INQUA Focus Group on Paleoseismology and Active Tectonics

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The West Beverly Hills Lineament and Beverly Hills High School: An Unexpected Journey

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Abstract: *Results of geotechnical studies for the Westside Subway were disclosed in a public hearing on Oct. 19, 2011, showing new "active faults" of the Santa Monica fault and the West Beverly Hills Lineament (WBHL), identified as a northern extension of the Newport-Inglewood fault. No faults had been physically observed; the faults were all interpreted from cone penetrometer probes, supplemented by core borings and geophysics. Several of the WBHL faults traversed buildings of the Beverly Hills High School (BHHS), triggering the school district to map and characterize these faults for future planning efforts, and to quantify risk to the students in the 1920's high school building. 5 exploratory trenches were excavated within the high school property, 12 cone penetrometers were pushed, and 26-cored borings were drilled. Geologic logging of the trenches and borings and interpretation of the CPT data failed to confirm the presence of the mapped WBHL faults, instead showing a 3° NE dipping sequence of mid-Pleistocene alluvial fan deposits conformably overlying an ~1 Ma marine sand. Using ^{14}C, OSL, and soil pedology for stratigraphic dating, the BHHS site was cleared from fault rupture hazards and the WBHL was shown to be an erosional margin of Benedict Canyon, partially buttressed by 40-200 ka alluvial deposits from Benedict Wash. The consequence of the Westside Subway's active fault maps has been the unexpected expenditure of millions of dollars for emergency fault investigations at BHHS and several other private properties within a densely developed highrise urban environment. None of these studies have found any active faults where they had been interpreted, mapped, and published by the subway's consultants.*

Key words: *Fault investigation, hazard communication, ethics*

INTRODUCTION

In the 1992 AEG Annual Meeting's field trip guidebook, the West Beverly Hills Lineament (WBHL) was first identified as a geomorphic feature and placed into a structural context as a step-over between the Santa Monica and Hollywood faults (Dolan and Sieh, 1992).

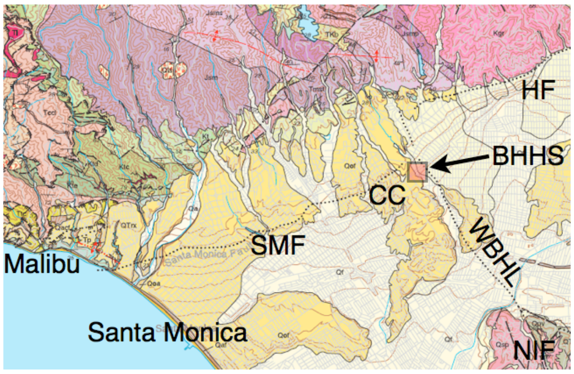

Fig. 1: Geologic map of the Beverly Hills High School (BHHS) project site, showing the predominantly Mesozoic crystalline and metamorphic rocks of the Santa Monica Mountains to the north (top) and the Quaternary alluvial fan and fluvial deposits to the south (Yerkes and Campbell, 2005). CC – Century City; HF – Hollywood fault; NIF – Newport-Inglewood fault; SMF – Santa Monica fault; WBHL – West Beverly Hills Lineament.

Subsequent tectonic modeling of the western LA basin assumed the presence of this N-S tectonic feature and built upon it (Hummon et al., 1994) and it became included on multiple maps (e.g. Yerkes and Campbell, 2005), despite objections from geologists of the Beverly Hills Oil Field, bisected by the lineament, who stated that no such structural feature was possible based on their 300+ well logs and operational history (Lang, 1994). Paleoseismic studies of the Santa Monica and Hollywood faults (Dolan et al., 2000a & 2000b) showed evidence for a Holocene event on each, but the two events could not be temporally correlated and the faults had average return periods of about 10 ka. Neither fault has been zoned active under the California Alquist-Priolo Earthquake Fault Zone Act despite the 13 years since the studies were published, and even less attention was given to the WBHL as a potential fault hazard because 1) it was secondary to low activity faults, 2) it had never been mapped at a scale usable for assessment, and 3) it had never been confirmed as a fault.

Westside Subway Extension Geologic Studies

Preliminary geologic studies were completed for the EIR of the extension of the Westside Subway from Los Angeles to Santa Monica. The Metro Board approved the EIR in Sept. 2010. Additional fault-specific investigations were authorized by the Metro Board in Oct. 2010 to better understand the neotectonic structures and fault rupture hazards of the Century City/Beverly Hills area of western Los Angeles (Fig. 1), as they related to proposed subway station locations. The results of that work were presented to the Board (PB, 2010) and simultaneously released to the public via press releases, an open Board meeting at Metro, and posted videos of the meeting onto YouTube [http://www.youtube.com/watch?v=Omx2BTIpzAk].

