Elastoplastic Deformation in a Wedge-Shaped Plate Caused by a Subducting Seamount

Min Ding[1,2], Jian Lin[1]

1. Woods Hole Oceanographic Institution, Dept. Geology and Geophysics, 266 Woods Hole Road, Woods Hole, MA 02543;
2. Massachusetts Institute of Technology, Earth, Atmospheric, and Planetary Sciences, 77 Massachusetts Avenue, Cambridge, MA 02139.

Introduction: We conducted a series of static numerical experiments using COMSOL Multiphysics 4.3 to investigate the evolution of deformation and fault-like shear zones (referred to as faults) in the upper plate caused by the subduction of a seamount.

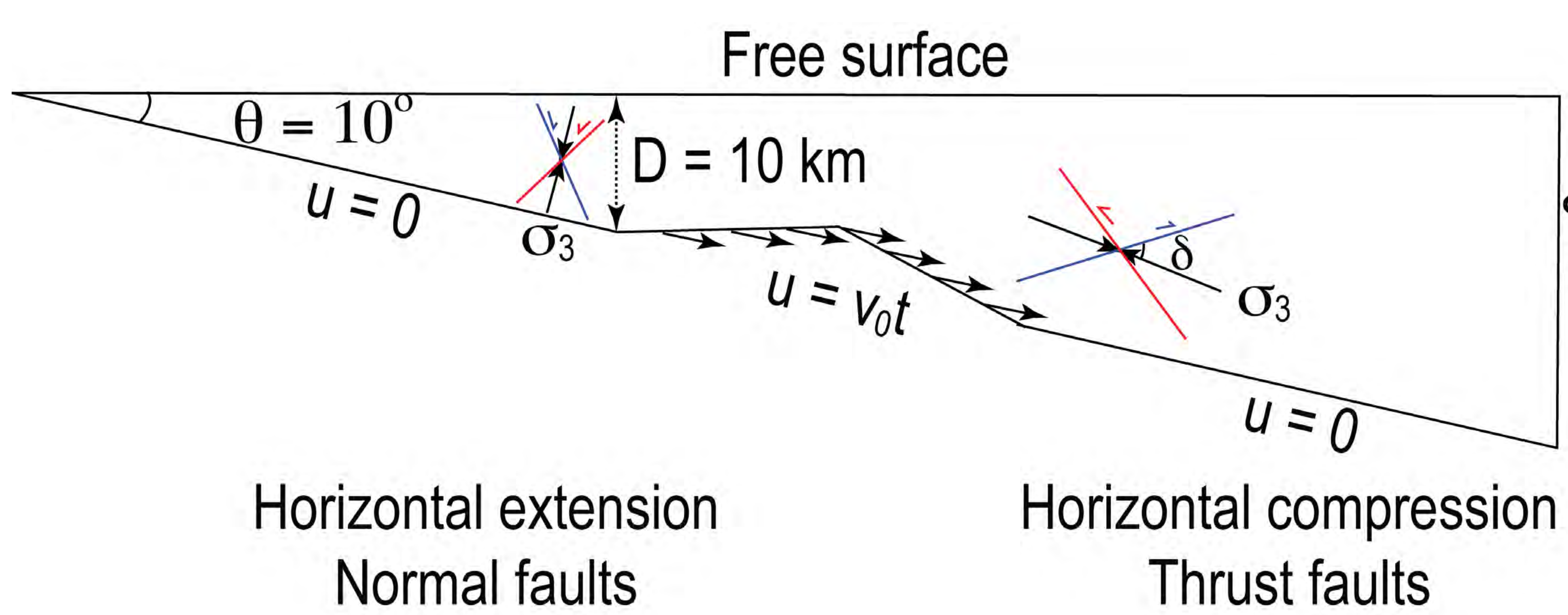

Figure 1. Model set-up and anticipated stress field.

Elastoplasticity: We modeled the mechanical failure using the Mohr-Coulomb failure law, in which shear strength is:

$$\tau = \tan(\phi)\sigma_n + c\rho gz.$$

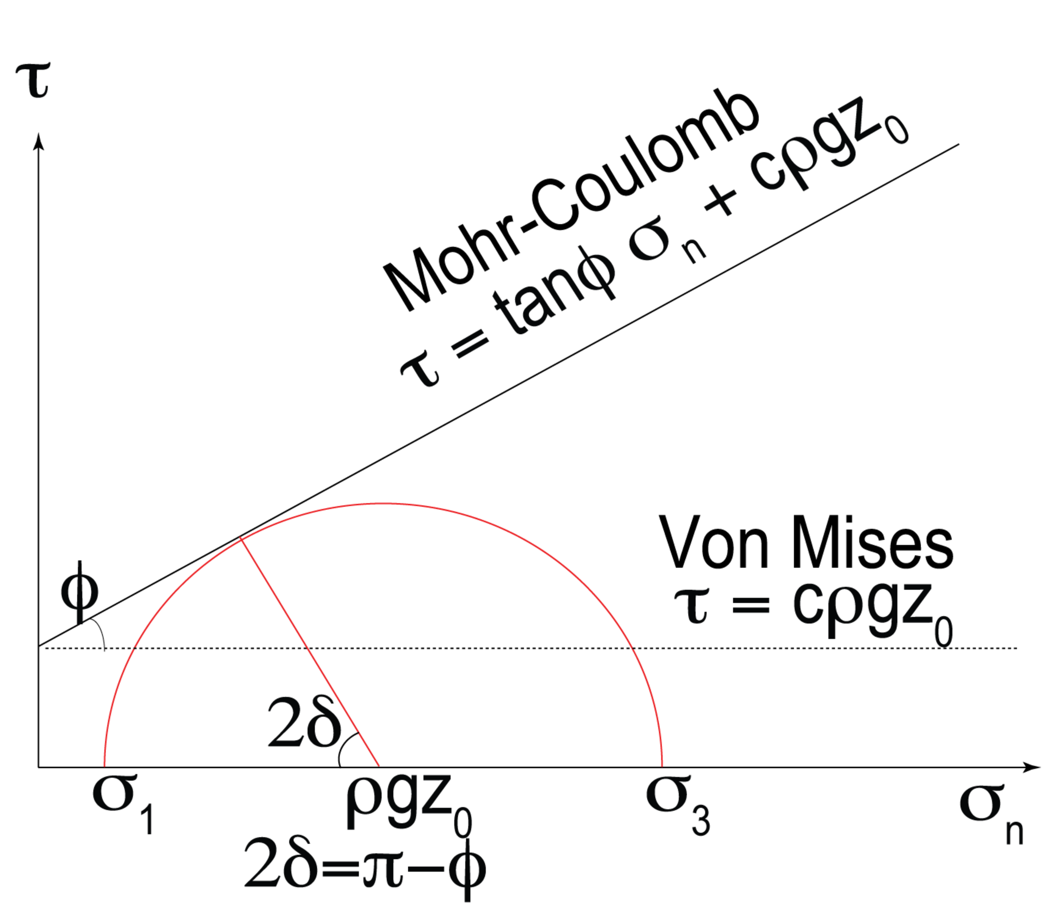

Figure H. Mohr-Coulomb and Von Mises Failure criteria.

Results:

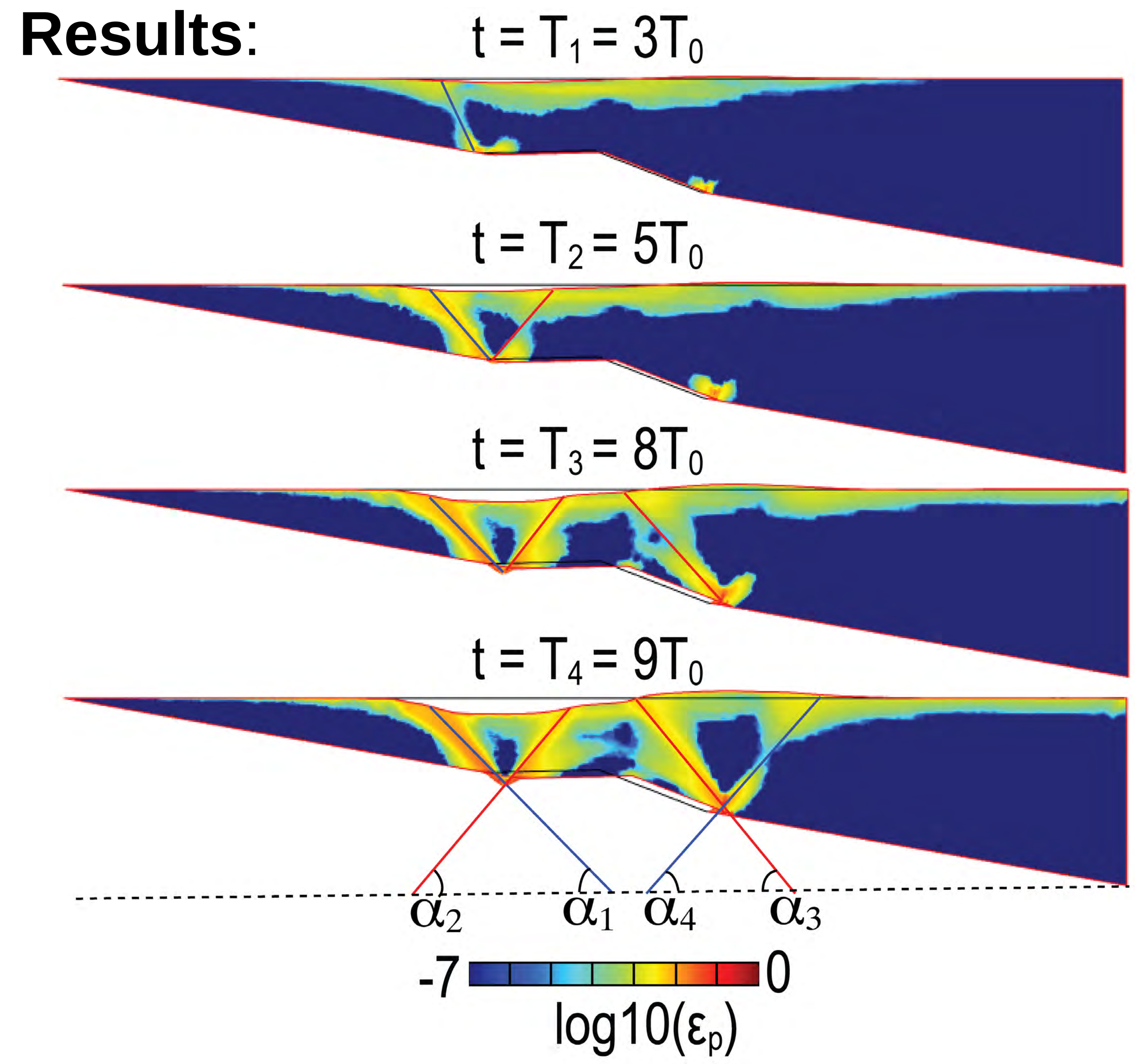

Figure 3. Snapshots showing a sequence of faults cutting through the entire plates (results of Model 2b): (a) right-dipping normal fault; (b) left-dipping normal fault; (3) right-dipping thrust fault; and (d) left-dipping thrust fault.

Model number	Input				Output							
	θ(°)	ϕ(°)	D(km)	T_0(yr)	T_1/T_0	α_1(°)	T_2/T_0	α_2(°)	T_3/T_0	α_3(°)	T_4/T_0	α_4(°)
1a	0	0	10	200	1	51	1	49	1	58	1	48
1b	0	30	10	200	4	58	4	55	10	45	10	41
2a	10	0	5	100	1.5	52	2	49	5.5	48	8	47
2b	10	0	10	200	2.5	49	4.5	54	7	49	9	48
2c	10	0	20	400	6	58	N/A	N/A	N/A	N/A	20.5	57
3a	10	30	5	100	2	63	2	52	18	39	18	31
3b	10	30	10	200	5	63	5	61	N/A	N/A	21	34
3c	10	30	20	400	8	60	13	63	N/A	N/A	22	45
4a	20	0	5	100	2	50	2	50	13	47	13	48
4b	20	0	10	200	4	49	4	52	N/A	N/A	12.5	50
4c	20	0	20	400	7.5	49	N/A	N/A	N/A	N/A	18	51
5a	20	30	5	100	3	63	9	50	N/A	N/A	52	38
5b	20	30	10	200	5	79	7	43	N/A	N/A	49	35
5c	20	30	20	400	7.5	80	N/A	N/A	N/A	N/A	40	41

Table 1. Results of a series of numerical experiments, showing the durations of the seamount movement that are required for the sequence of faults to cut through the upper plate, T_1 to T_4, and the dipping angles of the through-going faults, α_1 to α_4. In all calculations, $V_0 = 5\times10^{-5}$ km/yr. $T_0 = 0.001\ D/V_0$ is characteristic time.

Conclusions: Modeling results revealed that a pair of conjugate normal faults first appeared in the thinner part of the upper plate, followed by another pair of conjugate thrust faults in the thicker part of the plate. The durations of the seamount movement required for faults to cut through the entire plate are larger for deeper seamounts, greater dipping angles of the plate, and for the Mohr-Coulomb than the Von Mises criterion.

Excerpt from the Proceedings of the 2012 COMSOL Conference in Boston