

Historia de la Volcanología

Clase 1

Introducción y reseña histórica

Evolución de las ideas: de las leyendas clásicas a las teorías modernas

Volcanología de campo y experimental

Erupciones históricas

Thera (Santorini) 1650 AC; Vesuvio 79 DC; Tambora 1815; Krakatoa 1883, Montagne Pelée 1902, Surtsey, 1963; St Helens 1980, Nevado del Ruíz 1985, Pinatubo 1991

Perspectivas y Temas de actualidad

Historia de la Volcanología

Introducción y reseña histórica

Fuego y viento en el mundo antiguo

Anaxágoras

siglo V AC

vientos internos de la Tierra

Aristóteles

384-322 AC

fuego interno

Séneca

65 AD

combustión interna

Plinio El Viejo

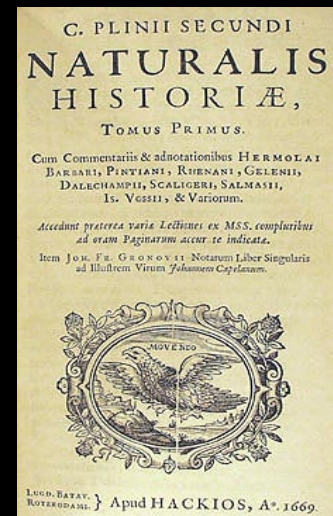
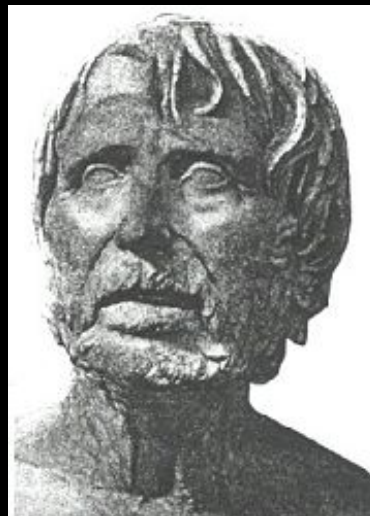
79 AD

primera expedición científica a un volcán

Plinio El Joven

79 AD

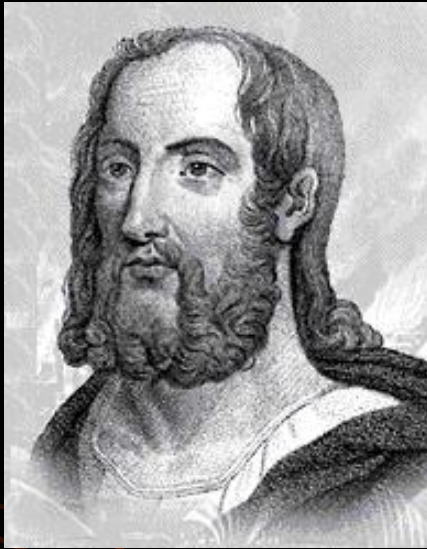
primer relato visual de una erupción



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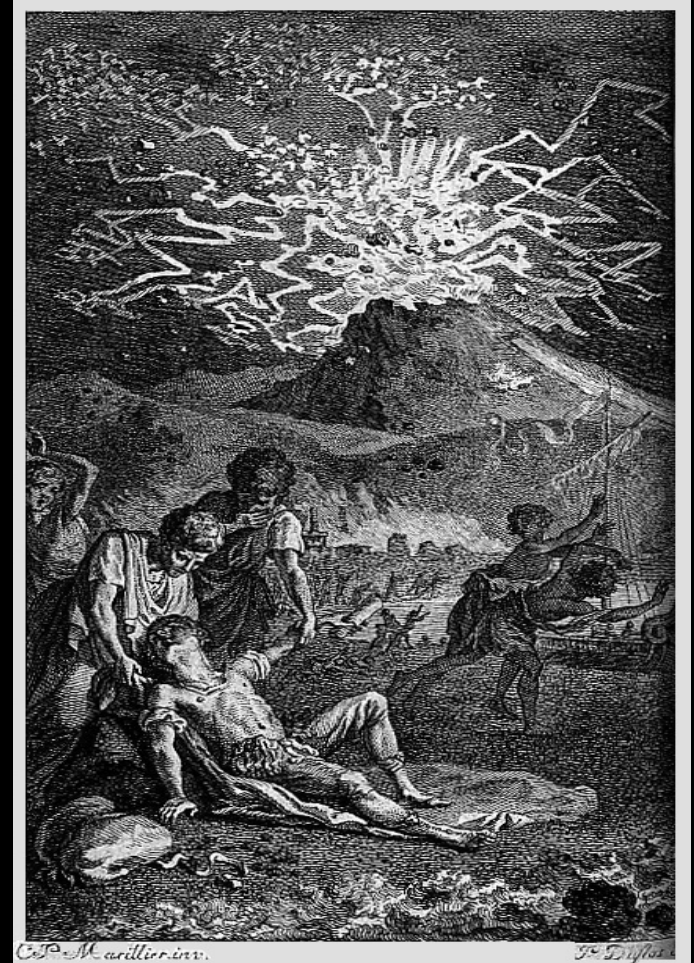
Introducción y reseña histórica

