Integrated Lithospheric Conductivity Modelling in the Pyrenees using Laboratory and Field Data

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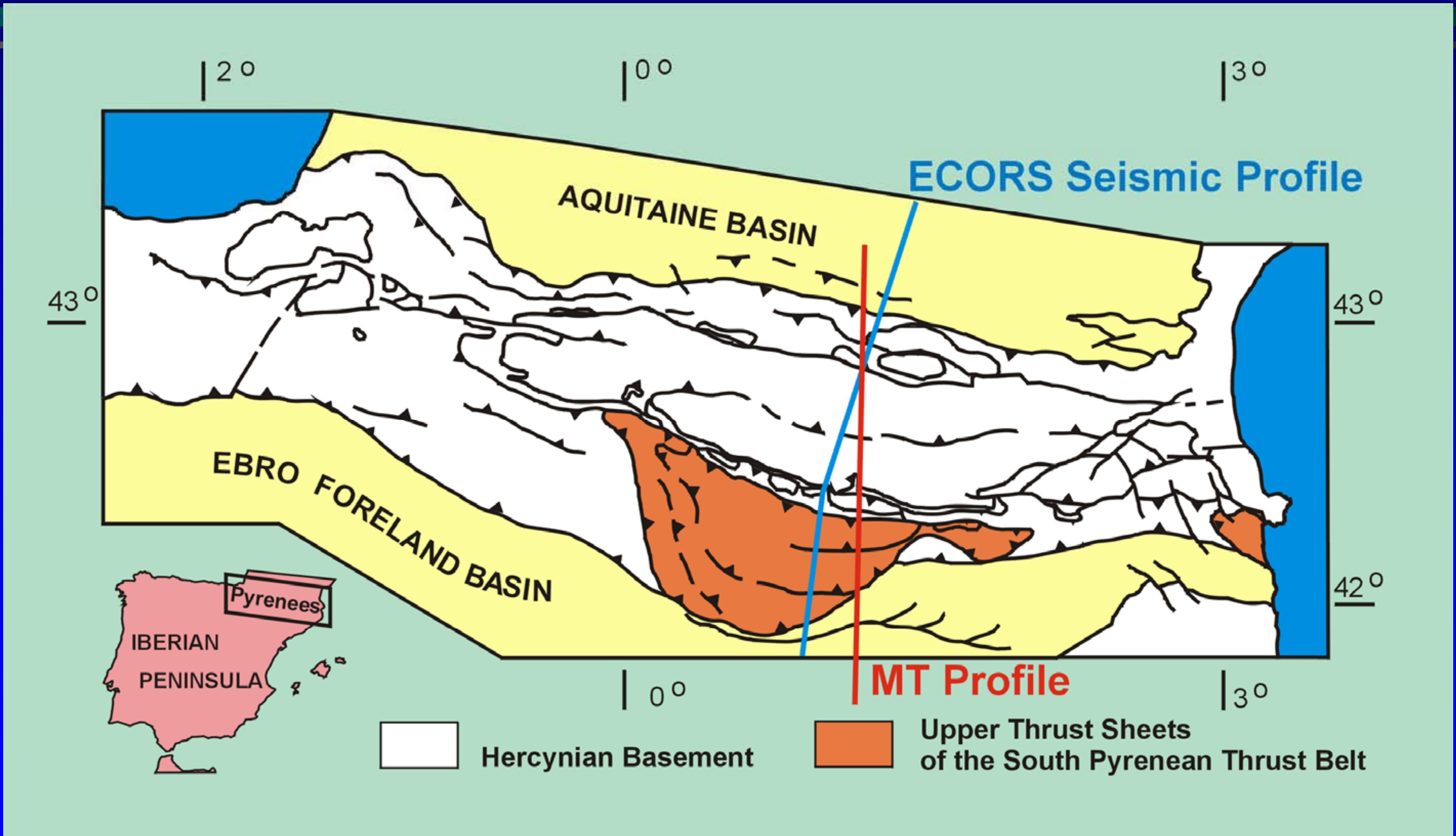
Structure

- Introduction - Subduction in the Pyrenees
- Mixing Models
- Model Inputs
- Effective Conductivity Modelling
- Partial Melt Fraction Modelling
- Summary

Introduction - Subduction in the Pyrenees

- ECORS-Pyrenees deep reflection seismic balanced cross-section indicates subduction of the Iberian plate under the European plate
- Coincident MT studies confirms the subducting plate and shows that it has a high conductivity (0.33 S/m)

