EPSC 240: GEOLOGY IN THE FIELD

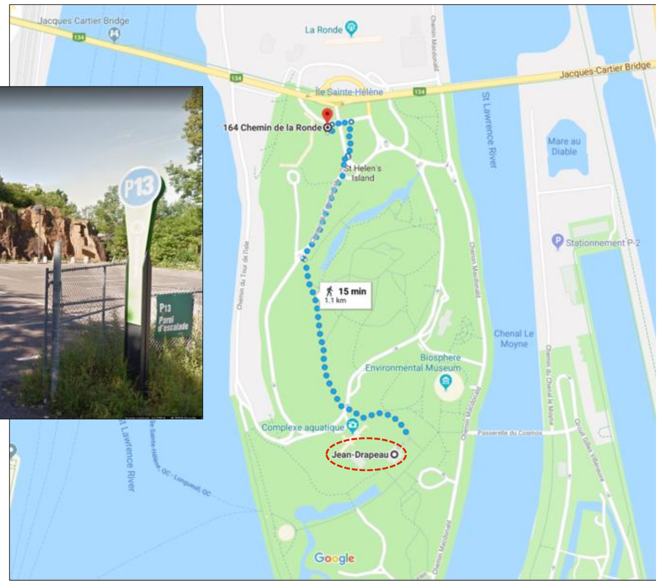
VOLCANIC ROCKS & DIATREMES

Hopi Buttes, Arizona, USA. Credit: James White

WEDNESDAY

- Volcanic rocks on Île Ste-Hélène
- -4^{o}C, windy
- Either meet at 1:35 in FDA 348 and go to Parc Jean Drapeau together, <u>or</u> meet us at the outcrop at 2
- Tickets

WEDNESDAY



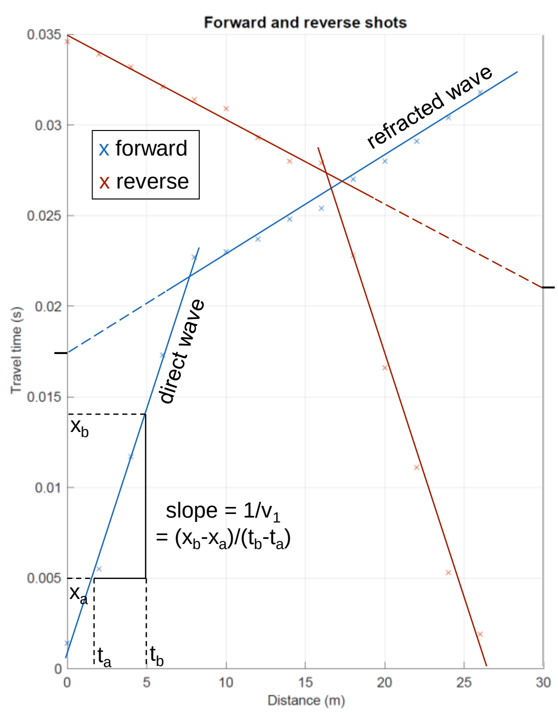
- South side of P13

SEISMICS REPORT

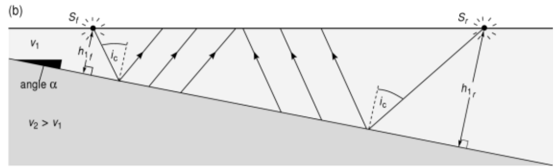
- Calculate v_1, v_{2d}, v_{2u} from slopes
- v_{2d}, v_{2u} (down/up dip) are <u>apparent</u> velocities
- Extrapolate slopes of refracted wave arrivals to x = 0, solve for depth to bedrock (h_1, h_2)

$$t = \cancelto{0}{\frac{x}{v_2}} + 2h_1\sqrt{\frac{1}{v_1^2} - \frac{1}{v_2^2}}$$

- Note: the distance h is normal to the bedrock, not vertical distance



SEISMICS REPORT



- Calculate dip angle (γ or α) using your v_{2d} and v_{2u} from slopes
- Calculate angle of incidence θ_{12} and check your answers for apparent velocities with the equations

➔ How accurate are the velocities derived from the t-x plot?

