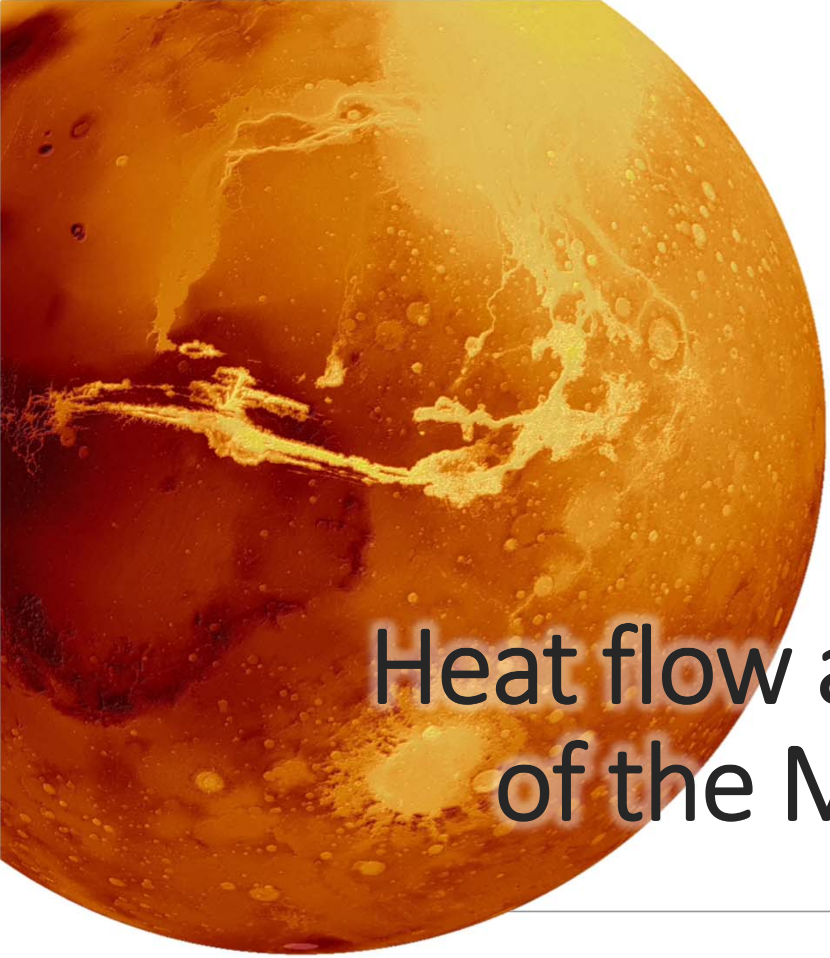
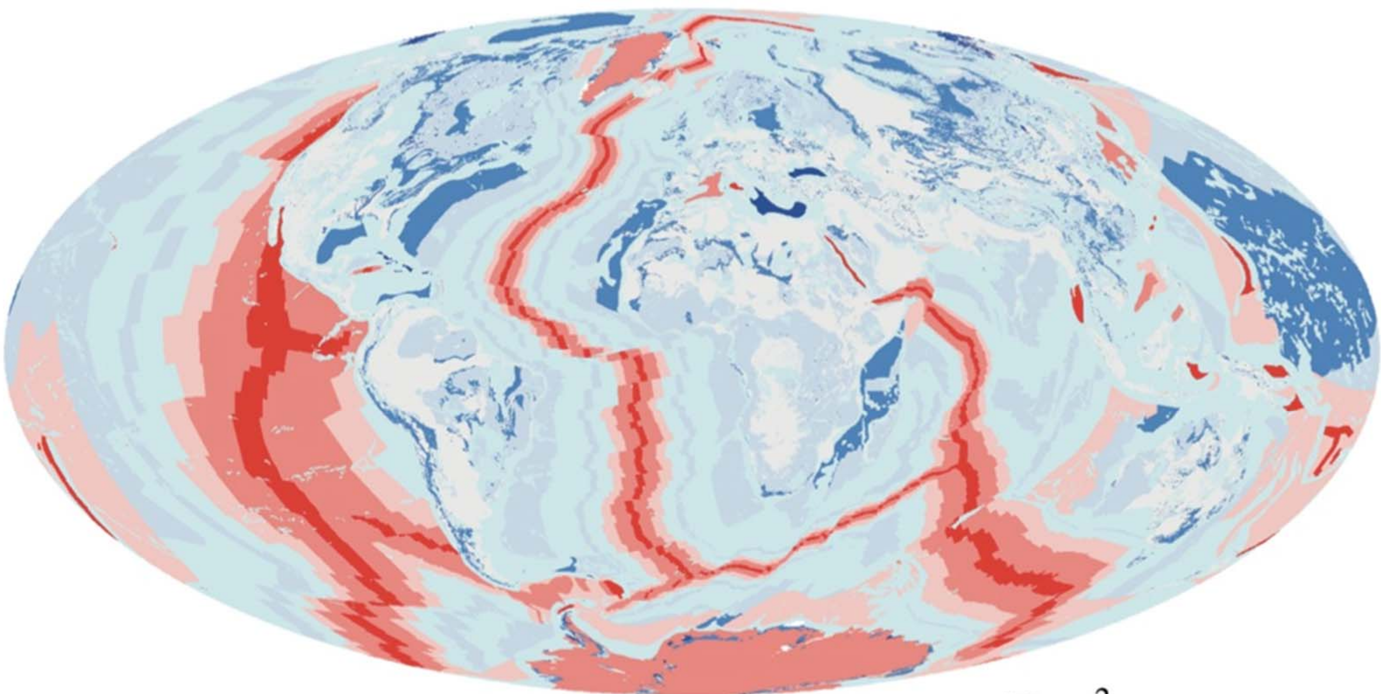