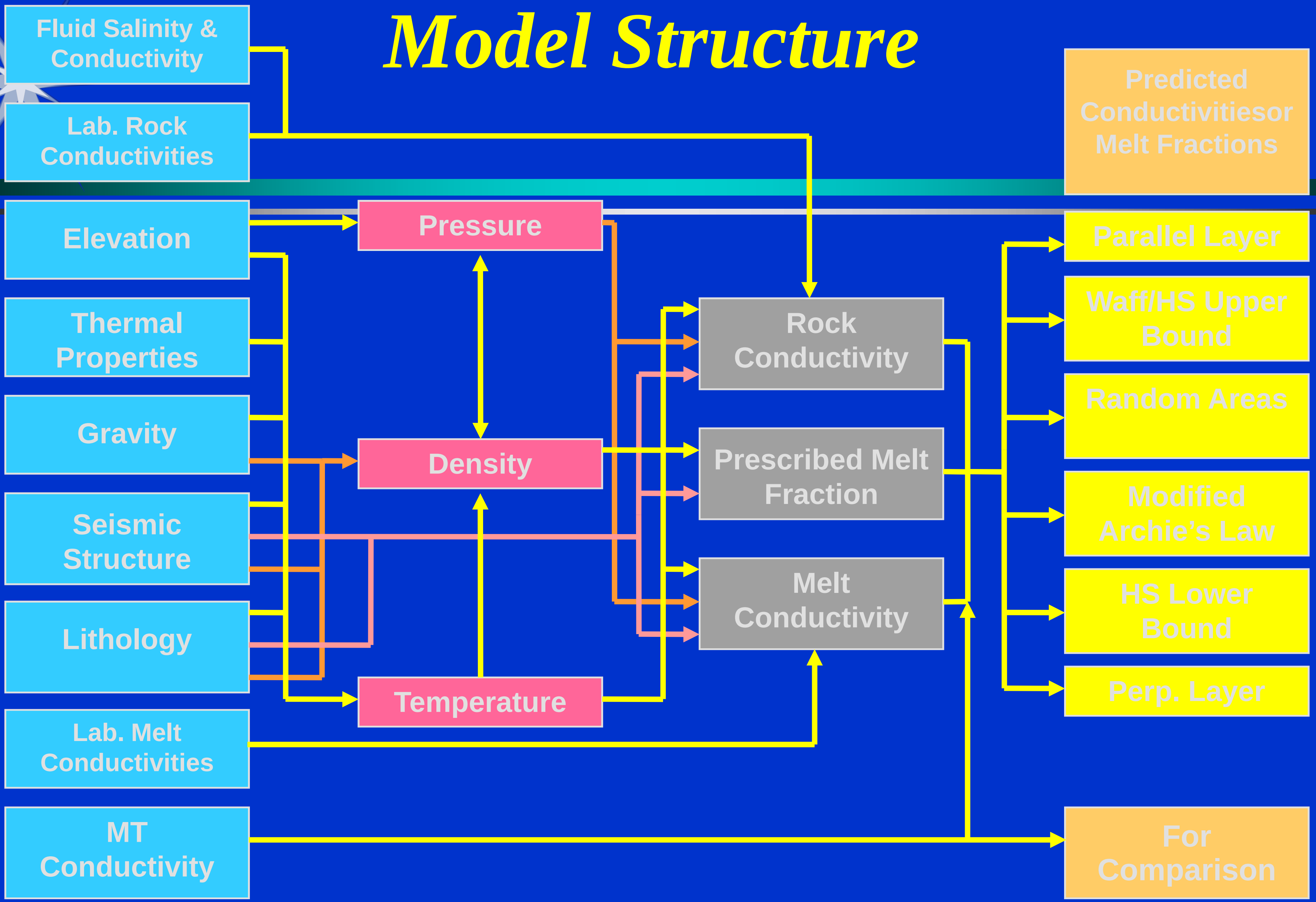
Location of the Study



Questions

- What are the mechanisms of the conductivities in the crust and mantle?
- What is the mechanism of the high conductivities in the slab?
- If the slab high conductivities are caused by partial melting, what is the partial melt fraction and what is the melt connectivity?
- Why is there no surface volcanism in the Pyrenees?

Model Structure



Mixing Models

6 mixing Models have been used:

- **Parallel model** (arithmetic mean)
- **Hashin-Shtrikman upper bound**
- **Waff's model**

} **Well Connected Melt**

- **Random model** (geometric mean)
- **Modified Archie's law**

} **Moderately Connected Melt**

- **Hashin-Shtrikman lower bound**
- **Perpendicular model** (harmonic mean)

} **Badly Connected Melt**

Model Inputs I

- **Grid** — 2 dimensional. Size: 300 km x 120 km
  Resolution: 10 km x 5 km
- **Structure** — From coincident ECORS seismic profile
- **Lithology** — Sandstone, limestone, metasediments, granodiorite, basic amphibolite, granulite, mantle $(Mg_{0.9} Fe_{0.1})SiO_4$
- **Rock Matrix Conductivity** — From laboratory experiments at *in situ* lithostatic and fluid pressures and temperatures. Expressed as P,T dependent Arrhenius equations.

