The nature of vulcanicity: forms and causes

What you need to know
The nature of vulcanicity and its relation to plate tectonics
The forms of volcanic hazards
The spatial distribution, magnitude, frequency, regularity and predictability of hazard events.

Normal Resource Package on Volcanic Hazards:
https://583daeb7-8767-411c-9387-a7803a5f9622.filesusr.com/ugd/927b29_3c3d11725a2645bba46b8704ce558989.pdf

Introduction:

Ninety five per cent of active volcanoes occur close to the major tectonic plate margins, the rest occur in intraplate locations and are often associated with hotspot activity. On average, one or two eruptions per year originate from no previous historical activity worldwide.

The nature of volcanic hazards depends upon the type of material extruded and the power of the volcanic eruption.

The nature of the three main types of magma:

Magma type	Nature
Rhyolitic	Rhyolitic magma is viscous ('sticky'). High viscosity is related to high silica content (65 to 75 per cent). Silica originates from the destruction and melting of plates. Rhyolitic magma traps gas and coagulates up in the vent of the volcano. Pressure builds up over time until it is suddenly released in a catastrophic eruption. Lavas have relatively low temperatures of between 650 and 900°C, flow slowly and can damage property. Large explosive eruptions can be highly dangerous.
Andesitic	Andesitic magma has intermediate viscosity, with intermediate silica content (55 to 65 per cent). Lavas have temperatures between 800 and 1000°C. Eruptions can be very destructive, especially when the volcano has been dormant and hasn't erupted recently.
Basaltic	Basaltic magma has a low-silica content (45 to 55 per cent) and is relatively fluid because of its low viscosity (low gas content). Eruptions are effusive (non-explosive) and regular. Lavas have temperatures between 1000 and 1200°C and can flow quickly over long distances.

Volcanic hazards

There are a range of volcanic hazards, which include the following:

- **nuées ardentes/pyroclastic flows**
- **lava flows**
- **mudflows/lahars**
- **pyroclastic and ash fallout**
- **gases/acid rain**
- **tephra**

Large angular fragments (volcanic blocks) and aerodynamic volcanic bombs ejected during explosive eruptions are known as **pyroclasts**. These volcanic rocks can crush people, buildings and cars when they fall close to the volcano. Material that travels further tends to be smaller in size and is known as **tephra** if it is over 2mm in diameter or **volcanic ash** (less than 2mm), this material generally causes fewer deaths, although it can cause damage on a larger scale.

Clouds of **tephra** and **volcanic ash** ejected from the volcano can rise up and form an eruption column up to 45km into the atmosphere. It can then be transported on the wind over long distances. Tephra and ash falls will cover all surfaces including buildings, roads and farms over thousands of kilometres and cause major disruption to everyday life. The weight of ash falls can collapse buildings through roof loading; this is a fairly rare occurrence and tends to happen when over ten centimetres of ash accumulates. *This was the case when in August 2010 and January 2014 when Mount Sinabung erupted and blanketed cities in North Sumatra. Ash is abrasive and can cause corrosion of metals.* It may cause breathing problems for humans and animals and will blanket vegetation, preventing photosynthesis and plant growth, ultimately causing crop failure.

If the eruption column collapses a dangerous fluid-like **pyroclastic flow** composed of hot rocks, ash and volcanic gases can travel down the flanks of the volcano. Pyroclastic flows are the most destructive and deadly volcanic hazards. They can move at hurricane-force speeds of up to 200 metres per second with temperatures up to 1000°C often incinerating everything in their path. People cannot outrun pyroclastic flows. Trees are stripped of their bark and can be knocked down over ten or more kilometres away from the volcano.

Lateral volcanic eruptions occur when the summit crater is blocked or when a landslide or a lava dome collapses and exposes the underlying magma. This can cause a particular type of pyroclastic flow known as glowing avalanches or ***nuée ardentes*** (in French), which contain denser material and may only travel 50km from the volcano.

Lahars are dangerous mudflows and they represent the second greatest threat to humans after pyroclastic flows. When water from rivers, snow-capped volcanoes or crater lakes mixes with rock fragments and volcanic ash, it combines to form fast-flowing mudflows or lahars that rush down the slopes of a volcano. In steep areas lahar speeds can reach 200 km per hour and decelerate in lowland river valleys. Lahars can also be formed when rainfall occurs after an eruption.

