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Vegetation Lineaments Near Pearblossom, CA:
Possible Indicators of Secondary Faulting Subparallel to the San Andreas Fault

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Abstract

A cluster of twenty-four vegetation lineaments on Holcomb Ridge near Pearblossom, California were identified on Google Earth imagery. They ranged in length from 0.21 to 2.29 km (mean 0.8 km). The cluster is roughly 13 km long by 2 km wide, and is approximately 3 km north of the San Andreas Fault (SAF). The cluster and the VLs are subparallel to the SAF. None of the lineaments coincide with faults in the USGS and CGS databases, although one falls along a suspected or concealed fault identified by Dibblee. Seismicity (1932-2011) in the cluster is uncorrelated with the veg lines. Several lineaments are crossed by the California aqueduct. A few are coincident with elongated metamorphic units mapped by Dibblee as Precambrian marble pendants, dolomite and mica schist. Field reconnaissance revealed a number of low scarps and offset channels on several of the veg lines. These veg lines presumably trace out relatively shallow, long-lasting moisture sources, though where they correlate with marble, soil chemistry or Jointing may also play a role. If these veg lines mark the surface traces of faults, they may indicate the presence of a heretofore unrecognized region of localized lithospheric fracture associated with forebergs of the SAF. Work is underway to determine whether they are active faults.

1. Introduction

Vegetation lineaments (VLs) often mark the surface traces of faults, especially in the desert (Rymer et al. 2002; Treiman et al. 2012). Gouge and different rocks across the fault plane act as aquatards to inhibit subsurface water flow. Water accumulates uphill of the fault and rises to or near the surface. With moist soil closer to the surface, plants grow more readily, producing VLs. VLs may be either discrete strips of enhanced vegetation or relatively abrupt ~linear boundaries to ground cover (Lynch 2005; 2007; 2012). VLs can also be produced in a number of ways that are unrelated to faulting. For example, VLs are found in valleys along streams and at boundaries in rocks such as dikes cutting granitic rocks.

While VLs are most evident on major faults, any fault in a vadose zone of fractured material reaching to the water table can also produce them, including secondary faulting of a plate boundary and forebergs. A foreberg is a narrow ridge of tectonically-produced hills rising up to 100 m above the surrounding alluvial fans. They are usually subparallel to the major controlling faults and often are associated with positive flower structures generated by uplift and deformation (Bayarsayhan et al. 1996; Bayasgalen et al. 1999).

The main topographic feature in the area is Holcomb Ridge, a NW trending spine of late Cretaceous granodiorite with embedded linear metamorphic units (Dibblee 2002; Morton and Miller 2006). It is bounded on the south by the San Andreas Fault and to the north by the Cajon Valley Fault (Kenney 1999). Though most prominent east of Big Rock Creek, Holcomb Ridge appears to have lower elevation extensions reaching as far west as Pearblossom. The area is part of a regional restraining bend in the SAF (Hill and Dibblee 1953). The SAF strikes N63W while the relative direction between the Pacific and North American Plates is 315°, a difference of 18° from the SAF's strike. Weldon (1986), Weldon et al. (1993), Kenney (1999) and Kenney and Weldon (2004) discuss the late Quaternary deformation of rocks and dynamics of this area. Holcomb Ridge would appear to be a foreberg, because it is an elongated, perhaps anticlinal structure that is subparallel to the SAF.

In this paper we describe some newly recognized VLs and possible foreberg-style faulting north of the SAF on the north slopes of Holcomb Ridge near Pearblossom, California in Los Angeles County. Several of them are crossed by the California aqueduct. Preliminary field investigations show evidence for faulting along the VLs.

