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The 1980 Mount St. Helens Eruption

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WILSON, L.J. (1982). The 1980 Mount St. Helens Eruption. *Proceedings of the Shropshire Geological Society*, **2**, 16-18. The volcano of Mount St. Helens is sited above where a crustal plate is submerging into the mantle.

On the 18th May 1980 the northern side of the volcano began to slip, pressure was relieved at the summit and an explosive cloud rose vertically. As the weight of overlying rock on the magma was released, it broke through laterally.

An important idea that has emerged in the last decade is that almost all volcanic liquids are not simple liquids such as water which deform and flow when stressed. Volcanic liquids only flow when the stress exceeds a certain amount. The flow rate is related to the apparent viscosity. Lava/ash/mud/debris flows all have the property of having a threshold before they will flow.

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The Earth is an active planet. Motions in the mantle have an effect on the crust causing it to be broken up into sections. New material comes up from the mantle mainly along the centres of ocean basins and in order to conserve surface area, in places such as island arcs and continental margins, part of the crust is pushed down, to be recycled in the mantle. At the boundary of continental and oceanic plates, new magma is generated where the down-going plate rubs past the floating plate and a mixture of basaltic material and sediment is reworked and rises, sometimes to be erupted at the surface. Mount St. Helens is sited above a location where a crustal plate is submerging into the mantle.

Very basic material, rich in metals, low in silica, tends to produce either long lava flows or sinter cones or scoria cones. A low viscosity magma (runny) generally has an appreciable amount of gas in it. Gas bubbles form, rise through the magma and may coalesce to form bubbles up to 10 m (*sic.*) across. Such a bubble bursting at the surface produces a spray of fragments called pyroclasts. The low viscosity is a chief reason for the violence of such eruptions.

The Mount St. Helens eruption occurred in a more viscous magma so gas bubbles have difficulty diffusing and do not coalesce. The many small bubbles can be seen in lumps of cooled magma. In basaltic eruptions such as Mount Etna or some Icelandic volcanoes, some gas is released carrying material nigh into the air, but viscous lava flows travel considerable distances across land. In some acid liquids (high in silica) the viscosity is so high that the magma does not disrupt at the surface. However in such magmas large amounts of gas are dissolved. These form little bubbles and tear the magma apart when they connect to form a continuous gas space. At the surface these large areas of gas force large blobs of magma out in a continuous jet, as in the eruption of Hekla in Iceland.

An eruption cloud can be up to 10 km high and its speed is such that atmospheric gas is taken up and mixed with the pumice. The pumice is hot and heats the air which decreases in density and becomes more buoyant. Provided enough air is dragged in, the mixture becomes less dense than the air and drags pumice with it until the weight of individual pieces overcome the drag and they fall out of the cloud to form a layer over the ground. A short phase of the Mount St. Helens eruption was of this type.

Dispersal of the pumice can be studied to derive cloud height. This is useful because the height of the cloud top is a function of the rate at which magma is squirted out of the vent (height is proportional to the root of eruption rate).

In certain circumstances convection clouds are not stable; they become overloaded with pumice and collapse back to the ground. The resulting deposit is an ignimbrite and the ground cloud which produces it is a pyroclastic flow. This is a very dangerous deposit because its speed can be as high as 300 m per sec. Small scale pyroclastic flows occurred on Mount St. Helens.

Mount St. Helens is one of a group of volcanoes about 70 km apart in the Cascades Range which is 7 million years old. Volcanic events started about 1 million years ago. Mount St.

Helens sits on the roots of an earlier volcano about 57 thousand years old. The last recorded activity was 1842-57. The material is very acid dacite, some basaltic andesite, some basalt and is therefore very viscous and liable to explosive eruptions.

The first signs of activity were on 20th March 1980 when a fairly major earthquake was detected at some depth in the crust about 20 miles north of St. Helens. This was probably associated with new magma coming up into the base of the volcano. Nothing happened until 27th March when the first small explosions began at the summit. There were many smaller earthquakes during that week. Small explosions continued in the following weeks and a well developed crater appeared.

