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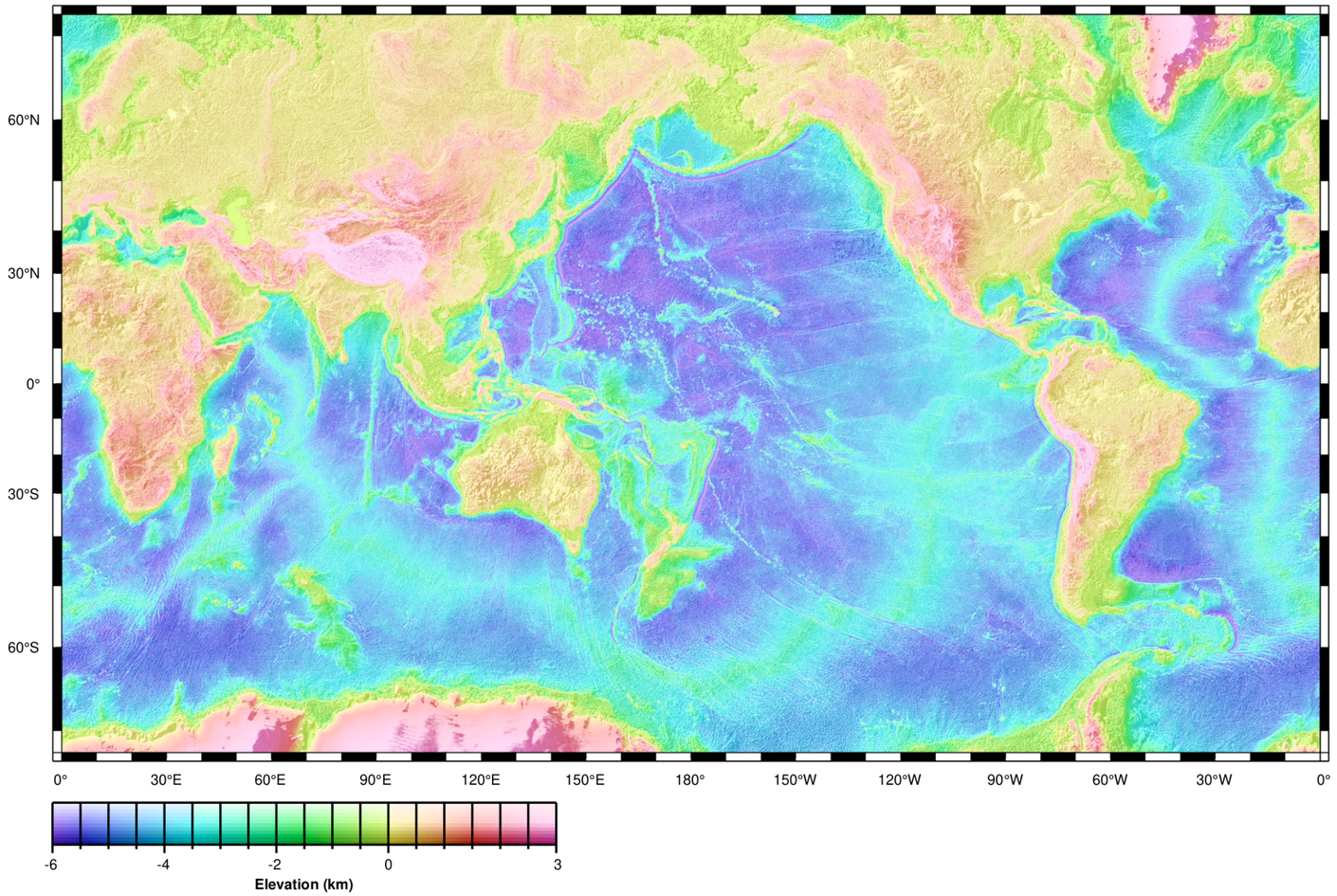
Lecture 5: Hot spots and seamounts

The topography and geology of the seafloor offers some of the only clues we have to understa hidden workings of the mantle below. We have discussed some of the largest features of ocea today we consider the small seamounts and their critical role in this story.

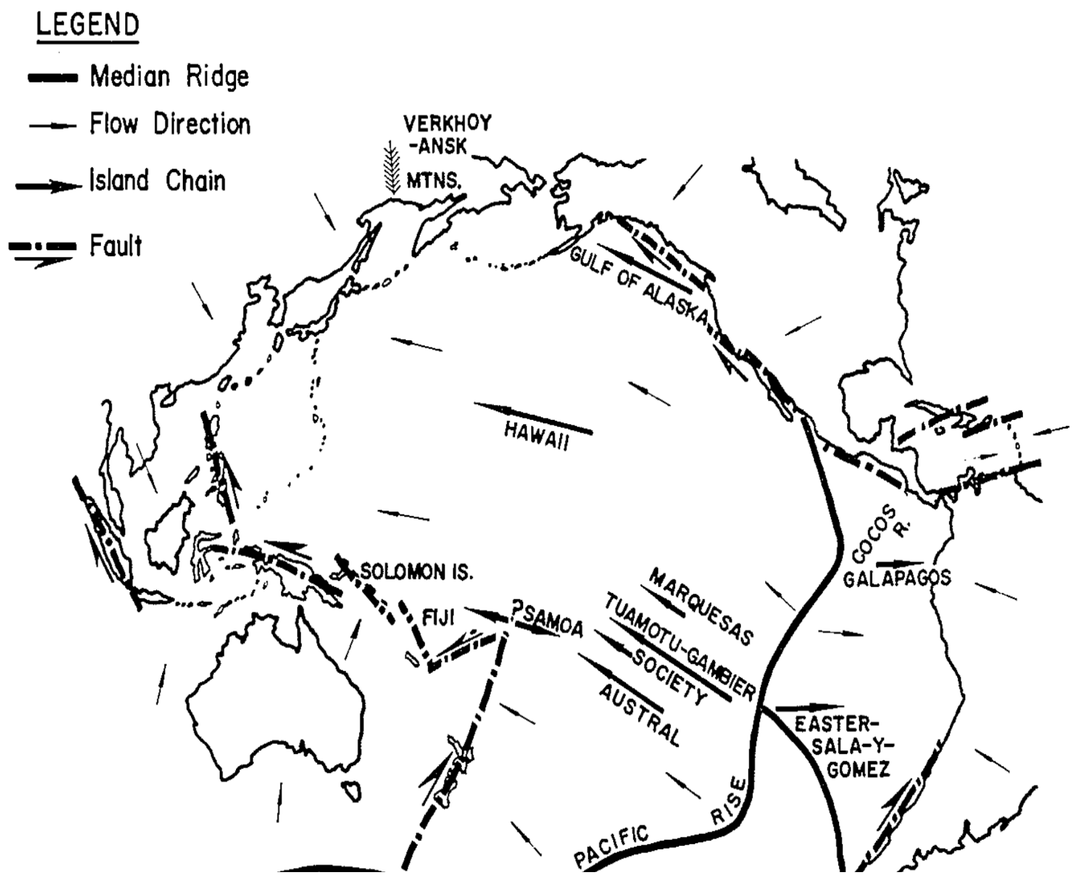
- Models of mantle convection and implications for volcanic islands
- Plumes and hotspots
- Free air anomalies and the **swell**
  - Explaining swells (thick crust vs thin lithospheric mantle)

We acknowledge and respect the lək̓ʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱S historical relationships with the land continue to this day.

