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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Alan Williams (NPA Group), Michael King (NPA Group), Geoff Lawrence (TREICoL) and Jan Roelofsen (IHS Energy)

Abstract

SAR (Synthetic Aperture Radar) seep detection has now become a technique of choice for many major players seeking a low cost, non-invasive, offshore basin screening tool, combining advantages over optical remote sensing methods of being operational both night and day and through heavy cloud cover. The commercial SAR archives (primarily ESA and Radarsat) now contain an invaluable resource of multiple pass data over many of the world's current deep-water hot-spots that give the explorer an opportunity for reducing (or eliminating) source risk at an early stage in the exploration cycle

As the result of screening over 75% of the worlds' sedimentary basins with SAR, regional seep distribution patterns have now been revealed which, in many cases, relate closely to both the basin style and the established seepage patterns from known producing basins. When such data have been followed-up by other low cost data-sets such as multi-beam bathymetry, gravity and shallow coring, significant competitive advantages in acquiring key acreage have resulted.

Recently integrated satellite seep data from two undrilled frontier basins, Cariaco basin, Venezuela and deep-water Campeche, Mexico will be compared with similar data from two present-day exploration hot spots, deep-water Congo Fan, Angola and the Santos Basin, Brazil. In these basins, where major new discoveries are now being made, positive results from early SAR seep screening studies in the mid 90's gave the first indications that deep-water petroleum systems were present.

Historical Introduction

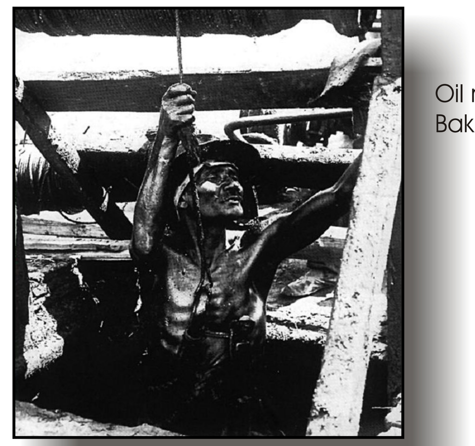
Surface oil and gas seeps have long been known to generations of oil explorers as the pathfinders to deep-seated oil and gas accumulations, especially in the Middle East.

The knowledge that surface seepage has a direct link to subsurface oil and gas accumulations is not new and was the stimulus for many of the world's early major oil and gas discoveries by the pioneers of our industry. Although Colonel Drake may disagree, the world's first major oil discovery was in fact made in Baku, Azerbaijan in the 1860's (Fig 1) when the term 'mining for oil' was indeed true (fig .1). Photos of the fleets of oil derricks taken 100 years apart in Baku (fig. 2) look strikingly similar.

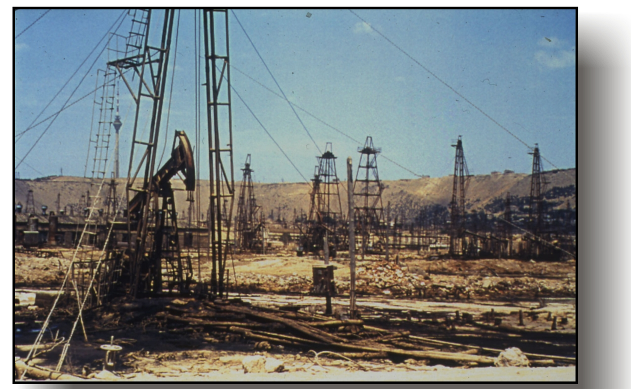
The following decades spanning the late 19th century and the first half of the 20th century heralded the discovery of many of the worlds giant oil fields and was invariably linked to the presence of oil and gas seeps. In Latin America, the key dates were the discoveries at Golden Lane, Mexico in 1910 and at La Barroso, Venezuela in 1922. The full roll call of the world's major onshore giant discoveries that were based initially on the presence of surface seepages is -

Sumatra (1885),
Texas (Spindletop, 1901),
Oklahoma (1905),
Persia (Majid-I-Sulaiman, 1908),
Mexico (Golden Lane, 1910),

Venezuela (Los Barroso, 1922),
Iraq (Kirkuk, 1927),
East Texas (1930),
Bahrain (1932) and
Kuwait (Burgan, 1938).



