INTRODUCTION

Ojakangas (1964, 1968) documented paleocurrent directions and associations of sedimentary structures, stratigraphic changes in sandstone composition primarily reflecting changes in provenance, and overall stratigraphic-structural relations of the Sacramento Valley. These three components (sedimentology, petrology, and structure) formed the basis for Ingersoll’s (1976) dissertation (both Ojakangas and Ingersoll were supervised by W. R. Dickinson at Stanford University). Fundamental breakthroughs in understanding occurred between the times of Ojakangas’ and Ingersoll’s dissertations, which allowed the latter to integrate these fields in a way not previously possible.

SEDIMENTOLOGY


Ingersoll (1978b) utilized the model of Mutti and Ricci-Lucchi (1972) to delineate horizontal and vertical trends in submarine-fan facies of the Upper Cretaceous part of the Great Valley Group. This facies analysis was combined with a synthesis of all available paleocurrent and paleoecological data to outline the depositional history of the Great Valley basin (Ingersoll, 1979).

Subsequent sedimentological research has refined interpretations of processes and products of submarine deposition, paleoecology, and paleogeography (e.g., Garcia, 1981; Cherven, 1983; Suchecki, 1984; Ingersoll and Nilsen, 1990; Graham and Lowe, 1993; Williams et al., 1998).

PETROLOGY AND PROVENANCE

Bailey and Irwin (1959) first recognized systematic stratigraphic changes in sandstone composition in the Sacramento Valley, and Brown and Rich (1961) utilized these petrologic intervals for mapping. Following Ojakangas’ (1968) refinement of these petrologic intervals, Rich (1971) and Dickinson and Rich (1972) named five petrofacies along the west side of the Sacramento Valley. At the same time, Mansfield (1971, 1979) studied comparable petrofacies of part of the San Joaquin Valley. This petrofacies work overlapped publication of the definitive method of petrographic analysis of graywacke and arkose by Dickinson (1970a). Dickinson et al. (1969) also documented in greater detail diagenetic changes in Great Valley strata, as previously discussed by Ojakangas (1968).

Ingersoll (1978a, 1983) refined the Sacramento and San Joaquin petrofacies and designated petrostratigraphic units, which are mappable over the entire Great Valley. Ojakangas (1968), Dickinson and Rich (1972), Ingersoll (1978a, 1983) and Mansfield (1979) all related changes in petrofacies to provenance changes in the Sierra Nevada and Klamath Mountains (Fig. 1). Additional work by Bertucci (1983), Seiders (1983, 1989), Suchecki (1984), Seiders and Blome (1988), and Short and Ingersoll (1990) refined provenance interpretations through combined study of sandstone and conglomerate petrofacies. Additional detailed insight regarding evolution of the Sierra Nevada magmatic arc was provided by analysis of radiogenic isotopes of Great Valley petrofacies (Linn et al., 1991, 1992).
During the plate tectonics revolution of the late 1960s and early 1970s, major aspects of California geology were reinterpreted. Hamilton (1969) suggested that Pacific oceanic plate “under-flowed” California throughout the Mesozoic and created the Franciscan subduction complex, as well as the Sierra Nevada Batholith, by generating melts at depth. Ernst (1970) proposed that the fault contact between the Franciscan Complex and the Coast Range ophiolite was the crustal remnant of the late Mesozoic subduction zone. At the same time, radiometric dating of plutons in the Sierra Nevada was delineating migrating patterns of magmatism (e.g., Evernden and Kistler, 1970) (Fig. 2). Dickinson (1970b, 1971, 1973, 1974a, 1974b) discussed how forearc basins such as the Great Valley formed between growing subduction complexes and active magmatic arcs. In fact, the Great Valley forearc basin has served as the type forearc basin in subsequent discussions (e.g., Dickinson and Seely, 1979; Ingersoll, 1982; Dickinson, 1995).

