**TEACHING NOTES AND TIPS**

**I. INTRODUCTION**

**The RCL sedimentary module is planned as a 3-part sequence:**

(1) The very short powerpoint “Rupturing Continental Lithosphere: Introduction (from Dorsey 2013)” is the starting point\*. It will give students a preview of the scientific goals and findings of the RCL Initiative and a context for their study of the role of sediments in the evolution of rifts.

(2) The lab exercise (“Bathymetry of rifted margins” lab) is designed as the first activity in the “Rupturing Continental Lithosphere” mini-lesson sequence\*. In this exercise, each student investigates the geometry of the Red Sea (a cratonic rift) and of the Gulf of California (an orogenic rift) by creating a contoured bathymetric map and one or more topographic profiles of each area using GeoMapApp. Each student examines the geometry of the Gulf of California in detail by constructing a series of topographic profiles across successive extensional basins, compiling the profiles on a single graph, and calculating average depth for each profile using Excel.

**(3) The final part, a powerpoint lecture and accompanying problem set (“Role of Sedimentation in Rifting”),** asks students to investigate the role of isostasy and the role of sedimentation in the development of rifted margins. Students will use their observations of Gulf of California bathymetry to estimate the depth of basin fill. Students will examine the relationship between sedimentation in extensional basins and thinning of crust and mantle lithosphere.

\* The other modules in the Rupturing Continental Lithosphere mini-lesson series are also designed to follow both the “RCL Introduction” powerpoint lecture and the “bathymetry of rifted margins” lab investigation.

**III. ROLE OF SEDIMENTATION IN RIFTING ACTIVITY (POWERPOINT LECTURE AND PROBLEM SET)**

**Prerequisite knowledge (students)**

 Familiarity with the main features of rift basins and rifted margins (transition between continental crust and oceanic crust, nature and geometry of faults, factors that may influence rift basin processes and morphology).

**Description of activity**

 The “Role of Sedimentation in Rifting” activity is designed to follow the “Bathymetry of a Rifted Margins” lab. Students will use water depth measurements from their bathymetry spreadsheets for one of the calculations. If students did not do the bathymetric profiles exercise, they could use GoogleEarth to find the maximum depth of the Alarcon basin before starting this exercise.

The “Role of Sedimentation in Rifting” activity consists of a powerpoint lecture with an embedded set of problems for students to solve. The problems are worked out, and the answers are included on slides in the powerpoint presentation. (Answer slides have a gray background in contrast to the blue background used for other slides.) The activity could be done either by the class as a whole, or by groups of students who work together on the problems and compare results before the answer slide is shown.

The sequence of isostasy problems progresses from estimating the thickness of the lithosphere, to investigating the isostatic effect of filling a basin with water or with sediment (the Alarcon Basin is used as an example), to examining how crustal thinning affects the depth of sedimentary basins. In the final part of the exercise, students are given a cross-section of the Upper Delfin Basin, and are asked to calculate what rifting parameters (starting thickness of crust, starting thickness of mantle lithosphere, density of sediment fill) could produce the observed crustal structure. The first three experiments in this final section use different possible values for the starting thickness of mantle lithosphere; this value is important but is not well known. In the fourth experiment, students will use a new (higher) value for the average density of sediments filling the basin; average density would increase with increasing thickness of sediments. Students will need copies of the Upper Delfin basin cross-section by Martin-Barajas, in press, (there is a copy in the powerpoint lecture) to determine thickness values to use in the final part of the exercise.

**Options for more advanced work:**

The file “Problem 4.1, 4.2, 4.3, 4.4 calculations.xlsx” is the excel spreadsheet that we (Dorsey and Cashman) used to solve for parameters that could produce the crustal structure of the Upper Delfin basin. If, instead of (or in addition to) the 4 experimental conditions suggested in the problems, students were given the more open-ended assignment of finding one or more sets of initial thicknesses and densities that could produce the observed structure of the basin, this spreadsheet provides a way for the instructor to check many different possible answers easily.

 Two published articles are suggested for possible student follow-up reading and reflection.

**Tips for instructor**

1) Make this a fully in-class exercise, so students interact with the instructor and with each other. Follow through in class to make sure students grasp the key principles: role of isostasy in basin development; sediments are not just a passive record

 of basin history but exert direct control on rift processes and crustal composition.

2) Encourage students to identify the assumptions made and to identify the next step in problem-solving.

3) Leave time at the end of class to look at the “big picture”. Discuss the consequences of rapid deposition, burial, heating and metamorphism of sediments in the evolution of new crust in developing rift basins. Slides 45-48 in the powerpoint presentation show evidence for the thickness and character of newly-formed crust based on seismic profiles. Articles by Dorsey and Umhoefer, 2012, and by Dorsey et al, 2013, provide great additional information and discussion of ideas introduced in this activity.

4) Suggestions for further reading:

Dorsey, R.J., and Umhoefer, P.J., 2012, Influence of sediment input and plate-motion obliquity on basin development along an active oblique-divergent plate boundary: Gulf of California and Salton Trough: *in* C. Busby and A. Azor, *Ed.s,* Tectonics of Sedimentary Basins: Recent Advances, Blackwell Publishing, doi: 10.1002/9781444347166.ch10.

Dorsey, R.J., P.J. Umhoefer, M.E. Oskin, and R. Arrowsmith, 2013, Rupturing Continental Lithosphere in the Gulf of California and Salton Trough, GeoPRISMS Newsletter, 30, p.1-6.