Heat flow and thermal structure of the Martian lithosphere

LAURA M. PARRO

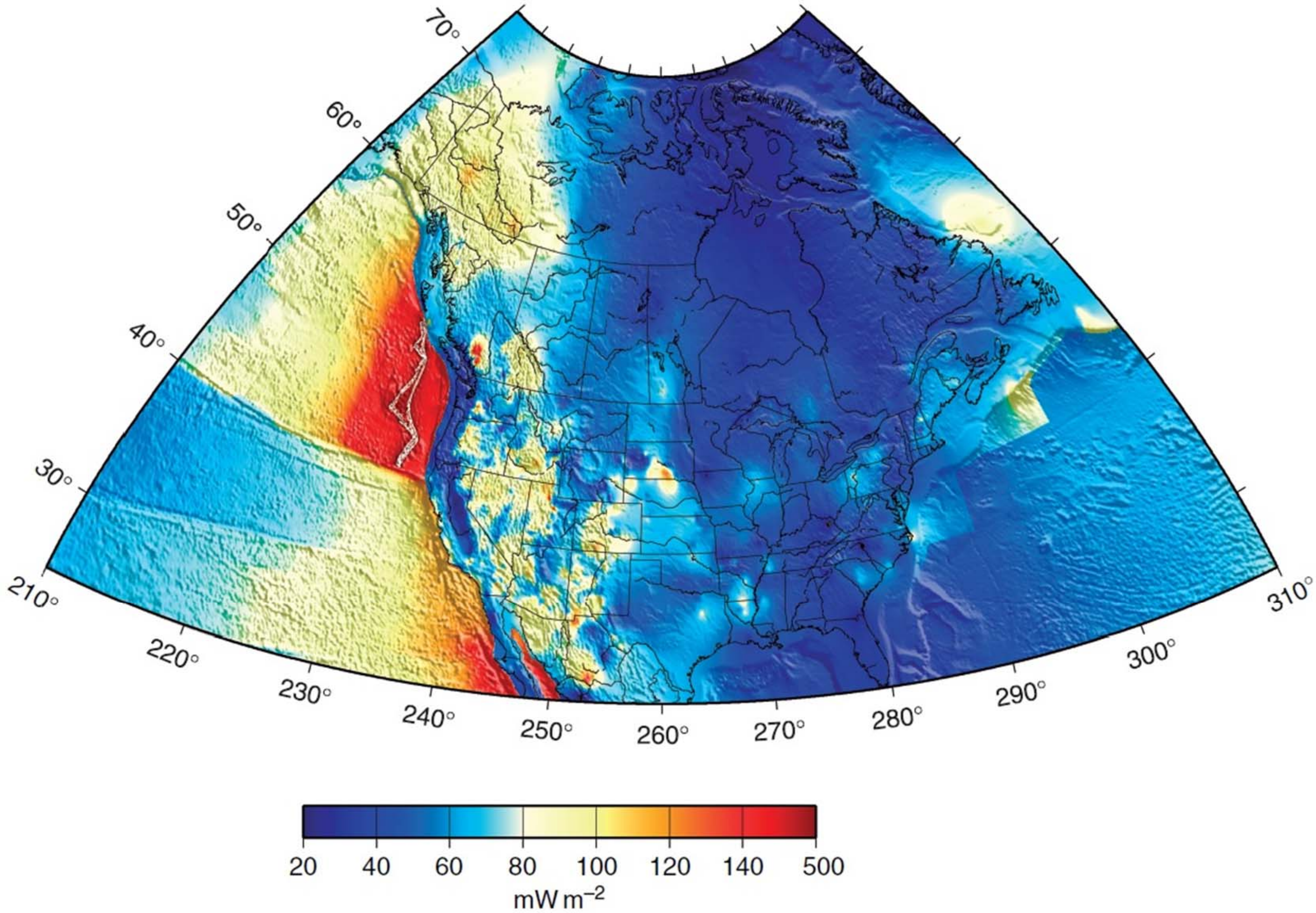
INTRODUCTION: HEAT FLOW

Heat flow is the movement of heat (energy) from the interior of a planet to its Surface.



Davies and Davies (2010)

Heat flow map of North America. Adapted from Blackwell and Richards (2004)



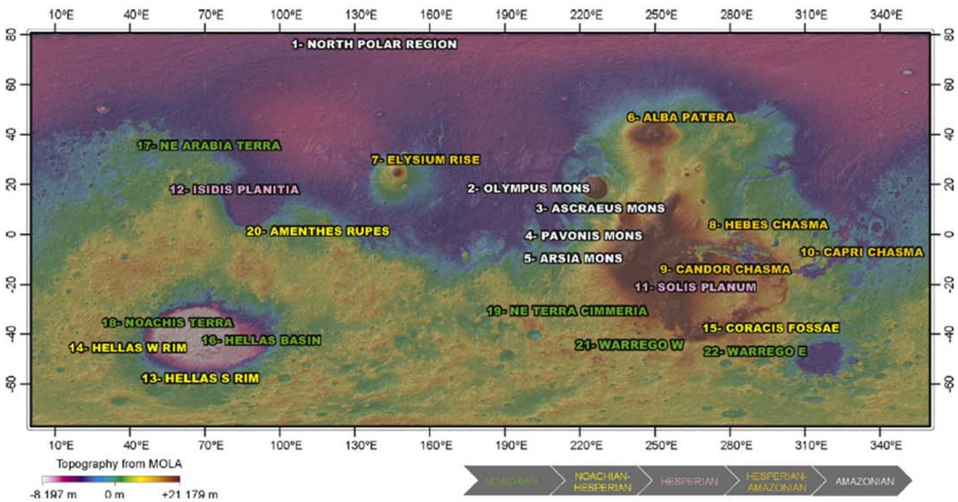
THERMAL STATE AND MECHANICAL STRUCTURE OF THE LITHOSPHERE

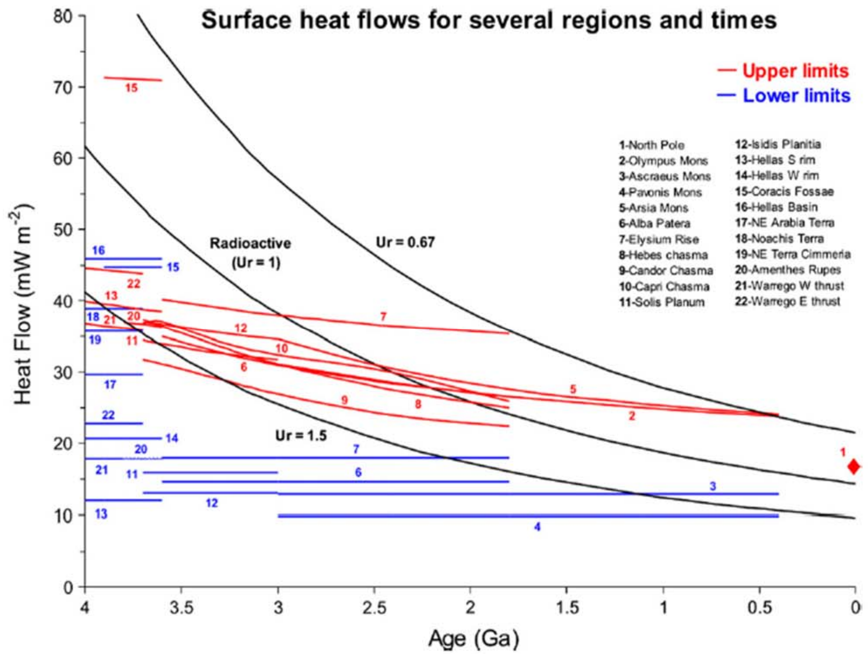
HEAT FLOW ON MARS

✖ Direct measurements → InSight mission

- Effective elastic thickness of the lithosphere (T_e)
- Depth of the brittle-ductile transition beneath large thrust faults (BDT)

