VOLCANIC HAZARDS TO ENERGY INFRASTRUCTURE—ASH FALLOUT HAZARDS AND THEIR MITIGATION

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This paper is based upon a map being prepared for the U. S. Department of Energy, which show critical elements of the energy infrastructure of the western U. S. (commercial generating facilities, major pawer transmission lines, reservoirs, etc.), together with volcanic centers and their hazard zones. The goal is to integrate graphically the volcanic hazard information with the network of government and commercial energy systems, and to qualitatively assess volcanic risk. The purpose of the study is to identify facilities at risk and to serve as the base for volcanic hazard assessment for new or existing sites. For this paper, we concentrare mainly on the effects of volcanic ash fallout and mitigation of those effects on energy infrastructure.

INTRODUCTION

By the very nature of the resource. geothermal arcas can be affected by earthquakes, landslides, wildfires, hydrothermal explosions and volcanic eruptions. Volcanic activity that can affect geothermal development includes lava flows, pyroclastic flows, volcanic mudflows (lahars), lightning, and ash fallout. During the preparation of a map evaluating the effeers of volcanic activity on the energy infrastructure of the United States, Heiken et al. (1994) found rhar rhe most common and widespread hazard is volcanic ash fallout. The purpose of this brief paper is to evaluate the effects of ash fallour on commercial electrical generating facilities and the power grid.

Saemundsson (1995) covers hazards associated with the exploitarion of high-temperature geothermal fields, including lava flows. The hazards of hydrothermal explosions and landsliding arc covered in papers by Browne (1995) and Flynn (1995).

ASH FALLOUT

The effects of an explosive volcanic eruption and subsequent ash fallouts can be far-reaching. A region's transportation, communication, and energy generation and transmission systems can be paralyzed for months. It can take weeks to months to clear roads and to replace electrical lines, generalors. and switchyards that shorted because they were coated with fine ash. Life is miserable because of swirling clouds of volcanic dust. Internal combustion engines cease to work—air filters clog and moving parts are quickly abraded.

The properties of an ash fallout from a small eruption can be illustrated by the 1986 eruption of Augustine Volcano in Alaska, which sent eruption plumes to the east and south of the volcano, passing over Anchorage. Ash layers a few millimeters to a fer centimeters thick draped thousands of square kilometers like a light snowfall. Anchorage. 280 km NE of the volcano, was showered with ash for 9 days after the eruption began. Median grain size of the ash at Anchorage was around 30 μm and consisted of glass shards broken from the foaming rising magma. glassy lava fragments from the older lava dome, and mineral fragments [Rose et al., 1988). As is the case for most small eruptions like this one, the glass shards were coated with acid condensates and very fine dust; this bonding of the finer ash to groin surfaces may occur because of static charge (Gilbert et al., 1991). Thesc ashes arc typical of those in fallouts from the hundreds of active or dormant stratovolcanoes along the Pacific Rim.

The physical properties of volcanic ashes depend mostly on their relative proportions of glass, mineral. and rock fragments. Also important to the physical properties are chemical compositions of these components and their grain size. Fine-grained glassy volcanic ash is used commercially as an abrasive. but there are few quantitative data available on its abrasive qualities. The hardness of components of a volcanic ash (based on the Moh's Scale used by mineralogists—1=talc; 10=diamond) can be approximated with silica-rich glass–5.5 and minerals ranging from 2 for some clays to 7 for quartz.

The Effects of Ash Fallout on Electrical Generating and Supply Systems

This compilation (Table I) refers only to volcanic eruption phenomena that would most likely affect the energy infrastructure of the western United States—*volcanic ash fallout, flooding, and lightning*. Massive avalanches, pyroclastic flows, and lava flows will most likely affect areas within a few tens of kilometers of a volcano, and within the U. S. would occur only in a few places. e.g., Washington, Oregon, Alaska, and Hawaii. Many of these data are from the May 18, 1980 eruption of Mount St Helens, Washington, for which there were observable effects on the energy infrastructure.

Flooding and Increased Stream Sedimentation

Before the May 18, 1980 eruption of Mt. St. Helens, water levels were lowered 15 m behind three nearby hydroelectric dams as a precautionary measure against overtopping of those dams by mudflows or floods. Volcanic mudflows eventually raised the level of one reservoir 0.6 m. No generators were affected by the St. Helens eruption.

After the May, 1980 eruption of Mount St. Helens, there was increased sedimentation and subsequent flooding and silting up of channels along the Toutle, Cowlitz, and Columbia risers. Sediment erosion from St. Heiena' avalanche and pyroclastic flows was estimated to be at 38 x 10^6 m^3 (50 mcy) per year for the firs; 7 to 10 years after the eruption and wuuld total 760 x 10^6 m^3 (1 bcy) over 50 years. An embankment dam was constructed on the Toutle River to contain much of the material in the avalanche deposit (U. S. Army Corps of Engineers, 1984).

Thr Trojan Nuclear Plant was the most important civil works structure affected by mudflow sedimentation. This plant, with a rated electrical production of 1.13 million kW, is located on the Oregon shore of the Columbia River. 8 km upstream from the mouth of the Cowlitz River. It is cooled by water pumped from the river. Soundings taken a few days after the May 18 eruption showed that as much as 12 m of sediment had been deposited in the channel adjacent to the plant resulting in a minimum bottom depth of 11 m (U.S. Corps of Engineers, 1984). Because the intake structure was located at a depth of only 3 m, this posed no serious threat to the cooling system (Schuster, 1983). In a worst-case scenario modeled by Portland General Electric Company, of an eruption on the WSW-flank of St. Helens, there would still not be any threat to the cooling intake. However. 10 years later the plan! is being closed because of political, not volcanic pressures

In Mexico during the 1942 eruption of Parícutin, volcanic ash-laden floods washed out hydro dams. During the 1975 eruption of Ruapchu, New Zealand, floods filled the tunnel and aqueduct of a hydroelectric power system under construction (Blong, 1984).

Lightning

Within the eruption columns and under eruption plumes close to volcanoes, there can be intense lightning and St. Elmo's fire. In 1963, during the eruption of the Icelandic volcano Surtsey, steam from the US Naval Research Laboratory sailed and flew around the eruption column and plume, measuring potential gradients. At Surtseg lightning was confined to the