$$\gamma_1 = \frac{1}{2}[\sin^{-1}(\frac{v_1}{v_{2d}}) - \sin^{-1}(\frac{v_1}{v_{2u}})]$$

$$\theta_{12} = \frac{1}{2}[\sin^{-1}(\frac{v_1}{v_{2d}}) + \sin^{-1}(\frac{v_1}{v_{2u}})]$$

Apparent velocity **down dip** =

$$v_{2d} = \frac{v_1}{\sin(\theta_{12} + \gamma_1)} < v_2$$

Apparent velocity **up dip** =

$$= \frac{v_1}{\sin(\theta_{12} - \gamma_1)}$$

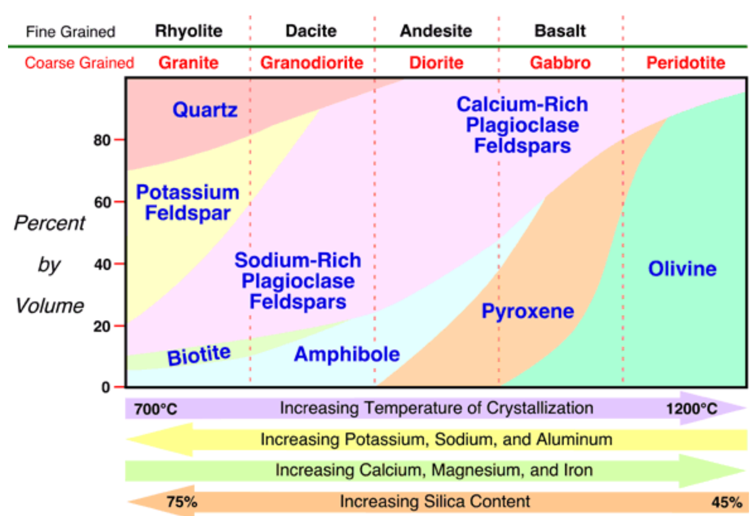
SEISMICS REPORT

- Reports as described in lab handout, except
- Reduce methods to a few sentences (describe what we would have done)
- Word limits for all sections are guidelines ➔ can reduce by 50%

EXTRUSIVE IGNEOUS ROCKS

- Lava, ash, debris, mixture of all

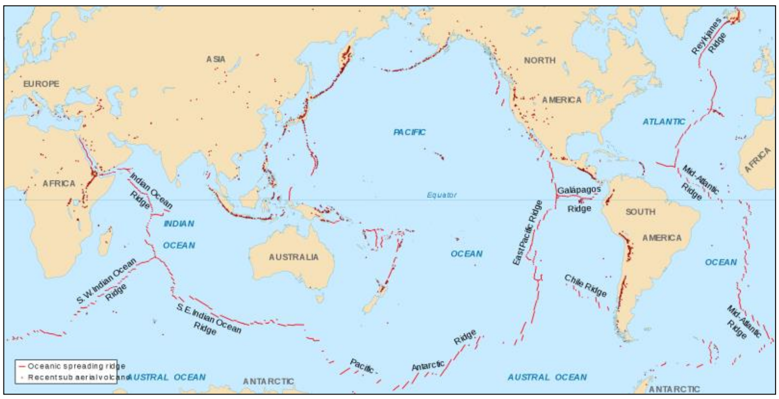
IGNEOUS ROCK CLASSIFICATION



www.physicalgeography.net

VOLCANOES

- Volcanoes are the surface expression of Earth's dynamic system (transfer of energy and mass from the interior to surface)



wikipedia

MID OCEAN RIDGE VOLCANOES

VOLCANOES ON LAND

- Stratovolcanoes, shield volcanoes, lava domes; tuff cones, scoria cones; calderas

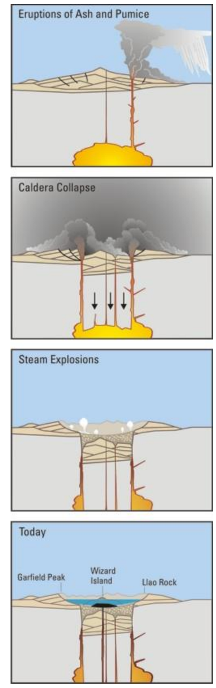



EFFECT OF SILICA

- Shield volcanoes form from effusive eruption of low-viscosity lava (basalt) ➔ gently sloping
- Stratovolcanoes form from intermediate-viscosity lava. Mixture of flows, ash, pumice (composite volcanoes) ➔ steeper slopes
- Lava domes form from high viscosity lava (rhyolite). Too thick to flow ➔ solidifies in volcanic edifice