Oil mining Baku c.1850



Oil Derricks Baku. 1898 (left image) compared to 1998 (right image)

Sampling Seeped oil for geochemistry

Offshore Seeps

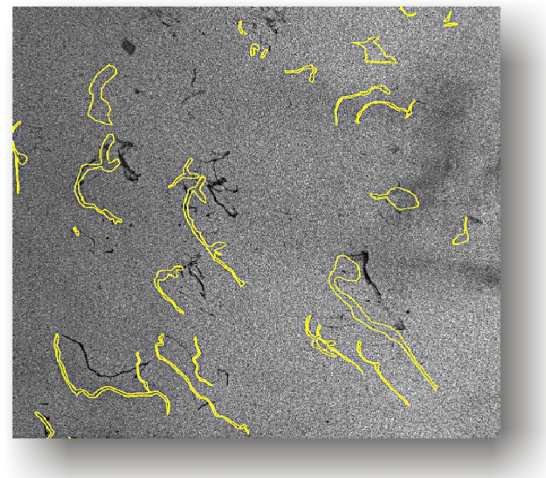
In undrilled or under-explored parts of offshore basins, oil seeps are valuable indicators of the presence of both a mature source and leaking traps and hence help risk reduction at an early stage. SAR satellites (fig 3) scan the oceans continuously on fixed polar orbits and observe both night and day and unaffected by cloud cover, thereby being suitable for both exploration and environmental purposes.

Offshore, oil seeps are easier to detect than onshore due to the fact that seeping oil is typically transported to the surface as oil-coated gas bubbles which burst on reaching the surface, leaving the oil behind on the surface as a thin oil film (fig.4) which over time, coalesces to form a slick that is large enough to be detectable from aircraft (fig 5) or from space (fig 6)

Surfacing oil coated gas bubbles (1m diameter pancakes)

EnviSat (ASAR antenna underneath)

High rank seepage slicks Gulf of Mexico



Repeating oil seeps, southern Caspian

Satellite Seep Detection

Radar or SAR (Synthetic Aperture Radar) satellites are able to image surface oil seeps remotely as oil slicks suppress normal wave activity such that no signal is returned to the satellite and the slick is 'imaged' as a clearly-defined dark area of backscatter reduction.

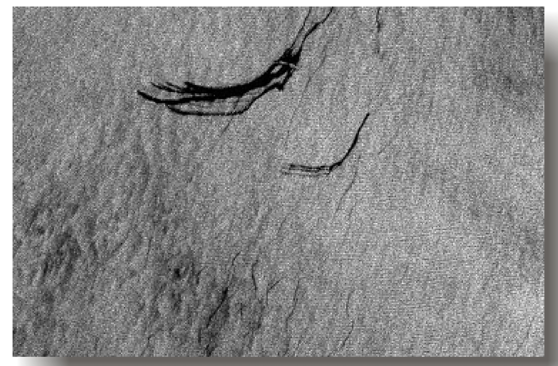
SAR satellites have return visit times of around 1 month (varies with each sensor) thereby being suitable for both exploration and environmental purposes. They provide a variety of swath widths for regional oil seep screening, a swath of either 100 x 100km (ERS) or 165 x 165kms (Radarsat Wide 1) with ground resolutions of between 25-30m. are ideal Satellite data are being continuously acquired, thus providing multi-temporal satellite data over any area of the globe. Having temporal coverage allows repeat seeps to be recorded and therefore provides the location for follow-up surface sampling from which key geochemical properties of the oil leaking from the target reservoir can be obtained ahead of the drill.

Seepage Slick Classification

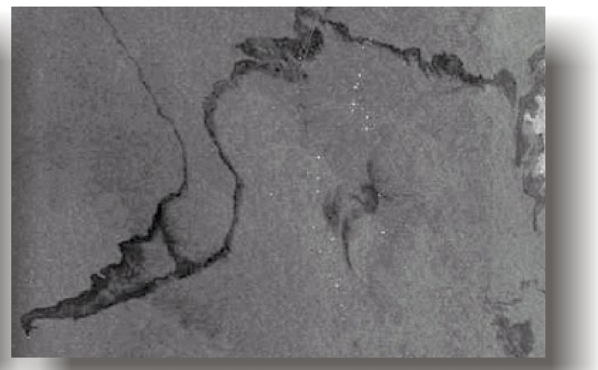
There are 3 principal slick categories that we can determine from satellite SAR Data, viz.
- Seepage slicks
- Pollution Slicks
- Natural Film Slicks

