SUMMARY OF GEOLOGIC CONDITIONS AT BLAKE ESTATE
Kensington, California

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*Hand-drawn plates were included in the original report provided to UC Berkeley Department of Landscape Architecture and Environmental Planning, and are not included in their entirety in this digital version.

Preface

This investigation originates from a request from John Norcross, senior horticultural and arboretum superintendent/manager at Blake Garden, for classification of the rock present at Blake Garden. This request arose during the site analysis process for Landscape Architecture 102, a studio taught by Professor Linda Jewell at UC Berkeley during the Spring 1998 semester. During that semester, the studio program sought to redesign Blake Estate as an arboricultural research institute.

To date, there is no singular resource available that describes the site geology at Blake Estate. This investigation is a compilation of regional, local, and site geology, and as such, may provide a unique reference for current operations at the garden, for future or proposed improvements to the site, and for studios and research in the Department of Landscape Architecture and Environmental Planning that focus on Blake Garden.

This investigation has two intended functions: first, to develop the research and writing skills of the author, and second, to serve as an informational resource for Blake Estate. It does not constitute nor replace a professional investigation by practicing geoscientists licensed by the State of California. All interpretations and inferences are those of the author and have not been reviewed by a registered geologist or certified engineering geologist. Furthermore, conditions observed by the author at the site represent current conditions as of the date of this investigation. Site conditions may evolve over various rates of time. No warranty, expressed or implied, is provided by the author. Final interpretations regarding the geologic conditions at the site should be made by a registered geologist or certified engineering geologist. Consult local, county, and state codes and regulations to determine whether the services of a registered geologist, certified engineering geologist, or licensed geotechnical engineer are required when proposing improvements to the site.

Acknowledgments

First, I would like to express my thanks to Assistant Professor Dr. Patricia Lindsey for her support and financial assistance of this project. I would also like to thank Aleksandra Dudukovic for much appreciated review of the manuscript and assistance with manuscript production. Mr. Perry Wong, California Division of Mines and Geology, provided valuable assistance in locating several resources. Mr. Alan Kropp, Alan Kropp & Associates, generously shared his knowledge of and experience with East Bay landslides and the Blakemont slide specifically. John Norcross, Blake Garden, spent a rainy morning graciously sharing his knowledge of the site and provided an informative walking tour. However, despite all the help I have received in gathering information, all geologic interpretations contained herein are solely my own.

I. Introduction

Blake Estate, including both the Blake House and Blake Garden, occupies nearly 11 acres on a west-facing slope of the Berkeley Hills in Kensington, Contra Costa County, California. The estate serves as the official residence of the President of the University of California as well as a publicly accessed garden managed by the UC Berkeley Department of Landscape Architecture and Environmental Planning (Figure 1).

The site is bound by Rincon Road on the northeast, Highgate Road on the southwest, a Carmelite monastery on the northwest, and single-family residences on the southeast (Plate 1). The estate is commonly divided into six areas: the Entrance, the Cut-Flower Garden, the Australian Hollow, the West of the House, the Redwood Canyon, and the Formal Garden. The Entrance includes Rincon Road, two parking lots, and the entrance drive leading to Blake House. The Cut-Flower Garden is located in the eastern corner of the site and includes a horticultural production area, greenhouse, a small storage structure for gar-

Figure 1: View from the Blake House northeastward across the rectangular pool to the grotto.

den equipment, and a four-square magnolia garden. The Australian Hollow is located downslope of the Cut-Flower Garden and occupies the southern corner of the site. The Australian Hollow is characterized by a wetland-like area at the base of steep slopes. The West of the House area is located downslope of the house and includes a series of diamond-shaped pathways and a promontory overlooking the San Francisco Bay. The Redwood Canyon is located northwest of the house and is dominated by a redwood grove planted when the garden was first created. The Formal Garden occupies the area between the parking lots and the house and features a stone grotto/staircase and a rectangular reflecting pool.

The site has an elevation difference of approximately 105 feet between the Rincon Road entrance and Highgate Road (UC Berkeley Department of Landscape Architecture, undated). The upper half of the site has a slope of approximately 10%, whereas the slope below the house is much more dynamic with slopes between 5% and 90% (Plate 2). Seasonal streams flow along the northwest and southeast sides of the site. The northwest stream flows through the Redwood Canyon area and the southeast stream flows through the Cut-flower Garden and Australian Hollow areas (Figures 2, 3). Although flow is seasonal

Figure 2 (left): Looking downstream of the northwest stream.
Figure 3 (right): Looking upstream of the southeast stream.

in the southeast stream, John Norcross has observed that the streambed is wet year-round (personal communication, 1999).

II. Purpose and Scope of Work

The purpose of this project was to compile a summary report of geologic conditions at the Blake Estate. This report discusses the regional geologic and seismologic context for the site, identifies geologic hazards in the vicinity and at the site, and characterizes the site geology.