The active fault map (PB, 2010) was highly alarming for the community (Fig. 2). It showed two wide zones of faults, one trending generally ENE as active strands of the Santa Monica fault zone and another generally NNW as active faults of the West Beverly Hills Lineament, now also correlated to the active Newport-Inglewood fault which was previously terminated 5 km to the south in the Baldwin Hills (Fig. 1).

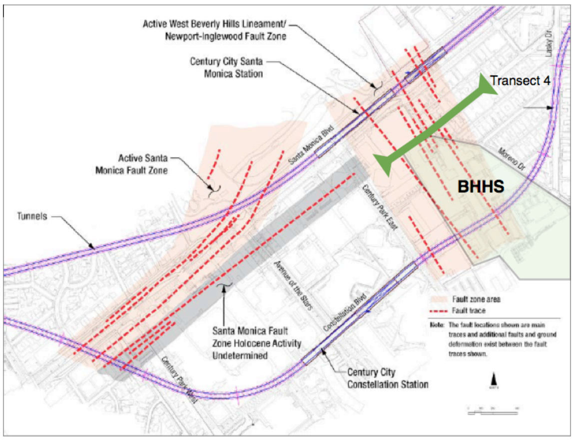

Fig. 2: The fault map released by Metro (PB, 2010) showing the two fault zones, the proposed tunnel alignments and station locations, and their relationship to Beverly Hills High School (BHHS) and Transect 4 (Fig. 3).

Because of the urban environment, the investigative tools used by the Metro consultants relied principally upon stratigraphic correlation of transects of cone penetrometer (CPT) probes generally spaced about 15 m apart, supplemented with occasional cored borings and seismic reflection geophysical profile lines. The CTP logs were compiled into interpreted sections showing the stratigraphy and the faults, generally drawn perpendicular to the transect. Transect 4 is of greatest relevance to BHHS (Fig. 3).

As mapped, almost the entire WBHL fault zone trended directly through the BHHS campus (Fig. 2), necessitating immediate concern for the safety of the students and employees within the iconic 1920s school building. Within the month, BHHS contracted Leighton Consulting Inc. (LCI) to undertake a detailed geologic investigation to locate and more accurately map the faults through the campus, and if possible, to better quantify the hazard that they posed. This paper summarizes the results of that study.

INVESTIGATION

To locate and map the faults accurately enough for campus planning, the BHHS consultants relied upon a suite of investigative tools similar to Metro's consultants (borings and CPTs) but also excavated ~270 m of exploratory trenches (Fig. 4) across available portions of the BHHS campus to precisely locate, geologically log, and kinematically quantify the fault displacements that had been mapped through the school property.

Fig. 4: One of the exploratory trenches excavated to expose and map the faults that were mapped through the BHHS, part of which is seen at the top of the photo. Each bench is about 1.3 m in height; shoring was used where space did not permit benching. No faults were found in this trench.

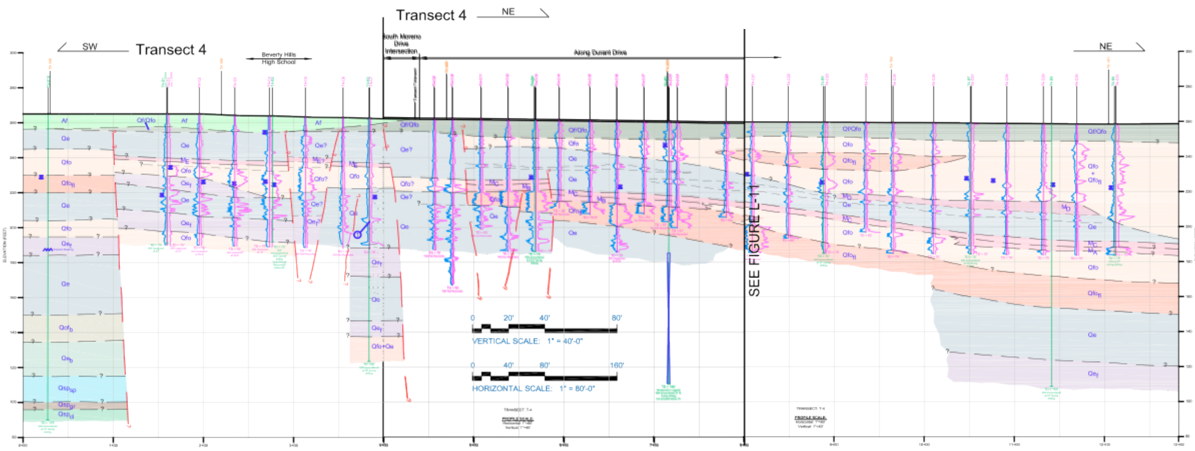

Fig. 3: The Transect 4 cross-section lying immediately north of BHHS (Fig. 2) showing the alluvial stratigraphy and the multiple faults, as originally interpreted from the cone penetrometer test probes and borings (PB, 2010).

