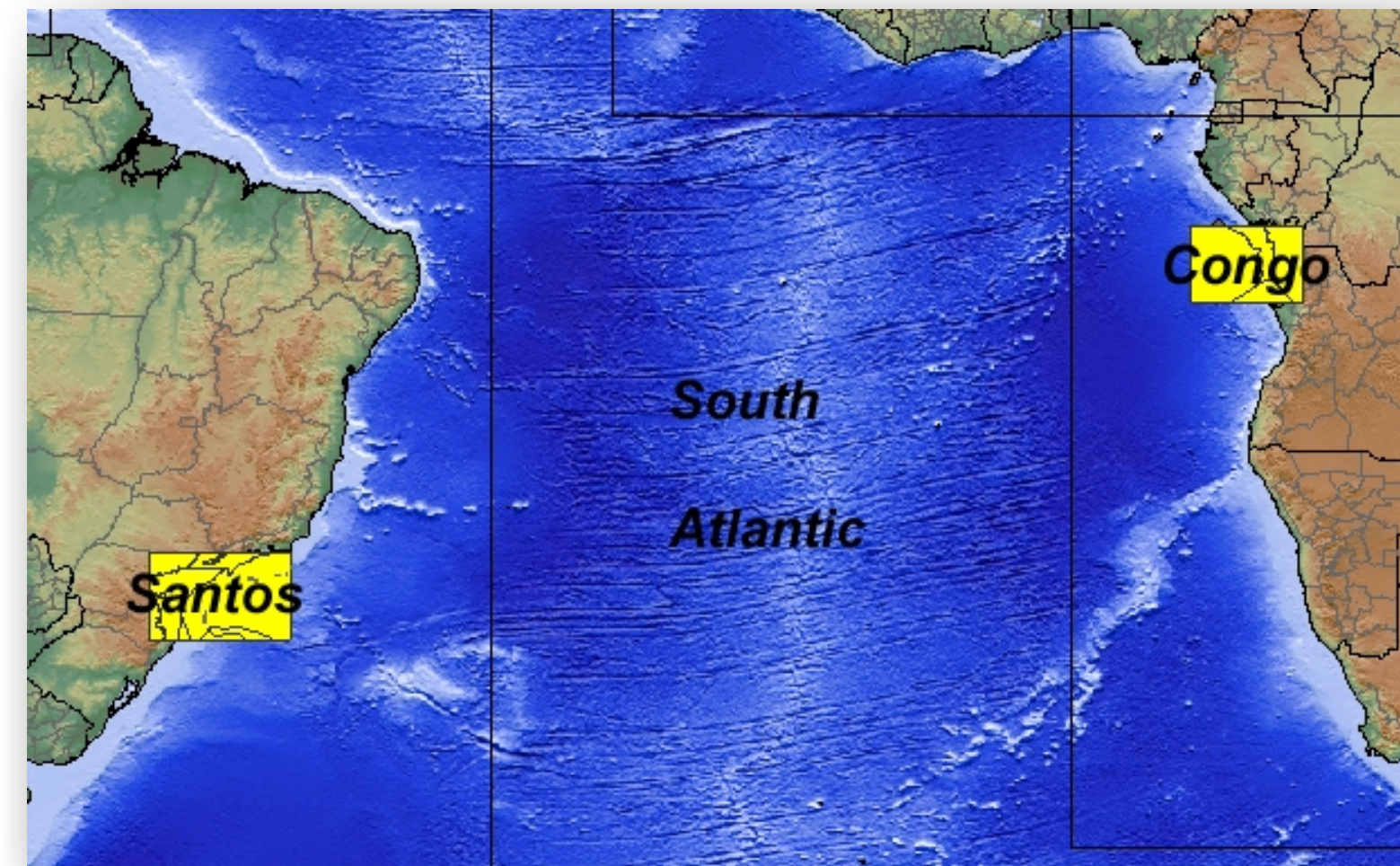




Exploring for Deepwater Petroleum Systems with Satellite SAR (Synthetic Aperture RADAR). Fact or Fiction? Comparing Results from Two of Today's Hotspots (Congo and Santos) with Two of Tomorrow's (Campeche and Cariaco)

