Chutes and Ladders: metamorphic conditions of exhumed simulated rocks

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Key Points:

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Abstract

```
## Loading libraries:
## magrittr
## tidyr
## readr
## purrr
## mclust
## ggforce
## dplyr
## patchwork
## gridExtra
## gganimate
## ggridges
## progress
## metR
## parallel
## Loading functions
```


1 Introduction

2 Methods

2.1 Numerical model

2.2 Marker tracing

A set of markers, $M = m_1, m_2, \ldots, m_i$, are initialized randomly in the model domain. Markers are traced by: 1) selecting all markers within a 760 km wide and 11 km deep section extending from $x = 500$ km to approximately the trench, 2) save marker properties and positions, 3) if timestep $\leq \alpha$, 4) update markers. Where α is the number of timesteps for marker tracing.

Slab rollback eventually leads to mechanical interference between the stiff convergence region centered at $x = 500$ km and trench sediments. Sediments pile up against the barrier as the accretionary wedge deforms against the convergence region. Thickening trench sediments flatten the slab causing intense crustal deformation of the forearc and backarc regions. The abrupt change in dynamics makes marker P-T conditions meaningless after interference begins. The number of timesteps for marker tracing, α, is chosen algorithmically by computing the topographic height of the sediment pile against the convergence region. Markers tracing stops when the sediment pile becomes the overall topographic high, usually within one or two timesteps after interference. Marker paths from timestep $\leq \alpha$ are used for classification (Table 1).

Table 1: Summary of marker tracing results by numerical model

model	z_{cpl} [km]	Δz_{lith} [km]	age [Ma]	$\vec{v}_{conv}$ [$\frac{km}{Ma}$]	n_{marx}	n_{rec}	σ_{rec}	n_{sub}	σ_{sub}	ratio	σ_{ratio}	P_{max} [GPa]	$\sigma_{P_{max}}$	T_{max} [C]	$\sigma_{T_{max}}$
cda46	66	46	32.6	40	**	**	**	**	**	**	**	**	**	**	**
cdb46	74	46	32.6	66	**	**	**	**	**	**	**	**	**	**	**
cdc46	69	46	32.6	80	**	**	**	**	**	**	**	**	**	**	**
cdd46	67	46	32.6	100	**	**	**	**	**	**	**	**	**	**	**
cde46	72	46	55	40	**	**	**	**	**	**	**	**	**	**	**
cdf46	78	46	55	66	**	**	**	**	**	**	**	**	**	**	**
cdg46	78	46	55	80	**	**	**	**	**	**	**	**	**	**	**
cdh46	59	46	55	100	**	**	**	**	**	**	**	**	**	**	**
cdi46	80	46	85	40	**	**	**	**	**	**	**	**	**	**	**
cdj46	70	46	85	66	**	**	**	**	**	**	**	**	**	**	**
cdk46	58	46	85	80	**	**	**	**	**	**	**	**	**	**	**
cdl46	65	46	85	100	**	**	**	**	**	**	**	**	**	**	**
cdm46	79	46	110	40	**	**	**	**	**	**	**	**	**	**	**
cdn46	70	46	110	66	**	**	**	**	**	**	**	**	**	**	**
cdo46	68	46	110	80	18,764	11,660	1	7,104	1	1.64	0	6.03	0	786.2	0

model	z_{cpl} $[km]$	Δz_{lith} $[km]$	age $[Ma]$	$\vec{v}_{conv}$ $[\frac{km}{Ma}]$	n_{marx}	n_{rec}	σ_{rec}	n_{sub}	σ_{sub}	ratio	σ_{ratio}	P_{max} $[GPa]$	$\sigma_{P_{max}}$	T_{max} $[C]$	$\sigma_{T_{max}}$
cdp46	64	46	110	100	**	**	**	**	**	**	**	**	**	**	**
cda62	80	62	32.6	40	**	**	**	**	**	**	**	**	**	**	**
cdb62	79	62	32.6	66	**	**	**	**	**	**	**	**	**	**	**
cdc62	78	62	32.6	80	**	**	**	**	**	**	**	**	**	**	**
cdd62	77	62	32.6	100	**	**	**	**	**	**	**	**	**	**	**
cde62	87	62	55	40	**	**	**	**	**	**	**	**	**	**	**
cdf62	82	62	55	66	**	**	**	**	**	**	**	**	**	**	**
cdg62	75	62	55	80	**	**	**	**	**	**	**	**	**	**	**
cdh62	70	62	55	100	**	**	**	**	**	**	**	**	**	**	**
cdi62	91	62	85	40	18,775	18,775	0	0	0	Inf	**	7.67	0	855.4	0
cdj62	77	62	85	66	**	**	**	**	**	**	**	**	**	**	**
cdk62	72	62	85	80	**	**	**	**	**	**	**	**	**	**	**
cdl62	67	62	85	100	**	**	**	**	**	**	**	**	**	**	**
cdm62	88	62	110	40	**	**	**	**	**	**	**	**	**	**	**
cdn62	77	62	110	66	**	**	**	**	**	**	**	**	**	**	**
cdo62	74	62	110	80	**	**	**	**	**	**	**	**	**	**	**
cdp62	75	62	110	100	**	**	**	**	**	**	**	**	**	**	**