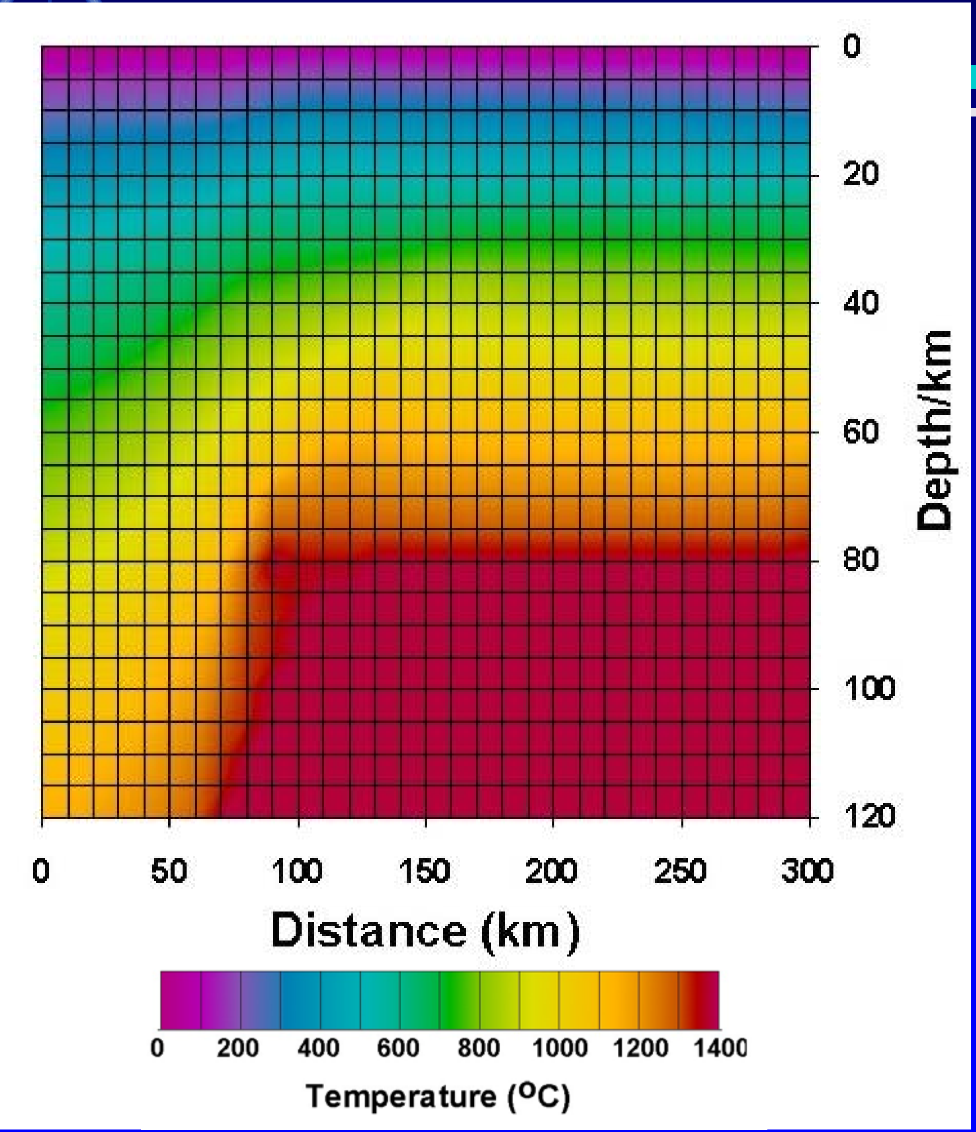
Model Inputs II

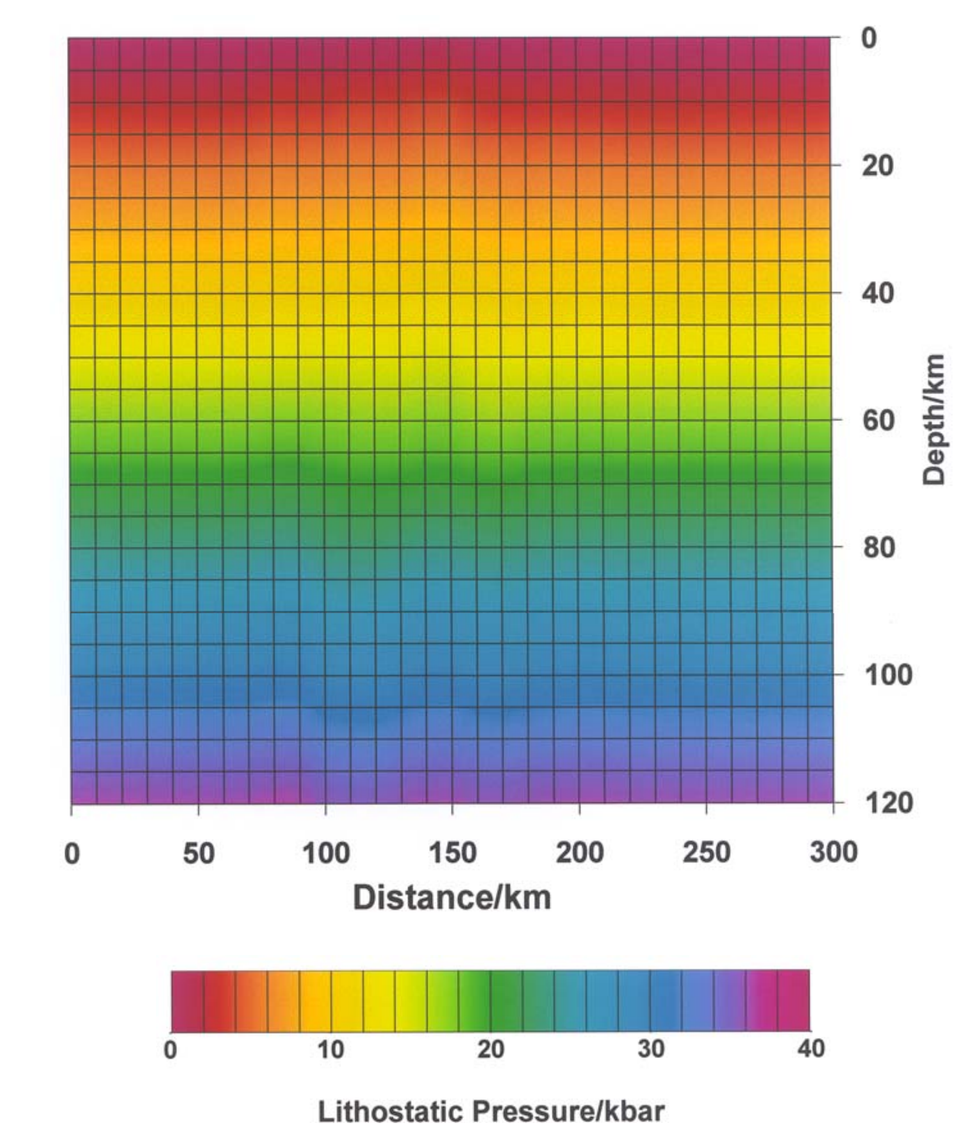
- **Fluid Conductivity** — Rock conductivities made using 0.5 M NaCl saturations corrected to 2 M NaCl solution conductivities
- **Melt Conductivity** — From laboratory studies available in the literature. Variable between 0.5 S/m and 15 S/m.
- **Thermal Properties** — Heat production, thermal conductivity and surface heat flow taken from the literature and field observations

Model Inputs III

- **Temperature** — **2 dimensional distribution calculated from the thermal properties using the method of *Zeyen and Fernandez* [1994]**
- **Lithostatic Pressure** — **2 dimensional distribution calculated from rock densities corrected for temperature variations using data in *Zeyen and Fernandez* [1994]**
- ***In Situ* Conductivity** — **Obtained from coincident magneto-telluric studies**

