



ERTH 491-01 / GEOP 572-02
Geodetic Methods

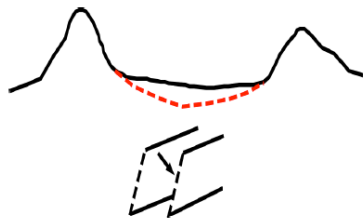
**– Lecture 27: Modeling - Volcano Deformation
cont'd / Surface Loading –**

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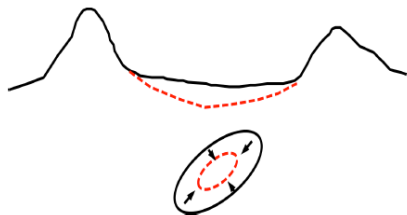
November 23, 2015

Source Models: Okada (1985), Yang (1988)

Rectangular dislocation source (Okada, 1985)



Ellipsoidal pressure source (Yang, 1988)



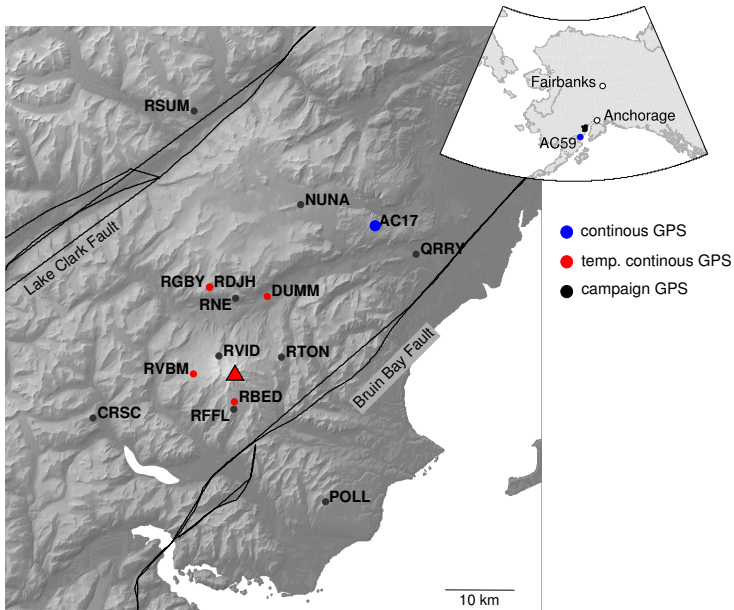
Jeff Freymueller

Model parameters: lat, lon, depth, length, width, dip, strike, source strength

Mt Redoubt, Alaska, 2009



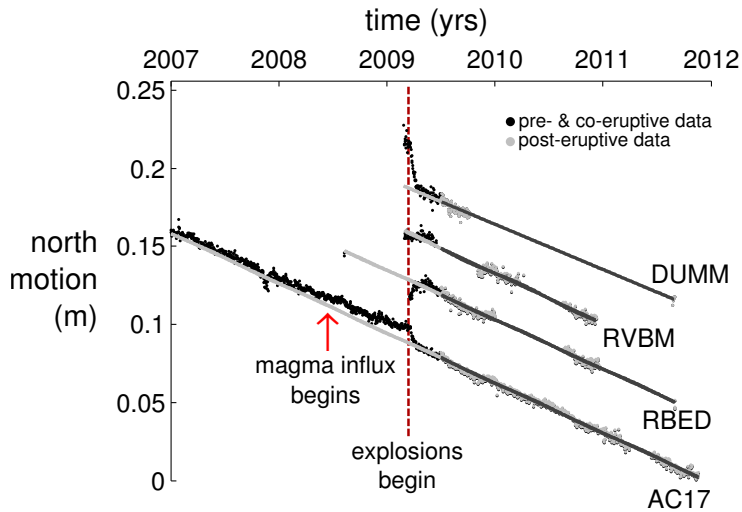
1. Weeks to Months: Mt. Redoubt Source Models



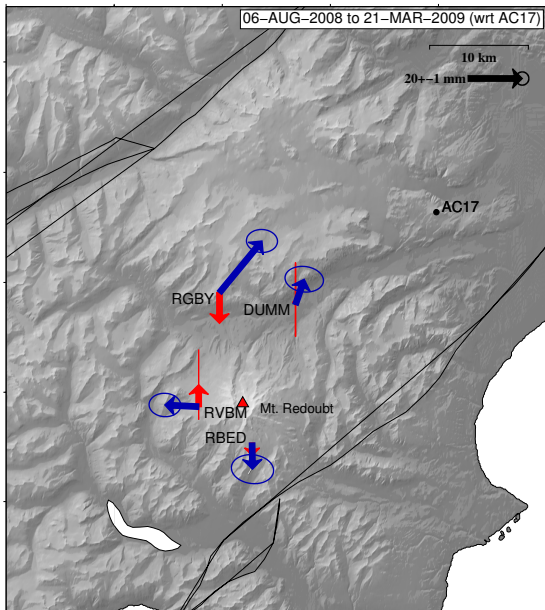
Source Estimation:



- Pressure Point Source (Mogi, 1958)
- degenerate prolate spheroid / conduit (Bonaccorso and Davis, 1999)
- general (prolate) spheroid (Yang 1986, Newman et al. 2006, Battaglia et al. 2012)
- Grid search over spatial domain (models non-linear in space)
- Least squares inversion for volume change



GPS Time Series relative to North America



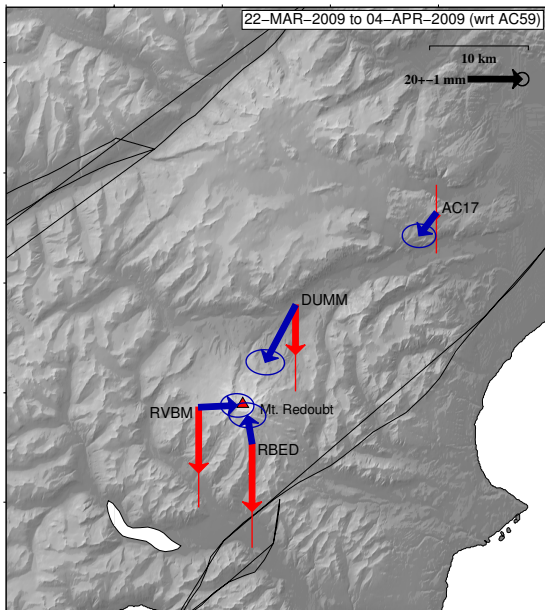
Pre-eruptive Phase – Inflation







Data
horizontal 
vertical 

Model
horizontal 
vertical 

Explosive Phase – Deflation

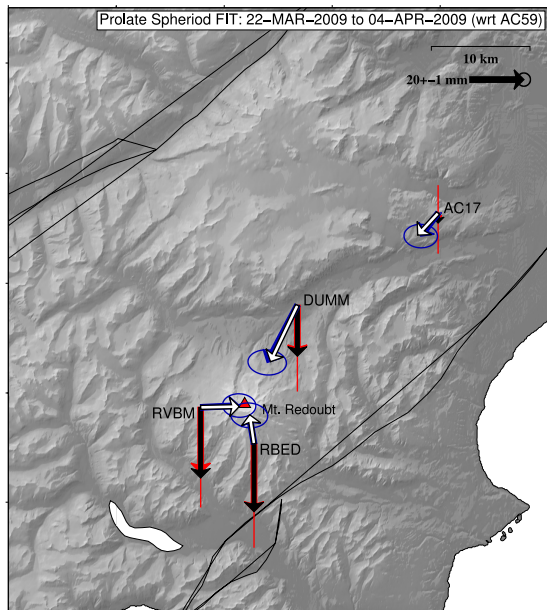


Data
horizontal 
vertical 

Model
horizontal 
vertical 

Explosive Phase – Deflation

Prolate Spheroid FIT: 22-MAR-2009 to 04-APR-2009 (wrt AC59)



General Spheroid:

$$r = 0.5 \text{ km E of dome}$$



$$d = 9.17^{6.92}_{15.17} \text{ km}$$



$$a = 4.50^{1.25}_{>10.00} \text{ km}$$

$$b = 0.475^{0.3}_{>4.00} \text{ km}$$

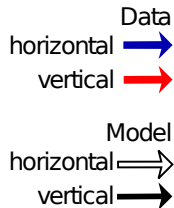
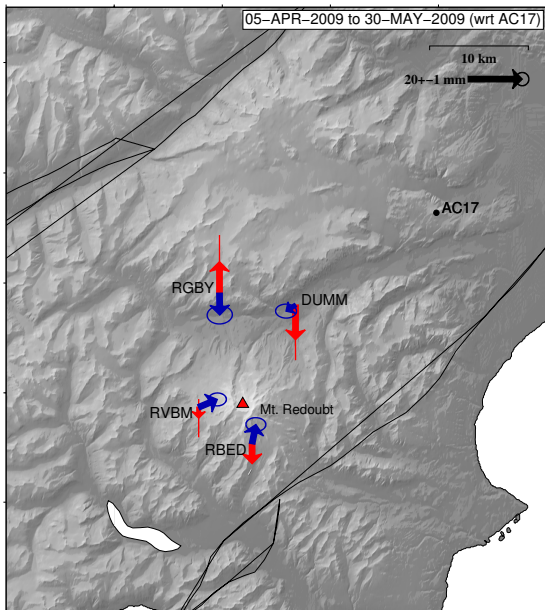
$$\Delta V = -(0.05^{0.028}_{>0.1}) \text{ km}^3$$

F-Test: Spheroid preferred.