In many of our surveys around the world, pollution slicks are, sadly, by far the dominant group but this is not he case in the southern Gulf of Mexico where the dominant slicks are seepage slicks

Slicks detected by SAR cannot be assigned an unambiguous seepage origin without ground truthing follow-up at sea. However, with experience, certain characteristics can be interpreted with varying degrees of probability as to their origin, repeatability being one of the major defining criterion
We interpret 3 seepage slick categories,
Rank 1 (definite seeps) = green colour
Rank 2 (probable seeps)= red colour
Rank 3 (Possible seeps) = pink colour
Unassigned (Undetermined Origin) = cyan colour
Pollution categories,
Rank 1 (definite) = yellow colour
Rank 2 (probable) = orange colour
These conventions are followed in the body of this poster



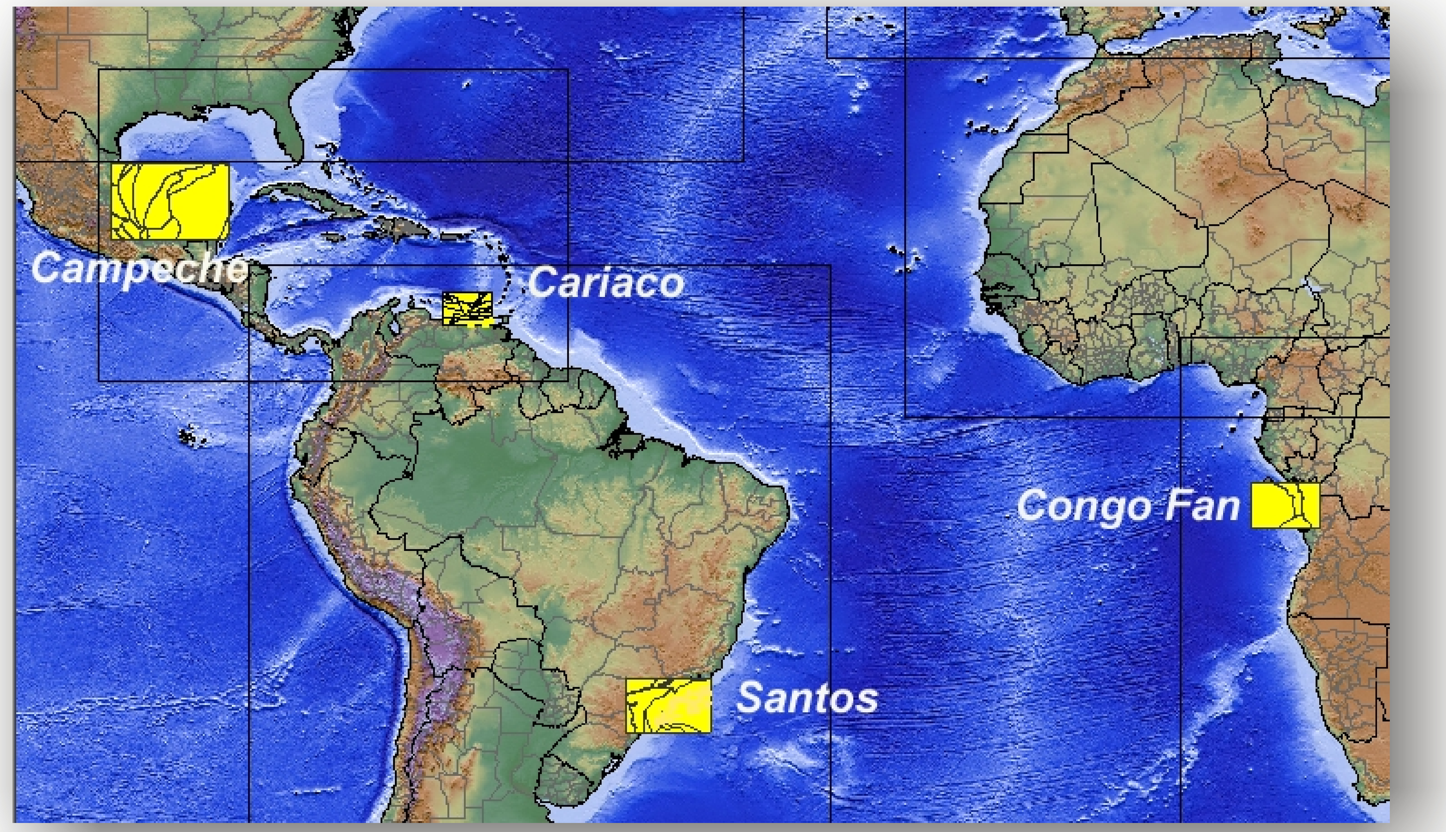
Nested oil seep Cariaco basin



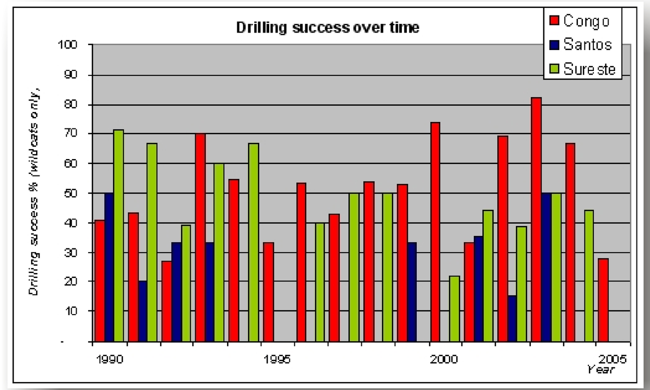
Prestige oil spill NW Spain