Features of the seafloor



A possible origin of the Hawaiian Islands (Tuzo Wilson, 1963)



"It is less obvious why a stream of volca
arise like a series of bubbles from a poin
island of Hawaii which is far from the ri

Tuzo Wilson, *A possible origin of the H*
1963

Possible convective models

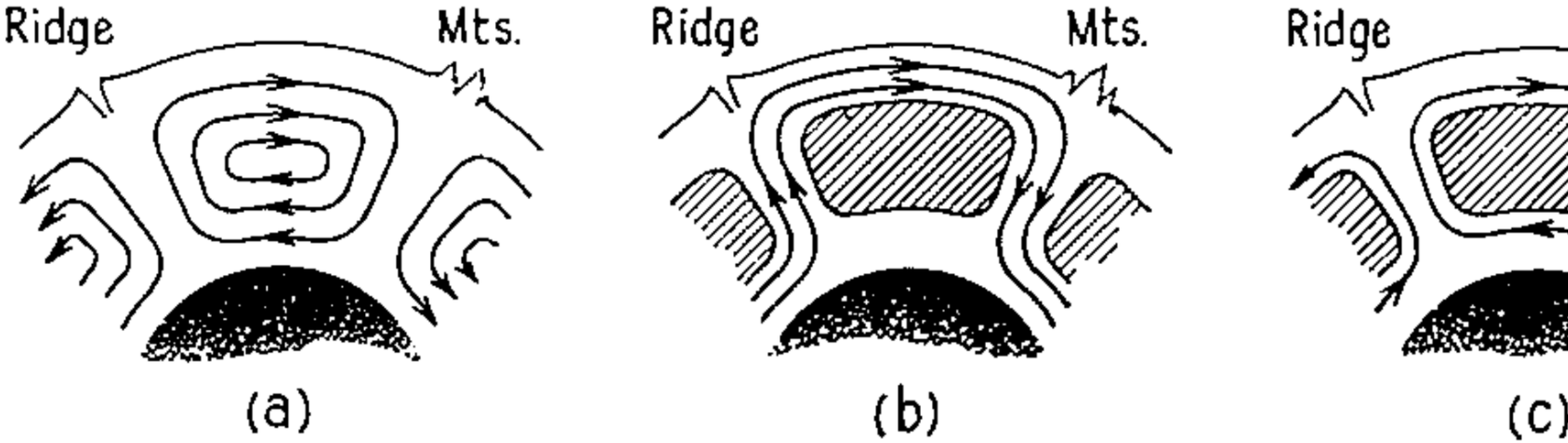


FIG. 2. Three possible modes of convection in the Earth's

The volcanic consequences of each convective model

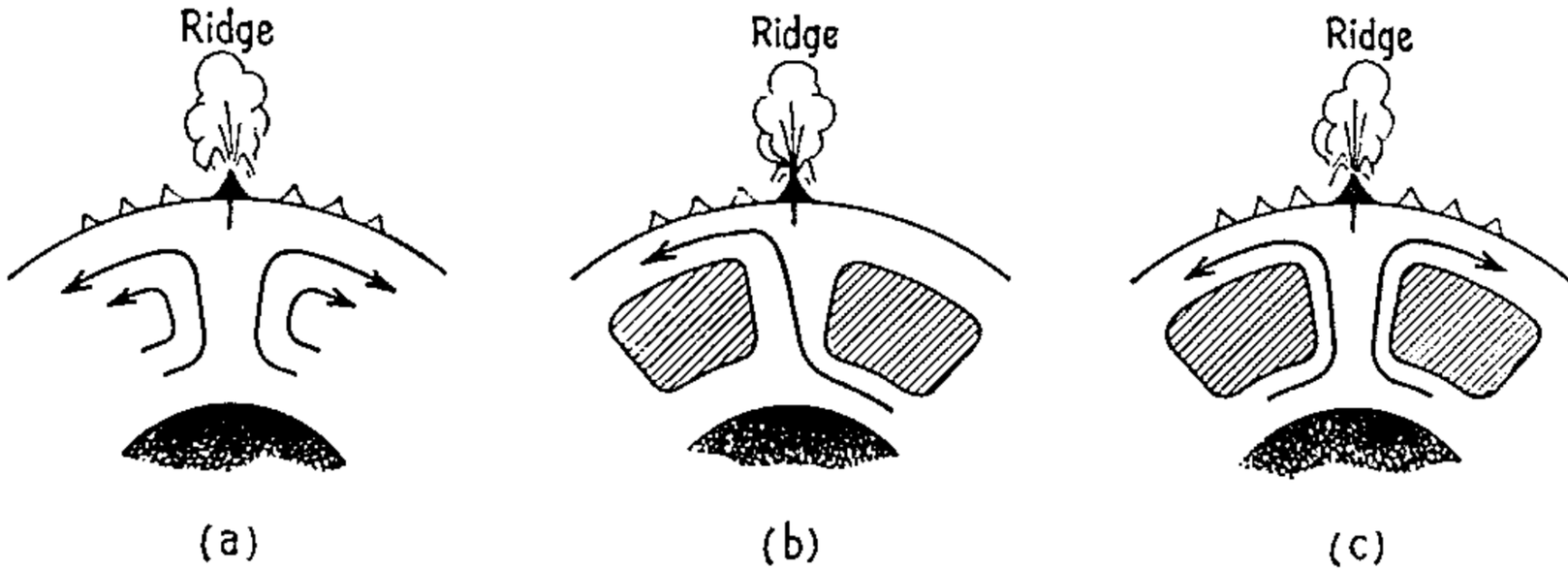


FIG. 3. Some possible patterns of convection, showing that, if active volcano
rising vertical currents, chains of extinct volcanoes might be formed by the horiz
the currents. The shaded areas represent stable cores of cells.

