APPENDIX VII

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

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PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address
Dr. David T. Sandwell
Institute for Geophysics
Univ. of Texas at Austin
Austin, Texas 78712

2. NSF Program
Ocean Sciences

3. NSF Award Number
OCE-8609141

4. Award Period
From 7/1/86 To 6/30/88

5. Cumulative Award Amount
$33,000

6. Project Title
Thermal Stress and Transform Faults in Spreading Wax

PART II—SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

Several studies have proposed that transform faults in the seafloor (connecting spreading ridge segments) are thermal contraction cracks. This behavior has been simulated in the laboratory using a tank of molten wax with a thin frozen layer on top (Figure 1). The thin wax layer is slit with a razor knife and the two plates of wax are pulled apart at a constant rate. Spontaneously, a pattern of ridges and transform faults develop and persist until spreading ceases. We proposed that the transform faults in the wax are caused by thermal contraction of the cooling plate. An unusual property of wax is that it contracts by about 10% after it freezes. The hypothesis is that the transform faults relieve the component of thermal stress that is parallel to the spreading ridge. One of the predictions of the model is that the spacings of the transform faults should increase as the spreading rate is increased.

With NSF funding we have performed two series of wax tank experiments in order to test the thermal stress model of transform faults. The first set of experiments were performed at Scripps Institution of Oceanography using the experimental setup developed by Martin Kleinrock (Figure 1). The initial results (Figures 2 and 3) show that transform spacing increases with increasing spreading rate in agreement with a simple thermoelastic stress model. In February of 1988 we performed a second series of experiments at the Hawaii Institute for Geophysics (HIG). (The wax tank was moved from Scripps to HIG causing a delay in our work.) In all of these experiments we observed an increase in transform spacing with increasing spreading rate (Figure 2) although we have not had the time nor the funds to analyze the results.

In addition to measuring transform spacing, we made some detailed measurements of wax topography using a device developed under this grant (Figure 4a). In particular we were interested in measuring the magnitude of the thermoelastic stress by measuring the topography that develops at the free end of a cooling wax plate (Figure 4b). Some preliminary results (Figure 5a) show the downward curvature of the plate at an extinct spreading ridge. This curvature is in qualitative agreement with the predictions of the thermal stress model (Figure 5b) and will enable us to estimate the magnitude of the thermal stress that produces the transform faults.

Our major problem in analyzing the results of these experiments has been limited funding. We proposed a very modest funding of $37k but our budget was cut to $33 k. This cut reduced the funded man months from 4.5 to 2.5. In addition, our travel expenses increased because the wax tank was moved to Hawaii. Thus, some of the travel costs were funded under a NASA grant. We hope to obtain additional funding to complete this research.

PART III—TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM Check (✓)	Approx. Date
a. Abstracts of Theses	*				
b. Publication Citations	*				
c. Data on Scientific Collaborators	*				
d. Information on Inventions	*				
e. Technical Description of Project and Results	▨	* - Partial		*	7/89?
f. Other *(specify)*	▨				

