Geology of the Monterey Formation of California
With Comments on Recent Oilfield Developments

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Diatomaceous rocks and their diagenetic equivalents, chert, porcelanite and siliceous mudstone are abundant in Miocene deposits of the Pacific region. Of these, the Monterey Formation is the best known and most extensive. Its origin is tied to a fortuitous combination of tectonic, climatic and oceanographic events. In Oligocene-Early Miocene times, a change from subduction to a transform margin resulted in extension of the borderland and formation of new marine basins isolated from terrigenous input. In Miocene times, global cooling and changes in ocean circulation resulted in increased upwelling and productivity, and rapid accumulation of relatively undiluted biogenic sediment. Near the end of the Miocene, plate motion shifted from transtension to transpression, resulting in mountain building and a sudden influx of terrigenous material; this signaled the end of Monterey-style deposition in most areas of California.

Rapid burial and basin-margin uplift continued through the Pliocene to the present, creating an ideal setting for oil field formation. As burial proceeded, soft diatomaceous rocks were converted to brittle chert, porcelanite, and siliceous mudstone. With further burial, organic-rich Monterey rocks generated hydrocarbons. Rocks overlying or adjacent to the Monterey included porous sandstones that made ideal reservoirs. Oil migration was aided by fractures in brittle Monterey rock types. Approximately 29 Billion barrels of oil have been produced in California, with roughly 90% probably sourced from the Monterey. Most of this oil has been produced from clastic rocks, leaving enormous amounts of oil still trapped in the matrix of low permeability Monterey rock types.

In 2011 a report by INTEK, funded by the federal government, claimed that the Monterey Formation contained 15 billion barrels of recoverable oil, making it the largest resource base in the US. Using the INTEK numbers at face value, economists at USC predicted that California could experience an enormous economic boom. Both reports have been criticized as being wildly optimistic and not factually based, but not before they created a firestorm of public controversy resulting in new regulations on fracking.

The main problem with the INTEK report was incorrectly assuming the Monterey would behave like the new tight oil and gas plays (i.e. Bakken, Marcellus) elsewhere in the U.S.; but the Monterey has little in common with these plays. While it is clear that tremendous amounts of oil do remain within Monterey “shales” and diatomite, no easy way has been found to extract it. For decades operators have been using every available technique for enhancing production. This includes water flooding, steam flooding (lateral and huff-and-puff), CO2 flooding, and acidization, utilizing both vertical and horizontal injector and producing wells, some of which are fracked. There is no Monterey “Revolution”, however, operators will continue to seek better ways to extract the tremendous volume of oil remaining for many years to come.

Dr. Tom Mackinnon received BA and MA degrees in Geology from the University of California at Santa Barbara in 1970 and 1975 respectively, and a Ph.D. in geology from the University of Otago, New Zealand in 1981. In New Zealand he worked on the regional geology of the Torlesse subduction complex (cf. Franciscan). From 1981 to 2008 he worked for Chevron in California, including eight years as coordinator of Chevron Stratigraphic Schools and many years working sporadically on the Monterey Formation. Tom is currently working on structural and metamorphic problems in the Eastern belt of the Franciscan Complex in Grindstone Creek, west of Willows, CA.