Plinio El Jóven



...veniva prima spinta verso l'alto da un soffio d'aria e poi, improvvisamente, come vinta dal proprio peso, ricadeva e si espandeva lateralmente"
Il flusso di magma forma una colonna eruttiva densa e pesante e non può più innalzarsi sopra il vulcano
Formazione correnti di miscele di gas e particelle solide
Surge: fase gassosa abbondante
Flussi piroclastici: miscela più densa
Esse scendono lungo le falde del vulcano
Le particelle sono trasportate e sedimentate da un flusso molto ricco di gas ...

Pompei
Calchi di un gruppo di persone soffocate dalla cenere



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Neptunistas y Plutonistas en el Renacimiento

<i>R. Descartes</i>	<i>1650 AD</i>	<i>núcleo incandescente de la Tierra</i>
<i>A. Kircher</i>	<i>1665</i>	<i>primer mapa global de volcanes</i>
<i>F. D'Arezzo</i>	<i>1670</i>	<i>primeros experimentos de fusión de rocas</i>
<i>W. Hamilton</i>	<i>1776</i>	<i>pionero de la volcanología de campo</i>
<i>A.G. Werner</i>	<i>1780</i>	<i>volcanismo originado en el mar (neptunismo)</i>
<i>J. Hutton</i>	<i>1785</i>	<i>magma en la corteza (plutonismo)</i>
<i>L. von Buch</i>	<i>1799</i>	<i>minerales por cristalización de magma</i>



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Neptunistas y Plutonistas en el Renacimiento

Neptunistas europeos observaron principalmente volcanes extintos cercanos a potentes secuencias sedimentarias marinas que contenían carbón (e.g. A.G. Werner). La teoría 'geognóstica' de Werner coincidía con las ideas bíblicas contenidas en libro del Génesis donde está la idea del 'mar primitivo'

•Plutonistas ingleses (e.g. J. Hutton y su 'Theory of the Earth' y más tarde J. Playfair y su 'Illustration of the Huttonian Theory of the Earth') basaban su teoría en argumentos físicos y químicos. Sin embargo, aun pensaban que las rocas volcánicas se formaban al interior de la Tierra cerca de las grandes intrusiones (idea precursora del metamorfismo).

•Ambas teorías -y el áspero debate que motivaron- se construyeron sin observar específicamente eventos volcánicos contemporáneos y evidentemente estaban influenciadas por las creencias vigentes en la época.

➤ Deducción (Descartes) vs. Inducción (Bacon)

➤ Método hipotético-deductivo (Popper)..datos!



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Introducción y reseña histórica

Hacia las teorías modernas

El aporte de la química y la física desde el siglo XIX

<i>A. von Humboldt</i>	<i>1822</i>	<i>cadena de volcanes y tectónica profunda</i>
<i>C. Darwin</i>	<i>1835</i>	<i>crystal settling y diferenciación magmática...</i>
<i>S.D. Poisson</i>	<i>1835</i>	<i>alta presión y solidificación a alta T°</i>
<i>W. Hopkins</i>	<i>1839</i>	<i>decompression melting</i>
<i>R. Bunsen</i>	<i>1851</i>	<i>magma mixing</i>
<i>O. Fisher</i>	<i>1881</i>	<i>corrientes de convección internas</i>
<i>A. Wegener</i>	<i>1912</i>	<i>deriva continental</i>
<i>A. Holmes</i>	<i>1916</i>	<i>basaltos generados por fusión de peridotita</i>
<i>N.L. Bowen</i>	<i>1928</i>	<i>cristalización fraccionada y serie de Bowen</i>

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Hacia las teorías modernas



Ch. Darwin

Darwin presencia la erupción de 1835 del volcán Osorno:

'durante la noche del 19 de Enero de 1835, el volcán Osorno se pone en erupción...y a las 3 de la madrugada asistimos al más magnífico de los espectáculos. Llamas rojas, negros objetos proyectados incesantemente al aire, que después caen. El fulgor es suficiente para iluminar el mar. Durante la mañana el volcán recobra su tranquilidad'

...y también realiza un estudio del volcán

Antuco:



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Volcanología de campo y experimental

