



The deliberate search for stratigraphic and subtle combination traps: Using exploration analogues to develop exploration strategy.

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Stratigraphic and subtle combination traps have a well-documented track record as significant hydrocarbon resources. By reviewing the exploration history and geological/geophysical components of previously drilled examples it is possible to distil key elements from stratigraphic and subtle combination traps that can be applied as analogues in the development of strategies for exploration. This perspective is demonstrated by four arguments pertinent to exploration of the Northwest European Continental Shelf (NECS). Firstly, examples of exploration trends which have been collated from global analogues can provide insight into developing exploration strategy by providing information on what types of trap are likely to provide future targets and in which geological settings. Secondly, key learning from specific NECS case studies can demonstrate the key elements of how and why specific stratigraphic traps have resulted in commercial discoveries. Thirdly, an overview of the exploration potential for the UKCS can be used as an analogue to infer which geological settings are likely to provide significant opportunity for stratigraphic trap exploration in the NECS. Lastly, techniques are available by which the challenge and risk of developing an exploration strategy focused on evaluating stratigraphic and subtle combination traps can be significantly alleviated.

Stratigraphic and subtle combination traps are herein defined as traps that cannot be defined by structural closure alone. Through evaluating key global statistics related to stratigraphic and subtle combination traps it can be demonstrated that stratigraphic and subtle combination traps have historically represented a key hydrocarbon resource. Within this resource base there are specific stratigraphic trap mechanisms that are more commonly encountered and by analogue should offer greater potential as exploration targets (figure 1).

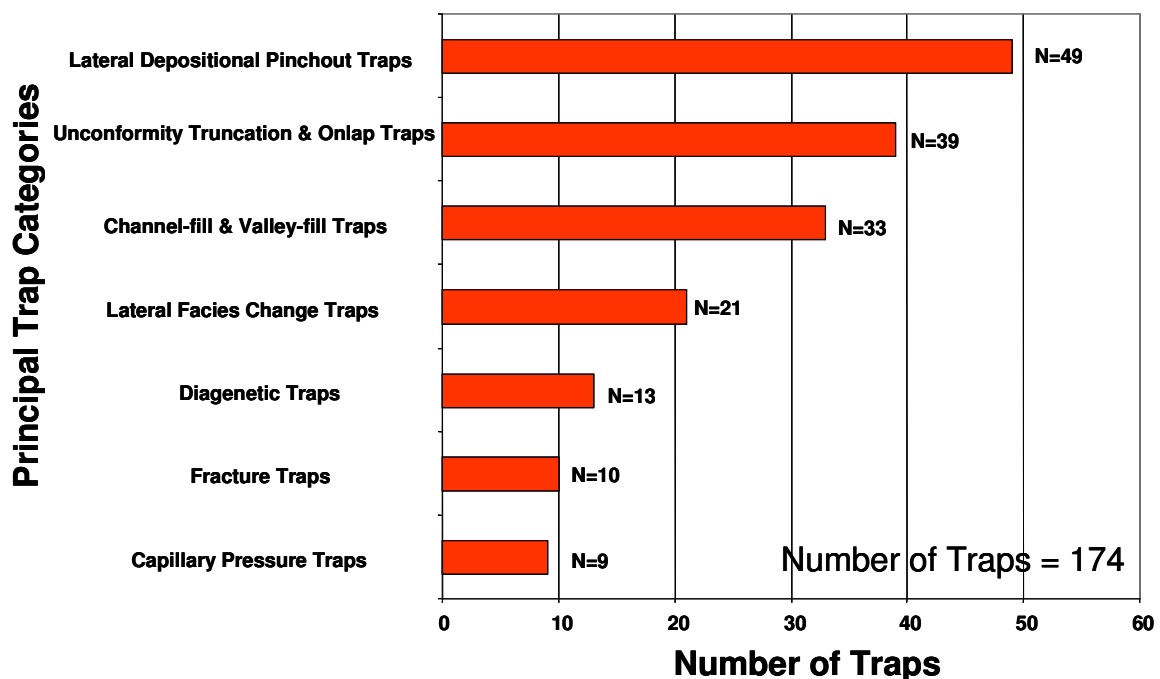


Figure 1. Distribution of principal trap categories for stratigraphic and subtle combination traps.
(Allen et. al., 2006)



Figure 1 is based on an evaluation of global stratigraphic and subtle combination traps and portrays the principle trap categories associated with 174 commercial fields (Allan et. al., 2006). The most promising stratigraphic trap geometries for future exploration success include lateral depositional pinchout traps, channel fill and valley fill and lateral facies change traps, all of which are commonly associated with deep water facies and are best evaluated through techniques based on 3D seismic data. Although such targets are the focus for exploration efforts in Angola, Brazil, Nigeria, and the US's Gulf of Mexico (Alexander Gas and Oil feature 2004), significant exploration opportunity also exists on the Northwest European Continental Shelf (NECS) where stratigraphic and subtle combination traps form an attractive play type. At least 48 producing fields within the NECS have resulted from stratigraphic and subtle combination traps with paleostructural subcrop traps dominating (figure 2).