In total, 5 trenches were excavated, 12 CPTs were pushed, and 26 borings were continuously cored along two transects. The initial borings were emplaced E-W across the center of the campus to correlate with the best location for the surface trenching (Fig. 4). Early on it was realized that the borings should extend through the alluvial fan deposits, upon which the school was built, and into an underlying ~1Ma marine unit (San Pedro Fm) because this contact was easily identified and correlated from boring to boring (Fig. 5).

Fig. 5: Borehole correlations were made across all of the borings on the two transects to look for vertical separations of key marker units that might confirm the faults shown by Metro. Here, there is excellent correlation of the underlying San Pedro contact between borings CB-3 (left) and CB-4 (right) at ~25-30 m, despite being on opposite sides of a mapped fault.

Metro's Transect 4 (Fig. 3) was completely redone using CPTs and borings in adjacent positions that were also drilled deeper to reach the San Pedro contact (Fig. 6). The alluvial fan stratigraphy was correlated using mainly the boring cores because the physical recognition of stratigraphic correlations could be observed, discussed, and agreed upon. CPT correlations suffer from cone variations, divergence from vertical, and indirect subjectivity. Within the alluvial stratigraphy, a series of buried paleosols were observed and these provided the most powerful correlations across the borings (Fig. 6).

Pedogenic development of the geomorphic surface that forms the primary school site indicated that the soils are a minimum of 80-100 ka, and could be considerably older (ECI, 2012). This surface soil, combined with the time required to form the multiple buried paleosols, showed that the alluvial fan deposits are of considerable age, a discovery that raised questions with respect to the degree of hazard posed by the mapped faults. In the Metro study, no stratigraphic age estimates were made (PB, 2010); the faults were simply assumed to be Holocene in age and thus active by definition. So in addition to locating and mapping the faults in this new study, there was now a possibility that they could be inactive. If the faults could be shown to have no Holocene-age displacements, then per the California criteria, the faults would be considered inactive, and the hazard to BHHS would be negligible. To achieve this, borings alone were not adequate, the faults needed to be exposed in trenches where their rupture age could be documented.

The primary trench was begun 8 m from the BHHS building and excavated 100 m down the eastern lawn (Fig. 4). The slope that forms this dramatic presentation to the school is the scarp-like feature that defines the WBHL. No faults were present in the trench. Continuous, mid-early Pleistocene alluvial fan stratigraphy lay unbroken along the entire trench until erosionally removed by incision of Benedict Canyon wash on the eastern margin (Fig. 7). The fan deposits dip 3° NE, exactly as were correlated in the boring transects (Fig. 6), and daylight out the slope face, demonstrating that the genesis of the slope is erosional and not structural. The incision of Benedict Creek would have isolated the upper geomorphic surface, allowing the surface soil to form. Based on that pedogenic profile (ECI, 2010) this occurred 100+ ka. Subsequent alluvial fill buttressed the lower 15 m of the slope (Fig. 7). Buried paleosols within the Benedict Canyon alluvium provide a minimum pedogenic age of ~40 ka for the uppermost 5 m, and a similar OSL age of ~25 ka (ECI, 2010; LCI 2010). No fault offsets were present within the Benedict Canyon alluvium.