model	z_{cpl} [km]	Δz_{lith} [km]	age [Ma]	$\vec{v}_{conv}$ [$\frac{km}{Ma}$]	n_{marx}	n_{rec}	σ_{rec}	n_{sub}	σ_{sub}	ratio	σ_{ratio}	P_{max} [GPa]	$\sigma_{P_{max}}$	T_{max} [C]	$\sigma_{T_{max}}$
cda78	87	78	32.6	40	**	**	**	**	**	**	**	**	**	**	**
cdb78	94	78	32.6	66	**	**	**	**	**	**	**	**	**	**	**
cdc78	97	78	32.6	80	**	**	**	**	**	**	**	**	**	**	**
cdd78	97	78	32.6	100	**	**	**	**	**	**	**	**	**	**	**
cde78	90	78	55	40	**	**	**	**	**	**	**	**	**	**	**
cdf78	90	78	55	66	18,934	8,486	735	10,448	735	0.82	0.13	7.24	0.23	826.5	0.7
cdg78	88	78	55	80	**	**	**	**	**	**	**	**	**	**	**
cdh78	85	78	55	100	**	**	**	**	**	**	**	**	**	**	**
cdi78	97	78	85	40	**	**	**	**	**	**	**	**	**	**	**
cdj78	91	78	85	66	**	**	**	**	**	**	**	**	**	**	**
cdk78	84	78	85	80	**	**	**	**	**	**	**	**	**	**	**
cdl78	77	78	85	100	**	**	**	**	**	**	**	**	**	**	**
cdm78	78	78	110	40	**	**	**	**	**	**	**	**	**	**	**
cdn78	87	78	110	66	**	**	**	**	**	**	**	**	**	**	**
cdo78	85	78	110	80	**	**	**	**	**	**	**	**	**	**	**
cdp78	78	78	110	100	**	**	**	**	**	**	**	**	**	**	**
cda94	95	94	32.6	40	**	**	**	**	**	**	**	**	**	**	**

model	z_{cpl} $[km]$	Δz_{lith} $[km]$	age $[Ma]$	$\vec{v}_{conv}$ $[\frac{km}{Ma}]$	n_{marx}	n_{rec}	σ_{rec}	n_{sub}	σ_{sub}	ratio	σ_{ratio}	P_{max} $[GPa]$	$\sigma_{P_{max}}$	T_{max} $[C]$	$\sigma_{T_{max}}$
cdb94	101	94	32.6	66	**	**	**	**	**	**	**	**	**	**	**
cdc94	108	94	32.6	80	**	**	**	**	**	**	**	**	**	**	**
cdd94	113	94	32.6	100	19,732	12,302	60	7,430	60	1.66	0.02	7.47	0.01	862.6	0
cde94	100	94	55	40	**	**	**	**	**	**	**	**	**	**	**
cdf94	104	94	55	66	**	**	**	**	**	**	**	**	**	**	**
cdg94	104	94	55	80	**	**	**	**	**	**	**	**	**	**	**
cdh94	104	94	55	100	**	**	**	**	**	**	**	**	**	**	**
cdi94	101	94	85	40	**	**	**	**	**	**	**	**	**	**	**
cdj94	102	94	85	66	**	**	**	**	**	**	**	**	**	**	**
cdk94	101	94	85	80	**	**	**	**	**	**	**	**	**	**	**
cdl94	107	94	85	100	**	**	**	**	**	**	**	**	**	**	**
cdm94	106	94	110	40	**	**	**	**	**	**	**	**	**	**	**
cdn94	102	94	110	66	**	**	**	**	**	**	**	**	**	**	**
cdo94	98	94	110	80	**	**	**	**	**	**	**	**	**	**	**
cdp94	108	94	110	100	**	**	**	**	**	**	**	**	**	**	**

2.3 Maker classification

3 Results

4 Discussion

5 Conclusion

6 Open Research

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7 References

A Appendix