2. Principal Investigator/Project Director Name *(Typed)*
Dr. David T. Sandwell
Dr. Martin Kleinrock

3. Principal Investigator/Project Director Signature
David T. Sandwell

4. Date
12/20/88

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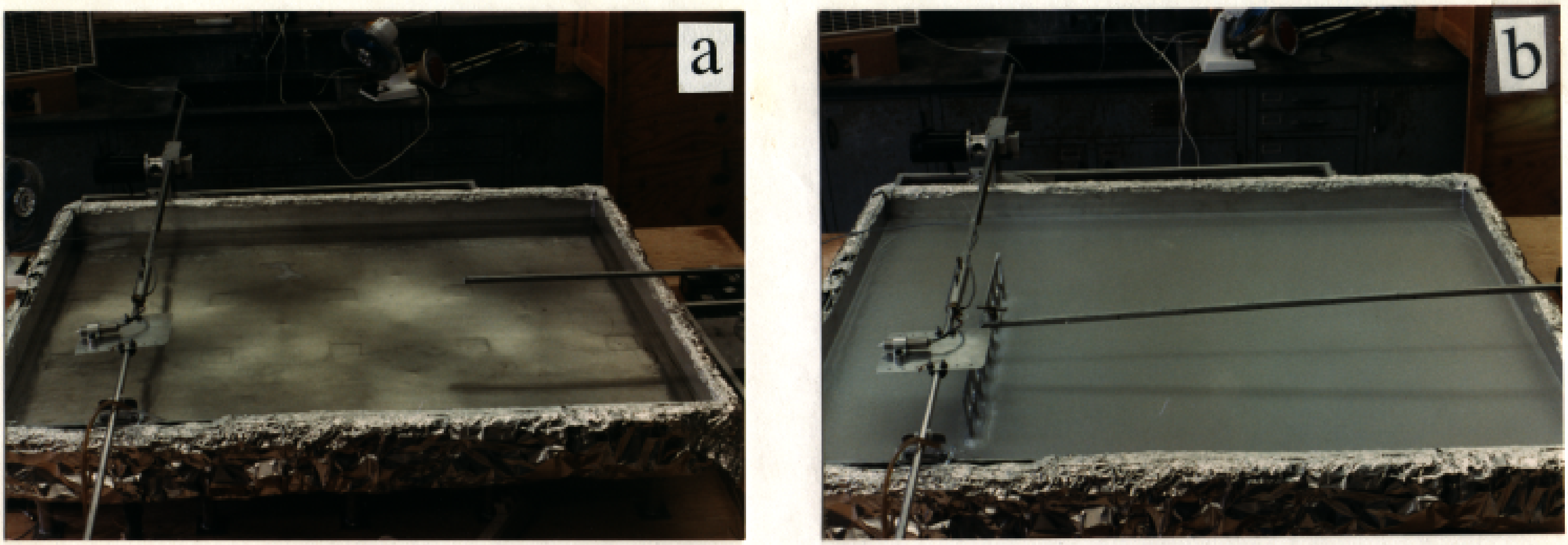
Form Approved OMB No. 3145-0058