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Location of Santos and Congo Basins

Introduction

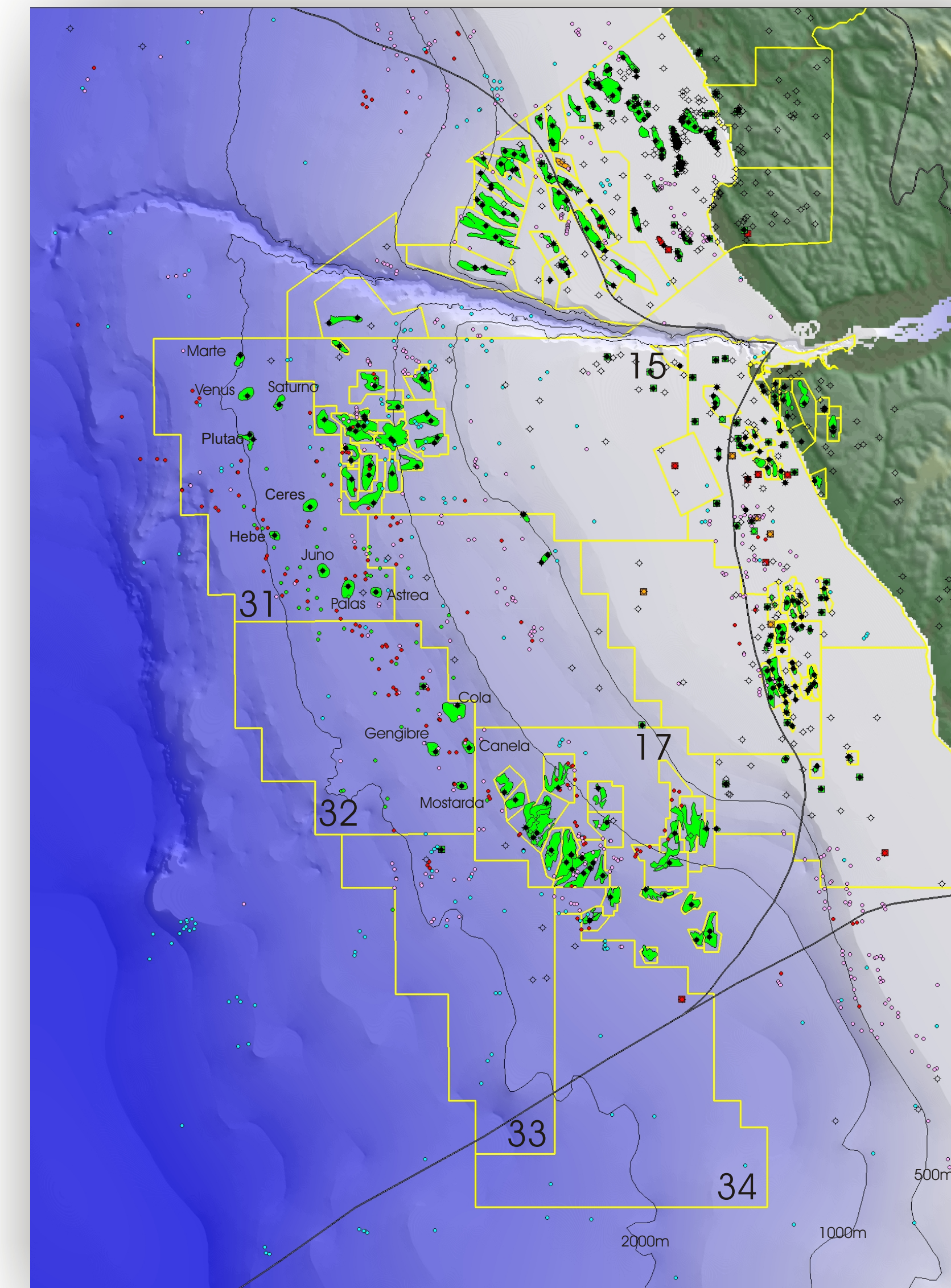
The data for the Congo Fan was one of the earliest regional seep screening projects undertaken by NPA, well before the deep-water blocks were announced. The detection of a wide area of large-scale repeating seepage slicks in water depths of 1500-2500m, especially in deep-water blocks 31 and 32 (as opposed to blocks 33 and 34) was one of the factors that encouraged many of the existing licence holders to lower their risk on source and thus enter a competitive bid.