The volcanic consequences of each convective model

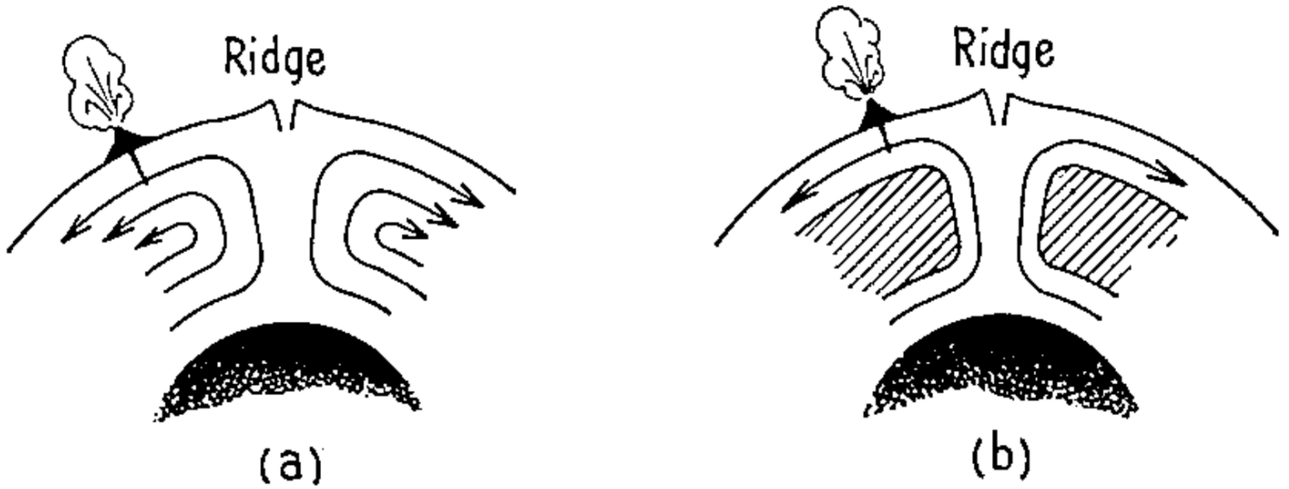


FIG. 4. Diagram to illustrate that in general if lava is generated at some oth
convecting system than over a rising current, then only one volcano will be gener

The source of lavas must be deep

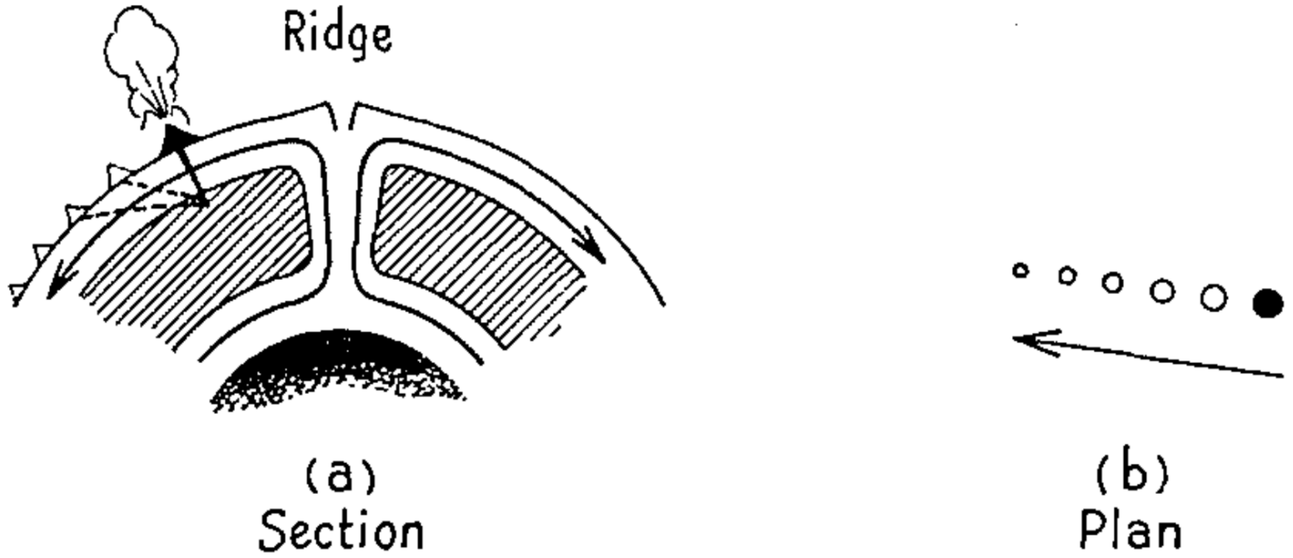


FIG. 5. Diagram to illustrate that if lava is generated in the stable core of a co
and the surface is carried by the jet stream, then one source can give rise to a ch
volcanoes even if the source is not over a rising current. This is proposed as a p
of the Hawaiian chain of islands.

The plume

"In my model there are about twenty deep mantle plumes bringing heat and relatively primordial m
the asthenosphere and horizontal currents in the asthenosphere flow radially away from each of t
This model is compatible with the observation that there is a difference between oceanic island ar
basalts."

Jason Morgan, *Convection Plumes in the Low*

The ages of ”rising bubbles”

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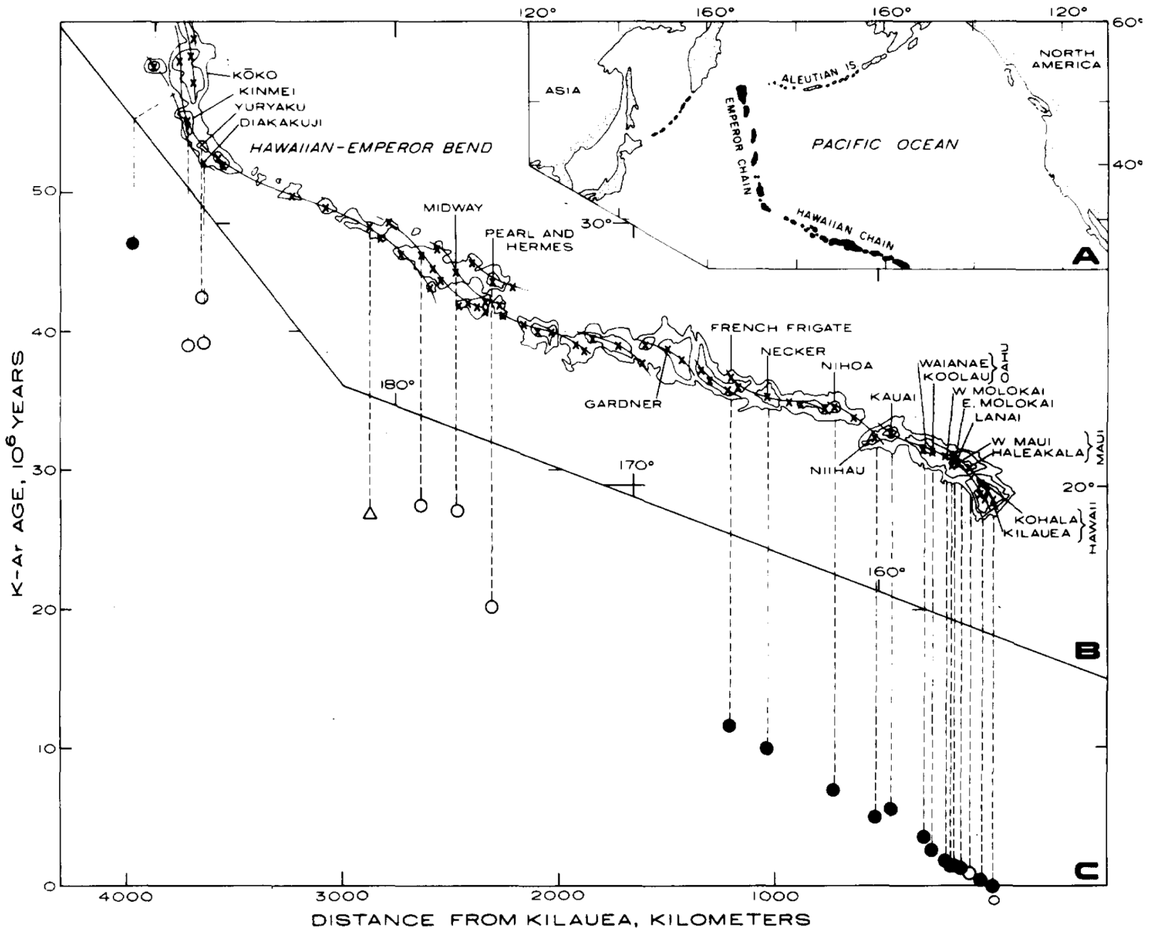