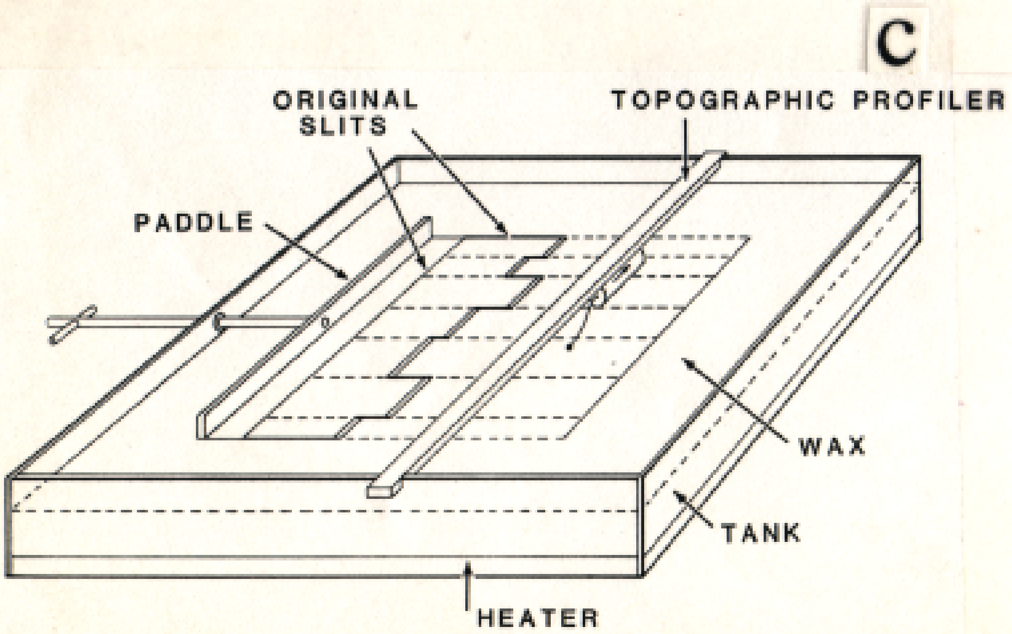
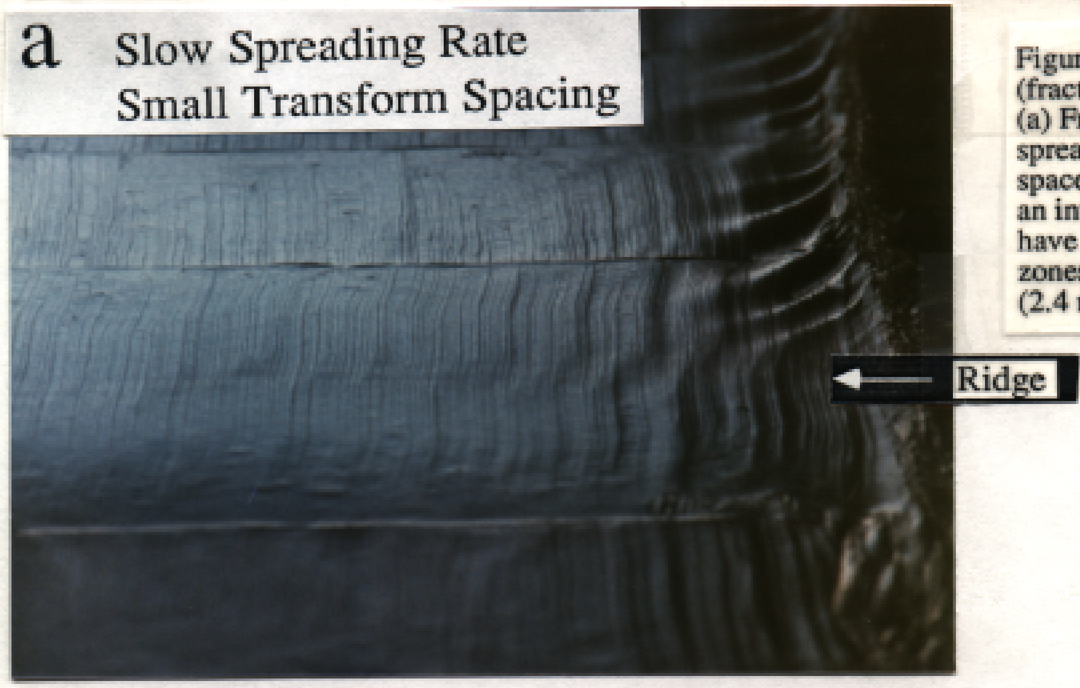
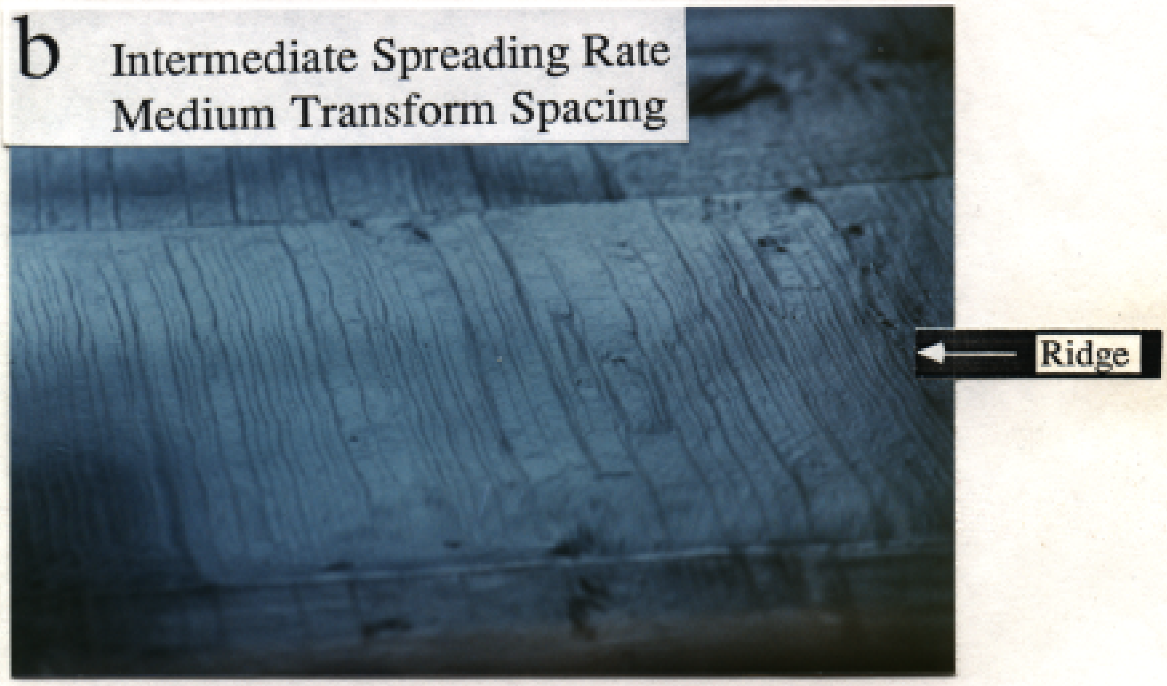