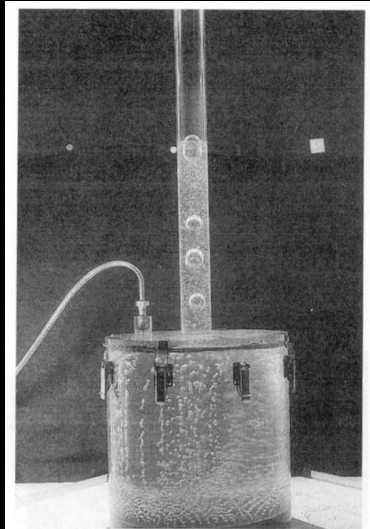
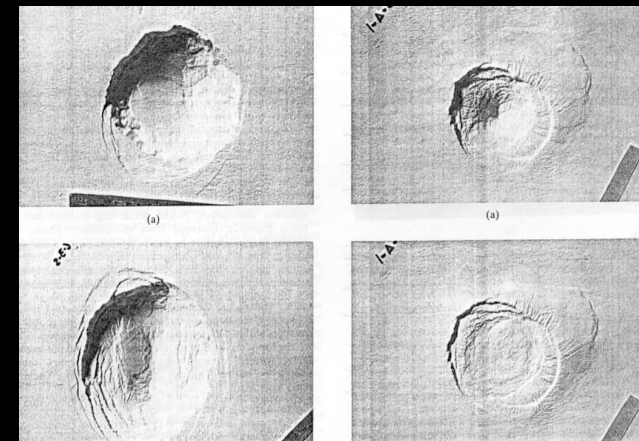
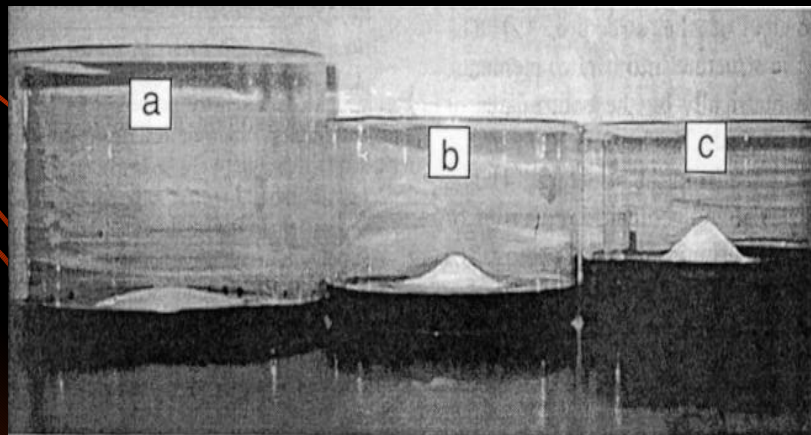
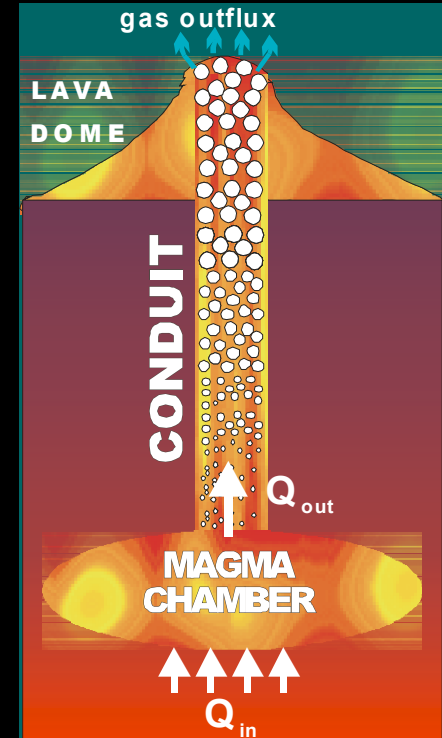


FIGURE 13 Laboratory volcano with a more viscous viscosity oil (1 Pa s), analogous to a Strombolian eruption. (Reprinted with permission from Vergnolle and Jaupart, 1990.)

