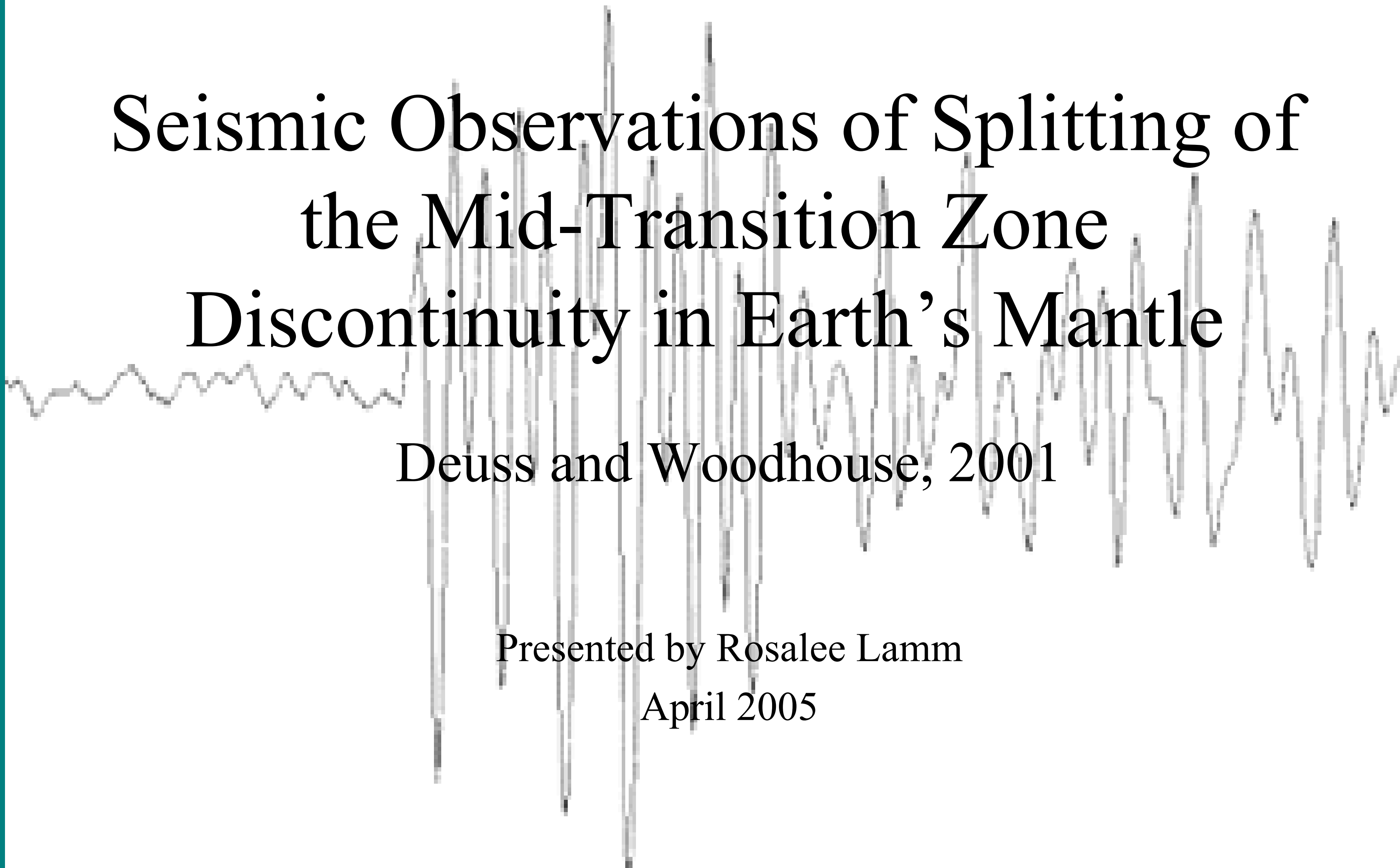

Seismic Observations of Splitting of the Mid-Transition Zone Discontinuity in Earth’s Mantle

