GPD-501

CHANGES OF PHYSICAL PARAMETERS INSIDE EARTH

Presented by:

Md Ashraf

DENSITY INSIDE THE EARTH

Adam's-Williamson equation

$$\frac{d\rho}{dr} = -\frac{\rho(r)g(r)}{\varphi(r)}$$

Where

$\rho(r) =$ Density at radius r

$g(r) =$ Gravitational acceleration at radius r

$\varphi(r) =$ Seismic parameter $\quad \varphi = \alpha^2 - \beta^2 = \frac{K}{\rho}$

Order of the Effective parameter:

1.Seismic → 2. Gravity → 3.Density

- Average Earth's density ~ 5.513 g/cm3.
- INNER CORE: ~12.9 g/cm3.
- OUTER CORE: ~ 11.0 g/cm3.
- LOWER MANTLE: ~ 5.0 g/cm3.
- UPPER MANTLE: ~ 3.9 g/cm3.

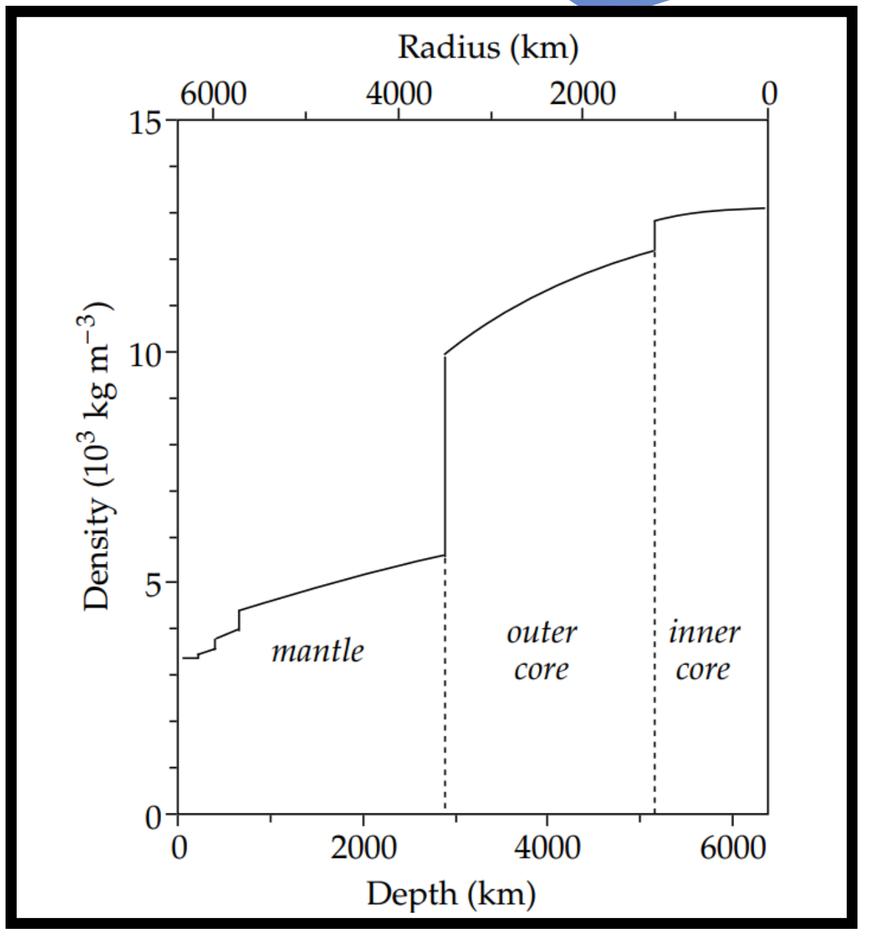


FIG: DISTRIBUTION OF DENSITY WITHIN THE EARTH

Gravity and pressure inside the Earth

Gravity Equation:

$$g(r) = -G\frac{m(r)}{r^2} = -\frac{G}{r^2}\int_0^r 4\pi x^2 \rho(x)\,\mathrm{d}x$$

Where;

$\rho(x)$ = Density at radius x

G= Universal gravitational constant

$g(r)$ = Gravitational acceleration at radius r

- Gravity increases from 9.8 m/s² at the surface and peaks at 10.8 m/s² near the Core-Mantle Boundary (CMB).
- After the CMB, gravity decreases almost linearly to zero as it approaches the Earth's center.

