The Predictive Power of Depositional Paradigms When Chasing Deep Water Sand-rich Turbidites*

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Abstract

A systematic petroleum exploration of deep water turbidites was triggered as part of a larger process during the worldwide expansion of seismic surveys since the 1980's, and seasoned by increasing quantity and quality. A great number of published articles and case histories have emphasized successful campaigns in the Tertiary and Cretaceous sand-rich turbidites in deep waters of sedimentary basins like the Gulf of Mexico, Campos, Congo, Niger Delta, and Mozambique, to mention a few.

On the other hand, failures of years and even decades in exploratory campaigns revealed a much less successful history in other basins, which can be accounted for by claiming the poor sand nature of certain basins or the erratic behavior of sand-rich turbidite sedimentation. Part of the disappointing results are due to the failure in recognizing or utilizing the most basic set of depositional paradigms related to turbidite sedimentation. These have a fundamental importance in the identification of turbidites, especially in seismic data.

Paradigms imprint attributes on seismic data as evidence of turbidites and serve to calibrate and constrain our search. Especially when looking in open and vast deep water regions. Depositional paradigms were comprehensibly relegated to the background due to the tremendous success of the binomial amplitude anomalies-DHI's and turbidites. The identification and mapping of such attributes, produced by depositional paradigms, provides the predictive stratigraphic framework for sand-rich turbidites in deep water, mitigating the exploratory risk. Such paradigms are flexible enough to accommodate the intrinsic difficulties in various basins at different levels of knowledge and exploration. Here I will discuss some of the depositional paradigms and associated attributes to recognize deep water sand-rich turbidite deposits in seismic surveys.

References Cited

Bruhn, C.H.L., 2001, Contrasting types of Oligeocene/Miocene, giant turbidite reservoirs from deep water Campos Basin, Brazil: Reservoir, v. 28/8, 10 p.

Cainelli, C., and M. Carminatti, 1994, Seismic criteria to recognize potential deep-sea sandstones in Brazilian passive margin basins: AAPG Annual Meeting Expanded Abstracts, p. 114.

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GTW Brasil, May 2014

AAPG Latin America Region | Geosciences Technology Workshops 2014

Co-hosted with

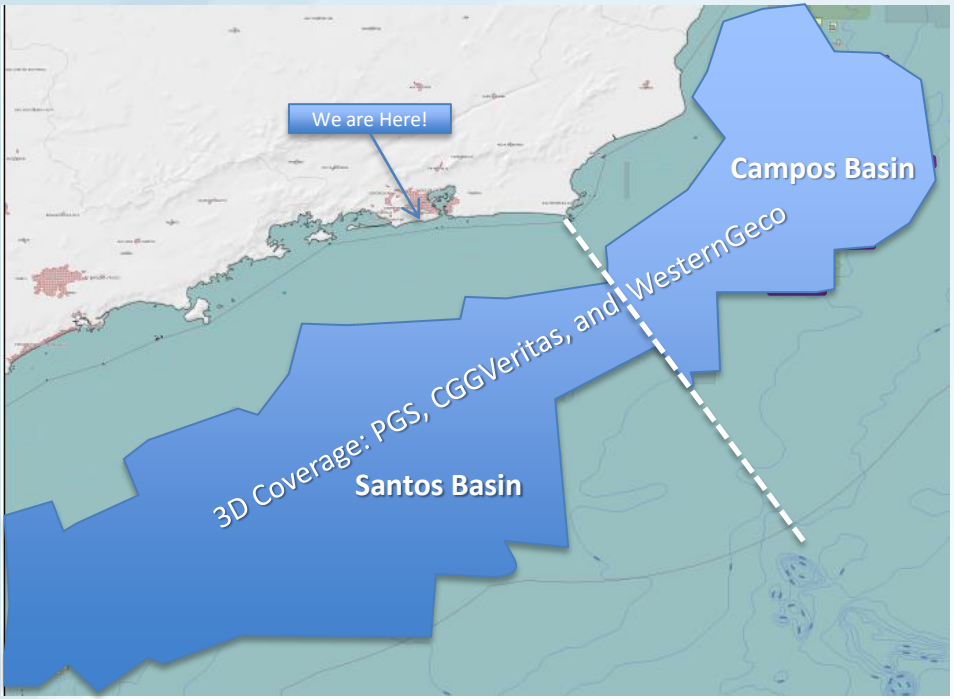
World´s Deep Water Activities

- BANUS Region concentrates 70% of volumes, activities and production in world´s deep waters
- Main deep water targets: Cretaceous and Tertiary sand-rich turbidites and nowadays pre-salt

Source: Company Information,

World´s Deep Water Exploration and Production Expansion

Large 3D Survey Database



Main Factors Fostering the Deepwater E&P Activities

- Massive use of 3D seismic surveys with increasing quality
- Drilling and production equipment capable to operate in deep waters
- Positive results from deep water deposits in size and production to sustain commercial development