} Indirect methods





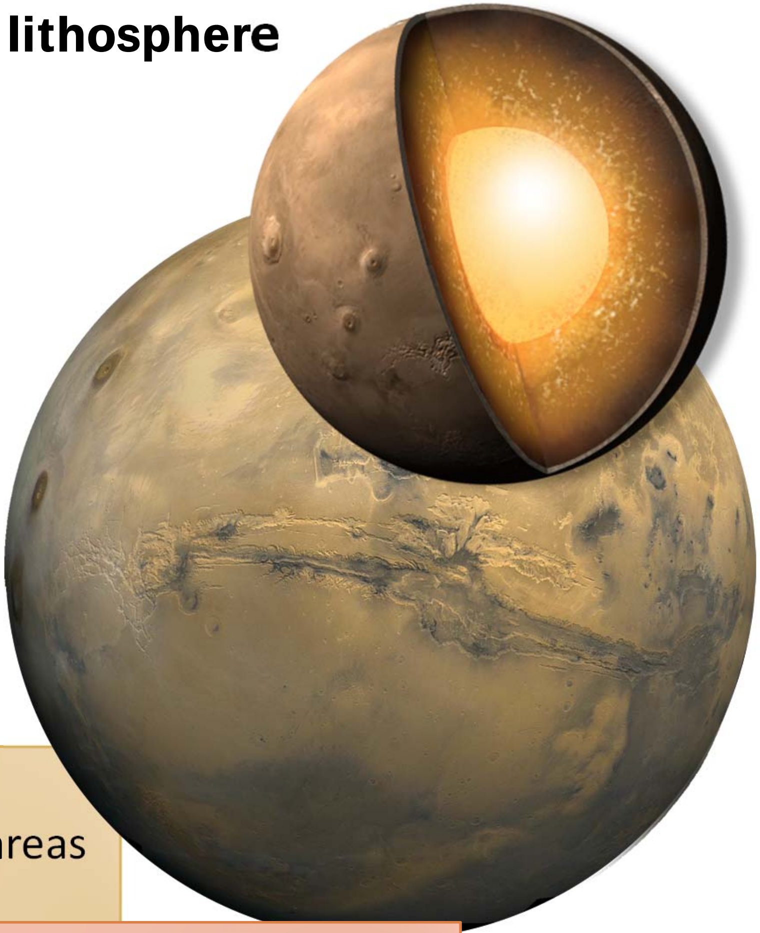
Heat flow in the past (paleo-heat flows) **Ruiz et al., 2011**

MOTIVATIONS

Thermal state of the martian subsurface and lithosphere

Present-day pattern of heat flow of the planet:

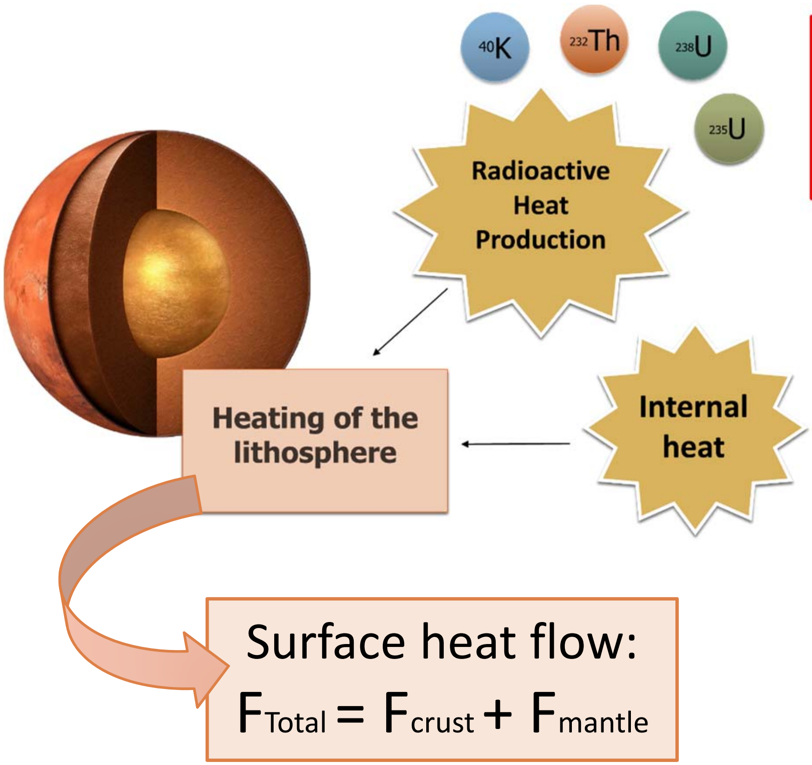
- Global heat flow model at the present.
- Compared these results with our previous knowledge on the heat flow history.
- Compared with the data obtained by InSight



Geodynamics of the planet, evaluate landing zones, the distribution of groundwater or clathrates, areas with higher thermal gradient, etc.

