Leighton Consulting, Inc.
A LEIGHTON GROUP COMPANY

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Project No. 603314-008

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Attention: Mr. Kevin H. Brogan, Partner

Subject: Addendum to Second Response to California Geological Survey Review Comments Fault Rupture Hazard Review Beverly Hills High School 241 South Moreno Drive Beverly Hills, California CGS Application No. 03-CGS0960

In accordance with your authorization, Leighton Consulting, Inc. (Leighton) has prepared this addendum to our second response dated December 28, 2012 to the California Geological Survey's review of our April 2012 report which summarized our fault hazard assessment of the West Beverly Hills Lineament in the campus of the Beverly Hills High School located in western Beverly Hills, California. The California Geological Survey has requested additional information with respect to our second response report. For the ease of reference, the requested information provided in email format to Leighton is reiterated below followed by Leighton's responses.

COMMENT AND RESPONSE:

California Geological Survey Comment: Do I have your permission to contact Bob Graham to review the references he provides in support of the "tens of thousands of years" age for the clay films. I didn't see how the data and conclusion from these papers applied to the findings at the school site. I wanted to review my understanding of the papers with him and have him make sure I am correctly interpreting the data and conclusions.

Leighton Response: Dr. Robert Graham's response is included.

California Geological Survey Comment: In our first letter we noted the fractures in FT-4 showed offset and should be addressed. No discussion of FT-4 was provided in the most recent report, so if you could provide us with an explanation of these features, taking into account that this slope (before fill placement) likely had a different orientation than the slope to the north at FT-2.

Leighton Response: During logging of Trench FT-4 we documented several clay filled fractures between Stations 0+58 to 0+68 (Plate 6, Leighton 2012a). The fractures between Stations 0+62 and 0+68 were traced upwards from the bottom of the trench and the fractures at Station 0+62.5 and 0+65 showed apparent vertical offset of up to 1.25 inches, east side up, of a gravel bed near their upper end. While these fractures showed offset of the gravel bed, they were observed to not extend to the upper surface of Unit No. 6, did not offset the base of Unit No. 3 above and did not offset the top of Unit No. 8 lower in the trench (Plate 6, Leighton, 2012a). Prior to creation of the current fill topography (N35°W) the original slope in FT-4 was oriented approximately N40°E (Hoots, 1931). We were unable to assign a strike to the fractures observed in Trench FT-4 as they were observed to be discontinuous to the southern wall. Since we have only observed these types of fractures with east side up apparent displacement in close proximity to previously existing slopes, such as in Trench FT-2, we stand by our statement that these fractures are near-surface phenomena caused from outward dilation and downslope rotation of the east side of the fracture during seismic shaking from one of the regional faults in the area

Based upon the lithologic characteristics of Unit No. 4, described in Trench FT-3 (Plate 5, Leighton 2012a) we feel that Unit No. 4 in Trench FT-3 correlates well to Unit No. 4 in Trench FT-4, which, based upon the minimum ages assigned to Unit No. 4 of Trench FT-3 begets a minimum age of Unit No. 4 in Trench FT-4 to be much greater than 100kya. The fractures do not extend to the top of Unit 6, are lower statigraphically and thus older than Unit No. 4. The fractures in Trench FT-4 do not offset the top of Unit No. 6 nor the base of Unit No. 3. The features are not Holocene age faults nor even related to Holocene deformation.

California Geological Survey Comment: Cross section C-C' shows 2 major fault splays (one between CB-23/CB-26 and one between CB-23/CB-24). Only the southernmost fault splay is addressed while the northern fault splay (which has more stratigraphic throw in the Qsp than the southern one) is not addressed at all. It appears the northern fault zone affects the same units (2 and 3) and appears to deform Unit 1. Please address this fault.