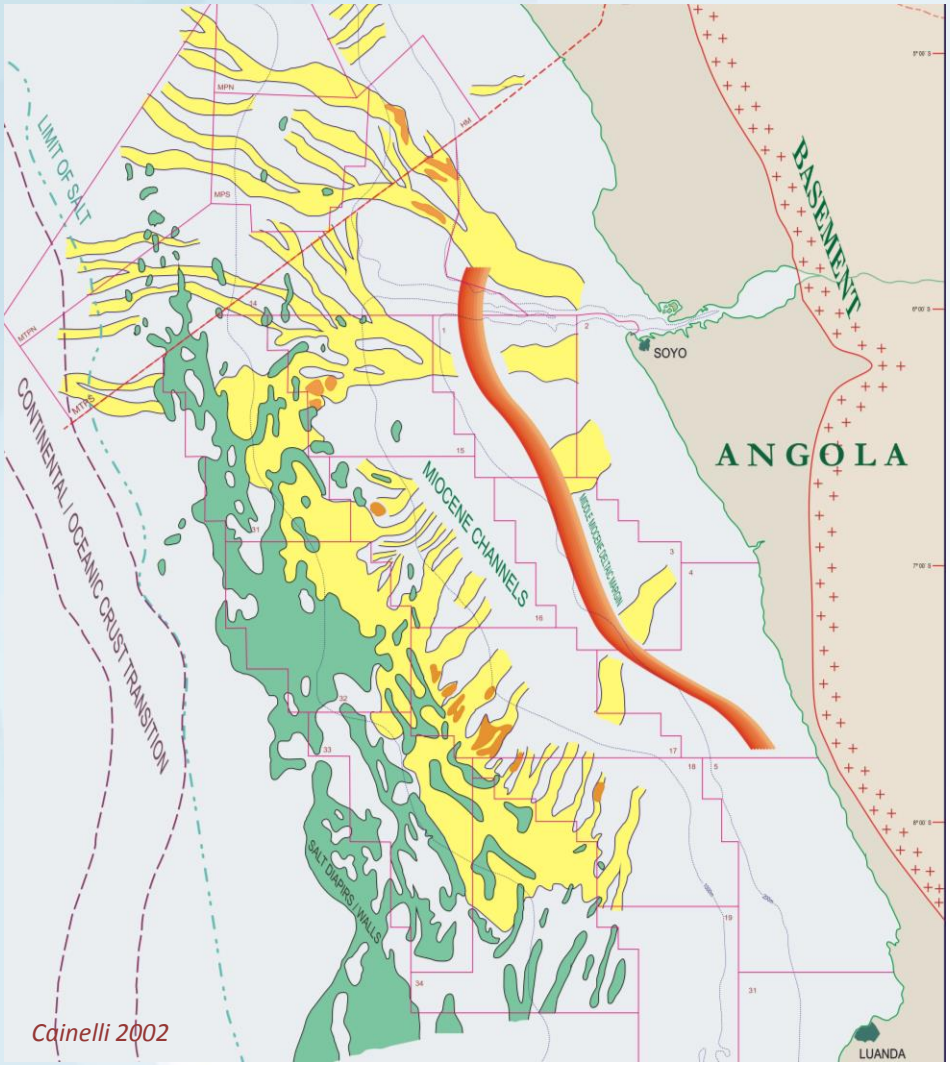
Main Seismic Facies seen in 3D Surveys

- Delta-fed meandering systems
- Channel-fan systems

Source: Company Information,

Main Seismic Facies: Delta-Fed Meandering Channel System

Miocene Channels – Lower Congo Basin



Cainelli 2002

3D Seismic Amplitude Map

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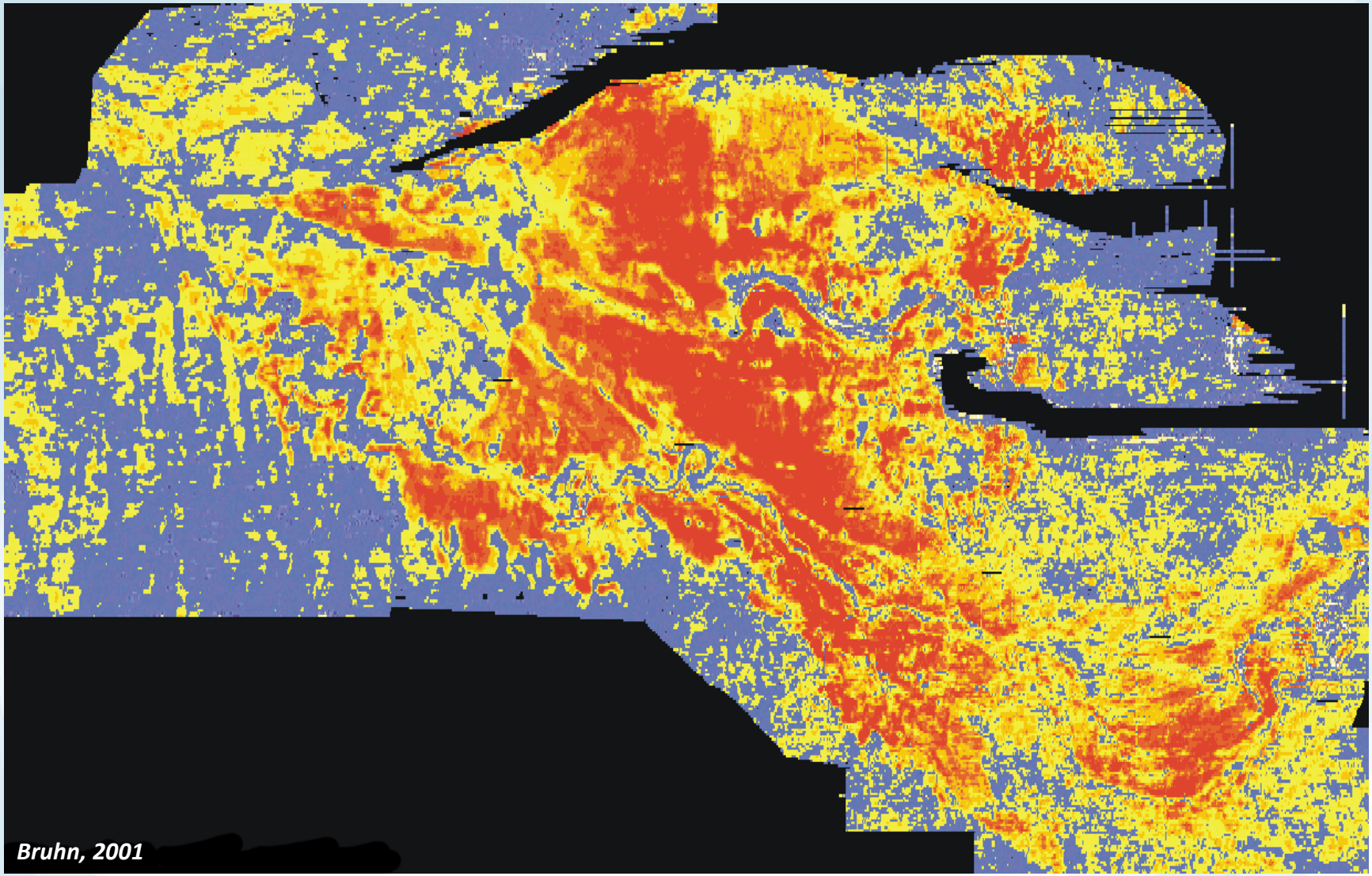
Source: Company Information,

Main Seismic Facies: Channel-Fan System



Source: Company Information, Petrobras,

Three Key Elements for Existence of Sand-Rich Turbidites

1 – Supplier: any element capable to concentrate sand as rivers, deltas, coastal systems, sand-rich shelves

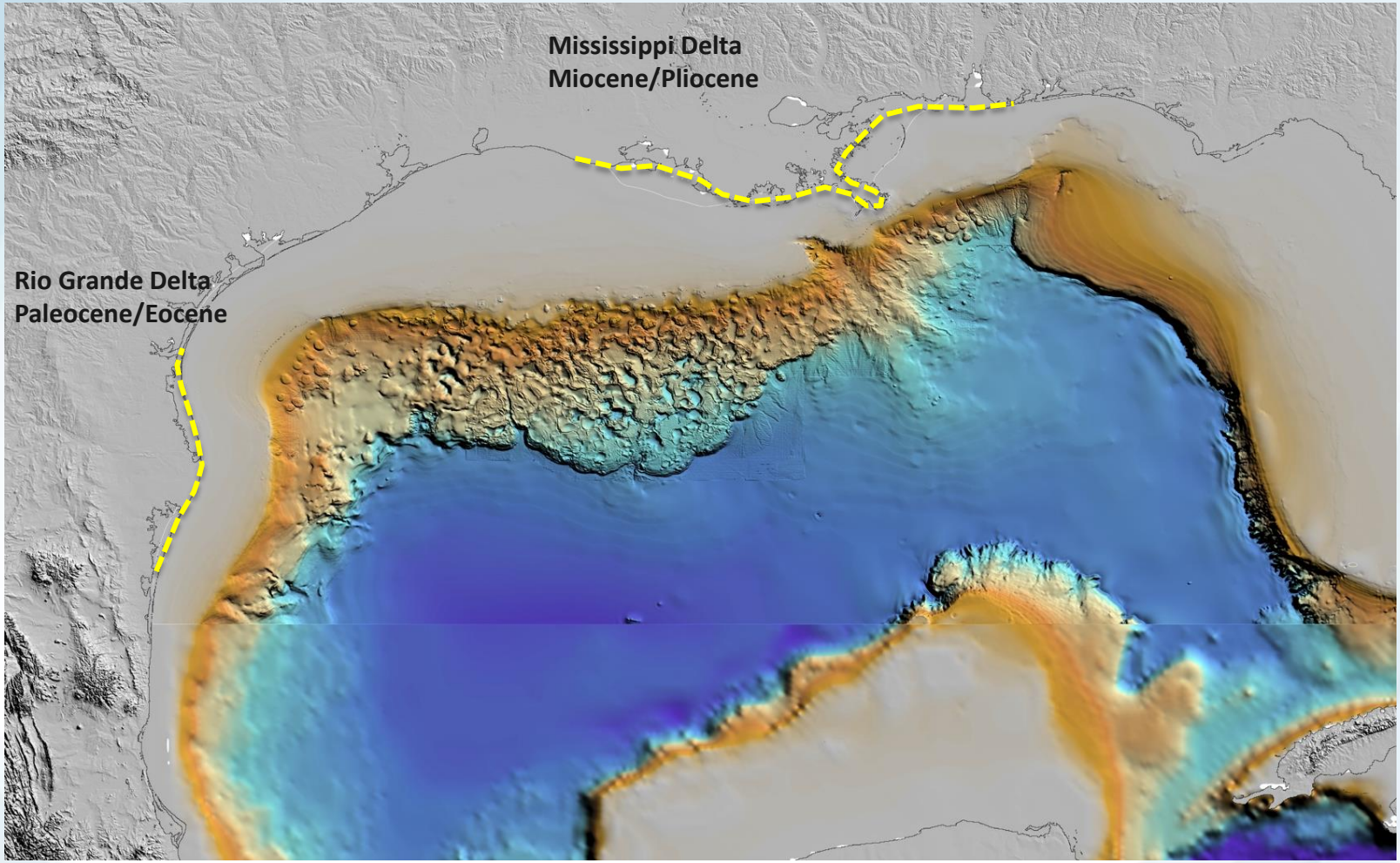
2 - Distributor: any element capable to transfer river or shelf sands to slope and basin plain

