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MAP OF LANDSLIDE GEOMORPHOLOGY OF OREGON CITY, OREGON, AND VICINITY INTERPRETED FROM LIDAR IMAGERY AND AERIAL PHOTOGRAPHS

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INTRODUCTION

Landslides are a prominent hazard in the Oregon City, Oregon, area. Several landslide studies and maps exist for the area, for example, by Hammond and others (1974) and by Schlicker and Finlayson (1979). Both of these maps used U.S. Geological Survey (USGS) 7.5 minute quadrangles as base maps on which outlines of slide areas were identified.

During 1996 and 1997, heavier than normal rains in Oregon caused thousands of landslides. Over 700 of these landslides were mapped in the Portland metropolitan area (Burns et al., 1998). Some of these slides were the reactivation of ancient and historically active landslides, and some were new failures. Many of these slides occurred within the Oregon City area; an inventory of these landslides is available through Oregon Department of Geology and Mineral Industries Special Paper 34 (Hoffmeister, 2000).

During the 2005-06 winter season, Portland and most of western Oregon again experienced heavier than normal rainfall, which resulted in hundreds of landslides. Again, many of the landslides were reactivation of older landslides, making the identification of these existing ancient and historic landslides an obvious priority in the attempt to begin the reduction of the risk from landslides. Several of these reactivated landslides occurred in the Oregon City area, impacting infrastructure as well as several residential homes and an apartment complex.

The accompanying map (Plate 1) is designed to provide timely access to new information about potential landslide hazards in the Oregon City area. The new information comes from two sources, a recently completed geologic map of the Oregon City 7.5 minute quadrangle (Madin, in preparation) and high-resolution topographic data in the form of a digital elevation model (DEM) derived from light detection and ranging (LIDAR) surveys conducted by the City of Oregon City. This landslide information will eventually be published both as part of the geologic map and as part of a regional landslide geomorphology map. Oregon City is the first Oregon community for which this kind of high-resolution landslide geomorphologic mapping is available.

METHODS

The two primary data sources used to make this map were serial stereo air photos of a variety of scales, and a LIDAR-based DEM provided by the City of Oregon City. Landslide geomorphology from both sets of imagery was compiled and then combined using geographic information system (GIS) software (MapInfo™).

The majority of landslide topography occurs in canyons that cut the Oregon City plateau. Slopes are typically forested, and topography is obscured when forest cover is intact. In an attempt to get around this problem, a time series of air photos was examined (1939, 1948, 1956, 1964, 1973, 1980, 1990, and 2000). For all of these photo series, stereo photo pairs were examined to look for topography characteristic of landslides such as steep arcuate scarps (cliffs), hummocky topography, and cracks and grabens (troughs or depressions) on the surfaces of slopes and irregular lobate toes. The outlines of areas of landslide topography were transferred from the stereo photos to the GIS by heads-up digitization on a georeferenced (UTM Zone 10, NAD 27) image of the USGS 1:24,000 scale topographic map (digital raster graphic: DRG). The transfer was accomplished with the DRG zoomed to scales between 1:12,000 and 1:6,000.

After the completion of the aerial photography analysis, high-resolution bare earth LIDAR data became available from the City of Oregon City. LIDAR data are collected by scanning the ground with a laser rangefinder flown in a precision-navigated aircraft. The resultant cloud of elevation data is processed to remove laser returns from vegetation and structures, leaving an accurate and detailed model of the shape of the ground surface.

We processed the Oregon City LIDAR data-points to produce a DEM grid (Oregon State Plane N, 1983) with 5 ft by 5 ft cells, then enhanced that DEM with both relief shading and slope maps to highlight subtle topography. We also produced elevation contours at 2 ft intervals to help visualize the data. We then digitized the areas of landslide topography directly from LIDAR imagery at a scale of 1:2400, again using topographic evidence such as scarps, hummocky terrain, and lobate toes. An additional advantage of the LIDAR data was that we could instantly produce topographic cross sections along a suspect slope. With the LIDAR data it was also possible to see subtle fan deposits at the mouths of small canyons that we interpret as debris flow or earth flow deposits.