Subsequently BP Exploration and partners acquired Block 31 in 1999 and have now drilled 9 major oil discoveries over a four year period, viz

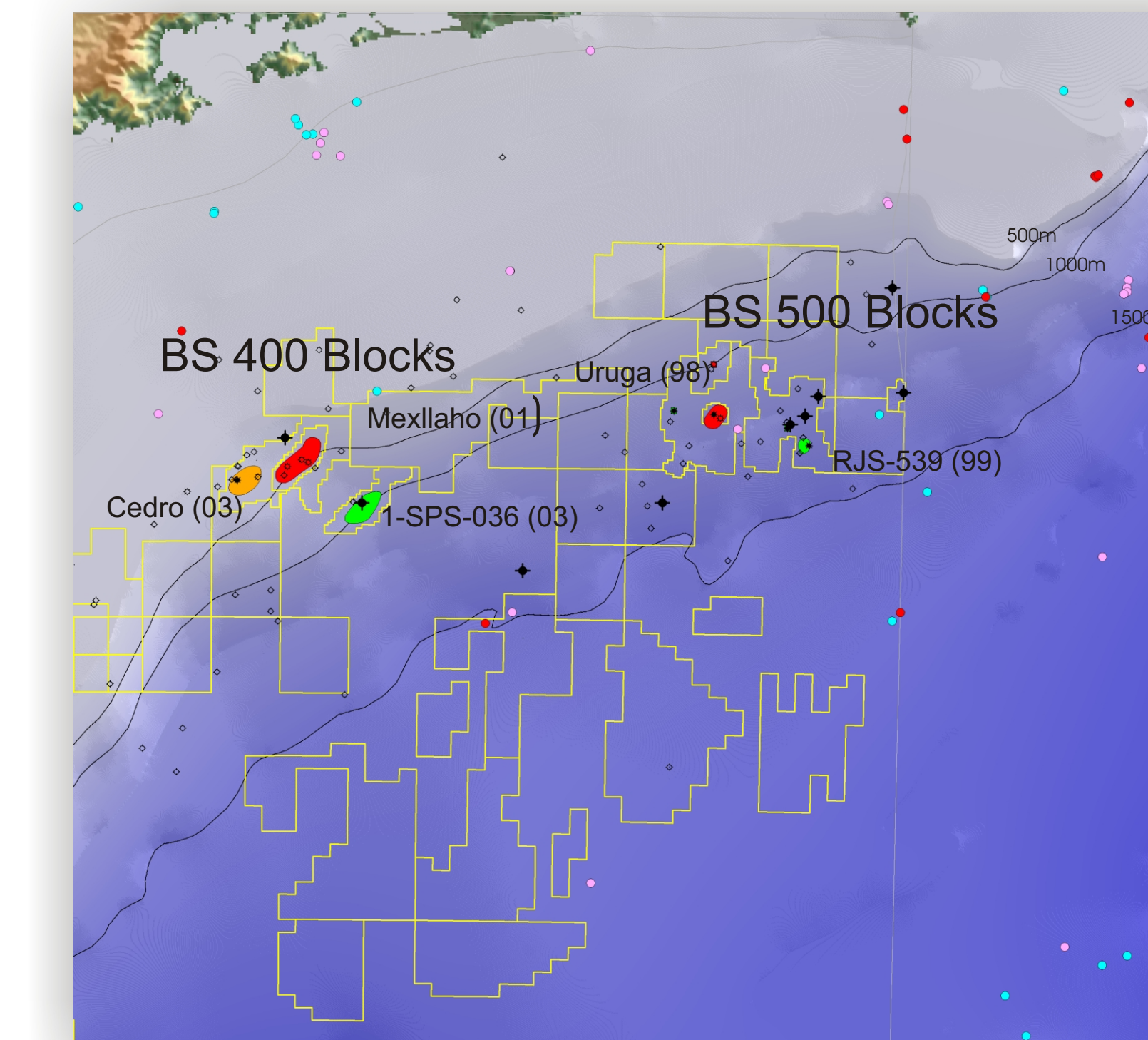
2002 - Plutao,
2003 - Saturno and Marte
2004 - Venus and Palas
2005 - Ceres, Hebe, Juno and Astraea