Pressure Equation:

$$p(r) = \int_r^R \rho(r) g(r)\,\mathrm{d}r$$

- Pressure rises continuously as depth increases .
- The pressure gradient varies significantly at major seismic discontinuities.

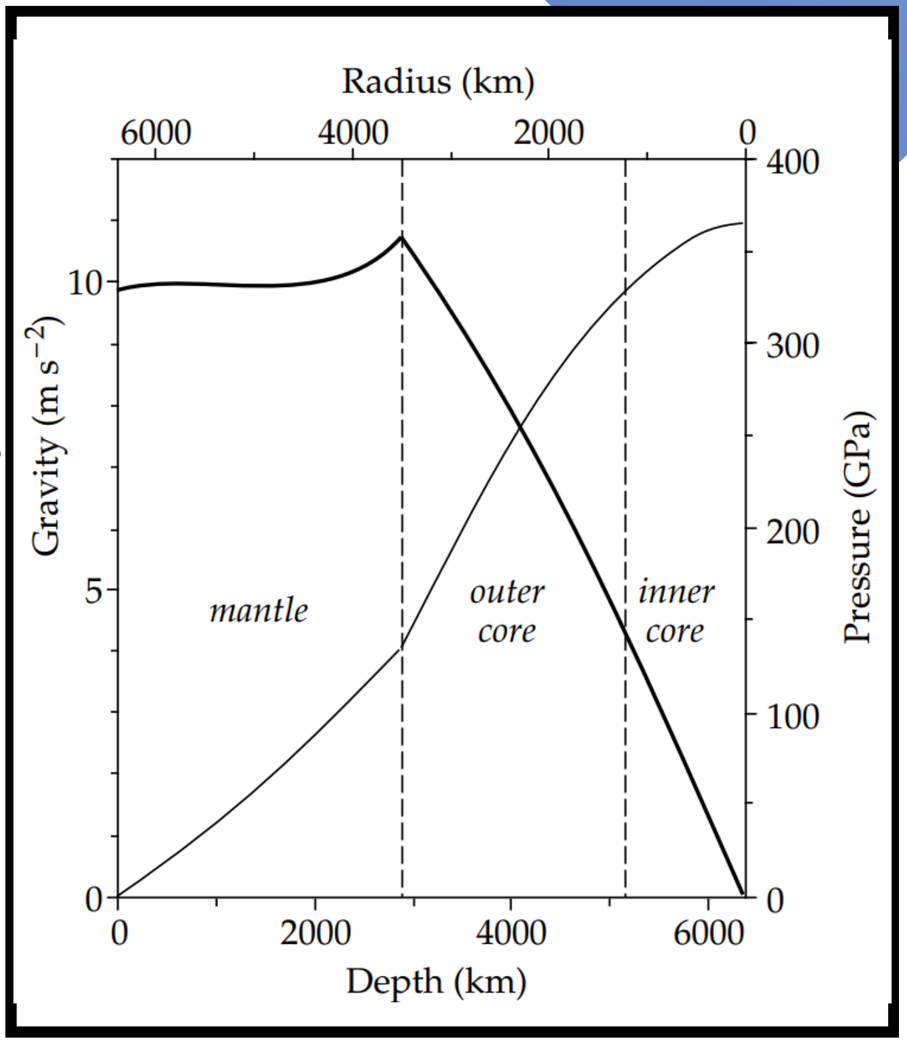


FIG: VARIATIONS OF GRAVITY (THICK CURVE) AND PRESSURE (THIN CURVE)

