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PS Barremian Basin Floor Fan Complex: An Untested Gas Play within the Northern Pletmos Basin*

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Search and Discovery Article #10234 (2009)

Posted March 18, 2010

*Adapted from expanded abstract and posters prepared for presentation at AAPG International Conference and Exhibition, Rio de Janeiro, Brazil, November 15-18, 2009

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Abstract

The Pletmos Basin, offshore South Africa, shows a history of strong strike-slip movement during the Late Jurassic-Early Cretaceous breakup and separation of Gondwana. It consists of a series of en echelon depocenters, each of which comprises a complex of rift half-grabens separated by horst structures and overlain by thick drift succession. The east-west striking Northern Pletmos Basin is similarly sub-divided by a 40-km long regional arch, a potentially prospective prominent feature with up to 4000 m of structural relief. This Transfer Zone Arch is the natural paleogeographic focal point for high-energy sand channels crossing between the adjacent basins. Good 2D data reveal several bright anomalies overlying the Barremian unconformity (9At1). The 9At1 unconformity eroded an arenaceous shelf with a feeder point on the northern rim of the Pletmos Basin. A massive sandstone, 25 m thick and interpreted to be channel fill, has been intersected in a nearby well and has porosities of 21 - 24%. This channel feature is highly erosive and follows a steep course down the northern flank of the Pletmos Basin, ensuring high-energy mass-flow deposits into the basin. It was intersected off-target at a base of slope setting. The associated mounded channel infill is easily identified and the top of channel infill is marked by a high impedance contrast. This sinuous channel feature can be followed along its entire course from its feeder point on the shelf, arcuating down the slope and flattening out at base of slope. This is interpreted to be the major sediment source which resulted in the formation of the Barremian deep-marine basin floor fan and channel complex. Its presence becomes more visual over the arch where channel and fan features combined with structure allow for traps resulting in bright spots. Charge is expected to come from deep-seated (possibly Kimmeridgian) marine and lacustrine source rocks developed in the deepest parts of the Pletmos Basin. Its presence is supported by deep-seated gas shows within three of the nearest wells, as well as the Superior High gas fields 40 km to the southwest. Up to six leads have been delineated, each with GIIP estimate (P50) ranging between 260 to 550 Bscf. A most likely deterministic resource estimate for the untested Barremian bff channel and fan complex is calculated at 2.44 Tcf.

Introduction

The Pletmos Basin is one of 5 sub-basins situated in the Outeniqua Basin off the south coast of South Africa ([Figure 1](#)) and covers approximately 18,000 km².

The Outeniqua Basin is bounded to the west by the Columbine-Agulhas Arch, to the east by the Port Alfred Arch, and to the south by the Diaz Marginal Ridge ([Figure 1](#)). It comprises a series of rift sub-basins which are separated by fault-bounded basement arches comprising Ordovician to Devonian metasediments of the Cape Supergroup as schematically illustrated in [Figure 2](#).

Basin Geology

A series of northwesterly striking faults (e.g., the Plettenberg, Superior, and Pletmos faults) subdivide the Pletmos sub-basin into half-grabens which exhibit different tectonic and sedimentary histories ([Figure 2](#)). The Northern Pletmos sub-basin comprises two en echelon depocenters, the Plettenberg Graben and the Superior Graben, which are separated by a 4000m prominent transfer arch. Sediment thicknesses of up to 9000m have been mapped adjacent to basin-bounding faults. The stratigraphy and chrono-stratigraphy of the Pletmos sub-basin ([Figure 3](#)) are derived from those of the Bredasdorp sub-basin and have been described by Brown et al. (1996). They utilize the time scale of Haq et al. (1988).

Early graben fill ([Figure 2](#)) consists of Synrift I sediments, which have been dated as Kimmeridgian but may be as old as Oxfordian in the deep undrilled areas. The overlying horizon 1At1 unconformity marks the onset of transform movement on the AFFZ and the onset of a second phase of rifting (Synrift II).