Figure 1. Wax tank used to model seafloor spreading and ridge segmentation by transform faults. (a) Wax is completely molten. (b) Wax surface is allowed to cool and the paddle is frozen into the wax. The wax surface is slit with a hot knife and the paddle is pulled from left to right. (The top to bottom bar holds the topographic profiler.) (c) Schematic diagram of experiment. (Note paddle direction is reversed).

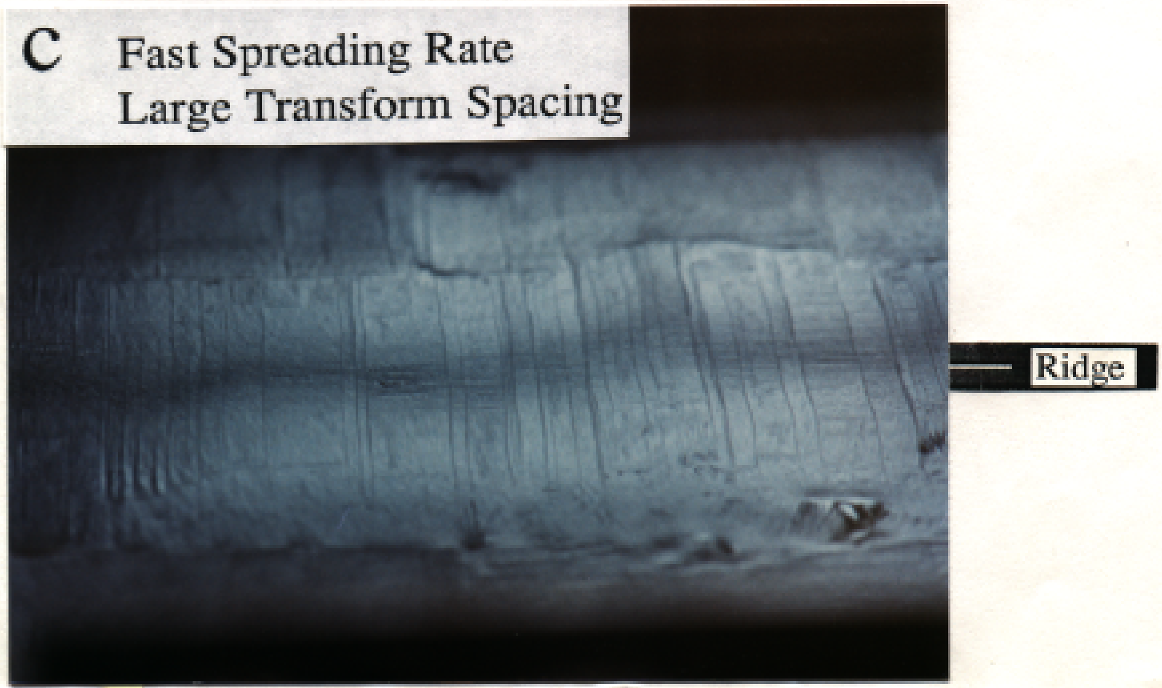
Figure 2. Transform faults leave traces (fracture zones) in the frozen wax. (a) Fracture zones that formed at a low spreading rate (1.4 mm/s) are closely spaced. (b) Fracture zones that formed at an intermediate spreading rate (1.9 mm/s) have an intermediate spacing. (c) Fracture zones that formed at a high spreading rate (2.4 mm/s) are widely spaced.