K-Ar ages from Hawaii chain volcanoes (Dalrymple et. al. 1977)

More gravity..

Gravity measurements are small variations in the acceleration due to gravity (similar to the w
you did from last lecture). How do we actually make these measurements?

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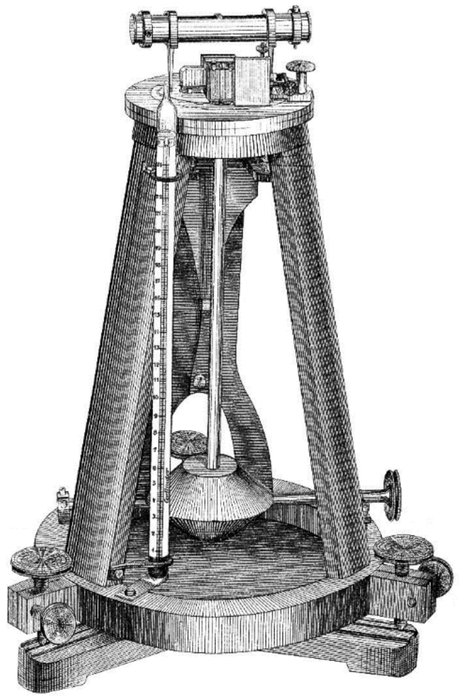

Pendulum of Sterneck 1887

The equation of simple harmonic mot
$T = 2\pi\sqrt{\frac{L}{g}}$, describes the relation
an easily measured property (T, the p
oscillation) to *gravity*, **g**.

Energy is added to the pendulum in a
to compensate for friction.

More gravity..

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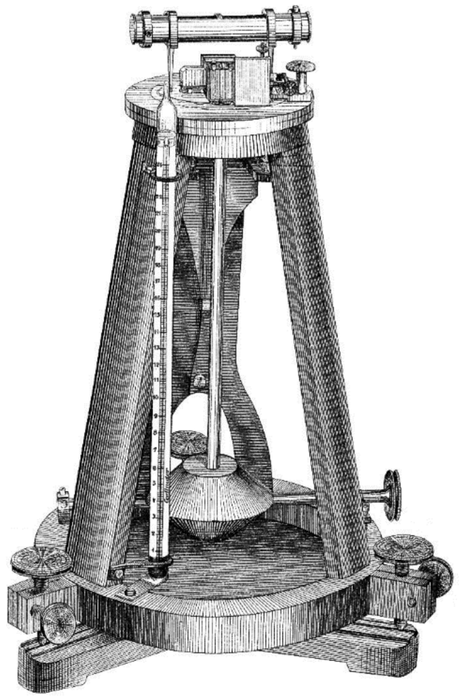

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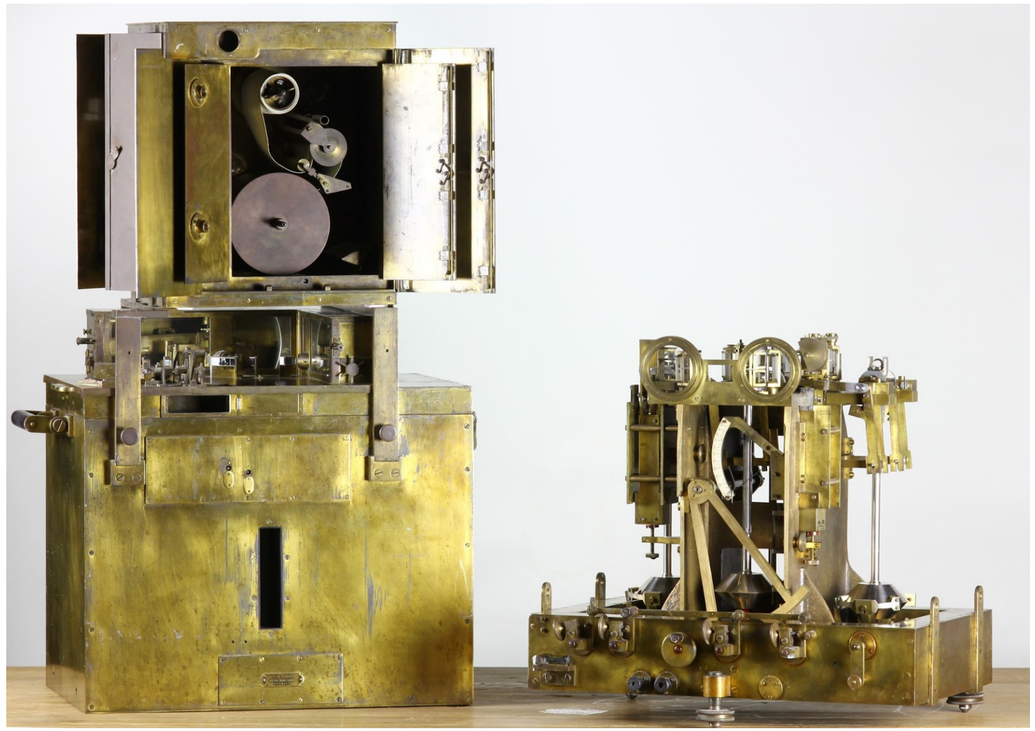
We keep talking about gravity measu
ocean.. how were these measuremen
ship?