2. Aerial Imaging and Spatial Setting

While surveying secondary fault structures along the SAF on Google Earth, we came across a cluster of ~ 24 VLs (Figures 1 - 3 & Appendix 1), 23 of which are draped over the northern flank of Holcomb Ridge and its northwesterly extension of low hills. Searches for 50 km north and south along the SAF revealed no similar structures. The VL cluster is subparallel to the SAF, and ~3 km north of it. It is roughly 13 km long by 2 km wide. The bearing of the cluster's long axis is ~297° (N63W), the same as the SAF's strike of N63W in this area. Excluding VL14 that bears NE, the VLs mean headings averaged 304° ± 11° (1σ), or N56W, consistent with the SAF's strike. VLs ranged in length from 0.21 to 2.29 km (mean 0.8 km). None of the VLs coincide with faults in the USGS and CGS databases, although VL15 clearly falls along a suspected or concealed fault identified by Dibblee (2002). The VLs fall in the Valyermo and Juniper Hills 7.5' quadrangles. VL1, VL2, VL5 & VL17 are crossed by the Pearblossom discharge line (an underground section of the California Aqueduct) and were associated with faulting by the California Department of Water Resources in documents in the 1960's and 1970s (Dow 1967; 1969).

According to the California State Water Project report (1974), "*During excavation of the discharge lines, a number of vertical to steeply dipping faults and shears were exposed, varying from 12 inches to 25 feet in width. The fault system within this area crosses the discharge lines roughly subparallel to the San Andreas fault zone. Although numerous faults are present in the foundation rock of the plant and discharge lines, they are not considered active, but a major quake along the San Andreas zone could cause some movement.*" Trench excavation logs noted a number of shear zones and gouge planes. In these reports, VLs in the vicinity were identified as marking fault traces on aerial photos. Even today, VL2 is apparent where it crosses the disturbed soil of the aqueduct south of the Pearblossom pumping plant (Figure 3).