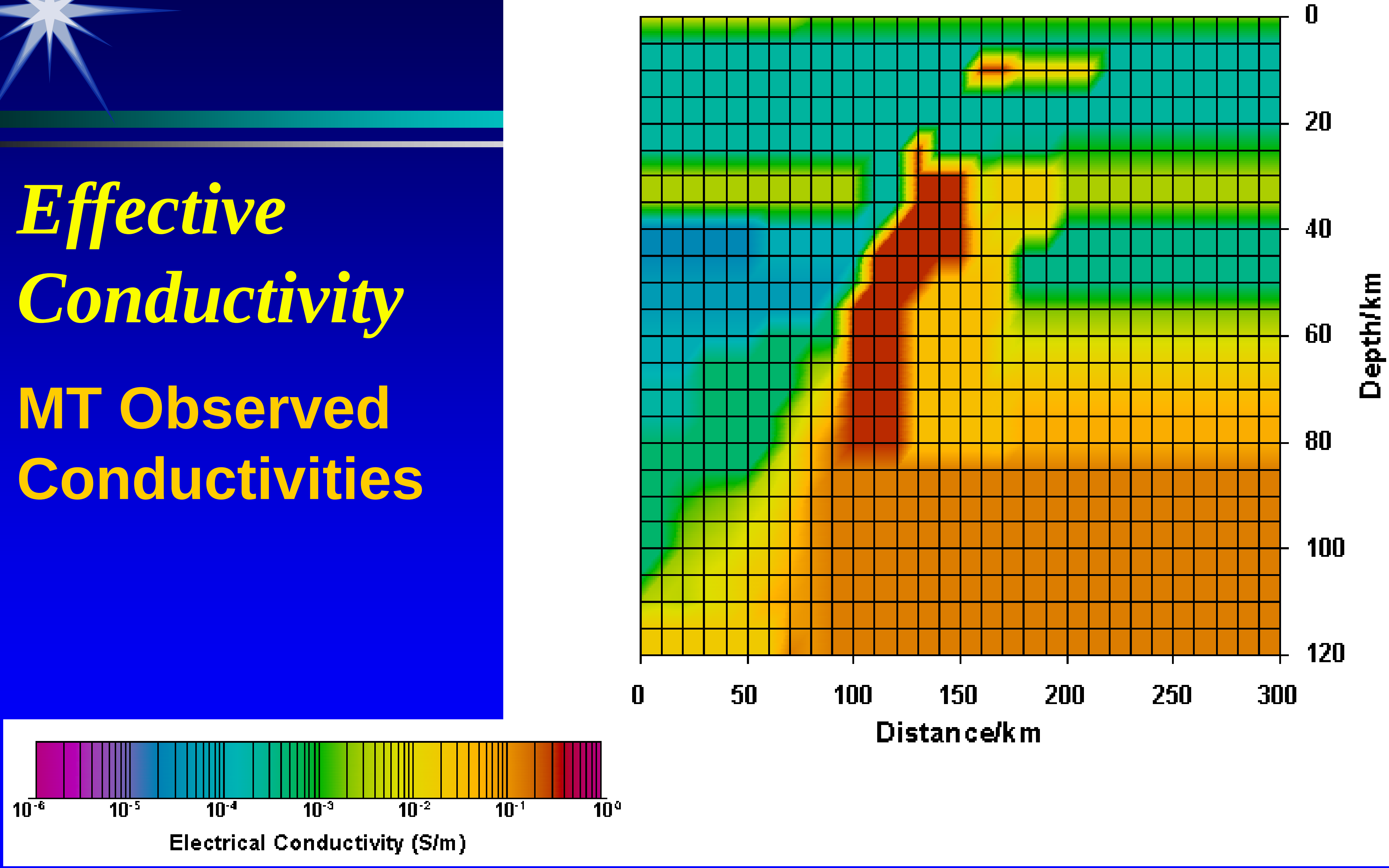
Temperature and Lithostatic Pressure





Effective Conductivity

MT Observed Conductivities

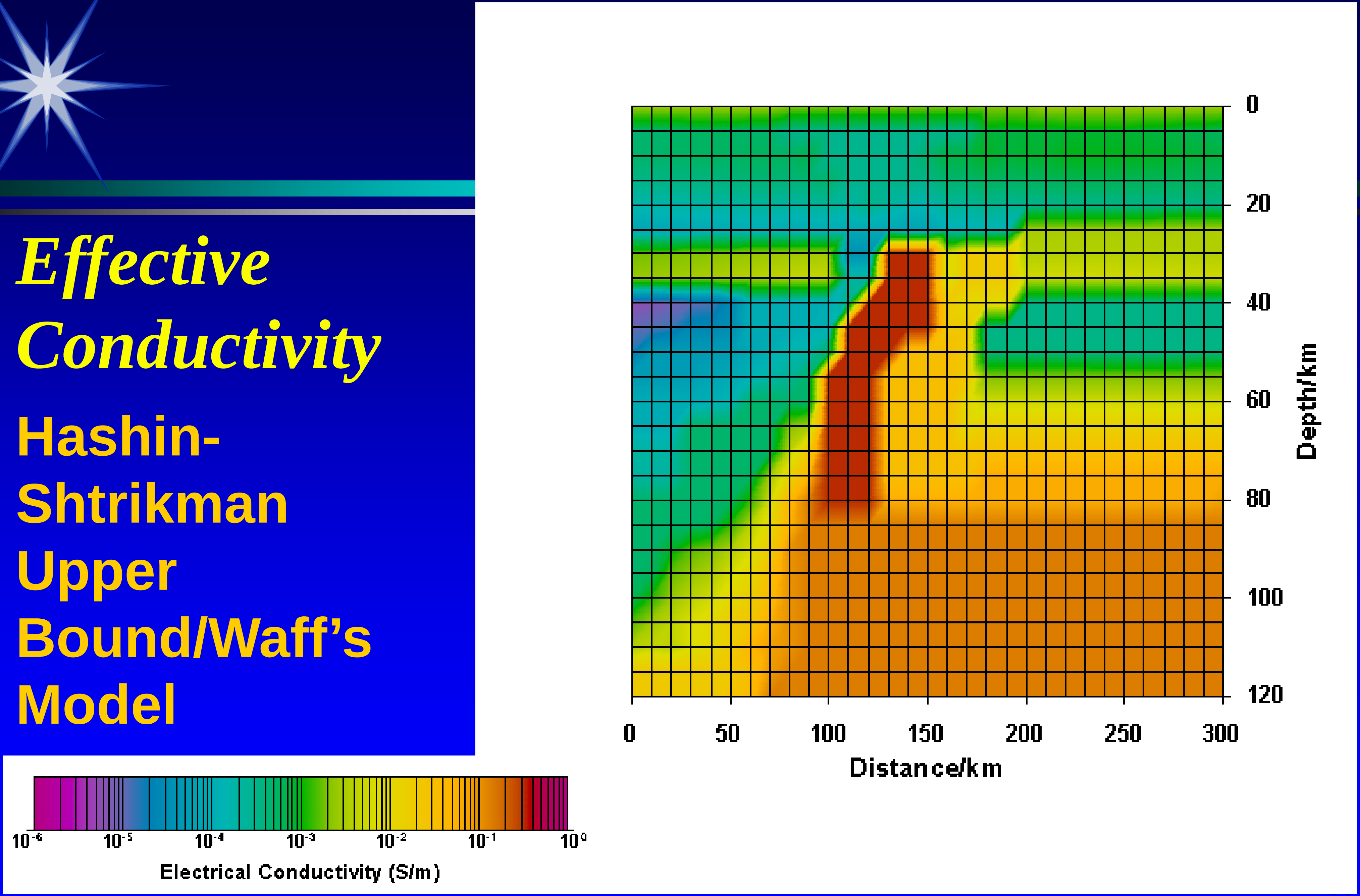


Effective Conductivity Modelling

- Input rock, melt and fluid conductivities as a function of temperature and pressure
- Input assumed partial melt fraction
