Supplementary Material:

Chemical Heterogeneities in the Mantle: Progress Towards a General Quantitative Description

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1 Supplementary Data

This section describes the additional material available through an external data repository.

The link to access all the files is:

`https://figshare.com/s/9a97a1d047e783be8e54`

(Note: the private link will be revised and made public once the manuscript is accepted for publication.)

List of the available files:

- `TWOPD-G-KIN.DATA.ZIP`
- `TWOPD-G-KIN.MOVIE1.AVI`
- `TWOPD-G-KIN.MOVIE5.AVI`
- `2D-G-KIN.DATA.ZIP`
- `2D-G-KIN.MOVIE5A.AVI`
- `2D-G-KIN.MOVIE5B.AVI`

1.1 1-D Simulations

The zip file `TWOPD-G-KIN.DATA.ZIP` includes the data from three 1-D simulations assuming an initial proportion of 1:1, 5:1 and 50:1 ($f = 1, 5, 50$). The details of the models are discussed in the main text. For every simulation there are two data files `TWOPD-G-KIN1.1.DAT` and `TWOPD-G-KIN2.1.DAT` for the case with 1:1 proportion, `TWOPD-G-KIN1.5.DAT`, `TWOPD-G-KIN2.5.DAT` and `TWOPD-G-KIN1.50.DAT`, `TWOPD-G-KIN2.50.DAT` for the models with initial proportion 5:1 and 50:1, respectively. The data files are divided in blocks, each block of data refers to a particular time step. Data are

stored every 20 time steps during the numerical simulation.

The first data file for each simulation (`TWOPD-G-KIN1.1.DAT`. `TWOPD-G-KIN1.5.DAT` and `TWOPD-G-KIN1.50.DAT`) includes in every block, distance, $G(*)$ (joules) and the grid step size for the two sub-systems. The number of grid points for sub-system A and B are 101 and 101 in the first simulation, 501 and 101 in the second simulation, 1001 and 101 in the third simulation. Time step is 4, 40 and 800 for the three simulations. Data are stored every 20, 20, 50 numerical time steps respectively. Time, distance and step size have arbitrary units.

The second data file of each simulation (`TWOPD-G-KIN2.1.DAT`, `TWOPD-G-KIN2.5.DAT` and `TWOPD-G-KIN2.50.DAT`) includes in every block, distance and abundance of nine oxides (wt%) describing the bulk composition at every grid point. The listed oxides are: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, Cr_2O_3, FeO, MgO, CaO and Na_2O.

Two animations `TWOPD-G-KIN.MOVIE1.AVI` and `TWOPD-G-KIN.MOVIE5.AVI`, available in the supplementary material, are based on the data in the zip file `TWOPD-G-KIN.DATA.ZIP`.

1.2 2-D Simulations

The results of two 2-D simulations are included in the zip file `2D-G-KIN.DATA.ZIP`. Both simulations are based on the initial proportion set to 5:1. The first simulation assumes that assemblage A becomes mobile at time=1000000 (arbitrary units) while in the second simulation the dynamic assemblage is B. The interface between the two sub-systems is a vertical line. The downward velocity of the moving assemblages is set to 0.00625 (arbitrary units). The new material entering from the top side has the same bulk composition of the initial assemblage (the initial composition can be found in the main text). Data are stored every 400 time steps and the simulation time step is 16 (arbitrary units). Each block of data defined by the label "ZONE" provides information related to a particular time step.

The first data file of each simulation (`2D-G-KIN1.5A.DAT` and `2D-G-KIN1.5B.DAT`) includes the distance x-direction, y-direction and $G(*)$. The number of grid points in the x-direction is 251 and 51 in sub-system A and B, respectively (total distance is 500 and 100 in arbitrary units). The number of grid points in the y-direction is 51 (total distance is 50 in arbitrary units). A block of data is divided in sub-blocks. Each sub-block consists of $(251 + 51) \times 51$ data points. The first sub-block contains the x-coordinate of the numerical grid, the second sub-block the y-coordinate and the third sub-block the $G(*)$ values at every grid point.