Major subsidence of the Outeniqua Basin after the transform-onset Mid-Valanginian unconformity (1At1) led to deep-marine, poorly oxygenated conditions within the Pletmos and other sub-basins. The 1At1-to-6At1 interval (Synrift II) comprises Hauterivian aggradational deep-marine claystones and thin turbidites, and it contains organic-rich shales which are significant as petroleum source rocks. The overlying late Hauterivian to early Aptian (6At1 to 13At1) interval is characterised by high-energy shelfal progradation (Transitional) from the northern margin of the sub-basin. The 6A sequence, consisting of interbedded claystones and shelf sandstones around the northern rim, is considered a Highstand Systems Tract due to a high relative sea level datum and sedimentation rates exceeding horizontal accommodation space change. The 9At1 unconformity ([Figure 4](#)) is a Type I sequence boundary which marks a rapid decrease in vertical accommodation space resulting in the deposition of the initial Barremian basin-floor fan channel and fan complex as well as the overlying lowstand wedge.

A period of sand starvation followed the erosive event that caused the mid-Aptian unconformity (13At1). Organic-rich shales were deposited in the southern Pletmos sub-basin and probably also in the Southern Outeniqua sub-basin during this period. Late

Cretaceous and Tertiary sediments were deposited in a shelf environment (Drift) and comprise interbedded calcareous sandstones and marls.

Truncation of the Tertiary and Upper Cretaceous successions by seafloor is evident over the northern flank of the sub-basin parallel with the coastline. This demonstrates a late tilting of the basin resulting in erosion of between 200 and 500m, especially over the up-thrown side of the Plettenberg Fault where erosion of more than 800m is possible.

Barremian Prospects

To date one well has intersected a western branch of the Barremian basin-floor fan channels, demonstrating 22m of water-wet massive channel sandstones (net/gross 88%, average porosity 22% with good permeabilities). This high impedance package shows contrasting seismic character on the eastern branch of the bff channel complex. DHI's synonymous with shallow gas accumulations (low impedance bright spots) have been delineated in a westerly direction at a base-of-slope location down the axis of the Northern Pletmos Basin ([Figure 4](#)).

Commercial gas flow-rates from fractured basement and overlying synrift sandstones on the Superior High, as well as the presence of deep-seated gas shows in surrounding wells, support the presence of deep-seated organic-rich shales within the early rift succession. Biomarker data (Davies, 1996) from associated condensates in the Superior Gas Field suggests that two phases of charge exist. The first, an oil charge, may be associated with a deep-seated Jurassic lacustrine synrift source. The second phase is a marine-derived wet-gas/condensate charge also from a synrift origin. Reactivation of normal faults resulting in late uplift of a central horst feature proximal to the transform fault ([Figure 4](#)) during late Barremian times may provide potential conduits for gas migration into the channel sandstones. Recent tilting and uplift of the northern flank may have provided an added mechanism for gas in deep-seated reservoirs to breach seals and migrate to shallow targets. Surrounding wells intersected good to fair quality Hauterivian to Barremian oil to wet-gas prone shales (30 to 90m thick). These are generally considered to be marginally mature to immature close to the bff complex and are not expected to charge the Barremian channel sandstones.

Anomaly 1 (see figure in [Table 1](#)) is a channel feature delineated by bright low impedance seismic character over an area of 32 km² with a 5.4 km² four-way closure. Anomaly 9 is a mass-flow feature covering 39 km² with a 4.4 km² domal closure. Anomaly 2 is another channel feature with a bright DHI, but it is considered to be of higher risk due to its dependence on the sealing capacity of a closing fault and the absence of domal closure. Prospect 3424A-5, a channel feature with a small domal closure (2.2 km²), has potential for a very large stratigraphic trap. This prospect lacks a bright seismic character, but it could possibly be charged by oil and wet-gas prone source rocks within the lower drift sequences of the Plettenberg Graben. Several other leads were mapped, but these are interpreted to be of higher risk, mostly due to lateral seal or reservoir quality risk.

Resource Assessment

A probabilistic resource assessment of Barremian prospects/leads is listed in [Table 1](#).