CALDERAS

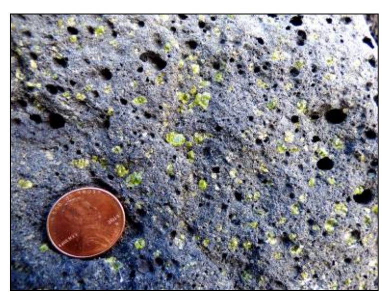
- Collapse structures formed by evacuation of magma chamber
- Rapid eruption of large volumes of magma removes underlying support for surface materials



wikipedia

DESCRIBING VOLCANIC ROCKS

- Aphanitic (groundmass)
- Porphyritic (phenocryst)
- Vesicular (vesicles)
- Pyroclastic
  Welded/poorly welded
- Xenoliths
  Composition, size/shape



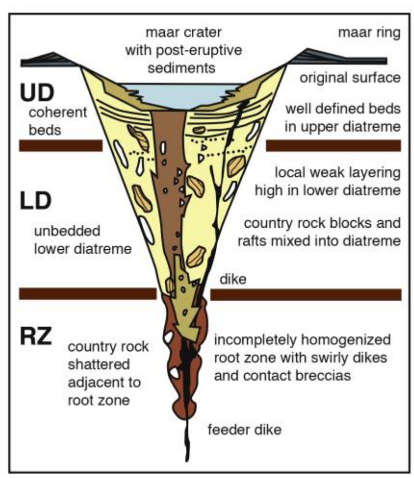
MAAR-DIATREME VOLCANOES

- **Maar**: Crater with floor below the pre-eruptive surface, surrounded by a relatively thin ejecta ring extending ~1 km from the crater rim.
- Ejecta ring: Volcanic debris (*pyroclastics*) such as ash, pumice, tuff.
- Can be formed by a *phreatomagmatic* eruption (lava encounters groundwater) ➔ Explosive!

Image: Smithsonian Institute

MAAR-DIATREME VOLCANOES

- **Diatreme**: Breccia-filled volcanic vent formed by a gaseous explosion
- *Upper bedded deposits*: formed by sedimentation on surfaces open to the atmosphere
- *Lower unbedded deposits*
- *Root zone*: transition from magmatic feeder dike to clastic deposits, formed by fragmentation of magma and enclosing country rock



White and Ross (2011) J Volcanol Geotherm Res 201: 1-29

DIATREME FILL

- Upper diatreme: bedded volcaniclastics

- Lower diatreme: breccia of country rock fragments in an aphanitic matrix

Photo: Round Butte, Hopi Buttes volcanic field. White line: transition between bedded upper diatreme and unbedded lower diatreme. Dashed line: zone with more country rock fragments. Height of photo ~8 m.

White and Ross (2011) J Volcanol Geotherm Res 201: 1-29

DIATREME FILL

- Diatreme fill becomes fluidized from vigorous streaming of magmatic volatiles though solid debris

  ➔ Separates the fine particles from the larger clasts

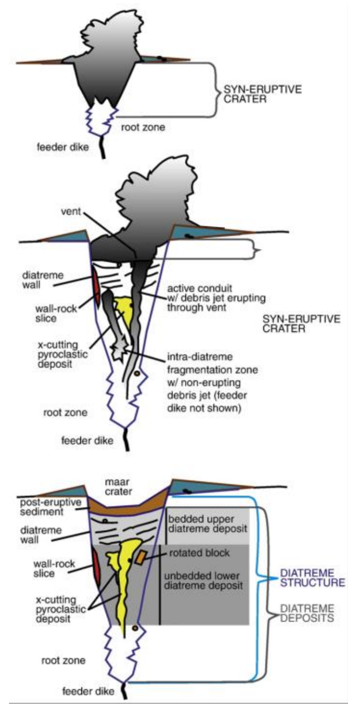
Photo: Standing Rocks West, Hopi Buttes volcanic field. Lower diatreme deposits showing steeply dipping contact between two units of unbedded pyroclastics. Height of image ~ 4m.

