

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

**QUATERNARY GEOLOGY AND LIQUEFACTION
SUSCEPTIBILITY, SAN FRANCISCO, CALIFORNIA
1:100,000 QUADRANGLE: A DIGITAL DATABASE**

By

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This database, identified as "Quaternary Geology and Liquefaction Susceptibility, San Francisco, California 1:100,000 Quadrangle: A digital database," has been approved for release and publication by the Director of the USGS. Although this database has been subjected to rigorous review and is substantially complete, the

USGS reserves the right to revise the data pursuant to further analysis and review. Furthermore, it is released on condition that neither the USGS nor the United States Government may be held liable for any damages resulting from its authorized or unauthorized use.

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INTRODUCTION

This Open-File report is a digital geologic map database. This pamphlet serves to introduce and describe the digital data. There are no paper maps included in the Open-File report. The report does include, however, PostScript plot files containing the images of the geologic map sheets with explanations, as well as the accompanying text describing the geology of the area. For those interested in a paper plot of information contained in the database or in obtaining the PostScript plot files, please see the section entitled "For Those Who Aren't Familiar With Digital Geologic Map Databases" below.

This digital map database, compiled from previously unpublished data, and new mapping by the authors, represents the general distribution of surficial deposits in the San Francisco bay region. Together with the accompanying text file (sf_geo.txt or sf_geo.pdf), it provides current information on Quaternary geology and liquefaction susceptibility of the San Francisco, California, 1:100,000 quadrangle. The database delineates map units that are identified by general age and lithology following the stratigraphic nomenclature of the U.S. Geological Survey. The scale of the source maps limits the spatial resolution (scale) of the database to 1:100,000 or smaller. The content and character of the database, as well as three methods of obtaining the database, are described below.

For Those Who Aren't Familiar With Digital Geologic Map Databases

For those interested in the Quaternary Geology and Liquefaction Susceptibility of the San Francisco, California, 1:100,000 quadrangle who do not use an ARC/INFO compatible Geographic Information System (GIS), but would like to obtain the paper map with explanation, two PostScript plot file containing map images of much of the data in the digital database, as well as a Portable Document Format file of the explanatory text have been included in the database package (please see the section "PostScript Plot Files Package" page 6). However, the plot files do require gzip and tar utilities to access the files.

Those interested who have computer capability can access the PostScript plot files or the digital dataset package in any of the three ways described below (please see the section "Obtaining the Plots from Postscript Files" page 6) including the Western Region Web Page (please see the section "Web Pages" page 7).

For those without computer capability, we have made the plot files available to an outside vendor or we can provide users with the PostScript plot files on digital tape that can be used by other vendors (please see the section "Obtaining Plots from an Outside Vendor" page 5).

DATABASE CONTENTS

The first digital package is the postscript plot file package consisting of two PostScript plot files of the maps and a Portable Document Format file of the explanatory text. A second digital database package consists of the geologic map database itself, and the supporting data, including base maps, map explanation, geologic description, and references .

POSTSCRIPT PLOTFILE PACKAGE

The first digital data package contains the PostScript images described below:

sf_plate1.ps	A PostScript plottable file containing an image of the Quaternary geologic map with base map and key of the San Francisco, California, 1:100,000 quadrangle.
sf_plate2.ps	A PostScript plottable file containing an image of the liquefaction susceptibility map with base map and key of the San Francisco, California, 1:100,000 quadrangle.
sf_geo.pdf	A Portable Document Format file of a report containing detailed unit descriptions and geological information, plus sources of data and references cited.

DIGITAL DATABASE PACKAGE

The second database package includes a geologic map database file for the San Francisco, California, 1:100,000 quadrangle. The digital maps, or coverages, along with their associated INFO directory have been converted to uncompressed ARC/INFO export files. ARC export files promote ease of data handling, and are usable by some Geographic Information Systems in addition to ARC/INFO (see below for a discussion of working with export files). The ARC export files and the associated ARC/INFO coverages and directories, as well as the additional digital material included in the database package, are described below:

ARC/INFO export file	Resultant Coverage	Description of Coverage
-----	-----	-----
sf-geol.e00	sf-geol	Depositional contacts, faults, and unit labels.
sf-liqu.e00	sf-liqu	Liquefaction susceptibility.
sf-hist.e00	sf-hist	Historical liquefaction events.
sf-topo.e00	sf-topo/	Topographic contours base map (from 1:100,000 scale originals).
sf-drain.e00	sf-drain/	Drainage base map (from 1:100,000 scale originals).
sf-cult.e00	sf-cult/	Cultural and map boundary base map.