a Slow Spreading Rate
Small Transform Spacing



b Intermediate Spreading Rate
Medium Transform Spacing



c Fast Spreading Rate
Large Transform Spacing

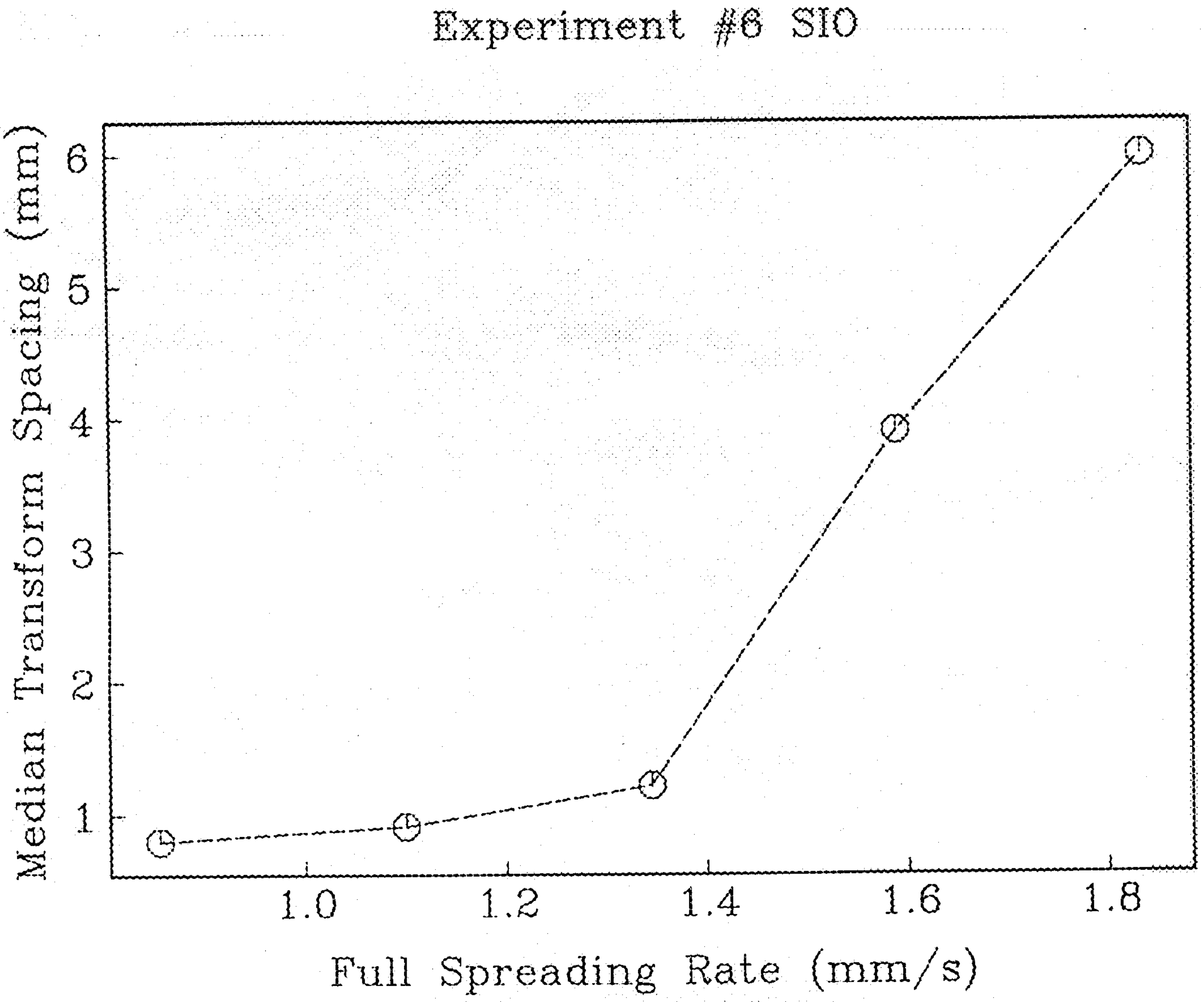


Figure 3. Median transform fault spacing versus spreading rate. These preliminary results are from a spreading wax experiment where the spreading rate was changed 5 times while all other variables were held fixed. More complete experiments were carried out at the Hawaii Institute for Geophysics in order to broaden the range of spreading rates and test the repeatability of these results. These more resent data have not been processed yet.

