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HOLOCENE BEHAVIOR OF THE SAN ANDREAS FAULT AT DOGTOWN POINT REYES NATIONAL SEASHORE CALIFORNIA

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for

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INTRODUCTION

During recent years, detailed subsurface investigations conducted along the earthquake-producing 1857 and 1906 segments of the San Andreas fault have yielded geologic data upon which to judge late Holocene paleoseismicity. At Pallett Creek, southeast of Palmdale (Figure 1), the 1857 segment of the San Andreas fault cuts a sequence of late Holocene marsh deposits. Kerry Sieh (1978) carefully logged exposures of the fault in a variety of bulldozer and backhoe cuts. Radiocarbon dates determined from organic-rich horizons cut by the fault indicate that prehistoric earthquakes similar to the 1857 event (i.e. $M_S \simeq 8.3$) have occurred at intervals varying from 50 years to about 300 years, with an average recurrence interval of 160 years. Farther north, at Wallace Creek in the Carrizo Plain (Figure 1), Hall and Sieh (1977) determined a late Holocene slip rate of about 37 mm/yr. for the last 3430 years and calculated an average recurrence interval of 250 ± 50 years for the 9-meter-displacement 1857 event and the pre-1857 slip events.

In an attempt to extend similar work to the northern portion of the fault, we have completed a preliminary subsurface evaluation of late Holocene paleoseismicity in the Point Reyes area north of San Francisco. During this past year, seven exploratory trenches were excavated across the 1906 trace of the San Andreas fault north of Dogtown (Figure 2). The geologic relationships exposed in the trenches indicate that at least four large pre-1906 earthquakes occurred at the site during the last 1400 years. Each earthquake produced displacements in an alluvial sequence during deposition of the sediments.

SITE SELECTION

The initial goal of our research effort was to select a site of Holocene deposition along the San Andreas fault that experienced surface faulting in 1906. To accomplish this, we conducted a systematic evaluation of all available pertinent historic information regarding the 1906 rupture. In addition, we completed a detailed analysis of aerial photographs for the on-land portion of the fault zone between San Juan Bautista and Point Arena (Figure 2). On the basis of this preliminary information, we selected a number of fault segments for more thorough ground investigations. Upon completion of the field evaluations, six sites were selected as potential candidates for detailed subsurface analysis. The locations of these sites are shown in Figure 2, and the technical criteria used to evaluate each one are described in Table 1.