More gravity..



Shipboard gravimeter built in 1923

The equation of simple harmonic mot

$T = 2\pi\sqrt{\frac{L}{g}}$, describes the relation

an easily measured property (T, the pe
oscillation) to *gravity*, **g**.

Shipboard accelerations are certainly
harmonic motion, however...

By precisely measuring the deflection
pairs of pendulums, gravity can be cor
under additional accelerations. A set
pendulums are needed to account for

More gravity..

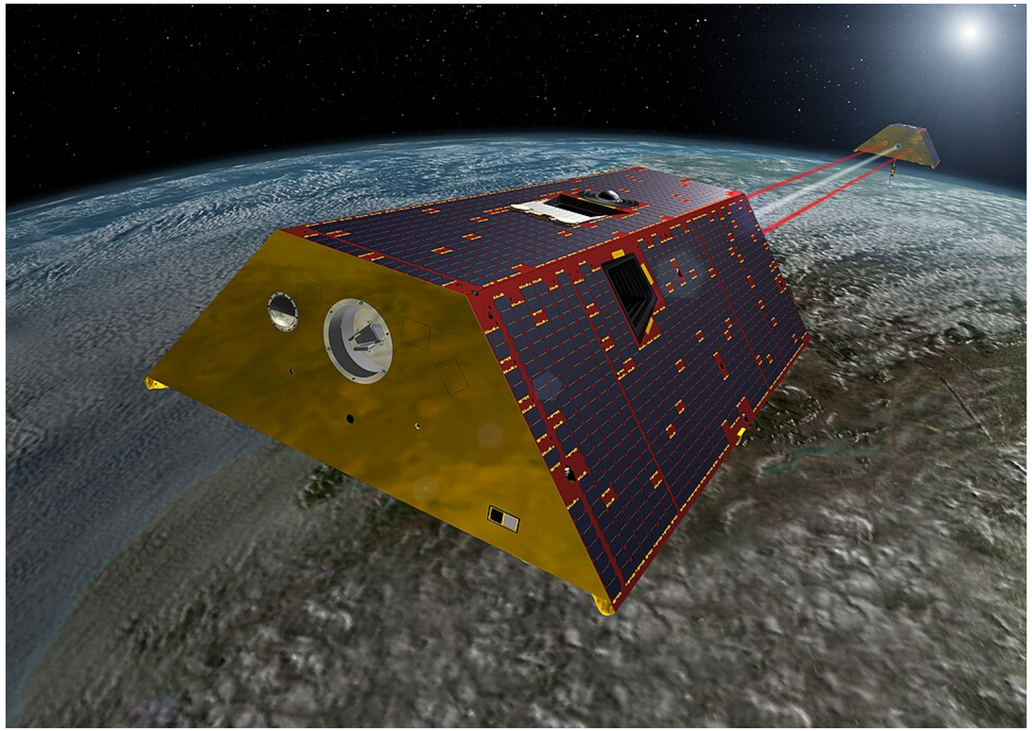
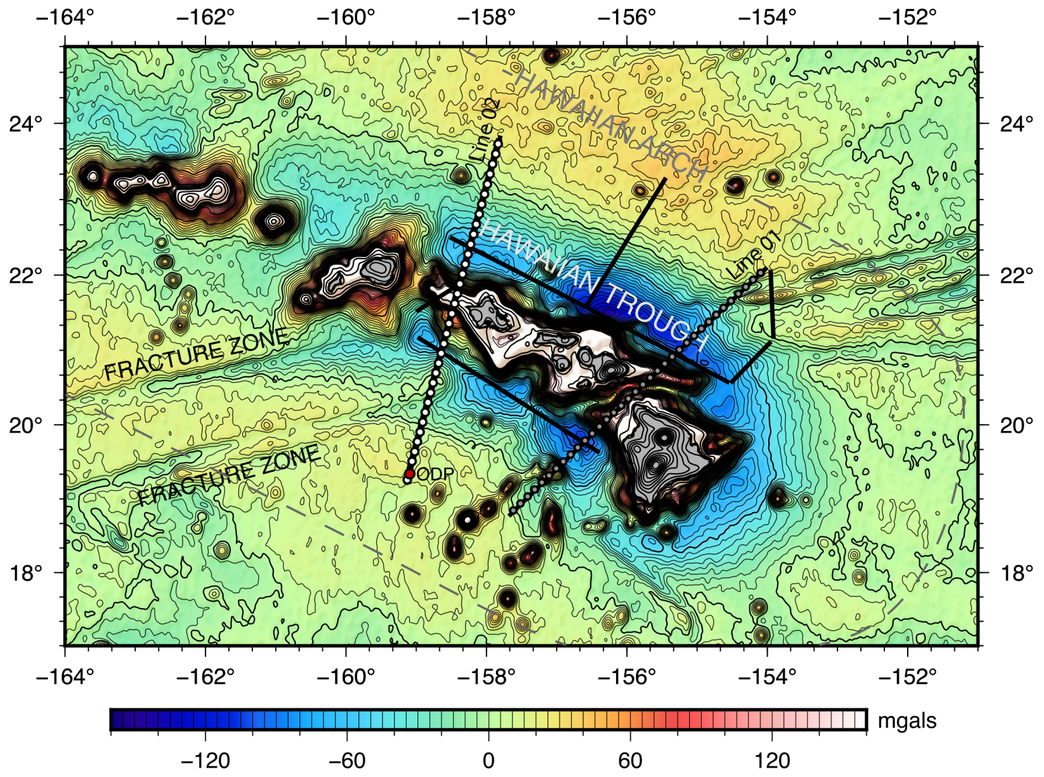


Illustration of the twin GRACE satellites

Today, we mostly measure gravity usi
The GRACE (Gravity Recovery and Cl
Experiment) mission launched in 200
missions using a similar approach are
planned for the future. These satellite
gravity up to 1000 times more accura
pendulums and have been really impo
observing gravity *change* on the Earth
to groundwater loss or ice sheet deca

More gravity..



