UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

DR-875

OCT 11 1966

Mr. Harold L. Price
Director of Regulation
U.S. Atomic Energy Commission
4915 St. Elmo Avenue
Bethesda, Maryland 20545

50-206

Dear Mr. Price:

Transmitted herewith is a report entitled "Comments on the Geology of the San Onofre Nuclear Generating Station, Camp Pendleton, California" by Alfred Clebsch, Jr. It is based on a review of information collected by Southern California Edison Company and its consultants, plus field observations and a review of geologic literature and an unpublished report of the Geological Survey. A draft was furnished to members of your staff last August and their review comments were utilized in preparing the final report.

We have no objection to your including this statement in the public record.

Sincerely yours,

William A. Extra

Acting Director

Enclosures

11 03
DR-875

Rec'd Off. Dir. of Reg.
Date 10-13-66
Time 2:00
Beth

FOIA-87-462
H19

8710210030 871014
PDR FOIA
SCHADRA87-462 PDR

19

19

DR-875

Comments on the Geology of the San Onofre Nuclear Generating Station, Camp Pendleton, California (AEC Docket No. 50-206)

by Alfred Clebsch, Jr.

INTRODUCTION

This report was prepared in response to requests from the Director of Regulation, U.S. Atomic Energy Commission, dated October 24, 1963, and December 22, 1965, for information on geologic conditions at the San Onofre site. It is based on a review of published geologic information, unpublished reports of the Geological Survey, and data collected by the Southern California Edison Company in their exploratory investigation and preparation of the site for construction, plus observations at the site and in the vicinity by the writer on October 29 and 30, 1963, and by James R. Wall and L. C. Dutcher of the Geological Survey on August 17, 1964. My initial observations were made prior to any excavation. Preliminary test drilling had been completed at that time, however. Wall and Dutcher visited the site after most of the excavating had been completed and before the start of construction of the containment sphere for the reactor.

The information developed by Southern California Edison Company is summarized in documents related to their application for a license to construct and operate the nuclear power plant. The principal ones are as follows: "Part B, Preliminary Hazards Summary Report, Southern California Edison Company, Nuclear Station at Camp Pendleton, California, Unit No. 1, dated January, 1963"; "Amendment No. 3, Application for Construction Permit and for License"; and, "Final Engineering Report and Safety Analysis, San Onofre Nuclear Generating Station, Unit 1."

The geology of Camp Pendleton, which includes the San Onofre site, has been mapped by R. F. Boss, F. H. Olmsted, F. S. Riley, and G. F. Worts, Jr. as part of an unpublished study of the Geology and Ground Water Resources of Camp Pendleton by Worts and Boss, prepared by the U.S. Geological Survey on behalf of the Navy Department. That map and pertinent descriptive material constitute the principal sources of specific geologic information on the site and vicinity; other general information on the geology of the region and on adjacent areas is included in reports by Woodford (1925), Jahns (1954), Yerkes and others (1965), and Allen and others (1965).

DR-875

GEOGRAPHIC AND GEOLOGIC SETTING

The site is on a northwest-trending section of the coast of southern California approximately 10 miles northwest of Oceanside and 5 miles southeast of San Clemente. It is on the southwestern edge of the exposed part of the Peninsular Ranges physiographic province (Jahns, 1954, p. 29-32), in which the primary topographic grain of the country is controlled by geologic structural trends. It is part of a major structural block bounded on the northeast by the northwest-trending Elsinore fault and on the southwest by the off-shore extension of the Newport-Inglewood zone of deformation (Yerkes and others, 1965, p. 714). The Elsinore fault is roughly 22 miles northeast of the site. The submarine extension of the Newport-Inglewood zone, as mapped by Emery (1960, fig. 6) also trends northwestward and is about 7 miles southwest of the site. Hester (1958), in his discussion of structural provinces of California (fig. 27-6 and p. 422) refers to this block, which extends into lower California, as "a mostly non-seismic block..."

In the general vicinity a nearly vertical cliff rises 80 to 100 feet above a narrow sandy beach. From the top of the cliff a flat to gently undulating terrace rises toward the San Onofre Hills to the northeast. The Coast Highway (U.S. 101) and the A.T. and S.F. railway parallel the coast on this terrace. The terrace is cut by short, steep-walled canyons, or barrancas, that trend nearly perpendicular to the shoreline. No well-defined valleys draining the mountains back from the coast cut the terrace within about a mile of the plant site.

The San Mateo Formation of Woodford (1925) of Pliocene(?) age is exposed in the lower two-thirds or so of the sea cliff; the upper third is made up of boulders, gravel, sand, and silt, which lie unconformably on the San Mateo, mapped by Worts and others as an unnamed deposit presumed to be of Pleistocene age. The San Mateo is underlain by the Capistrano Formation of Pliocene age.

