

with the main body of the crystal, and which yields a calcium-rich dolomite by solid-state diffusion. This can be demonstrated to be true of most dolomite which forms in the absence of extraneous phases of calcite and magnesian calcite, from both the marine-associated Coorong lakes and Deep Springs Lake, by employing the following methods: (1) progressive leachings, with attendant chemical analyses; (2) X-ray diffraction; and (3) electron microscopy. X-ray diffraction data show that it is also true of dolomite forming in the presence of such extraneous phases. Dolomite also forms in the presence of magnesite or calcian magnesite, in certain of the marine-associated Coorong lakes; such dolomite is slightly magnesium rich. This dolomite probably forms via a magnesium-rich precursor, deposited as a layer on the individual crystals of dolomite, in much the same manner as the calcium-rich layer on the calcium-rich dolomite. Carbon-14 dates of the calcium-rich dolomite from Deep Springs Lake yield growth rates of 500-900 angstroms/ 10^3 years.

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GENESIS OF CARBONATE RESERVOIR FACIES

Carbonate rocks with porosity characteristics adequate to form petroleum reservoirs commonly are highly specific bodies of rock. They are rare in occurrence and diverse in type. Most are complex, both internally and in their relations with associated non-reservoir rocks. Yet the occurrence of porosity in carbonate rocks is in very few cases fortuitous; some discernible order normally prevails in the facies complex containing the specific reservoirs. Examples of highly specific reservoir facies, where a knowledge of the rocks and an understanding of their genesis can be helpful, are Pennsylvanian phylloid algal reservoirs of the Paradox basin, stromatoporoid-rich bank margin facies of Devonian age in Alberta, and widely distributed algal mat reservoirs. Detailed study of the rocks and their pore systems can lead to more effective exploration and exploitation.

The existence of limestone and dolomite reservoirs commonly is directly related to the nature of the original sediment and to early diagenetic processes. In reservoirs retaining significant primary porosity, the size and interconnection of the original pores are more important than the amount of original porosity. Many carbonate reservoirs have pore systems of diagenetic origin. In these, the key factors are rock fabrics with components of different solubilities, or of different susceptibilities to such diagenetic processes as cementation or dolomitization. Factors favorable for reservoirs of primary porosity may be unrelated or opposed to those favoring diagenetic porosity. For example, some primary reservoirs consist of coarse, well-sorted calcarenites. In other facies complexes, these well-sorted rocks have low porosity and permeability, and the specific reservoirs occur in contemporaneous, poorly sorted, and mud-rich carbonates that were selectively dolomitized and leached.

Modern carbonate sediments of many textural types (mud, sand, and mud-sand admixtures) have porosities of 40-70 per cent. Newly deposited or reworked carbonate mud and some skeletal sand or growth frameworks may exceed 70 per cent porosity. Yet most ancient carbonate rocks have porosities of but a few per cent. Even the better carbonate reservoirs have only a small part of their original pore volume. This wholesale reduction in porosity is an important

but commonly neglected factor in carbonate rock interpretation. Reduction of porosity is accomplished mainly by introduced carbonate cement, probably involving thousands of pore volumes of interstitial water. In much limestone the volume of cement may approach or exceed that of the initial sediment. Compaction normally is minor, because of early cementation and compaction resistance of carbonate sediment. Locally, pressure-solution processes are important in porosity reduction. The aragonite-to-calcite volume increase can be only a small factor in the reduction of porosity.

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POSSIBLE NON-TURBIDITE ORIGIN OF DEEP-SEA SANDS IN CRETACEOUS FLYSCH (BAVARIAN ALPS, GERMANY) AND RECENT SAN DIEGO TROUGH (CALIFORNIA)

The Bavarian-Austrian flysch between the Rhine River and Vienna consists of Cretaceous clastic rocks, about 1,500 m. thick, deposited in an east-west-trending trough more than 500 km. long, 20-40 km. wide, and more than 200 m. deep. The directions of sediment supply, as inferred by sedimentary structures, grain-size variations, and heavy- and light-mineral distributions, were remarkably constant and parallel with the trough axis during long time intervals. Filling took place from both ends of the trough. The source area was at the west (Switzerland) during the Early Cretaceous, at the east (Bohemian Massif) during Turonian time, and at the west again during the Late Cretaceous. Within this flysch sequence the quartz-graywacke of the 200-m.-thick "Gault" Formation of Early Cretaceous (Albian) age was deposited as a continuous blanket. Single beds can be traced continuously for as much as 115 km. toward the western source area. Correlation was accomplished by comparison of the distinctive sequence, thickness, and petrography of individual beds ("fingerprint-type identification"). Grain-size, thickness, and content of unstable minerals in correlated sandstone beds increase slightly toward the source. Observations in the Bavarian flysch not easily explained by the hypothesis of avalanche-type, spasmodic turbidity currents include the following.

1. Sedimentary structures indicating breaks in sedimentation within graded beds or fluctuations in current velocity and type of material (concentrations of heavy-mineral layers in the upper part of graded beds; repeated grading within millimeter-thick laminae).
2. The consistency of bed thicknesses and current directions, as well as heavy- and light-mineral associations of individual beds through a distance of 115 km. The enormous amount of sand contained in one single bed (2-10 km.³) is more easily explained as grain-by-grain deposition from constant bottom currents with perennially fluctuating velocities.

Study of a large number of oriented, undisturbed box cores from the central San Diego trough and the La Jolla submarine fan shows that most of the sand layers have well-preserved sedimentary structures very similar to those observed in the Bavarian flysch. However, because of the absence of distinctive compositional differences in the mineral associations, individual sand layers could not yet be correlated through