Topic 9: Volcanoes and Plate Tectonics

https://geowiki.ucsd.edu/sio15

HW3 and online (videos and Gradescope also open)!

1

SIO15 for-credit Test 3 10/21

https://geowiki.ucsd.edu/sio15

will include HW1 questions!

Homeworks/Tests
Homeworks
Tests
Field Trips
other links
Earthwatch/News Clips
FACEBOOK PAGE
Tides
NASA Earth Observatory
Useful Booklets

ute a maximum of 5 points to the final cumulative score.
0 questions. You will have a total of 25 minutes to complete the test.
est, you can choose when to start, but you will then have to complete that test in 25 min. You can ta
valent to receiving 0 points.
- The tests will consist of multiple choice questions similar to those at the end of each of the lecture notes and the Google
- the tests are open-book (including the class website), but you will have a time limit on the test
- you will see each questions only once, and you cannot go back to see the question again
- Test grades will be posted through the Canvas Gradebook.

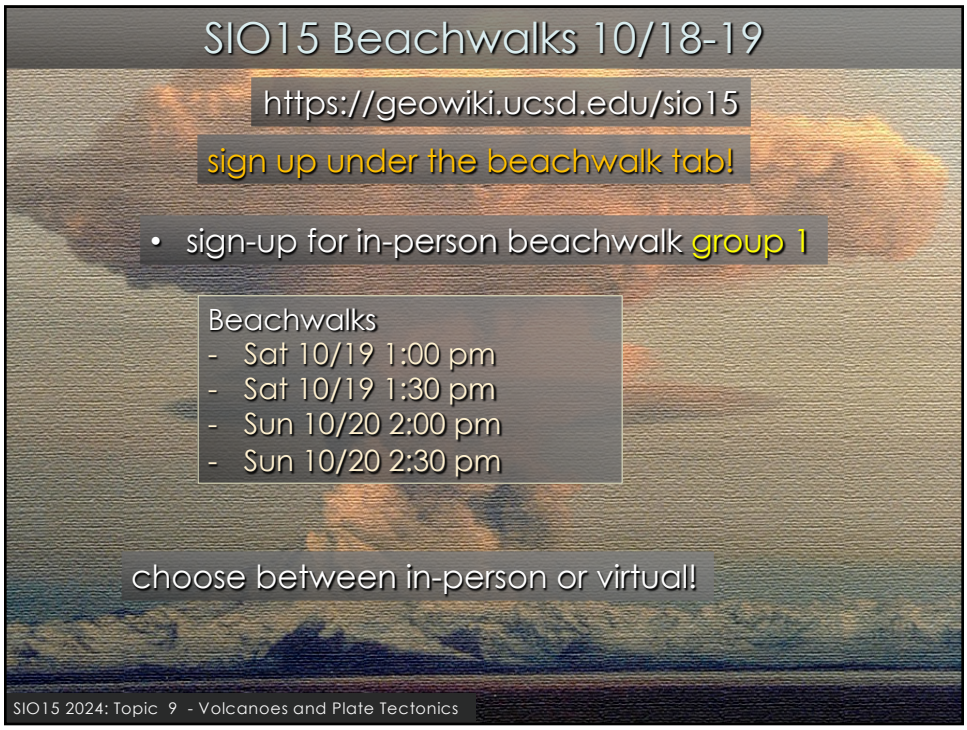
CODE OF CONDUCT

- Take the test alone. Working with somebody else on your test is considered cheating.
- Do not take your test with a fellow student. Each student may have a slightly different test.
- The test is open-book but you may not ask somebody else for answers. Asking someone for an answer is considered chea
- the tests of cheaters will be voided and the cheating will be reported to UCSD

Test Schedule - Material Covered

Test #	Date	Topics Covered*	Potential Homework questions
1	10/07	1-4	
2	10/14	5-7	
3	10/21	8-10,HW1	HW1 questions
4	10/28	11-13,HW2	
5	11/04	14-16,HW3	
6	11/12	17-19,HW4	