Thermal state and evolution of the terrestrial planets

Present-day heat flow model of Mars



1. The radiogenic heat production of the crust and the lithosphere mantle.

2. Scaling heat flow variations arising from crustal thickness and topography crustal thickness variations. New crustal thickness model

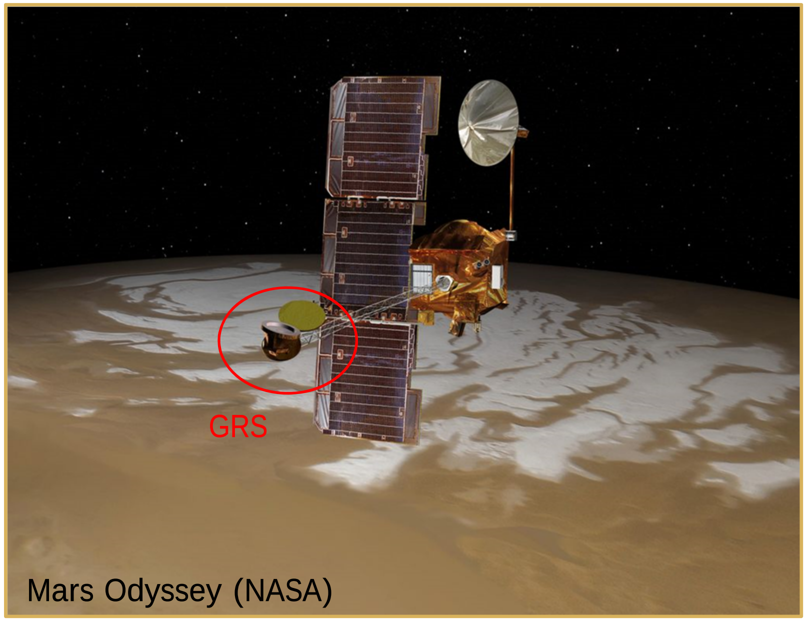
3. The heat flow derived from the effective elastic thickness of the lithosphere beneath the North Polar Region (NPR), as a control, also from the South Polar Region (SPR).

CRUSTAL AND MANTLE HEAT PRODUCTION

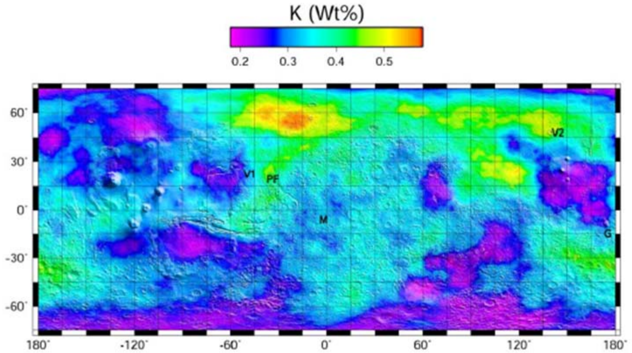
The crustal heat production is the sum of the heat-producing elements (HPEs)

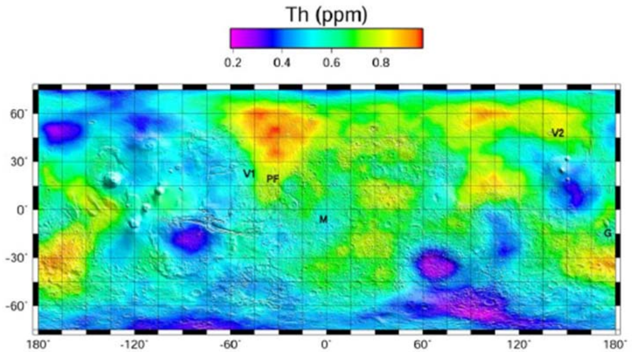
$$\boxed{H = h_{Th232} + h_{U238} + h_{U235} + h_{K40}}$$

HPE abundances on the surface of Mars have been estimated from measurements by the **GRS (2001 Mars Odyssey).** Th/**U** ratio = 3.8



Taylor et al. (2006)





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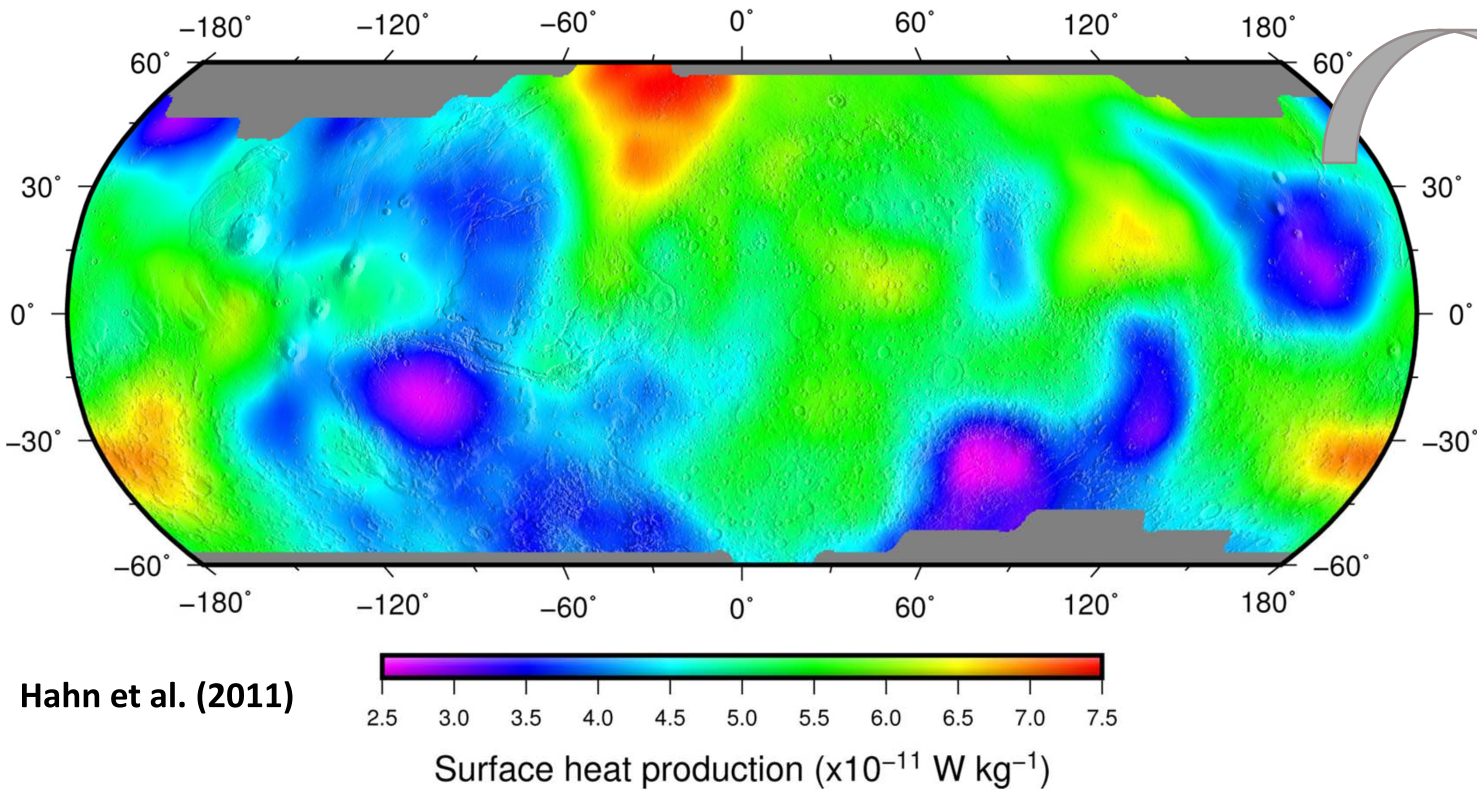