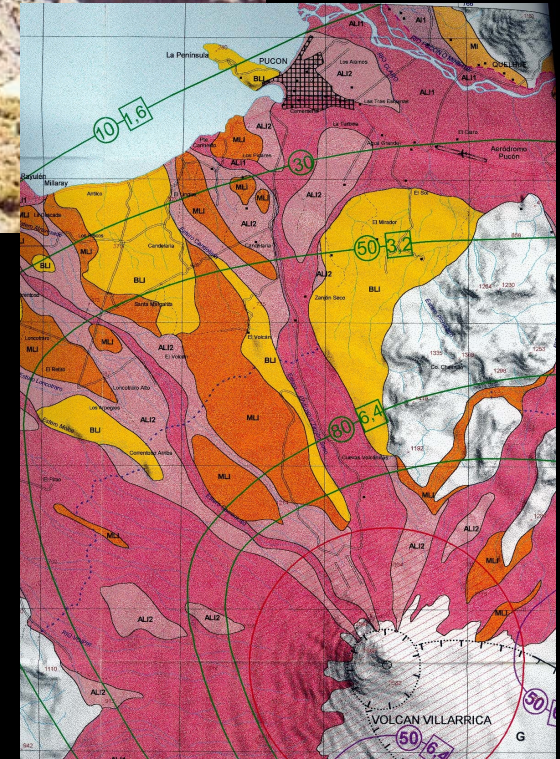
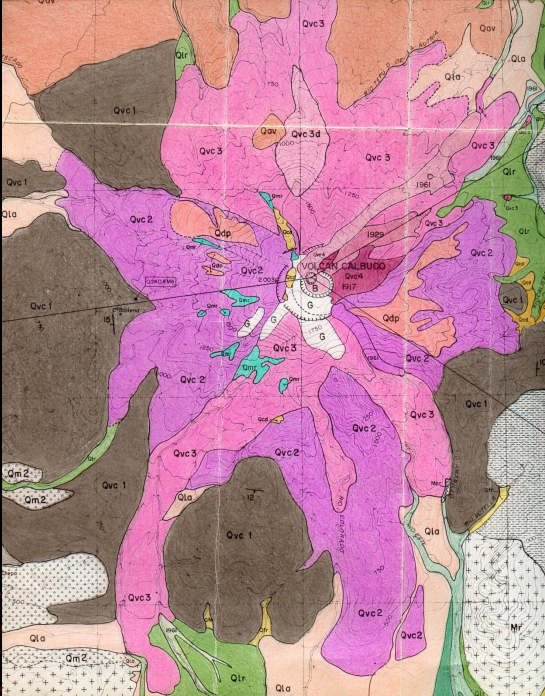


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02[1]Etna (strombolian)



Volcanología de campo y experimental



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Erupciones históricas que han marcado la historia del hombre y la Volcanología

Thera (Santorini) 1650 AC

Vesuvio 79 DC

Tambora 1815

Krakatoa 1883

Montagne Pelée 1902,

Surtsey, 1963

St Helens 1980

Nevado del Ruíz 1985

Pinatubo 1991

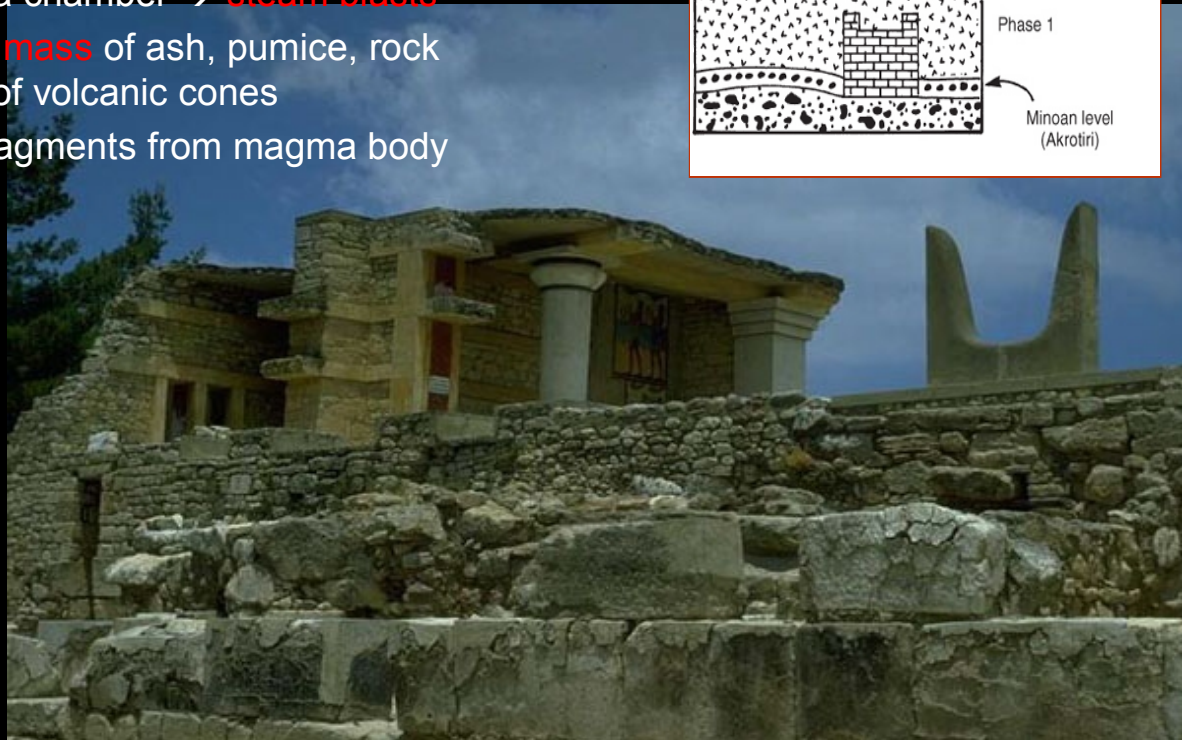
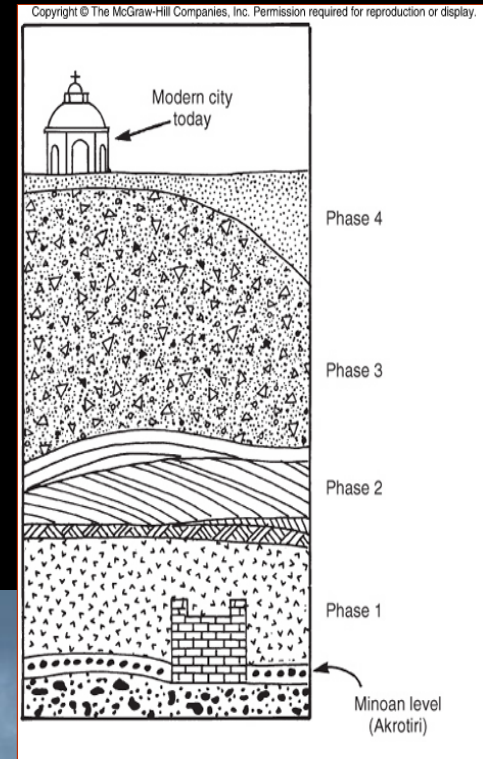
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Thera (Santorini) 1650 AC

