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National Quaternary Fault and Fold Database Data Compilation for the State of California

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ABSTRACT

The National Quaternary Fault and Fold database (Haller, et al, 1993) is an on-line resource at:

http://earthquake.usgs.gov/regional/qfaults/index.php.

The database primarily is text-based, containing descriptive data that serve a varied audience. Data fields contain information on geographic, geologic, and paleoseismic parameters critical in making geologic-based assessments of seismic hazards. Descriptive comments for values such as slip rate, recurrence interval, and most recent event can clarify, justify, or expound upon these parameters. Many of the comments in the database provide justification for the paleoseismic parameters contained in the National Seismic Hazards Maps. This study presents the data compilation of faults in California that pose a significant potential of producing M>6 earthquakes. Data for faults modeled in the California portion of the 1996 and 2002 National Seismic Hazards Maps is 90% complete. In addition, vector files of Quaternary and younger fault traces for California have been extensively revised from the previous digital version of the Jennings (1994) fault activity map of California (DMG, 2000). Faults were digitized and attributed using original scale source maps, resulting in a 54,600-record GIS file depicting Quaternary and younger faults on a state-wide scale.

INTRODUCTION

In 1993 the U.S. Geological Survey began developing a map and database of Quaternary faults and folds in the United States. This database would contain information on faults and associated folds thought to be the sources of M>6 earthquakes during the past 1.6 Ma. The National Quaternary Fault and Fold (Qt Flt) database is intended to be the USGS's archive for historic and ancient earthquake sources used in current and future probabilistic seismic hazard analyses (e.g. Petersen, et al, 1996; Frankel, et al, 1996; Cao, et al, 2003; Frankel, et al, 2002).

The Qt Flt database is a web-based resource that provides a single source summarizing important information on paleoseismic parameters. There are two components to the Qt Flt database: maps of Quaternary active and younger fault traces and compilation of existing data for Quaternary faults using the data fields delineated by Haller, et al (1993). Data are compiled from journal articles, maps, theses, and other reports. The database is text-based, searchable, and contains descriptive data that serve a varied audience. Data fields contain information on geographic, geologic, and paleoseismic parameters critical in making geologic-based assessments of seismic hazards (Tables 1-4). Descriptive comments for values such as slip rate, recurrence interval, and most recent event can clarify, justify, or expound upon these parameters. Many of the comments in the database provide justification for the paleoseismic parameters contained in the National Seismic Hazards Maps.

Maps of Quaternary and younger faults in California originally were to be digitally compiled at a scale of 1:250,000 using the digital fault activity map of Jennings (1994) (DMG, 2000). However, the source map scale used for Jennings (1994) was 1:750,000. Fault traces at this source scale were generalized and the location accuracy at best was within about 400 meters and at worst could be greater than a kilometer. For static digital raster maps this did not present a problem, but the Qt Flt database website now offers downloadable GIS spatial data, requiring location accuracy and accurate depiction of fault trace complexity. Consequently, fault trace locations were digitally revised using the original source scale Jennings (1975, 1994) used for the compilations.

RESULTS

There are two principal goals in the development of California's portion of the Qt Flt database. The first goal is to complete data compilations for the faults that have been modeled in the National Seismic Hazards Map. The second goal is to improve the spatial database (GIS) to more accurately depict Quaternary and younger faults in California. Tertiary goals were to continue fault compilations of the non-modeled faults in California.

To date the data compilation has been completed for ninety percent of the faults included in the California PSHA model. The faults remaining to be compiled included faults in the Santa Maria – San Luis Obispo region, faults in the Mojave Desert region, faults in the Transverse Ranges, and offshore faults near Point Reyes and the Eureka area (Figure 1). Faults in the Santa Barbara Channel and offshore of southern California were compiled by geologists with the Coastal and Marine Geology Program at Menlo Park.

We prepared detailed digital revisions to the digital version of the Jennings (1994) fault activity map of California (DMG, 2000). This digital database has been significantly expanded with respect to the detail and complexity of fault traces and

scope of fault trace attribution (Figure 2). The digital database currently is populated with over 54.6 k records containing 14 data fields. Of these records, 85% have been assigned a Qt Flt database ID number.