The second data file of each simulation (`2D-G-KIN2.5A.DAT` and `2D-G-KIN2.5B.DAT`) follows the same data structure, except that instead of $G(*)$, nine bulk oxides are listed in nine sub-blocks. The sequence of oxides is the same reported for the 1-D models.

The data in the zip file `2D-G-KIN.DATA.AVI` have been used to create two animations, `2D-G-KIN.MOVIE5A.AVI` and `2D-G-KIN.MOVIE5B.AVI`, both are available following the link to the external data repository.

2 Supplementary Tables

The following tables report the initial bulk composition and the proportion factor f of the two sub-systems for all the 43 cases considered in this study.

Table 1. Initial bulk composition of the two assemblages and proportion factor f.

bulk comp.	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)
oxides wt%	1(f=1)		2(f=1.2)		3(f=1.3)		4(f=1.6)		5(f=2)	
SiO_2	45.200	48.860	45.200	48.860	45.200	48.860	45.200	48.860	45.200	48.860
TiO_2	0.200	0.370	0.200	0.370	0.200	0.370	0.200	0.370	0.200	0.370
Al_2O_3	3.940	17.720	3.940	17.720	3.940	17.720	3.940	17.720	3.940	17.720
Fe_2O_3	0.200	0.840	0.200	0.840	0.200	0.840	0.200	0.840	0.200	0.840
Cr_2O_3	0.400	0.030	0.400	0.030	0.400	0.030	0.400	0.030	0.400	0.030
FeO	8.100	7.610	8.100	7.610	8.100	7.610	8.100	7.610	8.100	7.610
MgO	38.400	9.100	38.400	9.100	38.400	9.100	38.400	9.100	38.400	9.100
CaO	3.150	12.500	3.150	12.500	3.150	12.500	3.150	12.500	3.150	12.500
Na_2O	0.410	2.970	0.410	2.970	0.410	2.970	0.410	2.970	0.410	2.970
sum	100	100	100	100	100	100	100	100	100	100
	6(f=5)		7(f=20)		8(f=100)		9(f=500)		10(f=1000)	
SiO_2	45.200	48.860	45.200	48.860	45.200	48.860	45.200	48.860	45.200	48.860
TiO_2	0.200	0.370	0.200	0.370	0.200	0.370	0.200	0.370	0.200	0.370
Al_2O_3	3.940	17.720	3.940	17.720	3.940	17.720	3.940	17.720	3.940	17.720
Fe_2O_3	0.200	0.840	0.200	0.840	0.200	0.840	0.200	0.840	0.200	0.840
Cr_2O_3	0.400	0.030	0.400	0.030	0.400	0.030	0.400	0.030	0.400	0.030
FeO	8.100	7.610	8.100	7.610	8.100	7.610	8.100	7.610	8.100	7.610
MgO	38.400	9.100	38.400	9.100	38.400	9.100	38.400	9.100	38.400	9.100
CaO	3.150	12.500	3.150	12.500	3.150	12.500	3.150	12.500	3.150	12.500
Na_2O	0.410	2.970	0.410	2.970	0.410	2.970	0.410	2.970	0.410	2.970
sum	100	100	100	100	100	100	100	100	100	100
	11(f=1)		12(f=1.5)		13(f=2)		14(f=5)		15(f=20)	
SiO_2	47.434	48.860	47.434	48.860	47.434	48.860	47.434	48.860	47.434	48.860
TiO_2	0.317	0.370	0.317	0.370	0.317	0.370	0.317	0.370	0.317	0.370
Al_2O_3	7.978	17.720	7.978	17.720	7.978	17.720	7.978	17.720	7.978	17.720
Fe_2O_3	0.582	0.840	0.582	0.840	0.582	0.840	0.582	0.840	0.582	0.840
Cr_2O_3	0.288	0.030	0.288	0.030	0.288	0.030	0.288	0.030	0.288	0.030
FeO	7.595	7.610	7.595	7.610	7.595	7.610	7.595	7.610	7.595	7.610
MgO	26.035	9.100	26.035	9.100	26.035	9.100	26.035	9.100	26.035	9.100
CaO	7.902	12.500	7.902	12.500	7.902	12.500	7.902	12.500	7.902	12.500
Na_2O	1.869	2.970	1.869	2.970	1.869	2.970	1.869	2.970	1.869	2.970
sum	100	100	100	100	100	100	100	100	100	100
	16(f=100)		17(f=500)		18(f=1.32)		19(f=2)		20(f=5)	
SiO_2	47.434	48.860	47.434	48.860	48.940	48.860	48.940	48.860	48.940	48.860
TiO_2	0.317	0.370	0.317	0.370	0.393	0.370	0.393	0.370	0.393	0.370
Al_2O_3	7.978	17.720	7.978	17.720	10.394	17.720	10.394	17.720	10.394	17.720
Fe_2O_3	0.582	0.840	0.582	0.840	0.820	0.840	0.820	0.840	0.820	0.840
Cr_2O_3	0.288	0.030	0.288	0.030	0.237	0.030	0.237	0.030	0.237	0.030
FeO	7.595	7.610	7.595	7.610	7.074	7.610	7.074	7.610	7.074	7.610
MgO	26.035	9.100	26.035	9.100	18.887	9.100	18.887	9.100	18.887	9.100
CaO	7.902	12.500	7.902	12.500	10.505	12.500	10.505	12.500	10.505	12.500
Na_2O	1.869	2.970	1.869	2.970	2.751	2.970	2.751	2.970	2.751	2.970
sum	100	100	100	100	100	100	100	100	100	100