Free air gravity anomaly around Hawaii (~1000 km; Figure from Dunn et. al. 2024). Recall
gravity anomalies are only corrected for the elevation difference from sea-level of the mea
practice, a specific geoid is used and it may not be perfect, but this **anomaly** highlights gravi
due to more (positive anomaly) or less (negative anomaly) mass than expected beneath the

Swells and depth anomalies

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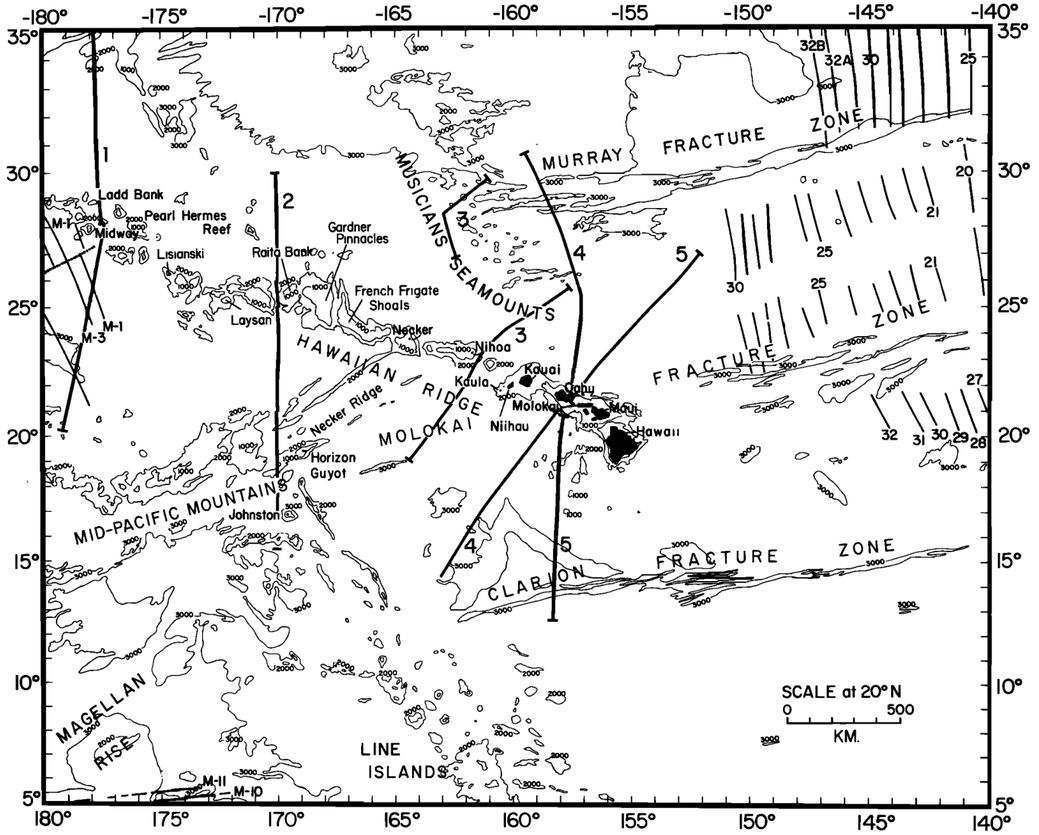
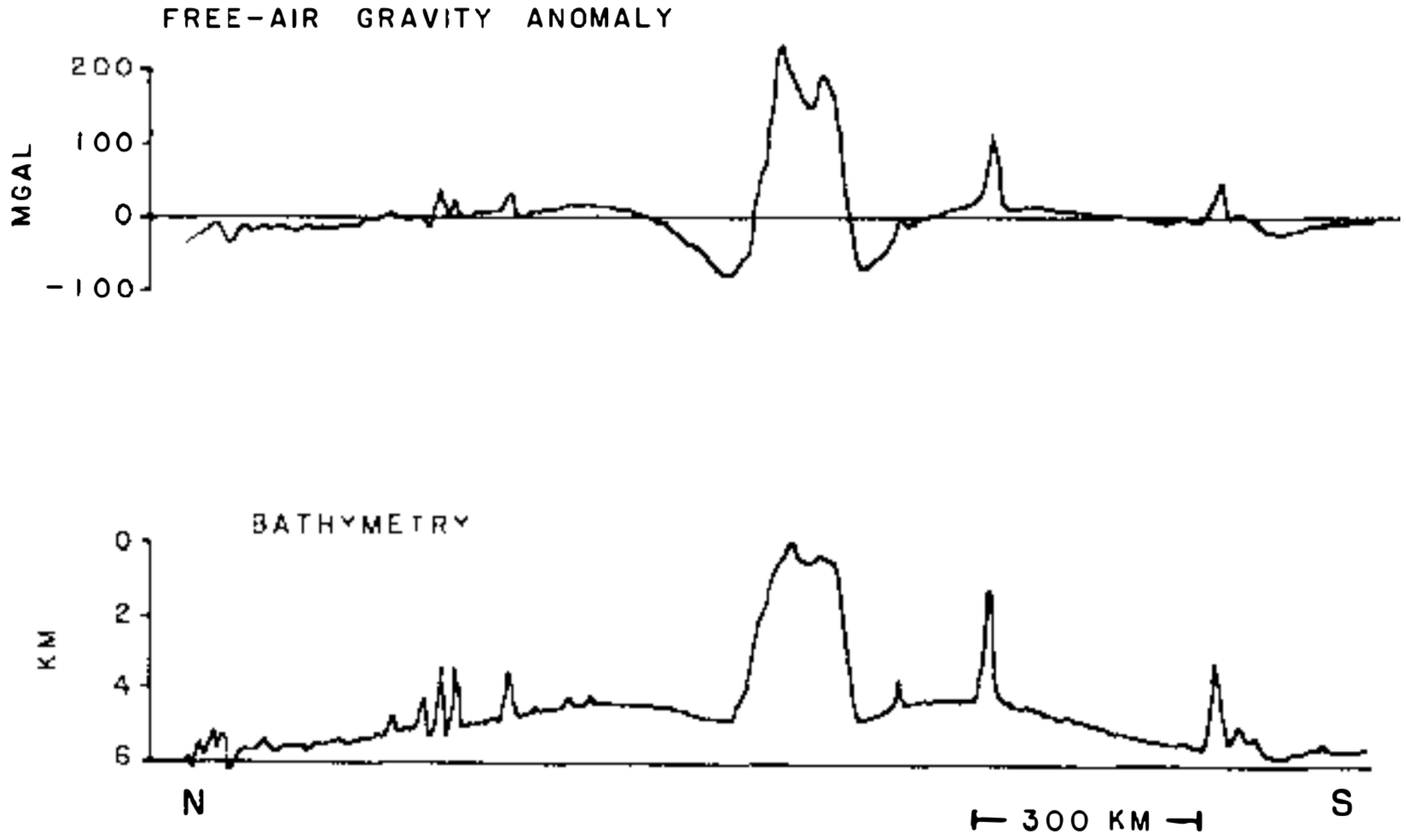