Fin de la era Minoica y fin de la Edad del Bronce

Around 1628 B.C.E. Santorini underwent series of eruptions:

- 6 m thick layer of air-settled **pumice**
- Several meter thick deposits from hot water when seawater reached magma chamber → **steam blasts**
- Up to 56 m thick **jumbled mass** of ash, pumice, rock fragments from collapse of volcanic cones
- Layers of ash and rock fragments from magma body **degassing**

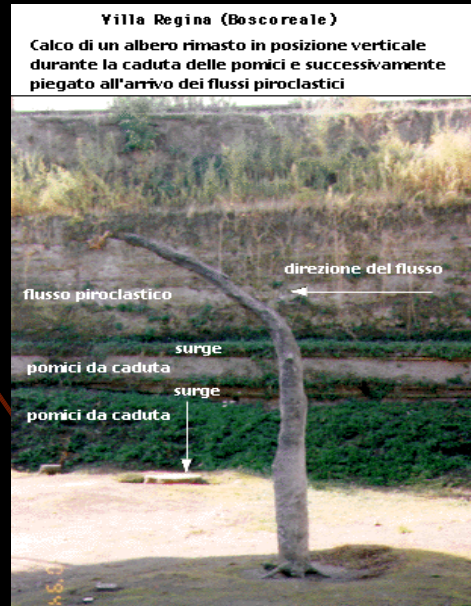
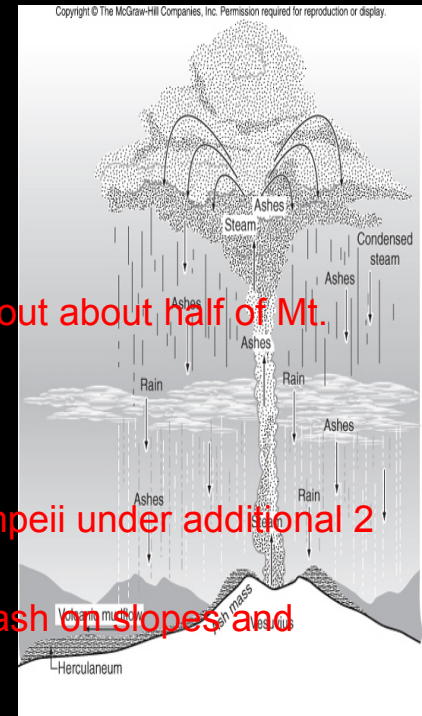


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Vesubio 79 DC

Pompeya y Herculano y las erupciones 'plinianas'

- Cities of Pompeii and Herculaneum buried by massive eruption which blew out about half of Mt. Vesuvius
- Clouds of hot gas (850oC) and ash enveloped city, burying many in pumice
- Many tried to escape near sea, but were found buried by pyroclastic flows
- Last phase of eruption blew ash up to 32 km in the atmosphere, buried Pompeii under additional 2 m of debris
- Water from erupted ash cloud condensed and fell back as rain, mixed with ash on slopes and created mudflows (lahars) that buried city of Herculaneum up to 20 m deep
- 4,000 people killed



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Tambora 1815 AD

The 'year without summer'