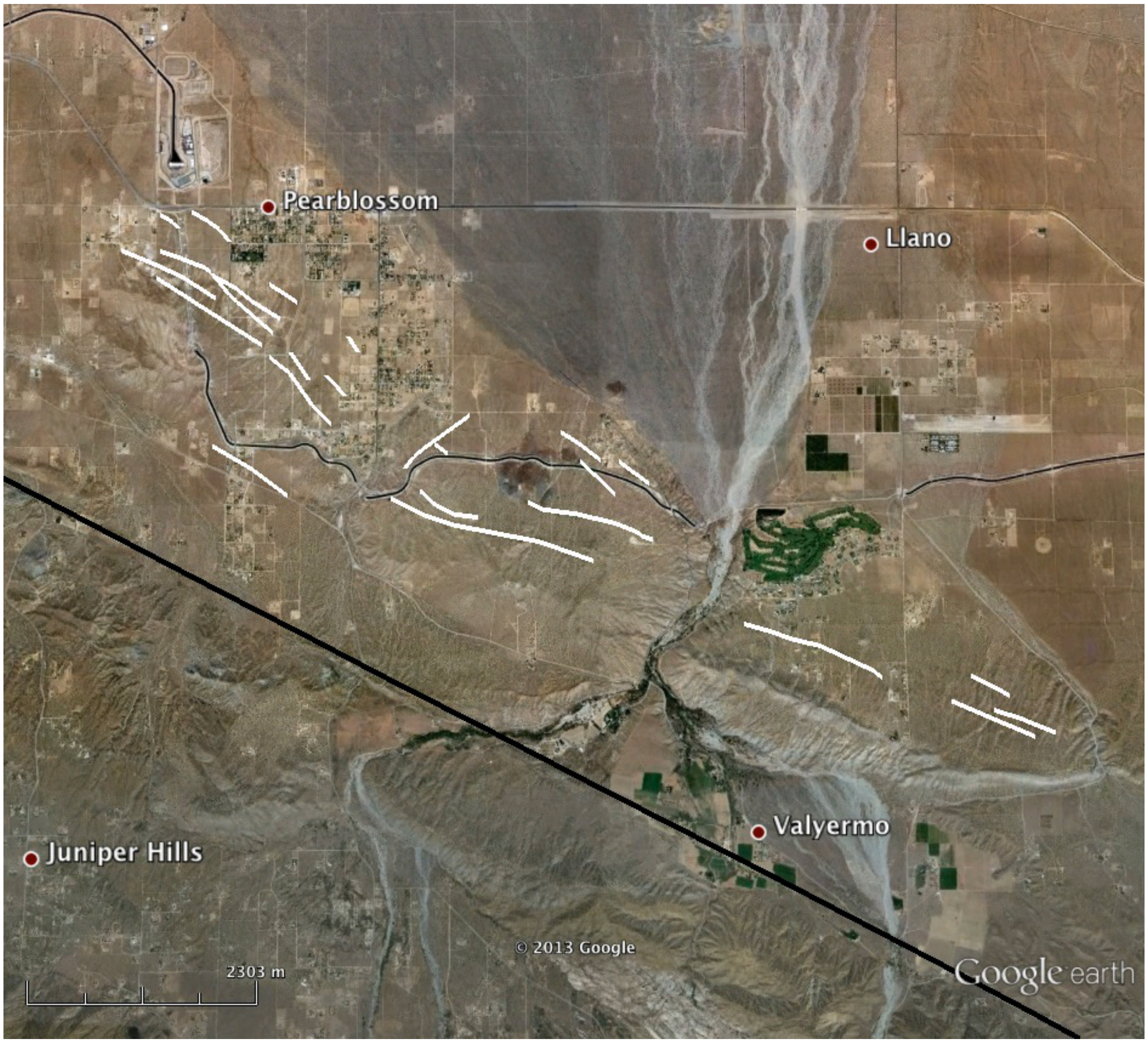

Figure 1. Pearblossom Vegetation Lineaments (white lines) marked on Google Earth imagery. The thick black line is the main trace of the San Andreas Fault. VLs mentioned in the text are labeled (see Appendix I for full list). Holcomb Ridge trends parallel to the San Andreas Fault and is dissected by Big Rock Creek. Image is 13 km wide.

Figure 2. Google Earth image of vegetation lineament VL11 in Crystalaire, CA between Valyermo Rd and 165th St. E