2


SIO15 Beachwalks 10/18-19
https://geowiki.ucsd.edu/sio15
sign up under the beachwalk tab!
• sign-up for in-person beachwalk group 1
Beachwalks
- Sat 10/19 1:00 pm
- Sat 10/19 1:30 pm
- Sun 10/20 2:00 pm
- Sun 10/20 2:30 pm
choose between in-person or virtual!
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https://www.shakeout.org/california
Home
Other ShakeOuts
Other Languages
Contact / FAQ
Search
Login
The Great California ShakeOut
10/17
10:17 am
Register Here!
Why Participate?
Who is Participating?
How to Participate
Resources
News & Events
Partners & Sponsors
GET READY TO SHAKEOUT!
This year's International ShakeOut Day is October 17, when millions of people worldwide will participate in earthquake drills at work, school, or home!
At 10:17 am (local time) on 10/17, you can join millions of people across California practicing earthquake safety. While we encourage you to participate with everyone, you can register your ShakeOut drill for any day of the year, and drill at a time of your choice. You can also include people in multiple locations through video conferencing.
If Possible
Using Cane
Using Walker
Using Wheelchair
Start here to be included in the 2024 Great California ShakeOut!
ShakeOut en Español
LEARN THE LATEST
ShakeOut Participant Update Newsletters
How to Participate
Information for individuals, schools and many types of organizations
ShakeOut Participant Resources
"Drill Broadcast" recordings and scripts, manuals, earthquake safety videos, posters, graphics, and much more
Media / PIO Resources
B-Roll, PSAs, Drill Broadcasts, Web resources, Key Messages, Media Venues, and more.
Frequently Asked Questions
9.8 million registered
5 days 21 hours until the 2024 California ShakeOut
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2023 Great Shakeout Mishap - SMH

EARTHQUAKE ALERT TEST GOES OFF HOURS EARLY

Some West Coast residents were jolted awake Thursday when they received an earthquake alert test that was sent to their cellphones at 3:19 a.m. because of a time zone mix-up, the U.S. Geological Survey said.

Planned for 10/19 *10:19 am* PDT

> 1M people got alert at 3:19 am

- if you are on freeway: do nothing!? THINK!
- if you are in bed: get up/under table!

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The Two Principal Types of Volcanoes

Shield Volcano

effusive

short video 7c

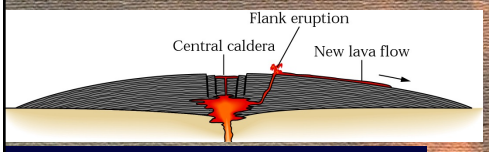
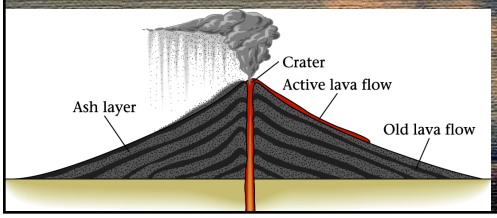


Image: S. Marshak "Earth, Portrait of a Planet"

Hawaii; Etna; Iceland; Erta Ale, Nyamuragira/Africa

Composite Volcano (Stratovolcano)

explosive



Fuji; Vesuvius; St. Helens; Pinatubo; Popocatepetl

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Examples of Composite Volcanoes

"...anything that looks beautiful is potentially dangerous..."

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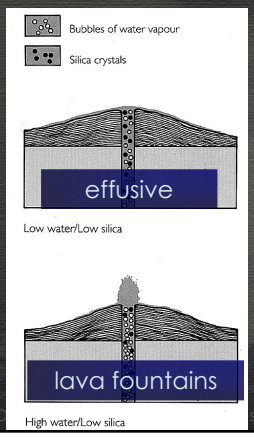
Style of Volcanism and the 3 Vs

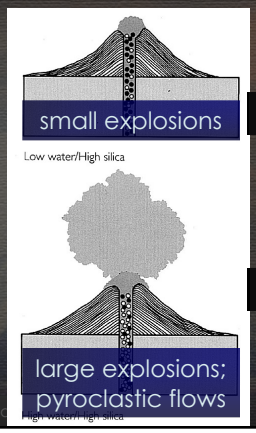
short video 7a
topic 9

- Viscosity
- amount of dissolved Volatiles
- Volume

low viscosity (shield)

high viscosity (strato)





less water → less vigorous

more water → more vigorous

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Topic 9: Volcanoes and Plate Tectonics

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Paricutin, Mexico 1943

In 1997, CNN named Parícutin one of the Seven Natural Wonders of the World.[3] The same year, the disaster film *Volcano* mentioned it as a precedent for the film's fictional events.