- Use mixing models with different degrees of connectivity
- Calculate effective conductivity
- Compare with MT observations of effective electrical conductivity

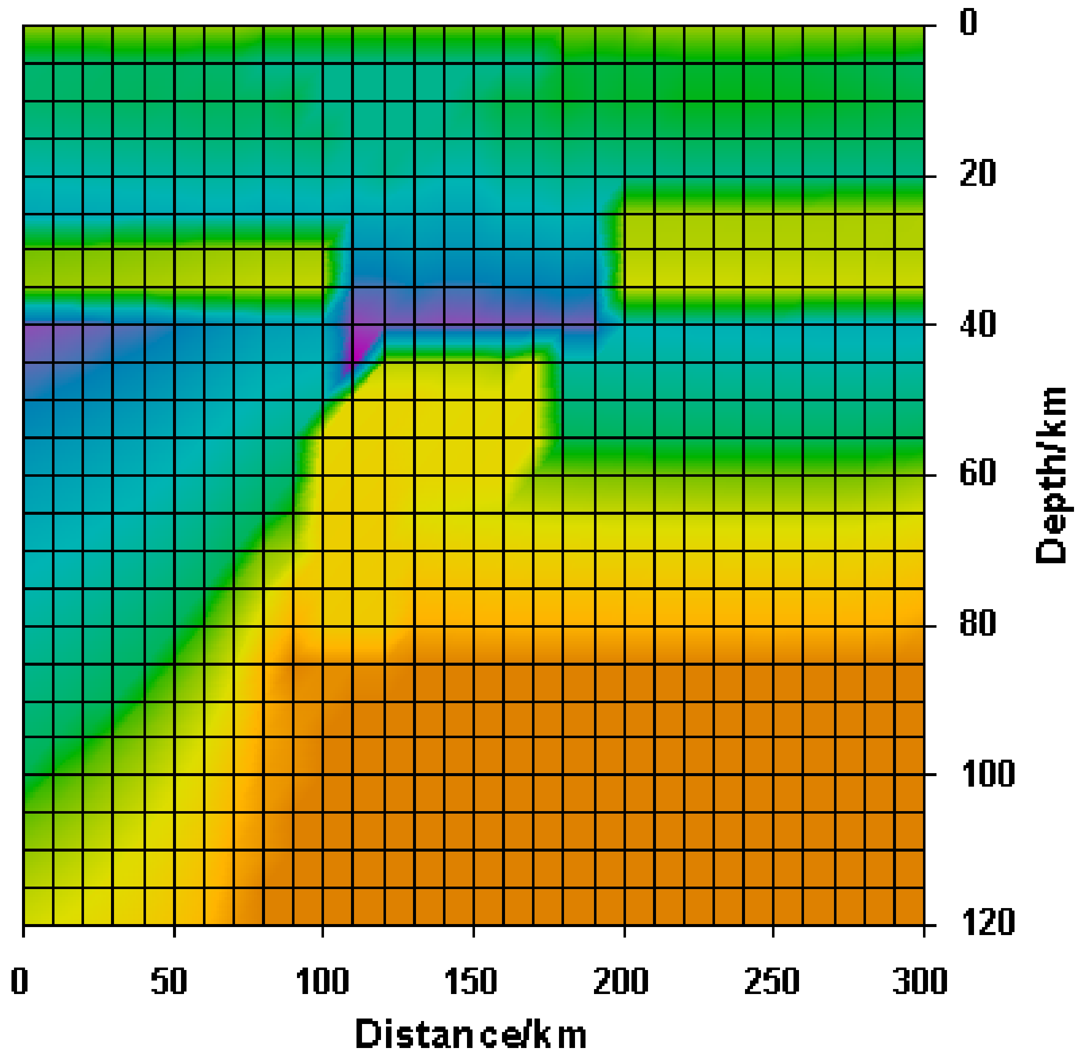
Effective Conductivity

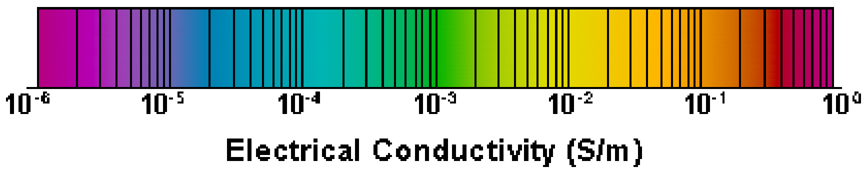
Hashin-Shtrikman Upper Bound/Waff's Model



