

**Annual Report, 1999**  
**Historic and Paleoseismic Behavior of the Southcentral San Andreas  
Fault Between Cholame and the Carrizo Plain**

Submitted by Lisa B. Grant

Dept. Environmental Analysis & Design, University of California  
Irvine, CA 92697-7070; lgrant@uci.edu

Collaborative project with Ramon Arrowsmith of Arizona State University

**Purpose**

This project is part of a collaborative investigation of the historic and paleoseismic behavior of the southcentral San Andreas fault between Cholame and the Carrizo Plain with Ramon Arrowsmith, and students Elizabeth Stone and Jeri Young.

To evaluate seismic hazard in California, it is essential to understand the behavior and earthquake potential of the San Andreas fault. Despite the tectonic complexity of southern California and the large number of active faults, the San Andreas fault dominates seismic hazard assessments because of its high moment release rate and documented historic and prehistoric frequency of generating large magnitude earthquakes (WGCEP, 1988). In addition, data on the earthquake history of the San Andreas fault forms the basis of numerous models of fault behavior and calculations of seismic hazard. Despite the relatively large amount of data available, there are many questions about segmentation models for the San Andreas, the rupture patterns of prehistoric earthquakes, and patterns of earthquake recurrence (Grant, 1996).

The Cholame segment of the San Andreas fault has been defined as the section of the fault between Highway 46 at Cholame and Highway 58 in the northern Carrizo Plain (WGCEP, 1988. See Fig. 1 of Arrowsmith's progress report). The northern segment boundary is defined by the location where the fault behavior changes from partially creeping to locked. This location has also been the southern termination of recent Parkfield ruptures (Bakun and Wentworth, 1997). The southern segment boundary is defined by the increase in geomorphic offsets attributed to the 1857 earthquake in the Carrizo Plain as mapped by Sieh (1978). Many attempts to characterize the earthquake potential of the Cholame segment have emphasized the need for better paleoseismic data (WGCEP, 1988; SCECWG, 1994; Arrowsmith et al., 1997). In addition, paleoseismic studies in the Carrizo Plain have raised questions about recurrence models that can be better tested if data are obtained for the Cholame segment (Sieh and Jahns, 1984; Grant and Sieh, 1994).

The objectives of the project are to:

- date the penultimate rupture by paleoseismic excavation.
- estimate the magnitude and extent of past ruptures along the San Andreas fault between the northwestern Carrizo Plain and Cholame
- measure slip along the Cholame segment from the 1857 earthquake
- test the Cholame segmentation model, as defined by the Working Group on California Earthquake Probabilities (1988).

## Progress and Results

1) Paleoseismic Investigation: During the 1999 budget year we made significant progress toward achieving our goals. Our most important accomplishments are completion of a paleoseismic trench and submission of a manuscript to *BSSA*. If published, this manuscript would contribute the first paleoseismic data from the Cholame segment.

We worked collaboratively on all aspects of the project. (See Arrowsmith's report for additional information and figures.) Stone did the largest amount of work as part of her M.S. thesis. She was supervised by Arrowsmith during the academic year, and by myself during the summer. Arrowsmith and I both assisted her with field work, analysis of data, and preparation of a manuscript for *BSSA*. In spring 1999 the three of us visited several potential trench sites and secured permission to excavate at the LY4 site (Figs. 1 & 2 of Arrowsmith's report). Stone and Arrowsmith surveyed the trench site and then I joined them for opening the trench. I supervised and assisted Stone with preliminary interpretations of the trench stratigraphy, and reviewed the work and interpretations as they progressed over the summer. We jointly completed a first draft of the manuscript at the end of the summer using radiocarbon dates for age control.

Our analysis suggested the possibility that the fault had ruptured after 1857, so we did additional work to try to date the youngest event rather than assume that it was the 1857 rupture. Stone separated pollen from samples of several horizons. The quantity of pollen was insufficient for radiocarbon dating, but the upper layers contained exotic (i.e. non-native species). I worked with Stone to research the dates of introduction of these exotic species in California and thereby to assign maximum ages to the layers containing these pollens species.

The results of our study imply that the recent rupture history of the Cholame "segment" of the San Andreas fault differs significantly from characterizations by WGCEP (1988), SCECWG (1994) and others. Our primary findings and conclusions are summarized in **Table 1** (attached) and in the following abstract from our submitted paper (Stone, Arrowsmith and Grant):

We conducted a paleoseismic study on the San Andreas fault (SAF) southeast of Cholame, CA to investigate the record of earthquakes within an 80 km paleoseismic data gap that exists between Parkfield and the Carrizo Plain. At the LY4 site, located 37.5 km southeast of Highway 46 along the SAF, we excavated a fault-perpendicular trench on an alluvial fan that emanates from the Temblor Mountains to the northeast and crosses the fault trace at the distal end of the fan. We found evidence of four ruptures within the stratigraphy. Because of limitations in the production and preservation of datable material, the only age constraints are radiocarbon dates on a paleosol three units below the oldest event horizon and the presence of recently introduced exotic pollen species in an upper unit. The radiocarbon dates indicate there have been at least four surface rupturing events at the LY4 site since 1070-1280 cal AD. The presence of exotic (historic) pollen in a unit possibly cut by the youngest event suggests that it may have occurred after 1873 and therefore might have ruptured during the 1881 Parkfield event.