The original paper copy map compiled by Jennings (1975, 1994) was prepared at a scale of 1:750,000. The 1994 map was scanned and digitized at 1:750,000. Therefore, the location accuracy of digital traces was no better than ± 400 meters and in some cases the location accuracy of faults was no better than ± 1.5 km. In order to improve location accuracy for the spatial data used in the California portion of the Qt Flt database, the original sources used by Jennings (1975, 1994) were scanned and digitized on screen (Figures 3-5). Original source scales ranged from 1:250,000 (DMG offshore Continental Margin maps) to 1:12,000. The most common scales used were 1:24,000 and 1:62,500. Fault traces from the Northern California Quaternary Fault Map Database (Graymer, et al, 2006) were incorporated in the fault activity map. Also, faults from the statewide collection of 1:24,000 Alquist-Priolo Earthquake Fault Zone maps (Bryant and Hart, 2007) were digitally converted and incorporated into the database. This database is not intended to replace or supersede the Official Maps of Earthquake Fault Zones and location of fault traces shown should not be substituted for site-specific fault-rupture investigations required by the Alquist-Priolo Earthquake Fault Zoning Act.

Associated with the fault trace locations are 231 paleoseismic study sites in California that have been summarized in the database. The site locations are included as a separate GIS file. Typical data summarized includes type of data observed, fault name, section name, and site location coordinates (Table 4).

METADATA

Fault compilations prepared for the National Quaternary Fault and Fold Database are text-based descriptions prepared using Microsoft Word. These text files are transmitted to K. Haller, USGS Golden and are converted to database files.

The fault activity database was compiled in the MapInfo 8.0 Geographic Information System and exported in both MapInfo and ESRI shape file formats. The fault activity database consists of three tables: the fault map, section boundary locations, and paleoseismic location sites (Tables 1-4).

Fault traces were compiled at the largest available scale from published sources (published maps ranges in scale from 1:100,000 to 1:12,000). Original source maps were scanned using a large-format scanner. The scanned maps were georeferenced using control points to link map edge tics and cultural features. The fault traces and supporting attributes were vectorized using heads-up digitization.

Vectorized maps and the associated digital files were compiled from source maps at scales of 1:12,000 to 1:100,000. Although the digital format of the dataset permits viewing the data at a larger scale, the detail and accuracy of the line and point data is compromised at scales larger than 1:12,000. Viewing the data at a larger scale

will not result in greater detail than that presented at the original source scale and should not be used from investigations requiring greater detail.

SUPPLEMENTAL DATA

Information on specific faults can be reviewed at the USGS National Quaternary Fault and Fold Database website: http://earthquake.usgs.gov/regional/qfaults/index.php . The database can be queried using three distinct interfaces. There are two map interfaces, using either static 1° x 2° quadrangles, or a dynamic ARC IMS system linked to the digital fault and fold GIS files. Vector file and the attribute tables can be selectively downloaded. Users can also query the database, using either simple queries, such as fault name, or complex user-defined combinations such as location, fault activity, and geologic characteristics.

NON-TECHNICAL SUMMARY

We compiled a digital map and database of Quaternary and younger faults in California. These data summarize geologic, geomorphic, and geographic information for faults in California that are considered to be sources of earthquakes greater tan magnitude 6 (M>6). The database is designed to address the requirements of a large group of users ranging from the science community to the general public. The database is an on-line resource that can be found at http://earthquake.usgs.gov/regional/qfaults/index.php. The database is searchable any of three ways: map-based searches using either a static map with indexed faults, a dynamic map that can be enlarged for detailed visual searches, zoomed out for more regional context, and grouped with user-controlled layers such as rivers, roads, cities and towns.

REPORTS PUBLISHED

Individual fault database summaries are published on the U.S. Geological Survey's website at http://earthquake.usgs.gov/regional/qfaults/index.php. GIS spatial data for California can be queried and downloaded at the USGS website above. An earlier version of California's GIS fault database can be downloaded in ESRI Shape and MapInfo tab files at the California Geological Survey's website:

http://www.conservation.ca.gov/cgs/information/publications/Pages/quaternaryfaults_ver2.aspx

A revised version (version 3.0) of the California Fault Activity Database will be published in the near future.

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Table 1. National Quaternary Fault and Fold Database Selected Data Fields from Haller, et al (1993)

Field Name	Comments
Structure Number	Follows numbering sequence outlined in Haller, et al (1993). For California, numbers 1-600 are available.
Structure Name	Uses earliest given name for structure unless there is a more commonly used name in recent literature. Need to determine reference in which name was originally assigned and identify other names used for structure.
Synopsis	Brief summary of amount of data that exists for a structure.
Geologic Setting	General statement regarding setting, total displacement, and age of displacement.
Sense of Movement	Choice of T, R, D, S, or N. Faults with oblique slip, combinations with principal sense of displacement first.
Slip Rate	Data field only allows value ranges (>5 mm/yr; 1-5 mm/yr; 0.2-1 mm/yr; <0.2 mm/yr; unknown, probably __). Comments field allows discussion of range of published values and uncertainties.
Recurrence Interval	Generally based on geologic/paleoseismic studies. Includes time interval for which recurrence interval is valid.
Dip	Measure value and range. Generally data from surface/trench observations, but can include discussion of subsurface observations when available.
Dip Direction	General dip direction (N, W, S ,E, NW, NE, SW, SE)
Geomorphic Expression	Brief description of structure's geomorphic expression, such as scarps, offset stream channels, closed depressions.
Detailed Studies	Location and description of paleoseismic studies, primarily trenching studies.
Timing of Most Recent Paleoevent	Generally field for most recent of penultimate event, if known. There is separate data table for historical surface-rupturing earthquakes.
Consensus Values	For California, fields added fro slip rate and Mw Max earthquake, based on Petersen, et al (1996) and Cao, et al (2003)
References	List of references used for fault compilation.