3 - Acummulator: any element/region capable to preserve and gather sand

Source: Company Information,

Three Key Elements for Existence of Sand-Rich Turbidites

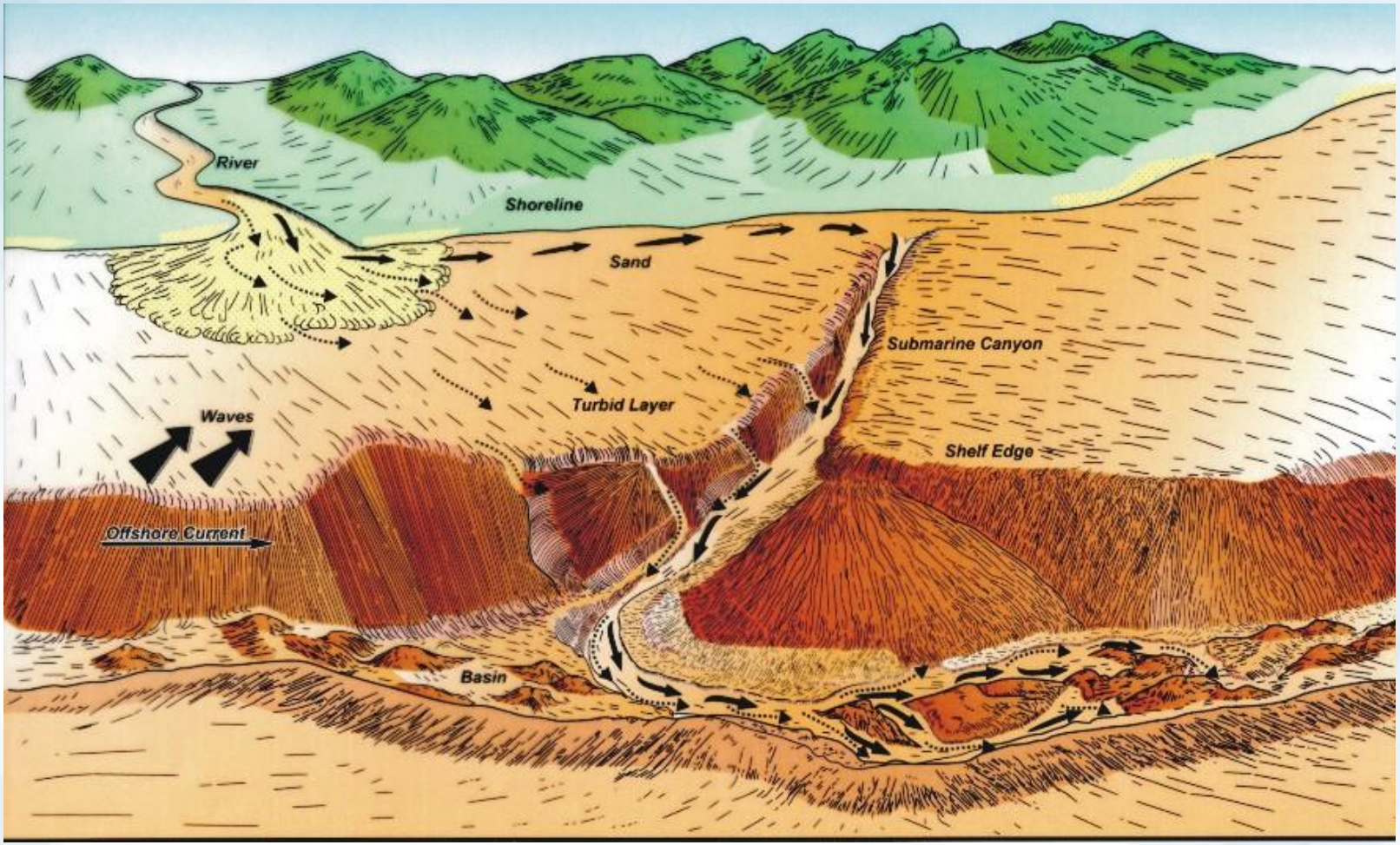
1- Supplier: any element capable to concentrate sand
Examples: rivers, deltas, coastal systems and sand-rich shelves



Source: Company Information

Three Key Elements for Existence of Sand-Rich Turbidites

2- Distributor: any element capable to transfer river or shelf sand to slope and basin plain
Examples: currents, sea level falls, earthquakes, incised valleys, mature canyons



