Supplement

1D Steady-State Models

Table S1 Parameters used for the steady-state conductive thermal model of Nanga Parbat Massif. Ind-1 and Ind-2, respectively, refer to high and low heat-producing crustal layers. BG refers to basement gneiss, which is present in the core of NPM and has high surface RHP.

	Crustal depth range (km)	Radiogenic heat production (μWm^{-3})	Thermal Conductivity ($Wm^{-1}K^{-1}$)
Model 1			
Upper crust (Ind-1)	0 - 20	4.0	2.3
Mid crust (Ind-2)	20 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 2			
Upper crust (Ind-1)	0 - 15	4.0	2.3
Mid crust (Ind-2)	15 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 3			
Upper crust (Ind-1)	0 - 10	4.0	2.3
Mid crust (Ind-2)	10 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 4			
Upper crust (Ind-1)	0 - 5	4.0	2.3
Mid crust (Ind-2)	5 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 5			
Upper crust (BG)	0 - 5	5.33	2.3
Mid crust (Ind-2)	5 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 6			
Upper crust (BG)	0 - 10	5.33	2.3
Mid crust (Ind-2)	10 - 30	2.0	2.5
Lower crust	30 - 60	0.4	2.6
Model 7			
Upper crust (BG)	0 - 10	5.33	2.3
Mid crust (Ind-2)	10 - 30	1.0	2.5
Lower crust	30 - 60	0.4	2.6