Table 2 – Data Fields for Digital Fault Activity Map

Field Name	Comments
FLT_NAME	Fault name, may be the same as FLT_ZN_NAME, but may be a differently named component of a fault zone.
FLT_ZN_NAME	Fault zone name, may be the same as FLT_NAME.
FLT_AGE	Age of displacement for a fault, HIS – faults with historic displacement (last 200 years), HOL – faults with Holocene displacement (last 11,000 years), LTQT – faults with late Quaternary displacement (last 750,000 years), QT – faults with undivided Quaternary displacement (last 1,600,000 years).
SLIPRATE	Geologic slip rate, defined in millimeters per year, >5 – faults with slip rate greater than 5 mm/yr, 1-5 – faults with slip rate between 1 mm/yr and 5 mm/yr, 0.2-1 – faults with slip rate between 0.2 mm/yr and 1 mm/yr, <0.2 – faults with slip rate less than 0.2 mm/yr.
SOM	Sense of displacement, D – dextral (right-lateral strike-slip), S – sinistral (left-lateral strike-slip), N – normal, R – reverse, T – thrust (<45 degrees), for combinations of slip, principal sense is first.
JEN_ID	Fault identification number used by Jennings (1994), originally used as an id number to catalog changes from the 1975 version of the fault activity map, not intended as a comprehensive fault database numbering system.
QFLT_ID	Fault (structure) identification number used in National Quaternary Fault and Fold database.
SECT_No	Alphanumeric numbering system used in National Quaternary Fault and Fold database to identify specific fault sections, which may be delineated by different fault ages, slip rates, fault geometry.
SECT_NAME	Section name assigned in National Quaternary Fault and Fold Database, corresponds to SECT_No.
FLT_SOURCE	Reference for source of mapped fault trace(s).
LTYPE	Line types: (on land) solid - well located, dashed - approximately located or inferred, dotted - concealed, (offshore) solid - well defined; dashed – inferred.
LVALUE	Defined field used to represent LTYPE, line values recorded in the LVALUE Field: 1 - solid; 2 - dashed; 3 – dotted.
VERSION_No	Sequential number used to identify the database version released.
VERSION_DATE	Date of release for a specific version of fault map database

Table 3 – Data Field for Section Boundaries

Field Name	Comments
FLT_NAME	Fault name, may be the same as FLT_ZN_NAME, but may be a differently named component of a fault zone.
SECT_NAME	Section name assigned in National Quaternary Fault and Fold Database, corresponds to SECT_No.
QTFLT_ID	Fault (structure) identification number used in National Quaternary Fault and Fold database.
SECT_No.	Section name assigned in National Quaternary Fault and Fold Database, corresponds to SECT_No.
SECT_EP	Approximate location of section boundary: N for northern boundary; S for southern boundary; W for western boundary; E for eastern boundary.

Table 4 – Data Fields for Paleosites

Field Name	Comments
SITE#	Unique identification number, using QTFLT_ID number, followed by individual site number
SITE_NAME	Paleosite name as appears in literature. If not named, will assign name in database
STUDY_TYPE	Type of data reported: slip rate; recurrence interval; event chronology; Most Recent Event; slip/event; fault geometry; fault recency
FLT_NAME	Fault name, may be the same as FLT_ZN_NAME, but may be a differently named component of a fault zone.
QTFLT_ID	Fault (structure) identification number used in National Quaternary Fault and Fold database.
REF	Reference(s) for study site.
LONG	Longitude coordinate for study site.
LAT	Latitude coordinate for study site.