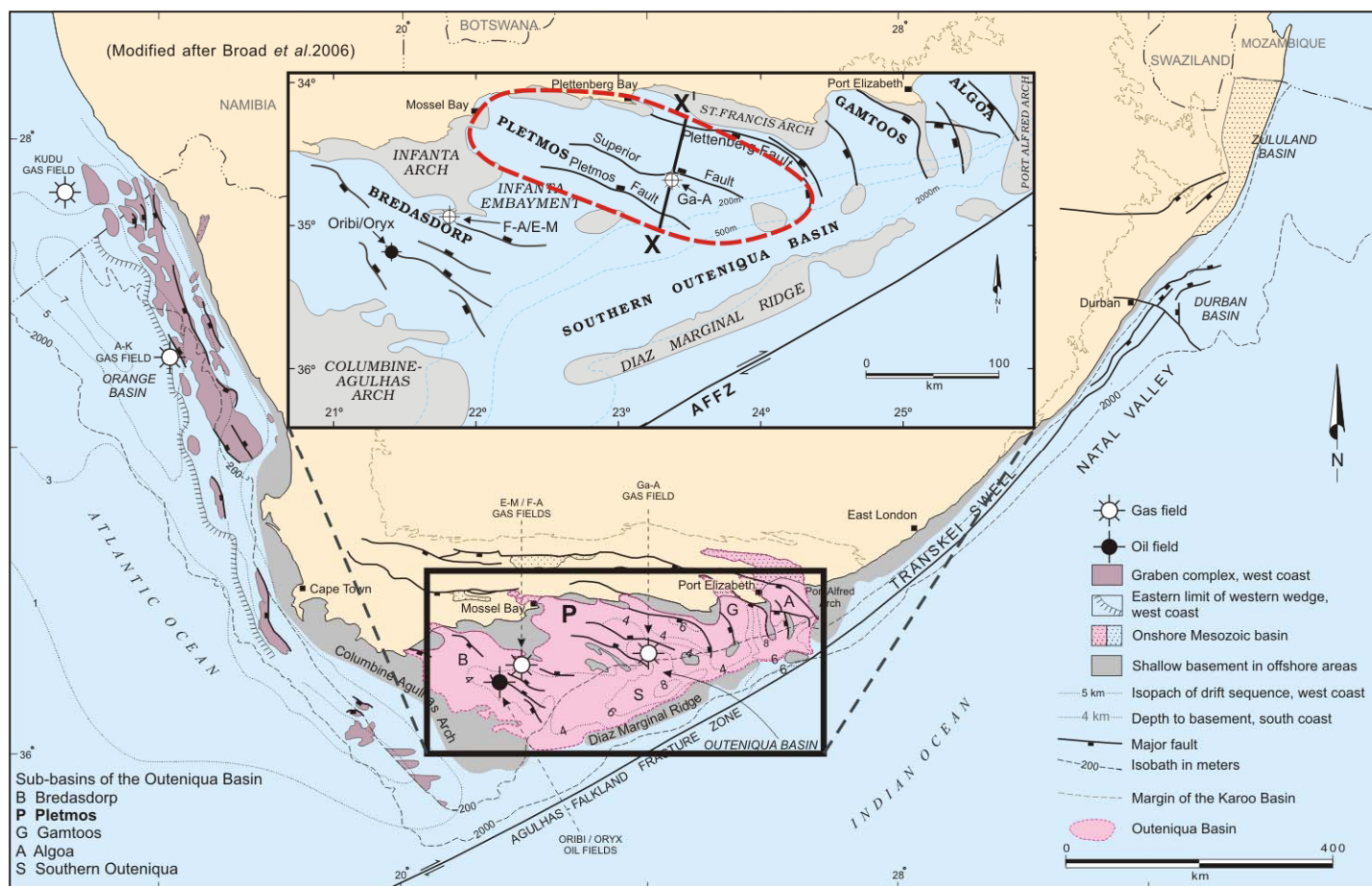
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