remain the preferred target,” says Robert. “This industry perspective is perfectly understandable and is related to the specific challenges associated with stratigraphic and subtle combination traps, such as poor seismic resolution, which can make it difficult to identify the up-dip or lateral seals to a trap to prove closure and also increase risk on quantifying anticipated in place hydrocarbon volumes.”

“It is also possible to misinterpret a large combination trap as a small structural closure through failing to recognise the stratigraphic component, or to fail to recognise a stratigraphic or subtle trap due to an unfamiliarity with unconventional trapping mechanisms, such as basin-