AAPG EXPLORER

Cint Moore will present his paper, "Pioneering the Global Subsalt-Presalt Play: The World Beyond Mahogany (USA) Field," at the upcoming AAPG Annual Convention and Exhibition in New Orleans.

By the way, 'pre' and 'sub' differ

Advancements Push 'Salt' Plays

BY LOUISE S. DURHAM, EXPLORER Correspondent

You can call it subsalt exploration, presalt exploration or whatever makes you happy.

Just don't forget to call exploration beneath salt bodies a big deal.

These plays are not new, yet the announcement of the giant Petrobras-operated Tupi field presalt oil discovery in 2006 offshore Brazil in the Santos Basin triggered major excitement in the E&P community and elsewhere.

Boasting indicated reserves of as much as eight billion barrels of oil equivalent, Tupi represented the biggest find since the 13 billion barrel Kashagan Field was discovered six years earlier in 2000.

MOORE

Today, offshore Brazil has become a hot-spot for presalt exploration, with discoveries becoming almost routine.

It's common to hear subsalt and presalt used interchangeably – but that's not necessarily proper. Or even correct.

AAPG member Clint Moore, vice president of corporate development at ION Geophysical Corp., described the differences in a paper he gave at the recent 2009 AAPG International Conference and Exhibition in Rio de Janeiro:

- Presalt – exploring beneath an autochthonous salt layer that overlies stratigraphically **older** rock.
- Subsalt – exploring beneath an allochthonous salt layer that overlies stratigraphically **younger** rock.

Presalt plays have been explored and developed for many decades, according to Moore, who noted the earlier plays usually were under somewhat thin, continuous salt beds – the kind that aren't particularly challenging when it comes to seismic imaging and drilling operations.

As salt feeders migrate into slightly higher density overlying sediments, the resulting domes, ridges, walls or other type structures that are formed often create significant hydrocarbon traps.

This is particularly common in the subsurface of the deepwater regions of the Gulf of Mexico.

On the downside, these are highly complex structures that play havoc with seismic imaging.

Simply put, seismic waves have a tendency to scatter into multiple paths when traveling through low-density salt. The imaging process may not be able to adequately deal with this scattered energy, ultimately resulting in incorrect information about prospective formations below the salt.

First Steps

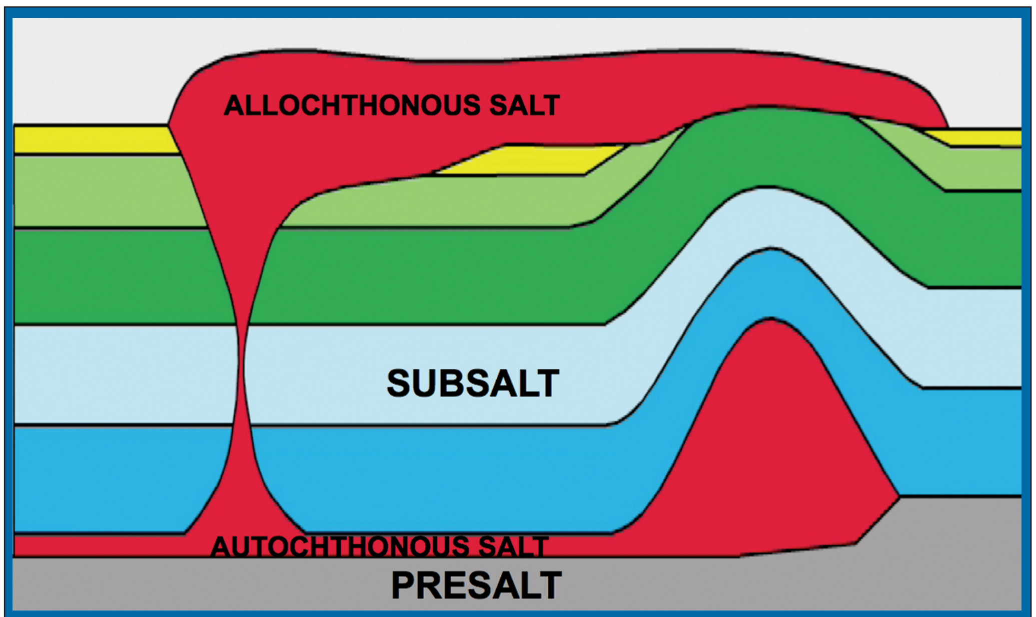
The Gulf of Mexico might be viewed as the industry's training lab for subsalt exploration – and Moore, who worked the Gulf plays, has been a part of the industry's subsalt story from its beginning.