The scope of work performed for this project included the following tasks:

- Literature research

  I reviewed available literature and maps in order to characterize regional geology and seismology and to identify geologic hazards in the vicinity and at the site. These resources included: United States Geological Survey (USGS), California Division of Mines and Geology (CDMG), and USDA Soil Conservation Survey (SCS) maps and reports; consultants' reports performed in the site vicinity; geoscience journal articles; local field trip guides produced by professional geoscience organizations; and Contra Costa County Planning Department documents. These resources were located at the UC Berkeley Geology and Geophysics library, USGS library (Menlo Park, CA), CDMG library (San Francisco, CA), and at the Contra Costa County Planning Department. I also consulted historical records and accounts regarding Mr. and Mrs. Blake, Ms. Symmes and the Blake Estate.

- Aerial photo review

  I performed an historical aerial photo review to identify the location of cut/fill areas, geomorphic expressions of the Hayward fault, and landslides at the site. The photos I reviewed were at Pacific Aerial Surveys/Hammon, Jensen, Wallen &

Associates, Inc. (Oakland, CA), USGS, and CDMG.

- Field confirmation of geologic data

  I briefly visited the site on November 19 and December 14, 1999 in order to confirm and refine information regarding geologic site conditions collected during the literature research and aerial photo review tasks.

The information collected as part of the above tasks was then analyzed and organized for the preparation of this report.

III. Site History

Anson Stiles Blake and Anita Symmes Blake began planning for a new residence in 1922 when the University of California condemned the Piedmont Avenue property on which their house stood to construct Memorial Stadium. According to Mr. and Mrs. Blake, they set their sights on family property located north of Berkeley that:

> was a mile from where the little street car ended, and it was open land, largely pasture land, but sloping down from the top of the ridge above to the more level land below. It was bounded by two little lines of drainage, really streams at that time, and there were wild flowers everywhere; houses were not in sight. Down below we faced El Cerrito, that big mound on the shoreline, with an adobe of the Castro family which was still there. Down at the foot of the grade not far away was the 'metanza', a saughtering field for the cattle owned by the Spainards. Along our southern stream was a trail . . . followed by the coyotes that went for the offal from the slaughtering field. When we got there we heard almost the last howls of the coyotes. There were not many left, but everything else was left, and it seemed as though we would never have a garden.
>
> (A.S. Blake 1957)

The house was designed by the San Francisco-based architectural firm of Bliss and Faville[1]; and "its placement was carefully considered to provide a windbreak for an extensive garden" (I.R. Blake 1971). Mr. and Mrs. Blake moved into their new house in 1923, and lived there until their deaths in 1959 and 1962, respectively.

In 1959, the Blakes had deeded their house and garden to the University of California. After Mrs. Blake passed away, the University performed a limited restoration of the house. Once the repairs were completed, the Pyrtanean group, a women's organization at the University, moved in and lived at Blake House until 1964. The Blake House underwent a major renovation in 1967 before then UC President Charles Hitch moved in with his family and made it their residence. The house has continued to serve as the official residence of the UC president ever since.

IV. Regional Geology and Seismicity

Geology

The Berkeley Hills are a part of a northern extension of the Diablo Range, part of the central Coast Ranges of California. These hills run from Richmond southward to Redwood Canyon (east of Oakland and San Leandro). The Berkeley Hills are bound on the northeast by the Calaveras fault and on the southwest by the Hayward fault (Case 1963, Perkins 1974). The geologic history of the area now occupied by the Berkeley Hills is a complex series of physiographic forms, rock types, folding, and faulting. The Berkeley Hills are the most recent landform of an area that was previously part of an ocean. A generalized summary of the geologic history of the Berkeley Hills follows; interested readers are directed to the references listed at the end of this report for details.

The oldest rocks in the vicinity of the Berkeley Hills are remnants of an ocean environment. These rocks constitute the Franciscan Formation which includes marine sedimentary, volcanic, and metamorphic rocks deposited along a convergent plate margin (subduction zone). Some Franciscan rocks are up to 200 million years old (early Jurassic period) (Irwin 1990, Page 1992). The Berkeley Hills remained part of an ocean while marine igneous rocks of the Coast Range Ophiolite (dated at 153-165 million years ago, middle and late Jurassic period), marine sedimentary rocks of the Great Valley Sequence (65-163 million years ago, late Jurassic and Cretaceous periods), and Tertiary marine sedimentary rocks (26-65 million years ago) were transported to the area via plate tectonics or were deposited in the area (Wagner 1978, Irwin 1990, Page 1992). The last rocks deposited in this ancient ocean environment of the pre-Berkeley Hills were those of the Monterey Formation, which include marine sedimentary rocks of Miocene age (13-26 million years old) (Wagner 1978, Page 1992).

Approximately 13 million years ago, the sea level decreased and the Berkeley Hills area was no longer submerged underwater. Continental alluvial fan sediments eroded off of a topographic high located in the vicinity of what is now San Francisco Bay and were deposited into a topographic depression now known as the Berkeley Hills. These sediments constitute the Orinda Formation (Contra Costa Group), which is dated at approximately 10-13 million years old. Volcanic flows and sediments as well as continental and lake sediments (Grizzly Peak, Siesta, and Bald Peak Formations of the Contra Costa Group) were deposited over the Orinda Formation while the Berkeley Hills area continued to be topographically low yet still above sea level (7-10 million years ago). Following the deposition of the Contra Costa Group rocks, there was extreme folding and faulting of all the rock units (Case 1963, Wagner 1978, Page 1992).

