Paleoseismic Investigation of the San Andreas Fault Zone in Portola Valley, San Mateo County, California

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1.0 INTRODUCTION

Large historic earthquakes occurred on the San Francisco Peninsula segment of the San Andreas fault zone in 1906 and 1838 (Hall and others, 2001). A number of paleoseismic investigations on the San Francisco Peninsula indicate ground rupturing earthquake events have occurred during the Holocene on one trace of the Peninsula segment, locally known as the Woodside trace. However, prehistoric late Holocene paleoearthquakes have not been identified and dated with confidence. Based on previous investigations, the well located Woodside trace steps or bends to the right in central Portola Valley, creating a pull-a-part basin in which Holocene alluvial, fluvial and marsh deposits have accumulated.

The primary goal of this investigation is to expand and refine, to the extent possible, the late Holocene history of ground rupturing events on the Peninsula segment of the San Andreas fault zone. This investigation expands upon investigations previously conducted on property known as Spring Ridge (Wright and others, 1999), extending them further northwest and into the central portion of the pull-a-part basin on property known as the Jelich Ranch. The Jelich Ranch occupies a depositional environment more conducive for preserving a record of late Holocene earthquakes. The timing of this investigation was critical because of the pending sale in 1999 of the Jelich Ranch property for development, which would preclude further paleoseismic investigations on that property. The Jelich Ranch property was sold in late 1999, prior to award of this investigation, and is now known as the White property.

2.0 BACKGROUND INFORMATION

In central Portola Valley, the Peninsula segment of the San Andreas fault zone is interpreted as consisting of two mapped, subparallel northwest-trending fault traces, referred to as the Woodside and Trancos traces (Dickinson, 1970). As shown on the Town of Portola Valley (Town) Geologic Map, the Woodside trace is located on the southwest side of the "rift" valley and the Trancos trace is located on the northeast side, adjacent to Portola Road. The Woodside trace is the local trace of the San Andreas fault zone that ruptured the ground surface during the 1906 earthquake. The location of the 1906 surface rupture in the Portola Valley area has been documented by Tabor (1907), Lawson (1908), Dickinson (1970), and Pampeyan (1970), and more recently by Wright and others (1999). Lawson (1908) described and photographed the fault

rupture across Portola Road, about one quarter mile north of the study area and to the southeast across Alpine Road.

In the central Portola Valley area, the Trancos trace is mapped as lying subparallel to, and up to several hundred feet northeast of, the Woodside trace. The Trancos trace was originally identified by Dickinson (1970) based primarily on his interpretation of topographic and tonal lineaments on 1963 and 1968 aerial photographs. As mapped by Dickinson and shown on Town maps, the Trancos trace/lineament is continuous along the northeast side of the central Portola Valley and along the northeast side of "The Sequoias" (a retirement community) further southeast. As seen on 1941 aerial photographs prior to the development of "The Sequoias", the Trancos lineament in central Portola Valley locally consists of two subparallel topographic/tonal lineaments up to about 80 feet apart. On the White property, the traces/lineaments closely coincide with cut and fill slopes associated with historical grading activities. To the southeast, the northwest-trending Trancos lineament lies along the northeast side of central Portola Valley and ends against the more westerly striking structure of the hills underlying "The Sequoias" site. Further south, the lineament steps to the northeast into the drainage of Corte Madera Creek. There is no indication that ground rupture occurred on or in the immediate vicinity of the Trancos trace in 1906.

3.0 SCOPE OF INVESTIGATION

As previously noted, at the time the proposal for this investigation was submitted, the sale of the Jelich Ranch was pending. Prior to the award of this investigation, the property was sold and Geomatrix was awarded a proposal to conduct an Alquist-Priolo Fault Zone hazard investigation of the Woodside and Trancos traces for planned development of the property, as required by the State of California and the Town. The initial scope of work developed for the White property included five (5) trenches: Trench T-1 located across the Trancos trace on the Spring Ridge property, Trenches T-2A and T-2B located across the Trancos trace along the northern boundary of the White property, Trench T-3 located across the Woodside trace on the White property, and Trench T-4 located on the Spring Ridge property. At that time it was anticipated that proposed Trench T-4, located at the northwest margin of the Spring Ridge property would be the focus of this paleoseismic investigation, should it be awarded. The investigation for the White's proceeded with the excavation of Trench T-3. On award of this investigation, Trench T-4 was excavated next. Based on the findings of Trench T-4, Trench T-5 and subsequently Trench T-6 were excavated to follow features to the north on the White property. Trench T-1 was excavated subsequent to Trench T-5 and prior to Trench T-6. Based on the findings from Trench T-1, proposed Trenches T-2a and 2b were not excavated.