Many of these discoveries are in water depths in excess of 2000m and 2000m and most with impressive flow rates of > 5200 bopd.

In Block 32, Total and partners have also been successful with 4 discoveries over 2 years.



Seepage slicks, IHS wells, fields and blocks over bathymetry



Seepage slicks, IHS wells, fields and blocks over bathymetry

Santos Summary

There have been fewer deep water discoveries in the Santos basin. However success has been found in the BS 500 blocks with the RJS-539 discovery in 1999 and in BS-400 blocks in 2001 to 2003 when 3 discoveries were made, Mexilhao (01) Cedro (03) and 1-SPS-036 (03).

The seepage indicated over the large Santos Basin is scattered, in marked contrast to the Congo Fan and the adjacent Campos Basin. The concentration is along the bounding fault along the shore and inboard of the Merluza Field. This may indicate long-travelled seepage out of the basin, a feature shared with the Campos Basin to the north.

The Santos Basin, like those off Angola, results from Atlantic opening. An Early Cretaceous asymmetric rift with half grabens (the bounding faults of which up-dip toward the coast) developed from oblique extension. A thick Aptian evaporite is succeeded by a post-rift Albian platform carbonate and a Late Cretaceous to Recent predominantly deltaic and turbidite clastic sediments. The Basin is characterised by distinct geographic tectonic zones related to inherited basement structures and to salt movement, so that individual depocentres have migrated in time.

Why isn't there the prolific seepage similar to the Congo Fan? There are factors that should enhance seepage: thick sediments and overpressure is high, although not uniformly and there are mobile salt and diapirs, although these do not reach the seafloor. The Late Cretaceous siliciclastic sandstones are poorly permeable, which may limit seepage locally, but this is probably not a reason for scarce seepage regionally.

There are at least two petroleum systems in the Santos Basin. Nearer shore, in the north and central part of the Basin there is a pre-salt sourced system associated with 30° API and heavier oil, believed to have biodegraded through flushing. This region corresponds to the most scattered seepage-slicks. In deeper water, in the central and south part of the Basin, there are post-salt sourced (lacustrine black shales) systems that produce gas and light oils, as at the discoveries in BS400 and BS500. Seepage-slicks would not be expected in this region, and there are only one or two.

The slicks have not been well-sampled over the whole Basin, much of it being from single scene cover. More interpretation is therefore underway to confirm the gas-prone nature of the Basin or to identify more seepage that would indicate liquid oil.