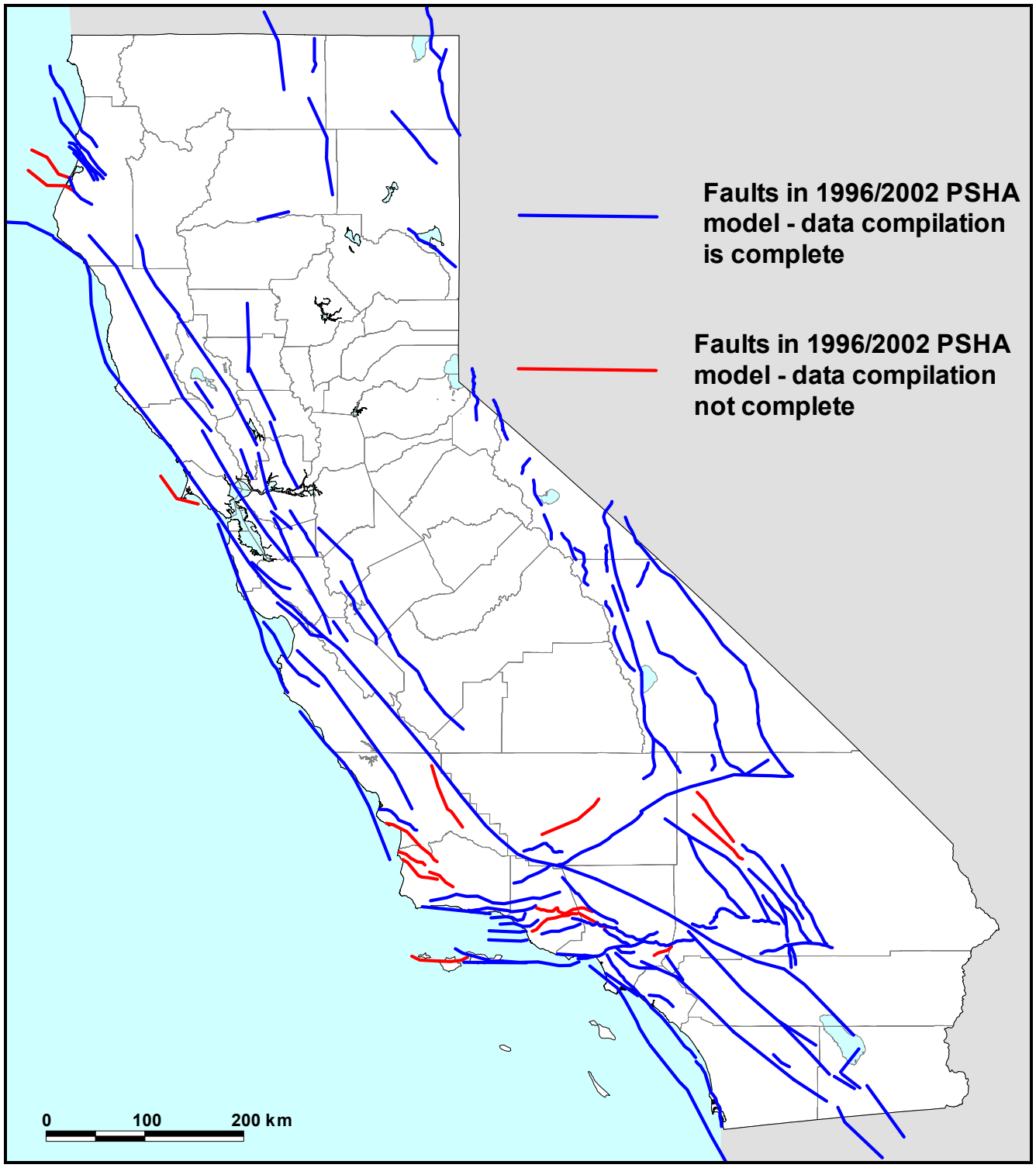

Figure 1. Distribution of faults considered in the 1996/2002 California portion of the National Seismic Hazards Maps. Faults shown in red remain to be compiled in the National Quaternary Fault and Fold database. To date ninety percent of the data compilation for faults in the California model has been completed.