VARIATION OF VELOCITY INSIDE EARTH

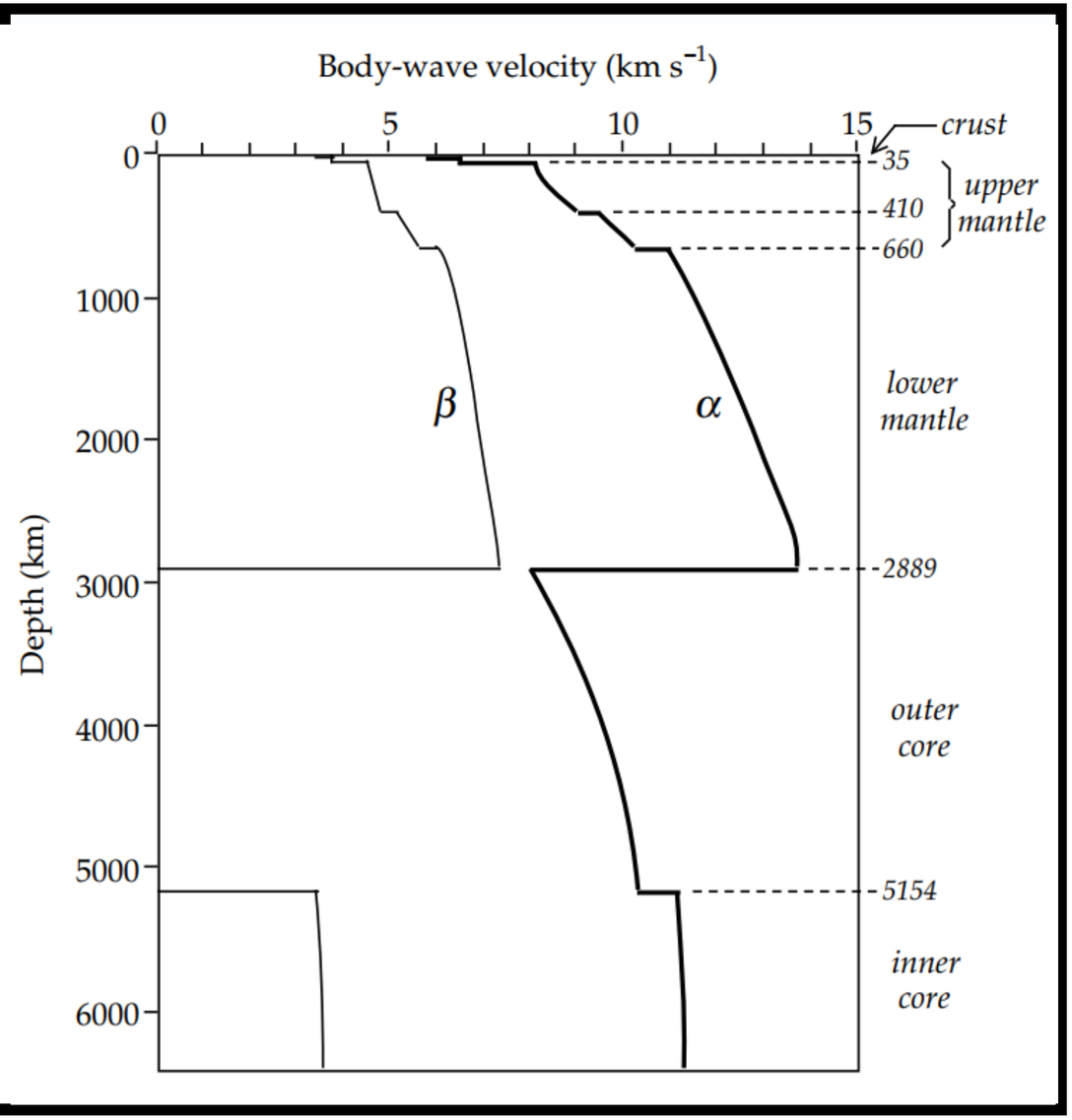


Fig:Variation of P and S wave velocity with depth

$$\alpha = v_p = \sqrt{\frac{K + \frac{4\mu}{3}}{\rho}}$$

$$\beta = v_s = \sqrt{\frac{\mu}{\rho}}$$

Where,

α = P-Wave Velocity

β = S-Wave Velocity

K = Bulk Modulus

μ = Shear Modulus

ρ = Density

- For liquid Outer core, shear modulus = 0 resulting S-wave velocity = 0.

TEMPERATURE INSIDE EARTH

The travel times of seismic body waves reveal critical phase transitions at specific depths.

- **Olivine–Spinel Transition**: Occurs at approximately 400 km depth.
- **Spinel–Perovskite Transition:** Occurs around 670 km depth in the upper mantle.

$$T = T_o \left(\frac{\rho}{\rho_o} \right)^{\gamma}$$

Where,

T = Temperature

γ = Gruneisen Parameter

ρ = Density

- The Temperature rises significantly at the CMB.
- Temperature in the Solid inner core must be less than melting point and in the molten outer core must be greater above the melting point
- At depths of 100 to 250 km, the temperature is close to where dry mantle rock melts, meaning the rock is almost or partially melted