- At least 6 months and probably about 3 years of increased steaming and small phreatic eruptions preceded the 1815 Tambora eruption, the largest in historical time.
- A moderately large explosive eruption occurred on 5 April 1815, from which ash fell in east Java and thunderlike sounds were heard up to 1,400 kilometers away.
- A still larger eruption occurred on 10-11 April, beginning as 'three columns of fire rising to a great height' and ultimately ejecting about 50 cubic kilometers of magma (dense rock equivalent).
- The eruption left a deep summit caldera where previously a much higher stratovolcano had stood.
- Earthquakes were felt as far away as Surabaya (500 kilometers), possibly reflecting the caldera collapse.
- In parts of Europe and in North America, 1816 was known as 'the year without a summer'. M. Shelley wrote Frankenstein.



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Krakatoa 1883 AD

Calderas, explosiones y tsunamis

- A series of cataclysmic explosions began at mid-day on August 26, and ended on August 27 with a paroxysmal eruption.
- On this day, the northern two-thirds of the island collapsed beneath the sea, generating a series of devastating pyroclastic flows and immense tsunamis that ravaged adjacent coastlines.
- The events that began on August 26 killed over 36,000 people and destroyed hundreds of coastal villages and towns.

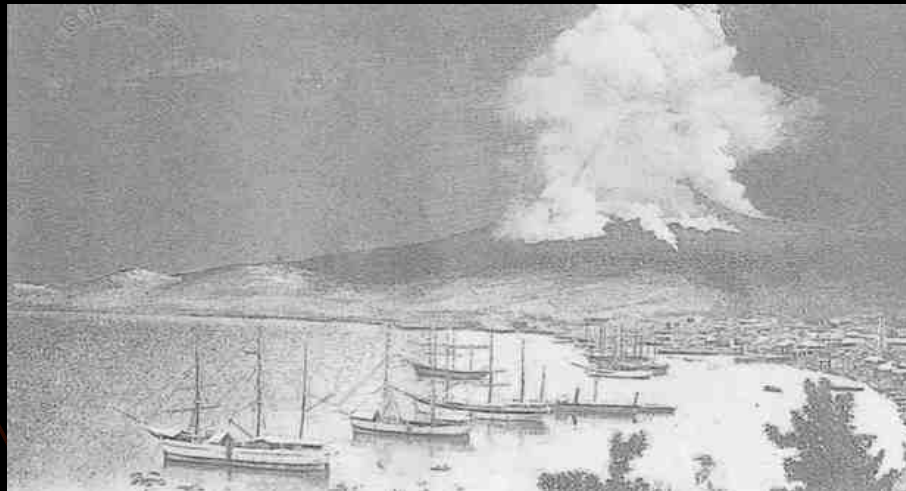
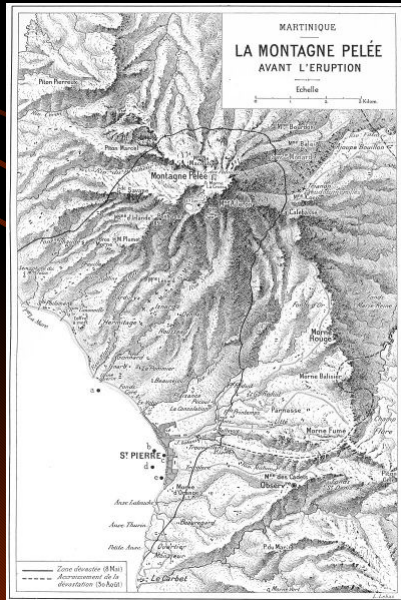


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Montagne Pelée 1902 AD

Colapso de domos y 'nubes ardientes'

- An extremely destructive eruption accompanied the growth of a dome at Mount Pelée in 1902.
- The coastal town of St. Pierre, about 4 miles downslope to the south, was demolished and nearly 30,000 inhabitants were killed by an incandescent, high-velocity ash flow and associated hot gases and volcanic dust.
- Only two men survived; one because he was in a poorly ventilated, dungeon-like jail cell and the other who somehow made his way safely through the burning city.