Deuss and Woodhouse, 2001

Presented by Rosalee Lamm

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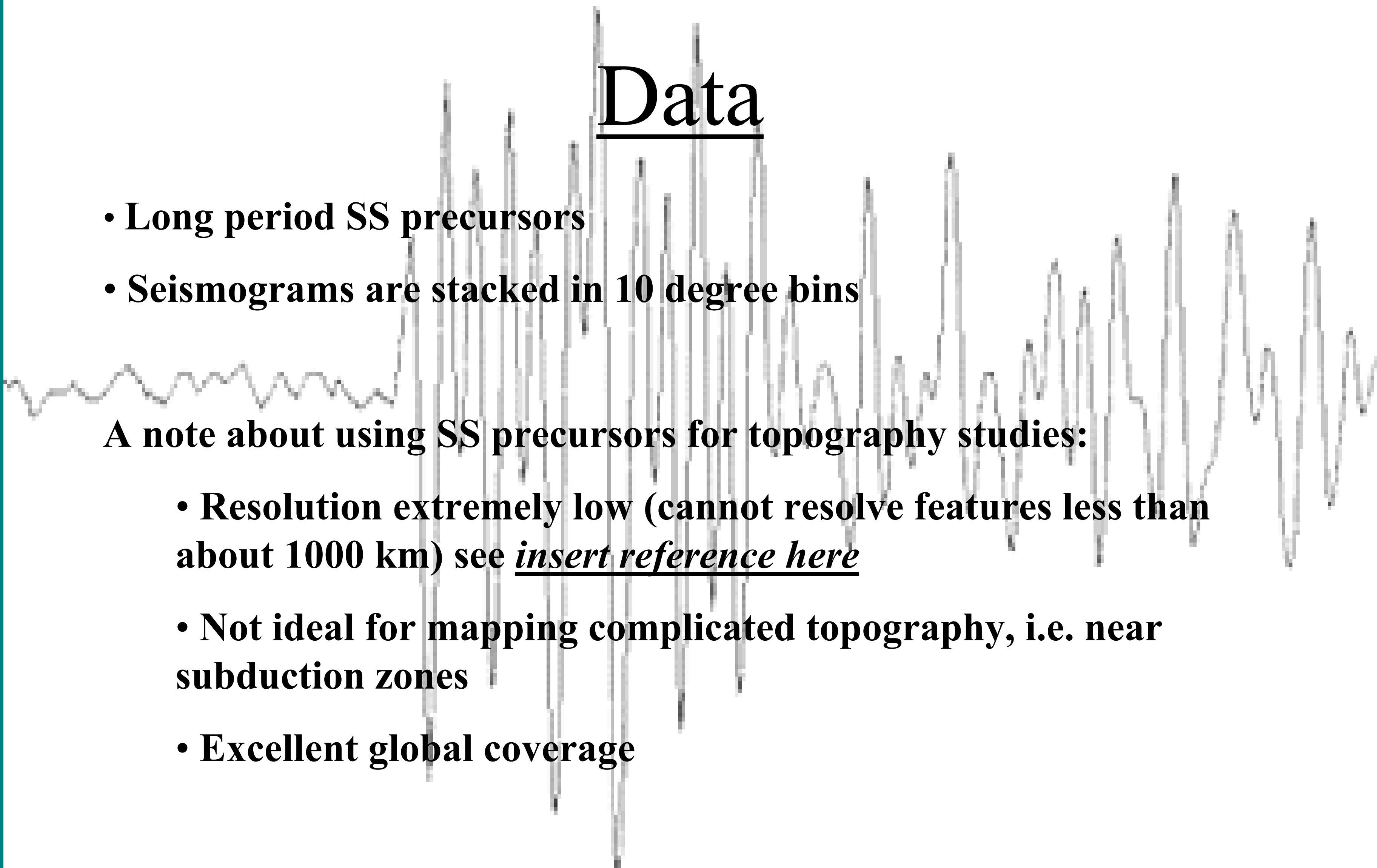
Data



- **Long period SS precursors**
- **Seismograms are stacked in 10 degree bins**

A note about using SS precursors for topography studies:

- **Resolution extremely low (cannot resolve features less than about 1000 km) see *insert reference here***
- **Not ideal for mapping complicated topography, i.e. near subduction zones**
- **Excellent global coverage**

Results

- Globally seen arrivals from 410 and 660 discontinuities
- Arrivals from the 520 discontinuity either:
    - Are absent
    - Show a single arrival
    - Show a double arrival
- These observations (of the 520) correlate neither with surface tectonics, nor with global tomography maps

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Fig. 1. Stacked traces for an east-west cross section through North America. On average, 160 seismograms are stacked in one trace. The traces show peaks in amplitude related to reflections from the major discontinuities at about 410 and 660 km. Between the "410" and "660" arrivals, there are signals from a range of depths; all traces with two reflections are marked (gray boxes). Note the multiple arrivals from "660" in cross section cC (white box), confirm earlier observations of multiple discontinuities in this region (*21*). Numbers (1) and (2) above the traces indicate the traces shown in Fig. 3.