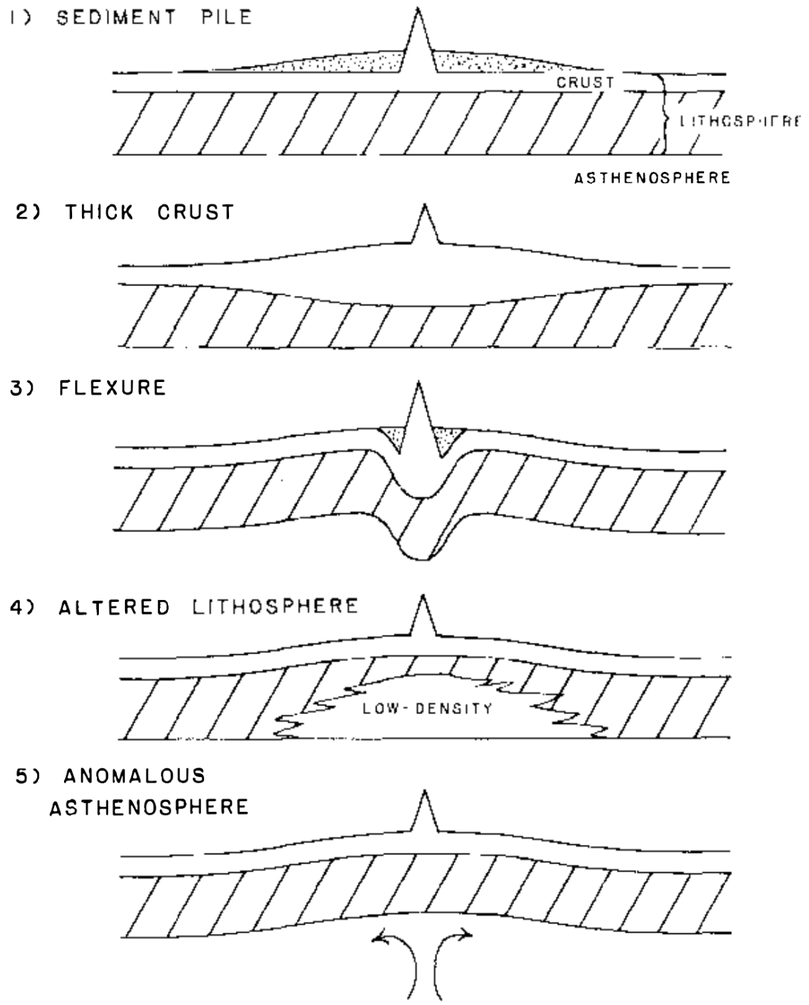
Bathymetry of the Pacific. Transect #5 is the next figure. (Watts 1976).

Swells and depth anomalies



Transects across Hawaii (Crough 1983)

How are swells supported?