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Plate Boundaries and Volcanism

- 90% of volcanism along plate boundaries (with 80% along mid-ocean ridges)
- 10% at intra-plate hotspots/rifts

Image: S. Marshak "Earth, Portrait of a Planet"

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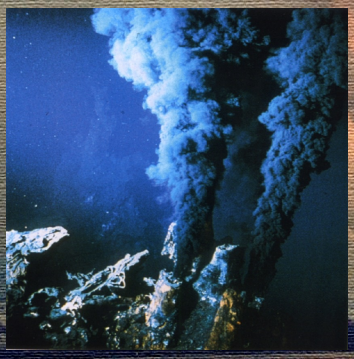
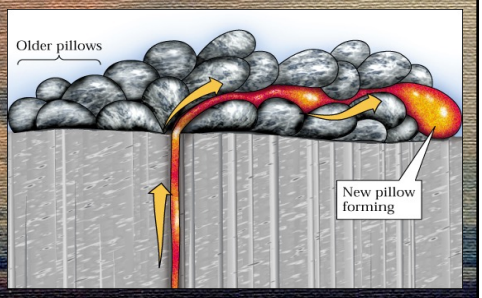
Mid-Ocean Ridge Volcanism

- majority of volcanism (80% of total magma production)
- non-explosive eruptions

- pillow lava
- black smokers





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Strato Volcanoes

- common
- subduction zones
- dangerous on continents

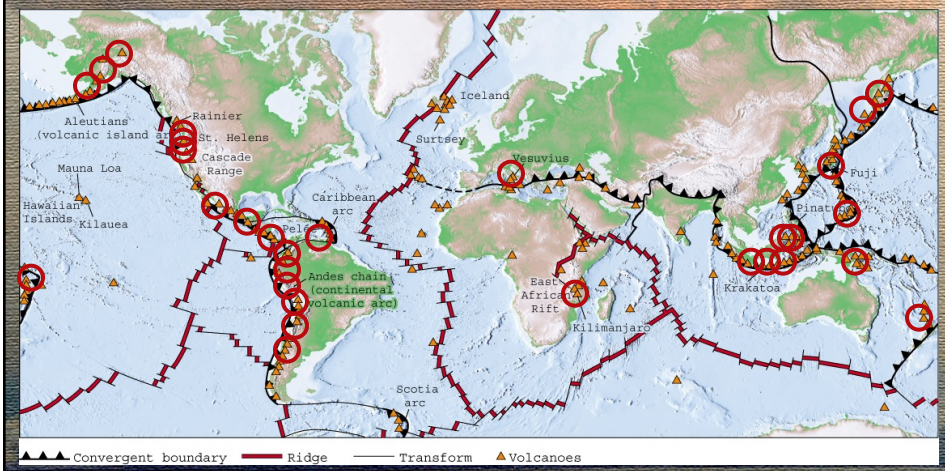

Image: S. Marshak "Earth, Portrait of a Planet"