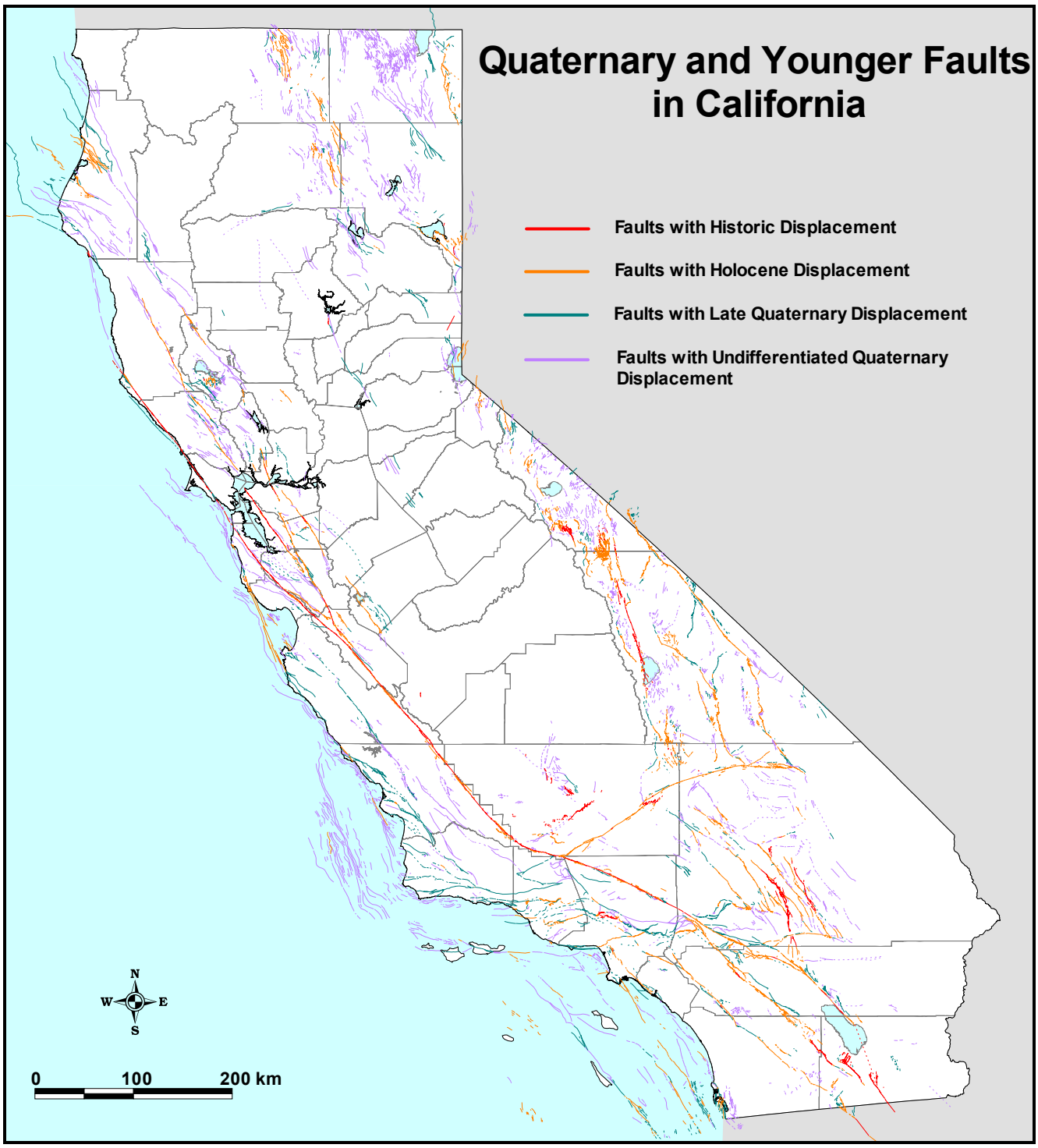

Figure 2. Digital database of Quaternary and younger faults from the fault activity map of California. Fault traces from DMG (2000) have been extensively re-digitized using mapping from fault trace sources at map scales ranging from 1:12,000 to 1:100,000.

