DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN FILE MAP

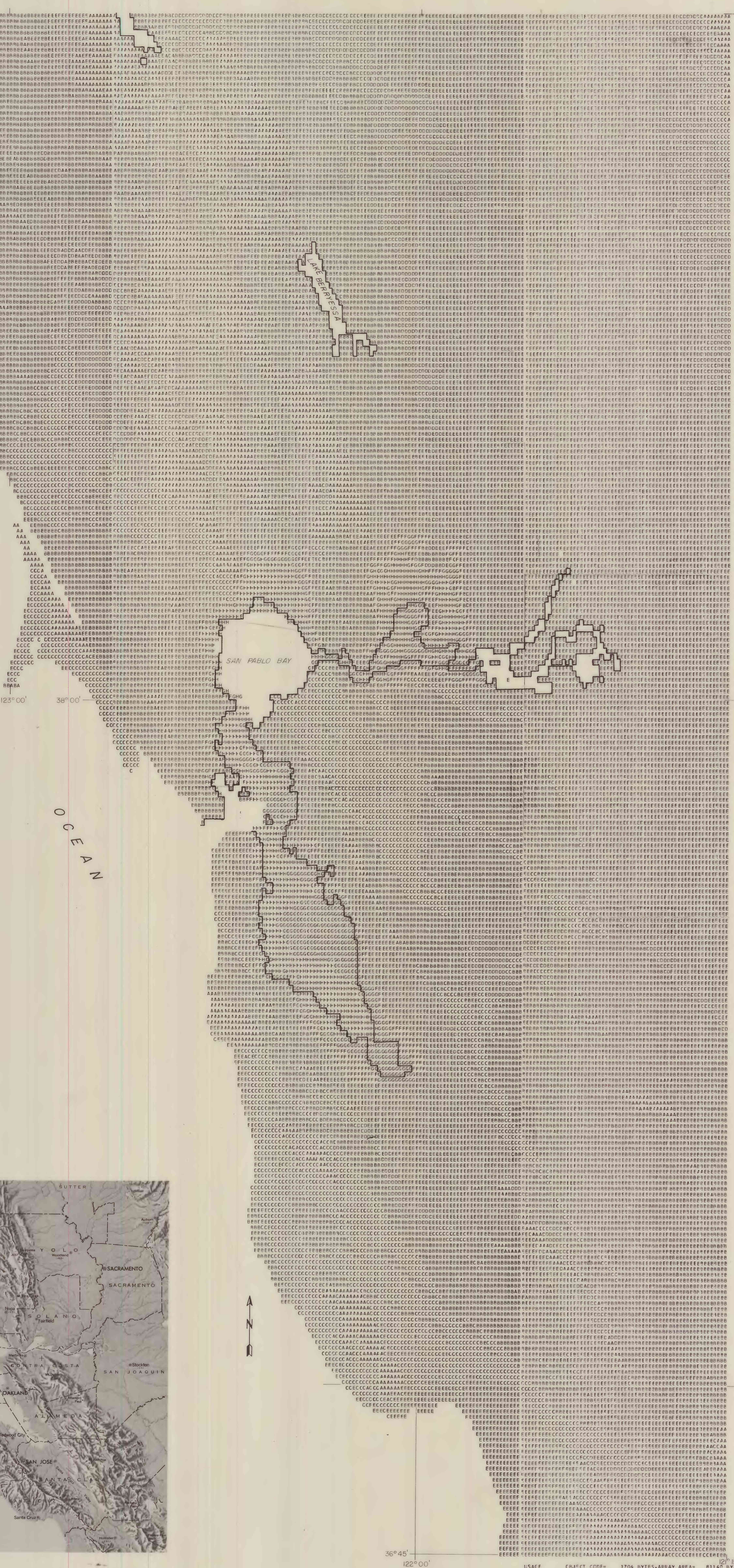
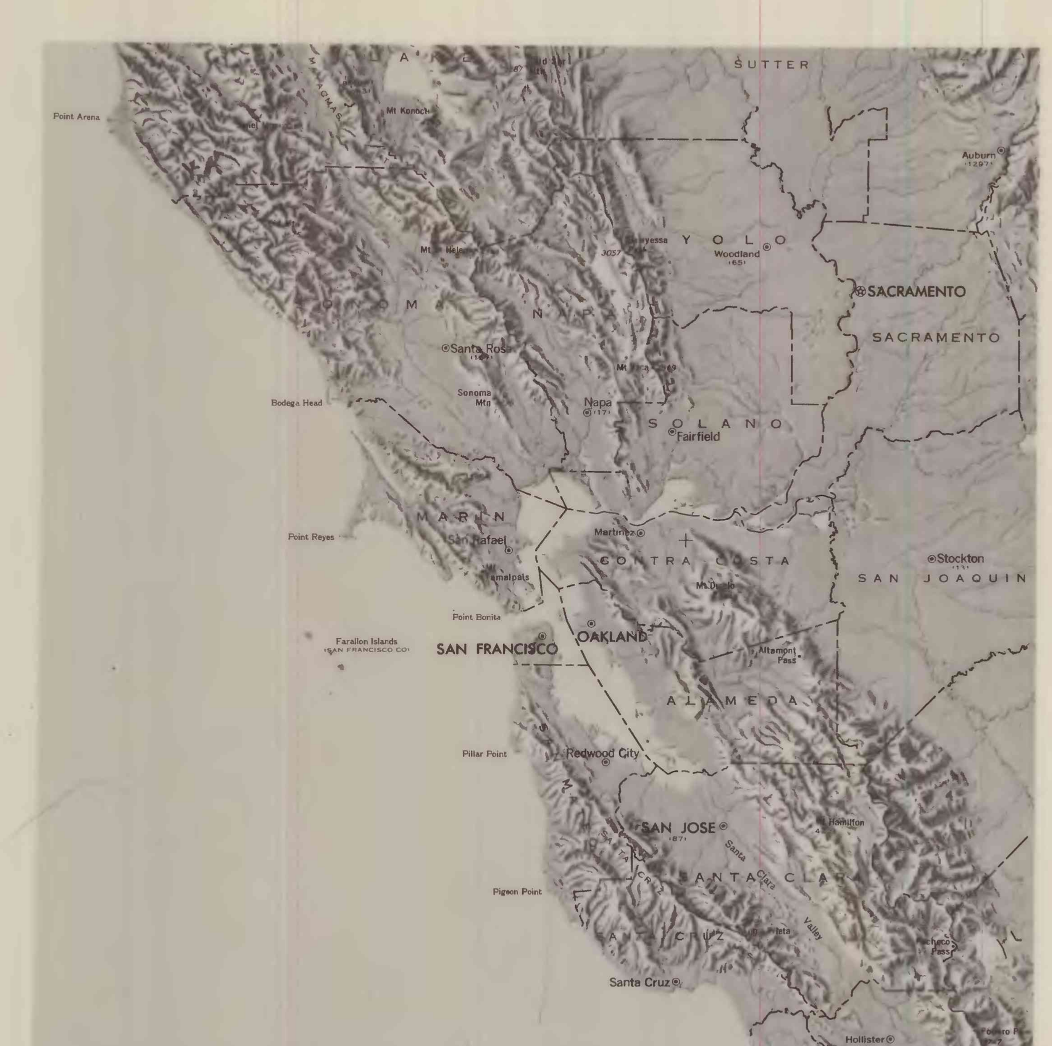