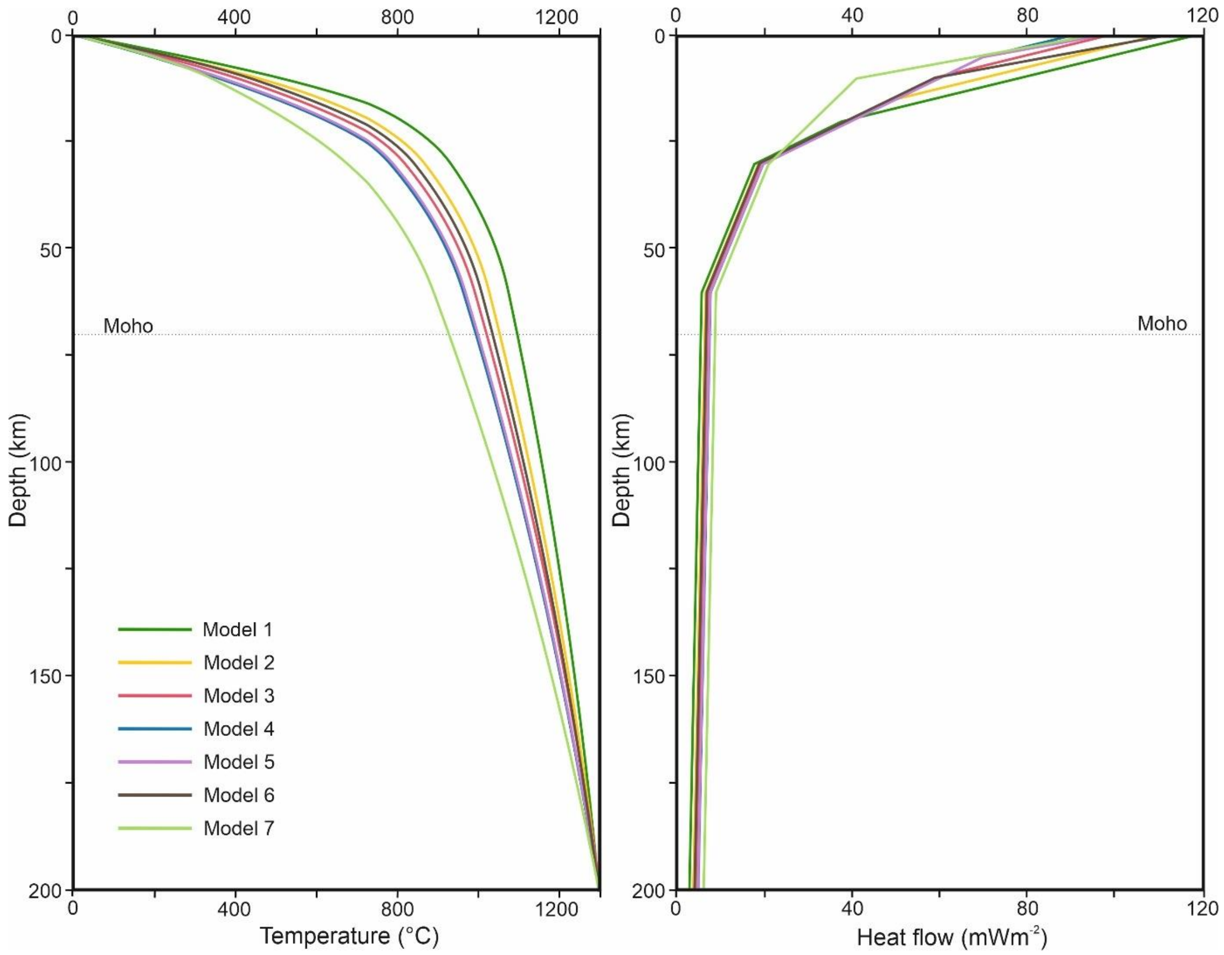

Figure S1 1D steady-state conductive geotherms and heat flow plots for different modeling scenarios with varying parameters in the Nanga Parbat Massif. In Models 1 to 4, the thickness of the heat-producing upper crust with 4 µW m^{-3} is reduced from 20 km to 5 km, while the crust with 2 µW m^{-3} increases from 10 to 25 km. Models 5 and 6 assume a highly enriched upper crust (5.33 µW m^{-3}) with thicknesses of 5 and 10 km, respectively. Model 7 assumes a 10 km thick enriched upper crust (5.33 µWm^{-3}) but a 20 km thick slightly depleted midcrust.

Table S2 Parameters used for the steady-state conductive thermal model of Kohistan arc. Koh-F and Koh-M, respectively, refer to the upper felsic and lower mafic Kohistan crust overlying the Indian crust.

	Crustal depth range (km)	Radiogenic heat production (μWm^{-3})	Thermal Conductivity ($Wm^{-1}K^{-1}$)
Model 1			
Upper crust:			
Koh-F	0 - 10	1.0	2.3
Koh-M	10 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 30	4.0	2.3
Ind-2	30 - 40	2.0	2.5
Lower crust	40 - 70	0.4	2.6
Model 2			
Upper crust:			
Koh-F	0 - 10	1.0	2.3
Koh-M	10 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 25	4.0	2.3
Ind-2	25 - 40	2.0	2.5
Lower crust	40 - 70	0.4	2.6
Model 3			
Upper crust:			
Koh-F	0 - 10	1.0	2.3
Koh-M	10 - 20	0.08	3.0
Mid crust:			
Ind-2	25 - 40	2.0	2.5
Lower crust	40 - 70	0.4	2.6
Model 4			
Upper crust:			
Koh-F	0 - 10	1.0	2.3
Koh-M	10 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 30	2.0	2.3
Ind-2	30 - 40	1.0	2.5
Lower crust	40 - 70	0.4	2.6
Model 5			
Upper crust:			
Koh-F	0 - 10	1.0	2.3
Koh-M	10 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 30	1.0	2.3
Ind-2	30 - 40	0.5	2.5
Lower crust	40 - 70	0.4	2.6
Model 6			
Upper crust:			
Koh-F	0 - 15	1.0	2.3
Koh-M	15 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 30	1.0	2.3
Ind-2	30 - 40	0.5	2.5
Lower crust	40 - 70	0.4	2.6
Model 7			
Upper crust:			
Koh-F	0 - 15	1.0	2.3
Koh-M	15 - 20	0.08	3.0
Mid crust:			
Ind-1	20 - 30	2.0	2.3
Ind-2	30 - 40	1.0	2.5
Lower crust	40 - 70	0.4	2.6