During approximately the same time period, the fault ruptured 5 times at the Bidart fan in the Carrizo Plain (Grant and Sieh, 1994). It is possible that our trench at the LY4 site does not contain all rupture events, but that is also a possibility at the Carrizo trench sites. Therefore, it appears that the average recurrence time for surface ruptures at the Bidart fan is *less* than the average recurrence time for the LY4 site – the opposite of our expected results. It also appears that the most recent surface rupture occurred after 1873 rather than in 1857 as has widely been assumed. We did not collect pollen from all layers, and the stratigraphic units near the top of the trench are discontinuous, so the evidence for post-1857 rupture is not definitive.

## 2) Measurement of 1857 displacement across the fault from analysis of cadastral surveys.

The results of our paleoseismic study may explain why early historic surveys across the San Andreas fault between Cholame and the Carrizo Plain appear to have significant errors. Grant and Donnellan (1994) successfully measured the amount of displacement from the 1857 earthquake near Wallace Creek in the Carrizo Plain by analyzing cadastral surveys and remeasuring original monuments. We attempted the same type of investigation further north along the Cholame segment. The original pre-1857 surveys were conducted by the same surveyor (James E. Freeman) who surveyed the Wallace Creek area. Therefore, systematic errors should be similar to those reported by Grant and Donnellan (1994). In my progress report last year I summarized preliminary analysis that suggested coseismic displacement was 6.8 – 7.9 m, and I proposed to spend much of my time in 1999 analyzing errors in the surveys and uncertainty in the apparent displacement. I attempted to do this during the 1999 budget year, but I found the errors to be intractable and temporarily abandoned the analysis. I now suspect that the “errors” I found were actually measurements of post-1857 (probably 1881) displacement across the fault. I plan to reassess the survey data in 2000. (See proposal.)

3) Publications – We submitted a full manuscript to BSSA (below) and published several abstracts. See my full list of Publications and Products for abstracts.

- Stone, E. M., J. R. Arrowsmith, and L. B. Grant, Recent rupture history of the San Andreas fault, southeast of Cholame in the northern Carrizo Plain, California, in review for *Bull. Seism. Soc. Amer.* Submitted Dec. 23, 1999.

## **References**

- Arrowsmith, R., K. McNally and J. Davis (1997). Potential for earthquake rupture and M7 earthquakes along the Parkfield, Cholame, and Carrizo segments of the San Andreas Fault, *Seismological Research Letters*. 68, 902-916.
- Bakun, W.H. and C.M. Wentworth (1997). Estimating earthquake location and magnitude from seismic intensity data, *Bulletin of the Seismological Society of America*. 87, 1502-1521.
- Grant, L.B. (1996). Uncharacteristic earthquakes on the San Andreas fault, *Science*. 272, 826-827.

Grant, L.B. and A. Donnellan (1994). 1855 and 1991 surveys of the San Andreas Fault; implications for fault mechanics, *Bulletin of the Seismological Society of America*. 84, 241-246.

Grant, L.B. and K. Sieh (1994). Paleoseismic evidence of clustered earthquakes on the San Andreas fault in the Carrizo Plain, California, *Journal of Geophysical Research*. 99, 6819-6841.

Southern California Earthquake Center Working Group (SCECWG) on the Probabilities of Future Large Earthquakes in Southern California (1994) *Seismic Hazards in Southern California: Probable earthquakes, 1994-2024*, *Bulletin of the Seismological Society of America*. 85, 379-439.

Sieh, K.E. (1978). Slip along the San Andreas fault associated with the great 1857 earthquake, *Bulletin of the Seismological Society of America*. 68, 1421-1448.

Sieh, K.E. and R.H. Jahns (1984). Holocene activity of the San Andreas fault at Wallace Creek, California, *Geological Society of America Bulletin*. 95, 883-896.

Southern California Earthquake Center Working Group (SCECWG) on the Probabilities of Future Large Earthquakes in Southern California (1994) *Seismic Hazards in Southern California: Probable earthquakes, 1994-2024*, *Bulletin of the Seismological Society of America*. 85, 379-439.

Stone, E. M., J. R. Arrowsmith, and L. B. Grant, Recent rupture history of the San Andreas fault, southeast of Cholame in the northern Carrizo Plain, California, in review for *Bull. Seism. Soc. Amer.* Submitted Dec. 23, 1999.

Working Group on California Earthquake Probabilities (WGCEP), Probabilities of large earthquakes occurring in California on the San Andreas Fault, U.S. Geological Survey Open File Report, OFR 88-398, 62 pp., 1988.

**Table 1.** Average recurrence intervals through AD 2000 for sites along the southern San Andreas fault. (from Stone, Arrowsmith and Grant, submitted)

| <b>Paleoseismic site</b>   | <b>Number of ruptures</b> | <b>Maximum age (<math>2\sigma</math>) of oldest rupture (cal AD)</b> | <b>Average Recurrence (years)</b> |
|----------------------------|---------------------------|--|-----------------------------------|
| Cholame                    | 4                         | 1070   | 233                               |
| Bidart Fan <sup>1</sup>    | 5                         | 1218   | 156                               |
| Mill Potrero <sup>2</sup>  | 3                         | 1450   | 183                               |
| Pallett Creek <sup>2</sup> | 10                        | 700  | 130                               |
| Wrightwood <sup>3</sup>    | 11                        | 400  | 146                               |
| Indio <sup>2</sup>         | 4                         | 1050   | 238                               |

References:

<sup>1</sup>Grant and Sieh (1994)

<sup>2</sup>WGCEP (1988)

<sup>3</sup>Fumal, et al., (1993), Weldon (1991)