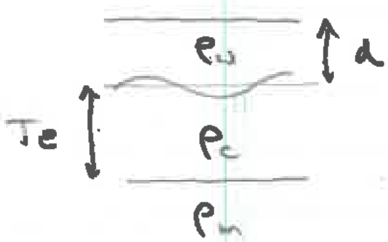
Lecture 24

WATTS: Gravity and Flexure

We have now explained almost all the topographic features on earth. Continents, plateaus + mountain ranges float. Mid ocean ridges result from thermal contraction on the earth's boundary layer ages. Island chains result from volcanism associated with mantle plumes (fixed hot spots).

Long term loads like volcanic islands can be of small enough scale to be supported by the elastic lithosphere, or may be large enough to "float". If they are supported elastically they will produce larger gravity anomalies than if they "float" — in which case the gravity anomaly will be produced by a dipole (− from root and + from topographic load).

If sediments or volcanic loads act on a flexed and fill in flexural depressions:



$$\frac{1}{\alpha} = \frac{1}{1 + \frac{k^4 D}{(\rho_m - \rho_c) g}} = \frac{(\rho_m - \rho_c) g \, \bar{u}_z^B}{(\rho_c - \rho_w) g \, \bar{h}}$$

Basement / lithosphere response ($\bar{u}_z^B$)

ampl of $k = \frac{2\pi}{\lambda}$

topographic expression ($\bar{h}$)

$$\Delta g_c = 2\pi G (\rho_c - \rho_w) \bar{h} \, e^{-kd}$$

$$\Delta g_m = -2\pi G (\rho_m - \rho_c) \bar{u}_z^B \, e^{-kd} \, e^{-kT_e}$$

$$\frac{\Delta g_c + \Delta g_m}{\bar{h}} = 2\pi G (\rho_c - \rho_w) e^{-kd} \left(1 - \frac{e^{-kt}}{\alpha} \right)$$