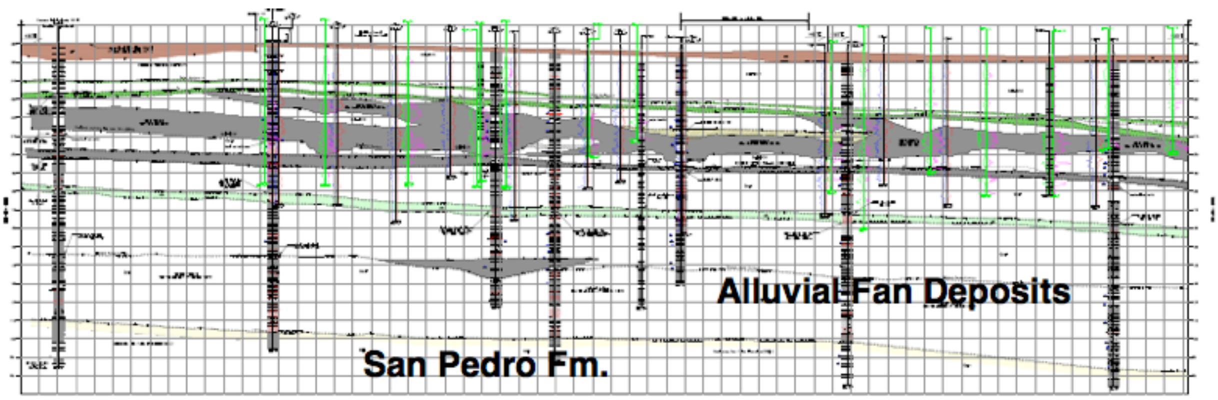

Fig. 6: The cross-section from Fig. 3 as revised by the new cone penetrometers and borings. The green highlighted layers are paleosols that have been correlated across the section, effectively eliminating the necessity for fault offset anywhere in the section. The base of the section is the ~1 Ma San Pedro marine sand (LCI, 2011).

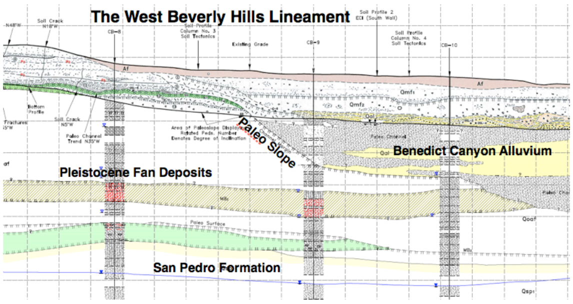

Fig. 7: Trench log (from Fig. 4) and extended cross section showing the alluvial unconformity that explains the origin the West Beverly Hills Lineament as an erosional channel margin that has been partially backfilled by undeformed 30-200+ ka Benedict Creek sediments.

The only N-S fault observed was in one of the shorter trenches where two fault-like features, 3 m apart, were observed to vertically displace an alluvial layer by 10 cm, with an unknown, but minor, lateral slip component. This fault was vertically truncated by an overlying cobble deposit and all subsequent strata. The depth of the event horizon was 2-3 m beneath the >80-100 ka surface soil, and with other intervening paleosols adding to the age, it is reliably concluded that this fault's single displacement event occurred at least 300 ka. Although unproven, it is more likely that this minor feature was not a tectonic fault, but the geologic evidence for a >300 ka seismic event (a seismite) that generated a liquefaction failure within the alluvial channel deposits.

DISCUSSION

The lack of faults was unanticipated. While it had been hoped that the faults could be demonstrated to be inactive, there was no expectation that faults would not be present. Faults had been interpreted from considerable data, subjected to expert analysis, had been through a Metro peer review process, and yet they were not there. However, this should be a lesson to all that geologic interpretation is still an interpretation and is not, in fact, a fact. The presence of faults was anticipated, so it was easy to interpret even minor, stratigraphic irregularities as faults. When a fault was interpreted it was drawn essentially perpendicular to the transect line, despite no trend information from the 2-D transect. The faults were labelled as "active faults" because of the paradigm within which they were modelled, despite having no age control on the sediments that were interpreted as offset. In addition, they were drawn long distances from the transect from which they were interpreted (Fig. 2) and as such they impacted numerous high-value properties.

The result of the Metro fault report, and the manner of its very public release, has led to the unexpected, and unwelcome, expenditure of millions of dollars by the BHHS, and millions more by other affected property owners. The City of Los Angeles cancelled previously approved development and redevelopment plans until the owners could address this new fault concern, leading to the loss of millions in cancelled contracts and business delays. Homeowners and building owners in Beverly Hills and Century City were shocked to learn their property was bisected by an active fault, and concerned that their real estate values would plummet as a result. And, Metro used the findings of their fault report to change an already approved subway alignment to avoid placing stations within the new active fault zones, and instead directed the subway directly under BHHS, a change that generated a firestorm of protest.

The finding by BHHS that the faults mapped through the school do not exist came as a pleasant surprise to the school's Board and community leaders. Similar findings by other affected property owners and developers are still coming in, but to date, none of them have found active faults through their properties as interpreted and mapped (Fig. 2). This consistent refuting of the active fault map is alarming. That such a critical map could be released to the public without any concrete evidence of a fault's existence or activity is inconsistent with good professional practice. It is the equivalent of shouting "Fire" in a crowded theatre. That is illegal. What is probable in this case is that years of litigation can be anticipated over the unexpected and apparently unnecessary expenditure of tens of millions of geologic (and legal) dollars by BHHS and the other affected owners.

Acknowledgements: The project summarized in this paper was made possible by Tim Buresh and the Beverly Hills Unified School District, with the participation of many other geologists and professionals. The thorough project review by J. Treiman and B. Olson of the Calif. Geological Survey is acknowledged.

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