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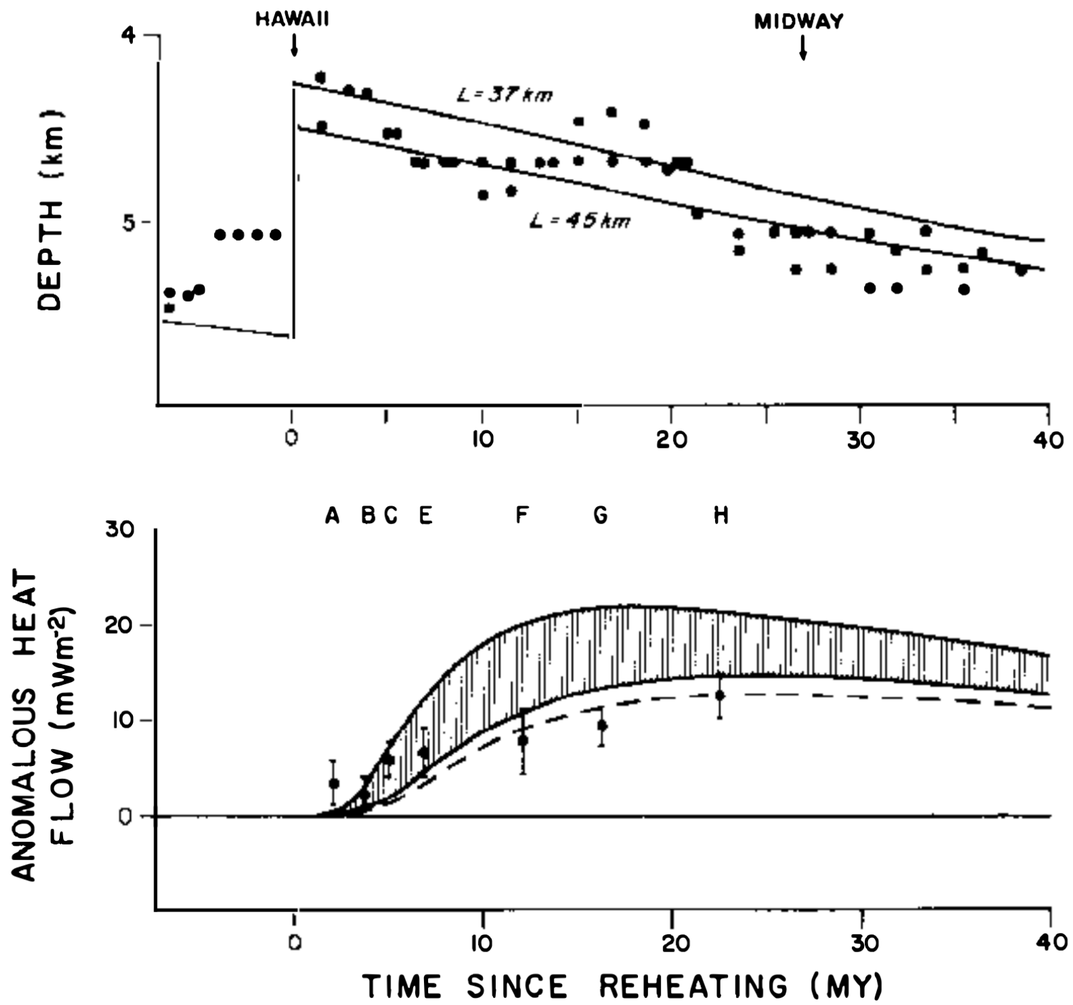
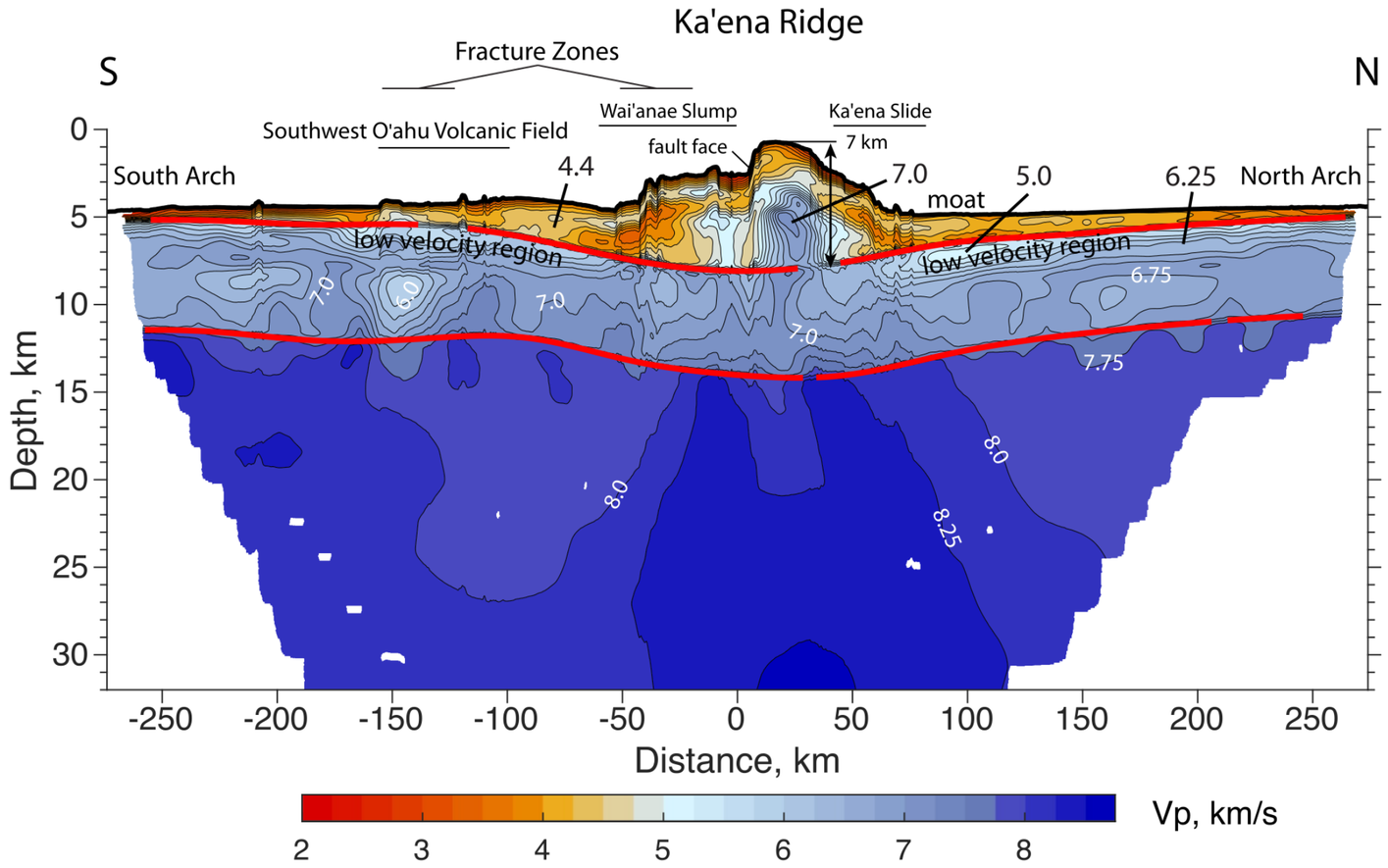
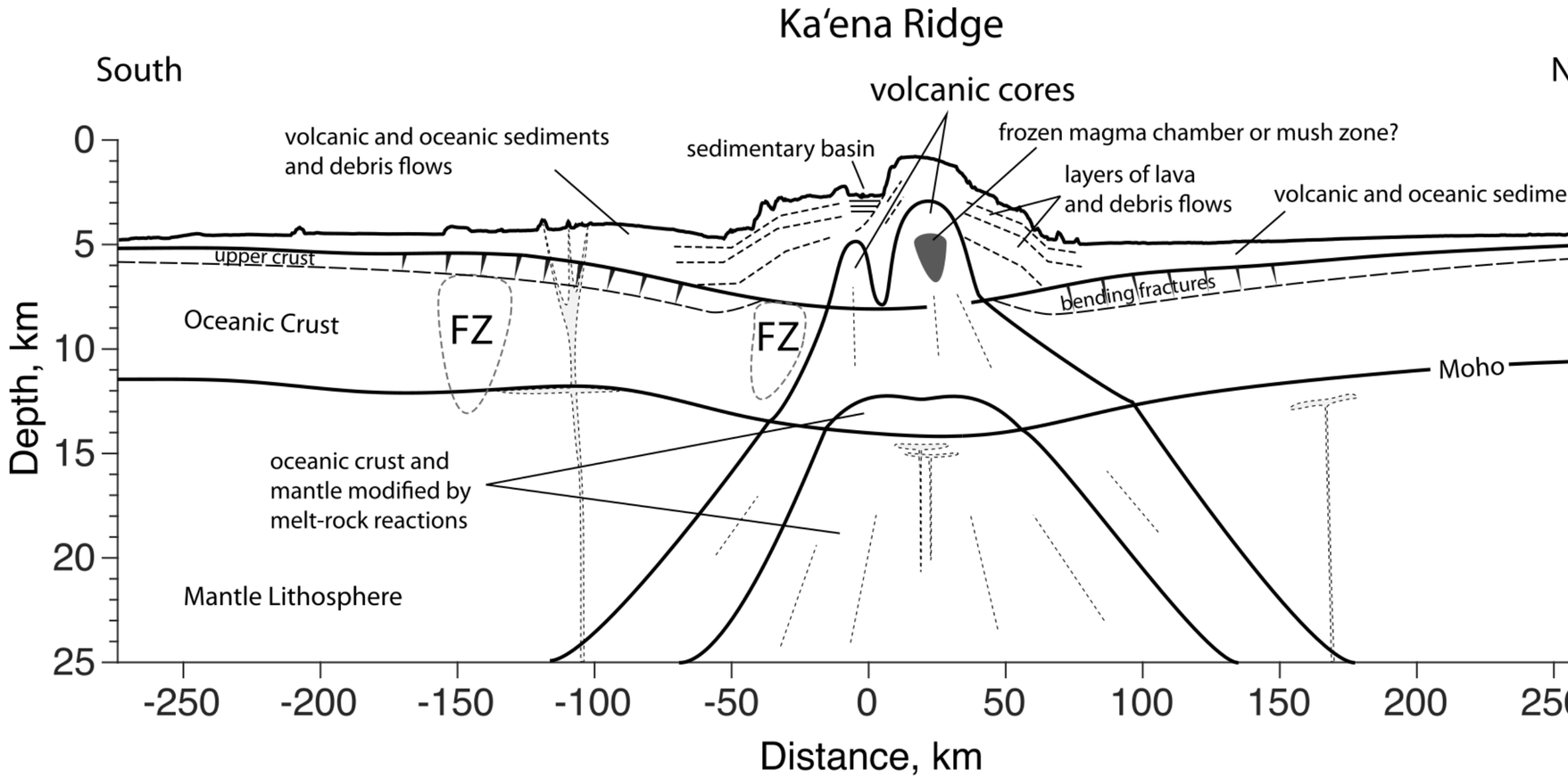


Constant crustal thickness



Dunn et. al. 2024

Constant crustal thickness



Dunn et. al. 2024