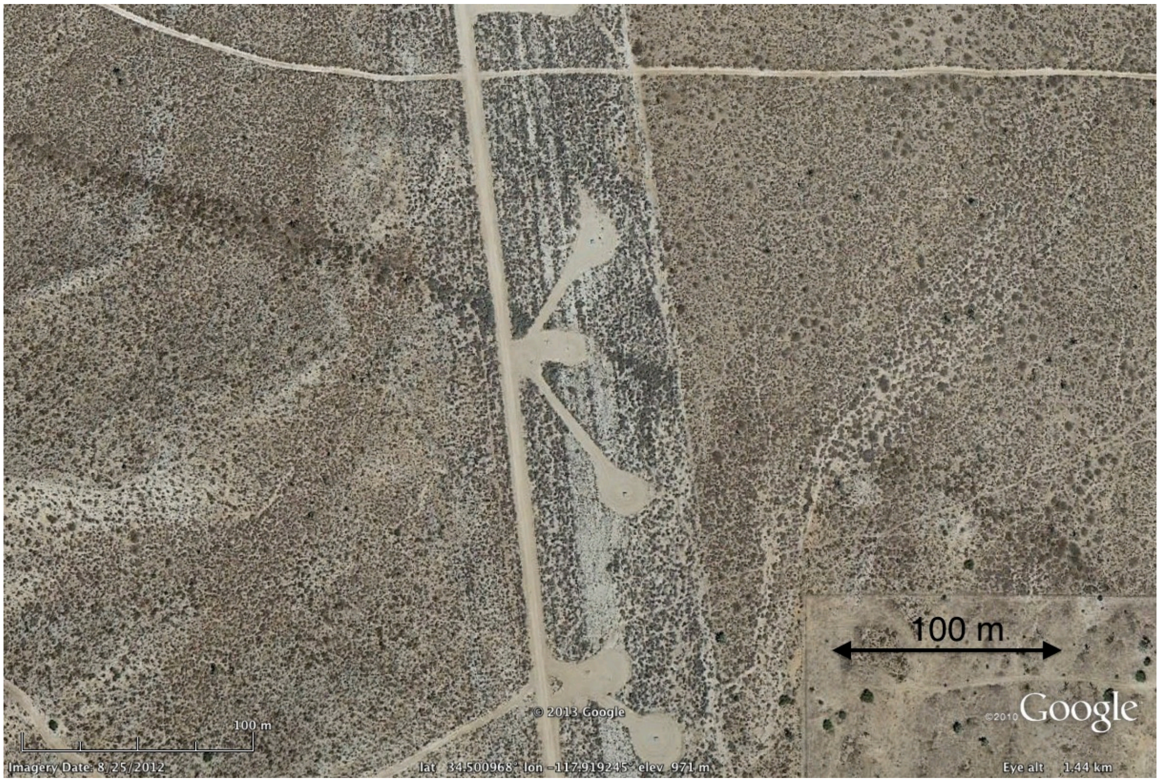

Figure 3 Google Earth image of an underground section of the California Aqueduct crossing VL2. The ground was scraped clean during construction and VL2 has reestablished itself in the disturbed soil. At the left are twin chevron-shaped outcrops uphill (toward the bottom of the picture) of VL2. Field investigations found them to be fine-grained granitic rock. The apices of the chevrons are parallel to the VL. The northern terminations of the outcrops coincide with the VL. North of the VL, no outcrops are present, and only eroded and deposited grus is found.

Many of the VLs occur in thin patches of Holocene sediments overlying sparsely exposed medium to fine grained massive Mesozoic quartz-monzonite/granodiorite. Several VLs (9,10,18 & 21) are precisely coincident with elongated metamorphic units mapped by Dibblee (2002) as Paleozoic limestone or dolomite marble pendants and mica schist. Morton and Miller (2006) map the country rock as monzonite and the linear metamorphic units as Paleozoic marble. Based on recent earthquake relocations for 1932-2011, the VLs did not appear to be correlated with seismicity.

When elevation profiles on Google Earth are examined, many but not all of the VLs are associated with subtle topographical structures, often slope breaks or small scarps. These findings were confirmed in the field. We note, however, that scarps, like VLs, can be caused by faults and by underlying rock, for instance by differential erosion of contrasting rock types. They can also be caused by groundwater sapping.

3. Field Investigations

Several field surveys were conducted in 2012 and 2013 to search for evidence of stream offsets, topographical features and evidence of recent activity. Real-time GPS and imagery available on a smart phone verified the locations of the VLs. It was not always possible to easily recognize the VLs *in situ* because visibility was impeded by the larger plants. Additionally, the edges of the lineaments are not sharply defined.

The VLs' contrast is due entirely to denser plant growth and larger plants, not to localized soil color differences. This was evident, especially where dirt roads crossed the VLs and no color contrast was seen. While tall trees (2-4 m height) like California Juniper (*Juniperus californica*) and Joshua (*Yucca brevifolia*) were prominent, most of the plants defining the VL's consisted of low shrubs and grass. The plants were generally much darker than the surrounding light colored tan and gray soil.

Many - but not all - VLs were found to be coincident with subtle topographical structures like scarps and ridges, usually rounded and with low relief. In some cases, the topography may have been controlled by differential weathering of bed rocks rather than tectonic movement. This was observed near some metamorphic bodies, e.g. VL10.

While all the VLs were visited, detailed surveys were only done on VL2 and VL11. Both were clearly evident on aerial photos and were mostly on natural, undisturbed terrain. VL2 was of particular interest because it was crossed by the aqueduct and was visible as a continuous VL on either side (Figure 3). VL9, VL10, VL21, VL18 and VL23 also appear to be crossed by or intersect the aqueduct at other locations.

VL2: Unlike many of the VLs, VL2 was clearly visible in the field (Figure 4). A number of fine-grained aplite-like outcrops trending down hill terminated at the VL, below which was only finer grained grus from weathered monzonite. Where the VLs are roughly perpendicular to the direction of channel flow, a few offset channels were found, usually but not always right lateral (Figure 5). Additionally, several topographic features were found parallel to VL2, most notable being two chevron-shaped outcrops whose apices were parallel to the VL and whose northern ends terminated on the VL (left hand side of Figure 3).

VL11: This lineament was in much denser vegetation than in the vicinity of VL2 and visibility was limited by the large number of tall Juniper trees. While there was some evidence of right lateral offset channels, no systematic conclusions could be drawn. VL11 coincides with a linear metamorphic unit (VL2 did not) and scattered cobbles of marble were found that confirmed previous geologic mapping. VL11 obliquely crosses W Ave Y-8 but no soil color variations were found in the dirt road. The lineament arguably splits into two strands. The main (south) strand occurs on a small slope break and the north strand coincides with an eroded scarp about 3 meters high (Figure 6). VL9 and VL11 together were mapped as a possible single fault by Morton and Miller (2006).