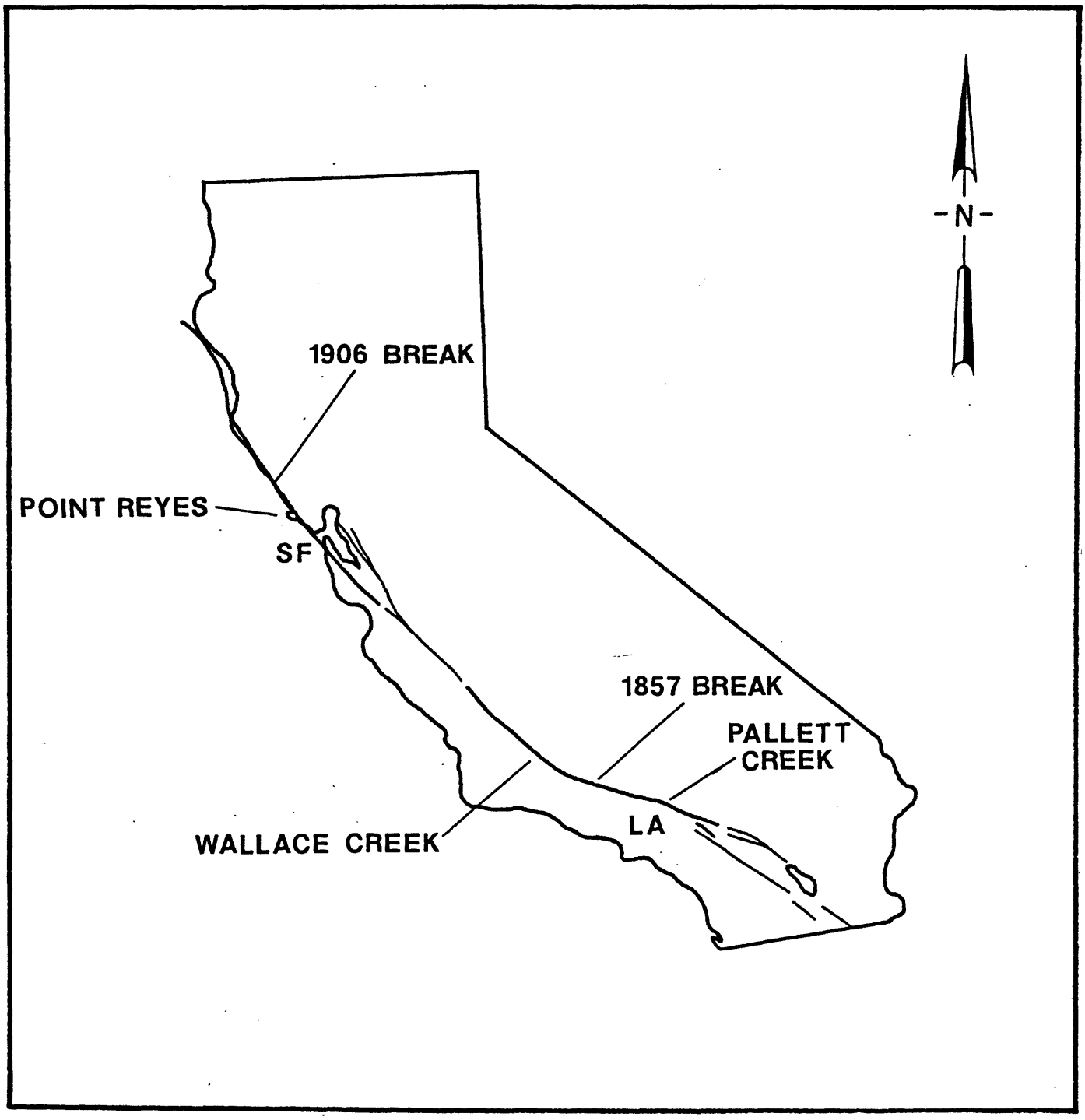

FIGURE 1. ACTIVE SEGMENTS OF THE SAN ANDREAS FAULT SYSTEM THAT HAVE EXPERIENCED SIGNIFICANT SURFACE FAULTING ASSOCIATED WITH GREAT EARTHQUAKES.