ASCII text files, including explanatory text, Portable Document Format files, and a ARC Macro Language file for conversion of ARC export files into ARC coverages:

sf_geo.pdf	A Portable Document Format file of a report containing detailed unit descriptions and geological information, plus sources of data and references cited.
sf_geo.txt	A text-only file containing an unformatted version of sf_geo.pdf
sf_db.pdf	This file.
sf_db.txt	A text-only file containing an unformatted version of sf_db.pdf
import.aml	ASCII text file in ARC Macro Language to convert ARC export files to ARC coverages in ARC/INFO.

The following supporting directory is not included in the database package, but is produced in the process of reconvertng the export files into ARC coverages:

info/	INFO directory containing files supporting the databases. This directory is not included in the database release, but is created in the process of converting the export files into ARC coverages.
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Database Release Format

The database was compiled using ARC/INFO, a commercial Geographic Information System (Environmental Systems Research Institute, Redlands, California), with version 3.0 of the menu interface ALACARTE (Fitzgibbon and Wentworth, 1991, Fitzgibbon, 1991, Wentworth and Fitzgibbon, 1991). It is stored in uncompressed ARC export format (ARC/INFO version 7.x) in a compressed UNIX tar (tape archive) file. The tar file was compressed with gzip, and may be uncompressed with gzip, which is available free of charge via the Internet from the gzip Home Page (<http://w3.teaser.fr/~jlgailly/gzip>). A tar utility is required to extract the database from the tar file. This utility is included in most UNIX systems, and can be obtained free of charge via the Internet from Internet Literacy's Common Internet File Formats Webpage (<http://www.matisse.net/files/formats.html>). ARC/INFO export files (files with the .e00 extension) can be converted into ARC/INFO coverages in ARC/INFO (see below) and can be read by some other Geographic Information Systems, such as MapInfo via ArcLink and ESRI's ArcView (version 1.0 for Windows 3.1 to 3.11 is available for free from ESRI's web site: <http://www.esri.com>).

OBTAINING PLOTS WITHOUT A COMPUTER

Obtaining Plots from an Outside Vendor

For those interested in the Quaternary Geology and Liquefaction Susceptibility, San Francisco, California 1:100,000 quadrangle who do not use computers, we have made the PostScript plot files available from Capitol Color (phone: (800) 700-2656 or (408) 727-7560, FAX: (408) 727-0737). They will provide plots of the PostScript images of the geologic map (sf_plate1.ps) and the liquefaction susceptibility map (sf_plate2.ps) with the geologic description and discussion (sf_geo.pdf), for a fee (around \$25 per plate, with discounts for orders of multiple copies). We will also provide the PostScript plot files on digital tape for use by other vendors. A 14 MB compressed tar file (sf_map.tar.gz, 60 MB when uncompressed) of the PostScript plot files can be obtained by sending a tape with request and return address to:

San Francisco Quaternary Geology and Liquefaction
Susceptibility 1:100,000 quadrangle PostScript Plotfiles
c/o Database Coordinator
U.S. Geological Survey
345 Middlefield Road, M/S 975
Menlo Park, CA 94025

Do not omit any part of this address!

The gzip tar file will be returned on the tape. The acceptable tape type is:
2.3 or 5.0 GB, 8 mm Exabyte tape.

Make sure your vendor is capable of reading these tape types, PostScript plot files and Portable Document Format files. Important information regarding tape file format is included in the section "PostScript Plot Files" below, so be certain to provide a copy of this document to your vendor.

OBTAINING PLOTS FROM POSTSCRIPT FILES

PostScript Plot Files Package

For those interested in the Quaternary Geology and Liquefaction Susceptibility, San Francisco, California, 1:100,000 quadrangle who do not use an ARC/INFO compatible GIS system, but would like to obtain the paper maps with explanations, we have included a separate data package (sf_map.tar.gz) with two PostScript plot files and a Portable Document Format file containing the geologic description and discussion. It contains a color plot of the Quaternary geologic map (sf_plate1.ps), the Liquefaction Susceptibility map (sf_plate2.ps) and the geologic description and discussion (sf_geo.pdf).