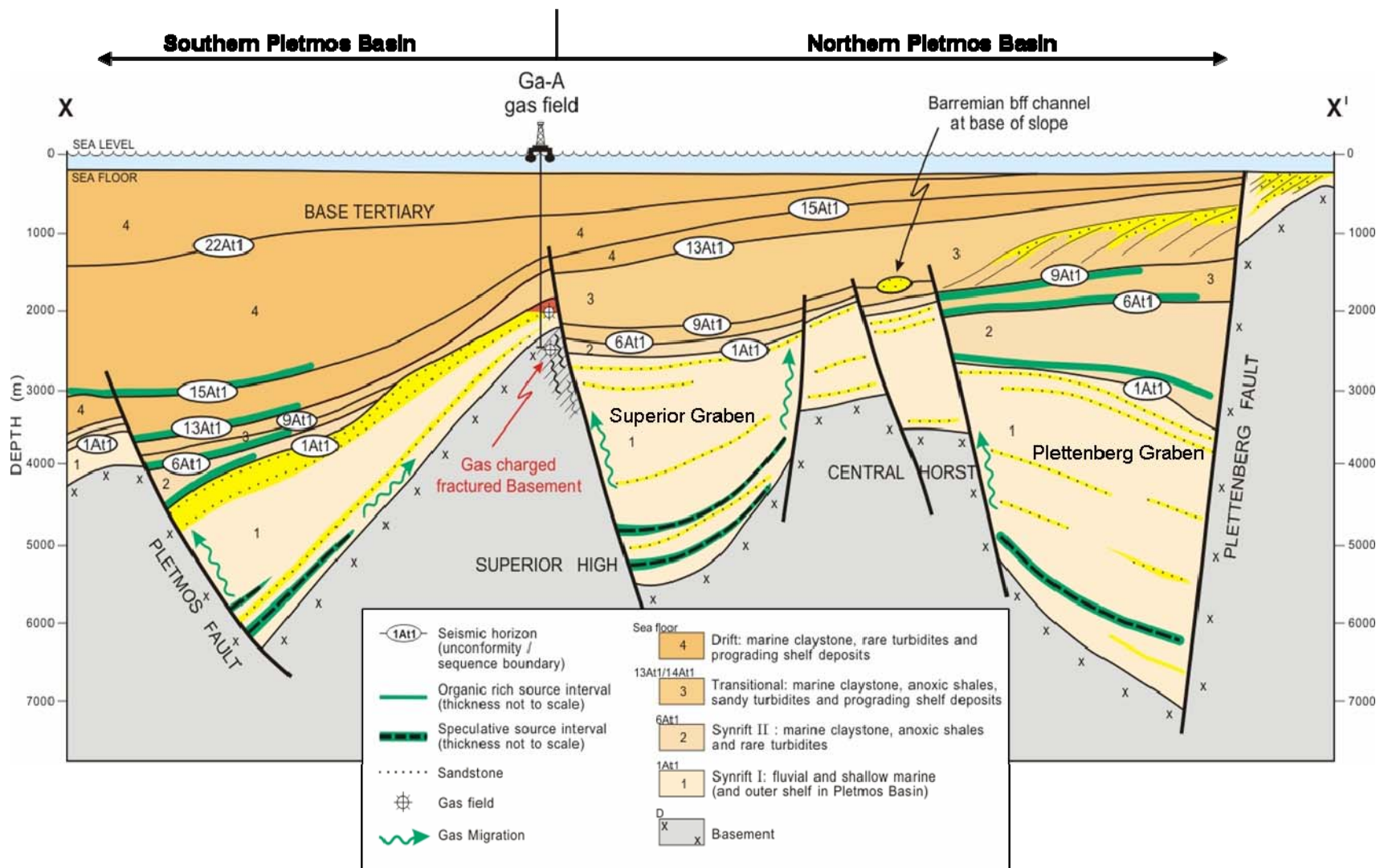


