Introduction

Mud-rich deep-sea-fan systems throughout the world yield significant accumulations of hydrocarbons. However, these distinctive turbidite deposits remain as yet poorly understood. Although several modern mud-rich deep-sea fans such as Mississippi fan (Kastens and Shor, 1985; Stelting et al., 1985; Bouma et al., 1986), Amazon fan (Damuth et al., 1983; Flood and Damuth, 1987; Damuth et al., 1988; Manley and Flood, 1988), Bengal fan (Emmel and Curray, 1985), and Rhone fan (Droz and Bélache, 1985) have been extensively studied, relatively few ancient mud-rich deep-sea fans have been described in detail. McCabe (1978) and Melvin (1986) provided useful descriptions of two Carboniferous delta-fed mud-rich fan sequences, although no ancient fans of this type have been directly related to hydrocarbon accumulations. In this chapter, we present a detailed stratigraphic study of facies associations, sandstone distribution, and sandstone geometries and the relation of these to hydrocarbon production in the Forbes Formation, an ancient mud-rich turbidite system of the California Great Valley forearc basin.

The mud-rich turbidite sequence of the Upper Cretaceous (Santonian to Campanian) Forbes Formation in the Sacramento basin is one of the most prolific producers of nonassociated gas in California and is one of the best-studied ancient mud-rich turbidite sequences in the world. Drilling activity for Forbes targets has remained steady despite recent nationwide industry decreases (Weagant, 1986). Analyses of a large number of wells (more than 5,000), many miles of seismic-reflection data, cores, and nearby outcrops of gas-productive strata have contributed to our knowledge of this depositional system, which may serve as an analogue for similar, less-understood systems in other parts of the world.

Cumulative gas production from Campanian reservoirs in the Sacramento basin through 1984 exceeded 1.3 trillion cubic feet ($3.7 \times 10^{10}$ m$^3$), with gas reserves being more than 250 billion cubic feet ($7.1 \times 10^{9}$ m$^3$) (California Division of Oil and Gas, 1984). The Arbuckle Gas Field (Fig. 22-1) in Colusa County in the central Sacramento basin (T.13-14N.,R.2W.), approximately 50 miles (80 km) northwest of Sacramento, has produced more than 70 BCFG ($2.0 \times 10^9$ m$^3$) from reservoir sandstones deposited as channel-levee complexes of the mud-rich deep-sea-fan system of the middle member of the Forbes Formation. An anticlinal feature near the town of Arbuckle was originally identified seismically and penetrated by several shallow wells beginning in 1950. The Arbuckle Gas Field was discovered in 1957 when the Western Gulf Oil Company successfully completed the Arbuckle Unit C-1 well at 5,581 to 5,608 feet (1,701-1,709 m) and 5,873 to 5,910 feet (1,790-1,801 m), with a flow pressure of 1,245 psi (8.6 x 10$^3$ kPa) through a 1/2-inch (1.3-cm) choke and an IP of 7.9
Fig. 22-1. Sacramento basin and surrounding areas showing location of the Arbuckle Gas Field and outcrops of Great Valley sequence. Abbreviations: GVS, Great Valley sequence; SF, San Francisco. Cross section A-A' is shown in Figure 22-2.