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Shield Volcanoes
Mt. Etna
• relatively rare
• rifts
• some hotspots
Aleutians (volcanic island arc)
Rainier
St. Helens
Cascade Range
Mauna Loa
Hawaiian Islands
Kilauea
Caribbean arc
Pelée
Andes chain (continental volcanic arc)
Scotia arc
Iceland
Surtsey
Vesuvius
East African Rift
Kilimanjaro
Fuji
Pinatubo
Krakatoa
Convergent boundary
Ridge
Transform
Volcanoes
Image: S. Marshak "Earth, Portrait of a Planet"
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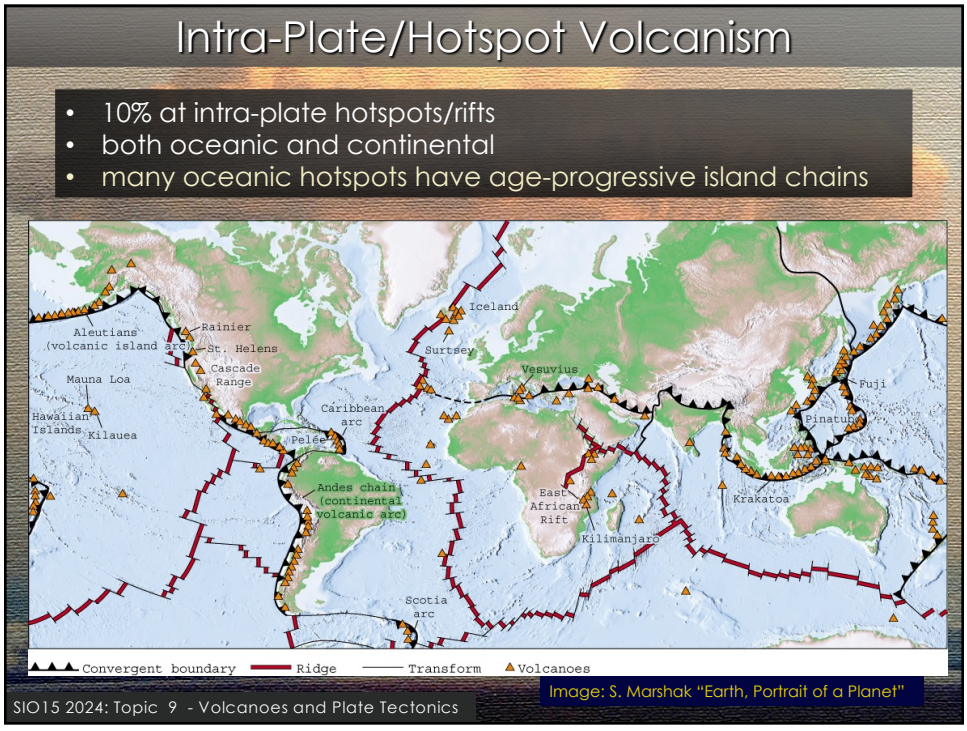
Intra-Plate/Hotspot Volcanism
• 10% at intra-plate hotspots/rifts
• both oceanic and continental
• many oceanic hotspots have age-progressive island chains
Aleutians (volcanic island arc)
Rainier
St. Helens
Cascade Range
Mauna Loa
Hawaiian Islands
Kilauea
Caribbean arc
Pelée
Andes chain (continental volcanic arc)
Scotia arc
Iceland
Surtsey
Vesuvius
East African Rift
Kilimanjaro
Fuji
Pinatubo
Krakatoa
Convergent boundary
Ridge
Transform
Volcanoes
Image: S. Marshak "Earth, Portrait of a Planet"
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Hot Spot Volcanism

- places with lots of magma in mantle (mantle plume)
- overriding plate moves away -> volcanoes go extinct -> chain
- Hawaii most productive volcanoes

- can be intra-plate
- dangerous on continents
- Yellowstone Earth's worst!

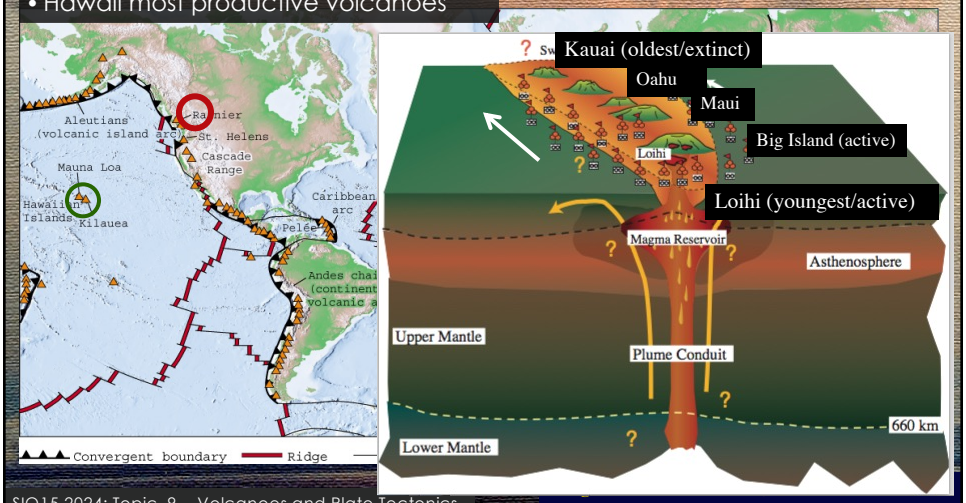

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Plate Boundaries with NO Volcanism