Dense natural film slicking

Study areas location map

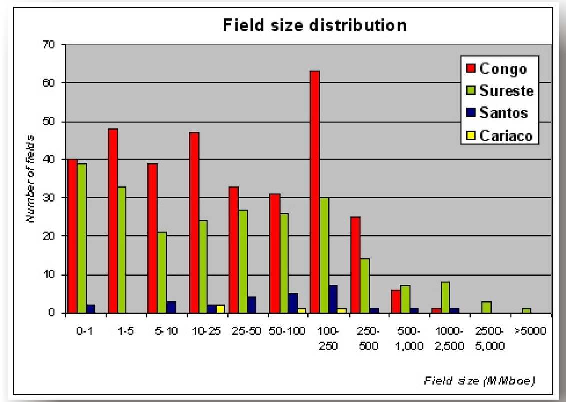


IHS Energy Basin Analysis Date



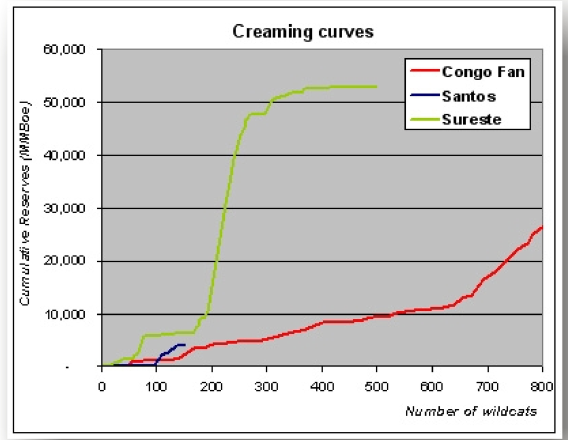
Drilling Success

- Congo shows an impressive trend 70-80% drilling success in 2002- 04 period
- Sureste basin shows a steady success rate at around 42-50%
- Santos lower success rate on a cyclical trend



Field Size Distribution

- Congo is impressive - more than 60% of new fields are in the 100 to 250 Mb range
- Sureste - only a few giant fields eg Cantarel; most fields less than 250 Mb
- Santos only moderate field sizes



Creaming Curves

- Congo steady curve with later jump in post 2000 from deep water discoveries
- Sureste, big jump when Cantarel discovered but has flattened since fewer wildcats with moderate reserves

www.npagroup.com

Alan@npagroup.com, michael.king@npagroup.com, geoff.lawrence@npagroup.com, jan.roelofsen@ihsenergy.com

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