Will Volcanoes Erupt in New England?

Mantle upwelling at the edge of the North American Continent

*Lecture to the 2018 Summer Interns*

*by Bill Menke*
My interest in volcanism started the year before, when I accompanied MIT Professor Tom MyGetchin to Pacaya Volcano (Guatemala)
Part 1

The youngest volcanoes on the East Coast of North America
Monterey Virginia area
area of folded sedimentary rock
Trimble Knob
area of folded sedimentary rock
48 Ma Basalts
Sunset Crater (Arizona) erupted ca 1085 CE
Part 2

What volcanism can tell us about the earth
digression

clouds
flat bottoms, all at about the same altitude
spaces between the clouds
clouds are really not the ‘complete thing’

they are the part that you can see
the 'complete thing' is a series of convection cells
temperature

altitude
pressure
Earth’s surface

dew point

mist

clear air

moist air at low altitude
The diagram illustrates the relationship between temperature, pressure, and altitude. The x-axis represents temperature, the y-axis represents pressure, and the z-axis represents altitude. The diagram shows the dew point, mist in air, and the Earth’s surface. The temperature decreases with altitude at a rate of 10 degrees Celsius per kilometer.
temperature

pressure

dew point

Earth’s surface

10 degC/km

mist in air

bottom of cloud

= cloud
Rain: water droplets more dense than air so they fall down
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depth, km

temperature, deg C

solidus

solid

partially molten

hot mantle at deep depth
magma ‘rains’ up, since it is less dense than rock
volcanism
tells us where the asthenosphere is upwelling
Part 3

The Northern Appalachian Anomaly
seismic velocity

a proxy

for temperature

rule of thumb

1% velocity change 100K
Earth

earthquake

upwelling = hot = slow

P wave

time
distance
anomaly = \text{observation} \text{ minus } \text{prediction}
former LDEO Graduate Student Vadim Levin
(now Rutgers Prof)
Levin, Lerner-Lam and Menke, 1995
“The interpretation of the velocity low #3 presents a challenge ... while elevated temperatures are often associated with low seismic velocity, #3 is unlikely to be of a thermal origin ... for at least 100 My this region has been tectonically quiet, and the temperature difference must have equibrated ... a temperature anomaly on the order of 800 degC is required for a 5% decrease of compressional velocity” ... [which is unrealistic]

Levin, Lerner-Lam and Menke, 1995
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Or is it?

Levin, Lerner-Lam and Menke, 1995
Schmandt and Lin, 2014
continental scale study
note parts of eastern US as slow (red) as western US
#3

Northern Appalachian Anomaly
(or NAA)

Schmandt and Lin, 2014
Cross-Section of the NAA

Schmandt and Lin, 2014
P wave delays

S wave delays

\( \delta \Delta T_p \) (s)

\( \delta \Delta T_s \) (s)

Lat (deg)

Lon (deg)

40

50

-2.5

+2.5

GF

AF

GMHS
Interpretation in terms of a small scale convection cell
How can we “prove” that the NAA is hot?
Can we prove that the NAA is **Hot**?

Hot material has characteristic ratio of compressional to shear wave velocity anomalies

2015 Summer Intern
Peter Skryzalin
Schmandt and Lin, 2014

Slow proxy for ‘hot’ but can also be proxy for ‘dense’

Fast proxy for cold proxy for ‘light’

-3.25 dVp/Vp [%] +3.25
Earthquakes generate both P waves and S waves and the two are affected by temperature and density in (slightly) different ways.
lab experiments and theoretical models

\[ r = \frac{\Delta V_p}{\Delta V_S} = 1.0 \quad \text{temperature, } T \]

\[ r = \frac{\Delta V_p}{\Delta V_S} = 1.8 \quad \text{density, } \rho \]
observations

$\Delta T_p$ and are $\Delta T_s$ are highly correlated

$r = \frac{\Delta T_p}{\Delta T_s}$ favors temperature

\[ \text{observations} \]

\[ \Delta T_p \text{ and are } \Delta T_s \text{ are highly correlated} \]

\[ r = \frac{\Delta T_p}{\Delta T_s} \text{ favors temperature} \]
Can we prove that the NAA Hot?

Hot material absorbs P and S waves more quickly than cold material

Former LDEO Graduate Student
Ted Dong
Hot material absorbs S waves very quickly.
outside NAA

within NAA

Dong & Menke, 2017

H/vQ

quality factor
Part 4: The Next Steps

infer mantle flow directions

confirm upwelling at the NAA

find where down-welling is occurring

consequences of the convection

is the asthenosphere deforming/eroding the continent?

could volcanism occur?
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recent paper by Vadim Levin and others
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could volcanism occur?

yes!

2017 Summer Interns

Dionne Hutson
Juliette Lamoureux
Alyssa Marrero
Part 4: The Next Steps

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could volcanism occur? Are we sure that volcanism hasn’t already occurred
Absence of Evidence is not Evidence of Absence
- Carl Sagan, Astronomer

Are we sure that no NAA-related volcanoes have erupted in New England?

unlike Virginia, the region has lots of volcanic features
furthermore, it was heavily eroded by the Pleistocene glaciers
a few, small volcanic features might have been ignored
Every geologist I’ve asked says this is a 200 My old dike but (as far as I know) no one has actually dated it.
so let’s start looking ...  

The End