Rocks at the Site

The geologic unit of principal interest at the site is the San Mateo Formation. It consists mostly of poorly consolidated medium to coarse sand, but it contains gravel beds as well as shale layers. The upper part of this formation is well exposed in a nearly vertical cliff that extends more than a mile northwestward from the plant site and for about three quarters of a mile southeast of the site. The plant is founded on the San Mateo Formation and most of the site has been excavated into it.

According to Worts and Boss, the San Mateo ranges in thickness from zero to more than 1,000 feet. Test drilling data included in the Preliminary Hazards Summary Report indicate that it extends to a depth of about 250 feet below sea level. Areal distribution of the San Mateo is limited to the vicinity of the lower reaches of San Mateo Creek; its eastward limit is generally marked by the Cristianitos fault.

Worts and Boss include a brief discussion of stratigraphic correlations proposed by various workers since Ellis and Lee (1919) first studied the area, but follow the usage of Woodford (1925). Woodford considered these rocks to be a doubtful correlative of the San Diego Formation of middle or late Pliocene age, which is exposed in the vicinity of San Diego. Although no information was developed during our two inspections of this site that would further refine the stratigraphic correlation of these rocks, they are lithologically similar and appear to occupy a stratigraphic position similar to the Niguel Formation, mapped by Vedder and others (1957) as upper Pliocene.

The San Mateo exposures consist of orange-brown to yellowish buff sandstone that has indistinct bedding marked by pebble beds. In gross aspect the rock appears massive, and has been described as dense, but it is cross-bedded, highly porous, and friable. The unit has been tilted slightly; dip measurements were not made, but the dip is very gentle and toward the northwest. Worts and Boss indicate a range of dips from 3 to 10 degrees, except near the Christianitos fault, where they measured dips of 75 degrees.

Locally the San Mateo Formation contains flat, elongate, angular, fragments of shale and siltstone that were deposited along with the sand and gravel. Some of the shale fragments are as much as a foot thick and several feet across; many are the size of boulders and cobbles. The presence of this material in an otherwise relatively uniform and massive sandstone suggests that the site of deposition was very near an outcrop of the Capistrano Formation, because the shale could not have been transported far without becoming rounded.

The unconsolidated rocks overlying the San Mateo sands are poorly sorted and contain interfingering lenses of gravel, sand, silt, and clay, which show abrupt changes in grain size both laterally and vertically. Although they were described by Worts and Boss as being chiefly of marine origin, they are similar in appearance to alluvial fan deposits. Some of the clay layers contain sand-filled mud cracks. In the vicinity of the site these materials are almost certainly of terrestrial origin.

The contact between the San Mateo rocks and the overlying material is sharp and distinct. The upper surface of the San Mateo has been eroded and is wavy, with amplitudes of 4 to 5 feet over distances of 20 to 100 feet. The drastic change in conditions of sedimentation have given rise to a marked change in color and lithology. Furthermore, the slightly warped bedding of the San Mateo sands has been truncated by the erosional surface.

The San Mateo is underlain by the Capistrano Formation of Pliocene age, which consists of shale, siltstone and, according to Worts and Boss, some conglomerate. Capistrano rocks are exposed about a mile southeast of the site on the east side of the Cristianitos fault. In these exposures the unit is a thin-bedded, gray to rusty brown silty, micaceous shale that has given rise to a distinctive landslide topography for a 3-mile stretch along the coast extending as much as an eighth of a mile toward the hills. Boss and Worts indicate a range in thickness of the Capistrano of zero to 500 feet.

SIGNIFICANT STRUCTURAL FEATURES

The geologic map prepared by Boss and others shows no faults through the site. My observations at the site were concerned primarily with determining whether there was evidence of geologically recent fault movement, on either the Cristianitos fault or possibly on other faults that had not been mapped. Such evidence would provide a rough indication of the tectonic stability of the site, or lack thereof.

The Cristianitos Fault

The principal tectonic feature of the general area is the Cristianitos fault. Its surface trace is about three-quarters of a mile due east of the plant site. From the point at which the fault intersects the shoreline (0.9 mile southeast of the site) it trends almost due north for about a mile, then trends north-northwestward. Boss and others map it as a normal fault, the rocks to the east having been moved upward with respect to those on the west. Their mapping suggests that in the vicinity of the San Onofre site it is nearly vertical and a relatively simple structure; however, they map several branches and related faults about a mile and a half north of the site on the north side of the valley of San Onofre Creek, and they infer a major branch beneath the alluvium of Cristianitos Creek and the lower part of San Mateo Creek.