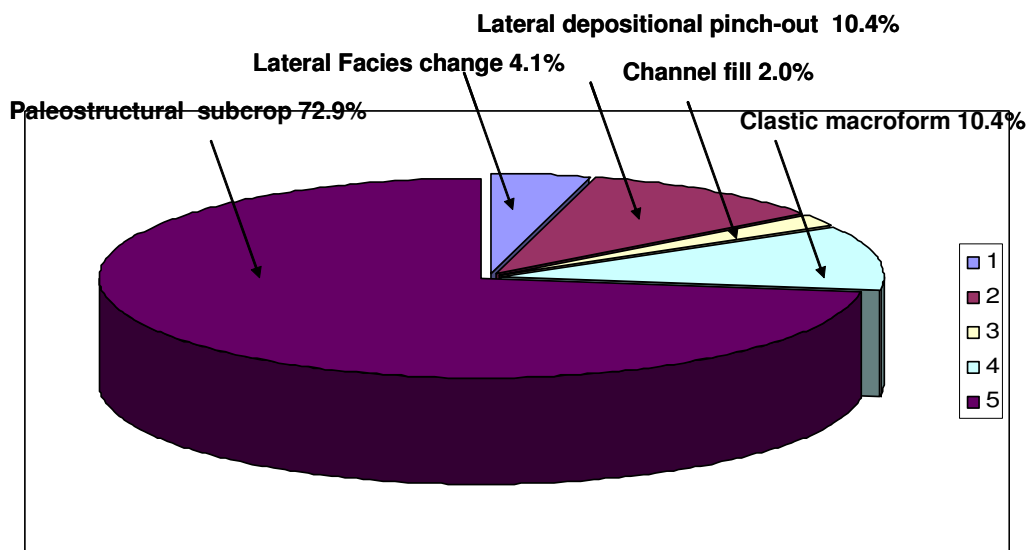


Figure 2. Stratigraphic and subtle structural trap mechanisms associated with 48 fields from the Northwest European continental shelf (source data C & C Reservoirs inc.).

It is important to note that the data collated as Figure 2 includes many of the earlier discoveries on the NECS e.g. Brent, Dunlin, Stafjord which although trapped by stratigraphic means were drilled due to their association with significant structures. Therefore, although paleostructural subcrop is an effective trapping mechanism, from the perspective of future exploration of the NECS, the search is more likely to be focused on synclinal areas as the bulk of significant highs have now been explored. In such settings trapping mechanisms such as lateral depositional pinchout, lateral facies change, clastic macroform and channel fill offer future exploration opportunities particularly for deeper water facies such as those associated with submarine fan and slope environments. This concept is illustrated by Figure 3. Figure 3 summarizes the distribution of depositional facies associated with stratigraphic and subtle combination traps from 48 NECS case examples. The distribution of depositional facies indicate that over 43% of the studied samples are related to deep water facies and reflects global trends indicating that deepwater facies to be attractive for stratigraphic plays.

Case studies from the NECS indicate that the finding of significant commercial discoveries, in deeper water facies has resulted from both serendipitous and planned exploration of stratigraphic and subtle combination traps. For example the serendipitous discoveries of Half Dan and Alba fields were stratigraphic trap discoveries resulting from extended reach horizontal drilling and drilling for a deeper target respectively. In contrast the Everest and Buzzard discoveries resulted from the development of stratigraphic play concepts and drilling after new seismic surveys had reduced risk to an acceptable level.