The final scope of work, therefore, consisted of:

- the excavation and logging of three backhoe trenches (T-3, T-5, and T-6) across the Woodside trace on the White property;
- the excavation and logging of one backhoe trench (T-4) across the Woodside trace on the Spring Ridge property;
- the excavation and logging of one backhoe trench (T-1) across the mapped Trancos trace on

the Spring Ridge property;

- evaluation of the trench data, including the results of radiocarbon analyses performed by Lawrence Livermore National Laboratory (LLNL) for the USGS (BAPEX); and
- preparation of a final technical report.

The trenches were logged under the direction of Todd A. Crampton (Project Geologist), with the assistance of Hans F. Abramson and Todd N. Loar (Staff Geologists), Brian Thompson (Project Geologist), and Phillip A. Frame, Consulting Geologist, all with Geomatrix.

4.0 FINDINGS

Trench T-1 is about 146 feet long up to about 13.5 feet deep. It was located on the Spring Ridge property to cross the two mapped traces/lineaments of the Trancos trace. The mapped traces/lineaments correspond on the ground to two subparallel, linear depressions. The trench exposed alluvial fan deposits consisting primarily of silt and clay with lesser amounts of sand and gravel to the depth explored. The upper approximately 1.5 feet is within the plow zone.

No evidence of faulting, significant ground deformation, or liquefaction is present in Trench T-1, nor are there any anomalous structures or features that could account for the origin of the lineaments. Two radiocarbon ages were obtained from charcoal samples from the lowest stratigraphic units (Units 1 and 2) in Trench T-1. A sample from near the top of Unit 1 at about yielded a calibrated (2 sigma) radiocarbon age of 4837 to 5441 BP, and a sample from near the bottom of Unit 2 yielded a calibrated (2 sigma) radiocarbon age of 4837 to 5258 BP.

Trench T-3 is about 284 feet long, up to about 7.5 feet deep and was located to cross the southeast projection of the Woodside trace located on the Spring Down Equestrian Center property directly north of the White property (HTA, 1991 and 1992). This projection crosses the trench at about Station 192. The trench exposed organic-rich marsh deposits (Unit 1), and fluvial deposits consisting primarily of silt to sand with local fine gravel and clean fine sand stringers (Units 2 and 3), and gravelly deposits (Unit 4). The upper approximately 1.5 feet is within the plow zone. The fluvial deposits are exposed throughout most of the trench and overly the marsh deposits northeast of about Station 195. A paleosol is developed on the top of Units 1 and 2 southwest of about Station 210. The top of the marsh deposits is planar, sharp, and dips gently to the southwest. Southwest of about Station 158, the base of the fluvial deposits overlying the marsh deposits consist of clean fine sand deposits with local fine gravel stringers up to 0.9 feet thick (Unit 2a). The upper contact is sharp and locally convex (dome-shaped) and the basal contact is sharp and planar. Similar clean fine sand deposits (Unit 3a) occur at the base of Unit 3 between about Stations 253 and 270, and the lower part of these deposits contains significant amounts of detrital charcoal.

The entire stratigraphic sequence is disrupted between Stations 243 and 252 on both walls of the trench, as most prominently displayed by the paleosol at the top of Unit 2, which steepens across this interval to form a west-facing monocline. The across-trench trend of this monocline is approximately N25W; the relief on the top of the paleosol across this interval is about 1.5 feet. Within this interval, the paleosol is pinched, warped, and locally broken, as are interbeds and

stringers within Units 2 and 3. A charcoal stringer appears to be offset about 0.3 feet (down-on-the-west) at about Station 244 on both walls of the trench. However, no discrete faults or clay-lined shears were observed in this interval. Groundwater was encountered on both sides of the disrupted zone. Projection of groundwater levels across the disrupted zone suggests that the groundwater level southwest of the disrupted zone is about 1.5 feet lower than northeast of the zone.

We interpret the zone of disrupted stratigraphy to be the result of past faulting, most likely during the 1906 event. We speculate that the clean fine sand deposits (Units 2a and 3a) overlying the marsh deposit (unit 1) may be liquefaction features (i.e., sand boils) related to pre-1906 earthquake events. A detrital charcoal sample from Unit 1 yielded a calibrated (2 sigma) radiocarbon age of 974 to 1227 BP.

Trench T-4 was excavated across the Woodside trace on the adjacent Spring Ridge property, about 100 feet northwest of Trench T3 excavated previously by Wright and others (1999). Trench T-4 was about 120 feet long and up to about 11.5 feet deep. Trench T-4 exposed alluvial fan deposits (Units 1 through 5) in the eastern part of the trench, overlain by fluvial deposits (Units 6 and 7) of the young Sausal Creek fan in the western part of the trench. The upper approximately 1.5 feet is within the plow zone. A paleosol is developed on the top of Units 3, 5 and 6. The contact between the fluvial and alluvial units is an angular unconformity. Groundwater was not encountered in the trench.