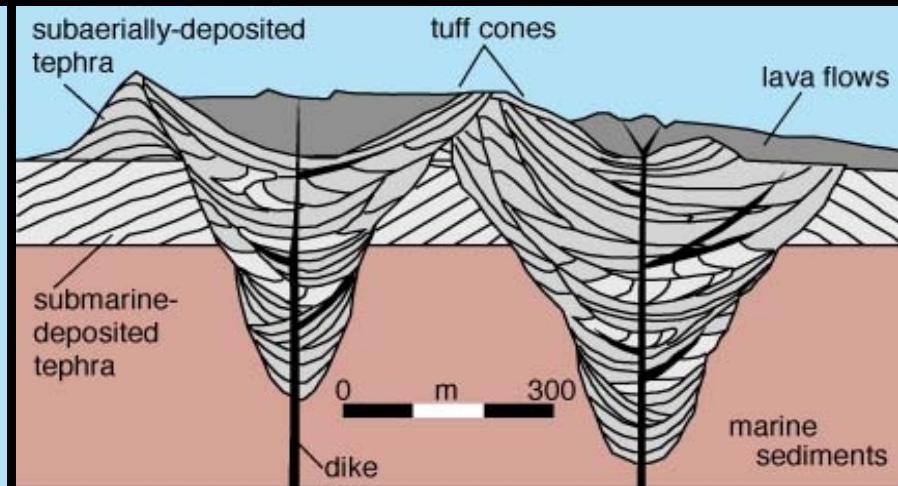
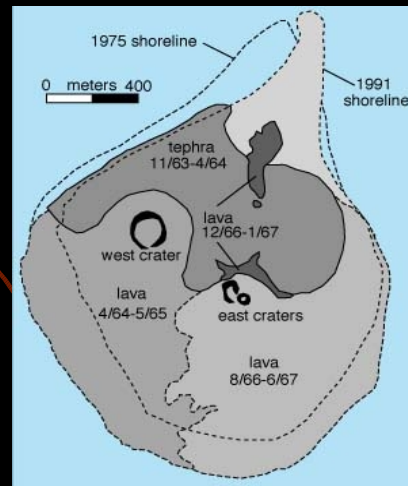
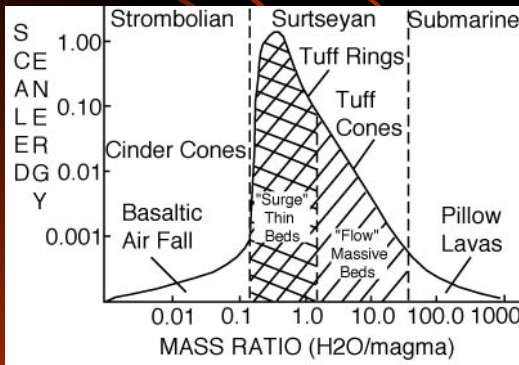


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Surtsey 1963 AD

Volcanismo explosivo subacuático

- The Surtsey eruption is among the longest eruptions to have occurred in Iceland in historical times (1963-1965)
- Explosive phases characterized the Surtsey eruption in the beginning, and due to the rapid cooling effects of the sea, the hot magma transformed into tephra. The tephra production was tremendous, and an island had already been formed the day after
- On April 4, 1964, a lava eruption commenced in the crater on Surtsey. The lava formed a broad lava shield that was, in the end, 100 m thick at the crater



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Saint Helens 1980 AD

Explosiones laterales, avalanchas y evolución de un domo

The activity began on March 15 with an increasing number of earthquakes beneath the volcano. The first phreatic eruption occurred on March 27, coincident with a high level of seismic activity. A summit crater formed and continued to enlarge for 2 months. Tephra erupted during this time was composed of pulverized old rock, no new magma; however, viscous magma was intruding high into the cone, forming a cryptodome whose surface manifestation was the famous "bulge" on the north flank. This bulge grew outward at a maximum rate of 8.2 feet per day (2.5 meters per day) with no acceleration or other significant change until the climactic eruption



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Saint Helens 1980 AD

Explosiones laterales, avalanchas y evolución de un domo

The May 18 eruption was apparently triggered by a magnitude 5.1 earthquake that caused the unstable north flank to fail as three great retrogressive landslide blocks. The **landslides** developed into a complex **debris avalanche** that sped down the valley. **Unloading** of the volcano by these landslides relieved pressure on the **cryptodome** and its associated hydrothermal system; the depressurized gases violently expanded and generated a northward-directed **lateral explosion or blast**. A **pyroclastic surge** or flow developed from the blast and fanned outward from the volcano, felling trees and killing most wildlife in a 550-square-kilometer area.



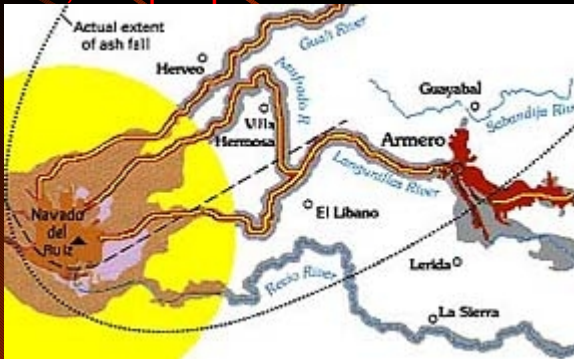
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Nevado del Ruiz 1985 AD

Fusión de hielo y lahares

After nearly a year of minor earthquakes and steam explosions, the volcano exploded violently on November 13, 1985. The initial blast began at 3:06 p.m., and two hours later pumice fragments and ash were showering down on Armero.