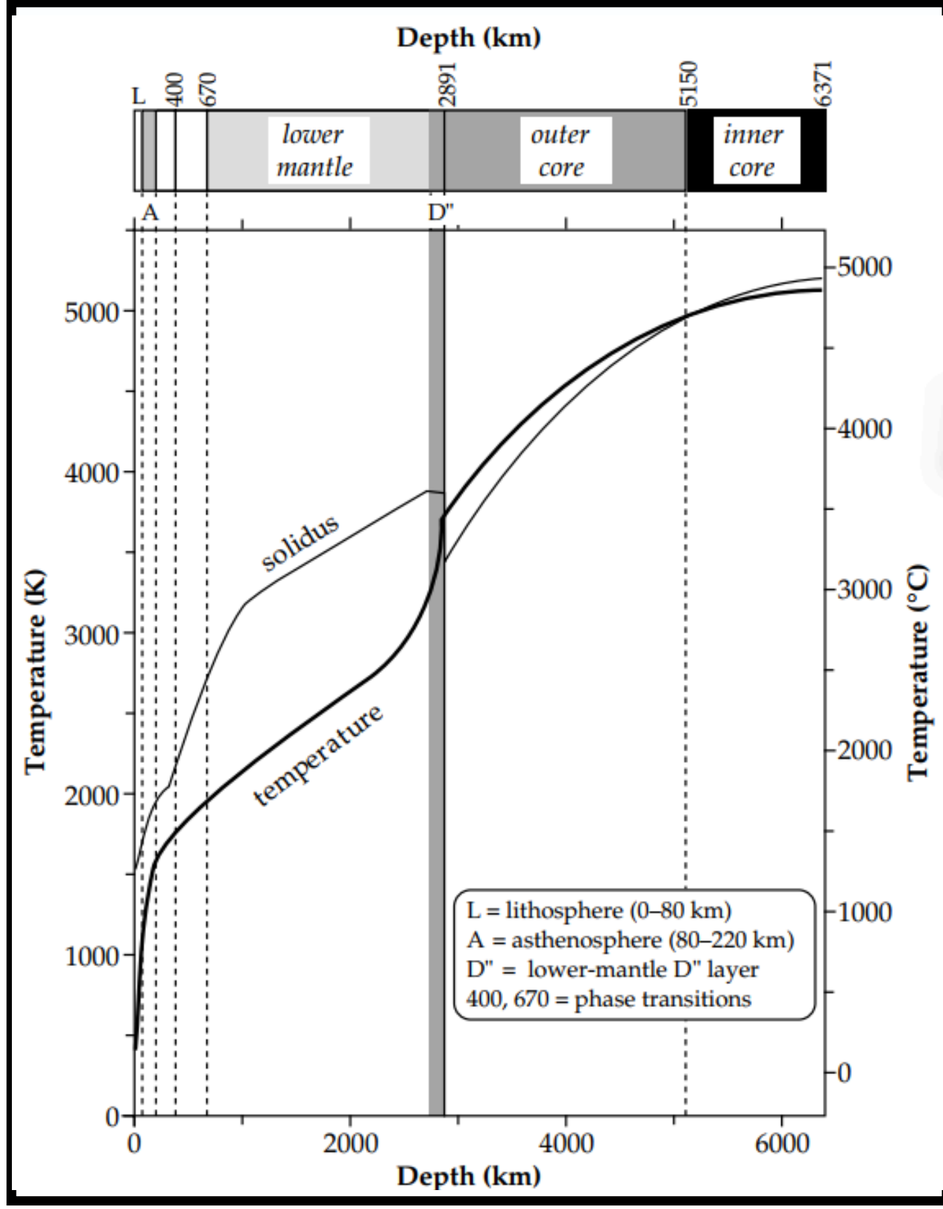
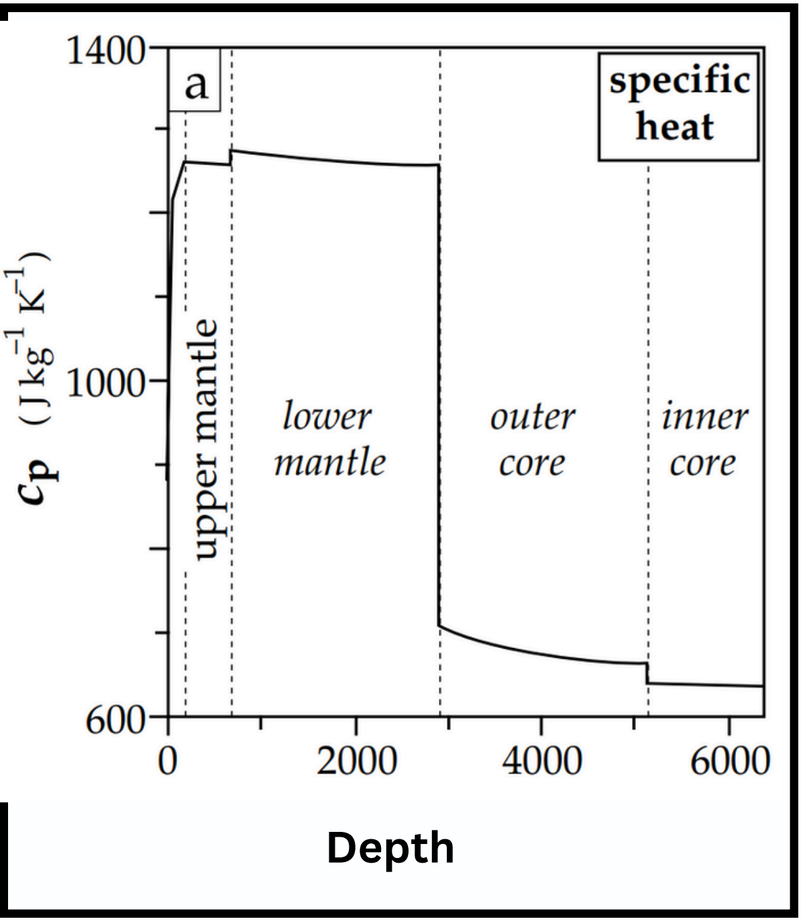