Table 2. (continue) Initial bulk composition of the two assemblages and proportion factor f.

bulk comp.	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)
oxides wt%	21(f=20)		22(f=100)		23(f=500)		24(f=1)		25(f=10)	
SiO_2	48.940	48.860	48.940	48.860	48.940	48.860	49.619	48.860	49.619	48.860
TiO_2	0.393	0.370	0.393	0.370	0.393	0.370	0.426	0.370	0.426	0.370
Al_2O_3	10.394	17.720	10.394	17.720	10.394	17.720	11.372	17.720	11.372	17.720
Fe_2O_3	0.820	0.840	0.820	0.840	0.820	0.840	0.918	0.840	0.918	0.840
Cr_2O_3	0.237	0.030	0.237	0.030	0.237	0.030	0.219	0.030	0.219	0.030
FeO	7.074	7.610	7.074	7.610	7.074	7.610	6.745	7.610	6.745	7.610
MgO	18.887	9.100	18.887	9.100	18.887	9.100	16.074	9.100	16.074	9.100
CaO	10.505	12.500	10.505	12.500	10.505	12.500	11.518	12.500	11.518	12.500
Na_2O	2.751	2.970	2.751	2.970	2.751	2.970	3.109	2.970	3.109	2.970
sum	100	100	100	100	100	100	100	100	100	100
	26(f=20)		27(f=100)		28(f=500)		29(f=1)		30(f=5)	
SiO_2	49.619	48.860	49.619	48.860	49.619	48.860	45.200	45.931	45.200	45.931
TiO_2	0.426	0.370	0.426	0.370	0.426	0.370	0.200	0.199	0.200	0.199
Al_2O_3	11.372	17.720	11.372	17.720	11.372	17.720	3.940	18.599	3.940	18.599
Fe_2O_3	0.918	0.840	0.918	0.840	0.918	0.840	0.200	0.351	0.200	0.351
Cr_2O_3	0.219	0.030	0.219	0.030	0.219	0.030	0.400	0.015	0.400	0.015
FeO	6.745	7.610	6.745	7.610	6.745	7.610	8.100	8.576	8.100	8.576
MgO	16.074	9.100	16.074	9.100	16.074	9.100	38.400	17.507	38.400	17.507
CaO	11.518	12.500	11.518	12.500	11.518	12.500	3.150	7.623	3.150	7.623
Na_2O	3.109	2.970	3.109	2.970	3.109	2.970	0.410	1.199	0.410	1.199
sum	100	100	100	100	100	100	100	100	100	100
	31(f=20)		32(f=100)		33(f=500)		34(f=1)		35(f=5)	
SiO_2	45.200	45.931	45.200	45.931	45.200	45.931	45.200	45.914	45.200	45.914
TiO_2	0.200	0.199	0.200	0.199	0.200	0.199	0.200	0.216	0.200	0.216