Leighton Response: The northern fault, between boring CB-23 and CB-24 offsets the upper San Pedro Formation (Qsp1) by approximately 46 feet north side down, whereas between borings CB-26 and CB-23 the Qsp1 is offset approximately 33 feet north side down with some undeterminable lateral offset (Plate 4, Leighton 2012c). Several fractures within Units No. 2 and 3 were observed on the east and west walls of Trench FT-5 and due to the randomness of the measurable orientations we postulated their existence to branching of the northern fault strand due to near surface shatter. These fractures displayed measurable strikes ranging from N25°E to N67°E with variable dips ranging from 21° to 70°north and 70°south. No offset across the fractures was observed in the northern portion of Trench FT-5. Unit 1 has an OSL age of ~60 kya, and a similar soil stratigraphic age. The interpretation that fits the data the best is that the faults that underlie FT-5 were most active during the time of deposition of the Cheviot Hills Formation (Kenny, 2012) and ended about the time that deposition ended. It is clear that the last events predated or were coincident with the abandonment of the paleo-Benedict Canyon wash through this area, and likely controlled its location. By the time of the easterly bypass incision of this now wind gap to form the present Moreno surface (dated in T-2 as 40-80 ka), and before the development of the soils that now cap the wind gap, this fault system was abandoned.

Based upon the lack of observable offset of Unit No. 1, which has been assigned an OSL date of approximately 60kya, the fractures, should they be considered faults, are clearly not active per the State's current definition.

We appreciate the opportunity to be of service to Hill, Farrer & Burrill, LLP, and the Beverly Hills Unified School District. If you have any questions, please contact the undersigned directly at the e-mail addresses and phone numbers listed below, or at 866-LEIGHTON.

Respectfully submitted,

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Attachments: References
2013-2-19 RC Graham Response

Distribution: (6) Addressee
(1) California Geological Survey

REFERENCES

Hoots, H.W., 1931, Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles, County, California: USGS Professional paper 165-C.

Kenney Geo Science, 2012, Geomorphic Structural and Stratigraphic Evaluation of the Eastern Santa Monica Fault Zone and West Beverly Hills Lineament, Century City/Cheviot Hills, California, report date July 18, 2012

Leighton Consulting, Inc., 2012a, Fault Hazard Assessment of the West Beverly Hills Lineament, Beverly Hills High School, 241 South Moreno Drive, Beverly Hills, California, Project No. 603314-002, dated April 22, 2012.

_____2012b, Initial Response to California Geological Survey Review Comments Fault Rupture Hazard Review, Beverly Hills High School 241 South Moreno Drive, Beverly Hills, California CGS Application No. 03-CGS0960, Project No. 603314-007, dated June 8, 2012.

_____ 2012c, Second Response to California Geological Survey Review Comments Fault Rupture Hazard Review Beverly Hills High School 241 South Moreno Drive Beverly Hills, California CGS Application No. 03-CGS0960, Project No. 603314-008, dated December 28, 2012.

R.C. Graham, 2/19/13
Response to Questions from Brian Olson, CGS.

McFadden and Weldon, 1987

1. There is no direct reference to a correlation between thickness of illuvial argillans and age mentioned in the paper. The closest correlation I found was the following sentence in the section on Soil Development in Pleistocene Terraces: "A significant amount of the clay in the argillic horizon is illuvial, occurring as coatings which thicken increasingly with time on the grains or peds, as pore-filling material, or as bridges." Is this the portion of the paper to which you were referring?

The data for clay films (= illuviation argillans) are presented in Supplementary Data Table A (see bottom of page 284 of McFadden and Weldon, 1987) and were referenced to the ages of the soils as presented in the paper itself.

2. Do the findings of this study apply to illuviation along a plane of weakness (i.e. fault plane), which is much more permeable than the surrounding soil? It seems the study involved observing illuviated clay in massive sedimentary deposits.

The soil chronosequences referenced in the report (and here) were all developed in alluvium. During the course of soil development, parent material sediments develop cracks due to minor shrink-swell caused by drying and wetting. These cracks define the boundaries of structural units (peds). Water, with clay in suspension, flows down those cracks during heavy rainfall, depositing clay. Similar flow and deposition occurs in abandoned root channels (tubular pores). These clay films are noted in soil descriptions. The point being that, even in unfaulted soils, there are pathways of preferential water movement/clay illuviation -- the morphologic results of which are recorded in soil descriptions and used for evaluating soil age.

It should be noted that the fault features sampled in FT-5 were not discrete cracks, but sediment in zones over the scale of several centimeters. So, the clay films noted in the thin sections were not deposited in fault cracks that would provide a direct, continuous pathway for water flow.

