Is It Trap? Is It Seal? A Move Towards Consistent Risking of Stratigraphic Traps*

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Abstract

Over the past decade, stratigraphic traps have been targeted for exploration drilling with increasing alacrity. As these endeavors have recorded notable success, it is likely that focus on these plays will continue. Pre-drill estimation of drilling success probability in this trap type is notoriously challenging, often because of confusion surrounding the definitions of the Trap and Seal geologic risk elements. Clarity during exploration is, however, essential if portfolio consistency is to be maintained. At the 2011 AAPG ICE, a Unified Upstream Risk Model was proposed to facilitate a common understanding of definition for nine independent geologic risk elements. This presentation is an elaboration of that scheme and focuses on the distinction between Trap and Seal. The issue is that the clear and simple distinction between the two risks in structural traps becomes potentially confusing in stratigraphic traps. The concept of Trap representing the presence of an antiformal configuration of reservoir rock; and Seal portraying the presence of a fine-grained capillary barrier immediately above the reservoir - is not so obvious in stratigraphic traps. The tangling arises because stratigraphic traps do not present an easily conceived view of Trap closure, i.e. a convex-upward structure. Similarly, Seal becomes perplexing because the presence of fine-grained rock above the reservoir only is no longer relevant. Rather, in stratigraphic traps, the presence of a capillary seal rock laterally adjacent to and below the reservoir must also be considered. Consequently, the differences between the two definitions can be unclear. The most common confusion revolves around into which risk element the up-dip pinch-out of reservoir resides. The same risk judgment is often assigned to both elements, thus double dipping. In addition, judgments are often assigned to the wrong element. Whilst the latter does not affect the overall estimated success chance of the prospect, it fails to accurately portray the geologic configuration of the prospect, rendering past-venture analysis inconsistent. Several schematics are here presented to outline the distinction between Trap and Seal in both trap types. As a codicil to the 2011 presentation on the Unified Upstream Risk Model, the authors offer this material as an opportunity to clarify Trap and Seal definitions in stratigraphic traps, an increasingly important component of many companies’ global prospect inventories.
A: Abstract
Over the past decade, stratigraphic traps have been targeted for exploration drilling with increasing alacrity. As these endeavors have recorded notable success, it is likely that focus on these plays will continue.

Pre-drill estimation of drilling success probability in this trap type is notoriously challenging, often as a consequence of confusion surrounding the definitions of the Trap and Seal geologic risk elements. Clarity during exploration is, however, essential if portfolio consistency is to be maintained.

At the 2011 AAPG ICE, a Unified Upstream Risk Model was proposed to facilitate a common understanding of definition for nine independent geologic risk elements. This presentation is an elaboration of that scheme and focuses on the distinction between Trap and Seal. Pre-drill estimation of drilling success probability in this trap type is notoriously challenging, often as a consequence of confusion surrounding the definitions of the Trap and Seal elements.

The issue is that the clear and simple distinction between the two risks in structural traps becomes potentially confusing in stratigraphic traps. The concept of Trap representing the presence of an artificial configuration of reservoir rock, and Seal portraying the presence of a fine-grained capillary barrier immediately above the reservoir—be it not so obvious in stratigraphic traps.

Several schematics are here presented to outline the distinction between Trap and Seal in both trap types. As a codicil to the 2011 presentation on the Unified Upstream Risk Model, the authors offer this material as an opportunity to clarify Trap and Seal definitions in stratigraphic traps, an increasingly important component of many companies’ global prospect inventories.

B: Introduction (Figures 1-3)
Over the past decade, stratigraphic traps have been targeted for exploration drilling with increasing alacrity. As these endeavors have recorded notable success, during the risking of exploration opportunities, particularly stratigraphic traps, the distinction between the Trap Closure and Trap Seal geologic risk elements can be confusing. ExxonMobil here looks to clarify the distinction by way of a codicil to the 2011 presentation on the Unified Upstream Risk Model, in which all nine of the company’s exploration geologic risk elements were described; the goal being to “Say What We Mean and Mean What We Say.” This initiative promotes a common understanding of the definitions of the individual geologic risk elements between geologists and managers, thus promoting clearly informed investment decisions.

C: Trap Closure risk element (Figures 4-15)
The Trap Closure geologic risk element describes the presence of a subsurface arrangement, geometry or configuration of rocks capable of detaining and retaining hydrocarbons migrated into the feature. It is important when risking exploration prospects to make a clear distinction between this Trap Closure geologic risk element and Trap Seal.