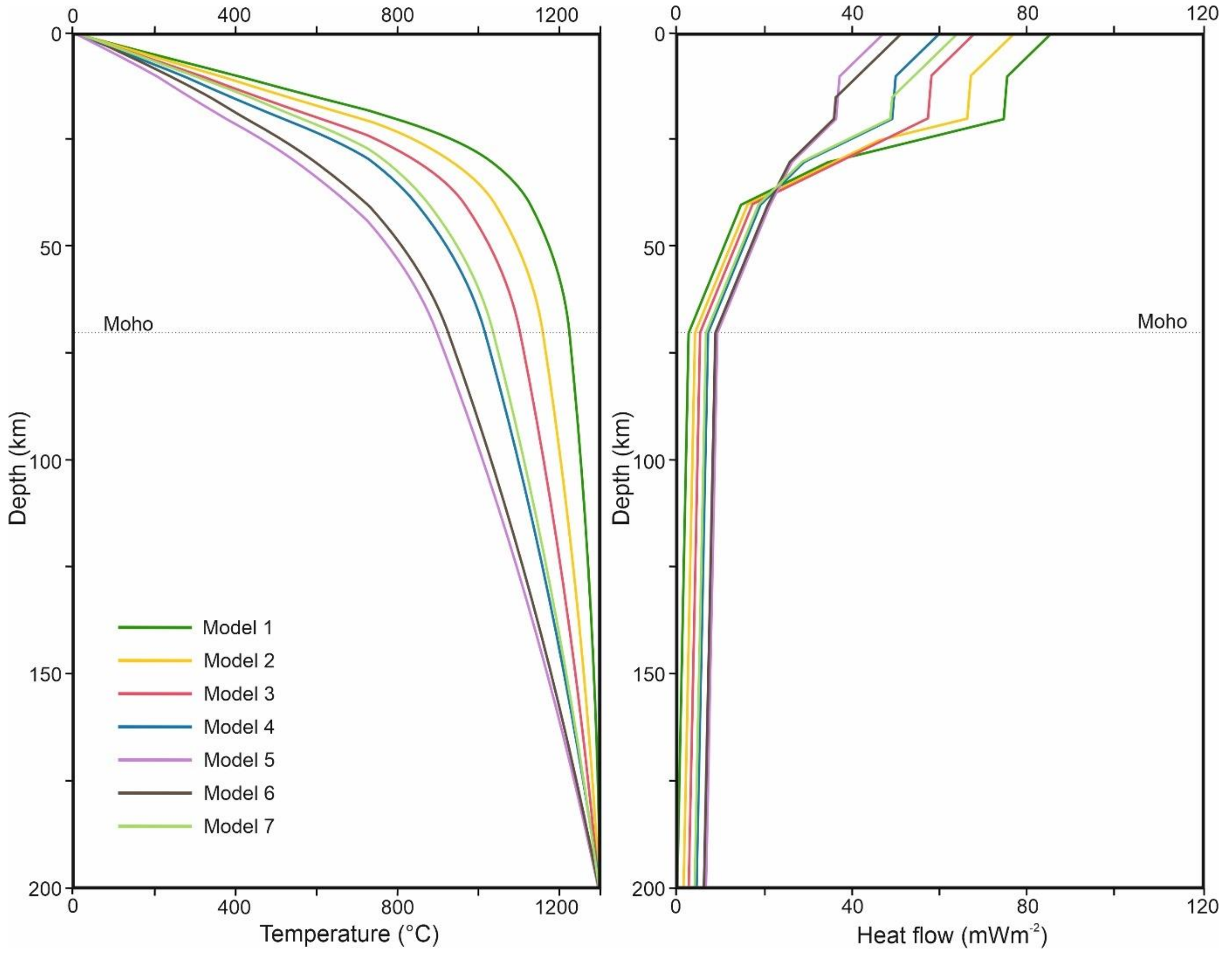

Figure S2 1D steady-state conductive geotherms and heat flow plots for Kohistan arc. In Models 1 to 5, the upper crust is assumed to comprise felsic (Kohistan batholith) and mafic (amphibolite-granulite) components, each with 10 km thickness. The weighted average radiogenic heat production of Kohistan batholith is 1 µW m^{-3}, and 0.08 µW m^{-3} for the mafic layer (Mukai et al., 1999). The lower crust for all models is assumed to be similar to the case of NPM, i.e., 30 km thick with 0.4 µW m^{-3}. For the mid-crustal region, two basements of Indian origin (Ind-1 & Ind-2) with different radiogenic heat production are assumed. For model 1, Ind-1 and Ind-2 are assumed to be 10 km each with RHP of 4 and 2 µW m^{-3}, respectively. For model 2, Ind-1 is reduced to 5 km, while Ind-2 is increased to 15 km. Model 3 assumes only Ind-2 (20 km thick) at mid-crustal level.

Table S3 Parameters used for the steady-state conductive thermal model of Karakoram. KB-Karakoram batholith, KMC-Karakoram metamorphic complex, DG-Dassu gneiss, HG-Hushe gneiss.