White and Ross (2011) J Volcanol Geotherm Res 201: 1-29

DIATREME FORMATION

- Cool deposition (absence of welding)
- Episodic processes (multiple ejecta-ring layers, multiple beds in the upper diatreme, and cross-cutting structures in the lower diatreme and upper diatreme)
- Strong or buttressed diatreme walls (steep pipe walls)
- In-ground energy release (broken-up country rock)
- Particle distribution by ballistic trajectories and pyroclastic density currents (ejecta rings)

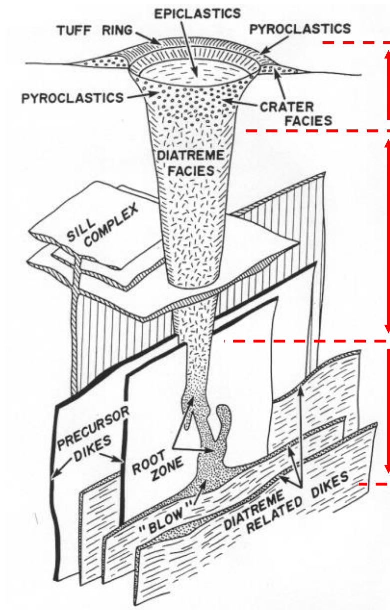
White and Ross (2011) J Volcanol Geotherm Res 201: 1-29



KIMBERLITES

- Special case of diatreme fill that is ultramafic
- Derived directly from the mantle
- Pressures of 6–8 GPa ➔corresponds to depths of 200–250 km
- Sometimes have diamonds!

KIMBERLITES - MORPHOLOGY



Components of a kimberlite:

Crater zone

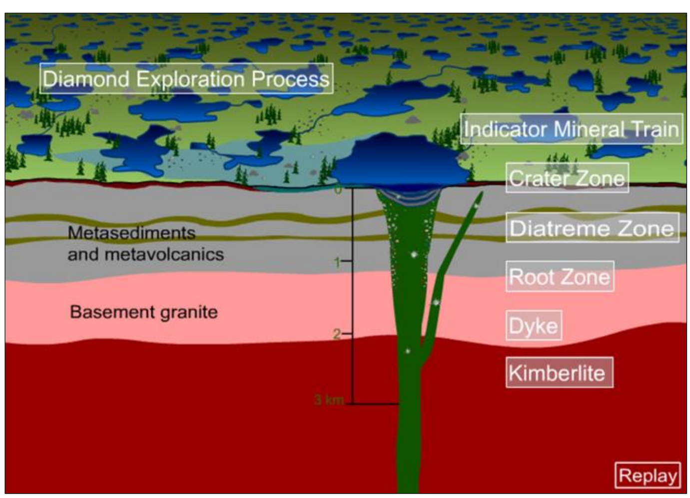
Diatreme zone

Root zone

http://www.bcminerals.ca/i/video/kimberlite-anim.swf

Mitchell (1986) Kimberlites, Plenum NY

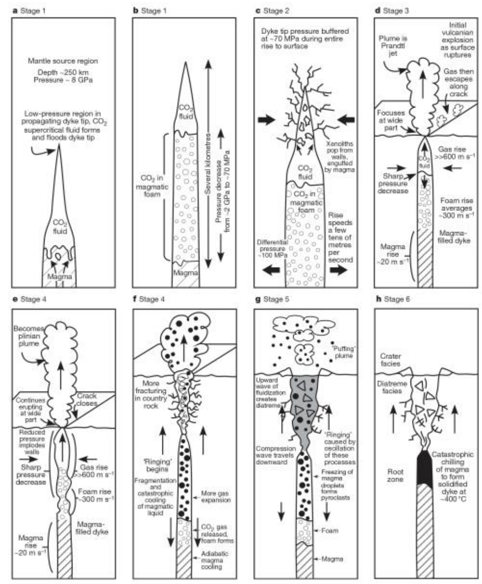
KIMBERLITES - MORPHOLOGY



kimberlite animation:
www.canterraminerals.com/s/home.asp

KIMBERLITE FORMATION

- Dyke initiation in a deep CO_2-rich source region in the mantle
- Rapid propagation of the dyke tip
- When the tip breaks the surface of the ground, gas release causes a depressurization wave to travel into the magma



Wilson and Head (2007) Nature 447: 53-57