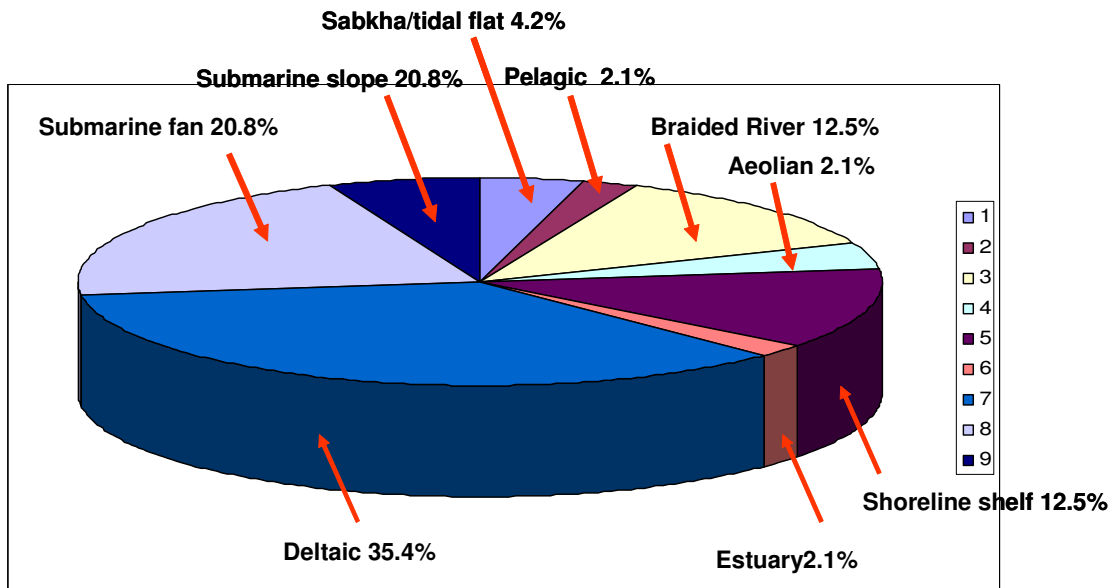


Figure 3. Depositional environments associated with stratigraphic and subtle structural traps collated from 48 fields from the Northwest European continental shelf (source data C & C Reservoirs inc.).

The potential for making other discoveries in stratigraphic and subtle combination traps on the NECS can be appreciated by considering the reasons behind past discoveries and the remaining potential of the UKCS and extrapolating to geologically related areas. DTI figures (DTI 2004) indicate that of the forecasted 4.1- 21.3 BBOE recoverable yet to find UKCS resource at least 50% is located within stratigraphic traps. The percentage of the remaining yet to find resource consists of stratigraphically trapped reserves comprising 5% remaining in pre-rift reservoirs primarily Carboniferous and Lower Permian, 17.5% in Upper Jurassic deep water plays, 33% in post rift Palaeogene and Lower Cretaceous deep water reservoirs.

Despite the key learning gained from evaluating global analogues and the remaining exploration upside in the exploration for stratigraphic and subtle combination traps structural traps are still the preferred exploration target due to specific challenges associated with stratigraphic and subtle combination traps. Such challenges include:

- (1) Relatively poor seismic resolution, which can make it difficult to identify the up-dip or lateral seals to a trap and prove closure.
- (2) The potential for misinterpreting a large combination trap as a small structural closure because of failure to recognize a stratigraphic component to entrapment.
- (3) Failure to recognize a stratigraphic/subtle trap because of an unfamiliarity with unconventional trapping mechanisms (e.g. basin-centre gas, subtle fracture, hydrodynamic traps).

Despite these challenges the identification and risking of stratigraphic and subtle combination traps can be alleviated by appropriate use of analogue data combined with the application of conventional and specific exploration techniques. Conventional techniques include the construction of a detailed sequence stratigraphic framework and interpreting facies maps based on a sequence stratigraphic correlation. Such techniques work at their best in areas of good quality seismic coupled with robust well control. However, a sequence stratigraphic framework approach may help to delineate a trap but do little to significantly reduce risk on a prospect. To further reduce risk the use of 3D seismic techniques including AVO, seismic amplitude analysis, sand body geometry analysis and onlap/offlap modelling



(for example see case studies in Morgan, R.K. & Walker, I.M. 2006) can be of benefit. Other tools suited to risk reduction on stratigraphic and subtle combination traps areas in use/under evaluation include:

- (1) Use of long offset 2D seismic for improved visualization of stratigraphic trap geometries.
- (2) Application of high resolution sea bed geochemistry calibrated to local well data and field or discovery.
- (3) Application of ocean bottom resistivity profiling cross calibrated to local well data, field or discovery to delineate potential volumes/areas of high hydrocarbon saturation.

With the wide range of geological tools and abundant analogues available to learn from, the problem of developing an effective strategy for evaluating stratigraphic and subtle combination traps distils to prospect/lead ranking and the associated distribution of exploration budget. Such a process can be relatively benign if ranking is confined to the comparison of stratigraphic traps and subtle combination traps.

Stratigraphic and subtle combination traps remain a significant exploration target globally and within the specific region of the NECS. Future exploration success in the search for such traps is likely to be afforded to the explorationist who remembers that failure to recognize a stratigraphic/subtle trap must also be considered an exploration risk and that many stratigraphic/subtle traps have been discovered by the second or third leaseholder on relinquished acreage.

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References

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