Hahn et al. (2011)

Average
4.86×10^{-11} W Kg^{-1}
or **0.14 mW m^{-2}**

The mantle heat production → we use **HPE mantle lithosphere** abundances **0.1 times** the average value for the martian crust

≈0.017 mW m^{-2}

Present-day thermal state of Mars

1. The radiogenic heat production of the crust and the lithosphere mantle.
2. Scaling heat flow variations arising from crustal thickness and topography variations → New crustal thickness model.
3. The heat flow derived from the effective elastic thickness of the lithosphere beneath the North Polar Region (NPR), as a control, also from the South Polar Region (SPR).

CRUSTAL THICKNESS MODEL

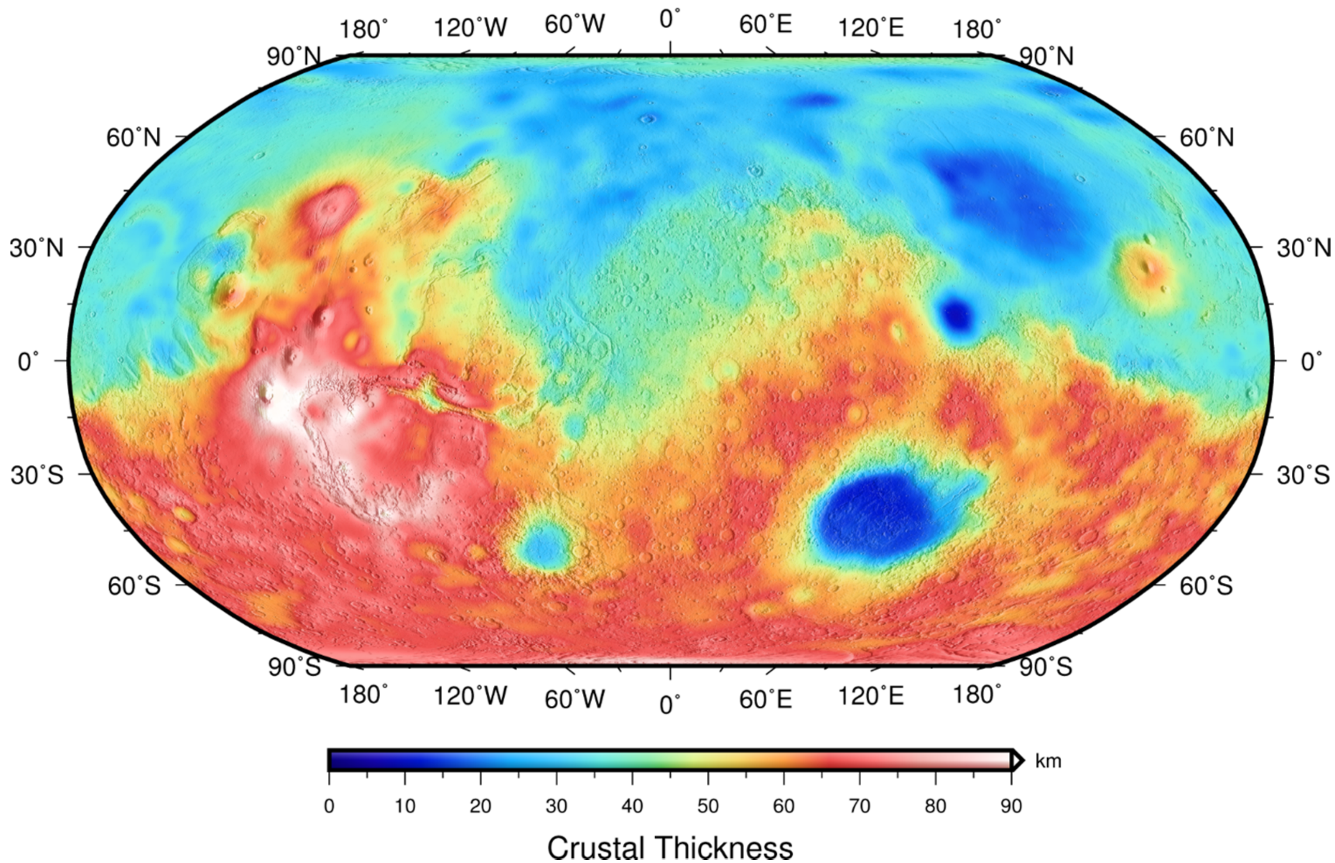
We **scale heat flow differences** across the martian surface due to **crustal thickness** and **topographic differences (MOLA)** in the planet.

\+

Gravity model

New **crustal thickness model**
Average: 50 km

Parro et al. (2017)



Present-day thermal state of Mars

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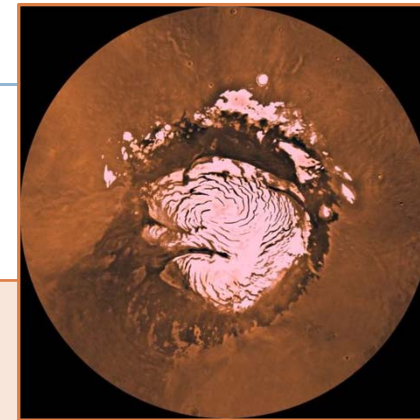
SCALING OF PRESENT-DAY SURFACE HEAT FLOW



We **scale heat flow** differences across the Martian surface using the expression:

$$F_{local} = F_{ref} + H_c\,\Delta t + (H_c - H_m)\,(\Delta b - \Delta t)$$

$\boldsymbol{F_{local}}$ = local heat flow for a given location on the surface of Mars
$\boldsymbol{F_{ref}}$ = reference value used for anchoring the model
$\boldsymbol{H_c}$ = crustal heat production = 0.14 mW m^{-2}
$\boldsymbol{H_m}$ = mantle heat production = 0.017 mW m^{-2}
$\boldsymbol{\Delta t}$ = difference between the local elevation and the elevation at the reference location.
$\boldsymbol{\Delta b}$ = difference between the local crustal thickness and the crustal thickness in the reference location.