Uplift of the present Berkeley Hills did not begin until about 1 million years ago, which makes the Berkeley Hills a very young and rapidly rising landform in terms of geologic time. The uplift of the Berkeley Hills appears to be the result of regional (western United States) horizontal compressive forces applied perpendicularly to the plate boundary between the Pacific and North

American plates along the west coast. Early in its history, the Hayward fault might have been the location through which this uplift was accomodated; that is, the Hayward fault may have accomomodated vertical displacement several million years ago. Today, the Hayward fault primarily accomodates horizontal displacement as a right-lateral strike-slip fault. The rapid uplift of the Berkeley Hills and the poor strength of many of its constituent rocks have been important factors for the presence of many of the landslides along the Berkeley Hills (Page 1992).

Seismology

The Hayward fault runs along the length of the East Bay at an average strike of N35°W, and traverses along or near the eastern end of the Blake Estate site (Dibblee 1980; Smith 1980; Lienkaemper 1992). Other active faults in the site vicinity are:

Concord fault	~14 miles to the northeast
Green Valley fault	~16 miles to the northeast
Pleasanton fault	~17 miles to the southeast
San Andreas fault	~18 miles to the southwest
Calaveras fault	~18 miles to the southeast
Napa fault	~18 miles to the northeast
Rodgers Creek fault	~18 miles to the north

The Hayward fault is a major fault within the San Andreas fault system, which serves as the plate boundary between the North American and Pacific plates. Like the San Andreas, the Hayward is typically a right-lateral strike-slip fault. Displacement along the Hayward fault began approximately 10 million years ago (probably primarily vertical), with right lateral strike-slip beginning 4-8 million years ago (Lienkaemper 1992). Estimates of cumulative displacement along the Hayward since its inception range from a few kilometers to as much as 190 km (Lienkaemper 1992). Earthquake hypocenters along the Hayward fault tend to occur between 2-13 km depth (Oppenheimer and MacGregor-

Scott 1992; Oppenheimer, Wong and Klein 1992).

The Hayward fault is divided into 2 segments, the northern segment and the southern segment. The northern segment of the Hayward fault (along which the Blake Estate is located) runs from Point Pinole on the San Pablo Bay south to San Leandro, and the southern segment is located between San Leandro and eastern San Jose.

The Hayward-Rodgers Creek fault[2] has been estimated to be the next major fault to produce a magnitude 6.7+ earthquake (a 32% probability) in the Bay Area by the year 2030, even surpassing the likelihood of a similar earthquake along the San Andreas. The probability of this magnitude 6.7+ earthquake occurring along just the northern Hayward fault segment by 2030 is 16% (WGCEP 1999). These estimates are based on recent research that compiled a more complete and accurate history of the northern segment of the Hayward fault over the past ~2400 years, including evidence that the last surface-rupturing event occurred sometime between 1640 and 1776. This research also estimated a recurrence interval for surface-rupturing events along the northern segment of <270-710 years (Hayward Fault Paleoearthquake Group 1999). If there were a magnitude 7.0 earthquake along the northern segment of the Hayward fault, geologists estimate that surface fault rupture would average approximately 3 feet from Richmond to San Leandro, with the greatest offsets up to 7-10 feet (Lettis 1996).

The first known written record of the Hayward fault also described the most recent major earthquake along the Hayward, when an ~M7 earthquake occurred along the southern segment on October 21, 1868. The earthquake caused surface rupture from Warm Springs in Fremont to potentially as far north as Mills College in Oakland. Damage was most intense near Hayward, with shaking felt as far north as Chico, as far south as Monterey, and as far east as Nevada (Lawson 1908).

The Hayward fault was not actually located and mapped until after the 1906 San Francisco Earthquake when Andrew Lawson, a UC Berkeley geology professor, described the Hayward fault and the 1868 earthquake in his report to the State of California on the 1906 San Francisco Earthquake:

> . . . the earthquake of 1868 was due to an earth-movement along the base of the hills which overlook San Francisco Bay on the east, and which are often referred to, particularly farther north, as the Berkeley Hills. These hills present a remarkably even, straight front, and without a doubt represent a degraded fault scarp. Along the base of this scarp a crack opened on the morning of October 21, 1868. This crack is regarded as the trace of the fault which caused the earthquake. Its position has been determined at intervals along a nearly straight line from the vicinity of Mills College, east of Oakland, to the vicinity of Warm Springs near the Santa Clara County line; but the evidence of its existence to the northward of San Leandro is not very satisfactory. The county was then unsettled, and the information consisted of reports of cow-boys riding the range. From San Leandro southeastward, however, the evidence is full and conclusive. (Lawson 1908)

Today, the Berkeley Hills are no longer simply regarded as a degraded fault scarp; however, their presence is related to the Hayward fault and regional Bay Area tectonics. In addition, the location of the Hayward fault is much better known; although the exact location and characterization of the fault in some places is still not yet conclusive. Some of these places are those areas of the Berkeley Hills currently overlain by landslide deposits, which obscure accurate location of the Hayward fault.