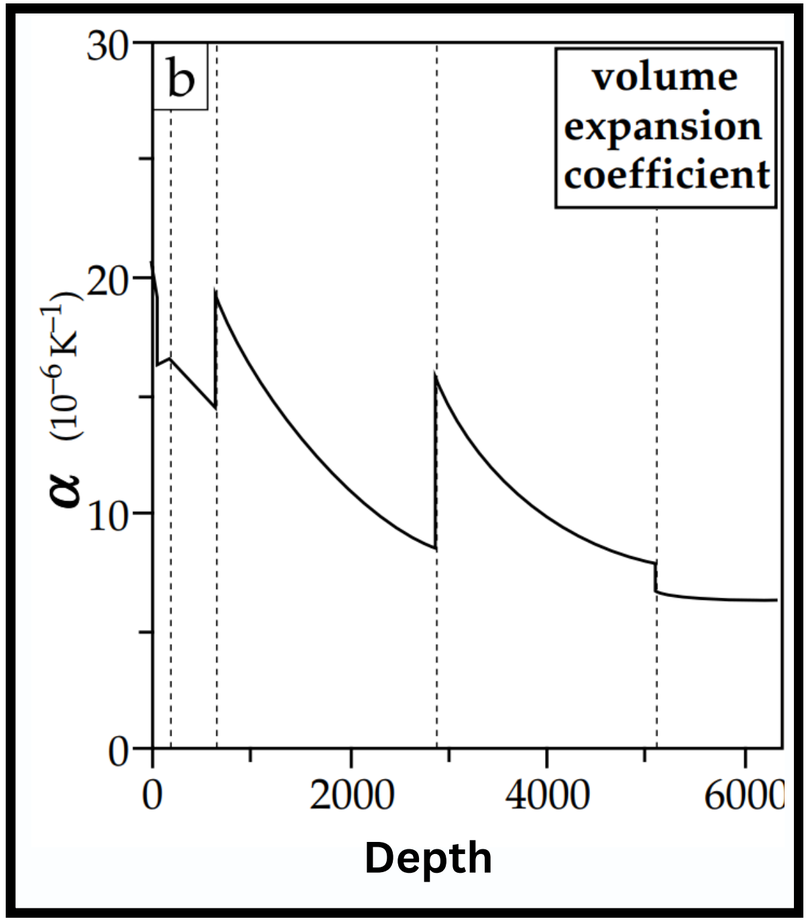
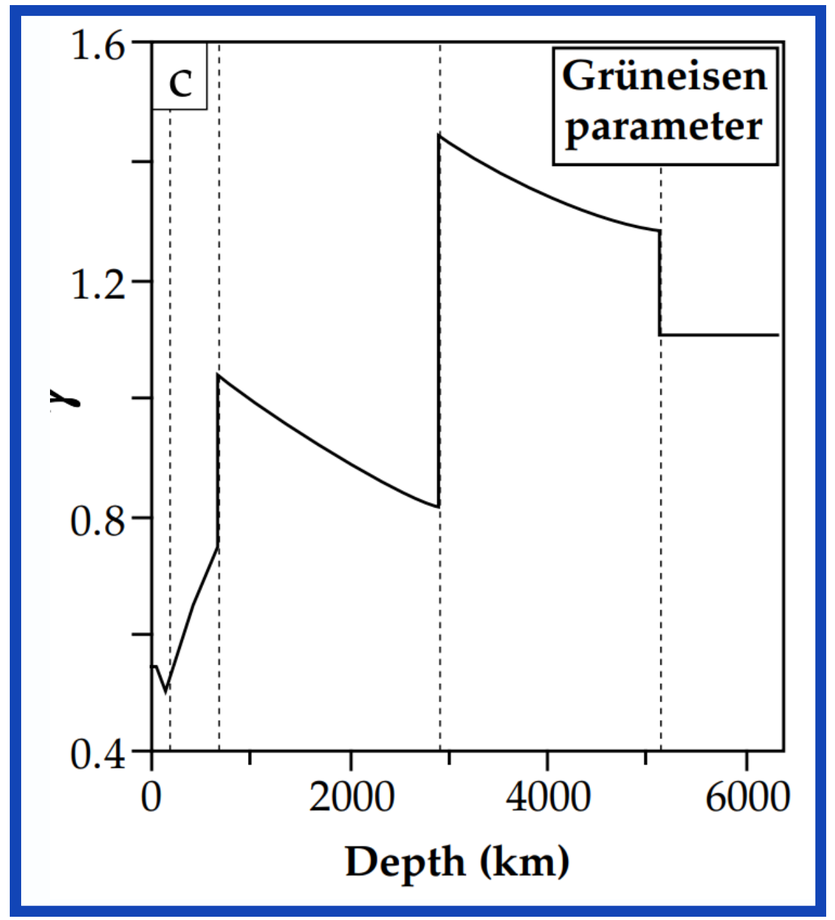


