CHAPTER 25

Butano Turbidite System, California

Tor H. Nilsen

Abstract

The Eocene Butano Sandstone was deposited as a submarine fan in a relatively small, partly restricted basin in a borderland setting. It is possibly as thick as 3000 m and was derived from erosion of nearby Mesozoic granitic and older metamorphic rocks located to the south. Deposition was at lower bathyal to abyssal water depths. The original fan may have been 120- to 160-km long and 80-km wide. Outcrops of submarine-canyon, inner-fan, middle-fan, and outer-fan facies associations indicate that the depositional model of Mutti and Ricci Lucchi can be used to describe the Butano Sandstone.

Introduction

The Butano Sandstone crops out discontinuously over a northwest-southeast distance of about 60 km in the Santa Cruz Mountains of northern California (Fig. 1). It was deposited in the La Honda basin and forms the reservoir for the La Honda and Costa oil fields in the northern part of the basin. The La Honda basin is bounded on the northeast by the right-lateral Pilarcitos and San Andreas faults, which truncate outcrops of the Butano Sandstone, and on the southwest by the right-lateral San Gregorio fault. The northwestern and southwestern margins of the La Honda basin are defined by Mesozoic granitic and older metamorphic rocks of the Montara Mountain and Ben Lomond Mountain areas, respectively. The La Honda basin forms one of several major Late Cretaceous and Tertiary basins that developed in the Salinian block, a crustal sliver bounded on the northeast and southwest by strike-slip faults and underlain by granitic rocks that accreted to the California continental margin in the Lower Tertiary.

The Butano was named for outcrops of sandstone and conglomerate on Butano Ridge (Fig. 1). Its areal distribution and stratigraphic relations have been studied by workers at Stanford University and the U.S. Geological Survey [1–3]. It ranges in age from Penutian (Early Eocene) to Narizian (Middle Eocene) and accumulated at lower bathyal to abyssal depths in a basin that had unrestricted access to the open ocean [4,5]. The Butano Sandstone unconformably overlies deep-marine shale of the Paleocene Locatelli Formation or rests nonconformably on granitic or metamorphic rocks of the Ben Lomond Mountain area. The Butano is conformably overlain by deep-marine shale of the Twobar Shale Member of the San Lorenzo Formation. Because the Butano Sandstone crops out in separate folded and fault-bounded blocks, no complete section is exposed. Although its total thickness is not known, its minimum thickness is 1500 m and its maximum thickness is 3000 m. Because outcrops are generally present within redwood forests and other areas of dense vegetation and abundant landsliding, beds and groups of beds cannot be traced laterally, and most stratigraphic information comes from measurement of sections in creek bottoms.

Fan Definition

The Butano Sandstone forms the southwestern part of a larger Eocene deep-sea fan that was truncated and dismembered by Late Cenozoic right slip of several hundred kilometers along the San Andreas fault [6]. The northeastern and most distal part of the deep-sea fan crops out east of the San Andreas fault in the Temblor Range (Fig. 1), where it forms the Point of Rocks Sandstone, from which oil is also produced [7]. Evidence that the Butano Sandstone was deposited as a deep-sea fan includes (1) microfauna indicative of deposition in deep-marine environments, (2) abundant turbidite and other sediment-gravity-flow deposits, (3) an outward-radiating paleocurrent pattern, (4) presence of almost all of the facies...
The Butano deep-sea fan, as well as the combined Butano–Point of Rocks deep-sea fan, generally fits the published models of Mutti and Ricci Lucchi [8] for fans of mixed-sediment origin. Although it is quite sandstone-rich and also contains coarse boulder conglomerate, it also has well-developed large inner-fan channels, smaller middle-fan distributary channels, and outer-fan lobes.

**Fan Divisions**

The three major outcrop belts of the Butano Sandstone, southern, central, and northern, contain the inner-fan, middle-fan, and outer-fan facies associations, respectively (Fig. 2). Lateral relations between facies associations are unclear, and the lateral extent of channels and lobes are uncertain because of the nature of the outcrops. However, the characteristic features of each facies association were determined from 12 measured sections, 1 in the northern, 10 in the central, and 1 in the southern outcrop belt (Fig. 3). Sections 1 to 11 were measured up to the base of the overlying Two-bar Shale Member of the San Lorenzo Formation, whereas section 12 has no recognizable stratigraphic boundary at either its top or base. These sections contain various megasequences characteristic of deep-sea fan facies associations.

The fan-fringe and basin-plain facies associations are not present in outcrop, except as thinner bedded turbidites between distinctive thickening- and coarsening-upward outer-

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**Figure 1.** Generalized geologic map of the Santa Cruz Mountains showing the distribution of Butano Sandstone. Numbers indicate locations of measured sections. Geology modified from Brabb [8].

**Figure 2.** Map showing distribution of deep-sea fan facies associations, paleocurrents, and longest clasts in conglomerate beds of the Butano Sandstone. Modified from Nilsen [11] and Nilsen and Simoni [12].