In his Rio talk, titled "Pioneering the Global Subsalt-Presalt Play: The World Beyond Mahogany (USA) Field," he noted that during the early 1980s – the general consensus among industry explorationists was that salt occurrence in the GOM was, for the most part, vertical – therefore, when drilling into salt it was assumed that the mass was a dome.

Early wells drilled into subsalt deposits failed to penetrate any significant thickness of reservoir quality rock beneath salt, leading many explorers to conclude that the GOM subsalt plays weren't particularly prospective.

But industry people as a rule aren't influenced by naysayers, and the majority continued to believe – and to keep exploring.

Moore was a senior geologist at Diamond Shamrock in 1985 when the company and partners drilled a structural prospect with amplitude across the structure at South Marsh Island Block 200. Unexpectedly, the well drilled through 1,000 feet of salt and 1,500 feet of shale before going through a thousand feet of highly porous and permeable sandstone.



Graphic by Mike Hudec, Bureau of Economic Geology, The University of Texas at Austin, Annotation by Cint Moore, ION Geophysical Corporation
A graphic representation of subsalt vs. presalt.

The dry hole was significant in that it proved high quality reservoir rock could exist beneath salt in the Gulf, prompting Moore to refer to the event as a "discovery moment."

In 1993 the lid blew off the GOM subsalt play when Phillips (operator) Anadarko and Amoco drilled the discovery well at the sizeable Mahogany field. The discovery garnered considerable attention even in the mainstream press, and the field subsequently became the first subsalt field to produce in the Gulf. According to one source cited by Moore, Mahogany Field has produced 28 MMBOE through September 2009 through perforated zones.

Moore, Anadarko's Mahogany discovery geologist, noted that Phillips bid on Mahogany armed only with 2-D data. After acquiring a 3-D survey, the company used its just-developed prestack depth migration imaging algorithm on the data to acquire a sufficiently-improved image of the geologic section beneath the salt to position the location of the wildcat well.

The 'In' Play

Once gaining legs via Mahogany, the subsalt became the "in" play – despite the fact that imaging was relatively sub-par owing to the lack of computational power to run the algorithms required to more accurately image the target reservoirs.

"Since its inception, the greatest challenge for the subsalt/presalt play concept has been explorers' difficulty in imaging the seismic data below and around salt in order to accurately locate the potential structures," Moore said.

"As a result of recent major advances in seismic processing algorithms and computer processing speeds, explorers can now see subsalt/presalt images much more clearly," he said. "And the most progressive are applying these latest technologies to more salt basins globally.

"A confluence of technological advancements led primarily by rapid increases in computation speed – allowing for both attendant decreases in cycle time and the inclusion of higher frequency data – have caused reverse time migration, or RTM, to provide much clearer images of subsalt structures," Moore added.

"We're also evaluating the utility of RTM," he said, "not only as a tool for determining reservoir structures but also for assessing the fluid contents within them."

While the earlier depth migration imaging efforts at Mahogany inferred possible structures below the salt, Moore emphasized that today's RTM results allow for optimal well placement because of the superior images of the salt and the subsalt structures. The availability of better raw data to use in advanced RTM processing also plays a major role in RTM success.

Reverse time migration became commercially viable in all phases of the imaging sequence in 2008, according to Moore. The RTM algorithm was first introduced in the early 1980s.

The mere mention of "algorithm" may send some folks running for cover, so Moore proffered a basic definition for RTM.

"When seismic waves move through rock layers they bounce around in all directions," he said. "Prior to RTM our algorithms assumed simplistic single-bounce propagation from the surface to the reflector and back to the surface.

"Reverse time migration uses the fundamental seismic wave equation that governs propagation of waves in the earth, thus resulting in a more accurate image," Moore noted.

"Unlike other approaches, RTM makes virtually no assumptions or 'short cuts' in the way it describes the behavior and geometry of seismic waves moving through the earth."

Dawn Patrols

New technology may bring new potential, but it's clear that the salt players' performance hasn't been too shabby using "old-fashioned" tools.

The discovery and development of presalt/subsalt fields over the years, using pre-stack depth imaging applied to data acquired via short offset 2-D and narrow azimuth 3-D seismic surveys has resulted in significant production and reserves.

If you're not impressed, just wait.

"This represents a fraction of the potential that will likely be globally discovered using new RTM technology," Moore asserted.

"We're really at the dawn of the pursuit of this play, now that we can image the geology more clearly and accurately," he said. "Now that we have a new tool to see under and within the salt basins of the world, it will make a huge difference in terms of the amount of oil and gas that can be discovered in these complex geological basins.

"I think," Moore added, "there are billions of barrels of oil and trillions of cubic feet of natural gas yet to be discovered under salt."