Figure 4. Vegetation lineament VL2 running horizontally across the image, view looking SSW. Top: wide angle view, aqueduct just off the left side of the picture. Bottom: Enlarged view.

Figure 5. Right lateral jog in channel wall immediately downhill from VL2. Displacement ~2 m.

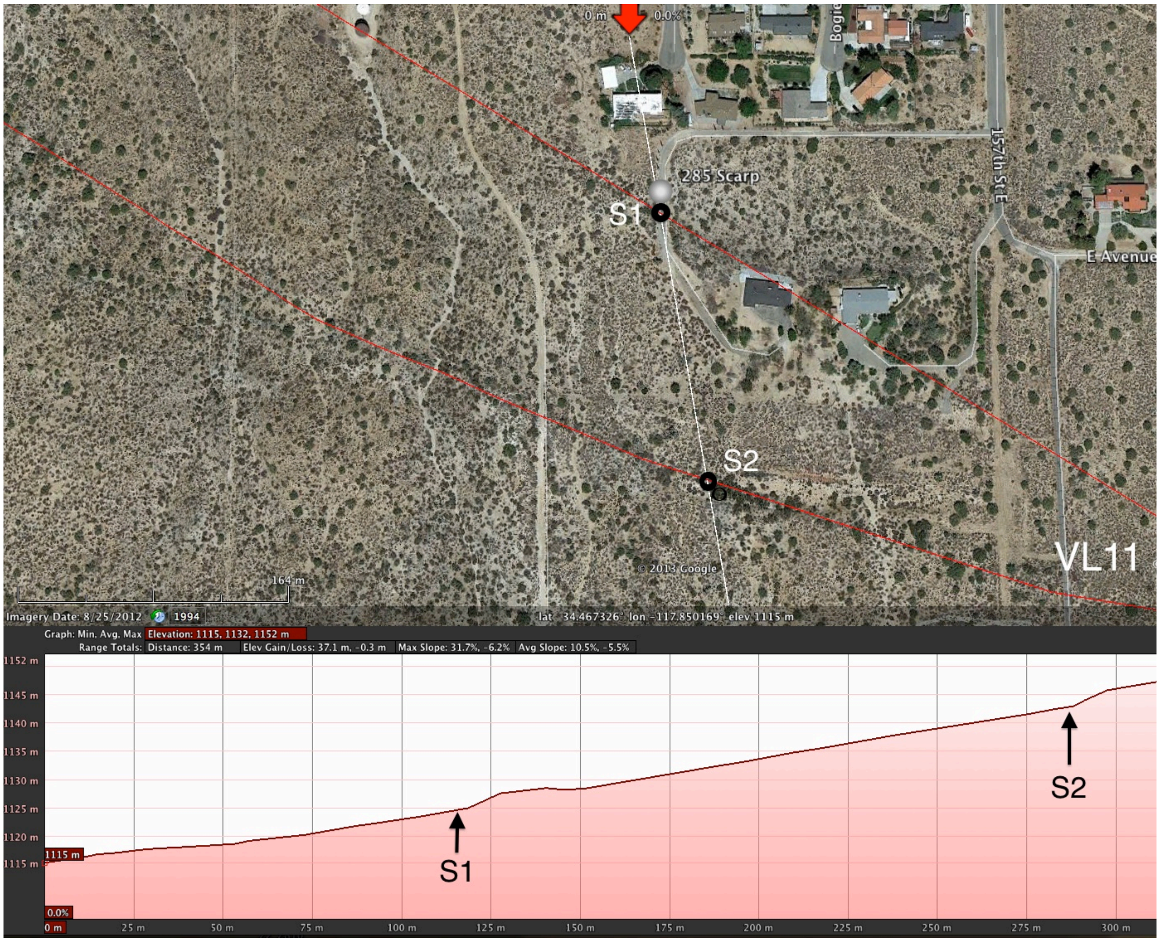

Figure 6. Elevation profile across two segments of VL11. Scarp S1 is very prominent in the field, and was a persistent feature upslope that may be part of a pressure ridge. Scarp S2 is evident but subtle. Both occur on the down hill side of the VL, which is typical of topographic structures coinciding with the VLs. Imagery and elevation data from Google Earth.