The Hayward fault experiences both fault creep, defined as steady displacement between earthquakes, and fault slip, which is the movement that occurs during earthquakes. Fault creep along the Hayward varies between 3.5-6.5

mm/year for much of its length; however, the creep rate in the vicinity of the Blake Estate is ~5-7 mm/year (Lienkaemper and Borchardt 1992). Fault slip during earthquakes along the Hayward is averaged at 8-11 mm/year (Lienkaemper 1992; Lienkaemper and Borchardt 1992; Hirschfeld 1999, WGCEP 1999).

V. Site Geology

> We viewed the property first on a glorious April day after a rain. The sun was shining, the buttercups yellow under foot and we hopped from hillock to hillock through marshy meadows to higher ground. Rolling hills were all about us, cattle grazing, meadowlarks singing; the settlement of houses was far below us and, beyond, the blue bay, San Francisco, the Golden Gate, the Marin shore. (Symmes 1945)

These words describe the first impressions by Mabel Symmes of the site that would become the Blake Estate. Ms. Symmes' impressions provide an idyllic description of the landscape that would become her home, including some observations on the geologic context of the site. She unknowingly identifies a dynamic topography shaped by faulting and landslides when she describes hopping from "hillock to hillock through marshy meadows to higher ground". Ms. Symmes probably did not understand the geologic processes shaping the landscape she saw; in fact, geologists are still trying to understand the complex relationship of the Hayward fault and local landslides in the site vicinity.

Petrology

Until the late 1960s, most geologists have mapped the Blake Estate as being underlain by Franciscan serpentinite with tectonic inclusions of lawsonite-bearing glaucophane schist (Brothers 1954, Radbruch and Case 1967). However, a detailed petrologic analysis led other researchers to express some uncertainty regarding the glaucophane schist outcrops on the site (Davis and Pabst 1960). In referring to the large glaucophane schist boulder in the West of the House area (Figure 4), Davis and Pabst explain:

> This schist block and others of similar or larger size in the area are regarded, in agreement with Brothers (1954, p.616), as tectonic inclusions within serpentinites of the [Hayward] fault zone, although it is impossible to ascertain whether the Blake Garden block is now in situ. [original italics] (Davis and Pabst 1960)

More recent, detailed mapping shows that landslides, rather than stable bedrock, immediately underlie the entire site (Nilsen 1973, Herd 1978, Dibblee

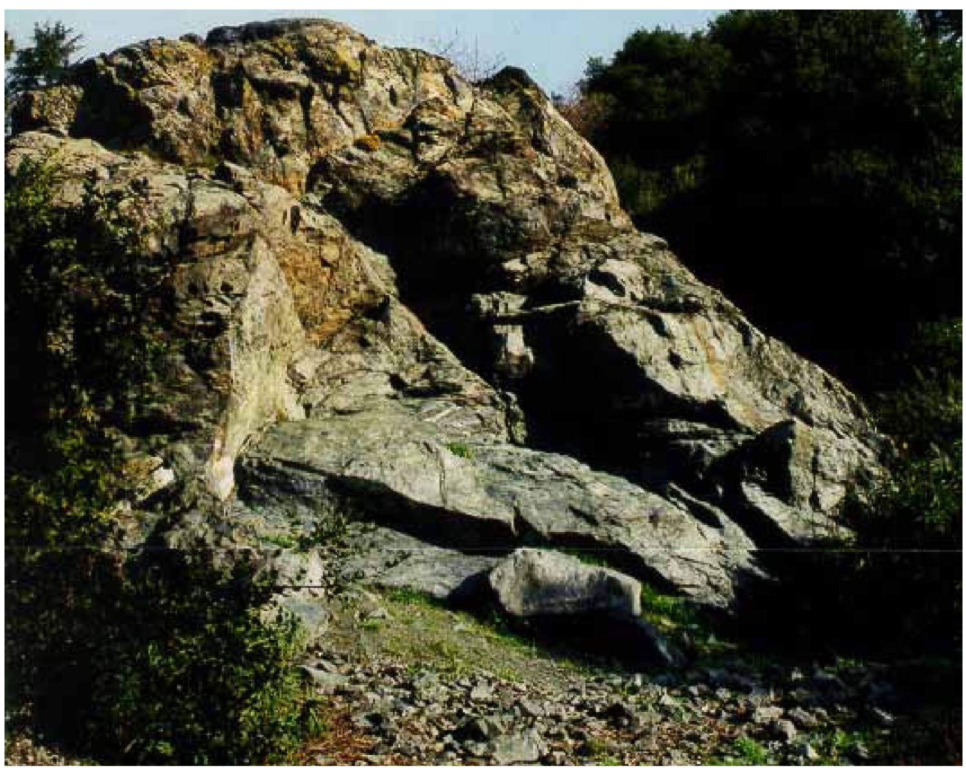

Figure 4: View of the south face of the large lawsonite-bearing glaucophane schist boulder in the West of the House area. Note the rock debris on the ground which may support the appearance of possible past quarrying seen on the rock face.

1980, Seidelman Associates 1994, Alan Kropp & Associates 1995). Furthermore, Alan Kropp & Associates (1995) characterize the underlying landslide as active[3]. This landslide is discussed in further detail in the following section on slope stability.