Figure 2: Schematic geological cross-section across the Pletmos sub-basin, illustrating structural styles and stratigraphic subdivision.

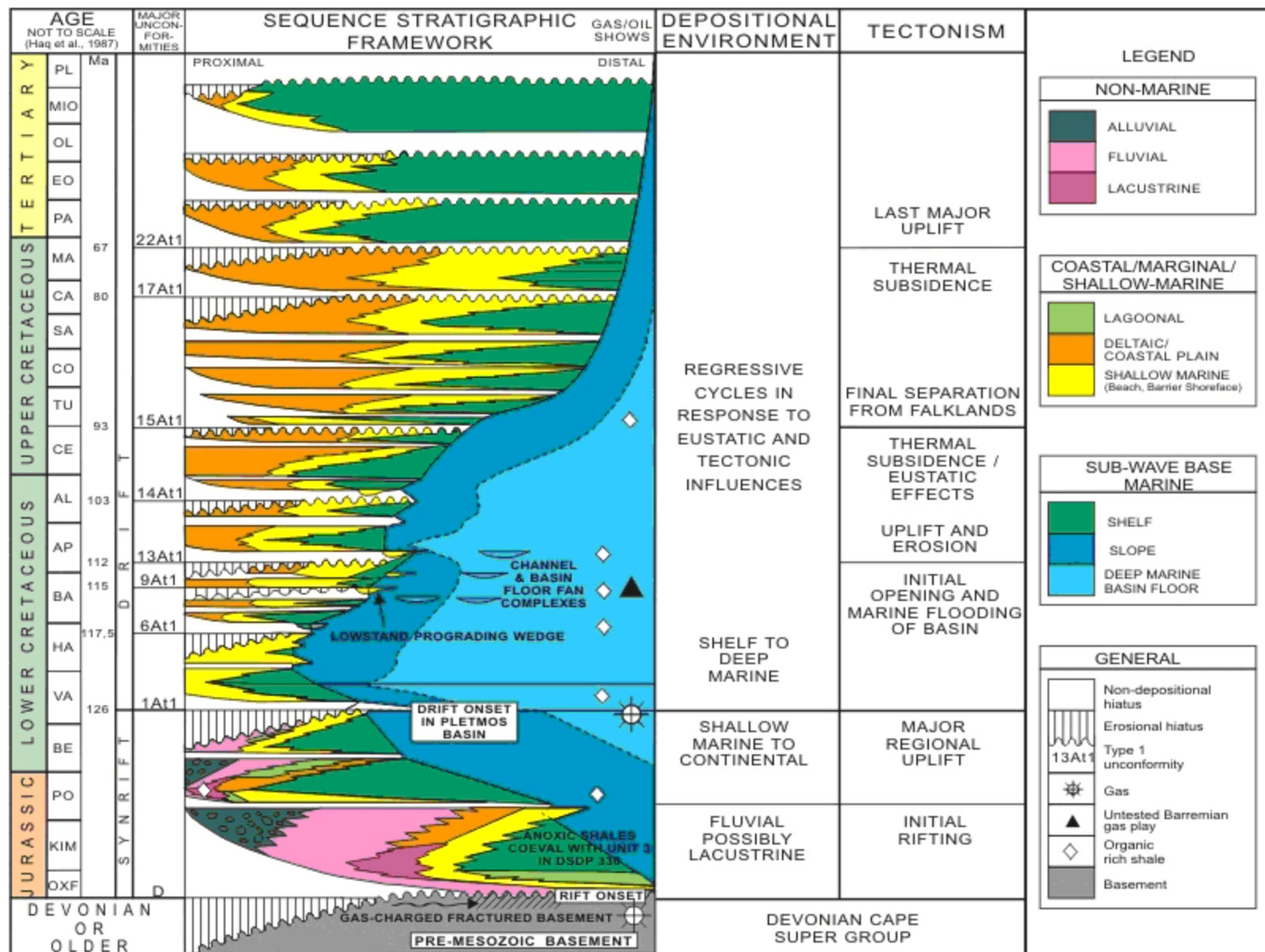


Figure 3: Generalized chrono-stratigraphic column for the Pletmos sub-basin.

