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ENGINEERING GEOLOGY OF THE PROPOSED NUCLEAR POWER PLANT ON BODEGA HEAD, SONOMA COUNTY, CALIFORNIA

by

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Abstract

This report summarizes and interprets the geologic data presented in previous reports by the Geological Survey. These data bear on the effect of large magnitude earthquakes on the foundation of the proposed nuclear power plant on Bodega Head, California.

The crucial geologic problem at the site involves an estimate of the probability of a sudden permanent displacement, by rupturing, of the foundation rock of the reactor during an earthquake. Any such prediction must be based to a great extent on experience in earthquake-affected regions; it can be made only with a relatively low degree of confidence because geologic knowledge of the phenomena being evaluated is incomplete, and in some instances rudimentary.

An upper limit on the probability of faulting is set by the probability of occurrence of severe earthquakes (Richter magnitude 8.0 and above) on the San Andreas fault. This has been estimated by several highly qualified seismologists to be on the order of one or two per century. The Bodega Head site is almost certain to experience one severe earthquake in the next 50 years, the assumed lifetime of the plant.

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The principal hazards to the plant from such a seismic event are twofold: (1) shaking of the ground due to seismic wave propagation, and (2) possible displacement of the foundation rocks due to faulting. The hazard due to shaking is being investigated by others, including the Seismology Division, U. S. Coast and Geodetic Survey. Prediction of possible displacement must be based largely on the distribution and characteristics of the surface faulting produced by the 1906 earthquake and to a lesser extent on the distribution of faults in the excavation for the reactor and on Bodega Head as a whole. The evidence is not adequate to suggest more than a general statement of probabilities.

The site is approximately 1,000 feet west of the west edge of the San Andreas fault zone, which is approximately 1½ miles wide here. The main surface rupture during the 1906 earthquake took place on the east side of the zone and had a horizontal displacement of 10-20 feet. Throughout Bodega Head, faults and joints are common in the granitic rocks with the largest ones trending northwest, northeast, and east. At the site, a principal structure is the Shaft fault, named from its exposures in the shaft excavated for the reactor. This fault, one of many tectonic faults in the granitic rock, is the only one that has been traced downward from the surface through Pleistocene sediments into the underlying granitic rocks. It strikes N. 40° E. and has been traced on the surface a total of about 230 feet. The maximum measured displacement in the sediments is 14 inches vertically and in the granitic rocks is at least 24 feet horizontally.

The Shaft fault in the bedrock is a zone that ranges from 2 to 10 feet in width and consists of several intersecting faults. This suggests that movement on the fault occurred several times, though the amount of vertical or horizontal movement during any one period of movement cannot be determined. It is not unreasonable, however, to expect that displacements totalling several feet have occurred at one time. The fault displaces Pleistocene sediments dated from geologic evidence as younger than 400,000 years and from radioactive carbon as older than 42,000 years. Faulting is, therefore, younger than the dated sediments, and may be younger than sediments that are not displaced, for in the soft sediments displacement may be taken up by plastic deformation rather than rupture.

Surface ruptures created during the 1906 earthquake have been described at many localities outside of the San Andreas fault zone (Lawson et al, 1908). The record of these events provides important clues for predicting future earthquake phenomena on Bodega Head. The character of the measured ruptures at these localities indicates that some of the faults parallel the San Andreas, others intersect it at acute angles, and still others are nearly normal to it.

The principal observations of ruptures outside the main fault zone after the 1906 earthquake were made at the Point Reyes Peninsula, the San Francisco Peninsula, and the Santa Cruz Mountains; undoubtedly faulting occurred in large areas elsewhere which were not studied.

No investigation was made at Bodega Head. Nevertheless, the data, particularly that from the Point Reyes Peninsula, can be used as a very general guide to the expectancy of fault displacements at various distances from the main fault zone during some future earthquake.

In general, the 1906 bedrock ruptures were reported by G. K. Gilbert to increase in abundance and amount of displacement towards the San Andreas fault zone. They occurred in the Point Reyes area as far as 10 miles west of the San Andreas zone, but the ones farthest out were barely discernible. At distances of a mile, horizontal displacement of 2 to 6 inches was observed. At Inverness, about 2,000 feet from the zone a horizontal displacement of 2½ feet was measured.

The geologic setting of Bodega Head is similar to that of Point Reyes Peninsula. The granitic rocks of both areas bound the western edge of the San Andreas zone and both bedrock masses are pervasively fractured and faulted. Topographic differences between the two areas are pronounced. Point Reyes is higher, thereby intercepting more rainfall; it is larger and contains a better-defined system of stream drainage. The topographic differences are considered to be of secondary importance insofar as predicting future faults is concerned. The two areas would be expected to react similarly to the stresses culminating in major earthquakes.

The probabilities of displacements on Bodega Head are estimated in the following tabulation. It is assumed that a severe earthquake, say of Richter magnitude 8.5, has its epicenter in the San Andreas fault zone in Bodega Harbor. The conclusions are only qualitative and perhaps somewhat subjective but cannot be refined from available knowledge.

Displacement on a fault in granitic rock of shaft	Probability
2 inches or less	Moderate to high
Approximately 1 foot	Low
Approximately 2 feet	Low, lower than above, but still a possibility
Approximately 5 feet	Remote

From general observations, it is clear that the likelihood of occurrence and the magnitude of sympathetic faulting outside of a major earthquake fault zone decreases with distance from the fault zone. From observations of sympathetic faulting in bedrock which accompanied the 1906 earthquake, the probability of displacements of as much as one foot appear to be remote at distances of more than 3 or so miles from the San Andreas fault zone.