- cont-cont collision
- transform boundaries

Image: S. Marshak "Earth, Portrait of a Planet"

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Why are Volcanoes so Different? – Plate Tectonics

- type of plate boundary
- type of plate

Mt. St. Helens (May 18, 1980)

Kilauea, Hawaii (1983-87)

Arenal, Costa Rica

Kilimanjaro Tanzania/Kenya (extinct)

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Type of Plate (Boundary) - Viscosity

controlled by
- rock type (SiO_2 content)

<- continent/ocean difference

↓

viscosity

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Viscosity

short video 7c

Lecture 2: resistance of material to flow

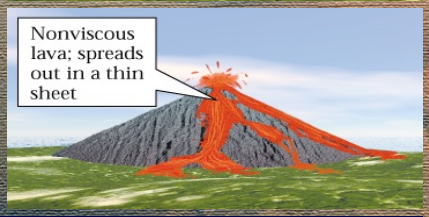

Image: S. Marshak "Earth, Portrait of a Planet"

- high viscosity: lava clogs vents -> explosive volcanism
- low viscosity: lava flows easily -> effusive volcanism

crustal rock more viscous than mantle rock!

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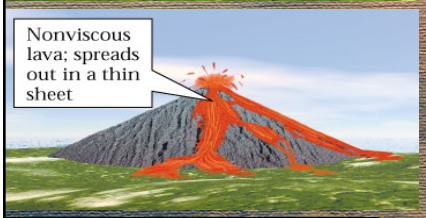
The 2 Main Factors controlling Viscosity

1) MORE SiO_2 makes lava MORE VISCOUS

2) HIGHER TEMPERATURE makes lava LESS VISCOUS

MORE VISCOUS
- high-SiO_2 (Quartz)
- cold



LESS VISCOUS
- low-SiO_2 (Olivine)
- hot

Image: S. Marshak "Earth, Portrait of a Planet"

SiO_2 = silica

short video 7d

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Crustal Rock Viscosity: Continents - Oceans

Continent-Ocean Difference

short video 7d

OCEANIC CRUST
- thin
- dense, dark rock

CONTINENTAL CRUST
- thick
- less dense, light rock

- thicker crust
- lighter rocks

→ higher viscosity

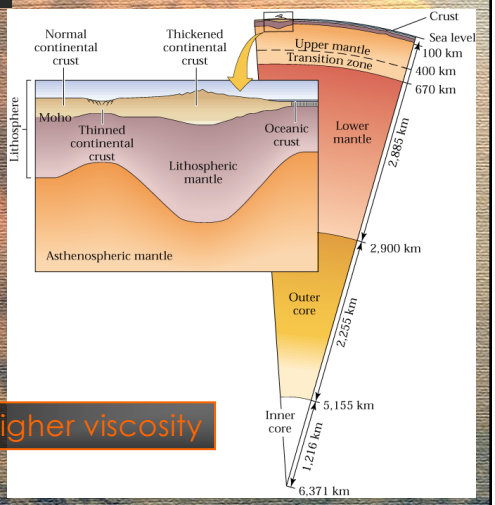

Image: S. Marshak "Earth, Portrait of a Planet"

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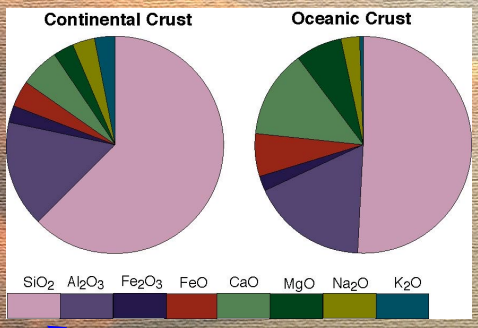
short video 7d

Crustal Rock Viscosity

- crustal thickness
- composition (SiO_2 content)