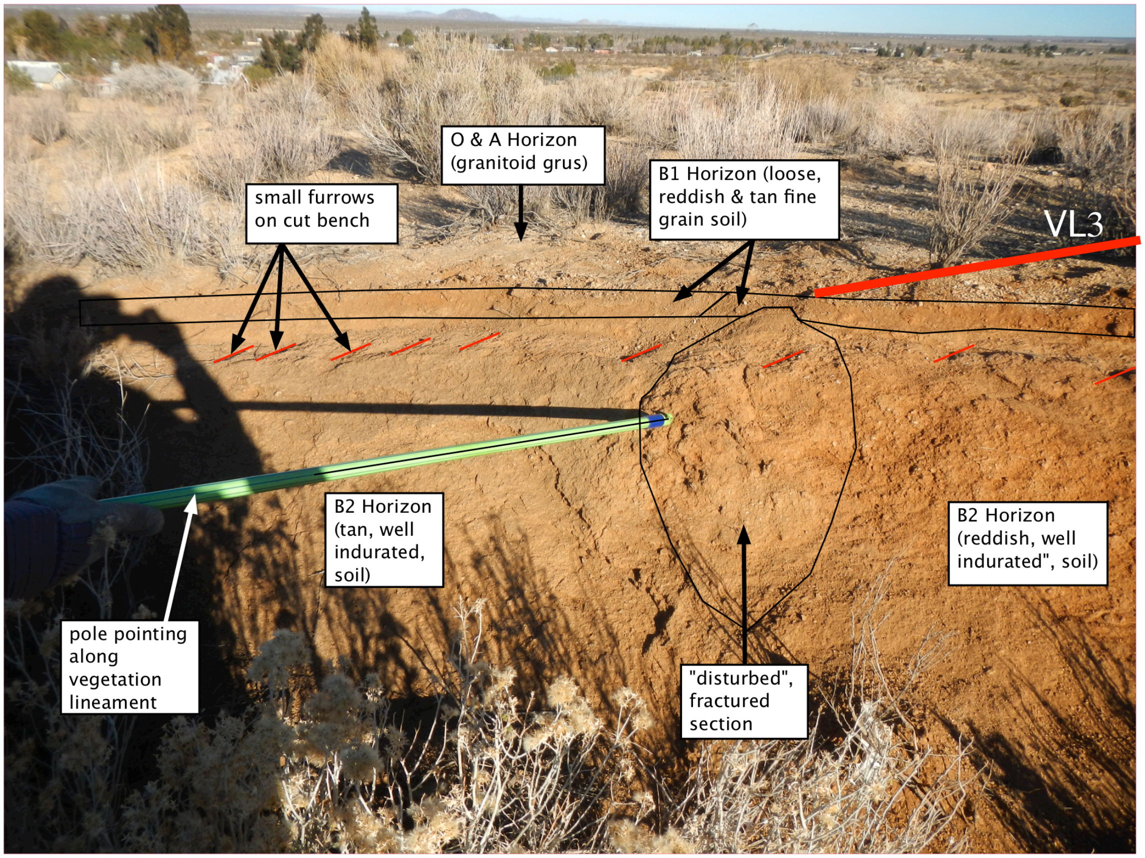

Figure 7. Exploratory trench across VL3 that revealed contrasting soils across the center of the VL, and an array of small furrows parallel to the VL. The thick, dark ~horizontal line is the shadow of a broom handle.

VL3: Based on bioturbation and exploratory trenching where VL3 crosses 121st Street E and road construction exposes a ~1 meter high cut, we found what appeared to be thin O and A soil horizons (few mm) consisting of light colored, tan granitoid Holocene grus. Below the grus was a few cm of reddish unconsolidated Pleistocene B-horizon soil that overlaid well indurated brown B horizon soil. The cleaned road cut at VL3 showed possible evidence of strike slip motion (Figure 7). On either side of a "disturbed" zone that appeared to be centered on the lineament, there were distinct soil color differences with approximate Munsell hues of 10YR northeast of the disturbed zone juxtaposed against hues of 7.5YR southwest of the zone. Additionally, a number of low furrows in a bench cut were roughly parallel to the lineament, perhaps indicating joints or fractures in the well indurated soil.