Source: Company Information,

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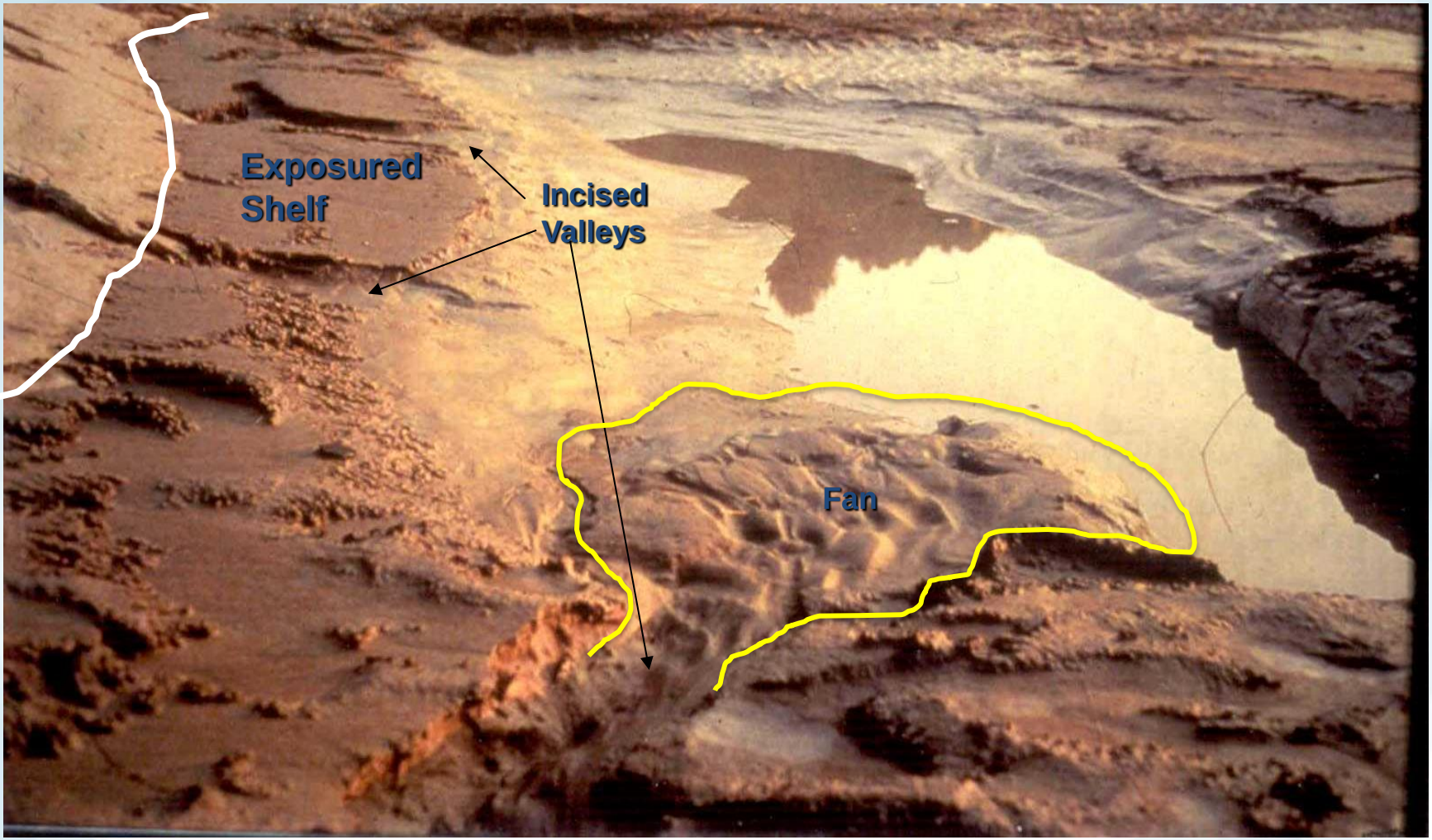


Source: Company Information,

Three Key Elements for Existence of Sand-Rich Turbidites

2- Distributor: any element capable to transfer river or shelf sand to slope and basin plain

Source: Company Information,

Sediment Plume – Catastrophic Flooding, February 1996

Source: Company Information,

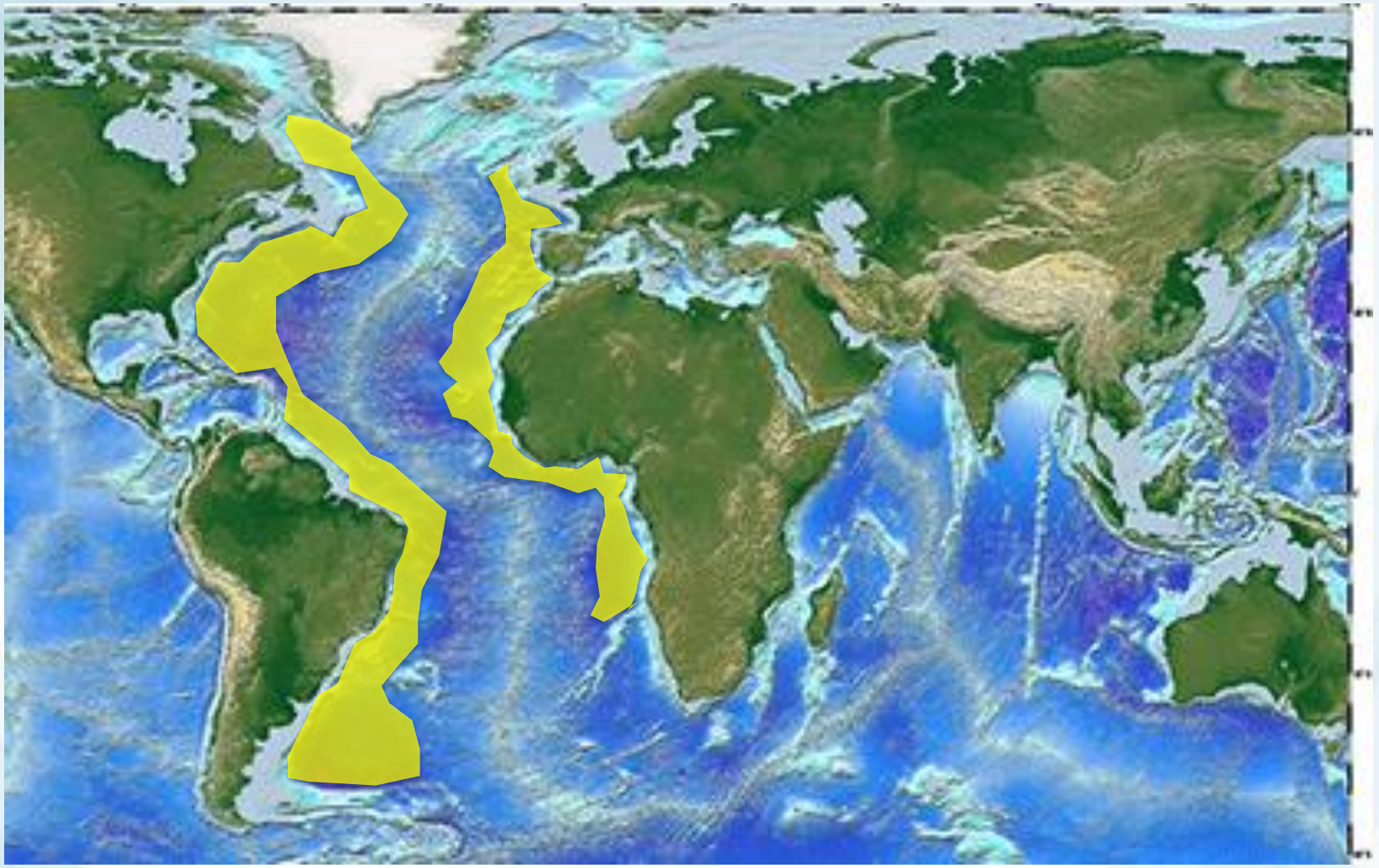
Three Key Elements for Existence of Sand-Rich Turbidites

2- Distributor: any element capable to transfer river or shelf sand to slope and basin plain