CONTINENTAL CRUST HAS MORE SiO_2 THAN OCEANIC CRUST



SiO_2: silica

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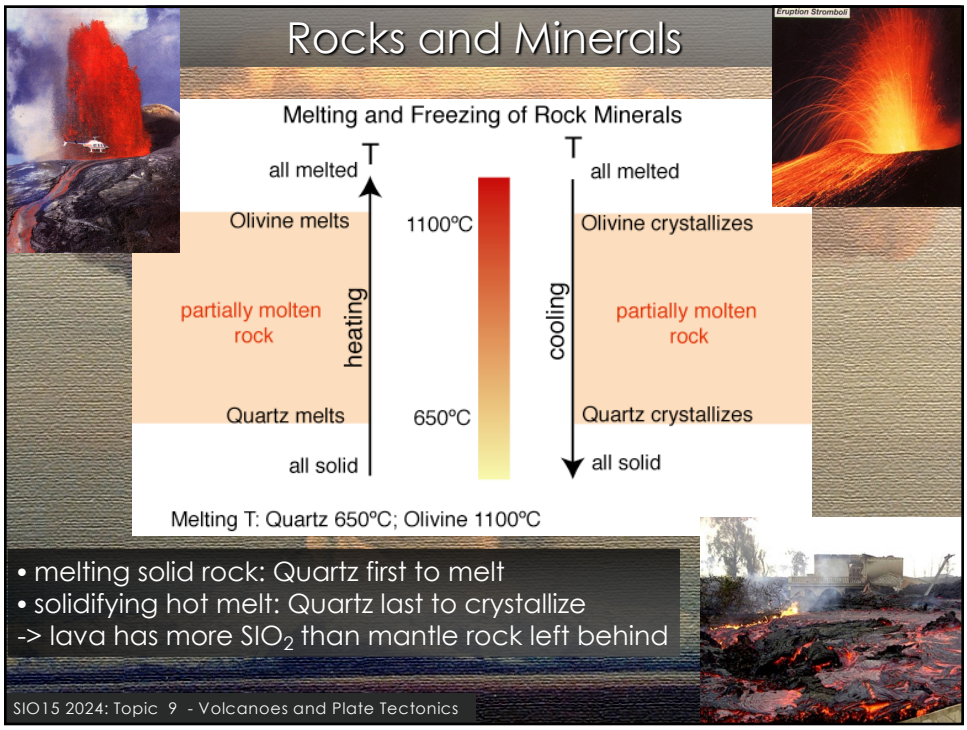
Rocks and Minerals
Eruption Stromboli
Melting and Freezing of Rock Minerals
T
all melted
Olivine melts
partially molten rock
Quartz melts
all solid
heating
1100°C
650°C
cooling
T
all melted
Olivine crystallizes
partially molten rock
Quartz crystallizes
all solid
Melting T: Quartz 650°C; Olivine 1100°C
• melting solid rock: Quartz first to melt
• solidifying hot melt: Quartz last to crystallize
-> lava has more SIO2 than mantle rock left behind
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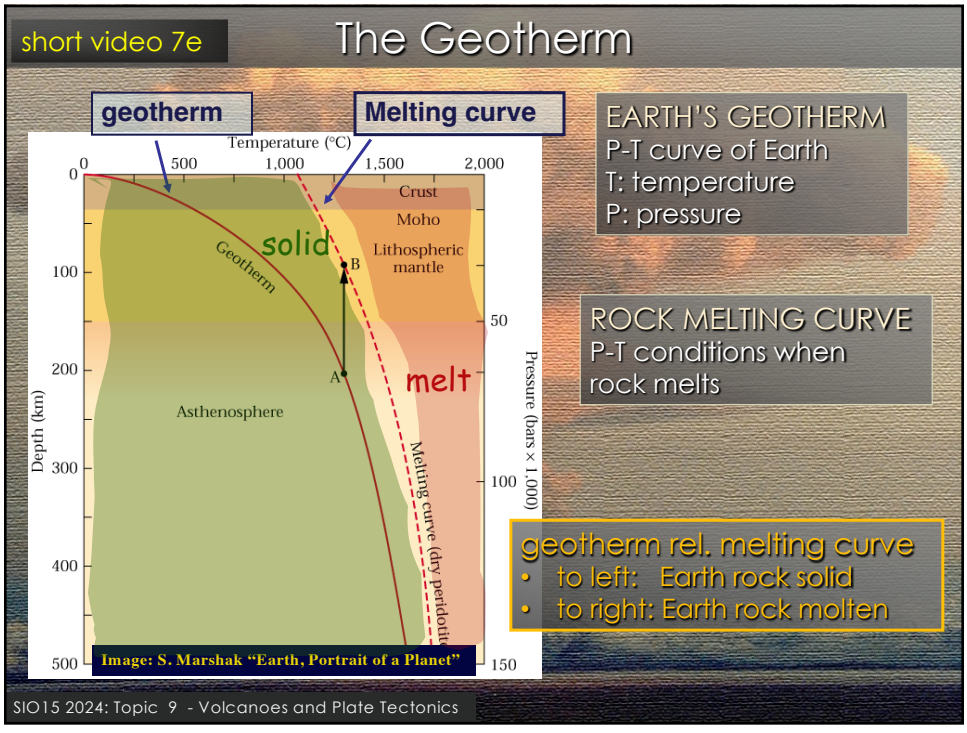
short video 7e
The Geotherm
geotherm
Melting curve
Temperature (°C)
0
500
1,000
1,500
2,000
Crust
Moho
Lithospheric mantle
solid
Geotherm
B
A
melt
Asthenosphere
Melting curve (dry peridotite)
Depth (km)
Pressure (bars × 1,000)
EARTH'S GEOTHERM
P-T curve of Earth
T: temperature
P: pressure
ROCK MELTING CURVE
P-T conditions when rock melts
geotherm rel. melting curve
• to left: Earth rock solid
• to right: Earth rock molten
Image: S. Marshak "Earth, Portrait of a Planet"
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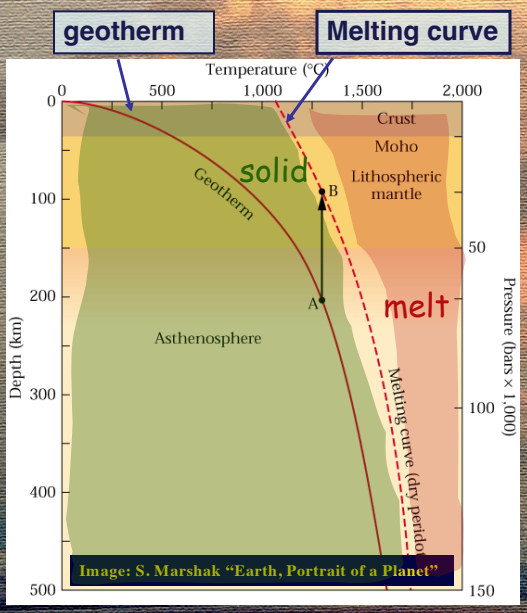
short video 7e