These plot files are available in any of the three ways described below, including the World Wide Web pages. However, the plot files are stored in gzip compressed tar file requiring gzip and tar utilities to access the file. These utilities are included in most UNIX systems, or can be obtained free of charge via the Internet from Internet Literacy's Common Internet File Formats Web page (<http://www.matisse.net/files/formats.html>). To read the Portable Document Format files, it is necessary to have Adobe Acrobat Reader. To obtain Adobe Acrobat Reader free of charge, go to the Adobe Web page at (<http://www.adobe.com>).

The PostScript images of plates 1 and 2 are 38 inches wide by 29 inches high, so it requires a large plotter to produce paper copies at the intended scale. In addition to size constraints, some plotters, such as those with continual paper feed from a roll, are oriented with the long axis in the vertical direction, so the PostScript image will have to be rotated 90 degrees to fit entirely onto the page. Some plotters and plotter drivers, as well as many graphics software packages, can perform this rotation. The geologic description and discussion is on 8.5 by 11 inch pages. Because this release is primarily a digital database, the plot files (and plots derived therefrom) have not been edited to conform to U.S. Geological Survey standards. Small units have not been labeled with leaders and in some instances map features or annotation may overlap. Sample plots by the authors have proven to be quite legible and useful, however.

Obtaining the PostScript plotfile package

1. Sending a tape with request

A 14 MB compressed tar file of the plotfiles and text can be obtained by sending a tape with request to:

San Francisco Quaternary Geology and Liquefaction
Susceptibility 1:100,000 quadrangle PostScript Plotfiles
c/o Database Coordinator
U.S. Geological Survey
345 Middlefield Road, M/S 975
Menlo Park, CA 94025

Do not omit any part of this address!

The compressed tar file will be returned on the tape. The acceptable tape type is:
2.3 or 5.0 GB, 8 mm Exabyte tape.

2. Anonymous ftp over the Internet

To obtain the tar file by ftp, log in to your UNIX system and do the following:

<code>cd local_directory</code>	-go to a directory to receive the tar file
<code>ftp wrgis.wr.usgs.gov</code>	-make ftp connection with the USGS computer WRGIS
Name: anonymous	-use "anonymous" as your user name
Password: your name	-use your own user name as password
<code>cd pub/geologic</code>	-go down to the pub/geologic directory
<code>cd ca/of97-715</code>	-go down to the open file directory
<code>type binary</code>	-change transfer type to binary
<code>get sf_map.tar.gz</code>	-copy the compressed tar file across Internet to your directory
<code>quit</code>	-close the ftp connection

3. From the Western Region Geologic Information Web Page.

The U.S. Geological Survey now supports a set of graphical pages on the World Wide Web. Digital publications (including this one) can be accessed via these pages. The location of the main web page for the entire U.S. Geological Survey is "<http://www.usgs.gov>". The web server for digital publications from the Western Region is "<http://wrgis.wr.usgs.gov>"; go to the California page to access this publication. In addition to providing easy access to the entire digital database, the Western Region web page also provides simple access to the PostScript plot files of the map and Portable Document Format files of the explanation sheet containing much of the data in the digital database for those interested in the Quaternary Geology and Liquefaction Susceptibility, San Francisco, California, 1:100,000 quadrangle who do not use digital databases (see below).

Extracting The PostScript Plotfile Package From The Tar File

1. If you obtained the plotfile package on tape:

put the tape in your tape drive	
<code>cd local_directory</code>	-go to a directory to receive the tar file
<code>tar xvfb /dev/rstn 20</code>	-/dev/rstn is the tape device with n an integer, this puts the tar file in local_directory
<code>gzip -d sf_map.tar.gz</code>	-makes a 60 MB uncompressed tar file sf_map.tar
<code>cd local_directory2</code>	-go to the directory that will hold the directory sf_map (if different from local_directory)
<code>tar xvfb {path to tar file}/sf_map.tar 20</code>	-extract the sf_map directory from the tar file.