- **North Polar Region (NPR)** = 17 mW m^{-2} (T_e) of 300 km
- **South Polar Region (SPR)** = 23.5 mW m^{-2} (T_e) of 161 km

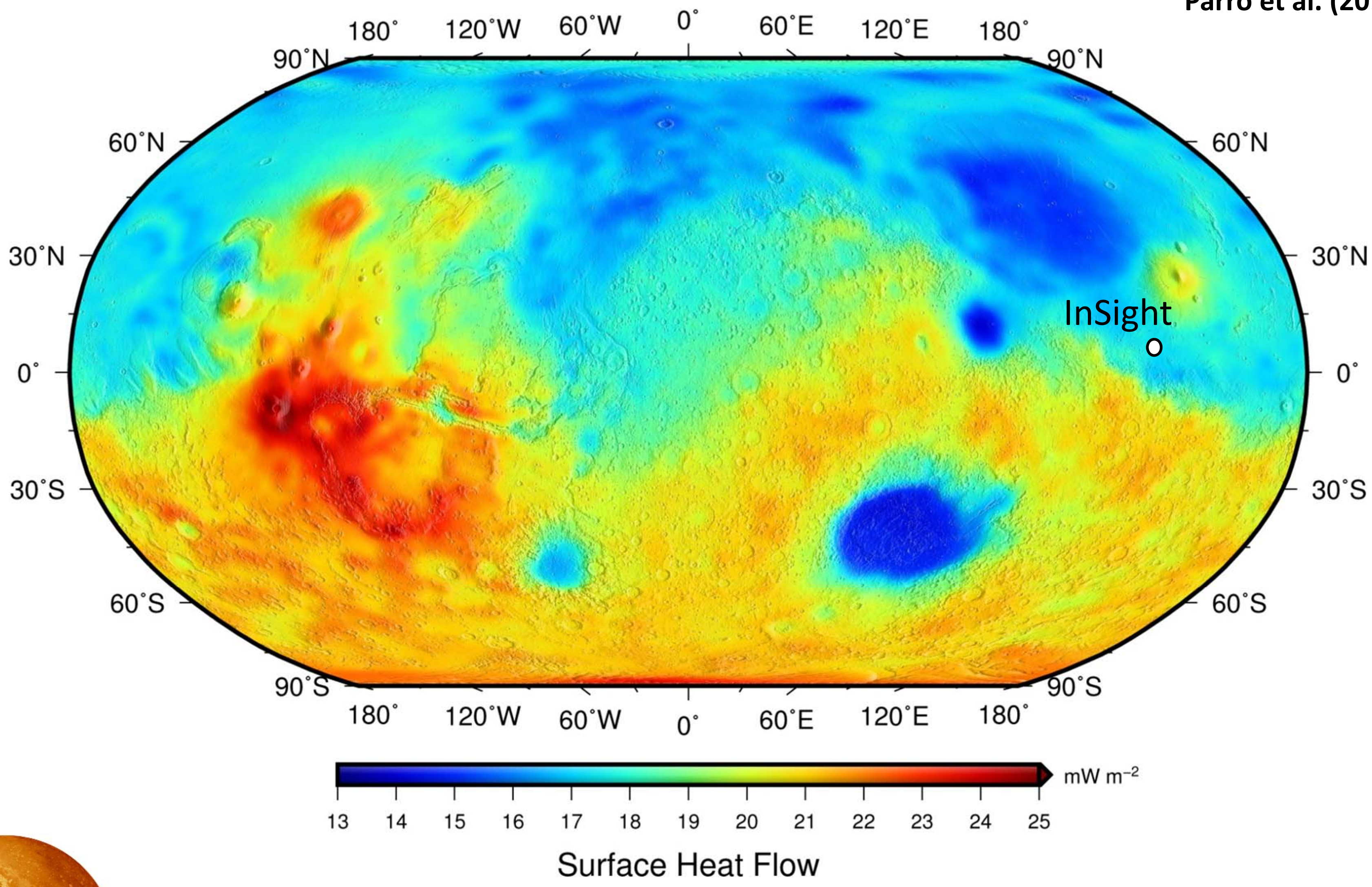
Surface topography → Mars Orbiter Laser Altimeter (MOLA) topography model
Crustal thicknesses → Our crustal thickness model

Crust density: 2900 kg m^{-3}
Lithospheric mantle density: 3500 kg m^{-3}

Conductivity: 2 W m^{-1} K^{-1}

RESULTS: PRESENT-DAY HEAT FLOW MODEL

Parro et al. (2017)