We compared the areas of landslide topography mapped in this study with those mapped in previous studies (Hammond and others, 1974; Schlicker and Finlayson, 1979; Burns, 1999). We found that previous maps identified most of the larger (greater than 5 acres) slide areas, but LIDAR data provided much more accurate delineation of the boundaries of the areas. Previous studies identified only a few of the smaller slide areas and *in several cases identified areas which did not show any visible landslide features on the LIDAR DEM*. Only the LIDAR DEM showed deposits of debris flows and earth flows. Our confidence in the existence, types, and boundaries of the larger slide areas identified on the LIDAR DEM is very high; we are less confident regarding the more numerous smaller slide areas.

MAP UNITS

Qls — Landslide Topography

Qls comprises areas of irregular topography, typically bounded on the upslope end by a sharp, commonly arcuate scarp (Figures 1 and 2). In some cases, complex lobate toes are present; in other cases, the downslope boundary of the area of landslide topography is marked by a break in slope or is difficult to discern. The mapped areas range from about 0.03 to 281 acres. We interpret the landslide topography to be the result of one or more past landslides, although we have no site specific information in any area that provides evidence of the age, amount of movement, or frequency of movement of any single landslide.

Most large areas of landslide topography occur along the rims of canyons, where strong, dense Boring Lava overlies weak Troutdale Formation mudstone and claystone (Madin, in preparation), and appear to be combinations of a block slide and rotational slumps. Scarps are typically steep, are up to 65 ft high, and commonly have a graben formed at the base. Smaller areas of landslide topography appear to be the result of one or more slumps and occur in slopes underlain by Troutdale Formation and Missoula Flood Deposits (Madin, in preparation). Many small areas of landslide topography are difficult to distinguish from QF fan/flow topography, described below.

QF — Fan/Flow Topography

The very high resolution of the LIDAR topographic data also allowed us to see subtle fan-shaped deposits at the mouths of small gullies (Figure 3) that we interpret as the result of one or more debris or earth flows occurring in the gullies. Many small fan-shaped deposits on slopes, typically bounded at the top by a subtle arcuate scarp, were also mapped as fan or flow deposits. The important difference between QF areas of landslide topography and the Qls unit topography is that QF deposits in many instances were produced by dangerous, shallow, rapidly moving flows — the entire gully upstream of an area of mapped QF deposits may be subject to the hazard.