2. If you obtained the database by anonymous ftp :

<code>gzip -d sf_map.tar.gz</code>	-makes a 60 MB uncompressed tar file sf_map.tar
<code>cd local_directory2</code>	-go to the directory that will hold the directory sf_map (if different from local_directory)
<code>tar xvf {path to tar file}/sf_map.tar 20</code>	-extract the sf_map directory from the tar file.

This process will create a directory "/sf_map" that contains the PostScript plot files as described above.

3. If you obtained the database from the web:

<code>gzip -d sf_map.tar.gz</code>	-makes a 60 MB uncompressed tar file sf_map.tar
<code>cd local_directory2</code>	-go to the directory that will hold the directory sf_map (if different from local_directory)
<code>tar xvf {path to tar file}/sf_map.tar 20</code>	-extract the sf_map directory from the tar file.

This process will create a directory "/sf_map" that contains the PostScript plot files as described above.

OBTAINING THE DIGITAL DATA

Digital Database Package

The digital database is in ARC export format, and therefore requires use of ARC/INFO or another compatible GIS system to access and manipulate the information contained within it. The digital database package can be obtained in any of three ways:

1. Sending a tape with request

A 14 MB compressed tar file of the database and related files can be obtained by sending a tape with request to:

San Francisco Quaternary Geology and Liquefaction
Susceptibility 1:100,000 quadrangle PostScript Plotfiles
c/o Database Coordinator
U.S. Geological Survey
345 Middlefield Road, M/S 975
Menlo Park, CA 94025

Do not omit any part of this address!

The compressed tar file will be returned on the tape. The acceptable tape type is:
2.3 or 5.0 GB, 8 mm Exabyte tape.

2. Anonymous ftp over the Internet

To obtain the tar file by ftp, log in to your UNIX system and do the following:

cd local_directory	-go to a directory to receive the tar file
ftp wrgis.wr.usgs.gov	-make ftp connection with the USGS computer WRGIS
Name: anonymous	-use "anonymous" as your user name
Password: your name	-use your own user name as password
cd pub/geologic	-go down to the pub/geologic directory
cd ca/of 97-715	-go down to the open file directory
type binary	-change transfer type to binary
get sf_data.tar.gz	-copy the compressed tar file across Internet to your directory
quit	-close the ftp connection

3. From the Western Region Geologic Information Web Page.

The U.S. Geological Survey now supports a set of graphical pages on the World Wide Web. Digital publications (including this one) can be accessed via these pages. The location of the main web page for the entire U.S. Geological Survey is "<http://www.usgs.gov>". The web server for digital publications from the Western Region is "<http://wrgis.wr.usgs.gov>"; go to the California page to access this publication. In addition to providing easy access to the entire digital database, the Western Region web page also provides simple access to the PostScript plot files of the map and Portable Document Format file of the explanation sheet containing much of the data in the digital database for those interested in the Quaternary Geology and Liquefaction Susceptibility,

San Francisco, California, 1:100,000 quadrangle who do not use digital databases (see below).

Extracting The Digital Database from the Tar file

1. If you obtained the database package on tape:

put the tape in your tape drive	
cd local_directory	-go to a directory to receive the tar file
tar xvfb /dev/rstn 20	-/dev/rstn is the tape device with n an integer, this puts the tar file in local_directory
gzip -d sf_data.tar.gz	-makes a 43 MB uncompressed tar file sf_data.tar
cd local_directory2	-go to the directory that will hold the directory sf_data (if different from local_directory)
tar xvfb {path to tar file}/sf_data.tar 20	extract the sf_data directory from the tar file.

2. If you obtained the database package by anonymous ftp :

gzip -d sf_data.tar.gz	-makes a 43 MB uncompressed tar file sf_data.tar
cd local_directory2	-go to the directory that will hold the directory sf_data (if different from local_directory)
tar xvfb {path to tar file}/sf_data.tar 20	-extract the sf_data directory from the tar file.

This process will create a directory "/sf_data" that contains the ARC export files and supporting files as described above in the database contents section.