3. McFadden and Weldon studied soils which developed in Cajon Pass over the last 500ka. Presumably the climate of Beverly Hills and Cajon Pass have differed from each other over that time period. Does that have any effect on the conclusions?

Soil chronosequences are most applicable for making interpretations of soils with similar environmental factors (climate, biota, topography, parent material). Exact matches are almost never made, but interpretations are made using the best approximations available. Currently, the Cajon Pass chronosequence area receives about 630 to 730 mm of precipitation annually, compared to the Beverly Hills area with about 440 mm. A higher mean annual precipitation should make for faster development of translocated clay (clay films), so the age estimates based on Cajon Pass soils are conservative. A Ventura chronosequence (see below)

receives about 400 to 500 mm per year. Climatic variation over the last few tens of thousands of years is likely relatively consistent among these sites since they are in the same region.

Graham and Kendrick, 2004

1. There is no direct reference to a correlation between thickness of illuvial argillans and age mentioned in the paper. The closest correlation I found was the notation of "Clay Films" in Table 1. The 11.5ka soil has common thin colloidal stains, whereas the remaining Pleistocene soils have thicker films that are bridging grains or filling pores. Is this the portion of the paper to which you were referring? Does the "Clay Films" category in Table 1 correlate to the "illuvial argillans" discussed in the Micromorphology section of the Beverly Hills report?

Yes, those are the data that I used from that paper. Clay films in this usage are the same as illuviation argillans. The latter term is more often used in soil micromorphology, while the former is more commonly used in field descriptions.

2. The youngest soil in this study is 11.5ka (Holocene/Pleistocene boundary). Does the absence of "Moderately thick to thick (~0.1 to 0.3 mm) illuviation argillans" in one studied soil warrant the conclusion of "tens of thousands of years to form"?

Between the McFadden and Weldon (1987) and Kendrick and Graham (2004) papers there are six pedons in the 11.5 to 12.4 ka range that have clay films no greater than "thin". Moderately thick or thick clay films are not present in those soils, but are present in 47 to 55 ka soils.

Further evidence that moderately thick to thick clay films in the Beverly Hills area take on the order of tens of thousands of years to form is found in soil chronosequences in the Ventura area (Rockwell et al., 1985), shown in the table below. As noted previously, the mean annual precipitation of the two sites is similar.

Soil Age (ka)	Site ID	Clay films	Source
2	V1, V6	None	Harden et al., 1986
40	V4, V5	2mk	Harden et al., 1986
0.5 – 5	Orcutt 0	None	Rockwell, 1982
8 – 12	Orcutt 1	1-2n	Rockwell, 1982
15-20	Honor Farm	2-3mk	Rockwell, 1982
15 – 20	Shell 2	3n-mk	Rockwell, 1982
25 – 30	Orcutt 2	3mk	Rockwell, 1982
30	Bankamericard	3mk-k	Rockwell, 1982
38	Oak View	3k	Rockwell, 1982

In this case, clay films do not achieve moderately thick status until the soil is at least >10,000 years old, and thick clay films are not found until soils are 30,000 years old.

In summary, based on the best available evidence from chronosequences bracketing the climate and geographic location of Beverly Hills, moderately thick clay films take more than 10,000 years to form and thick clay films are not found in soils younger than 30,000 years.

Additional references

Harden, J.W., A.M. Sarna-Wojcicki, and G.R. Demroff. 1986. Soils developed on coastal and fluvial terraces near Ventura, California. U.S. Geological Survey Bulletin 1590-B, US Gov. Print. Office, Washington, DC.

Rockwell, T.K. 1982. Soil chronology, geology, and neotectonics of the north central Ventura Basin, California. Ph.D. dissertation, University of California, Santa Barbara.

Rockwell, T.K., D.L. Johnson, E.A. Keller, and G.R. Dembroff. 1985. A late Pleistocene-Holocene soil chronosequence in the Ventura basin, southern California, USA. p. 309-327. *In* K.S. Richards et al. (eds), Geomorphology and Soils. G. Allen and Unwin, London.