Source: Company Information,

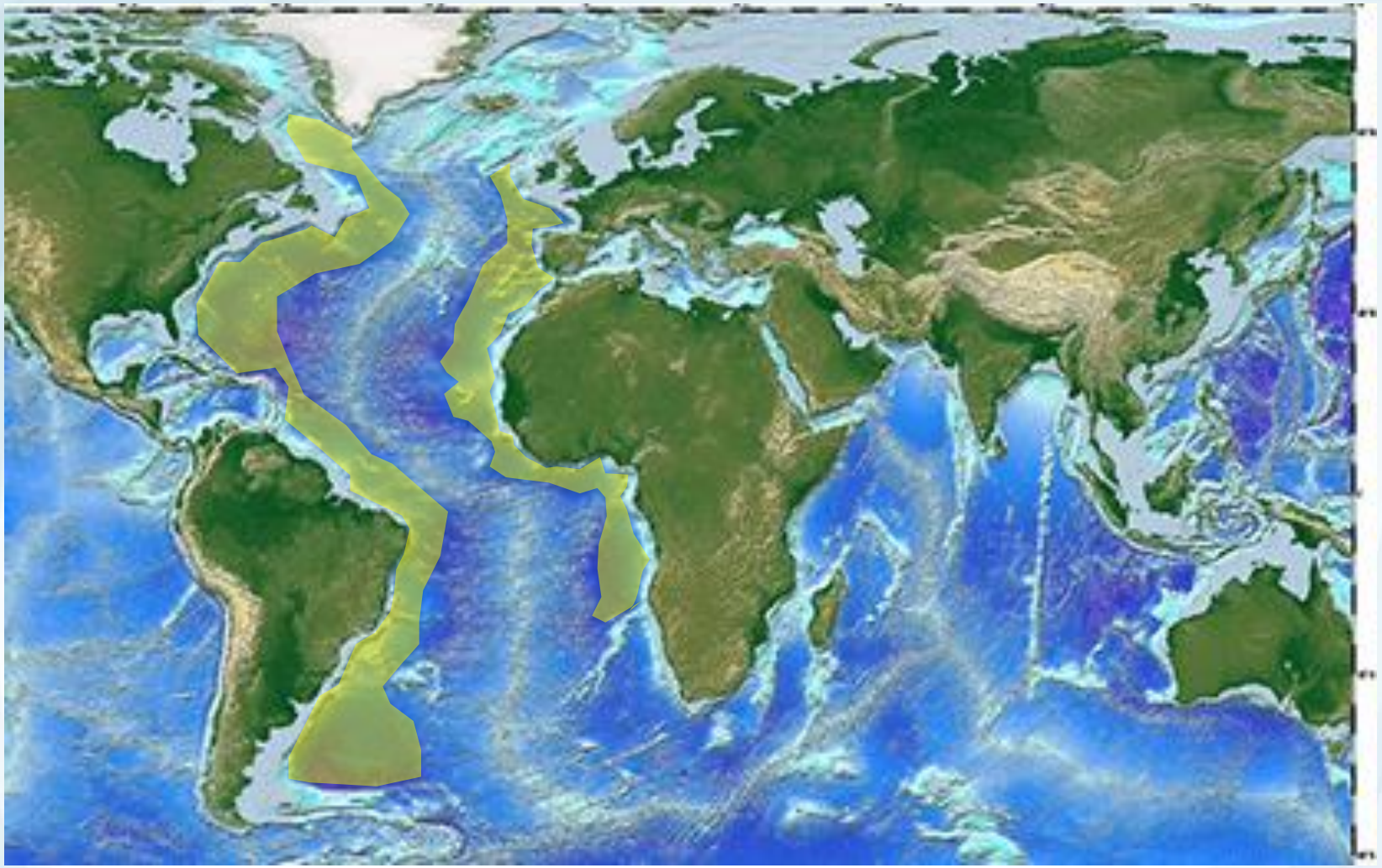
Three Key Elements for Existence of Sand-Rich Turbidites

3 - Acummulator: any element/region capable to preserve and gather sand
Example: continental basin plain and sub-basin created by mobile salt and shale



Source: Company Information,

How to Identfy Sand-Rich Turbidites in Seismic Lines on Vast Oceanic Basins?



Depositional Paradigms can help to mitigate the risk (Cainelli & Carminatti, 1994)

Source: Company Information,

Paradigm Definition

- **Paradigm** is the series of basic assumptions, ways of thinking, and methodology that are commonly accepted by members of a scientific community

- **Depositional Paradigm** is the series of basic concepts that controls the deposition of determined sedimentary deposit commonly accepted by the geoscience community

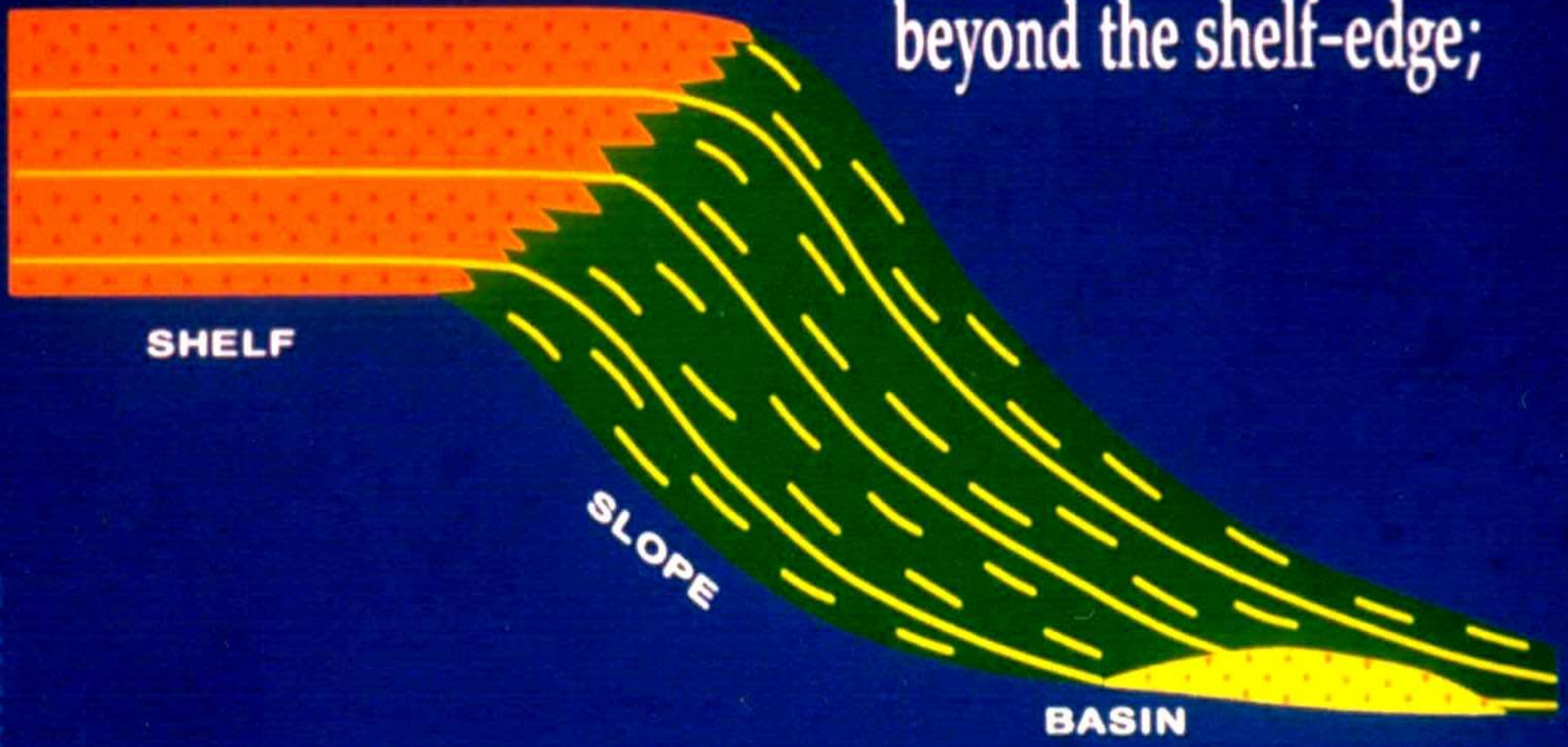
Deep-Sea Sandstone Turbidite Depositional Paradigms:

- First – Turbidite deposits are located beyond the shelf edge
- Second – Turbidite deposits are products of unstable periods in the shelf/upper slope
- Third – Turbidite deposits are limited events within the slope /basin environments
- Fourth – Turbidite deposits are formed in turbulent flow medium

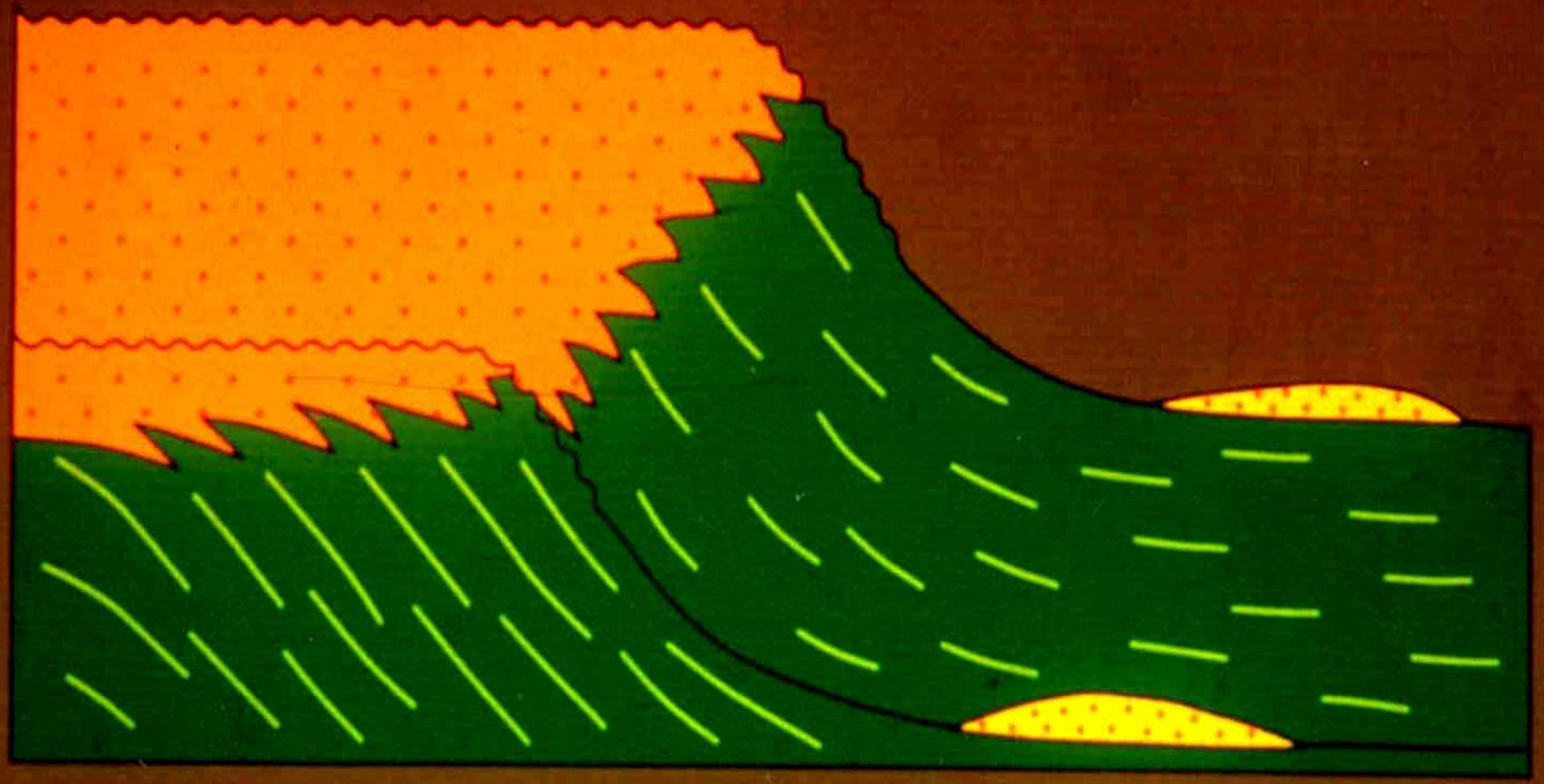
Source: Company Information,

DEEP –SEA SANDSTONE TURBIDITE PARADIGMS

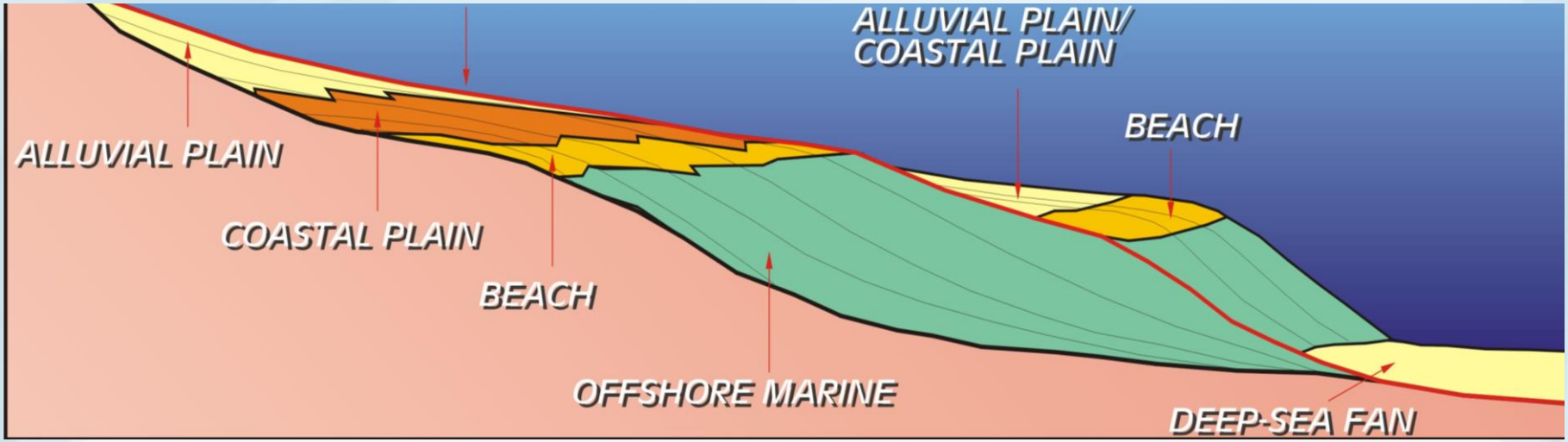
1st –Turbidite deposits are located beyond the shelf-edge;