Heat flow data distribution

www.ucm.es/upwards/

Navegar identificado | Buscar en la web

UNIVERSIDAD COMPLUTENSE MADRID

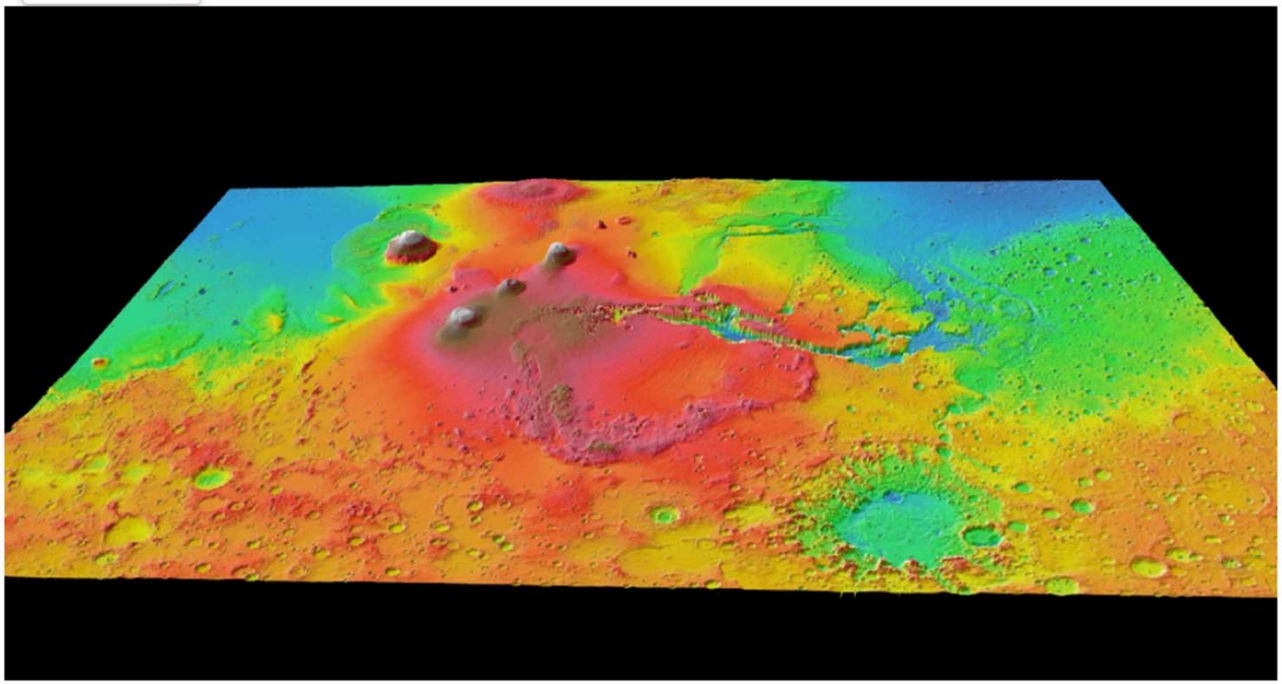
Upwards – Understanding Planet Mars

Proyectos de Investigación

UPWARDS - UCM | Project

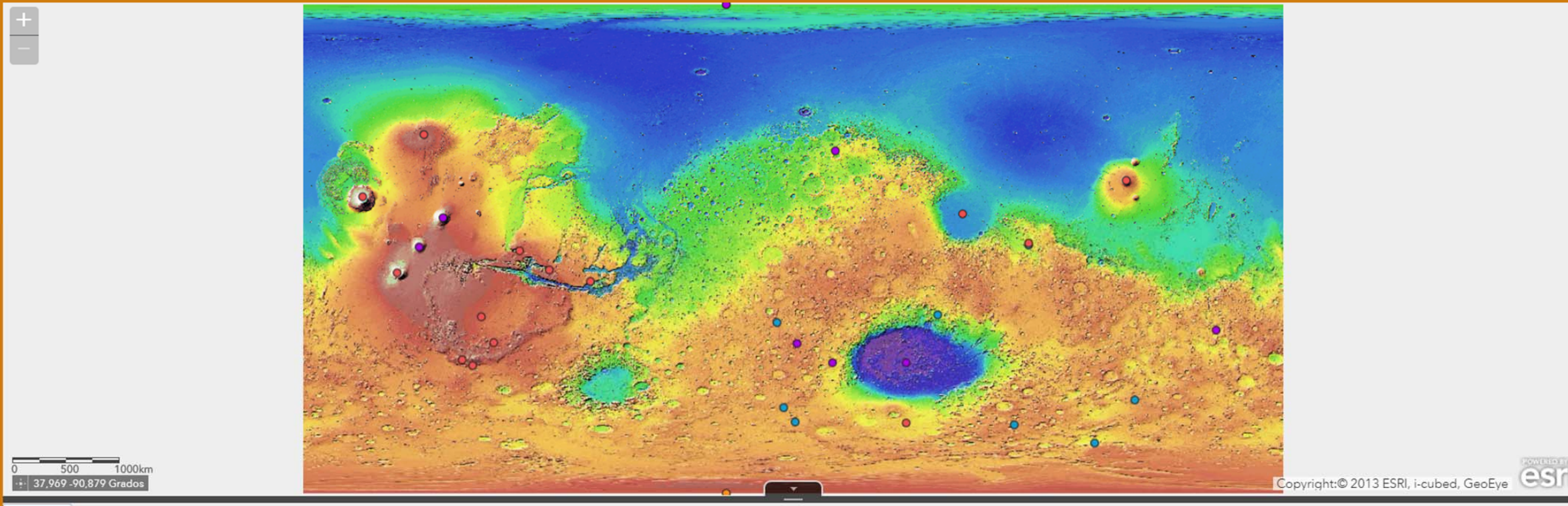
- Scientific staff
- Achievements
- Disclaimer

UP … orizon 2020, the European Union's most ambitious research and innovation programme, which aims at excellence in scientific production, in … the quest for answers to social challenges. UPWARDS is a cutting-edge project which, through the cooperation of groups of excellence, is bu … image of Mars, examining everything from the subsoil to the escape into space.



Heat flow data distribution

UPWARDS - UCM



SHF_datos

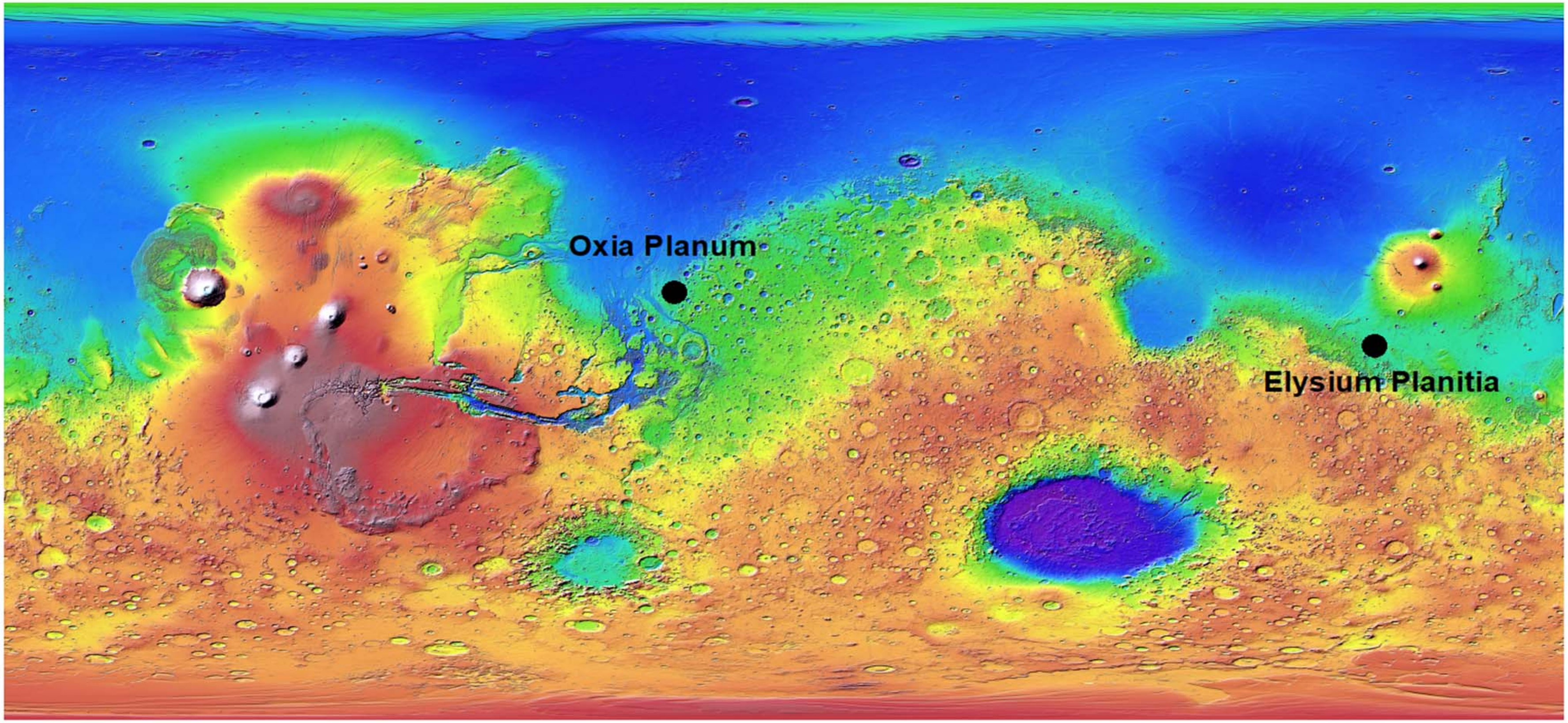
Opciones | Filtrar por extensión de mapa | Acercar a | Borrar selección | Actualizar