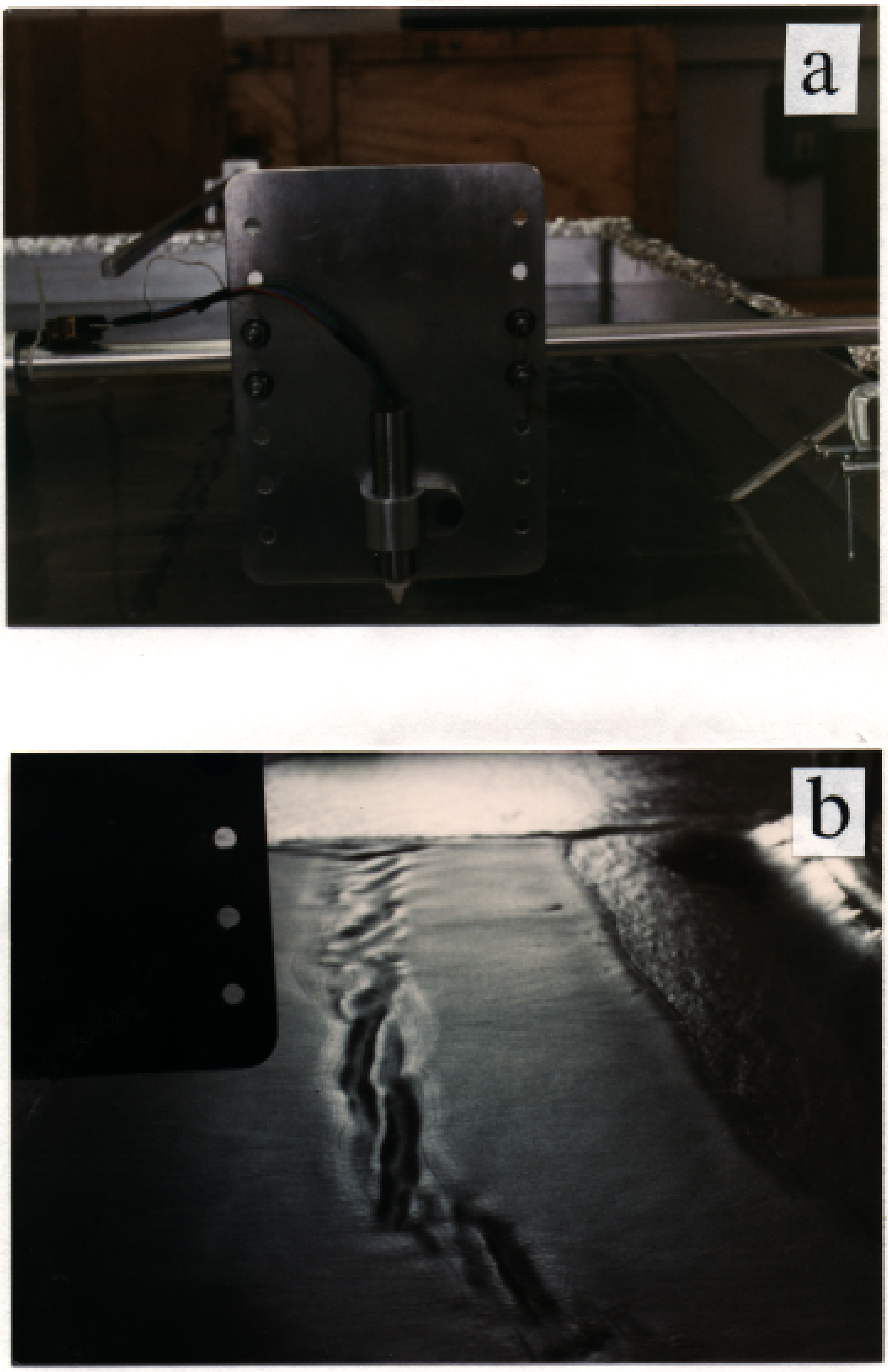


Figure 4. (a) Displacement transducer (topographic profiler) used to measure the topography of the wax surface. Variations in voltage from the transducer are digitized and recorded on a Macintosh computer. The device is linear over an 10 mm range and is precise to less than 10 μm. (b) The topographic profiler was used to measure the topography that develops at the free end of a cooling and thickening plate. Differential contraction of the cooling plate places the surface layer in compression and the second layer in tension. (This technique is also used to temper glass against surface cracks.) This continuous process creates a large thermal bending moment. At a free edge, the thermal bending moment causes the plate to flex downward.