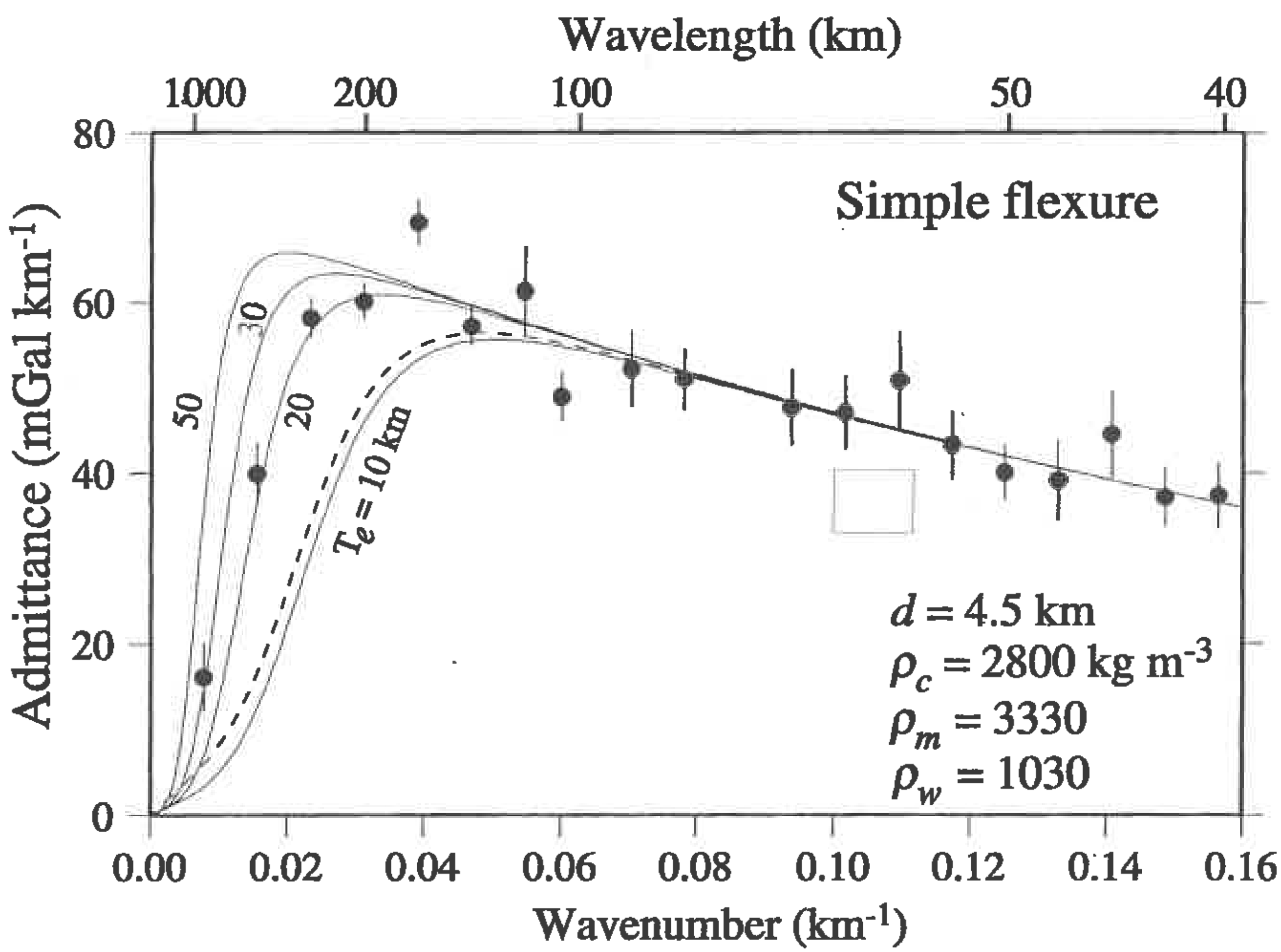
$\equiv$ Gravitational admittance

$1/\alpha = 1$ anom small

$1/\alpha \to 0$ anom large

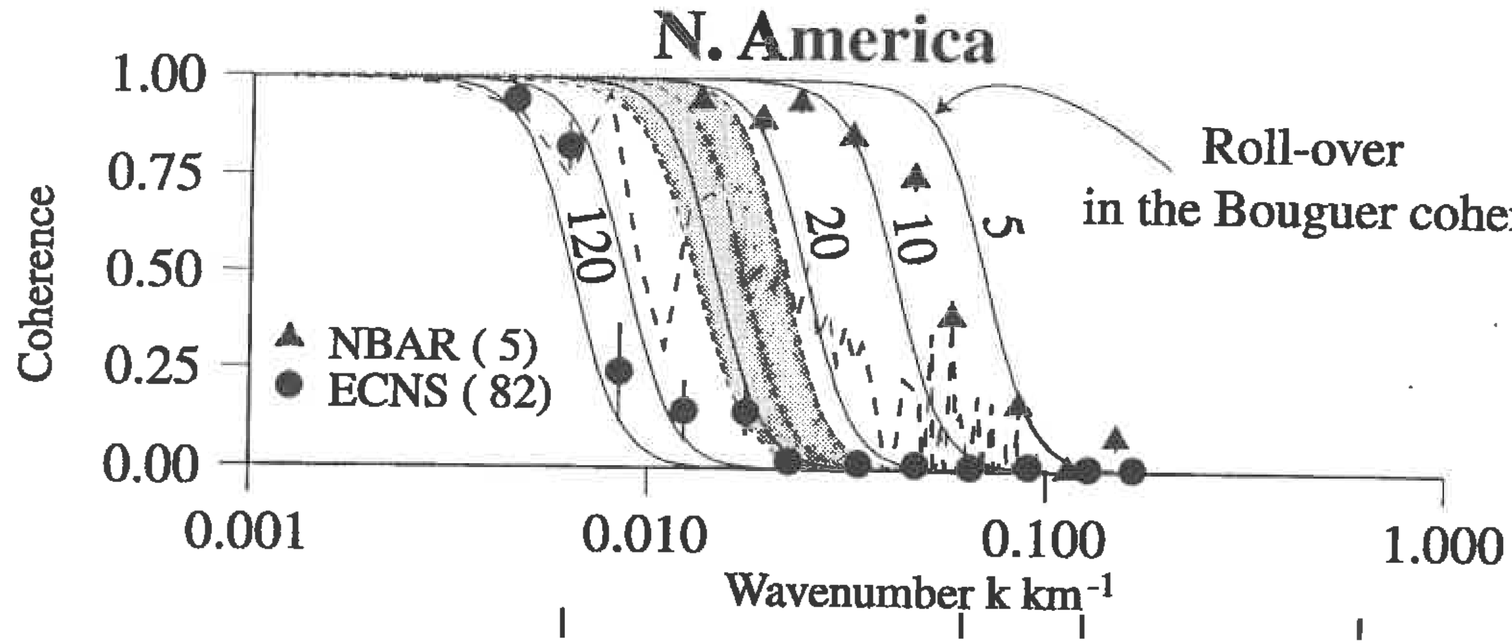
Gravity Admittance along Hawaiian_emporer Seamount Chain Suggests T_e~20 km

b)