	Crustal depth range (km)	Radiogenic heat production (μWm^{-3})	Thermal Conductivity ($Wm^{-1}K^{-1}$)
Model 1			
Upper crust (KB)	0 - 15	2.5	2.3
Mid crust (KMC)	15 - 25	1.0	2.5
Lower crust	25 - 70	0.2	2.6
Model 2			
Upper crust			
KB	0 - 15	2.5	2.3
KMC	15 - 30	1.0	25
Mid crust			
Ind-1	30 - 40	2.0	2.3
Ind-2	40 - 50	1.0	2.5
Lower crust	50 - 70	0.4	2.6
Model 3			
Upper crust			
KB	0 - 15	2.5	2.3
KMC	15 - 30	1.0	25
Mid crust			
Ind-1	30 - 40	1.0	2.3
Ind-2	40 - 50	0.5	2.5
Lower crust	50 - 70	0.2	2.6
Model 4			
Upper crust (KB)	0 - 10	2.5	2.3
Mid crust (DG)	10 - 30	3.15	2.5
Lower crust	30 - 70	0.2	2.6
Model 5			
Upper crust (KB)	0 - 10	2.0	2.3
Mid crust (DG)	10 - 30	2.5	2.5
Lower crust	30 - 70	0.2	2.6
Model 6 (KB-Kande pluton)			
Upper crust	0 - 10	5.0	2.0
Mid crust (HG)	10 - 30	2.0	2.3
Lower crust	30 - 70	0.2	2.6
Model 7			
Upper crust (KB)	0 - 10	2.5	2.3
Mid crust (HG)	10 - 30	2.0	2.5