3. If you obtained the database package from the web page:

gzip -d sf_data.tar.gz	-makes a 43 MB uncompressed tar file sf_data.tar
cd local_directory2	-go to the directory that will hold the directory sf_data (if different from local_directory)
tar xvfb {path to tar file}/sf_data.tar 20	-extract the sf_data directory from the tar file.

This process will create a directory "/sf_data" that contains the ARC export files and supporting files as described above in the database contents section.

Converting ARC export files

ARC export files are converted to ARC coverages using the ARC command IMPORT with the option COVER. In order to ease conversion and to maintain naming conventions, we have included an ASCII text file in ARC Macro Language that will convert all of the export files in the database into coverages and create the associated INFO directory. From the ARC command line type:

Arc: &run import.aml

ARC export files can also be read by some other Geographic Information Systems. Please consult your GIS documentation to see if you can use ARC export files and the procedure to import them.

ADDITIONAL INFORMATION

Digital Compilation

The geologic map information was digitized from stable original of the geologic map at 1:100,000 scale. The author manuscripts (ink on greenline) were scanned using a Anatech monochrome scanner with a resolution of 800 dots per inch. The scanned images were vectorized and transformed from scanner coordinates to projection coordinates with digital tics placed by hand at map corners. The scanned lines were edited interactively by hand using ALACARTE, color boundaries were tagged as appropriate, and scanning artifacts visible at 1:100,000 were removed.

Base Maps

Base Map layers were prepared from scale-stable printing positives of the U.S. Geological Survey San Francisco, California 1:100,000 topographic map, which has a 50 meter contour interval. Scanned and vectorized images were transformed from scanner coordinates to projection coordinates with digital tics placed by hand at map corners. The images were then trimmed interactively by hand using ALACARTE to conform to the area of the geologic coverages, and the four portions were combined. Small mismatches at the boundaries caused by slight differences in the original scans remain in the three base map coverages. These base map layers are digital images but no information other than location is attached to the lines. The base maps are provided for reference only.

Faults and Landslides

This map is intended to be of general use to engineers and land-use planners. However, its small scale does not provide sufficient detail for site development purposes. In addition, this map does not take the place of fault-rupture hazard zones designated by the California State Geologist (Hart, 1988). Similarly, the database cannot be used to identify or delineate landslides in the region. For a depiction of landslide distribution, see Nilsen and others (1979).

Spatial Resolution

Uses of this digital geologic map should not violate the spatial resolution of the data. Although the digital form of the data removes the constraint imposed by the scale of a paper map, the detail and accuracy inherent in map scale are also present in the digital data. The fact that this database was edited at a scale of 1:100,000 means that higher resolution information is not present in the dataset. Plotting at scales larger than 1:100,000 will not yield greater real detail, although it may reveal fine-scale irregularities below the intended resolution of the database. The base map layers also have a resolution of 1:100,000 and are provided for reference only.

Database Specifics

The map databases consist of ARC coverages and supporting INFO files, which are stored in a Universal Transverse Mercator (California coordinate system) projection (Table 1).

Table 1 - Map Projection

PROJECTION UNIVERSAL TRANSVERSE MERCATOR	
UNITS METERS	-on the ground
ZONE 10	-Arc/Info UTM zone corresponding to California coordinate system zone 10
PARAMETERS	
END	

The content of the geologic database can be described in terms of the lines, points, and the areas that compose the map. Descriptions of the database fields use the terms explained in Table 2.

Table 2 - Field Definition Terms

ITEM NAME	name of the database field (item)
WIDTH	maximum number of digits or characters stored
OUTPUT	output width
TYPE	B-binary integer, F-binary floating point number, I-ASCII integer, C-ASCII character string
N. DEC.	number of decimal places maintained for floating point numbers

LINES -

The lines (arcs) for sf-geol and sf-liqu are recorded as strings of vectors and are described in the arc attribute table (Table 3). They define the boundaries of the map units, the boundaries of open bodies of water, faults, and the map boundaries. These distinctions, including the geologic identities of the unit boundaries, are recorded in the LTYPE field according to the line types listed in Table 4 and 5.