The most enigmatic aspect of Great Valley geology is the origin of the Great Valley ophiolite, which in places depositionally underlies the western Great Valley Group. Bailey et al. (1970) and Moores (1970) proposed that the ophiolite represented oceanic crust accreted to the continental margin prior to initiation of the Great Valley forearc basin. Schweickert and Cowan (1975) proposed a model involving the collision of the west-facing continental-margin arc with an east-facing intraoceanic arc with backarc spreading; collision created the Nevadan orogeny, which immediately preceded and overlapped with initiation of Franciscan subduction in the latest Jurassic (Fig. 3). Ingersoll and Schweickert (1986) integrated this model with the contrasting Nevadan tectonic history of the Klamath area (e.g., Harper and Wright, 1984) and showed how a wide oceanic forearc basin could have formed in the Great Valley area at the same time that no such forearc basin formed in the Klamath area (Fig. 4). Dickinson et al. (1996) reviewed ongoing controversy concerning origin of the Great Valley ophiolite. Godfrey et al. (1997) provided seismic and gravity data consistent with thrust emplacement of the Great Valley ophiolite over Sierran basement during the Nevadan orogeny, as predicted by Schweickert and Cowan’s (1975), Moores and Day’s (1984), and Ingersoll and Schweickert’s (1986) models.

Additional insights regarding the Great Valley forearc basin were provided by subsidence and thermostratigraphic analyses. Dickinson et al. (1987) suggested that Cretaceous subsidence was primarily due to isostatic sediment loading on top of the residual deep oceanic crust, followed by rapid shallowing during flat-slab subduction. Moxon and Graham (1987) documented Late Cretaceous thermal subsidence along the east side of the basin, corresponding to eastward migration of the magmatic arc (i.e., Ingersoll, 1979) (Fig. 3), and latest Cretaceous uplift along the west side of the basin, corresponding to initiation of Laramide flat-slab subduction. Bostick (1974) and Dumitru (1988) documented low geothermal gradients within the Great Valley forearc, as predicted by the forearc model.

By the end of the Cretaceous, most of the Sacramento forearc basin had been filled nearly to sea level, to form a broad shelf (Dickinson et al., 1979; Ingersoll, 1982). Diverse depositional environments, ranging from nonmarine to coastal and deltaic to
slope to basin plain and submarine fan, during the latest Cretaceous to early Paleogene, are well documented in the subsurface, primarily based on oil and gas wells and seismic studies (e.g., Garcia, 1981; Ingersoll, 1982; Cherven, 1983; Nilsen, 1990). Almgren (1978) and Dickinson et al. (1979) summarized the Paleogene history of northern California, including the cutting and filling of submarine canyons in the forearc shelf.

Structural studies have demonstrated two important characteristics of the west side of the Great Valley. In many localities, the Coast Range fault (formerly considered only a thrust representing subduction displacement; e.g., Ernst, 1970) has demonstrable normal displacement that overprints older thrust displacement (Jayko et al., 1987; Krueger and Jones, 1989; Harms et al., 1992). Cenozoic and possibly Cretaceous uplift of the Coast Ranges was accomplished in part by extension along the Coast Range and related faults. Contractional deformation, in places of demonstrable Quaternary age, has overprinted this extension along the east side of the Franciscan Complex (e.g., Wentworth et al., 1984; Namson and Davis, 1988; Wentworth and Zoback, 1989; Unruh and Moores, 1992; Unruh et al., 1995).

CONCLUSIONS

Figure 4. Sequential paleotectonic diagrams for Middle to Late Jurassic in northern California. Active magmatic arcs are shown with smoke, inactive without. Active subduction zones are shown by barbed symbols; suture zones are shown by suture pattern. Rifted continental margin is shown by hachured line. Active spreading centers are shown by divergent arrows on double lines, without implication of exact spreading orientation; inactive spreading centers are shown by double lines without arrows. Transforms are shown by thin arrows. Southward propagating trench is shown by large arrow. Stippled pattern shows sites of deposition of the Mariposa and Galice formations, and the Great Valley (GV) forearc basin. Abbreviations: CRO—Coast Range (Great Valley) ophiolite; SO—Smartville ophiolite; JO—Josephine ophiolite; CRG—Chetco, Rogue, Galice arc complex; F—Franciscan Complex; LRPB—Logtown Ridge arc complex and 200my-old Peñon Blanco arc complex; CHGR—Copper Hill, Gopher Ridge arc complex; BMF—Bear Mountain fault; MF—Melones fault; SF—Sonora fault. Parentheses around ophiolite names indicate partial preservation within fault zones (from Ingersoll and Schweickert, 1986).

provided viable models to explain the initiation of the Great Valley forearc basin following the Nevadan orogeny. Subsequent work has added to the data base and modified existing models, but has not challenged the fundamental models.

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