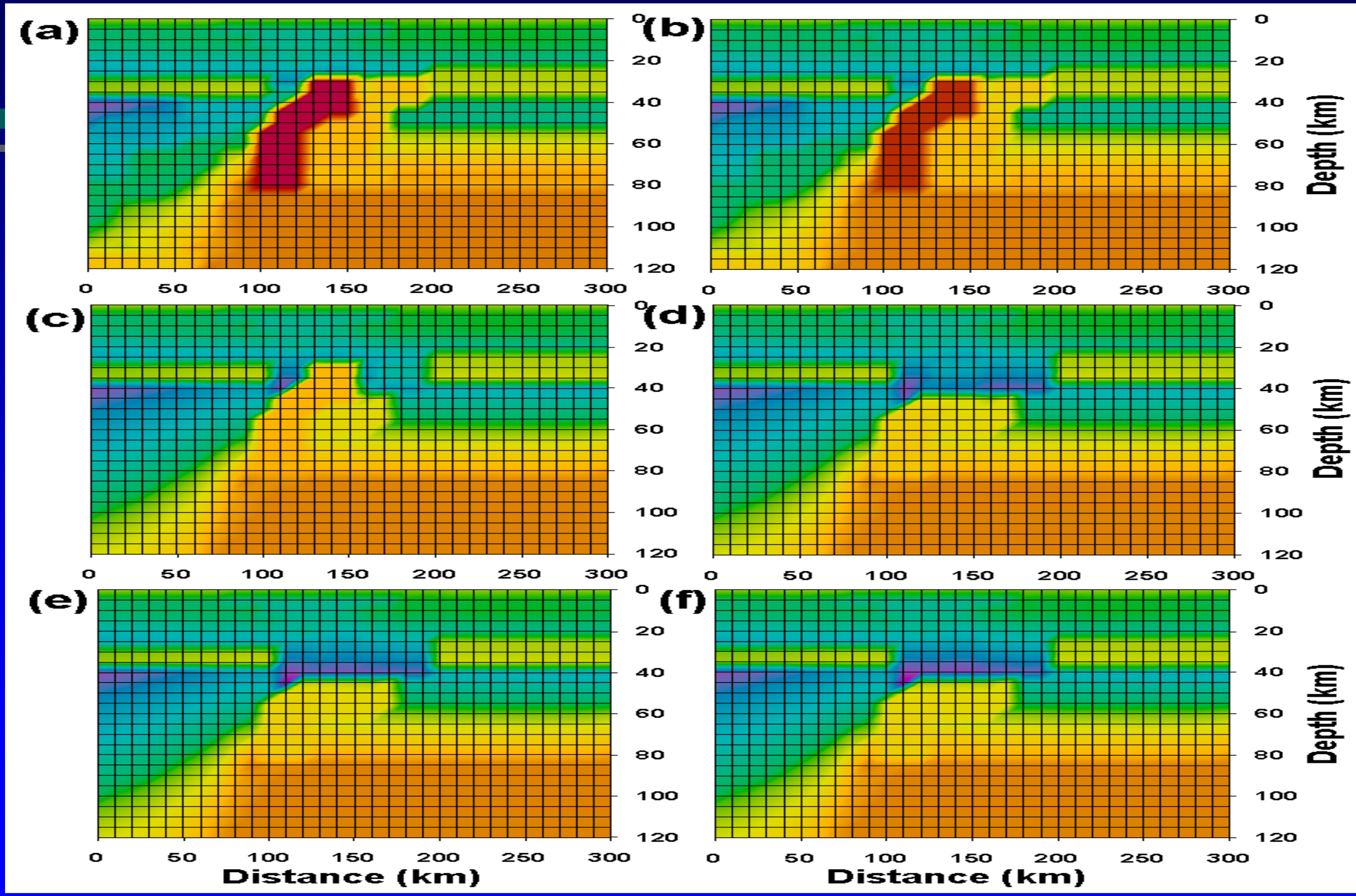
Effective Conductivity

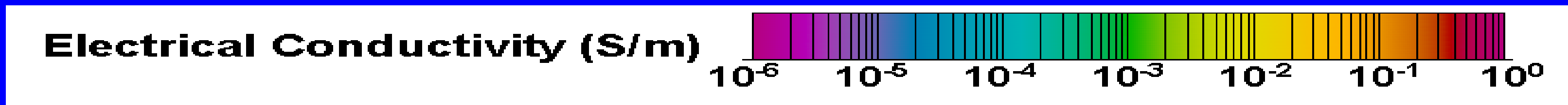
Hashin-Shtrikman Lower Bound





All Effective Conductivity Models



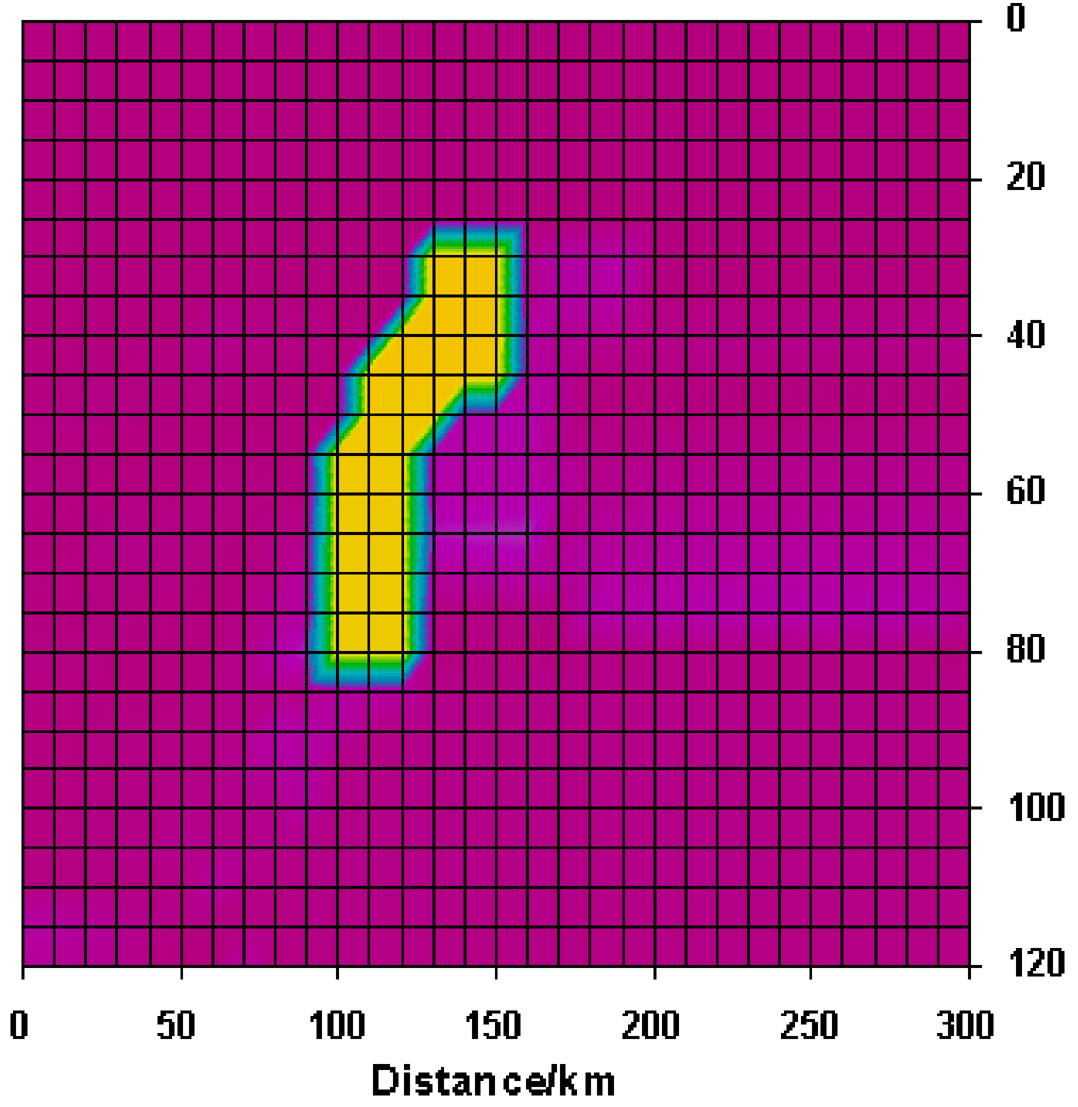


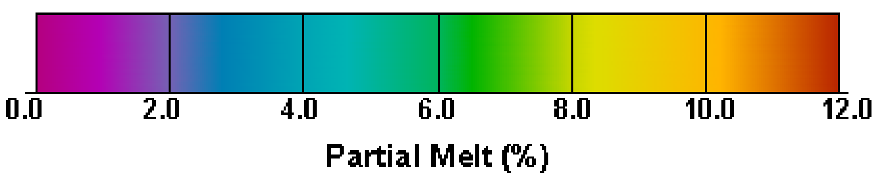
Melt Fraction Modelling

- ➔ **Input rock, melt and fluid conductivities as a function of temperature and pressure**