Table 3 - Content of the Arc Attribute Tables

ITEM NAME	WIDTH	OUTPUT	TYPE	N. DEC	
FNODE#	4	5	B	-	starting node of arc (from node)
TNODE#	4	5	B	-	ending node of arc (to node)
LPOLY#	4	5	B	-	polygon to the left of the arc
RPOLY#	4	5	B	-	polygon to the right of the arc
LENGTH	4	12	F	3	length of arc in meters
<coverage>#	4	5	B	-	unique internal control number
<coverage>-ID	4	5	B	-	unique identification number
LTYPE	35	35	C	-	line type (see Table 4)
SEL	1	1	I	-	user defined field used to save a selected set
SYMB	3	3	I	-	user defined field used to save symbol assignments (such as color)

Table 4 - Line Types for sf-geol recorded in the LTYPE Field

contact, certain
 contact, approx. located
 contact, concealed
 contact, inferred
 fault, certain
 fault, approx. located
 fault, concealed
 water boundary
 map boundary

Table 5 - Line Types for *sf-liqu* recorded in the *LTYPE* Field

contact, certain
contact, approx. located
fault, certain
fault, approx. located
fault, concealed
water boundary
map boundary

POINTS -

Historical Liquefaction Events (points), for sf-hist, are described in the point attribute table (Table 6). They define the location of liquefaction events. The identities of the points are recorded in the PTTYPER field by event type (Table 7).

Table 6 - Content of the Point Attribute Tables

ITEM NAME	WIDTH	OUTPUT	TYPE	N. DEC	
AREA	4	12	F	3	not used
PERIMETER	4	12	F	3	not used
<coverage>#	4	5	B	-	unique internal control number
<coverage>-ID	4	5	B	-	unique identification number
PTTYPE	35	35	C	-	point type
SAMPNO	35	35	C	-	not used
SEL	1	1	I	-	user defined field used to save a selected set
SYMB	3	3	I	-	user defined field used to save symbol assignments (such as color)
REFER	25	25	C	-	source of information
POINTNO	4	5	B	-	user defined field

Table 7 - Point Types Recorded in the PTTYPER Field

Pre-Loma Prieta Earthquake:

Sand boil
Ground settlement
Lateral spreading

Loma Prieta Earthquake:

Sand boils and / or sand intrusion
Ground settlement 1989
Lateral spreading 1989

AREAS -

Map units (polygons) for sf-geol are described in the polygon attribute table (Table 8). The identities of the map units from compilation sources are recorded in the PTYPE field by map label (Table 9). Map units are described more fully in the accompanying text file sf_geo.txt or sf_geo.pdf.

Table 8 - Content of the Polygon Attribute Tables

ITEM NAME	WIDTH	OUTPUT	TYPE	N. DEC	
AREA	4	12	F	3	area of polygon in square meters
PERIMETER	4	12	F	3	length of perimeter in meters
<coverage>#	4	5	B	-	unique internal control number
<coverage>-ID	4	5	B	-	unique identification number
PTYPE	35	35	C	-	unit label
SEL	1	1	I	-	user defined field used to save a selected set
SYMB	3	3	I	-	user defined field used to save symbol assignments (such as color)

Table 9 - Map Units

(See sf_geo.txt or sf_geo.pdf for descriptions of units)

af	Qhf	Qps
Qhc	Qhl	Qmt
Qhbm	Qha	Qoa
Qhs	Qf	br
Qhb	Qa	
Qht	Qpf	
	Qpa	

Liquefaction potential (polygons) for sf-liqu are described in the polygon attribute table (Table 10). The identities of the liquefaction potential units are recorded in the LIQPOT field (Table 11). The liquefaction potential units are vh = very high, h = high, m = moderate, l = low, vl = very low, and H2O = water.

Table 10 - Content of the Polygon Attribute Tables

ITEM NAME	WIDTH	OUTPUT	TYPE	N. DEC	
AREA	4	12	F	3	area of polygon in square meters
PERIMETER	4	12	F	3	length of perimeter in meters
<coverage>#	4	5	B	-	unique internal control number
<coverage>-ID	4	5	B	-	unique identification number
SEL	1	1	I	-	user defined field used to save a selected set
SYMB	3	3	I	-	user defined field used to save symbol assignments (such as color)
LIQPOT	5	5	C		liquefaction potential

Table 11 - Liquefaction Units

	m	H2O
vh	l	
h	vl	

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