One of the more recent geologic maps shows the site vicinity to be underlain by Franciscan melange east (upslope) of the Hayward fault and by serpentinite of the Coast Range Ophiolite west (downslope) of the Hayward fault (Graymer, Jones, and Brabb 1995). Though more detailed maps show the site to be underlain by a landslide, this map might actually suggest what kind of rock not only underlies the landslide deposit, but also provides the source material for the landslide deposit.

Slope Stability

Slope stability maps reflect the most detailed information known about the site, and show Blake Estate in an area mapped as "Unstable: Areas of any slope that are underlain by or immediately adjacent to landslide deposits" (Nilsen et al. 1979) or "on ground that has moved recently enough to affect works of man" (Bishop et al. 1973).

As previously discussed, an active landslide is mapped under the Blake Estate site (Nilsen 1973, Dibblee 1980, Seidelman Associates, Alan Kropp & Associates 1995). This landslide is locally named the "Blakemont" slide (Seidelmann Associates 1994, Alan Kropp, personal communication, 1999)[4] (Plate 1). The head of this landslide is mapped near the western/downslope extent of the existing Blake Estate parking lot along Rincon Road, and the slide extends downslope to the base of the East Bay Hills near Colusa Avenue in El Cerrito (Smith 1980, Seidelmann Associates 1994, Alan Kropp & Associates 1995). The Blakemont slide is inferred to be an old landform predating urban development in the area. In their 1994 report, Seidelman Associates estimated the age of the landslide to be Pleistocene (10,000 to 1.6 million years old); however, since the age of the Berkeley Hills are approximately 1 million years old, the

Blakemont slide must be younger than the hills upon which it is deposited. According to Alan Kropp (personal communication, 1999), the Blakemont slide likely consists of multiple shear planes, the shallowest of which may be at about 25 feet deep, the deepest as much as maybe 100 feet. The Seidelman Associates report concludes that the slide may be as deep as 65 feet.

Graymer, Jones, and Brabb (1995) have mapped Franciscan melange and serpentinite of the Coast Range Ophiolite at the site, and I suggest that the melange and serpentinite might actually underlie the Blakemont slide as well as provide the source material for the landslide deposit. By definition, melange consists of rock blocks within a finer-grained matrix, and serpentinite is a highly metamorphosed and deformed rock. These textural characteristics are preserved, if not enhanced, by landsliding. In addition, such a heterogenous mixture of geologic materials with varying strengths might tend to fail along multiple shear planes. Seidelman and Associates (1994) suggestion that the landslide consists of "floating" blocks, coupled with Kropp's judgment that the slide consists of multiple shear planes, would support the suggestion that melange and serpentinite underlie the landslide and provide the heterogeneous source material for the landslide. Such heterogeneity might explain Kropp's (personal communication, 1999) observation that different parts of the slide move at different rates.

Seidelman Associates only drilled one geotechnical boring on the Blake Estate grounds ("B-15"), located at the upslope side of the driveway turnaround (see Plate 2 for boring location). The boring log for B-15 indicates clays to about a 20 foot depth over a mixture of serpentine, shale, and melange of varying strengths. This boring describes the heterogenous nature of the landslide deposit and begins to suggest the potential difficulty in differentiating between landslide deposit and deformed, sheared, yet intact bedrock located adjacent to an active fault.

If there were an earthquake along the Hayward fault, ground rupture would probably not be the only hazard to which the Blake Estate would be susceptible. According to Seidelman Associates (1994), the greatest risk to the area in the vicinity of the Blakemont slide is the induced activation of the slide by an earthquake on the Hayward fault. Steinbrugge, et al. (1987) believe that "significant reactivation of the landslides [in the Berkeley-Kensington area] accompanied by ground failure may occur" in the event of a magnitude 7.5 earthquake along the Hayward fault. Lettis (1996) expects that many of the landslides in the Berkeley Hills, including the Blakemont slide, would suddenly move one to several feet during a magnitude 7.0 Hayward earthquake.

Geotechnical engineering and engineering geology investigations performed by local consultants in the vicinity of Blake Estate describe an area affected by landslides with distress to curbs, driveways, sidewalks and homes possibly caused by landslide movement or fault activity (Abel R. Soares and Associates 1978) and local landsliding (Geotechnical Engineering, Inc. 1996). In addition, the Blakemont slide has likely caused deformation to the asphalt and homes along Highgate over the past several years (John Norcross, personal communication, 1999) (Figures 5, 6, and 7).

A 1935 oblique aerial photo stored at Alan Kropp's office shows the lower portions of the Blakemont landslide below the Blake Estate. The area below the Blake Estate appears to be the last residences to have been built in the neighborhood, which were built in the 1940s. The land on which the houses were built shows obvious geomorphological features of an active landslide. It is not surprising that builders hesitated to construct residences in this area.

In my review of historical documents and literature regarding Blake Estate, I encountered observations that may suggest damage to the house as a result of the Blakemont slide. At the time of Mrs. Blake's death, the Blake house was in a condition of neglect and disrepair (Kerr and Kerr 1988). When the university assumed the care and control of the house, then UC president Clark Kerr and his wife Kay Kerr recalled that they:

> had Mr. [W.A.] Parish in the crew from the university looking at it and we found the structural problems - - you know, the

Figure 5: View of landslide-induced distress to the residence at 18 Highgate Road. Note the warped roof and cracks along the side of the residence.