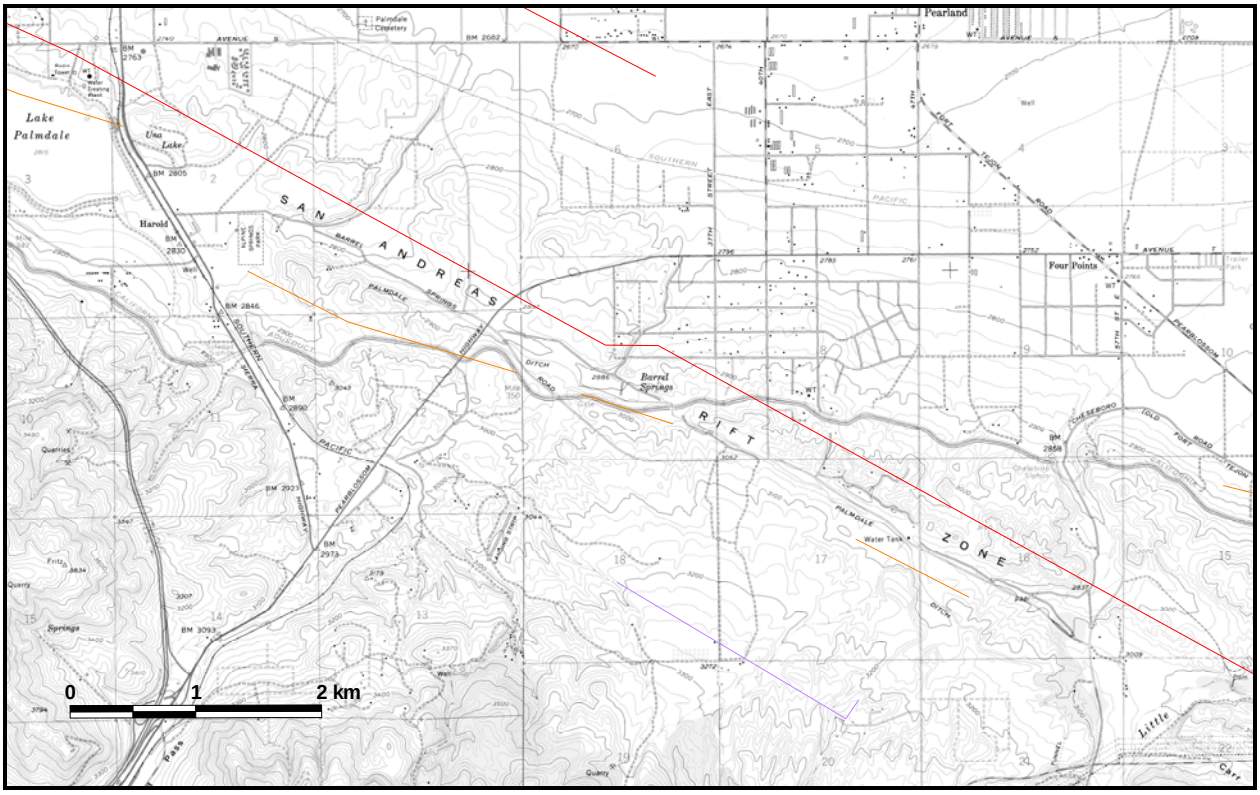

Figure 3a. Original digital line work of San Andreas Fault in the Palmdale area, based on the 1:750,000 compilation by Jennings (1994) (DMG, 2000).

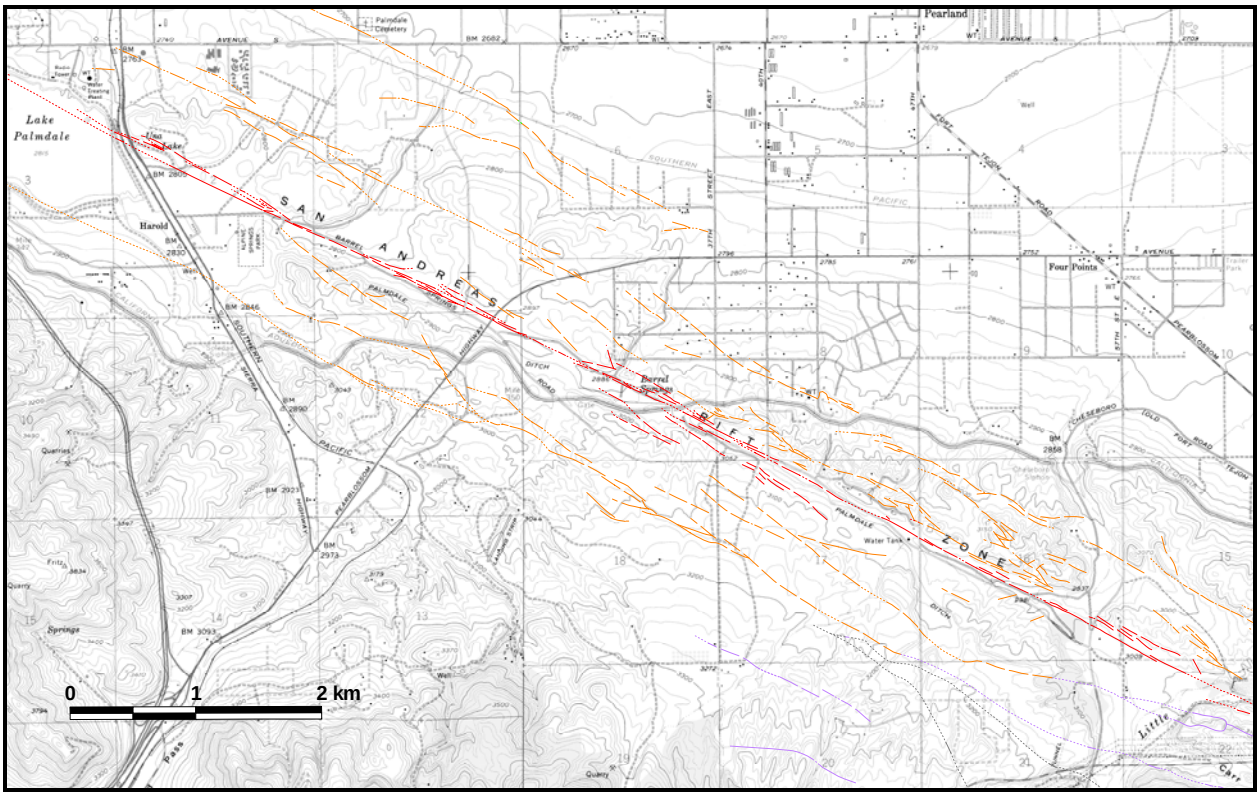

Figure 3b. Revised digital line work based on detailed mapping of San Andreas Fault at 1:12,000 scale by Barrows, et al (1985).