- ➔ **Input observed MT values of effective conductivity**
- ➔ **Use mixing models with different degrees of connectivity**
- ➔ **Calculate partial melt fractions required**
- ➔ **Compare with geological/geochemical constraints on melt production**

Melt Fraction

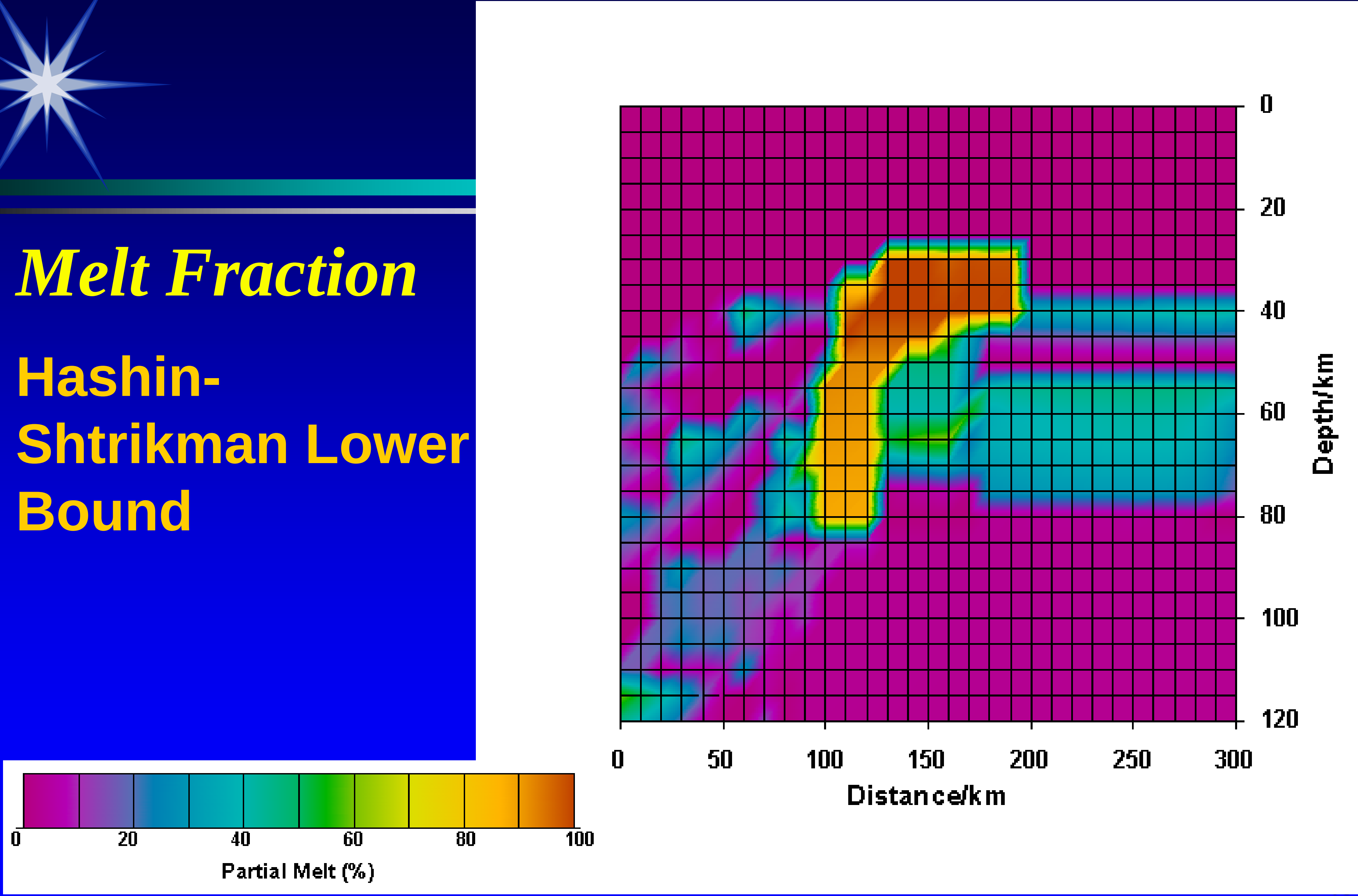
Hashin-Shtrikman Upper Bound/Waff's Model