Decompression Melting



ascending rock melts upon crossing the melting curve

- mid-ocean ridges
- continental rifts
- hotspots

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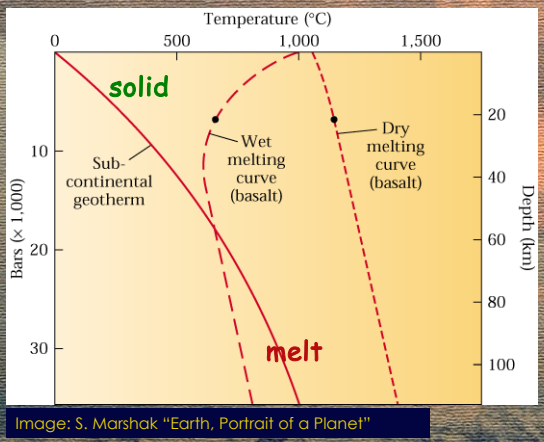
short video 7e

Injection of Volatiles



volatiles lower the melting temperature

- subduction zones

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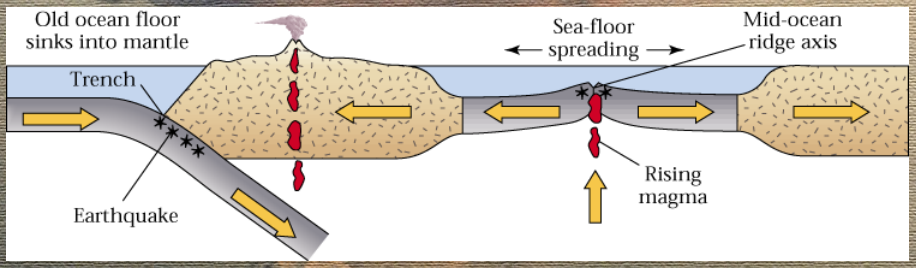
The Two Principal Melting Mechanisms