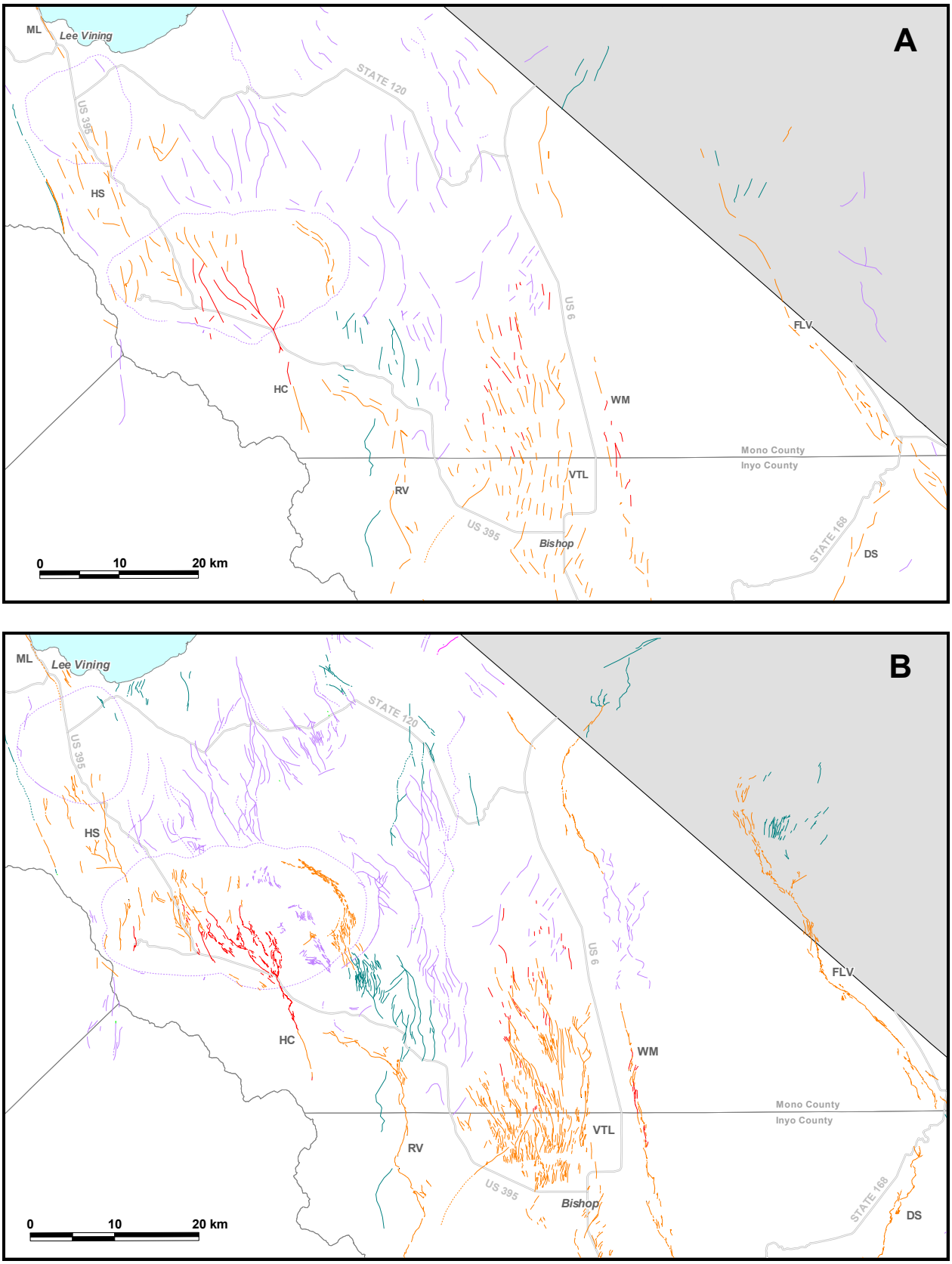

Figure 4. A) Digital fault traces in the southern Mono and northern Inyo county area, based on original Jennings (1994) compilation at 1:750,000. B) Revision of digital fault traces using original source scale mapping. Selected faults include: DS – Deep Springs fault; FLV – Fish Lake Valley fault zone; HC – Hilton Creek fault; HS – Hartley Springs fault zone; ML – Mono Lake fault; RV – Round Valley fault zone; VTL – Unnamed faults in Volcanic Tableland; WM - White Mountains fault zone.