DEFINITION: Trap Closure
"The probability that a geometric-geologic configuration of rock containing a significant accumulation of hydrocarbons exists in the subsurface”

Trap configuration types include:
- four-way dip closure (antiforms)
- faulted anticlines (‘three ways’)
- fault independent closures
- closures against escarpments
- sub-trap closures
- stratigraphic traps

Geologic considerations:
- closure weight
- closure area
- trap geometry
- trap complexity
- closure control
- vertical exaggeration
- vertical quality
- alternate geologic interpretations
- valid tests of similar trap configurations
- borehole data
- structural style
DEFINITION: Trap Seal
The probability that a geological trap will be adequately sealed such that hydrocarbon accumulation will remain isolated from other parts of the reservoir.

DEFINITION: Trap Closure
The probability that a geological trap will be adequately sealed such that hydrocarbon accumulation will remain isolated from other parts of the reservoir.

TRAP CLOSURE - SUCCESS
This map exhibits a geological feature demonstrating Trap Closure success. The trap’s area (and height) are sufficient to collect and retain a significant volume of hydrocarbons, indicating that the trap is filled to the mapped spill point.

TRAP CLOSURE - FAILURE
This map illustrates an example of Trap Closure failure. The mapped geologic structure (dashed contours) does not actually exist. No structural closure exists anywhere in the mapped area, and the hydrocarbons have passed unimpeded through the mapped reservoir.

TRAP SEAL - SUCCESS
This map exhibits a geological structure demonstrating Trap Seal success. The structure’s top seal and fault seal are adequate to prevent hydrocarbons from escaping. Any fluids that have migrated into the structure have been leaked out at the crest.

TRAP SEAL - FAILURE
This map illustrates an example of Trap Seal failure. The structure’s interpreted top and/or faults seals do not actually exist. Any in-migrating fluids that have entered the structure have either leaked up the fault plane or across the fault and into the overburden on the hanging wall.

D: Trap Seal risk element
(Figures 16-25)
The Trap Seal geologic risk element describes the presence of an impermeable rock located above, below and alongside a valid geologic Trap Closure that is capable of preventing hydrocarbons migrated into the feature from escaping. It is important when risking exploration prospects to make a clear distinction between this Trap Seal geologic risk element and Trap Closure.
E: Stratigraphic Traps
(Figures 26–41)

Confusion between Trap Closure and Trap Seal often occurs when risking stratigraphic traps. Geologists are frequently unclear to which geologic risk element particular observations and concepts are relevant. It is important to clearly define the difference between the two. Trap Closure pertains to the chance that a viable geologic configuration will exist in the sub-surface. In stratigraphic traps this is simply a run of dip in the interpreted direction of reservoir termination. Trap Seal, as with structural traps, pertains to the presence of impermeable rock around the reservoir — preventing imigrated hydrocarbons from escaping the trap. Examples are provided here of success and failure of each, in stratigraphic traps, in order to clarify the definitions in stratigraphic trap circumstances.

Takeaway Messages
• Risk is in the context of the trap seal and model [currents]
• The question to: "Is there a gas cap?" or "Is there a closing contour?"
• As implied "Two of dip" in a strat trap is Trap Closure
• The implied location of the targeted reservoir is Trap Seal

What's Required for a Strat-trap Seal?
1. Lateral pinch-out, above, below and around
2. Faulted and compartmentalized, in a sealed area

Figure 26 – Strat Traps – What's Required for a Seal?

Figure 27 – Strat Traps – Trap and Seal Success – X-section

Figure 28 – Strat Traps – Trap and Seal Success – Map

Figure 29 – Strat Traps – Up-dip Seal Failure – X-section

Figure 30 – Strat Traps – Up-dip Seal Failure – Map

Figure 31 – Strat Traps – Trap Closure Failure – X-section

Figure 32 – Strat Traps – Trap Closure Failure – Map

Figure 33 – Strat Traps – Lateral Seal Failure – X-section

Figure 34 – Strat Traps – Lateral Seal Failure – Map

Figure 35 – Strat Traps – Eroded Up-dip Seal Failure – X-section

Figure 36 – Strat Traps – Eroded Up-dip Seal Failure – Map

Figure 37 – Strat Traps – Base Seal Failure X-section

Figure 38 – Strat Traps – Base Seal Failure – Map

Figure 39 – Strat Traps – Eroded Lateral Seal Failure – X-section

Figure 40 – Strat Traps – Eroded Lateral Seal Failure – Map

Figure 41 – Strat Trap Risking – Take Away Messages