Petroleum Exploration and Development of the San Joaquin Basin, California: A Nearly Complete History?

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Abstract

The San Joaquin basin has over 130 oil and gas fields that have produced more than 14 billion barrels of oil and 13 trillion cubic feet of gas. The abundance of petroleum is due to the presence of two excellent source rock intervals, the Eocene Kreyenhagen Formation and the upper Miocene Monterey Formation, and a sand-rich stratigraphic column with Eocene to Pleistocene reservoir intervals.

The first field discoveries were near areas of surface oil seeps and included McKittrick, Coalinga, Midway Sunset and Kern River. Development was slow on the west side of the basin due to the lack of transportation infrastructure and low well productivity. However, the Lakeview Gusher and other well blowouts in the early 20th Century firmly established areas with high oil production rates. By 1909, with the knowledge that hilly regions of the basin contained favorable structures for oil, discoveries occurred on the major anticlinal structures at Buena Vista, Elk Hills, South Belridge and Lost Hills.

Subsurface data for the early geologists were limited to cuttings from wells drilled with cable tool rigs. By the 1920s, rotary rigs allowed deeper drilling and effective core barrels, invented by a geologist, supplemented borehole data. The new science of micropaleontology aided correlation and age control. In the early 1930s, Schlumberger introduced continuous resistivity and spontaneous potential logs of boreholes, which revolutionized subsurface interpretations.

The Ten Section field was the first San Joaquin Basin oil field discovered using geophysical methods. Based on a seismic reflection survey in 1934-35, the discovery well was drilled in 1936 and marked the first completion in the upper Miocene Stevens Sand. Additional fields on the Bakerfield Arch west of Bakersfield were quickly discovered using the new technology.

Following World War II exploration activity continued with modest success despite low oil prices. To offset declining production, over 30 water flood project were installed during the 1950s through 1960s. Water injection did not help recovery in heavy oil fields. In the 1960s, operators experimenting with steam injection in pilot projects at Coalinga, Kern River, Midway Sunset and South Belridge, had encouraging results.

In the mid 1970's, higher prices for crude plus success of steam flood pilots in fields with heavy oil led to "boom times" in the industry, with major project expansions and lease evaluations, and company staffs needing to expand. A wave of newly graduated geoscientists entered the petroleum profession to map detailed stratigraphy of injection zones. Steam operations (flooding or cyclic) ultimately reached 25 fields.

Contributing to the boom of the late 1970s and early 1980s was the improved understanding of producing the siliceous reservoirs of the Monterey and Reef Ridge formations. In South Belridge, the successful hydraulic fracturing of diatomite provided a method for commercial development and higher recovery. At Lost Hills, hydraulic fracturing of deeper Monterey and Reef Ridge reservoirs was extremely successful and set off a frantic drilling boom on the southeast nose of the anticlinal structure.

The crash of 1985 hit the geoscience profession hard. Drilling budgets dried up and staff levels were slashed. The survivors had to do more with less and turned to computers for assistance. Geologists were expected to learn and use newly developed software for cross sections, maps, geologic modeling and reservoir simulation. Operators also looked for new methods to get more production with less drilling cost and turned to horizontal wells. The first commercially successful horizontal well was drilled at Elk Hills in August 1988. Horizontal wells have been applied to many reservoir types across the basin, and, in some siliceous shale reservoirs, combined with fracture stimulations.

With rising petroleum prices in the early 2000s, exploration activity increased with significant 3D surveys. Successes include the discovery of a narrow deep anticline at Elk Hills, a stepout field from the North Shafter field (Rose field), and the discovery of an upper Miocene deepwater sand channels on the flank of Buena Vista Hills (Buena Vista Nose field).

Another industry crash occurred in the mid 2010s, not caused by oil prices drops but by litigation, legislation and industry missteps. From a practical standpoint, results are similar to the 1985 crash with reduced staff levels and limited budgets. To adapt to this new reality, many geoscientists have shifted from petroleum producing positions to groundwater studies or have transitioned to alternative careers such as subsurface carbon capture.

The lesson from this history is that times of crisis result in innovation and renewal. Although the current crash is more severe than any in the basin’s 130+ year history of oil production, and path forward is twisted and uncertain, innovation should prevail.