4. Discussion

In view of their clustering and common trend subparallel to the SAF, we believe these VLs are related and probably have a common origin, perhaps tectonic. These VLs presumably trace out relatively shallow and persistent moisture sources, though where they correlate with marble, soil chemistry or interface fracturing may encourage plant growth.

The actual number of VLs is subject to interpretation. Several of the VL's appear to line up and may represent through-going features. For example, VLs 10, 11 and 13 may be a single structure. The same is true of VL9 and VL19, and perhaps VL5 and VL22. Weaker VLs were also present but not cataloged here.

A number of faint VLs are found to the east in an adjacent area bounded roughly by Bob's Gap Rd, Pearblossom Hwy, 263rd St E and Holcomb Ridge Rd. These VLs rather suspiciously run more or less E-W and some are coincident with dirt roads. We have not included these VLs in this study, as they appear to be fundamentally different from the Pearblossom VLs.

5. Summary and Conclusions

We have described a cluster of vegetation lineaments (VLs) on Holcomb Ridge that are subparallel to the San Andreas Fault. These VLs may mark the surface traces of a number of secondary faults on forebergs, or alternatively, may mark rock boundaries that control near-surface water persistence. Most occur on or near slope breaks and some coincide with previously mapped linear metamorphic units of marble and schist. There is some indication of right lateral offset channels but no clear picture has yet emerged as to direction of motion, if any. An exploratory trench across one VL showed evidence of strike-slip faulting in the form of different subsurface soil colors on either side of the lineament and fracture zones coincident the VLs. All of the VLs are near the California Aqueduct and several of them are crossed by it. In this early study, we could not assess their current state of activity.

To extend this work, two projects seem reasonable: 1) trenching across selected lineaments to expose soil and rock morphology possibly indicative of faulting, and 2) obtaining high resolution lidar DEMs to search for subtle features like offset channels, scarps and ridges, displaced rock units, etc.

Acknowledgments

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Appendix I

Presented here is a list of the vegetation lineaments discussed in the paper, their names and locations, and Google Earth imagery of them.

Table A1

Pearblossom Vegetation Lineaments

name	center lat	center long	length (km)	mean bearing (°)
VL1	34.505170	-117.921466	0.24	308
VL2	34.501200	-117.919239	0.66	293
VL3	34.497318	-117.911652	0.91	303
VL4	34.496861	-117.912879	0.94	313
VL5	34.496112	-117.916550	1.39	303
VL6	34.497968	-117.907794	0.37	303
VL7	34.490814	-117.905671	0.36	326
VL8	34.492934	-117.895455	0.20	325
VL9	34.476176	-117.871588	1.40	287
VL10	34.478827	-117.883209	2.29	287
VL11	34.464039	-117.845510	1.59	291
VL12	34.456893	-117.821727	0.69	290
VL13	34.457047	-117.825379	0.96	293
VL14	34.482700	-117.891228	0.92	50
VL15	34.480851	-117.911175	1.00	303
VL16	34.504851	-117.916490	0.27	309
VL17	34.499972	-117.290762	1.14	297
VL18	34.480127	-117.870983	0.53	314

