San Joaquin Geological Society

November 18, 2008

by
Two Talks by Malcolm Allan and Stan Stearns

ABSTRACT - The Belridge Giant Oil Field: It keeps going and going... by Malcom Allen, Aera

The Belridge giant oil field is an elongated, faulted anticline aligned NW/SE on the west side of the sand Joaquin Valley, California. It has produced more than 1.2 billion BO & 1.05 billion CFG since being discovered in 1911. Current daily production is about 105 MB of oil and 54 MMCF of gas from 6730 wells draining three separate reservoirs.

The Pleistocene Tulare Formation produces heavy oil via steam flood from fluvio-deltaic sands. The Miocene Reef Ridge & Antelope Formations produce light oil from deep marine diatomites via hydraulic fractures. The Eocene to early Miocene Temblor (sub-Monterey) Formation produces light oil and gas from various marine sandstones. Each reservoir has a different geological setting, development history, production mechanism, and depletion plan. All three still have significant remaining oil-in-place and potential for reserves growth.

Aera Energy LLC (a company owned jointly by Shell and ExxonMobil) currently produces about 90% of the field's production and has been drilling 400-600 new or replacement wells per year. Each reservoir is split into various zones to handle the stratigraphic complexity. As each reservoir produces via a different mechanism and production method, there has to be synergy between the various surface and subsurface teams operating the field even though each well only produces from a single reservoir.

In order to maintain production and cost targets, field operations must run smoothly. Aera's 5 drilling rigs, 3 completion rigs, and 15 workover rigs have a constant appetite for new wells and remedial work for existing wells. To keep up with this demand, the geologic & reservoir management processes have been stream-lined and extensive use is made of 3D geological models. The scale of the field and the immense amount of hard data (historical & modern) that needs to be interpreted for effective reservoir management cause unique problems and opportunities the require efficient and streamlined processes.T

ABSTRACT - Elk Hills Field Overview: Its Past, Present and Future by Stan Stearns, oxy

Even as we approach the hundredth anniversary of the discovery of the Elk Hills Field, it continues to be one of the more significant producing fields in California. Gross production continues to be over 100,000 boepd, and over 60% of this is light liquid hydrocarbons. As it moves into its second century, the application of EOR technologies will ensure that Elk Hills Field remains one of the key producing properties in California.

The Elk Hills Anticline is located on the west side of the southern San Joaquin Basin, and is clearly visible from Bakersfield. The large surface anticline is composed of 3 separate, tightly folded anticlines at depth, the 29R, 31S and Northwest Stevens (NWS) structures. These formed in response to compressive stresses associated with convergence and strike slip deformation along the western boundary of the North American plate. The deformed sedimentary sequence is more than 24,000 feet thick as defined by three deep wells drilled in the field. Commercial oil and gas production is presently limited to the top 10,000 feet of section, and the three major producing intervals are Miocene to Pliocene in age. These are referred to, in ascending stratigraphic order, as the Stevens, the Shallow Oil Zone (SOZ) and the Dry Gas Zone (DGZ).

Production from the Elk Hills Oil Field Elk Hills began in 1919 from the SOZ which is composed of shallow-marine to fluvial sands of the Pliocene Etchegoin and San Joaquin formations. SOZ reservoirs are 2,000 to 4,000 feet deep, and produce 25° to 30° API oil and associated gas. The porosity in the deeper shallow marine reservoirs, the

Wilhelm, Gusher, and Calitroleum sandstones, ranges from 28 to 30% and permeability varies from 1 to 30 md. The shallower SOZ reservoirs include the SS1, SS2, Mulinia and Sub-Mulinia reservoirs. The sands are generally course to medium grained with an average porosity of 28% and permeabilities ranging from 100 to 1000 md.

Production from the deeper Miocene Monterey formation reservoirs began in 1976 in response to the Middle East oil embargo. The production is from Stevens deep marine turbidite sandstones and Antelope shales (porcelanites and siliceous shales), both members of the Upper Miocene Monterey Formation. The reservoirs are 5,000 to 10,000 feet deep, and produce 35° API gravity oil with abundant associated gas. The porosity of the Stevens sandstones range from 12 to 24% with permeability varying between 3 and 235 md. Most of the Stevens reservoirs are depleted, and are currently under waterflood. Matrix porosity of the Antelope shale ranges from 13 – 20% with permeability averaging less than one md. The significant controlling factor for productivity is these shales are the degree of micro/macro fractures present.

The primary development phase of the Elk Hills Field is waning and several EOR projects have been implemented, tested or are being considered. In the SOZ reservoirs a nitrogen injection project has been implemented, a crestal waterflood has been piloted and an alkaline-surfactant polymer pilot is in the planning stage. In the Stevens turbidite reservoir a CO2 injection pilot has been completed. The field has produced approximately 1.3 billion barrels of oil and 1.9 billon barrels of oil equivalent during its first 90 years of production. The large amount of remaining hydrocarbons in place ensures that through EOR projects the field will continue to produce for many years into the future.