

of this belt. A large area toward the northwest subsided as much as 6 feet.

Submarine landslides destroyed the waterfronts of Seward, Whittier, and Valdez. Landslides generated sea waves, and tsunamis caused additional damage.

In Anchorage, the jarring action of the earthquake liquefied sensitive sand and clay zones, causing large landslides which destroyed residential and downtown business areas. Long-period surface waves caused extensive damage to many large buildings. Detailed geological and soils studies have not been completed by government agencies and consulting firms. Recommendations have been made for future land use and for stabilization of two major slides by a gravel buttress and an underground sand-pile buttress.

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NEW FORAMINIFERAL ZONATION, UPPER MESOZOIC, SACRAMENTO VALLEY, CALIFORNIA

Six new foraminiferal zones have been established in the upper Mesozoic of the Sacramento Valley, California, as the result of detailed micropaleontological work in conjunction with several reconnaissance field mapping projects. The letter designations I, J-1, J-2, K, L, and M are proposed for these microfaunal zones. These designations are a downward continuation of the Upper Cretaceous zones of Goudkoff, who established the A through H Zones in 1945. The rocks on which this new zonation is based range in age from lower Early Cretaceous, Cenomanian stage, through Late Jurassic, Tithonian stage. Micropaleontological work is essential for mapping of this thick clastic sequence, because of the gross lithologic similarity and the lenticular, disconnected, and time-transgressive nature of the coarse clastic marker beds. This study covers a 150 mile \pm section along the regional strike of the outcrop along the western side of the Sacramento Valley, and also extends into the Redding area on the northeastern side of the valley.

Over 600 species, many of them new, and approximately 100 genera, including some new, were checked or recorded from more than 30 outcrop and well sections in the area. The new zones have been correlated approximately with the European stage classification. The I, J-1, and J-2 Zones range from Cenomanian to Aptian on the basis of both planktonic and benthonic Foraminifera; the K, L, and M Zones range from Barremian to Tithonian on the basis of cosmopolitan benthonic species. Correlations also were made between microfossil localities and northern California megafossil localities which have been equated with the European standard section.

Specific criteria for identification of the H Zone were not established by Goudkoff, but detailed study permits both identification and biofacies differentiation within it. The abundant and varied microfaunas of the "Middle" Cretaceous have made it possible to distinguish the I from the J Zones, separate the closely related J-1 and J-2, and divide the J-1 into three sub-Zones. The K, L, and M Zones are more difficult to differentiate, because of the absence of planktonics and the predominance of many similar *Nodosariidae*. The M Zone probably can be subdivided if more comprehensive work is done.

There is no faunal indication in the outcrop section of any unconformity between the Upper and Lower Cretaceous. Many species range through both Albian and Cenomanian sediments, without apparent interruption.

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REVIEW OF TERTIARY STRATIGRAPHY AND FORAMINIFERAL ZONATIONS OF WESTERN WASHINGTON STATE

Tertiary marine sediments and volcanic rocks ranging in age from early Eocene to late Miocene, or possible Pliocene, are present in southwestern Washington State. Total thickness of these rocks is more than 50,000 feet.

The Eocene history of the area is characterized by widespread vulcanism. Sedimentary rocks definitely dated as early Eocene have not been found in southwestern Washington. Middle Eocene rocks are represented by volcanics and interbedded sediments of the Crescent Formation and typically contain *Amphistegina californica* and *Asterigerina crassiformis*. Upper Eocene rocks are represented by the marine Raging River Formation and the non-marine Puget Group in the eastern part of the area. To the southwest, equivalents of these formations range from marine to non-marine facies and are mapped as McIntosh, Northcraft, Skookumchuck, and Cowlitz Formations. Further west, upper Eocene rocks are wholly marine and are mapped as the Cowlitz Formation. Total thickness of middle and upper Eocene rocks is at least 15,000 feet. Foraminiferal zones equivalent to Laiming's B Zones and B-1-A, A-2, and A-1 Zones of the California Eocene can be identified.

In early Oligocene time, regional subsidence, accompanied by notable pyroclastic vulcanism, took place and Oligocene rocks are characteristically tuffaceous.

Rocks assigned an Oligocene age have a maximum thickness of 9,000 feet in southwestern Washington and comprise the Lincoln Formation. Two lithologic members usually are distinguished: a lower basaltic sandstone member and an upper tuffaceous siltstone member. Three foraminiferal zones are recognized and are correlated with the Refugian and Zemorrian stages of California.

In early Miocene time, deposition continued uninterrupted in the same basins that were receiving Oligocene sediments. In middle Miocene time widespread diastrophic activity was accompanied by withdrawal of the seas from southwestern Washington, except along the present Pacific Ocean front and a deep embayment in the Grays Harbor-Montesano area.

In the Chehalis basin, Miocene sediments consist of 2,000 feet of wholly non-marine rocks comprising the Astoria (?) Formation (early Miocene) and Wilkes Formation (late Miocene).

In the Grays Harbor-Montesano basin, lower and middle Miocene rocks consist of an estimated 6,000 feet of marine sediments mapped as the Astoria Formation. The Astoria Formation is subdivided informally into three lithologic units which are assigned an early and middle Miocene age, equivalent to the Saucessian, Relizian, and possibly Luisian stages of California.

At Ocean City, sediments notably different from the typical Astoria Formation are correlated tentatively with the lower portion of the Astoria Formation.

Marine sediments of late Miocene to questionably Pliocene age occur only in the Grays Harbor-Montesano basin and the Pacific Ocean coastal strip. In the Grays Harbor-Montesano basin, these rocks are mapped as Montesano Formation and consist of 2,500 feet of marine conglomerate, sandstone, and siltstone containing Foraminifera which indicate a late Miocene age equivalent to the Mohanian and Delmontian stages of California. Along the Pacific Coast, in the vicinity of Ocean City, sediments of equivalent age are represented by up to 6,000 feet of sediments informally denominated