The exposure of the fault where it intersects the coast was examined, and at this point the San Mateo Formation is faulted against the Capistrano Formation. No evidence was found that the unnamed unconsolidated deposits overlying the San Mateo have been displaced by faulting. Thus the most recent movement on the Cristianitos fault near the site took place no longer ago than the age of the San Mateo Formation, and no more recently than the age of the unnamed deposits that overlie the San Mateo.

Inasmuch as the age of both these units is uncertain, it is not possible to determine the age of the most recent faulting with any degree of certainty. If the San Mateo Formation is as young as late Pliocene age, the most recent faulting could be as old as a million years. If the unnamed deposits are youngest Pleistocene, the most recent movement on the Cristianitos fault would have occurred at least ten thousand years ago.

It is significant that although Worts and Boss were able to trace the unnamed unconsolidated deposits southeastward more than nine miles from the San Onofre site and more than a mile and a half inland in the valleys of Las Flores and Aliso Creeks, they found no evidence that this unit has be faulted. They state that the prominent faults of the Camp Pendleton area"... were formed or reactivated during the period of regional tilting, but it is believed that little or no faulting has occurred since mid-Pleistocene time. This is indicated by the fact that none of the coastal terrace deposits show evidence of faulting. The coastal end of the Cristianitos fault has not displaced the overlying coastal terrace deposits."

During my visit to the site I examined the contact between the San Mateo and the overlying rocks in detail in several of the barrancas and along the sea cliff for joints and small faults that might displace the younger beds. At a point approximately half a mile southeast of the site vertical fractures striking N 40° W were observed that showed relative displacement of bedding in the San Mateo of two inches. These could not be traced upward into the overlying material. A quarter of a mile northwest of the site similar fractures showed displacements of four inches or less. They did not extend upward into the unnamed rocks.

The walls of the large barranca that cut through the site and of several others northwest and southeast of the site were examined along the contact between the San Mateo sands and the unnamed alluvial deposits for evidence of faults or joints trending parallel the shoreline; none was found.

During construction the site was visited by James R. Wall and L. C. Dutcher of the Geological Survey, who made the following observations and conclusions:

> "Close visual inspection was made of (1) the face of the cut, from top to bottom, along its entire length; (2) the floor of the excavation; and (3) the terrace surface along the edges of the excavation. the only part of the area that was not directly observed was the lowermost 10 feet of the containment sphere pit, which was at the time partially filled with water.
>
> "The stratigraphic section exposed at the excavation consists of an uppermost terrace deposit of poorly sorted and poorly consolidated sand, pebbles, and cobbles, overlying the massive San Mateo Sand. The San Mateo is composed chiefly of poorly cemented quartz sand, but locally contains inclusions of siltstone and shale derived from the Capistrano Formation. The size of the inclusions varies from a few inches to as much as 10 feet.
>
> "The contact between the San Mateo Sand and the overlying terrace gravels is clearly exposed along the entire extent of the cut. The contact between the San Mateo Sand and the underlying Capistrano Formation is not exposed at the excavation.
>
> "There is no evidence of structural anomalies in either the terrace deposits or in the San Mateo Sand. There is no displacement along the contact, and therefore no evidence of faulting."

CONCLUSIONS

Based on a review of the data provided and supplemented by independent review of geologic literature and field observations at the site and in the vicinity, the description of the geology of the San Onofre site included in the Preliminary Hazards Summary Report appears complete and substantially accurate. Our field investigations disclosed no evidence of faults through the site.

REFERENCES CITED

Allen, C. R. and others, 1965, Relationship between seismicity and geologic structure in the southern California region: Seismolog. Soc. America Bull., vol 55, no. 4, p. 753-797.

Ellis, A. J., and Lee, C. H., 1919, Geology and ground waters of the western part of San Diego County, California: U.S. Geological Survey Water-Supply Paper 446.

Emery, K. O., [illegible], The sea off southern California: John Wiley & Sons, Inc., New York.

Jahns, R. H., [illegible], Geology of the Peninsular range province, southern California and Baja California, in Jahns, R. H. (Ed), Geology of southern California: California Dept. Nat. Resources, Div. Mines, Bull. 170, p. 29-52.

Richter, C. F., 1958, Elementary seismology: W. H. Freeman and Co., San Francisco.

Vedder, J. G. and others, 1957, Geologic map of the San Joaquin Hills-San Juan Capistrano area, Orange County, California: U.S. Geological Survey Oil and Gas Investigation Map OM 193.

Woodford, A. O., 1925, The San Onofre breccia, its nature and origin: Calif. Univ. Pub. Dept. Geol. Sci. Bull. v. 15, no. 7, p. 169, 217-219.

Yerkes, R. F. and others, 1965, Geology of the Los Angeles Basin, California--an introduction: U.S. Geol. Survey Prof. Paper 420-A.