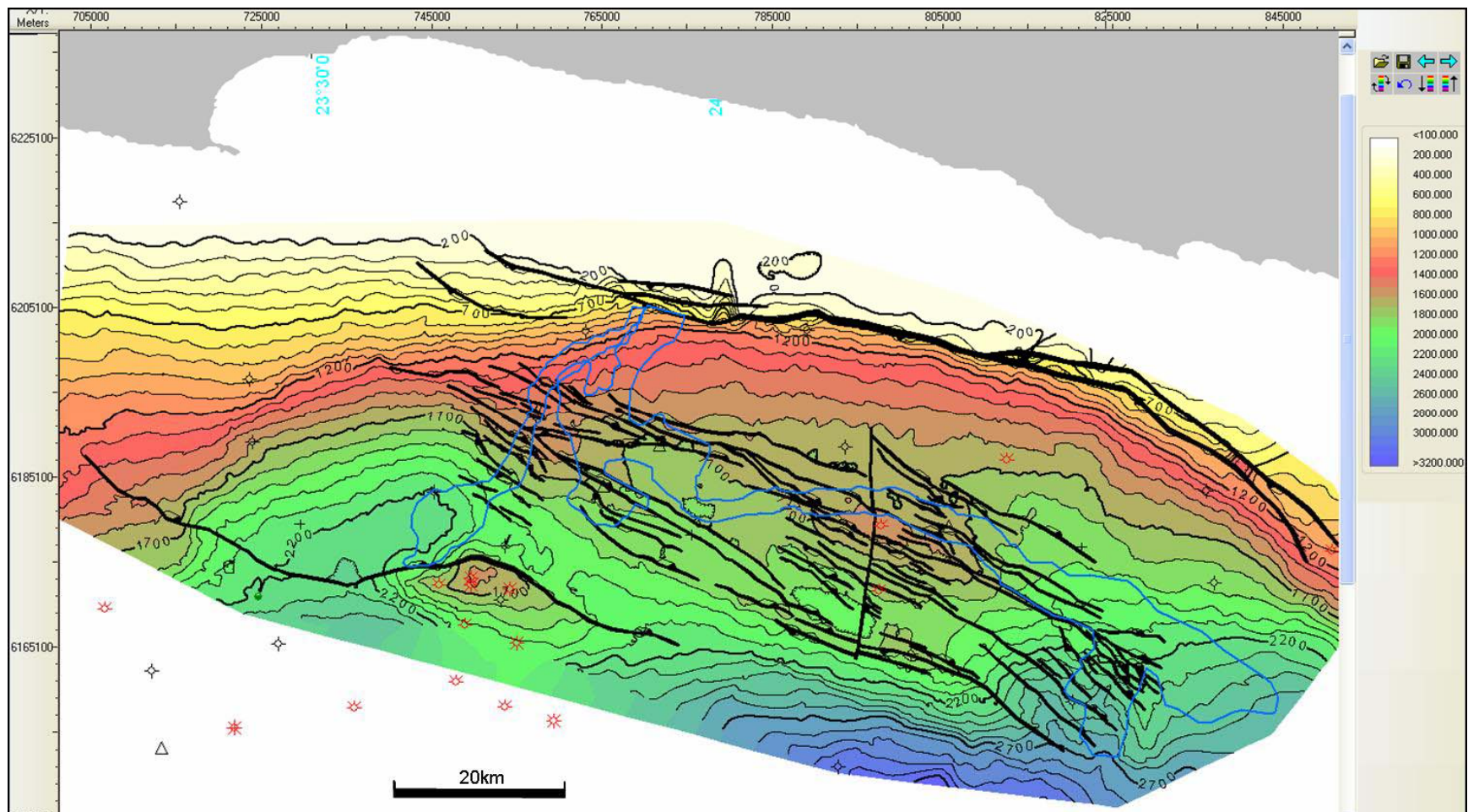


Figure 4: Depth to 9At1 (Barremian unconformity).

Prospects	GIIP (Bscf)				Undiscovered Recoverable Reserves (Bscf)			
	P90	P50	Mean	P10	P90	P50	Mean	P10
Anomaly 1	123	330	450	999	72	198	270	593
Anomaly 2	113	304	384	798	64	174	221	460
3424A - 5	49	156	221	492	28	90	127	284
Anomaly 9	100	340	511	1194	57	198	294	687
<i>Total</i>		1130	1566			660	912	

Leads	Deterministic GIIP (Bscf)	Undiscovered Recoverable Reserves (Bscf)
	Most Likely	Most Likely
Anomaly 6	537	349
Anomaly 7	310	202
Channel 8	197	128
Anomaly 5	239	155
Anomaly 3	674	438
<i>Total</i>	1957	1283

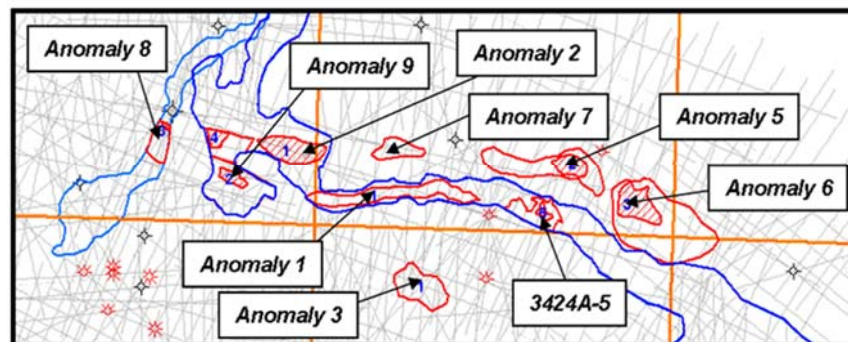


Table 1. A probabilistic resource assessment of Barremian prospect leads.