Data
horizontal 
vertical 

Model
horizontal 
vertical 

Effusive Phase – Deflation



Effusive Phase – Deflation

Prolate Spheroid FIT: 05-APR-2009 to 30-MAY-2009 (wrt AC17)

10 km
20+/-1 mm

RGBY

DUMM

RVBM

RBED

Mt. Redoubt





AC17

General Spheroid:

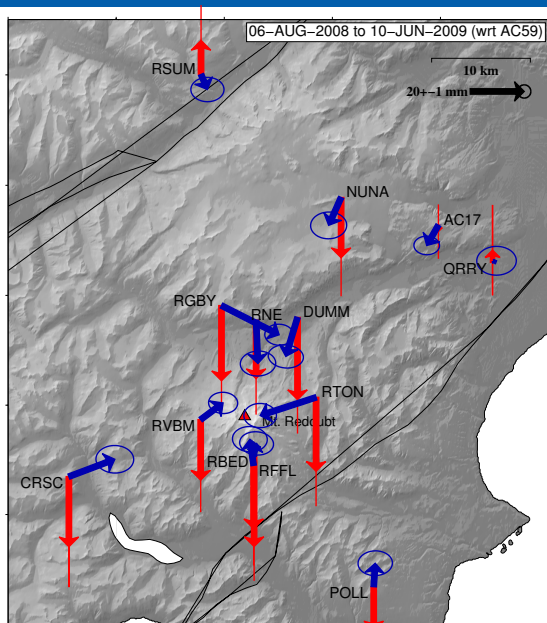
$$\Delta V = -(0.017 \begin{matrix} 0.011 \\ 0.023 \end{matrix}) \text{ km}^3$$

Mogi fits better

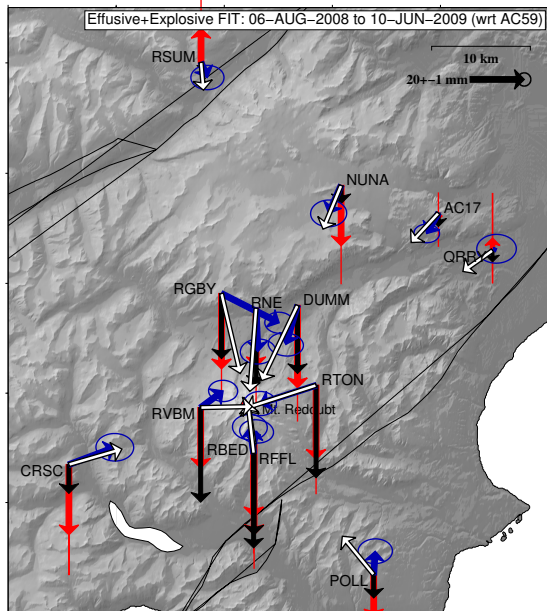
F-Test rejects Mogi

Data
horizontal 
vertical 
Model
horizontal 
vertical 

Full Eruption – Net Deflation



Full Eruption – Net Deflation



Explosive: Prolate Spheroid

$$r = 0.5 \text{ km E of dome}$$

$$d = 9.17^{6.92}_{15.17} \text{ km}$$



$$a = 4.50^{1.25}_{>10.00} \text{ km}$$



$$b = 0.475^{0.3}_{>4.00} \text{ km}$$

$$\Delta V = -(0.05^{0.028}_{>0.1}) \text{ km}^3$$

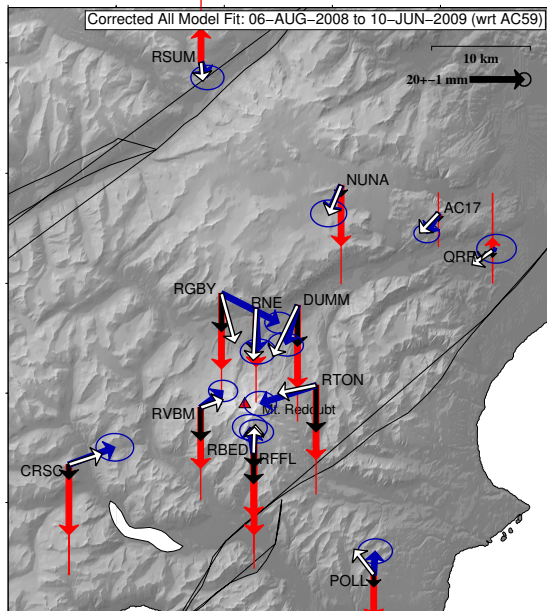
Effusive: same.