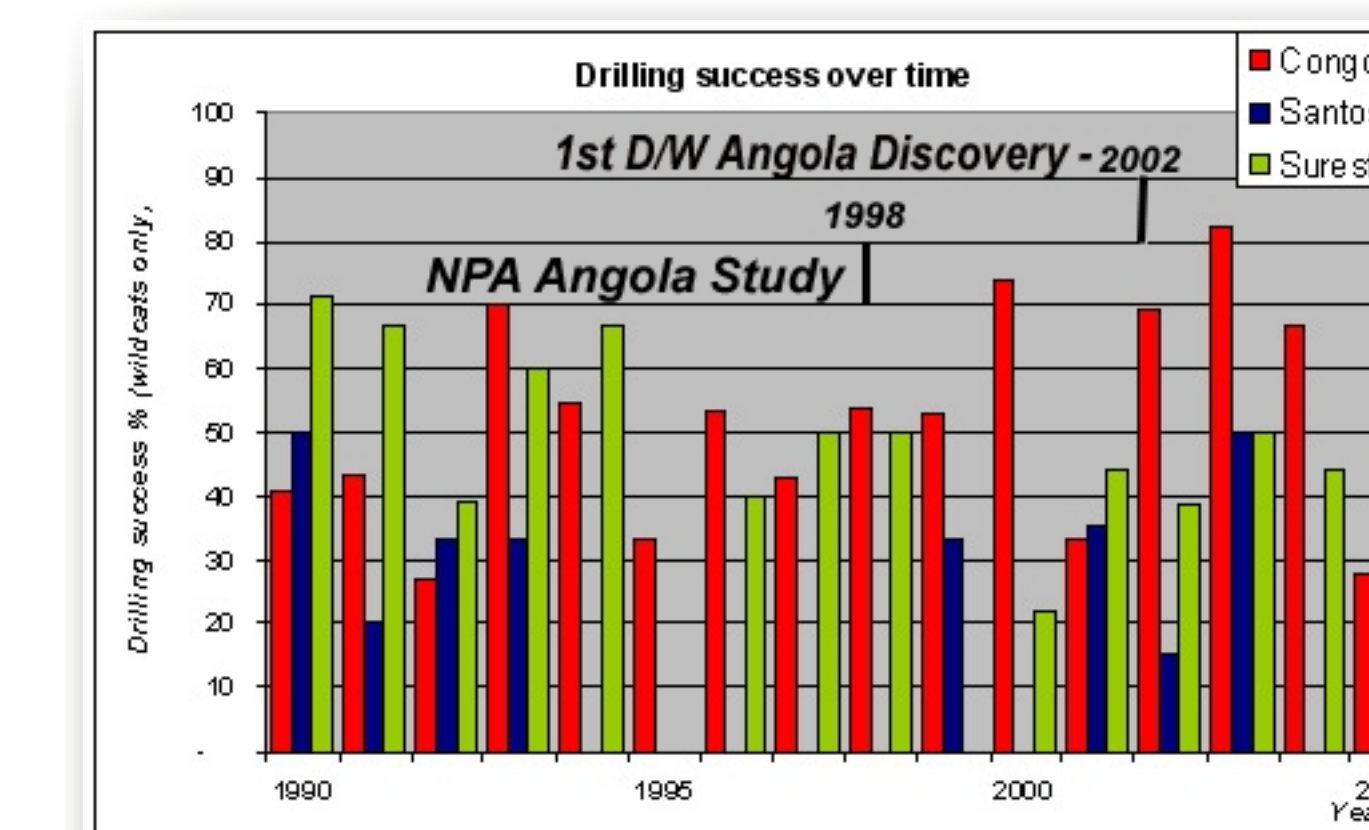
Santos drilling success over time, showing seep study completed pre first deep water discovery