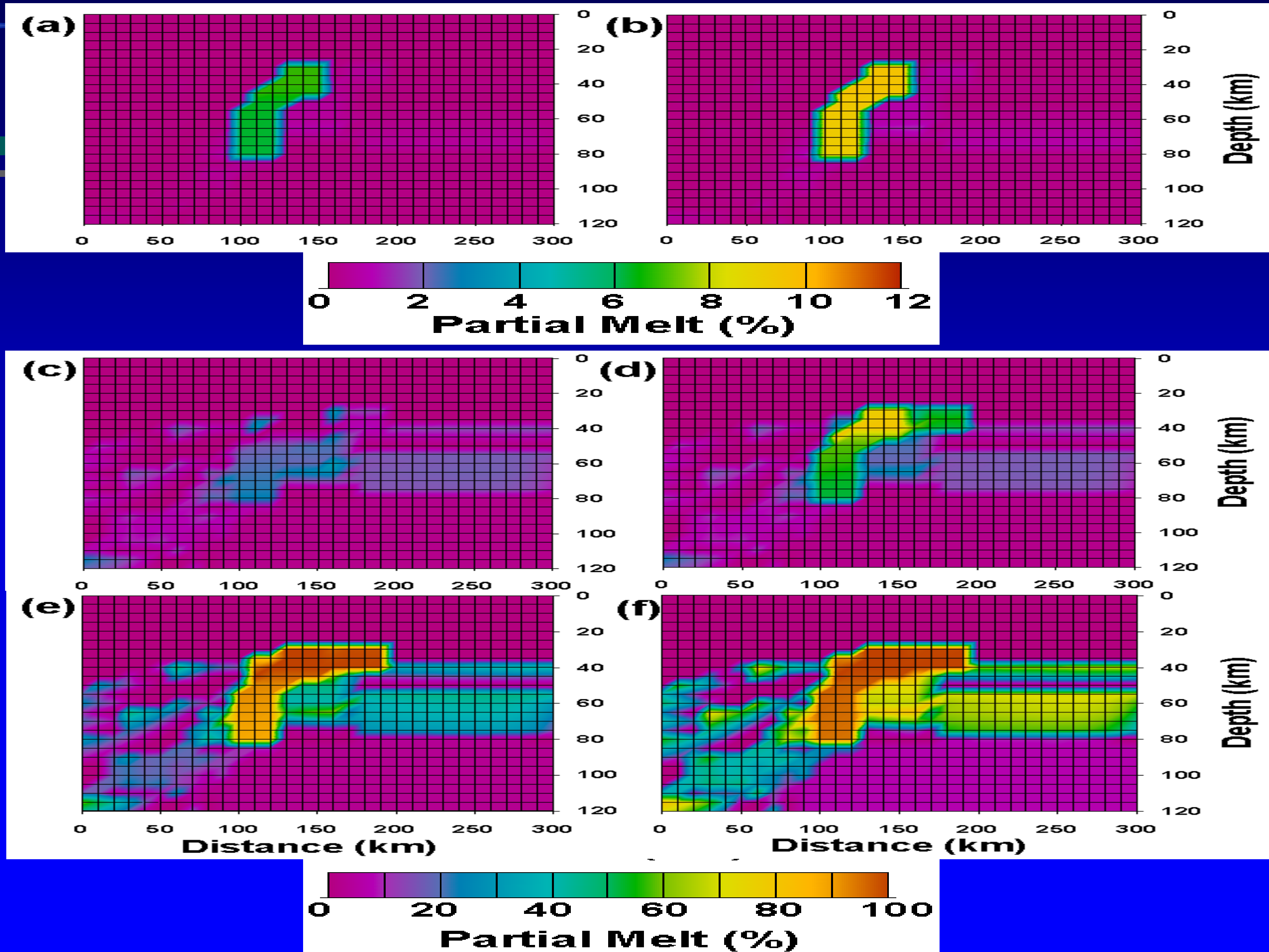


Melt Fraction

Hashin-Shtrikman Lower Bound



All Melt Fraction Models



Summary I

- A two-dimensional conductivity model for the Pyrenees has been constructed
- A good match to the conductivities observed by MT is possible
- Aqueous fluids alone can explain the conductivity in most of the profile
- Aqueous fluids cannot explain the conductivity of the subducting slab

Summary II

- Partial melting is likely to be the cause of the very high slab conductivities
- A partial melt fraction of at least 4.7% is necessary
- This is consistent with geochemical melting models
- The melt must be well connected
- The absence of surface volcanism is partly due to its compressive tectonic regime, and volcanism is likely in the Pyrenees if the area becomes extensive

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