$$\Delta V = -(0.017^{0.011}_{0.023}) \text{ km}^3$$

Data
horizontal 
vertical 

Model
horizontal 
vertical 

Final Model



Explosive: Prolate Spheroid

$$r = 0.5 \text{ km E of dome}$$

$$d = 9.17^{6.92}_{15.17} \text{ km}$$

$$a = 4.50^{1.25}_{>10.00} \text{ km}$$

$$b = 0.475^{0.3}_{>4.00} \text{ km}$$

$$\Delta V = -(0.05^{0.028}_{>0.1}) \text{ km}^3$$

Effusive: same.

$$\Delta V = -(0.017^{0.011}_{0.023}) \text{ km}^3$$

Pre-eruptive: Mogi

$$r = 1.25 \text{ km S of dome}$$

$$d = 13.50^{10.17}_{17.33} \text{ km}$$

$$\Delta V = 0.0194^{0.0092}_{0.0340} \text{ km}^3$$

2009 Redoubt Source Evolution



2009 Redoubt Source Evolution

Main Results:

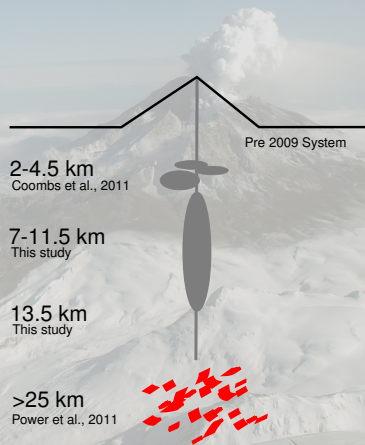
- pre-eruptive intrusion preceded seismic precursors
- dynamic change of source over weeks
- suggested process:



2009 Redoubt Source Evolution

Main Results:

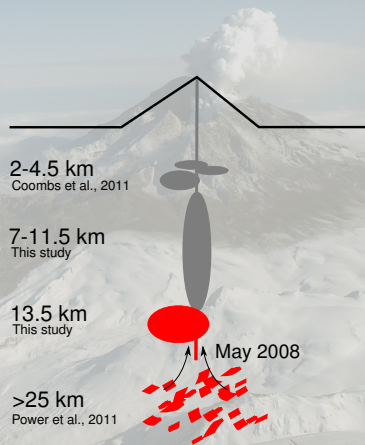
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2009 Redoubt Source Evolution

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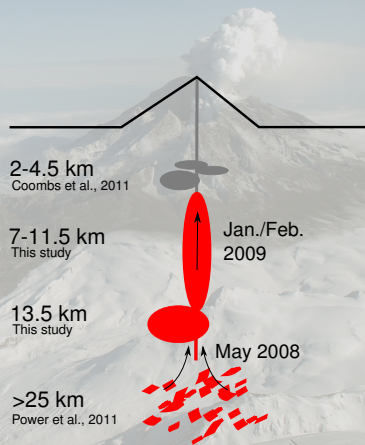
- pre-eruptive intrusion preceded seismic precursors
- dynamic change of source over weeks
- suggested process:



2009 Redoubt Source Evolution

Main Results:

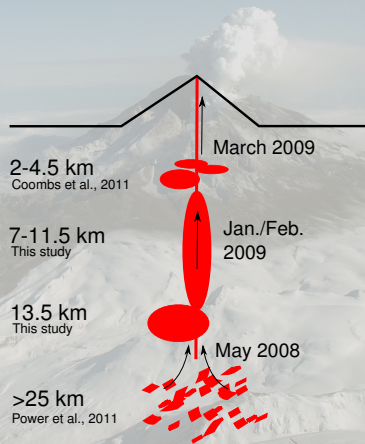
- pre-eruptive intrusion preceded seismic precursors
- dynamic change of source over weeks
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2009 Redoubt Source Evolution

Main Results:

- pre-eruptive intrusion preceded seismic precursors
- dynamic change of source over weeks
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2009 Redoubt Source Evolution

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- pre-eruptive intrusion preceded seismic precursors
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