Angola Summary

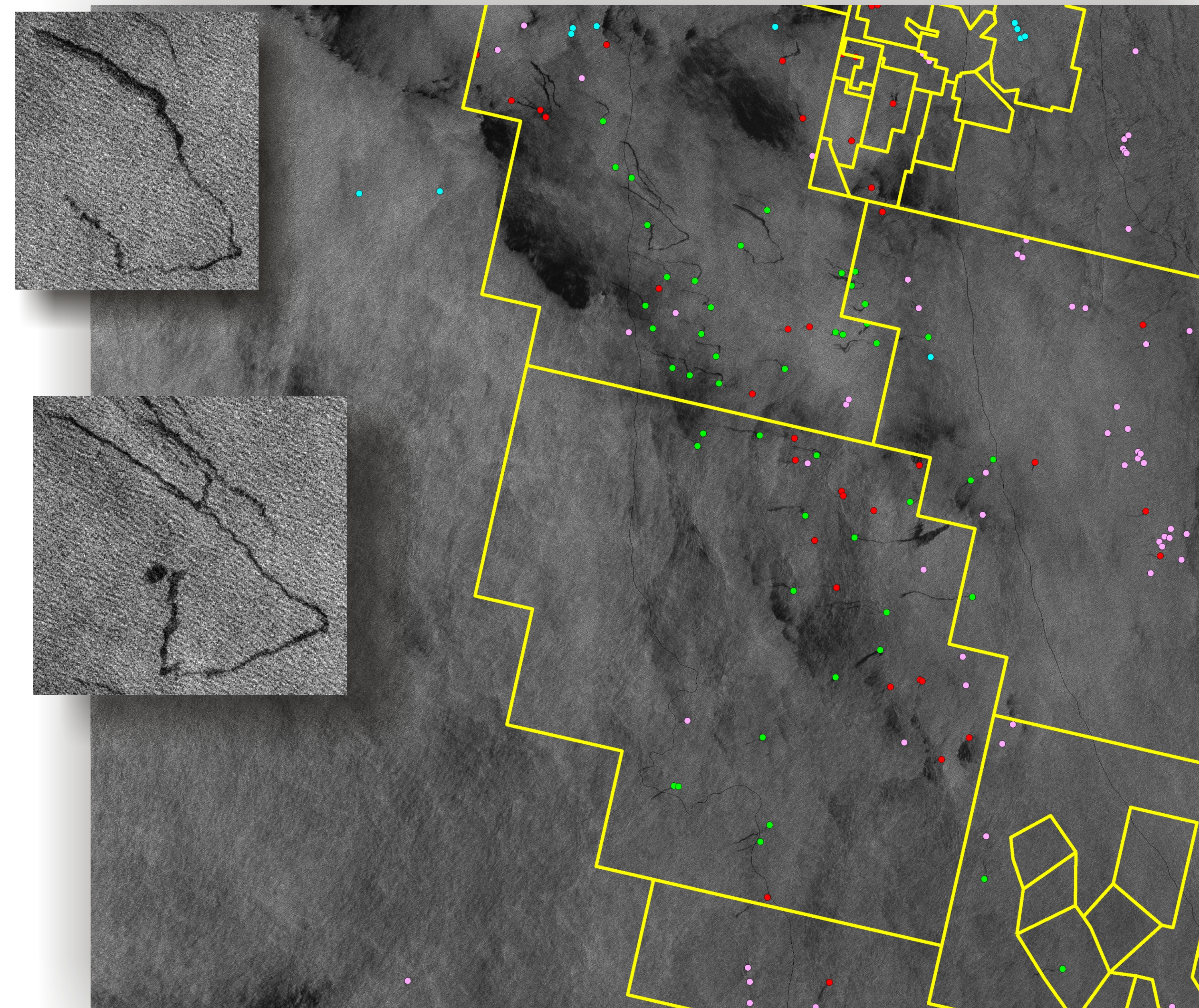
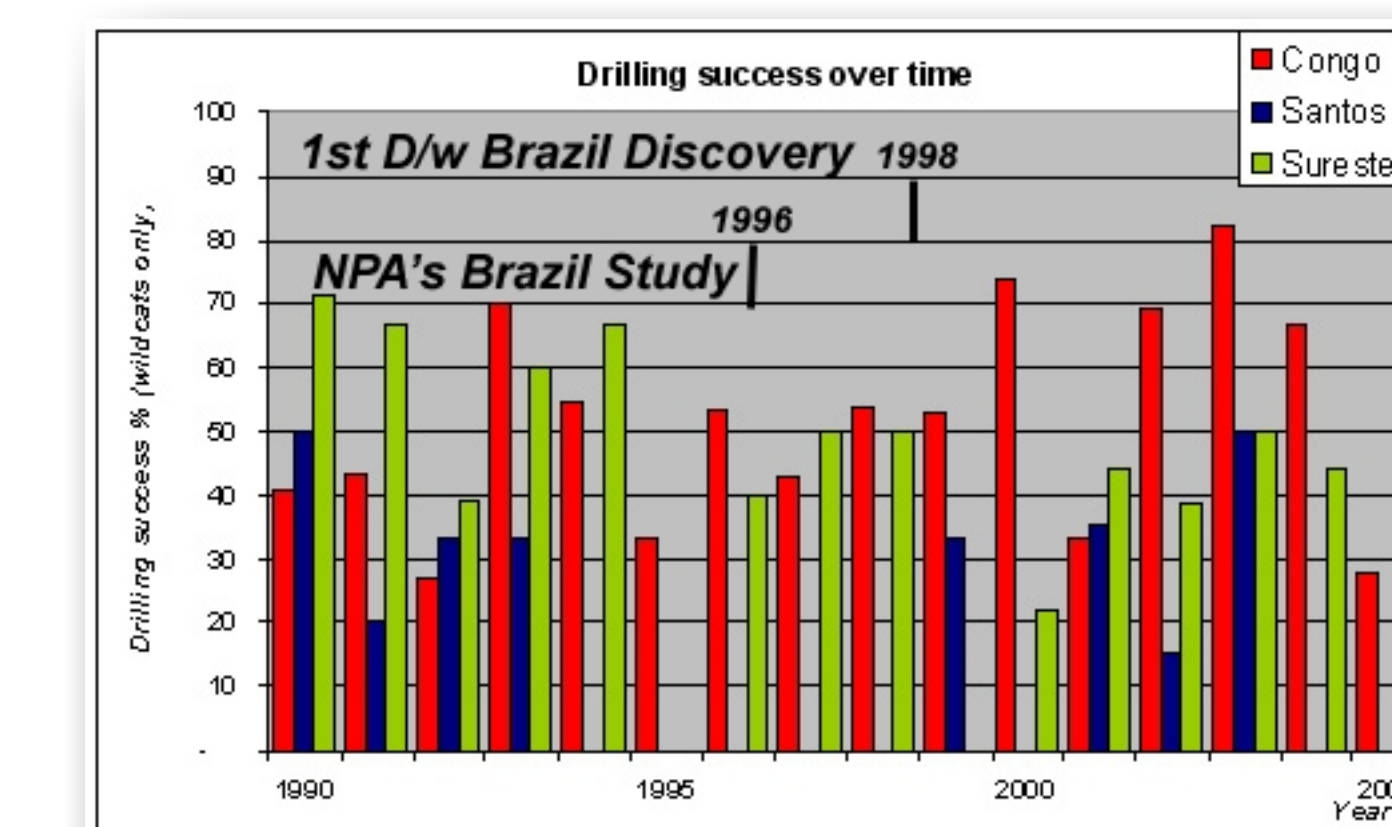
A 300km linear zone of intense seepage was mapped on radar from ERS and Radarsat satellites in 1997-1999, encouraging explorers that a working petroleum system existed in deepwater off Angola. It stretches from oil discoveries in Block 17 and 18 in the SE, through Block 32 to the recent discoveries of Block 31 in the NW and to Block 15 in the N. Studies show that most of the seepage is post-salt and therefore probably from Cretaceous marine shale source. 3D seismic and swath bathymetry are showing that most slicks are vertically above seafloor vents, gas mounds, and pock marks aligned along the trace of major faults. The fault structural control, diapiric salt, mud volcanoes and a high overpressure resulting from a thick sedimentary overburden from the Congo Fan are thought to enhance the seepage.

Several of the seepage-slicks repeat in time at exactly the same site, whilst others do not. This is likely because hydrates periodically block vents and limit seeped oil reaching the surface. Occasional explosive release of oil and gas from hydrates can form temporary giant slicks on the surface. Overpressure can cause well preventers to leak. An example can be seen at the Dalia discovery well, where oil has spread over 100 km2.

Seepage over the shallow water accumulations is much more muted and more ambiguous as there is extensive fragmenting oil pollution from established production and a busy shipping lane.



Angola drilling success over time, showing seep study completed pre first deep water discovery



High rank seepage slicks shown on Radarsat scene over deepwater blocks 31, 32 and 33

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