Decompression (divergent plate boundaries, hotspots)
Addition of Volatiles (subduction zones)



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Magma (below) and Lava (above)

Magma/Lava mix of:
- solid parts
- molten parts
- dissolved gases

partial melt: mix of solid and molten parts

minerals:
Quartz (> SiO_2)
Olivine (<SiO_2)

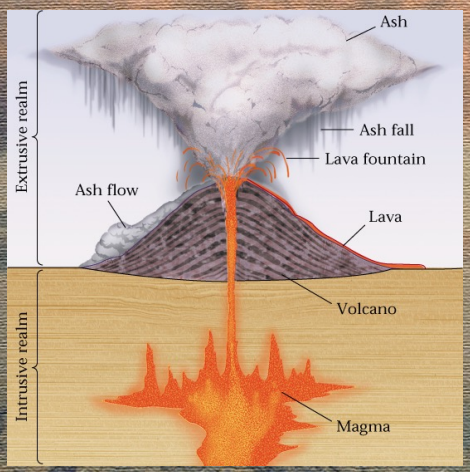

Image: S. Marshak "Earth, Portrait of a Planet"

melting T or freezing point:
650 - 1100°C

Quartz: 650°C
Olivine: 1100°C

y°F = x°C*9/5+32
1200 - 2000°F

oven T:
260°C/500°F

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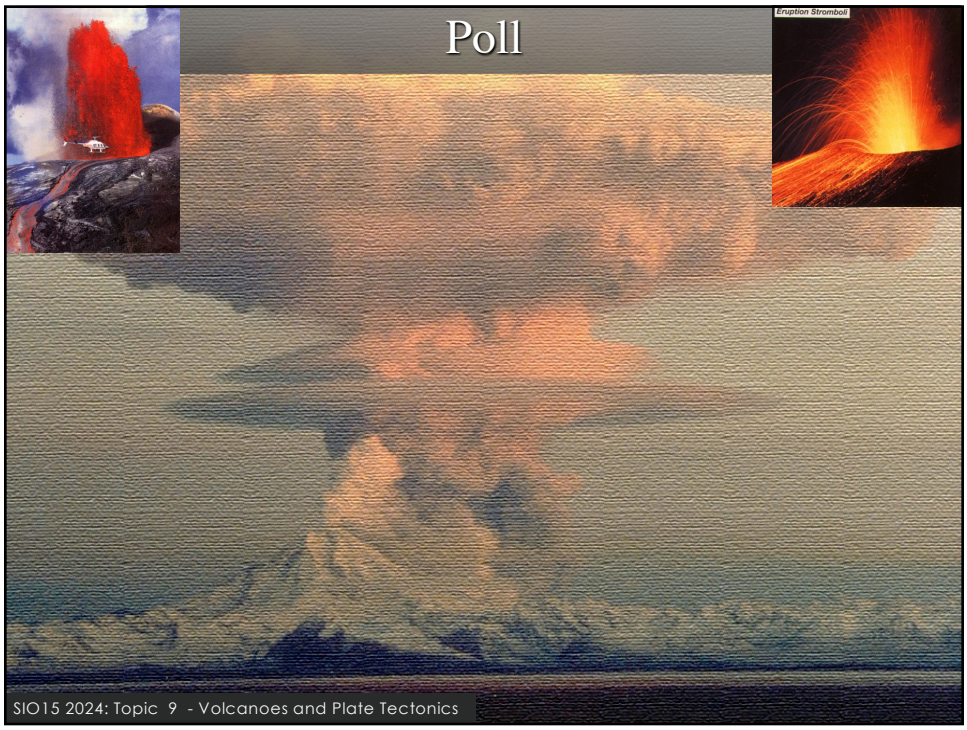
Poll
Eruption Stromboli
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