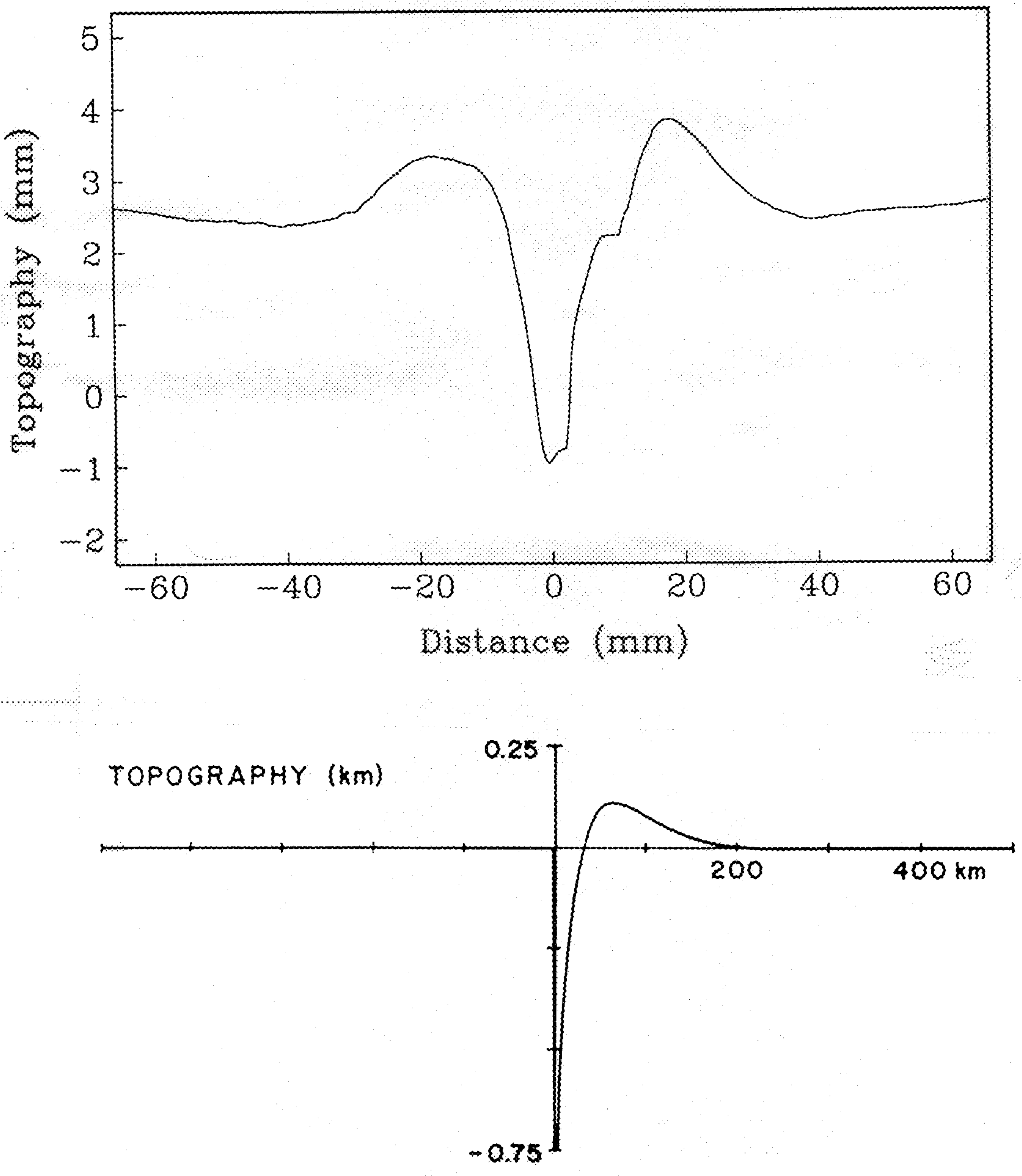


Figure 5. (a) Topography across a spreading center 2000 s after spreading was stopped. The central depression and flanking uplifts are the flexural response of the plate to the thermal bending moment at the nearly free edge (Distance = 0). (b) The wax topography shows qualitative agreement with a model for the topography caused by thermoelastic stress in the cooling oceanic lithosphere. The right half-plate has cooled for 20 Ma while the left-half plate is still hot (from Parmentier and Haxby, 1986). We plan to use these wax topography data and an appropriate wax model to estimate the thermal stress in the cooling wax plate.