Figure 6 (above): View to the southeast along Highgate Road. The residence at 18 Highgate Road is to the right. Note arcuate cracks in the asphalt, which represent small-scale deformation within the Blakemont landslide.

Figure 7 (right): View to the south across Highgate Road near 16 Highgate Road. Crack in asphalt is up to 3 inches wide. A driver of a car passing by while I took this photo said that the road was resurfaced two years ago. Clipboard for scale.

> foundation had sunk, and the front wall was maybe one foot lower from the front door to the window. As you walked, you were sure you were on a boat. That whole side of the house had sunk. There was nothing in the sunroom, it was just kind of a hole, which was later turned into a nice sunroom. (Kerr and Kerr 1988)

Major renovation was required to make the house livable for the first UC president,

> because the house had sunk about seven inches in the middle, right opposite the grotto. One of the major things we had to do was to try to level the house. When we did that, then put new foundations in – there's concrete columns that support the ground living floor. We had to lift the house, and when we did that it popped a lot of the remodelling that had been done by the Pyrtaneans because we were restoring it to its original shape. So walls cracked and wallpaper came off – that was expected to happen. And we raised the house to within three quarter[s] of an inch of level. But it took about two months to do that, just to raise the house. (Willer, Hail, Brocchini and Brocchini 1988)

There are several possible causes for the distress to the Blake House foundation: poor construction methods used for the original house, post-construction settlement, expansive soils, fault creep, and landsliding. I assume that given the Blake family's wealth, their house was constructed under good conditions with the most reliable methods available at the time. Therefore, the house distress was probably not caused by subpar workmanship. Approximately 1/4 inch over 12 feet of post-construction settlement of the foundation is expected within the first few years after a house is built, but 7-12 inches is an unusual amount of settlement. Expansive soils often cause seasonal distress to Bay Area foundations on the order of 3-4 inches of displacement, but again, 7-12 inches of expansion and contraction is extraordinary (Lou Gilpin, Gilpin Geosciences, personal communication, 1999). As discussed previously, though no fault creep has been observed in the site vicinity, landsliding would mask any fault creep, if present. I am not including the possibility of earthquakes since there have been no major fault events along the northern Hayward fault since the Blake House was constructed. Therefore, given observations of landslide-related distress to structures in the site vicinity the magnitude of distress to the Blake House seems most appropriately associated with reactivated or continued landsliding as mapped at the Blake Estate.

The house continues to undergo deformation associated with the Blakemont slide. During my visit on November 19, 1999, I observed cracks up to -inch wide in the perimeter foundation on the northwest side of the house. I was told that these cracks were patched three years ago; however, the patches have since failed. Additionally, Mr. Norcross said that many breaks in the irrigation pipes occur in the Redwood Canyon (personal communication, 1999), potentially a result of landslide deformation. A thorough evaluation of the house (including a floor level survey) and adjacent structures and infrastructure (roads, curbs, walls) can provide a preliminary evaluation to determine if, and to what magnitude, slope instability continues.

Based on aerial photo interpretation, I identified possible smaller scale landsliding on the Blake Estate (Plate 2). These smaller slides define much of the geomorphology on the lower half of the site, and I suggest that they might be small-scale adjustments to internal stresses within the larger Blakemont slide mass. The majority of the slides are characterized as slump-flow complexes, located along the northwestern and southeastern streams and below the house near Highgate Road. Other landslides include a slump immediately downslope of the house that defines the grassy flat area below the house and a slide along the southeastern stream. Based on the geomorphology of these landslides as observed in the aerial photos, I infer that they are no deeper than a maximum of 15 feet and are of recent age.

One interesting feature of the lower half of the site is the Australian Hollow (Figure 8). I hesitated to characterize the steep slopes and marshy area of the Australian Hollow as a landslide because I could not locate the toe of what should be a sizable deposit, considering the steepness of what would be the headscarp and lateral margins of the slide. My guess is that this feature had been a small quarry. Mr. Blake ran a quarrying business both before and after the Blakes lived on this site. According to Mr. Norcross (personal communication, 1999), the Blake site was originally intended as a quarry site. I can only guess that perhaps this small quarry was used for rock on the Blake property or for nearby properties and/or roads.

Unfortunately, I did not find any historic information regarding the use or placement of fill during the construction of the estate. However, it appears that fill was placed at the downslope, or southern, sides of both parking lots, as well as along the streamside edge of the four-square magnolia garden of the Cut-Flower Garden.

Figure 8: View to the north of the Australian Hollow area. Note cattails in the right midground, which favor moist to wet soil conditions. These soil conditions are likely a function of the bowl-shaped topography and the Australian Hollow spring. Steep slopes in the background are up to 90% grade.

Seismicity

According to the CDMG, the upslope half of the Blake Estate is within an Alquist-Priolo Earthquake Fault Zone for the Hayward fault, which means that that part of the Blake Estate is located near an active fault (CDMG 1982). Several maps show the Hayward fault passing through or adjacent to the eastern portion of the Blake Estate (Dibblee 1980; Smith 1980; Lienkaemper 1992). All three of these maps show at least a large portion of the northern Hayward fault at a scale of 1:24,000 and I have transferred this data to Plate 1. Because the fault traces shown on Plate 1 have been transferred from original maps that were at such a large scale, the locations of the fault traces are approximate at best. Plate 1 should not be used to identify the site-specific location of the Hayward fault traces in the vicinity of the Blake Estate; however, it does provide an idea of the location of a Hayward fault zone. Additionally, these three maps show almost three different locations for the location of Hayward fault traces. This discrepancy reflects the difficulty in identifying evidence of fault rupture in an area prone to landsliding.

