ABSTRACT

Exposed at the surface of the McKittrick Field are Monterey diatomites and related siliceous sedimentary rocks holding up to 832 million bbls of probable in-place reserves of oil. Getty Oil Company has narrowed the choice of extraction methods for the porous but low permeability rocks to open-pit mining and retortion or solvent extraction, which are being evaluated in pilot plants.

Field mapping, geophysical logging, core descriptions and laboratory analysis of mineralogy and reservoir parameters suggest division of the sequence into the following gradational units: younger aluvium, asphaltic alluvium (including a scrotaceous slag of burned diatomite), and colluvium breccia (depositional and tectonic); Tulare Formation; diatomaceous claystone and shale (composed of frustule fragments of opal-A), siliceous shale and porcellaneous shale (opal-CT), sandstone and tuffaceous carbonate of the McQuire Member of the Monterey Formation; and undifferentiated tuffaceous beds and exotic conglomerate.

Predominant Monterey depositional processes were short distance nepheloid flow and hemipelagic rain of diatoms onto dysoxic outer slope or deep basin environments, probably during blooms of cooler periods. Mass movement processes occurred with minor turbidity current transport.

The diatomite was tectonically displaced over Plio-Pleistocene beds during the mid-Pleistocene by SW-dipping high-angle reverse and thrust faulting. The McKittrick thrust fault is the basal sole thrust associated with and locally offset by imbricate synthetic and a few antithetic secondary faults. Gravity sliding may have been involved, notably in the northern part of the field. Continuing, episodic compression has thickened the section and destroyed some bedding, formed extensive breccia and caused plastic deformation and rotation of large diatomite blocks.

This complexity confuses diagenetic trends. The conversion of opal-A diatomite to opal-CT porcelanite and chert is observed with the destruction of fossils and porosity and formation of sheet-like or lepispheric structures accompanying increasing hardness, density and fracture frequency. Only general trends with depth are seen. Initial composition and position were important. Authigenic dolomite has replaced glass shards and some diatomite and occurs also as cement. Minor pyrite, gypsum and clay minerals have formed.

The 14^oAPI gravity oil is similar to crude of surrounding fields. Oil and tar seeps, gilsonite and asphaltic sands are commonly associated with faults. These relations plus the thermal immaturity of the diatomite suggest the oil has migrated into the diatomite, aided by the pervasive shearing, rock dilatancy and capillarity. The best host rocks are soft, earthy diatomaceous clays and shales. Harder siliceous shale (even where fractures drip with oil) and clastic units together account for only 35% of the oil reserve volume. Geologic descriptors and log calculations are not as reliable predictors of oil grade as systematic coring and assaying.

INTRODUCTION

Geological Implications

Exposed at the surface of the McKittrick Field, northwest of McKittrick, Kern County, California (Figs. 1 and 2) is an extensive deposit of Upper Miocene Monterey (Mohonian) diatomite and related siliceous deposits. These brown rocks and numerous tar seeps are surficial evidence of an estimated 832 million bbls of probable in-place oil. Field study, description of core and laboratory analyses facilitate an understanding of the sedimentology, paleogeography, tectonics, diagenesis, and oil migration in this portion of the southern San Joaquin Valley. The deposit is contemporaneous with producing and potential siliceous reservoir and source rocks around the circum-Pacific rim. Among these are the fractured Monterey Formation of offshore southern California and the Santa Maria Basin, as well as the Belridge Diatomite, Cahn Chert and Kreyenhagen Shale of the San Joaquin Valley.

The deposit consists of diatomaceous and siliceous mudstones, chert, tuffaceous and carbonate rocks, clastics, asphaltites, and depositional and tectonic breccias. The assemblage occurs with minor exotic conglomerates, in a province of imbricate overthrusting confused by diagenetic overprinting, brecciation, secondary faulting, and recent alluvial and colluvial mantling. These processes complicate but generally aid oil migration.

Brief History of the McKittrick Field

Discovery of oil seeps, brines (Fig. 3), and outcropping asphaltic sands led to the digging of shallow pits and tunnels, and organized exploitation dates from at least 1861 (Zulberti, 1956). Refining to kerosene and lubricating oil began in 1864 and the first well was drilled in 1867. The years 1878–1899 saw the beginning of practical development, including drilling to deeper oil sands (Zulberti, 1956). Deep activity for Eocene targets continues today. The McKittrick Field has produced almost 240 MM bbls of oil and 179 MM Mcf of gas as of January, 1982 (Conservation Committee of California Oil Producers, 1982). Paleontologists have studied the Pleistocene tar traps south of McKittrick since the early days of the field.

Recent Interest in the McKittrick Field

Conventional, secondary, and tertiary oil recovery methods have been largely unsuccessful in producing the heavy crude from the highly porous but very low permeability diatomite. Overburden pressure for such methods is inadequate and sufficient fracturing is not common in these semiplastic rocks. Getty Oil Company will therefore use what may be termed a "terminal" recovery method: open pit mining. Aimin to recover virtually all of the estimated 300–380 MM bbls of minable reserves, Getty Oil will develop the deposit much as the field began production over 120 years ago.

Interest in diatomite as a reservoir for oil instead of