Al_2O_3	3.940	18.599	3.940	18.599	3.940	18.599	3.940	18.582	3.940	18.582
Fe_2O_3	0.200	0.351	0.200	0.351	0.200	0.351	0.200	0.296	0.200	0.296
Cr_2O_3	0.400	0.015	0.400	0.015	0.400	0.015	0.400	0.005	0.400	0.005
FeO	8.100	8.576	8.100	8.576	8.100	8.576	8.100	8.015	8.100	8.015
MgO	38.400	17.507	38.400	17.507	38.400	17.507	38.400	18.551	38.400	18.551
CaO	3.150	7.623	3.150	7.623	3.150	7.623	3.150	7.459	3.150	7.459
Na_2O	0.410	1.199	0.410	1.199	0.410	1.199	0.410	0.962	0.410	0.962
sum	100	100	100	100	100	100	100	100	100	100
	36(f=20)		37(f=100)		38(f=500)		39(f=1)		40(f=5)	
SiO_2	45.200	45.914	45.200	45.914	45.200	45.914	45.200	45.804	45.200	45.804
TiO_2	0.200	0.216	0.200	0.216	0.200	0.216	0.200	0.281	0.200	0.281
Al_2O_3	3.940	18.582	3.940	18.582	3.940	18.582	3.940	18.319	3.940	18.319
Fe_2O_3	0.200	0.296	0.200	0.296	0.200	0.296	0.200	0.246	0.200	0.246
Cr_2O_3	0.400	0.005	0.400	0.005	0.400	0.005	0.400	0.015	0.400	0.015
FeO	8.100	8.015	8.100	8.015	8.100	8.015	8.100	7.482	8.100	7.482
MgO	38.400	18.551	38.400	18.551	38.400	18.551	38.400	18.834	38.400	18.834
CaO	3.150	7.459	3.150	7.459	3.150	7.459	3.150	8.295	3.150	8.295
Na_2O	0.410	0.962	0.410	0.962	0.410	0.962	0.410	0.723	0.410	0.723
sum	100	100	100	100	100	100	100	100	100	100

Table 3. (continue) Initial bulk composition of the two assemblages and proportion factor f.

bulk comp.	(A_0)	(B_0)	(A_0)	(B_0)	(A_0)	(B_0)
oxides wt%	41(f=20)		42(f=100)		43(f=500)	
SiO_2	45.200	45.804	45.200	45.804	45.200	45.804
TiO_2	0.200	0.281	0.200	0.281	0.200	0.281
Al_2O_3	3.940	18.319	3.940	18.319	3.940	18.319
Fe_2O_3	0.200	0.246	0.200	0.246	0.200	0.246
Cr_2O_3	0.400	0.015	0.400	0.015	0.400	0.015
FeO	8.100	7.482	8.100	7.482	8.100	7.482
MgO	38.400	18.834	38.400	18.834	38.400	18.834
CaO	3.150	8.295	3.150	8.295	3.150	8.295
Na_2O	0.410	0.723	0.410	0.723	0.410	0.723
sum	100	100	100	100	100	100