Dibblee (1980) mapped a single trace, shown as concealed by a landslide, that trends along the upper parking lot. This landslide is probably the Blakemont landslide, which Dibblee infers to be a younger feature that obscures any geomorphological evidence previously produced by the fault.

As part of the Alquist-Priolo Special Studies Act, the CDMG also mapped the Hayward fault based on aerial photo interpretation (Smith 1980). Smith identified two traces: the first was identified by a soil tonal lineament that trends along Rincon Road (seen in the 1950 aerial photos) and the second trace was identified by a linear trough with a deflected stream bed parallel to and upslope of the tonal lineament.

The most recent mapping of the Hayward fault in the vicinity of the Blake Estate also shows two traces (Lienkaemper 1992). Lienkaemper identified an upslope trace that approximately follows Smith's upslope trace based on weakly to strongly pronounced linear scarps and a strongly pronounced vegetation lineament. Lienkaemper's downslope trace is further downslope than any other researchers have mapped; in fact, it passes in between the greenhouse and the house in the vicinity of the grotto (Figure 9). This trace was identified from a linear break in slope and might explain the presence of the spring that is channeled through the grotto.

I also identified a depression at the eastern end of the site in the 1939 aerial photo. This feature is either a result of a singular left-stepping fault trace or it occupies the area between two fault traces, as suggested in the maps by Smith and Lienkaemper.

In addition to the main traces previously discussed, secondary faults have been identified in the field. Geotechnical engineering and engineering geology investigations performed by local consultants in the vicinity of Blake Estate describe evidence of secondary faults to the Hayward fault in fault investigation trenches (Zickefoose 1974; Abel R. Soares and Associates 1978, and Geotechnical Engineering, Inc. 1996).

Figure 9: View to the northwest across the lawn near the Cut-Flower Garden. This view looks along the approximate location of Lienkaemper's downslope Hayward fault trace.

Soils

> The house was placed on the edge of a bluff and was made, —the architect also being a garden lover—, long and narrow to break the wind. A temporary road was brought in from the south for the purpose of building and, beside giving time for the planning of the permanent entrance, it taught us a wholesome respect for adobe, which was to be part of our future soil; gooey, sticky stuff in winter that trapped any innocent unwary workman who ran off the packed road until his companions helped to lift his Ford back on again. The b-r-r-r-r of a stalled machine was a familiar sound for many years. In summer the adobe checked in big plates with deep cracks that swallowed any small thing dropped down them. It looked rich, however, so we considered thoughtfully and hopefully. (Symmes 1945)

Mabel Symmes' descriptions of the soils in the West of the House and Australian Hollow areas reveals what is probably a highly plastic, very expansive clay-dominated soil whose deleterious characteristics are exacerbated by winter rains and water fed by nearby springs.

Subsurface exploration of the soil was not in the scope of this project. However, the Soil Survey of Contra Costa County, California (Welch 1977) can provide a general, preliminary evaluation of the soils in the site vicinity. Blake Estate is mapped as being underlain by the soil type "Cof" – Cut and Fill Land soils of the Millsholm complex. This complex consists of a mixture of other soil types, including approximately 60% cut and fill land, 20% Millsholm loam, 10% Lodo clay loam, 5% Los Gatos loam, and 5% Los Osos clay loam. Such a variety of soils at Blake did not go unnoticed by Mrs. Blake, who encountered "every kind of soil, serpentine in some places, gravel in another, and adobe packed hard by the pasturing of the cattle" (Blake, A.S. 1957).

Cut and Fill Land soils (Cof) typically occur on slopes between 30% and 50% and are the result of "mechanical manipulation of steep soils on uplands for urban use" (Welch 1977). However at the Blake Estate, Anita Blake and Mabel Symmes planned the garden to take advantage of the site's varied topography and microclimate, and therefore designed for minimal earth movement (Haymaker 1987). It is possible that cutting and filling was performed to a lesser degree than in the surrounding area, and the soil may not be completely representative of the Cut and Fill Land soil type.

In addition, movement along the Hayward fault and landsliding such as that mapped at the site will change the soil conditions. There may be soil on the Blake site that originated offsite (upslope or adjacent to Blake Estate) and has since been transported to the site via fault movement and/or landsliding. These geologic hazards may also disrupt the soil profile that exists on the site. The variety of soils that Mrs. Blake observed may in fact be a result of a combination of previous land uses (e.g. cattle pasturing, possibly quarrying) and geologic hazards (fault movement and landsliding). Therefore, the use of USDA Soil Conservation Service maps (which should not be used to characterize site specific soil conditions in an urban area) proves especially problematic at the Blake Estate. Accurate characterization of the soils at the Blake Estate would require some form of exploratory soil sampling (test pits/trenches, drilling) at several locations, ideally including at least a few borings designed to penetrate any basal shear surface of the mapped landslide into bedrock.

