

AGE AND PALEOENVIRONMENT OF THE IMPERIAL FORMATION NEAR SAN GORGONIO PASS, SOUTHERN CALIFORNIA

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ABSTRACT

Microfossiliferous marine sediments of the Imperial Formation exposed in the Whitewater and Cabazon areas, near San Gorgonio Pass, southern California, are late Miocene in age and were deposited at intertidal to outer neritic depths, and possibly upper bathyal depths. A late Miocene age of 7.4 to >6.04 Ma is based on the ranges of age-diagnostic benthic foraminifers (*Cassidulina delicata* and *Uvigerina peregrina*), planktic foraminifers (*Globigerinoides obliquus*, *G. extremus*, and *Globigerina nepenthes*; zones N17–N19), and calcareous nannoplankton (*Discoaster brouweri*, *D. aff. D. surculus*, *Reticulofenestra pseudoumbilicata*, *Sphenolithus abies*, and *S. neobabies*; zones CN9a–CN11) coupled with published K/Ar dates from the underlying Coachella Formation (10.1 ± 1.2 Ma; Peterson, 1975) and overlying Painted Hill Formation (6.04 ± 0.18 and 5.94 ± 0.18 Ma; J. L. Morton in Matti and others, 1985 and Matti and Morton, 1993). Paleocologic considerations (sea-level fluctuations and paleotemperature) restrict the age of the Imperial Formation to 6.5 through 6.3 Ma.

Benthic foraminiferal assemblages indicate that the Imperial Formation in the Whitewater and Cabazon sections accumulated at inner neritic to outer neritic (0–152 m) and possibly upper bathyal (152–244 m) depths. Shallowing to inner neritic depths occurred as the upper part of the section was deposited. This sea-level fluctuation corresponds to a global highstand at 6.3 Ma (Haq and others, 1987). Planktic foraminifers suggest an increase in surface-water temperatures upsection. A similar increase in paleotemperatures is interpreted for the North Pacific from 6.5 to 6.3 Ma (warm interval W10 of Barron and Keller, 1983).

Environmental contrasts between the Whitewater and Cabazon sections of the Imperial Formation provide evidence for right-lateral displacements on the Banning fault, a late Miocene strand of the San Andreas fault system. The Cabazon section lies south of the Banning fault, and has been displaced west relative to the Whitewater sections. The Cabazon section was deposited at greater depths, suggesting that it accumulated farther offshore than the Whitewater section. If the Salton Trough was a southward-opening, elongated northwest-southeast basin similar to the modern Gulf of California, the Cabazon sequence probably has been displaced right-laterally from a position farther southeast of the Whitewater sequence. This relation requires late Miocene displacements greater than the present 12 km cross-

fault separation between the two Imperial sections in the San Gorgonio Pass area.

INTRODUCTION

The Salton Trough, formed by crustal thinning associated with rifting of the Gulf of California, was inundated by marine waters in the late Neogene. Sediments deposited during this marine incursion occur in discontinuous outcrops in the Salton Trough from just south of the Mexico-California border to San Gorgonio Pass (Fig. 1). Following recognition of these marine strata by early geologists and paleontologists (Arnold, 1904, 1906; Vaughan, 1904, 1906, 1917; Mendenhall, 1910; Kew, 1914; Hanna, 1926), Woodring (1932) named the sequence the Imperial Formation. Although there is disagreement, the age of the Imperial Formation is generally given as Pliocene (see summaries in Allen, 1957, and Winker, 1987), which is consistent with data that suggest the Gulf was initiated about 5.0 Ma by northwesternly translation of Baja California away from North America (Larsen and others, 1968; Moore and Curray, 1982; Curray and Moore, 1984).

Fossiliferous marine sediments in the northern end of the Salton Trough, near San Gorgonio Pass, were first recognized by Vaughan (1922) and subsequently assigned to the Pliocene Imperial Formation (Bramkamp, 1935; Woodring, 1932; Durham, 1950; Dibblee, 1954; Allen, 1957) (Fig. 2). The possible Miocene age of these marine sediments was first suggested by K/Ar dates in the overlying Painted Hill Formation (6.04 ± 0.18 and 5.94 ± 0.18 Ma; J. L. Morton in Matti and others, 1985). Microfossils (calcareous nannoplankton and foraminifers, this study) restrict the age of the Imperial Formation near San Gorgonio Pass to late Miocene, 7.4 to ≥6.0 Ma. This age is further restricted by paleoclimatic considerations to 6.5–6.3 Ma. The late Miocene age and the presence of outer neritic and upper bathyal marine waters in the San Gorgonio Pass area predate the assumed opening of the Gulf of California by rifting and supports tectonic models which propose the opening of a proto-Gulf with an extensional phase in the late Miocene (e.g. Stock and Hodges, 1989).

METHODS

Samples were collected from the Whitewater and Cabazon sections in 1979 and 1984 during regional geologic mapping studies by the U.S. Geological Survey (Matti and others, 1983, 1985, 1993; Powell, 1986). Stratigraphic and structural relations of these sections and samples were studied by J. C. Matti and D. M. Morton (unpublished). McDougall examined the benthic foraminifers and Poore examined the calcareous nannoplankton and planktic foraminifers. Foraminiferal samples were disaggregated with solvent (kerosene) and washed in water through a 63 micron screen. Smear slides were examined for calcareous nanno-

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