Experimental Method

The experimental apparatus consisted of a high-resolution load-and-position control electromechanical test system that included an aluminum load frame, a load cell, a PC-controlled servo-controller, a Teflon-coated Plexiglas box (dimensions are 130 cm long, 30.5 cm wide, and 28 cm high), three digital cameras, and a laser (see Figure 2 in Cruz et al., 2010). A vertical backstop was used to deform the scaled upper crustal material that consisted of a 28-mm quartz-sand layer on top of a 2-mm glass-beads layer that served as a detachment horizon. The backstop was driven at a constant velocity of ~ 10 cm/hr. The filling technique complies with that used in recent benchmarking experiments (S. Buiter and G. Schreurs, Geomod2008 Website, Analogue numerical comparisons, Setup and modeling procedure for experiments, 2008, www.ngu.no/geodynamics/2008ModelComparisons-Dec08c.pdf). The particle size of the sand and glass beads is ~300 μm and ~200 μm, respectively. The grain shapes vary from angular to well rounded. The internal friction angle of the sand is 33° and the interface friction angle between the glass beads and the Plexiglas is 25°, respectively. The Deformation of the analogue material over time was monitored using Particle Image Velocimetry (PIV). This non-invasive method uses a time-series of photographs of the deforming material to track the displacements of individual sand grains as the sand wedge is deformed. Photographs taken at a regular time interval can thus be used to calculate the scaled velocity field, from which the deformation and deformation rate tensors for each time increment can be calculated. This allows a direct quantification of the kinematics of the sand wedge for comparison with those produced by the numerical simulations. We calibrated the properties of the physical model against those assumed for the AFTB by comparing the relationship between fault dip and surface slope. We found that the surface slope of the sandbox is consistently higher than that expected for the AFTB for the range of values observed in the physical experiments (>4°). However, this difference is negligible (~1°). Even after applying a correction factor to account for this difference in the physical experiments, the results remain unchanged.

Numerical Method

In the Gale numerical models, we used the material properties (Table DR1), geometries, and configuration utilized in the physical experiments. We simulated a low viscocity (1 Pa • s) air layer on top of the simulated sand layer and used the measured densities from the experimental material including the glass beads (detachment horizon) and sand layer, 1407 kg/m^3 and 1538 kg/m^3, respectively, in the Gale simulations. The resolution of the Gale models is 128 x 16 elements along the x and y axes, respectively, and the number of particles per cell is 30. We imposed a velocity boundary condition to the vertical backstop in the simulation with a displacement of 2.5 cm per hr. Cruz et al., (2011) showed in their figure 5 that the evolution of the topographic slope of the physical experiments and Gale numerical simulations modeled with similar conditions to those used in this study show good correlation, implying that the materials and boundary conditions of both modeling approaches are comparable.

Table DR1. Summary of erosion-rule model parameters used in the theoretical predictions, physical experiments, and numerical simulations [*Hilley et al.*, 2004]

Parameter	Stage I	Stage II	Stage III
v	5.5 mm/yr	12.2 (21.0*) mm/yr	10.0 (20.0*) mm/yr
T	8 km	14 (8*) km	16 (8*) km
ka	4 $m^{0.6}$	4 $m^{0.6}$	4 $m^{0.6}$
h	1.4	1.4	1.4
m	0.4	0.4	0.4
n	1	1	1
Initial erosion time step	9.7×10^6 yr	6.4×10^5 yr	6.7×10^5 yr
Erosion time step	9.7×10^5 yr	6.4×10^5 yr	6.7×10^5 yr
K	1.4×10^{-5} $m^{0.2}$/yr	6.5×10^{-6} $m^{0.2}$/yr	6.7×10^{-6} $m^{0.2}$/yr
μ (internal friction)	0.6 (0.9^+)	0.6 (0.9^+)	0.9 (0.6^+)
μb (basal internal friction)	0.4 (0.8^+)	0.4 (0.8^+)	0.8 (0.4^+)
λ^+ (pore pressure)	0.7	0.7	0.7
λb^+(basal pore pressure)	0.7	0.7	0.7

(*) Stages II and III were scaled to 8 km of thickness modifying v to keep the interpreted vT product.
($^+$) Values used on the theoretical predictions

Videos:

Video DR1: AFTB_Stage_I.avi
Video DR2: AFTB_Stage_I_exp.mp4
Video DR3: AFTB_Stage_I_no_erosion_exp.mp4
Video DR4: AFTB_Stage_II_III.avi
Video DR5: AFTB_Stage_II_III_expr.mp4
Video DR6: AFTB_Stage_II_III_no_erosion.avi
Video DR7: AFTB_Stage_II_III_no_erosion_exp.mp4