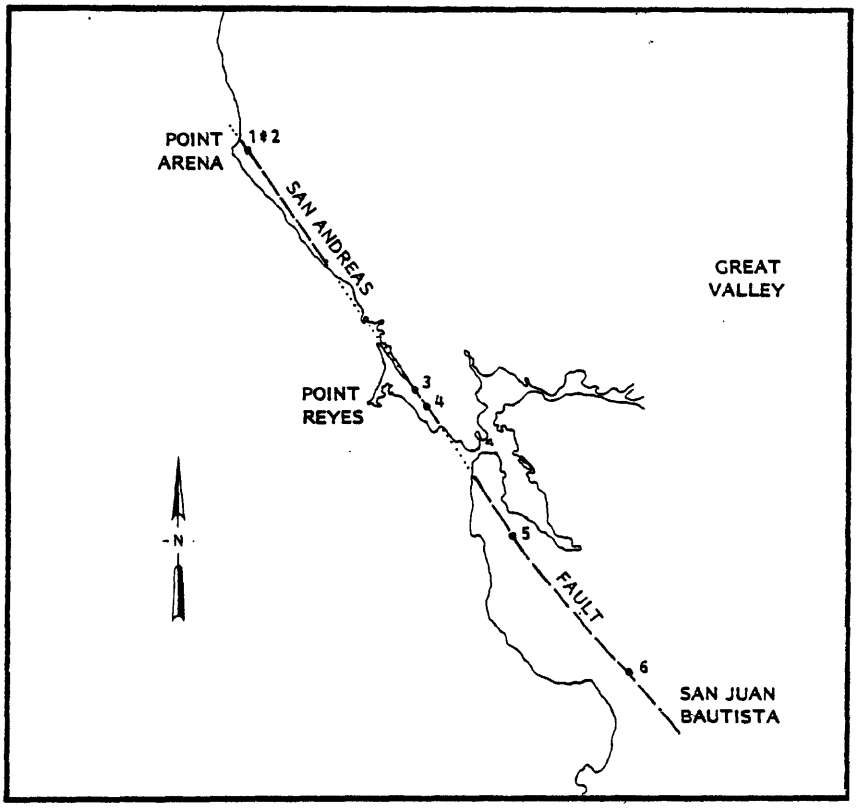

Figure 2. Location of six preliminary research areas along the 1906 trace of the San Andreas fault. Each area contains an exploratory trenching site which may be suitable for recurrence interval studies.

SITE NAMES

1 - Garcia River (Olsen Ranch)
2 - Garcia River (Jones Ranch)
3 - Vendanta Retreat
4 - Dogtown
5 - Portola Valley
6 - Anzar Road

TABLE 1 - Technical criteria for selection of possible exploratory trench sites along the 1906 break of the San Andreas fault.

Geologic Criteria

1. Site located on a section of the fault where physiographic evidence suggests that all or most of the Holocene faulting has been narrowly concentrated (i.e. the region is not characterized by multiple, branching or subsidiary faults).

2. Site is locus of Holocene deposition where sediments accumulate rapidly enough to form a record between successive surface faulting events.

3. Stratigraphy of the upper 4 to 5 meters of the site characterized by multiple, distinct, and laterally-continuous sedimentary units containing a sufficient amount of carbonaceous debris suitable for radiocarbon dating.

4. Site has water table deep enough to permit exploratory trenching to approximately 5 meters (minimum depth approximately 2 meters).

5. Site has well-documented history of the location and amount of 1906 ground displacement.

Logistical Criteria

1. Site is accessible to backhoe and other equipment.

2. Permission for access to investigate site can be secured from land owner.

On the basis of the technical criteria outlined in Table 1, each site was analyzed in order to choose the one with the highest research potential. To accomplish this phase of our research, we reevaluated each site by using sequential aerial photographs to determine if, indeed, the areas were characterized by a single master trace of the San Andreas fault. Once we were convinced of the single-strand nature of the fault at each locality, each site was revisited and evaluated in detail. Preliminary subsurface explorations of several of the potentially productive sites were conducted using both hand auger drilling equipment and exploratory backhoe test pits. Sufficient data were gathered through this preliminary phase of subsurface work to allow us to determine which of the six sites would be most productive for more extensive investigations.

Three sites were explored with backhoe equipment, and two of those were abandoned. Although the Garcia River (Olsen Ranch) site has well-preserved geomorphic features, it was rejected because of problems with high ground water. The Anzar Road site was eliminated because we found no well-defined stratigraphic horizons and no apparent subsurface evidence of faulting. In addition, there had been extensive bioturbation at the site. The only potentially productive site proved to be the one near Dogtown, which is located near the southern boundary of Point Reyes National Seashore.

DOGTOWN RESEARCH SITE

The Dogtown site is approximately 1 kilometer northwest of the small hamlet of Dogtown, formerly called Woodville (Figure 3). The research site itself is west of Highway 1 on the alluviated floor of a small valley that is part of the Pine Gulch Creek drainage system. Immediately south of the site, the valley is bounded by a prominent northwest-trending bedrock ridge. To the north, however, the valley floor extends relatively uninterrupted for approximately 1 kilometer before it terminates against higher topography. To the west and east, the valley is bounded by the mountainous topography of Inverness Ridge and Bolinas Ridge, respectively. The configuration of the tributaries of Pine Gulch Creek and the shape of the surrounding topography clearly are the result of tectonic activity along the San Andreas fault which bisects the valley.

