

The Experiment

The experimental setup, as shown schematically in figure 1, consisted of a rectangular tray of dimensions 114x36x10 cm³ with stainless steel side walls and an aluminum bottom (Ragnarsson *et. al.*, 1996). It was filled to a height of 8 cm with Shellwax Callista158¹. The bottom was heated by a regulated circulating water bath to maintain a constant wax temperature of $80 \pm 3^\circ \text{C}$, above the $\sim 71^\circ \text{C}$ melting temperature of Callista158. To solidify the wax surface, air of temperature $\sim 8^\circ \text{C}$ was blown down on the wax from a wide ventilation duct. Two vertical anchor plates of 3 mm thickness were frozen into the wax and pulled apart with a micro-stepping motor which can be set to full spreading rates from 1 $\mu\text{m}/\text{sec}$ to 1 mm/sec, although only pulling rates between 20 and 70 $\mu\text{m}/\text{sec}$ were used for results described here. To avoid a buildup of solid wax at the ends of the tray, each wax plate was melted off in overheated sections that were divided by 6 cm high stainless steel plates, preventing thermal cross-talk with the rest of the tray. Heaters along the side of the tray were used to prevent edge interactions from propagating into the center of the tray. The solid layer was illuminated from below by two fluorescent lamps placed into the molten wax along the side walls of the tray while the rift was imaged from above with a CCD camera connected to a digital image processing system and a high resolution VCR. Due to the light diffusing quality of the solidified wax, the crust appears white where the wax is thinner and black where it is thicker or not present.

¹ Callista158 was chosen for its ability to produce transform faults and stable orthogonal spreading. This capacity may be the result of its relatively sharp liquid-solid phase transition and the brittleness of its solid state.

The experiment was run by first turning off the cooling air and allowing all of the wax to melt. With the anchor plates positioned about 6 centimeters apart, the cooling air was turned on and a solid layer of wax approximately 3 mm thick was allowed to form on the surface of the wax. A strait rift was initiated by cutting the wax with a sharp knife, parallel to the anchor plates. The micro-stepping motor was then turned on and the plates were pulled apart with a constant velocity. The solidifying crust diverged laterally, keeping the position of the rift reasonably constant, within the field of view of the imaging CCD camera. During the run, digital images were acquired at regular intervals and continuous VCR recording was performed.

The temperature difference between the liquid wax below the solid crust and the cooling air above was kept within the same range ($\Delta T \sim 65^\circ \pm 5$ C for all runs of the experiment). A first order affect was noted as the spreading rate parameter was varied. For pulling speeds less than 25 $\mu\text{m}/\text{sec}$ (spreading rate < 50 $\mu\text{m}/\text{sec}$) the rift remained strictly orthogonal to the direction of spreading with minimal disturbances in the form of small and short lived transform faults or OSCs. An axial valley was present and reached depths of 2 to 5 mm below the level of the wax plates. Between spreading rates of 25 and 45 $\mu\text{m}/\text{sec}$ the rift behaved in a qualitatively different way. The rift axis remained level with the wax crust being created. OSCs and microplates dominated the morphology of the ridge. Non-orthogonally oriented sections of the ridge developed when the spreading ridge reconnected around microplates. These same quasi-stable sections were the sites of the formation of new microplates. Transform faults observed in this regime had small offsets and often were converted to OSCs. At higher spreading rates, above 45 $\mu\text{m}/\text{sec}$ an

axial topographic bulge of about 2 mm was present. A stable rift-transform geometry was observed, with all spreading occurring on orthogonally oriented ridge segments divided by transform faults offset by about 3 mm. It is important to note that there is a trade-off in parameter space between cooling efficiency and spreading rate.

This study will focus on the OSC and microplate regime, with a pulling rate (half spreading rate) of 35 $\mu\text{m}/\text{sec}$. Data is in the form of digital image time series and video recordings. We will ask the following questions about the wax experiment and then discuss our answers in terms of the model as an analogy to the East Pacific Rise (EPR), where many of the Earth's OSCs and microplates are found.

- i. How and why do OSCs form and become rotating microplates?
- ii. How does a microplate evolve with time? How is this related to its morphology?
- iii. How and why do microplates 'die' and move away from the rift?

We will first consider the second of these questions and then examine the first and last together, since they seem to be related. The choice of terminology for describing morphological features in the wax experiment follows from the literature on sea-floor spreading, both anticipating and aiding in the drawing of analogies between the two. For example, the wax plates that are formed at a spreading ridge and thicken as they move away from it (analogous to the oceanic lithosphere) will be referred to as the wax lithosphere, or simply the lithosphere.

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