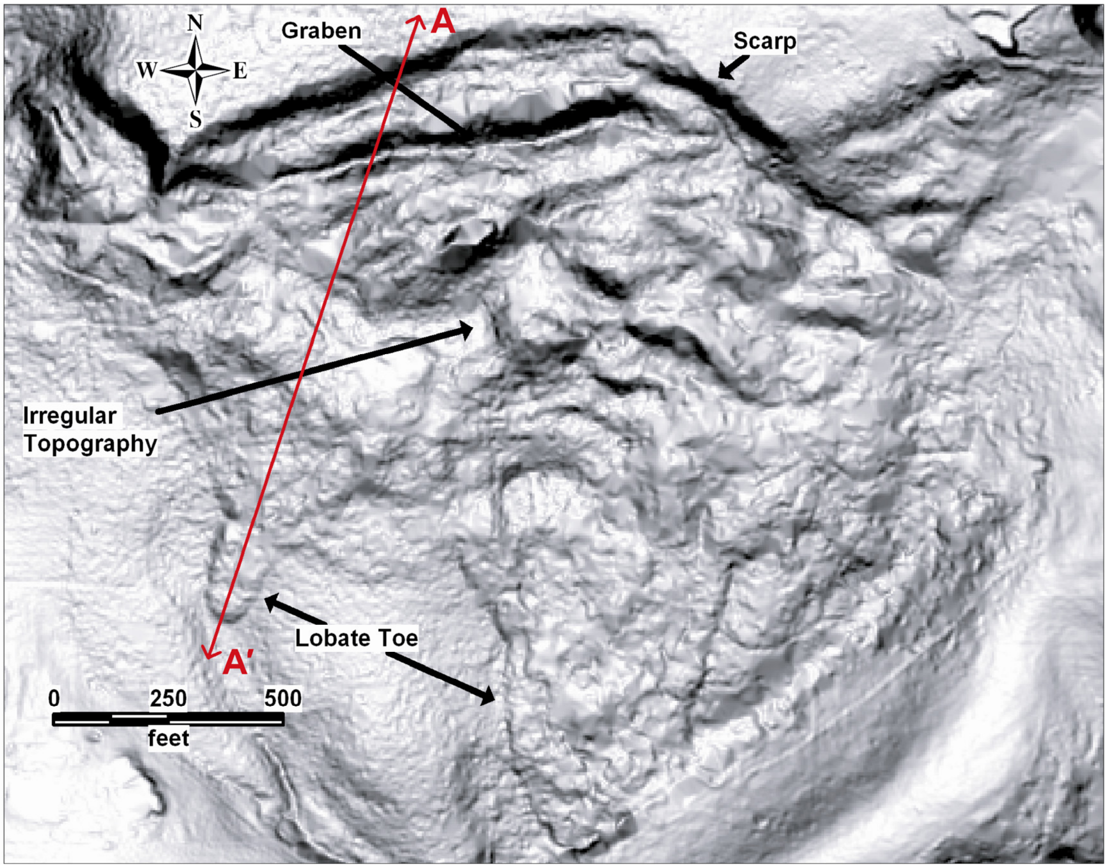

Figure 1. LIDAR slope map of large area of landslide topography, showing scarp, graben, irregular topography, and lobate toe. Red line A-A′ is line of cross section in Figure 2. Site is southeast of the intersection of South End Road and May Road.

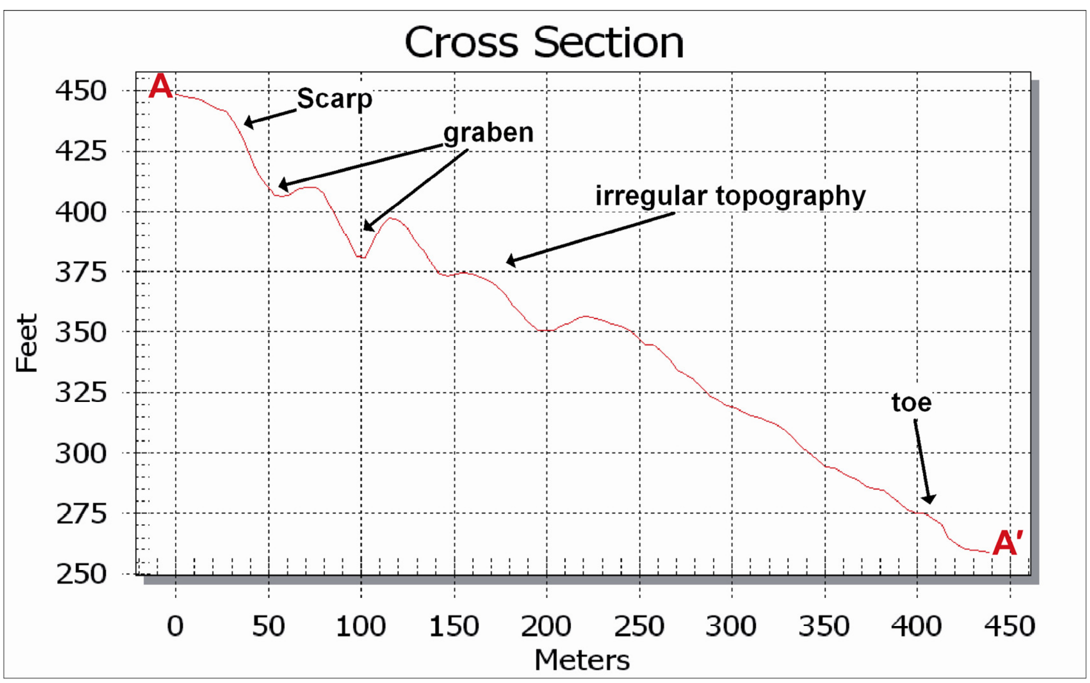

Figure 2. Topographic cross section of landslide topography in Figure 1. Note that the vertical scale is in feet; the horizontal scale is in meters. Vertical exaggeration is 3:1.

QF flow and fan deposits occur on steep slopes and small gullies underlain by Troutdale Formation and Missoula Flood deposits (Madin, in preparation) and are most common in Newell Canyon and the lower reaches of Abernethy Creek.