Strong evidence of surface faulting exists within the research area. This is true especially for the 1906 event. Immediately after the 1906 earthquake, G. K. Gilbert traversed this segment of the fault zone and carefully noted the surface features produced by the earthquake (Lawson, 1908). South of the Dogtown site, Gilbert noted that a row of eucalyptus trees was offset approximately 4 meters, and

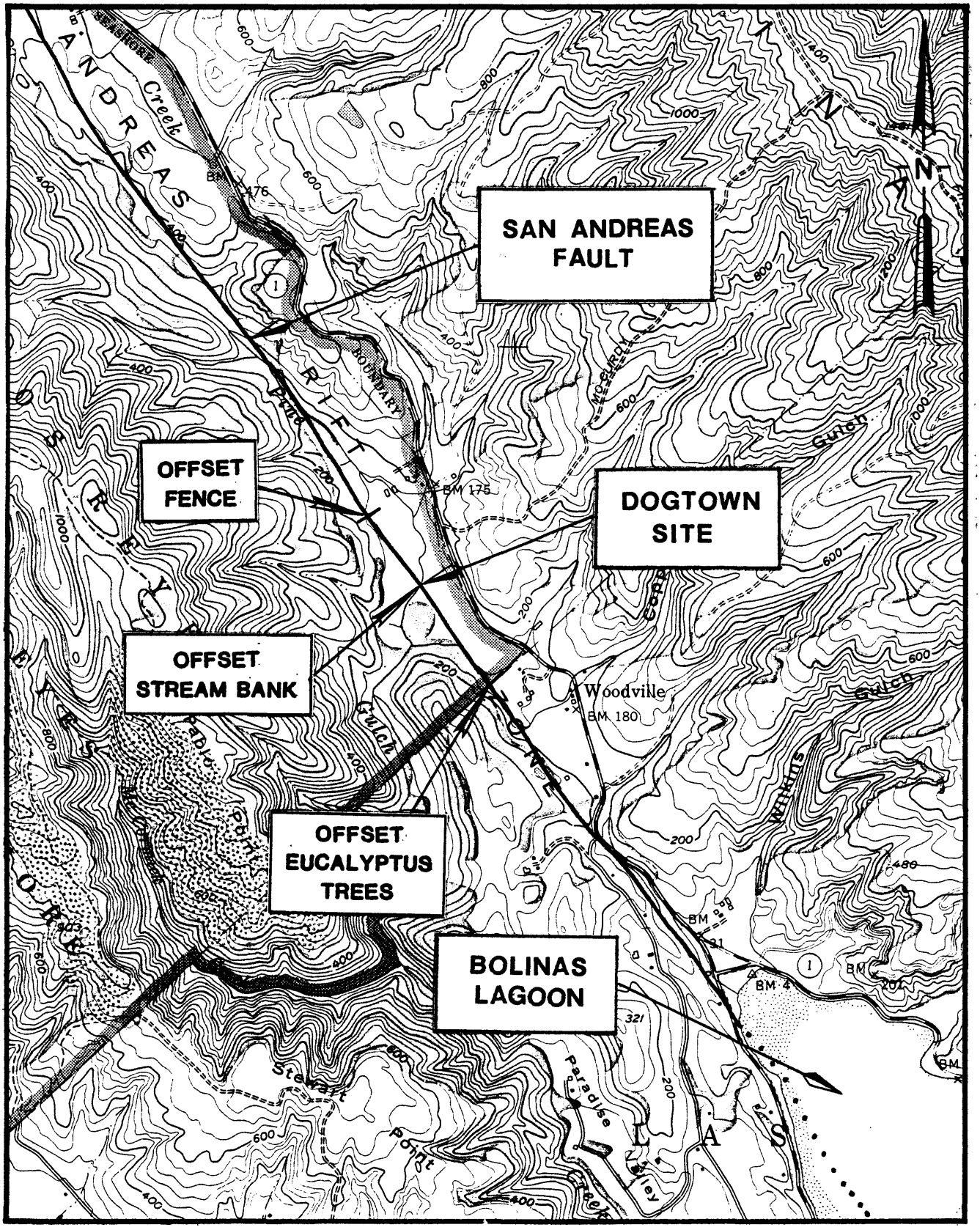

FIGURE 3. INDEX MAP OF THE DOGTOWN RESEARCH SITE
POINT REYES AREA

at the Strain Ranch, north of the site, a fence was offset nearly 3.5 meters (Figure 3). The Dogtown site is approximately equidistant between these two points and is in line with several fault-related geomorphic features. From the eucalyptus grove to the research site, the trace of the fault can be followed across the valley floor along a series of features such as offset stream channels, a low, east-facing scarp, and a sag pond. The most striking geomorphic feature formed along the master trace is the offset stream bank of Pine Gulch Creek, located immediately northwest of the research site. There the stream bank is approximately 2 meters high and has been offset nearly 4.5 meters along the 1906 trace.

On the basis of the surface data described above, the exploratory trenches were oriented to cross the most likely position of the 1906 trace where it traverses the relatively flat valley floor between Pine Gulch Creek and the sag pond south of the site (Figure 4). Seven backhoe trenches with a maximum depth of 3.5 meters and average depths of about 2.5 meters were excavated across the 1906 trace. Their aggregate length was approximately 150 meters. The presence of shallow ground water precluded excavation deeper than 3 meters in most of the trenches.

The walls of the excavations were logged geologically, and samples of carbonaceous materials were collected for radiocarbon dating. All of the excavations revealed clear evidence of the 1906 rupture. In addition, at least four seismic events that occurred prior to 1906 were indicated. The geologic data exhibited within the exploratory trench excavations have been compiled as a "schematic composite" of all of the trench logs (Figure 5). The locations of four preliminary radiocarbon dates that we feel are our most accurate values are shown on the composite log. Carbonaceous materials were sampled selectively to bracket the four pre-1906 seismic events. The reported ages are:

1906 Event

380 ± 85 years

Pre-1906 Event - I

740 ± 115 years

Pre-1906 Event - II

880 ± 75 years

Pre-1906 Events - III and IV

1410 ± 100 years

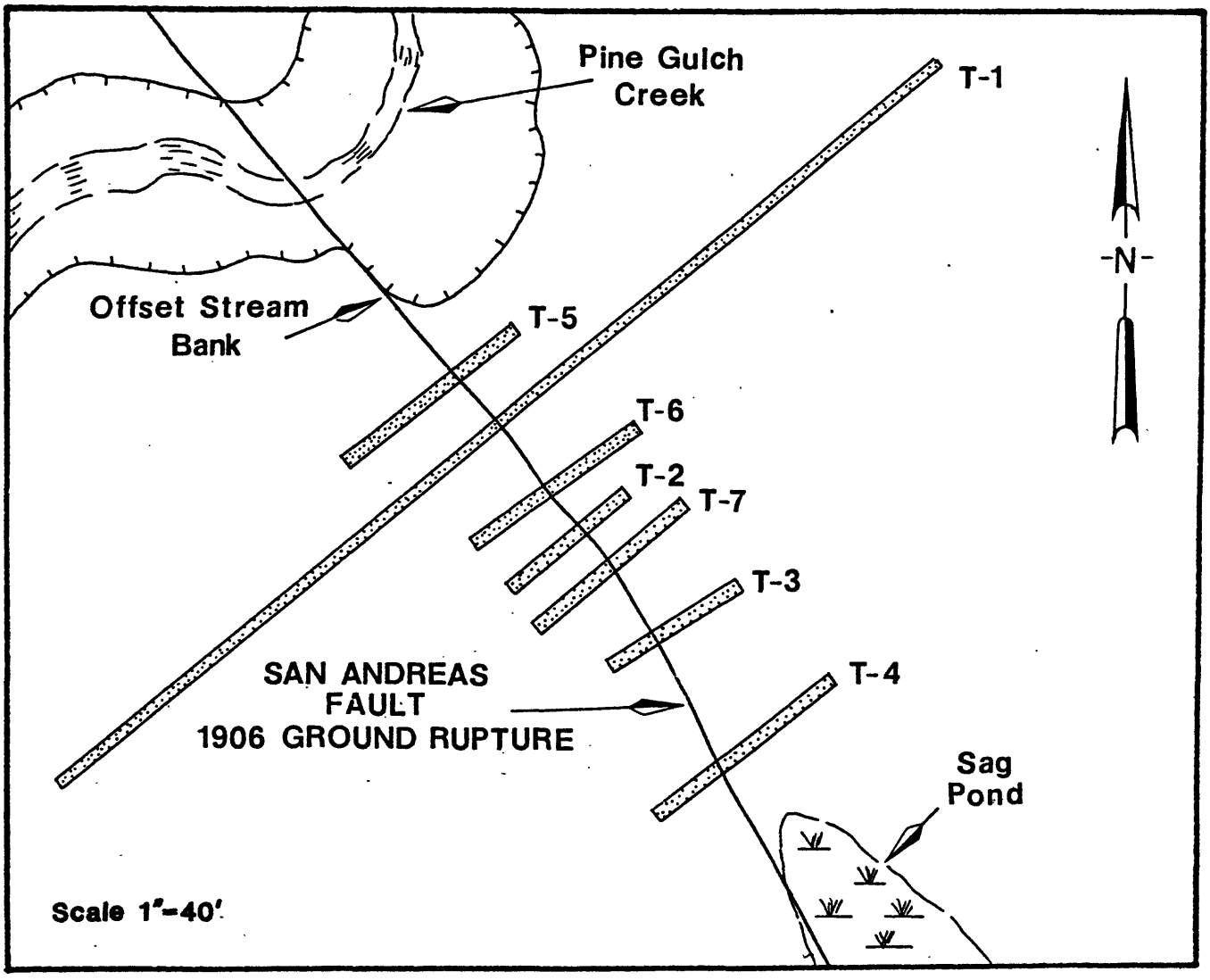

FIGURE 4. SCHEMATIC DISTRIBUTION OF THE
DOGTOWN EXPLORATORY TRENCHES

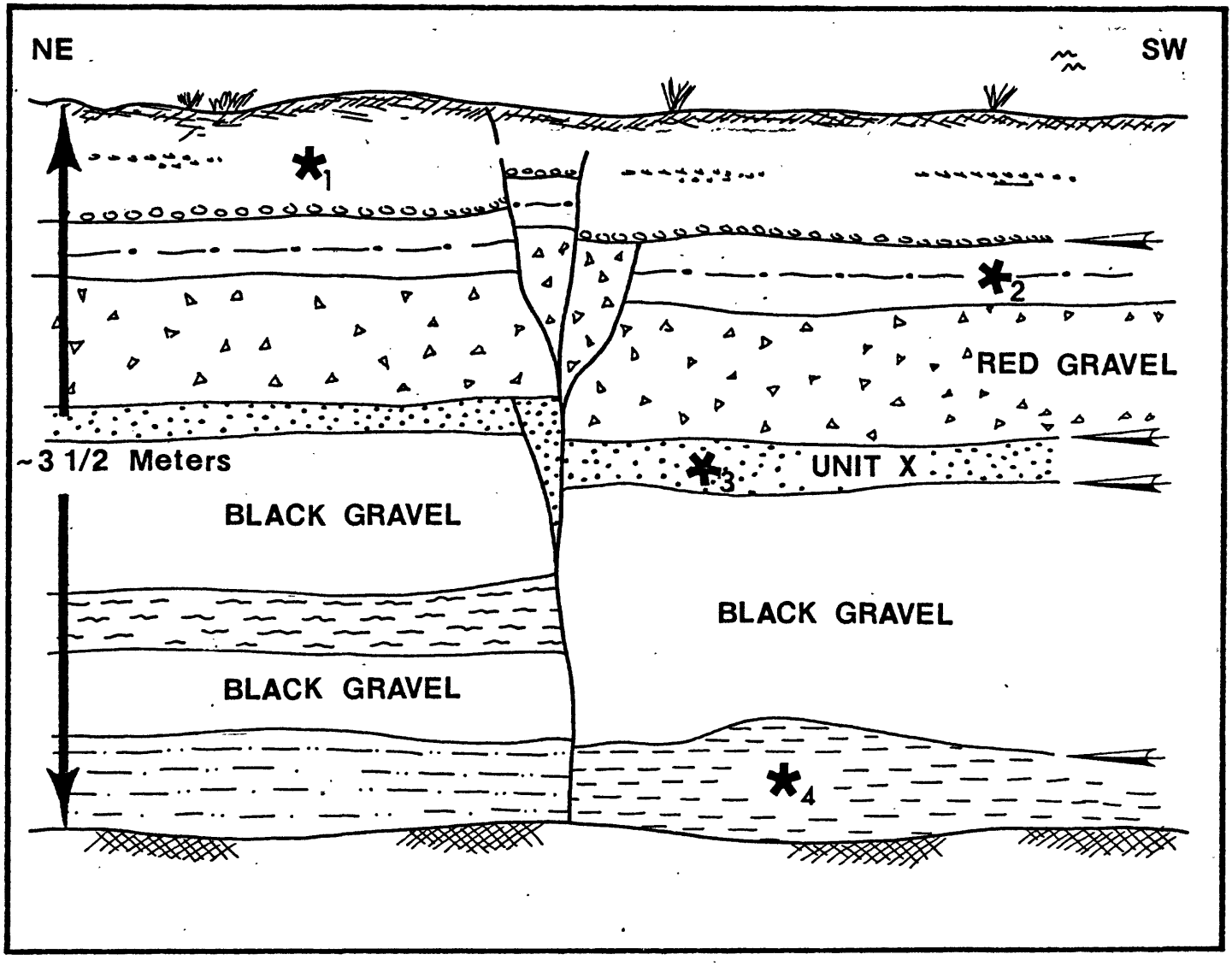

FIGURE 5. SCHEMATIC COMPOSITE OF SEVEN EXPLORATORY TRENCH LOGS

* Radiocarbon ages at locations shown

1. 380 ± 85 years
2. 740 ± 115 years
3. 880 ± 75 years
4. 1410 ± 100 years

Horizons formed following a seismic event.

CONCLUSIONS

As a result of our subsurface work, we now believe that at least four pre-1906 earthquakes can be demonstrated to have occurred at the Dogtown site. The two most recent events are defined by rupture surfaces that are truncated by unconformities while the two remaining events are recognized by decreasingly similar stratigraphic juxtapositions across the fault surface (Figure 5). These dissimilar stratigraphic juxtapositions could have resulted only from continued lateral movements. Indeed, there may be several seismic events recorded by each of these older stratigraphic offsets. Consequently, we are planning to do additional work in this area.

A proposal for a research grant that will enable us to continue our investigation of the Dogtown site during the academic year 1981-1982 has been tentatively approved. We believe this location to be the most informative locality north of Pallett Creek for establishing recurrence intervals on the San Andreas fault. At present, we have evidence that five, and perhaps more, seismic events causing significant ground rupture have occurred in this region during the last 1410 ± 100 years.

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