Watts (2001)

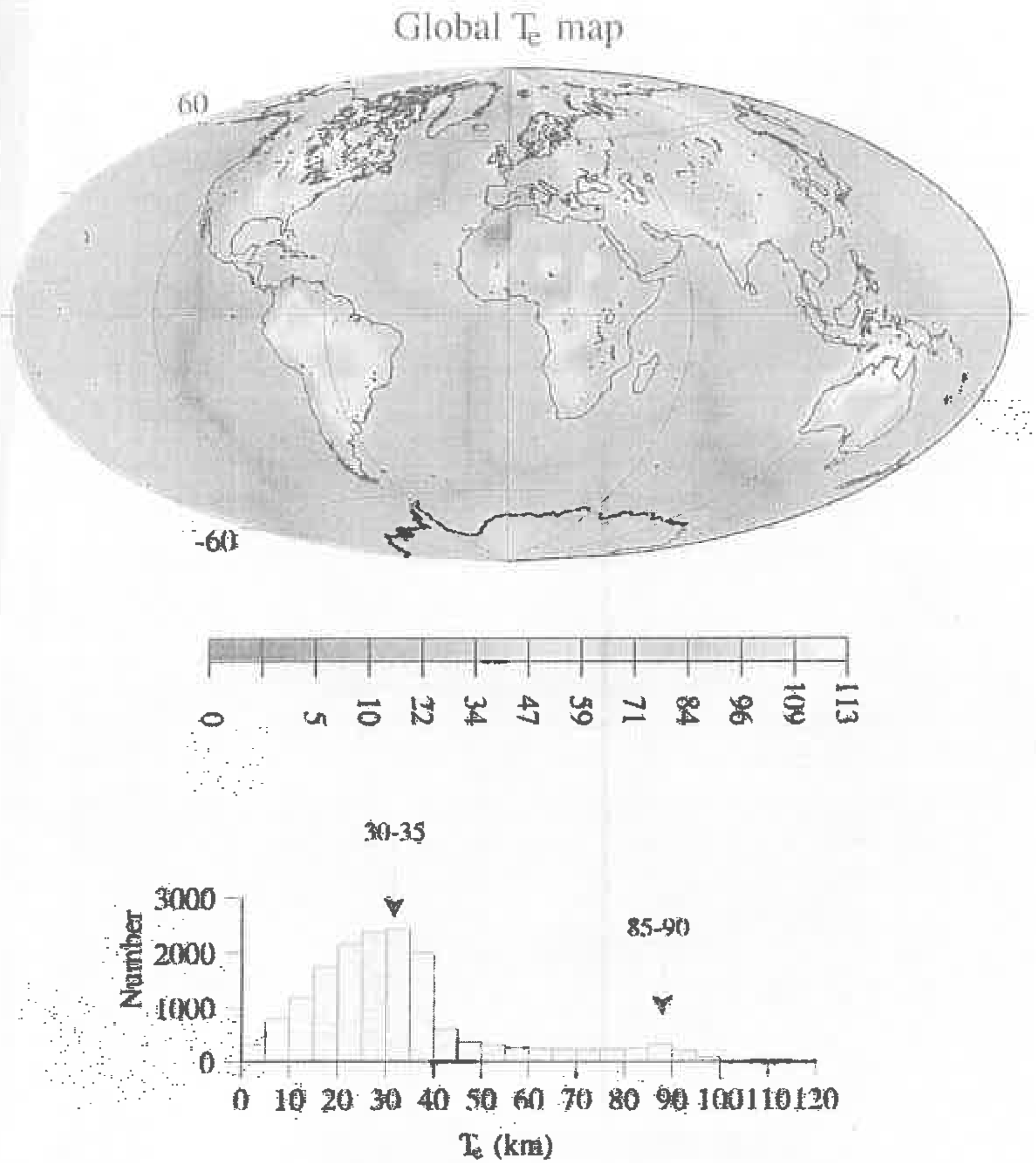
Coherence of topography and Bouguer gravity



NBAR = North Amer. Basin and Range, T_e ~5-10 km — ~0.5
ECNS = Eastern Canada Shield, T_e ~100 km — 100

D [10^{23} N-m]

Watts (2001)



Global T_e map
60
-60
0
5
10
22
34
47
59
71
84
96
109
113
30-35
85-90
Number
3000
2000
1000
0
0 10 20 30 40 50 60 70 80 90 100 110 120
T_e (km)

Watts (2001)