What's the meaning of this?

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Mineral physics explanation?

- May be due to both the $\beta - \gamma$ phase change and the gt – ca-pv phase change.
- Both phase changes occur at the same depth at 1500 degrees
- Gt – ca-pv has a clapeyron slope of 0 to -2 MPa/K, whereas the $\beta - \gamma$ phase change has a positive clapeyron slope, thus…
- Temperature variations would cause the pressures of these phase changes to be negatively correlated, causing two separate reflectors.

However….there is no correlation between tomography (which they assume to reflect mostly temperature) and the distribution of the double and single reflections. Therefore…

Perhaps the variations in transition depth of the two phase changes are caused by compositional variations.

Compositional Effects?

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- Iron partitioning between garnet and beta and gamma phases could reduce transition width, causing better observability of the discontinuity (*Weidner and Wang,* 2000).
- If Mg # is too low, the beta – gamma transition does not occur– this would cause no, or one (from gt – ca-pv), discontinuity.
- Low Ca content in gt would cause the transition to ca-pv not to occur.
- Water and other trace elements may also change the sharpness of the discontinuity.

❖ A single reflection could correspond to regions that are a) Ca-poor, b) Fe-rich, or c) low in water content. These factors may also explain the absence of an arrival.

Splitting observations, revisited:

Fig. 2. Global observations of the 520-km discontinuity. The cross sections are computed using the same data set as in Fig. 1.

Fig. 4. Global observations of single reflections and splitting of the mid–transition zone discontinuity. Double reflections determined using the cross-correlation technique are marked with a bold plus. Weaker double reflections (obtained by visual inspection) are also shown. In the case of a single reflection, the topography on the mid–transition zone discontinuity is determined and plotted as deviation from the average depth of 525 km. The topography measurements are corrected for crustal (*31*) and mantle (*25*) structure.

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Synthetics

- Created synthetic seismograms using 3 models:
  - (A) no mid-transition zone discontinuity
  - (B) one mid-transition zone discontinuity at depths of 525, 540, and 565 km
  - (C) split mid-transition zone discontinuity

The authors say that the observations are best fit with the split discontinuity.

From Figure 1, section a -- A

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Fig. 5. Synthetic seismograms computed with WKBJ ray tracing (*32*). (**A**) No mid–transition zone discontinuity. (**B**) One mid–transition zone discontinuity with an impedance contrast of 4.8% [i.e., the total contribution of the garnet and olivine transition (*30*)] at depths of 525, 540, and 565 km. (**C**) Split mid–transition zone discontinuity with the impedance contrast from mineralogy (1.66% and 3.13%) and one with slightly larger impedance contrasts of 2.4% and 4.3%.

Questions

• Do the synthetics really support their conclusions?

• Splitting of arrivals may be caused by small scale topography that the SS precursors are unable to resolve *insert reference*

• What are the implications of such compositional variation in the mantle?

• Could these splitting observations be artifacts?

From Figure 2, section a -- A

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Fig. 5. Synthetic seismograms computed with WKBJ ray tracing (*32*). (**A**) No mid–transition zone discontinuity. (**B**) One mid–transition zone discontinuity with an impedance contrast of 4.8% [i.e., the total contribution of the garnet and olivine transition (*30*)] at depths of 525, 540, and 565 km. (**C**) Split mid–transition zone discontinuity with the impedance contrast from mineralogy (1.66% and 3.13%) and one with slightly larger impedance contrasts of 2.4% and 4.3%.

Conclusions

- Mid-transition zone discontinuity arrivals are highly variable, showing single or double reflectors, or none at all
- May be explained by dual phase change
  - Arrival variations may reflect compositional variations
  - Implies that mantle transition zone (TZ) is quite heterogeneous; if these observations are robust, mid-TZ arrivals may be used as a "probe for composition" in the TZ.