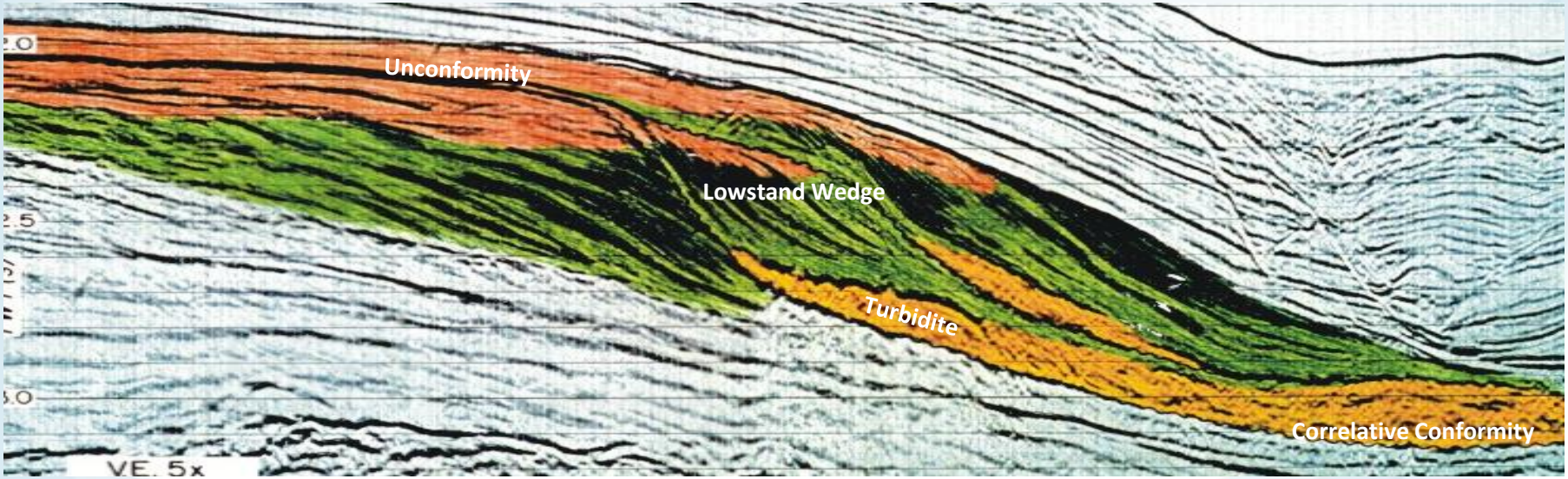
2nd - Turbidite deposits are products of unstable periods in the shelf / upper slope dynamics.



Second – Turbidites are products of unstable periods in the shelf/upper slope



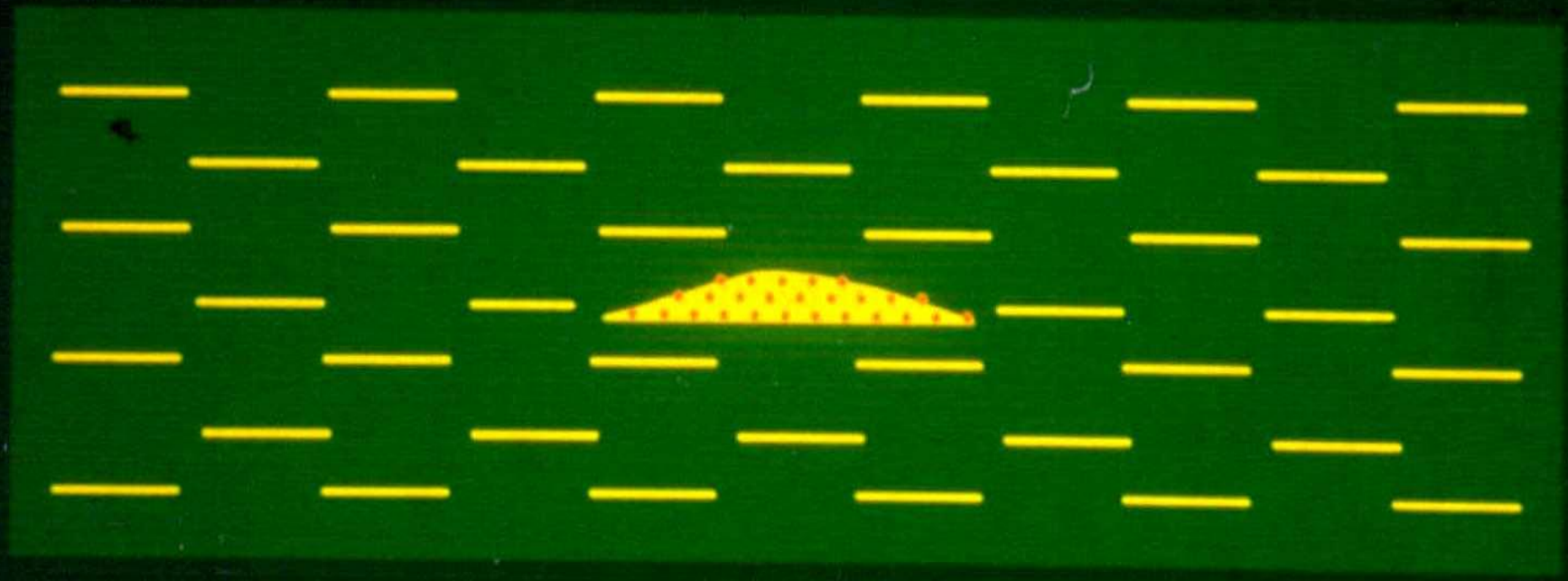
Close association between turbidites and unconformities/correlative conformities



Cainelli & Carminatti, 1994

Source: Company Information,

3rd - Turbidite deposits are limited events within the slope / basin environments;