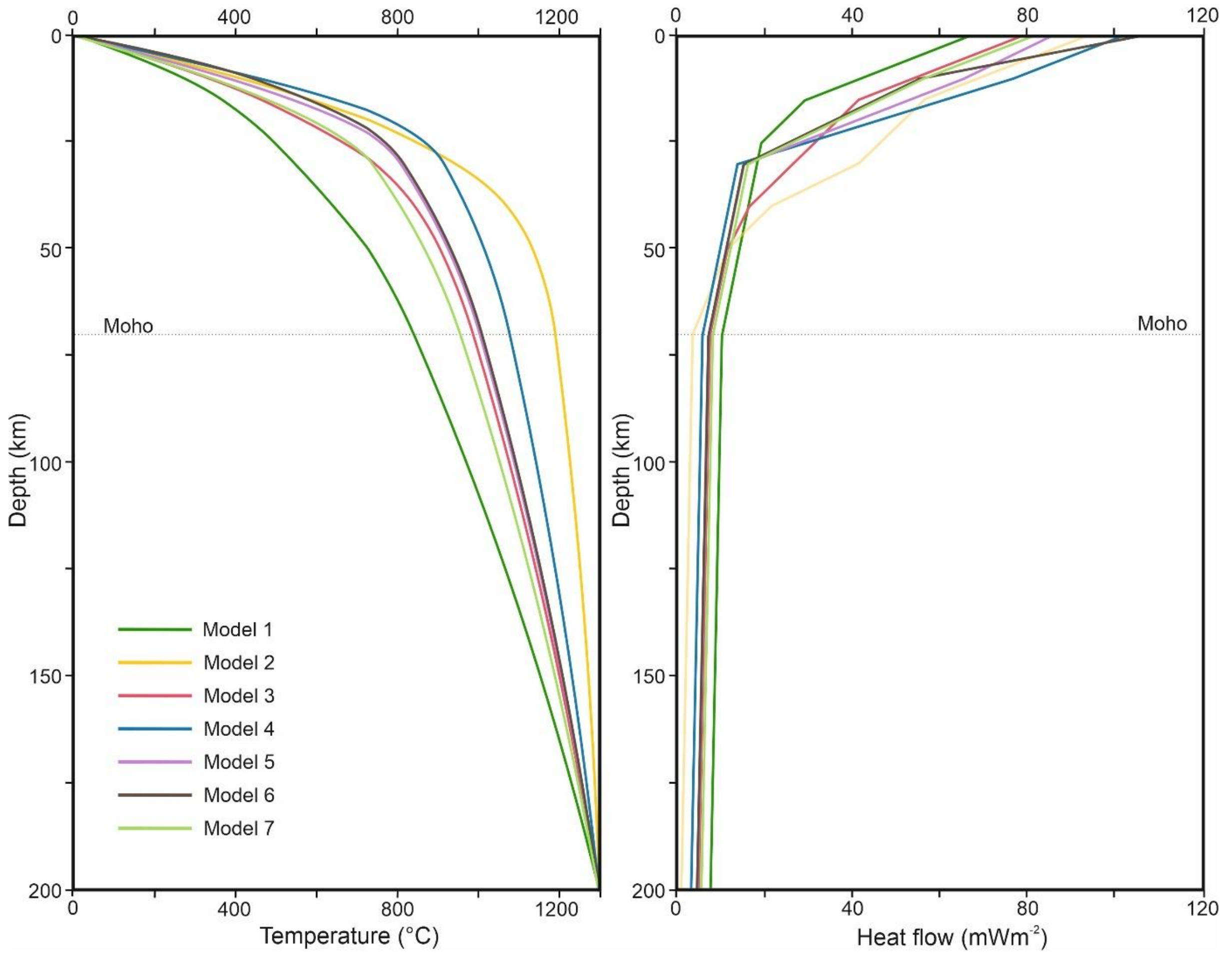

Figure S3 1D steady-state conductive geotherms and heat flow plots for different modeling scenarios with varying parameters in the Karakoram. For model 1, the 15 km thick upper crust comprises Karakoram batholith (KB), while the 10 km mid-crust comprises Karakoram metamorphic complex (KMC) with RHP values of 2.5 and 1 µW m^{-3}, respectively. Model 2 assumes a 30 km upper crust with KB and KMC, each 15 km thick, and a 20 km mid-crust comprising Ind-1 and Ind-2 with RHP of 2 and 1 µW m^{-3}, respectively. The lower crust for this model is 20 km thick with RHP of 0.4 µWm^{-3}. For model 3, the RHP of mid-crust is reduced by 50% (1 and 0.5 µW m^{-3}), while the rest of the parameters are the same as in model 2. For models 4 and 5, mid-crust (20 km) comprises Dassu gneiss (DG) with RHP of 3.15 (surface RHP) and 2.5 µW m^{-3}, respectively. The lower crust is assumed to be 40 km thick with RHP of 0.2 µW m^{-3} (model 4 to 7). Model 6 assumes the upper crust (10 km) comprising of Kande pluton with the mean surface RHP 5 µW m^{-3} and mid-crust (20 km) comprising of Hushe gneiss (HG) with RHP of 2 µW m^{-3}. For Model 7, RHP is assumed to be half (2.5 µW m^{-3}) of model 6, while other parameters are kept the same.

2D Thermal Models

Table S4 Input bottom temperatures (°C) for 2D thermal models at 10 km below sea level calculated from 1D models.

	Temperatures (°C) at 10 km from 1D steady-state conduction model		
	Model 1 Low RHP	Model 2 Moderate RHP	Model 3 High RHP
NPM	343	405	506
Kohistan	211	299	413
Karakoram	274	385	461
	Temperatures (°C) at 10 km from 1D transient advective-conductive model		
	Model 1 High exhumation-Low RHP	Model 2 Low exhumation-High RHP	Model 3 Low exhumation-Moderate RHP
NPM- core	623 (at 3 mm y^{-1})	657 (at 2 mm y^{-1})	564 (at 2 mm y^{-1})
NPM-side	510 (at 2 mm y^{-1})	577 (at 1 mm y^{-1})	478 (at 1 mm y^{-1})
Kohistan	257 (at 1 mm y^{-1})	432 (at 0.5 mm y^{-1})	318 (at 0.5 mm y^{-1})
KMC	407 (at 2 mm y^{-1})	482 (at 0.5 mm y^{-1})	410 (at 0.5 mm y^{-1})
KB	497 (at 3 mm y^{-1})	525 (at 1 mm y^{-1})	454 (at 1 mm y^{-1})

Table S5 Petrophysical parameters based on previous studies (Anees et al 2023, 2024) used for the 2D thermal models.

	Radiogenic heat production (μWm^{-3})	Thermal Conductivity ($Wm^{-1}K^{-1}$)	Specific heat capacity ($J\ kg^{-1}\ K^{-1}$)	Density ($kg\ m^{-3}$)
Nanga Parbat Massif				
Core gneiss	5.33	2.26	750.7	2650
Cover metasediments	2.06	2.15	753.8	2700
Pegmatite	4.79	3.37	754.5	2610
Granite	6.8	1.86	749.3	2590
Kohistan				
KLB	1.08	2.4	755.4	2700
Metavolcanics	0.5	2.13	760.4	2800
Karakoram				
KMC	2.01	2.2	750.9	2670
KB	2.36	1.68	766.6	2700