__OBJECTID	Lat	Long	Feature	Surface age	Te max (km)	Te min (km)	Curvature max (10-7 m-1)	Curvature min (10-7 m-1)	Crustal density (kg m-3)	Crustal thickness (km)	BDT depth max (km)	BDT depth min (km)	HF_H_4_Ga	HF_L_4_Ga	HF_H_3.9_Ga	HF
13	2	111	Amenthes Rupes	N-H					2900	50	35	27				
14	-34,5	-85,5	Coracis Fossae	N-H	12.5	10.3	6.4	4.9	2900	75					71.3	44.7
15	13	87	Iisidis Planitia	H	180	100	-0.02	-0.09	2900	10						
16	-25	-90	Solis Planum	H	37	24	6.4	3	2900	70						

32 entidades 0 seleccionado

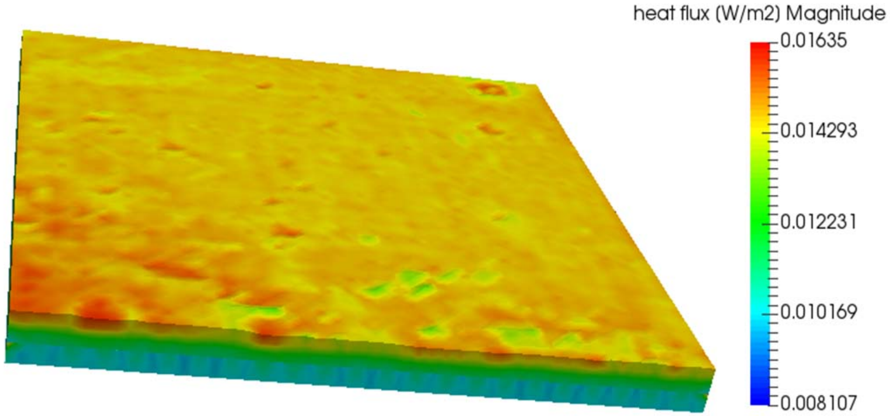
Heat Flow Web map http://www.ucm.es/upwards

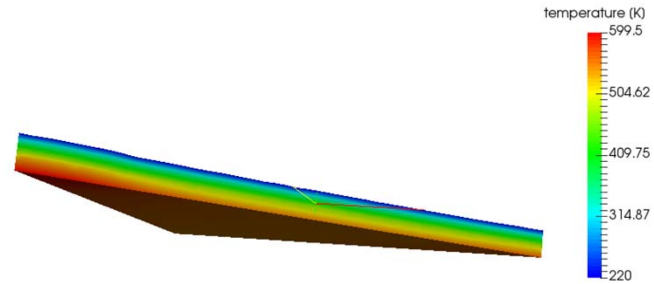
http://ucmadrid.maps.arcgis.com/apps/webappviewer/index.html?id=1ac196e992bd4b7393aa288d20801f4c


Oxia Planum
Elysium Planitia

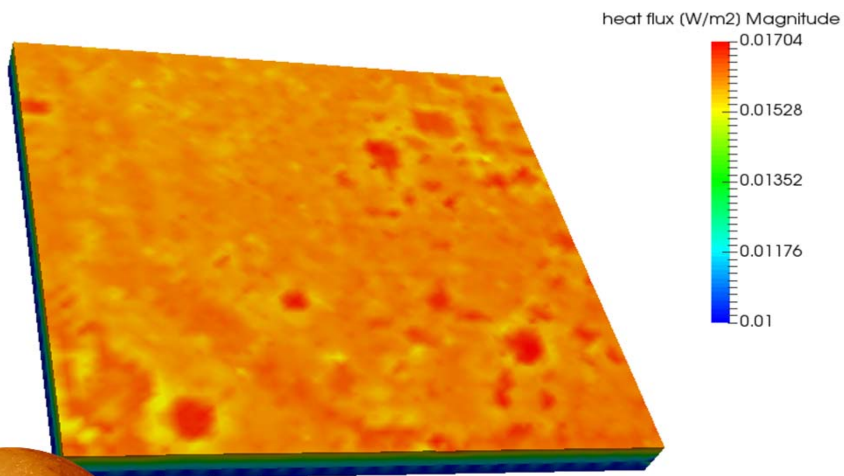
RECENT WORK

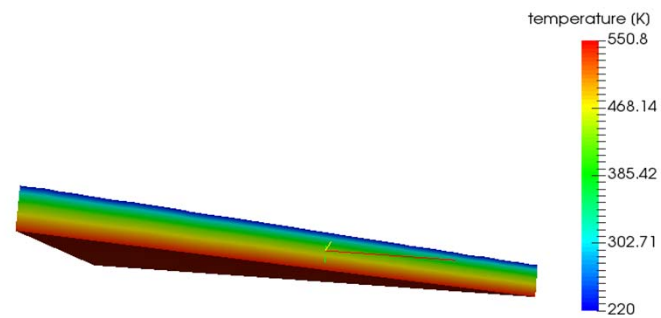
Elysium Planitia





Oxia Planum





FUTURE WORK