A zone of faulting is clearly present between about Stations 52 and 86 that is similar in width and character to the zone that was present in the nearby Trench T3 (Wright and others, 1999). The main zone of faulting is located between about Stations 62 and 77, and is predominantly within the alluvial deposits. Across this zone the units appear to be warped down-to-the-west, and are offset down-to-the-west across individual "shears", most of which appear to extend up to the plow zone. Across this zone the paleosol on the top of Unit 3 has an apparent total vertical offset of at least 6 feet. The main "shear" bounding this zone on the west has an across-trench strike of N38W, while the average across-trench strike of the other "shears" in this zone is N6W. Other "shears" such as those at about Stations 52 to 56, 80 and 86, appear to terminate upward before reaching the plow zone, and may represent pre-1906 ground rupturing earthquake events.

Nine (9) radiocarbon ages were obtained from detrital charcoal samples from Trench T-4. A summary of the calibrated (2 sigma) radiocarbon ages (BP) for units in Trench T-4 is presented below.

Alluvial Deposits:	Unit 1	4509 to 4242 BP
	Unit 2	4418 TO 4151 BP
	Unit 3	5467 TO 5047 BP
	Unit 4	2363 to 2747 BP (middle)
Fluvial Deposits:	Unit 6	478 to 304 BP
	Unit 7	478 to 304 BP (base)
		518 to 319 BP (middle)
		506 to 315 BP (top)

These dates are consistent with the radiocarbon age dates obtained from nearby Trench T3 (Wright and others, 1999), and the finding in that report that the modern Sausal Creek fan (Units 6 and 7) is younger than about 900 years.

Trench T-5 was excavated on the south side of the White property across the projection of the more northerly trending shears encountered in the fault zone in Trench T-4. The trench was about 140 feet long, up to about 13 feet deep, and exposed the same stratigraphic units and relationships that were present in Trench T-4. A paleosol is developed on the top of Units 1 through 6. Groundwater was at the bottom of the trench.

Between about Stations 22 and 29, the stratigraphy of Units 1 through 3 appears to be disrupted by faulting, particularly on the southwest wall. The average across-trench strike of this disrupted zone is N6W. No clay seams or similar features typical of shears are present, and it is possible that this deformed zone could be due to depositional and erosional processes, and/or deformation due to earthquake shaking. However, it is our opinion, as well as the consensus of others that studied the trench, that the units are faulted. Bounding "shears" on the southwest wall define a down-dropped block, back rotated to the east, with a maximum apparent vertical offset of about 1 foot on the top and bottom of Unit 2. No "shears" can be convincingly interpreted to offset the base of Unit 4. The "shears", if tectonic, may represent pre-1906 ground rupturing earthquakes.

Three (3) radiocarbon ages were obtained from detrital charcoal samples from Trench T-5. A summary of the calibrated (2 sigma) radiocarbon ages (BP) for units in Trench T-5 is presented below.

Alluvial Deposits:	Unit 4	2750 to 2866 BP (near base)
	Unit 5	2362 to 2744 BP (near base)
		316 to 510 BP (top)

Trench T-6 was excavated on the White property across the northward projection of the N6W-trending fault zone mapped in Trench T-5. The trench was about 83 feet long, up to about 14 feet deep, and with the exception of Unit 6, exposed the same stratigraphic units that were present in Trenches T-4 and T-5. The units in Trench T-6 are laterally continuous and dip gently to the west, and have relatively planar contacts. Groundwater was at the bottom of the trench. No evidence of faulting, significant ground deformation, or liquefaction was observed in Trench T-6. The "shears" mapped in Trench T-5 die out before reaching Trench T-6.

5.0 CONCLUSIONS

1. The N20-25W-trending, short, left-stepping, en-echelon fault zone associated with the active Woodside trace on the Spring Ridge property (Wright and others, 1999) continues northwest to the vicinity of Trench T-4. In Trench T-4, the fault zone apparently bifurcates, with a zone of (pre-1906?) faulting (Riedel Shears) continuing more northerly through Trench T-5 and dying out before reaching Trench T-6, and another zone of faulting (including 1906) projecting about N38W, toward the northwest end of Trench T-3;
2. In Trenches T-3 through T-5 there is evidence of pre-1906 earthquake events; however, the stratigraphic relationships in the trenches is incomplete or insufficiently constrained to

resolve individual events,

3. No suitable channels or other stratigraphic conditions are present for resolving individual slip events;
4. The tectonic signature of the 1906 ground rupture is muted in the section of young basin sediments exposed in Trench T-3; and
5. No evidence for the Trancos trace or associated lineaments was encountered in Trench T-1. This trace, if present at depth, is likely inactive.

6.0 REFERENCES

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