WHAT IS OUT THERE BEYOND MANTLE CONVECTION?

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OUTLINE

(1.) INTRODUCTION

(2.) MANTLE CONVECTION

(3.) BEYOND MANTLE CONVECTION
   * wavelets (geoid, feature extraction)
   * discrete particle method (colloids, blood and porous media)
   * large-scale solution of Poisson equation and surfaces of crystals.

(4.) Closing Remarks
Collaborators

M.J.B Kido                      Japan
Alain Vincent                  Canada
Xavier Thibert                 Canada
Ludek Vecsey                   Czech Republic
Marc Monnereau                 France
Klaus Regenauer-Lieb           Germany
Witek Dzwinkel                 Poland
Kris Boryszko                  Poland
Radek Matyska                  Czech Republic
Gordon Erlebacher              Florida State University
Oleg Vasilyev                  Univ. Colorado, Boulder

Cathy Hier Majumder

Erik O.D. Sevre

Zack Garbow                    University of Minnesota
John M. Boggs                  
Lilli Yang                     

and others, such as other Russians (Yuri, Bobby, Sasha, Taras, Arkady)
Mantle Convection: layered versus whole mantle convection in the last 20 years this question has remained unanswered.
In fact the mantle may be a lot more complicated


**Important issues:**
1. subduction, slab detachment
2. stagnant slabs in the transition zone
3. superplumes, upper-mantle plumes, plumes from the mid-mantle
4. shear zones
5. metastable phase transitions, phase transitions and earthquakes
6. adiabaticity in the mantle, superadiabatic and equation of state
7. effects of thermal conductivity and its coupling to mantle rheology
8. volatiles, water on transport properties
Temperature

Composition

$3\text{He}/4\text{He}$. Min $= 1.8$, Max $= 35.0$

$207\text{Pb}/204\text{Pb}$. Min $= 13.9$, Max $= 17.5$

Reference Case, present time
Seven cases: five simple as a key to understand two complex.
Horizontal temperature profiles across the hottest structure for the seven cases.
Interacting Ductile Faults

The Model: Lithosphere in Pure Shear

v=const
Interacting Ductile Faults

Strain-rates Wet A

3 kyrs

6 kyrs

Strain-rates Wet B
Interacting Ductile Faults

40 krys

Wet A

Wet B

47 krys
Interacting Ductile Faults
Many things still left to do in mantle convection but the efforts would be far greater than before. There are also many new fields being developed, non-linear geophysics (NG branch of the AGU).

- Fractals, chaos,
- self-organized criticality (Bak)
- wavelets
- cellular automata
- discrete particle approach, molecular dynamics.

Data deluge $\Rightarrow$ feature extraction

Data mining, clustering
Enormous amounts of data are being amassed in fields as diverse as genomics and geophysics.

It's sink or swim as a tidal wave of data approaches.

We must extract knowledge from such large stores of information "scientific visualization" or "DATA MINING".
Mother wavelet \( \psi\left( \frac{x-b}{a} \right) \)

\( x, \, b \) (multi-dimens.)

\( \vec{b} \) is position vector, \( a \) is scale

Multiple-scaled object to be examined

Wavelet transform picks up only the spatial distribution as a function of the moving \( \vec{b} \) with length scales of \( O(a) \).
Large-scale Solution of Poisson Equation

\[ \nabla^2 \phi = \sigma (x, y) \]

- Potential (local properties)
- Charge density (topography from Atomic Force Microscope)

20,000 grid points
GOAL is to look at large surface area of 100 microns $\times$ 100 microns

64 grid points for each atom

one million $\times$ one million grid points

$10^{12}$ points

need out-of-core Memory

around 1 Terabyte of Memory
visualization of Tera-scale Data
Closing Remarks

1. Many exciting things still left to be done in mantle convection, but has the field maxed out (every research specialty reaches a peak sometime.)

2. There are many exciting new things to do in the environmental sciences, provided one is willing to learn and to soak up new knowledge like a sponge.

3. A sound foundation in physics, chemistry and mathematics is needed to leap to other areas. that and hard work and curiosity.