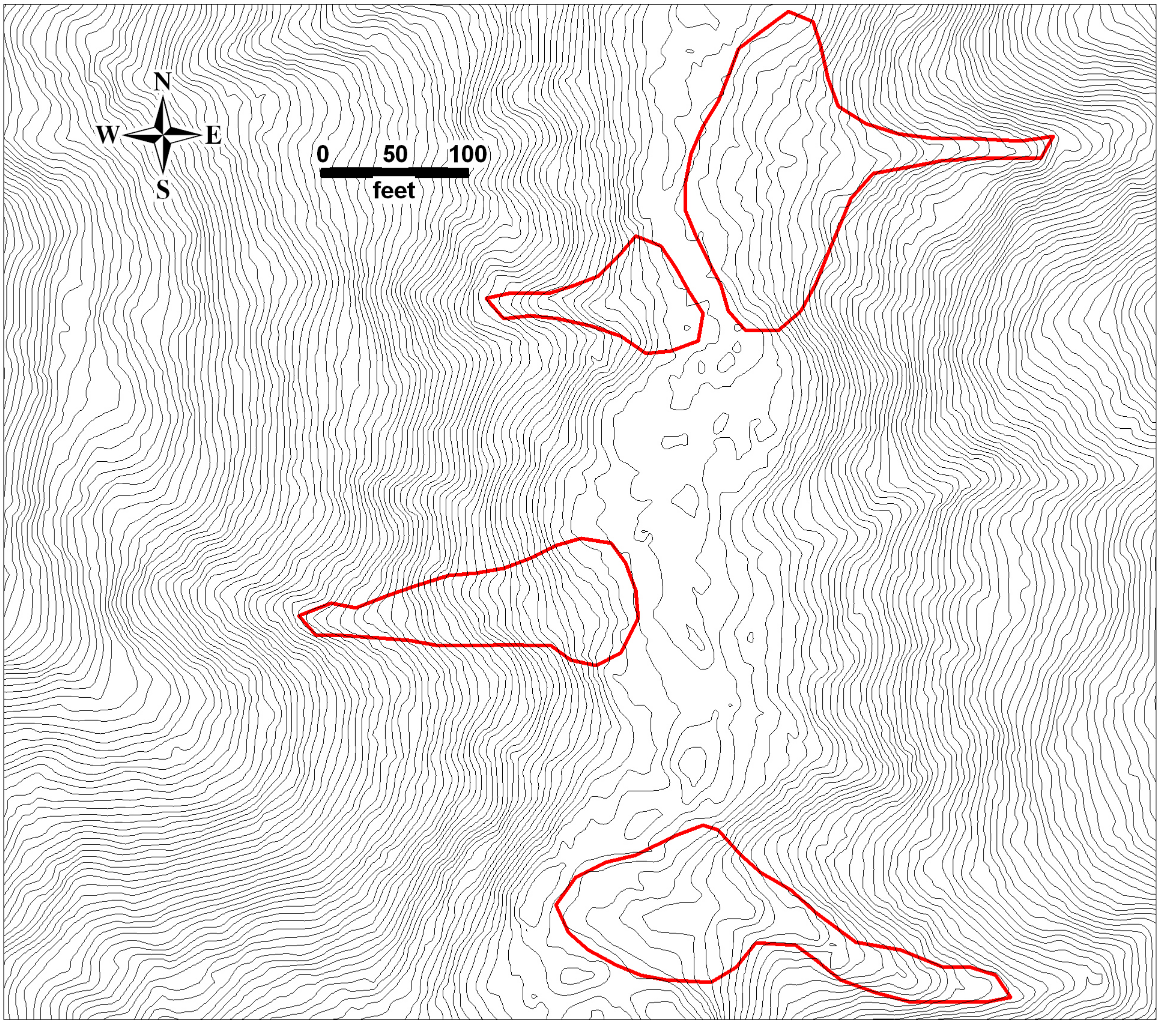

Figure 3. Debris flow or earth flow deposits outlined in red. 1 ft contours derived from LIDAR show subtle fan-shaped deposits at the mouths of small gullies intersecting the floodplain of Newell Creek.

CONCLUSIONS

The Plate 1 map provides a relatively complete inventory of areas of past landslide activity, which in many cases may span hundreds or thousands of years. Not all areas shown on this map are necessarily active landslides. Site specific study of any area identified in the map is required to determine the actual hazard and level of risk.

ACKNOWLEDGEMENTS

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