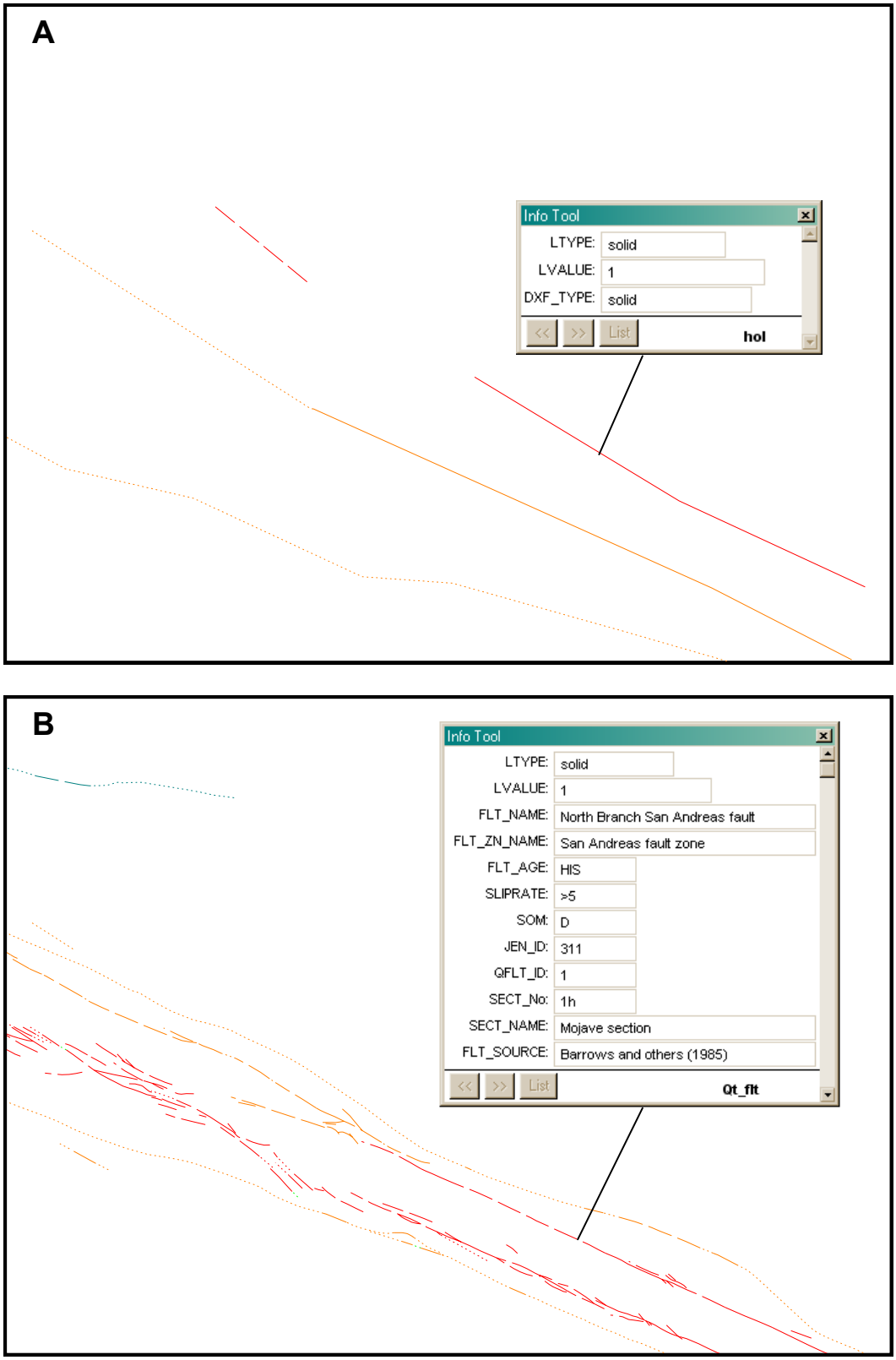

Figure 5. A) Feature attribution available for faults in digital version of Jennings (1994) (DMG, 2000). B) Revised feature attribution incorporating fault name, fault zone name, National Qt Flt ID number, section number, section name, slip rate, sense of movement, fault age, Jennings (1994) ID number, line type, and fault trace source.