Table 1

Group	Unit	Estimated Intensity Increment*	Letter Designation
1.	Hard rocks: granitics, metamorphics and young volcanics and intrusives	0	A
2.	Jurassic to Eocene sedimentary rocks; Franciscan sediments, volcanics, Serpentine; Miocene volcanics and intrusive rocks	1/2	B
3.	Oligocene, Miocene and early Pliocene	1	C
4.	Late Pliocene	1-1/2	D
5.	Quaternary sediments Dune sand Marine terrace Fan deposits Valley Fill Terraces Other Pleistocene	2	E
6.	Young Bay Mud		
	a. less than 15 feet	2-1/2	F
	b. 15-30 feet thick	3	G
	c. greater than 30 feet thick	4	H

*Intensity increments are added to the base intensity established for the hard rocks of Group 1.



A Digitized Seismic Susceptibility Map of San Francisco Bay Region, California
by
J. F. Gibbs and J. P. Eaton

Introduction

For many years it has been recognized that local ground conditions have a profound influence on the seismic intensities experienced at various sites during earthquakes (Lawson et al 1908, H. O. Wood, 1933). Intensities on weak water-saturated sediments can be as much as 3 or 4 intensity units higher than those on nearby outcrops of massive crystalline rock. A number of workers, especially in the USSR, have studied this problem; and useful empirical relationships between surficial geology and variations in seismic intensities have been developed. The topography, the thickness, relative firmness, and water content of sediments or the weathered layer beneath the site, and the relative firmness of the bedrock below are important factors in these empirical relationships. For brevity, we shall use the term "seismic susceptibility" to designate the effect of local geological conditions on the seismic intensity at a given site.