At 9:08 p.m., magma began to erupt from the summit crater for the first time (all previous eruptions were steam explosions). The violent ejection of this molten rock generated hot pyroclastic flows and airfall tephra that began to melt the summit ice cap. Unfortunately, a storm obscured the summit area so that most citizens were unaware of the pyroclastic eruption. Meltwater quickly mixed with the erupting pyroclastic fragments to generate a series of hot lahars. One lahar flowed down the River Cauca, submerging the village Chinchina and killing 1,927 people. Other lahars followed the paths of the 1595 and 1845 mudflows. Traveling at 50 kilometers per hour, the largest of these burst through an upstream dam on the River Lagunillas and reached Armero two hours after the eruption began. Most of the town was swept away or buried in only a few short minutes, killing 23,000 people.

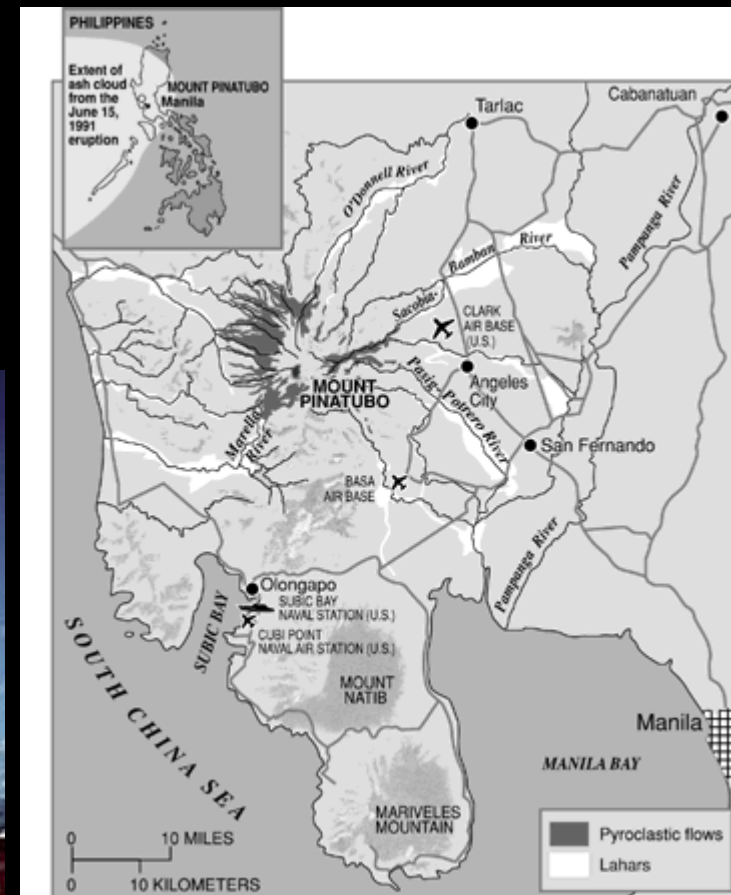


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Pinatubo 1991 AD

Explosiones, flujos piroclásticos y lahares

A huge cloud of volcanic ash and gas rose above Mount Pinatubo on June 12, 1991. Three days later, the explosive eruption was the second largest volcanic eruption of this century in the Earth and by far the largest eruption to affect a densely populated area. The eruption produced high-speed avalanches of hot ash and gas (pyroclastic flows), giant mudflows (lahars), and a cloud of volcanic ash hundreds of miles across.



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Perspectivas y temas de actualidad

(recuento no exhaustivo y un tanto arbitrario del profesor)

- Física de los agregados de partículas

Flujos granulares, mecanismos de transporte de corrientes densas y emplazamiento de depósitos piroclásticos

- Petrogénesis y 'Subduction Factory'

Origen de los magmas y procesos de diferenciación. El rol del agua y los volátiles en las zonas de subducción. Escala temporal de los procesos

- Relaciones entre Tectónica y Volcanismo

Relaciones causales; velocidad de ascenso y mecanismos de emplazamiento de magmas. Mecanismos de 'triggering'.

- Peligro y Riesgo Volcánico

Análisis semicuantitativo y modelación de escenarios

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Referencias y Lectura recomendada

Libros

Sigurdsson, H. (Ed.). 2000. Encyclopedia of Volcanoes. Academic Press.

Zeilinga de Boer, J. & Sanders, D.T. 2000. Volcanoes in the Human History. Princeton University Press.

Kraft, M. 1991. Volcanoes: Fire from the Earth.

Sigurdsson, H. 1999. Melting the Earth: the evolution of ideas about volcanic eruptions. Oxford University Press.

...y una lista de artículos se entregará en el Laboratorio

Buena suerte en curso!!