Basement Structural Evolution and Control of Petroleum-Producing Structures in the Los Angeles Basin Area

Marc J. Kamerling[1]

[1]Consultant, former Arco Exploration, Venoco, Inc., and Institute for Crustal Studies (now Earth Research Institute), UC Santa Barbara), marckam@frontier.com

Abstract

Oil production from "Schist Basement" as early as the late 1920's was obtained from wells in the coastal areas of the Los Angeles Basin. Regional structure maps of the basement of Los Angeles Basin were published in 1946, 1951, and 1965. Basement maps of some individual fields were published in 1972 and in the California Department of Conservation's Division of Oil and Gas "California Oil Fields", Volume II. Basement maps of some offshore areas using wells and seismic reflection data have been published within the last 20 years. Work on the nature of the basement in the Los Angeles Basin was published largely up to the 1990's with much work on the metamorphism and origin of the Catalina Schist and the Peninsular Range basement more recently. Wells drilled since the last comprehensive basement maps, integrated with updated gravity and magnetic maps, new cross-sections, seismicity, and offshore seismic reflection data were examined to provide sufficient additional data to generate a more complete updated basement map of the Los Angeles Basin area. In addition to the structure of the basement itself, the rocks deposited on and above basement, distribution of volcanic rocks and dike orientations, and paleomagnetic data, were also compiled to better understand the evolution of the basin. As noted by earlier workers, Catalina Schist of blueschist, greenschist, and amphibolite facies occur west of the Newport-Inglewood fault and Peninsular Range basement plutonic and metamorphic rocks occur east of the fault. Thus, the Newport-Inglewood fault is an important basement boundary. Catalina Schist outcrops on the Palos Verdes Peninsula and Santa Catalina Island and has been sampled on the sea floor offshore. Rocks overlying this basement are often a basal conglomerate and sandstone consisting largely of the basement rocks below. These deposits are typically early Mohnian but are Luisian age in some areas of Wilmington field. Molluscan fossils in the basal conglomerate and locally irregular basement surface indicate that the basement was near sea level in a "rough-coast" environment in upper Miocene time. Schist debris, presumably eroded off Catalina Schist highs occurs in widely scattered locations in southern California and the Transverse Ranges, as San Onofre Breccia. However, San Onofre Breccia in the western Transverse Ranges appears to be older Saucesian benthic Foraminifera stage, than San Onofre Breccia deposits along the south coast and in some wells in the Los Angeles Basin which are considered Luisian age. Thus, erosion of Catalina Schist occurred and ended at different times and places as the plate boundary evolved. Above the schist bearing sand and conglomerate and interbedded in some areas, is often bentonitic clay / volcanic ash. Modelo (Monterey Formation) typically described as the "Nodular Shale" in early well descriptions, of middle Mohnian age lies above this ash layer. In some areas the Monterey strata rests directly on the schist conglomerate or schist as exposed on the Palos Verdes Peninsula. On Santa Catalina Island the basal breccia/conglomerate is composed of clasts of the local basement, quartz diorite, greenschist with some blueschist clasts overlain by volcanic flows, flow breccias and volcanic ash. Thin layers of middle and late Miocene sediments are interlayered with these extrusive volcanic rocks. This implies a volcanic episode just prior to subsidence of the coastal basement. The rapid subsidence and burial of organic rich Modelo (Monterey) Formation led to the generation and migration of hydrocarbons into late Miocene to early Pliocene structures. As the basin subsided and surrounding areas were uplifted, large volumes of clastic sediments flowed into the basin. These deposits buried the Modelo source rocks and provided reservoirs for the oil fields. However, unconformities and local thickness variations indicate continued vertical activity. The faults along which many of the oil fields in the Los Angeles Basin are associated,

have a long and complex history as the plate margin evolved through subduction, extension, and transpression/compression. Earlier faults were re-activated, even though not necessarily aligned with the changing stress field and generated the structures that became oil fields. The middle Pliocene to present Pasadenan deformation has enhanced some of these structures and disrupted others. Various hypotheses have been proposed for the evolution of the Los Angeles basin including thermal subsidence, pull-apart basin extension, crustal extension, triangular basins related to rotation, and core-complex origins. These hypotheses will be reviewed considering the updated data, analyses and syntheses and some new insights proposed.