Much generalized information on surficial geology can be obtained from geologic maps, which are available in one form or another for many areas of interest. Specialized engineering-geology maps are even more useful wherever they are available, but coverage is poor. With care, the data on surficial geology from geologic maps can be interpreted in terms of the empirical relationships between surficial geology and seismic susceptibility to produce crude seismic susceptibility maps. The simple parameters read from geologic maps are not fully adequate to characterize the relevant surficial geology at a site, and more sophisticated parameters based on geological, geophysical, and engineering techniques that are currently under development are badly needed. For the present, however, available geologic maps provide the best basis for areal estimates of seismic susceptibility.

The need has arisen for digitized seismic susceptibility maps for use with computer programs that are being developed in attempts to predict and map seismic intensities that will be produced by future earthquakes of stipulated magnitude, epicenter, and focal depth (Friedman and Roy, 1969; and Schneider, 1970). In such computer programs, the intensity calculated for "standard" ground conditions at a given site (from empirical relationships giving intensity as a function of magnitude, epicentral distance, and focal depth) is corrected by a factor based on the seismic susceptibility of the site to obtain the predicted intensity. Such calculations are carried out for each point of a grid that covers the area of interest, and the final map of predicted intensities is obtained by contouring the grid point intensity values.

Method used to construct the map

The best available geologic map covering the 10 counties surrounding San Francisco Bay (Figure 1) is the 1/250,000 Geologic Map of California (California Division of Mines and Geology). Critical additional data on water- and mud-covered areas in and around the Bay were obtained from a special report prepared by Goldman (1969). The size of the area to be covered and the scale of the principal source map suggested a digitizing grid of 1 km x 1 km cells. For convenience, the digitizing grid actually used consisted of cells 1/2 minute of longitude wide and 1/2 minute of latitude high.

Assignment of seismic susceptibility factors to the grid cells on the map was based generally on guidelines contained in a summary of Russian work on the effect of surficial geology on seismic intensities presented by Popov (1959). Differences between degrees of intensity on the GEOFIAN scale used in the USSR are approximately the same as for the Modified Mercalli scale used in the United States.

The descriptions of rock units shown on the 1/250,000 geologic map were examined carefully and were compared with the representative geologic situations (especially as to lithology and degree of consolidation) described in Popov's summary by a group of Geological Survey geologists who were familiar with the geology of the San Francisco Bay region (Wentworth, written communication). In a general way, older units shown on the map are more firmly consolidated and are more stable seismically than the younger ones. On the basis of this examination and comparison, the mapped units were arranged in order of increasing seismic susceptibility (which generally followed age lines); and the ordered list was then broken into groups of units with similar properties. Again referring to Popov's summary, expected differences in seismic intensity between groups (both contiguous and non-contiguous groups) were estimated. A total difference of about 4 intensity units between the best and the worst situations was obtained, more or less by design, and the contiguous groups differed by an estimated 1/2 intensity unit. Because the assigned intensity differences are very tentative, the groups were designated by letter symbols -- A for the most stable units and H for the least -- rather than by numbers corresponding to the estimated intensity corrections with respect to a "standard" group of rocks (Table 1).

A translucent plastic overlay was ruled into 1/2' by 1/2' rectangles and superposed on the geologic map. A letter symbol corresponding to the average geologic situation in a given rectangle was then written directly on the overlay inside the rectangle. Digitization of the map was carried out directly from the overlay, which served as the instructions for the keypunch operator.

A proof-print of the deck of punched cards representing the digitized seismic susceptibility map was generated on the line printer and is shown in figure 2. The "map" is somewhat elongated in the north-south direction because the height to width ratio of the digitizing cell does not correspond to the shape of letters on the printer plot. Water-covered areas where information on near-surface geology was lacking were left blank. The approximate shorelines of San Francisco Bay and Lake Berryessa are outlined.

References

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A DIGITIZED MAP OF SEISMIC GROUND RESPONSE OF THE SAN FRANCISCO BAY REGION, CALIFORNIA

by
J. F. Gibbs and J. P. Eaton

1971

5 0 5 10 15 20 Mi

5 0 5 10 15 20 25 30 Km

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey standards and nomenclature.