FIG:VARIATIONS OF ESTIMATED TEMPERATURE AND MELTING POINT WITH DEPTH INSIDE EARTH

OTHER PARAMETERS INSIDE EARTH







(A) Specific Heat at Constant Pressure

$$C_p = \left(\frac{\partial H}{\partial T}\right)_P$$

(B) Volume expansion coefficient

$$\alpha = \frac{1}{V_1}\left(\frac{\partial T}{\partial V}\right)_P$$

(C) Gruneisen Parameter

$$\gamma = \frac{\alpha K_s}{\rho C_p}$$

REFERENCE

1. Williamson, E.D. & Adams, L.H., 1923. Density distribution in the London. Earth, J. Wash. Acad. Sci., 13, 413–428
2. Singh, Parminder & Channi, Harpreet. (2023). Geothermal Gradient in India—Comparison and Current Status. 10.1007/978-981-99-6774-2_33.
3. Class Notes By Proshanta Kumar Khan
4. William Lowrie
5. Fowler Book
6. Kennett, Brian. (1998). On the density distribution within the Earth. Geophysical Journal International. 132. 374 - 382. 10.1046/j.1365- 246x.1998.00451.x.
6. Volgyesi, Lajos & Moser, M. (1982). THE INNER STRUCTURE OF THE EARTH. Periodica Polytechnica Chemical Engineering. 26.
7. https://www.scientificamerican.com/article/the-temperature-of-the-earths-inter/
8. Dziewonski, A.M. & Anderson, D.L., 1981. Preliminary reference Earth model, Phys. Earth planet. Inter., 25, 297–356
9. Dziewonski, A.M., Hales, A.L. & Lapwood, E.R., 1975. Parametrically simple Earth models consistent with geophysical data, Phys. Earth planet. Inter., 10, 12–48.
10. OLDHAM, R. D.: The Constitution of the Interior of the Earth as revealed by Earthquakes. Quart. Journ. Geol. Soc. London. 1906 (62) 456-475
11. . GUTENBERG, B. - RICHTER, C. F.: P and the Earth's Core. Monthly Notices Roy. Astron. Soc. Geophys. Suppl. 1938 (4), 594-615.

THANK YOU!