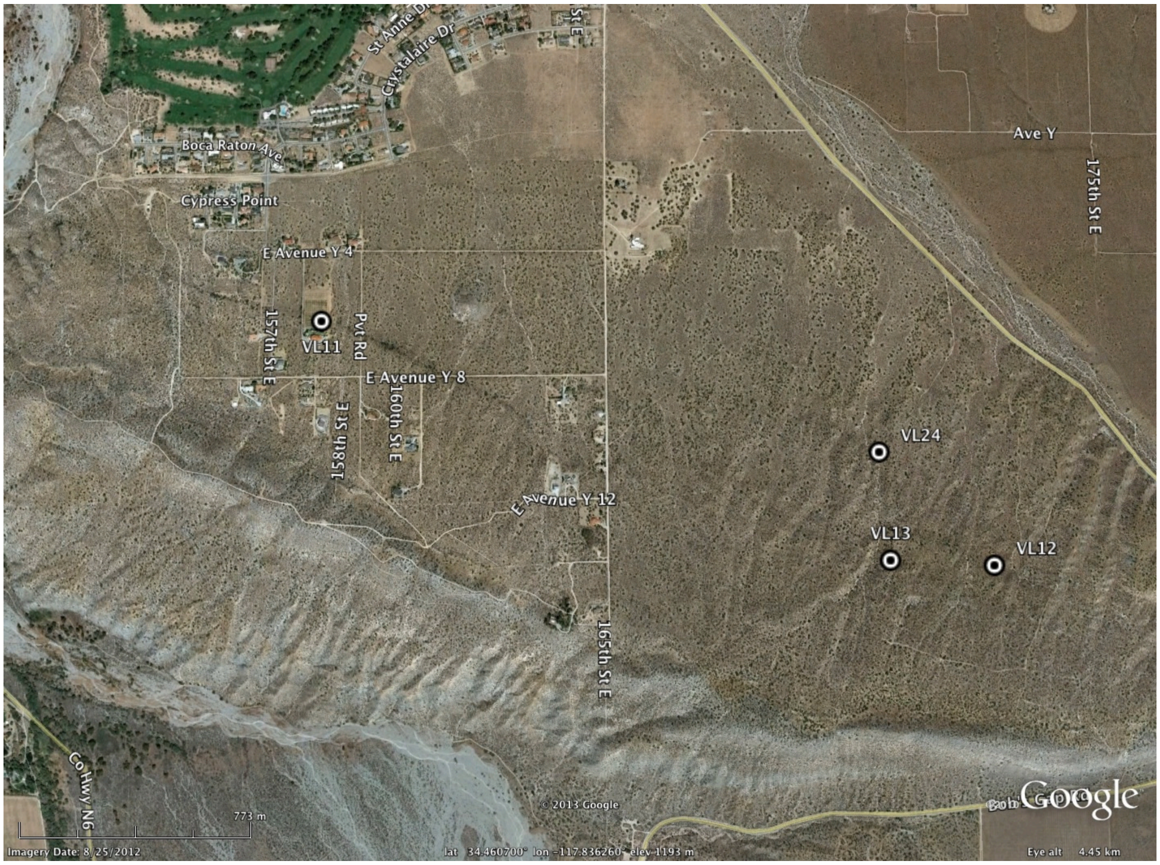
VL19	34.482868	-117.889217	0.21	305
VL20	34.488895	-117.901351	0.31	318
VL21	34.477012	-117.888793	0.70	295
VL22	34.488253	-117.905263	1.01	317
VL23	34.483249	-117.872979	0.56	306
VL24	34.460160	-117.825651	0.46	297

Figure A1


VL7
E Avenue W 10
133rd St E
135th St E
121st St E
Avenue W 12
123rd St E
126th St E
VL22
VL20
Co Hwy N6
E Avenue W 13
Ave W 14
136th St E
Ave X
Rose Tree Ln
VL14
VL19
Ave X 3
VL15
VL21
122nd St E
Homer Rd
VL10
Alada Ave
Farnese Av
Ave X 15
658 m
© 2013 Google
Google
Imagery Date: 8/25/2012
Eye alt 3.91 km
Figure A2


E Avenue X
Co Hwy N6
136th St E
Ave X
Ave X-3
VL14
VL19
VL23
Valyermo Rd
VL18
VL21
VL9
VL10
P Werner Way
Fort Tejon Rd
© 2013 Google
©2010 Google
647 m
Imagery Date: 8/25/2012
lat 34.475759° lon -117.881436° elev 1131 m
Eye alt 3.91 km

Figure A3


St Anne Dr
Crystalaire Dr
St E
Ave Y
175th St E
Boca Raton Ave
Cypress Point
E Avenue Y 4
157th St E
VL11
Pvt Rd
E Avenue Y 8
160th St E
158th St E
VL24
E Avenue Y 12
VL13
VL12
165th St E
Co Hwy N6
773 m
© 2013 Google
Google
Imagery Date: 8/25/2012
lat 34.460700° lon -117.836260° elev 1193 m
Eye alt 4.45 km
Figure A4