Third – Turbidites are limited events within the slope /basin environments

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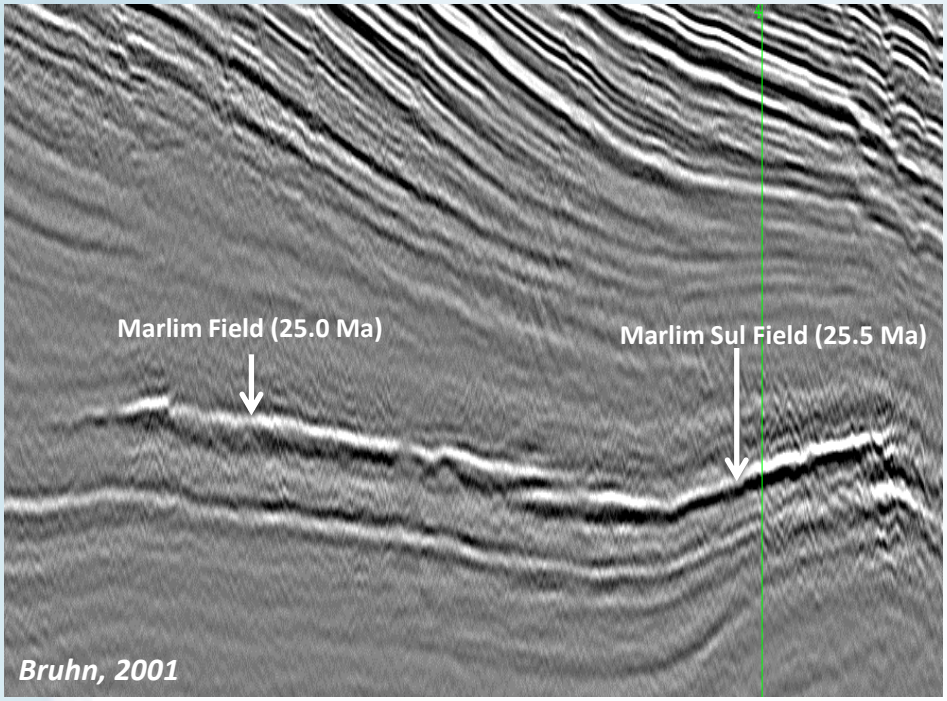
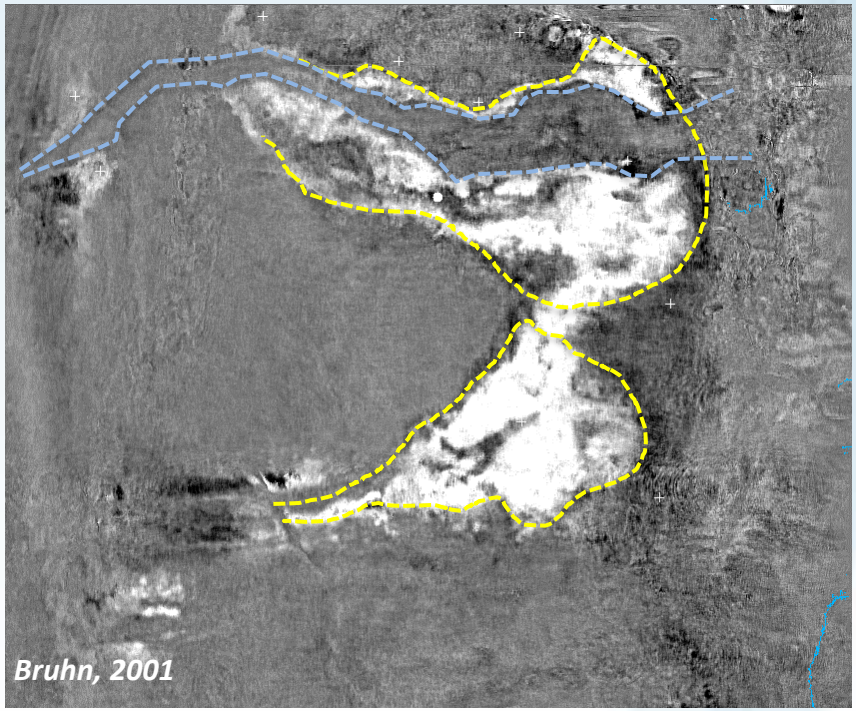
Source: Company Information, Tullow

Third – Turbidites are limited events within the slope /basin environments

Sand-Rich Lobes – Campos Basin

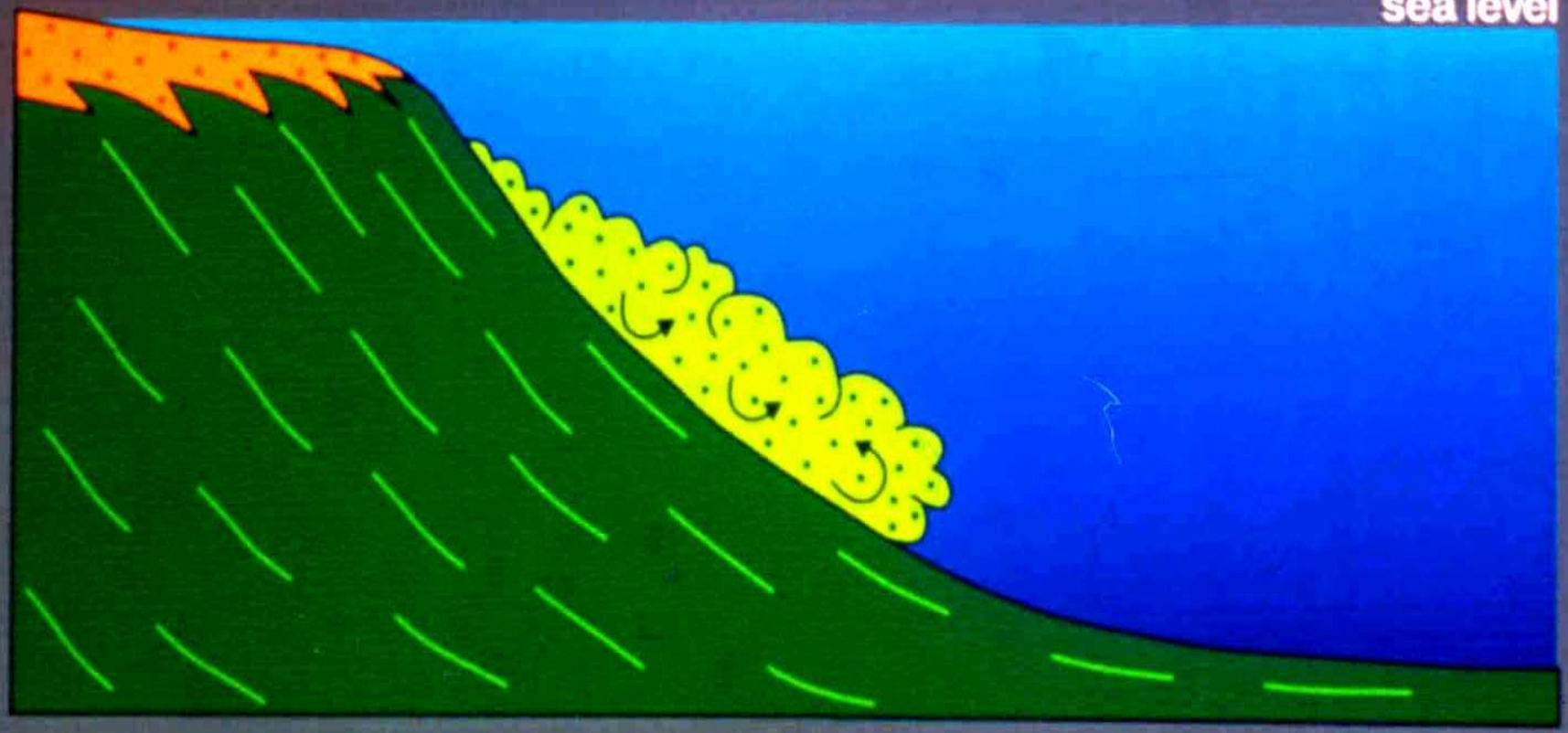


Amplitude Expression of Lobes in Marlin Field



Source: Company Information,

4th - Turbidite deposits are formed in turbulent flow medium.



Simple and Basic Depositional Paradigms can still mitigate the Risk!

SEISMIC ATTRIBUTES:

- Channelized facies (low continuity, high amplitude)
- Mounded external forms with internal chaotic sismofacies
- Association with canyons and channels
- Association with unconformities and correlative conformities

EXPLORING DEEP WATER REGIONS?

- Identify the deep waters DHI's **BUT**.....
- Take a look on the shelf. Lithic nature? Sand supplier?
- How the sand will be arriving in slope and basin regions? Are there mature canyons to funnel sand? Evidence of destructive margins? Evidence of sea level drops on the shelf? Evidence of unconformities? Etc?

Source: Company Information,

Limitations on Identifying Sand-Rich Turbidites in Seismic Data

- Poor regional control;
- Mounds can be formed by slumps, debris flows, erosional features
- Prediction of sand in mounds will be difficult in poor-sand systems

Source: Company Information,




BARRAENERGIA

Thank You!

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