STRATIFICATION OF MERCURY'S CORE

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THE CORE IS CONVECTING

t = t_0

Super adiabatic heat flow

Adiabatic temperature profile

Convective core
STRATIFICATION APPEARS AT THE TOP OF THE CORE

$t = t_1$

Adiabatic temperature profile

Convective core

Heat flow

Temperature

Radius $r$

$cmb$

$t_1$

$Q(r)$

$Q_x(r)$

$T_u(r)$

Convective core
THE STRATIFIED LAYER GROWS

Sub-adiabatic heat flow

Convective core

Convective layer

Stable layer

$t = t_2$
\[ Q_s + Q_L + Q_g = -k \frac{\partial T_a}{\partial r}(r_n) \]

\[ T_a(r_n) = T_c(r_n) \]

\[ -k \frac{\partial T_a}{\partial r}(r_n) = -k \frac{\partial T_c}{\partial r}(r_n) \]

\[ \rho C_p \frac{\partial T_c}{\partial t} = \frac{1}{r^2} \frac{\partial}{\partial r} \left( k r^2 \frac{\partial T_c}{\partial r} \right) \]
- core radius: 1950 km - 2050 km
- cmb temperature at $t = 0$: 2000 - 2100 - 2200 K
- thermal conductivity: $k \approx 30$-$50$ W/m.K
- exponential law for cmb heat flow:

$$ Q_{cmb} = C + Ae^{-t/\tau} $$
SIMILAR INNER CORE GROWTH

- inner core size: ~1200 km today
- stratified layer thickness: ~600 km today
- convecting layer thickness: ~100-200 km

Large Fe-S cores and Fe-S-Si cores:
- no inner core
- core entirely stratified after 1.2 - 1.6 Gyrs
TEMPERATURE EVOLUTION (FE-S CORE: 1950 KM)

STABLE LAYER MORE AFFECTED THAN CONVECTING LOWER CORE

Tcmb = 2000 K

Tcmb = 2100 K

Tcmb = 2200 K

stratification onset

today

stratification onset

stratification onset

- cmb temperature: 100 K higher
POWER AVAILABLE TO DRIVE A DYNAMO

A DYNAMO DURING THE WHOLE EVOLUTION

- Tcmb = 2200 K
- Tcmb = 2100 K
- Tcmb = 2000 K

Without stratification

With stratification

occurrence of core dynamo

Tcmb = 2200 K

Tcmb = 2100 K

Tcmb = 2000 K

Time [Gyr]

0 1 2 3 4
ENTROPY CONTRIBUTIONS

SMALLER SINK ENTROPY

Without stratification  \hspace{2cm} T_{cmb} = 2200 \text{ K}  \hspace{2cm} With stratification

\begin{align*}
\text{entropy} \, [\text{MW/K}] & \quad \text{entropy} \, [\text{MW/K}] \\
\text{time} \, [\text{Gyr}] & \quad \text{time} \, [\text{Gyr}]
\end{align*}

- \text{sources (S+L+G)}
- \text{sink (conductivity)}
PRELIMINARY RESULTS

- Mercury’s core likely thermally stratified
- cmb temperature rises by ~100 K
- minor impact on the adiabatic lower core
- more power available to drive a dynamo during the whole evolution

NEXT...

- coupled core-mantle model
- surface magnetic field
BACK-UP
From a coupled core-mantle evolution ($r_c = 2050$ km, $T_c = 2100$ K)