Springs

There are four springs on the Blake Estate site: one is a seasonal spring in the upstream reaches of the northwestern stream; the second is an intermittent spring in the Formal Garden area that outlets through the grotto into the reflecting pool; the third is a perennial spring on the north side of the Australian Hollow, and the fourth is a spring located south of the large glaucophane schist boulder in the West of the House area. The location of the seasonal spring along the northwest stream is not well-defined. The intermittent Formal

Garden spring is piped into the grotto, travels along a concrete-lined runnel and into the reflecting pool before it is finally piped into the northwest stream (Figure 10). As previously discussed, this spring may be a function of the Hayward fault. The perennial spring in the Australian Hollow outlets from a pipe placed in the side of the slope (Figure 11). Mr. Norcross was able to pipe the water produced from the spring into a plastic reservoir throughout the duration of the drought in the late 1980s and early 1990s (personal communication, 1999). I have previously suggested that quarrying may have occurred in the Australian Hollow area; such quarrying may have exposed the spring located there.

Figure 10 (left): View of the Formal Garden spring that drains through the grotto and into the rectangular pool.

Figure 11 (right): View of the Australian Hollow spring, which is hidden in the lush grasses below the elevated driveway seen at right.

VI. Discussion and Conclusions

Though the Blake family were not geologists, they originally chose and designed their estate based on how a number of geologic phenomena have shaped the land. They located the house on a prominent overlook: the upslope flat area is probably a function of movement along the Hayward fault and/or the Blakemont slide, whereas the steep slopes downslope of the house were created by small landslides. The grotto and the reflecting pool, possibly the most recongnized feature of the site, take advantage of a spring that may owe its existence to the Hayward fault.

Because of the presence of the Hayward fault, the site will likely experience significant ground rupture and shaking associated with a possible magnitude 6.7 earthquake forecasted in the next 30 years. These hazards may cause significant damage to a house that continues to be distressed by an active landslide. Such an earthquake will probably activate the sudden movement of one or more feet of the Blakemont slide, and I would add that an earthquake might impact the smaller landslides on site as well.

Based on the compilation of available literature sources and aerial photo interpretation, the Blake Estate site is a geologically dynamic place. In retrospect, because of the presence of the Hayward fault adjacent to and/or on the site and a large active landslide, it is fortunate that the Blake Estate site has not been subdivided and developed for several single-family residences. Additional residences on the site would put a greater number of people in danger during an earthquake and would result in greater property losses due to continued landslide movement. Instead, as one of the few large undeveloped parcels of land in the Berkeley Hills, the site affords a unique opportunity to investigate the relationship between the Hayward fault and large, active landsliding.

Mapped Traces of the Hayward fault

Dibblee (1980)
Solid line represents inferred location of the fault, dotted line represents where the fault is concealed.

Smith (1980)
Solid line represents inferred location of the fault, dashed line represents where the fault location is uncertain.

Lienkamper (1992)
Dashed line represents inferred location of the fault, hachures indicate the lower side of apparent vertical displacement.

Depression observed in the 1939 aerial photos by the author

Boundary of the Blakemont Landslide (Seidelman Associates 1994)

Blake Estate property line

Plate 1: Generalized Geologic Map.

Scale is approximately 1"=500'.
Aerial photo dated 7/10/93.

Qf	Artificial fill
Qls xxxx	Landslide (arrow delineates direction of movement)

Type
1 Slump
2 Debris flow
3 Slump/flow complex
4 Debris slide
5 Rockfall/Topple

Estimated depth
1 0-5 feet
2 5-10 feet
3 10-15 feet
4 15-20 feet
5 20+ feet

Age/activity
1 Recent, active
2 Recent, dormant
3 Ancient, active
4 Ancient, dormant

Certainty of interpretation
1 Certain
2 Probable
3 Questionable

Note: Blakemont Landslide characterized as Qls 3531.

Spring

Cut

Fill

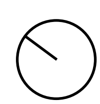

Plate 2: Surficial Conditions Map. Scale: 1″=100′

ENDNOTES

[1] There is some discrepancy in the literature regarding who actually designed the Blake House. The majority of sources refer to Walter Bliss as the designing architect (incl. Haymaker 1987); however I.R. Blake (1971) states that John B. Faville was the designer of the Blake House.

[2] The Rodgers Creek fault is believed to be the northern extension of the Hayward fault across San Pablo Bay, so geologists sometimes consider the Hayward and Rodgers Creek faults to be part of the same fault system.

[3] Alan Kropp defines an active landslide as exhibiting surficial evidence of movement (personal communication, 1999).

[4] Local homeowners have organized themselves into the Blakemont Property Owners Association, and in 1986 hired Seidelman Associates to conduct a geologic investigation in preparation for the organization of a geologic hazards abatement district (GHAD). A GHAD is an area organized by homeowners who have collectively decided to share the cost of mitigating a geologic hazard. The Seidelman Associates report was completed in 1994 but the property owners association did not pursue any mitigation measures at the time. As of the date of this report, Alan Kropp & Associates have been hired to perform a new investigation into the Blakemont slide (Alan Kropp, personal communication, 1999).

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