Prior to the beginning of the major phase of the eruption no completely new magma was erupted onto the surface although it was present. This was important because when predicting eruptions one looks for new magma at the surface; therefore no warning was given until the last moment, when new magma appeared explosively on the 18th May.

From the beginning of April onwards it became obvious that a bulge was appearing on the northern face together with large fissures. The northern face already contained a major fault. Observers interpreted this as a likely site for a debris avalanche and possibly for some explosive release of magma. In retrospect it was known that volcanoes in the USSR had produced sideways directed eruptions. Also, since the eruption, theoretical modelling has shown that when the side of a volcano falls off, there will be an extensive explosive wave. The U.S. Geological Survey was monitoring the northern face and one of their observers was killed, together with 50 other people who should not have been there, in the 18th May eruption.

On the 18th May 1980 the northern side began to slip, pressure was relieved at the summit and an explosive cloud rose vertically. As the weight of overlying rock on the magma was released it broke through laterally. A series of clouds containing large blocks of rock came out of the side, some at a vertical angle, some along the ground.

So many photographs were taken that a complete chronological record of the explosion clouds has been built up. From these a model can be constructed. The envelope of the cloud is measured from a fixed point on successive frames. If the scale is known, the distance scale can be calculated. The time the photographs were taken gives the time scale and thus the velocity can be calculated. Rates of change of velocity give the acceleration and, since acceleration is a measure of force, the forces can be calculated. The peak velocity of the magma was 120 m per sec. The sideways directed jets travelled some 12 km demolishing forests and climbing over ridges. By measuring the height of tree stumps the shape of the arc followed by the base of the cloud gives its speed.

Much of the snow melted in the eruption and formed mudflows which ran down into the Columbia River blocking the navigable channel. The wave of ash entered Spirit Lake causing large explosion craters by heating the ground water.

Two to three minutes after the lateral blast the volcano changed to a more conventional style eruption with most of the magma emerging vertically to form a typical cauliflower-shaped eruption cloud. This phase lasted 6-9 hours. Although impressive, the cloud was relatively innocuous because the ash was cool by the time it reached the ground. In contrast, the lateral blast was still incandescent after several kilometres.

After the eruption about a third of the missing volume of the volcano slid away in the landslide in the first few minutes of the 18th May eruption. During the next 8-9 hours when the vertical eruption was taking place the top of the mountain was bored out and material drawn into the eruption cloud. This caused most of the destruction of the peak, about 400 m. After the main blast had stopped late on the 18th a residual discharge of magma was occurring forming the bulbous dome 300 m across in the crater which at this time was 1500 m across.

Activity since the 18th May event has fallen into two phases. One phase involves the slow extrusion of new magma and the other phase consists of explosions in the new magma which break up the dome. From this either a small convection cloud is formed carrying fine ash away or a cloud of pumice and gas cascades down the hillside forming a dense ground-hugging cloud or pyroclastic flow.

The dome grew from 18th May to 12th June, when it exploded. Mainly ash was thrown up into the air clearing the vent. New magma came in to form a new dome which grew until 22nd July, when it exploded sending a cloud of pumice down the mountainside to form a layer of ash and pumice on the flanks. Another dome blew up on 5th August producing smaller flows of ash and pumice. On 16th October the last dome was destroyed and activity continued for three days. Since 18th October a new dome has been growing slowly and intermittently in the centre of the crater area and has now filled the hole and bulges out onto the surrounding terrain. A new pulse of magma arrives about every six weeks.

Considerable investigative work has since been carried out on such factors as depth, structure, grain size, temperature and mechanics of the deposits on the slopes.

A very important idea that has emerged in the last decade is that almost all volcanic liquids are not simple liquids such as water which deform and flow when stressed. Volcanic liquids only flow when the stress exceeds a certain amount. The flow rate is related to the apparent viscosity. Lava/ash/mud/debris flows all have the property of having a threshold before they will flow.

In the field the thickness of deposits can be measured together with their density. From known slopes and gravity, yield strength can be calculated. Viscosity can be measured in the field by simple means and shows that five days after the flows were emplaced they already had an order of magnitude greater viscosity than when they were moving; three weeks later they had 2.5 orders of magnitude greater viscosity.

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D.M. Jones