Effusive eruptions are associated with constructive plate margins, hotspots and the formation of shield volcanoes. These volcanoes form from low-viscosity, basaltic lava, which travel over long distances. Slow moving lava flows are common in Hawaii. Mauna Loa, Kilauea and Hualalai are the three active volcanoes on the Big Island. Of these, Kilauea has been erupting continuously since 1983, which makes it one of the most active volcanoes in the world. It has inundated homes in Kalapana town and destroyed over 200 structures including the Hawai`i Volcanoes National Park visitor centre.

As well as erupting rock, tephra and ash, volcanoes eject huge amounts of **volcanic gases**. These gases include hydrochloric acid, which condenses with water vapour and is rained out, as well as sulphur dioxide. Sulphur dioxide emissions can cause acid rain, ozone depletion and air pollution. *Mount Pinatubo ejected between 10 and 20 million tonnes of sulphur dioxide gas into the atmosphere during the volcano's eruption on 15 June 1991.*

When sulphur dioxide mixes with water and oxygen in the atmosphere it converts to aerosol particles of **sulphuric acid**. Sulphuric acid can trigger ozone depletion in the stratosphere. It can also reflect sunlight, reducing the amount of solar radiation that reaches the Earth. Over time, sulphuric acid droplets will fall back to Earth as acid rain. This can produce volcanic smog and damage or destroy vegetation. It can also cause breathing problems for downwind populations.

Spatial distribution of volcanic hazards

The frequency of volcanic eruptions depends largely on their location.

- **Composite volcanoes**, located on destructive plate margins, tend to erupt infrequently due to the viscous nature of rhyolitic or andesitic magma. Plates descend deep into the mantle and melt due to the surrounding heat and friction from the subduction process. The less dense magma, rich in silica formed here, rises to the surface to create composite volcanoes with a gaseous, explosive nature. The accumulating layers of lava – ash – lava – ash … gives these volcanoes their name ('composed' of many layers).
- **Shield volcanoes**, located on constructive plate margins or hotspots, tend to erupt frequently due to the fluid nature of basaltic magma. Over a hotspot, hot and runny basaltic magma rises and breaks through at the surface. The lava travels long distances before it cools forming low, wide volcanoes (like a 'shield' lying on the ground).

"Huge eruptions are associated with volcanoes that have not erupted in living memory. Mount Pinatubo, the stratovolcano on the island of Luzon in the Philippines, had not erupted for 400 years before it erupted in 1991 and therefore its magnitude was cataclysmic. It was the second largest volcanic eruption of the 20th Century and measured 6 on the Volcanic Explosivity Index (VEI), a relative measure of the explosiveness of volcanic eruptions. 42 eruptions with a VEI 8 or above have occurred in the past 36 million years, the most recent being the Oruanui eruption of Taupo Volcano around 25,360 years ago. It was the largest eruption in the history of New Zealand and generated 1,170 km^3 of volcanic deposits."

VEI	Ejected volume	Eruption type	Qualitative description
0	< 10,000 m^3	Hawaiian	Effusive
1	> 10,000 m^3	Hawaiian/Strombolian	Gentle
2	> 1,000,000 m^3	Strombolian/Vulcanian	Explosive
3	> 10,000,000 m^3	Vulcanian/Pelean	Severe
4	> 0.1 km^3	Pelean/Plinian	Violent
5	> 1 km^3	Plinian	Cataclysmic
6	> 10 km^3	Plinian/Ultra-Plinian	Paroxysmal
7	> 100 km^3	Ultra-Plinian	Colossal
8	> 1,000 km^3	Supervolcanic	Terrific

The regularity and predictability of hazard events

Vulcanologists have been increasingly able to predict when volcanoes are likely to erupt. They map and date previous lava flows and monitor the current state of the volcano. Ground deformation is measured using tiltmetres, GPS and ground surveying and is a sign of rising magma beneath the volcano. Increasing seismic activity as subsurface rocks are disturbed by rising magma and rising concentrations of volcanic gases such as sulphur dioxide can also forewarn of impending surface volcanic activity.

Most countries with active volcanoes located in them have national monitoring stations.

The Montserrat Volcano Observatory is funded from the U.K. Overseas Development Administration and the Government of Montserrat and advises islanders of the current hazard level for the Soufriere Hills Volcano. Sometimes volcanoes do erupt without warning. Mount Ontake was being monitored by the Japan Meteorological Agency but erupted unexpectedly in September 2014 killing 57 hikers who were found climbing the summit.