Handout 2.1 Classroom Exercise (Optional Exercise)

Following Objective 2.3 or 2.4, the instructor should break the class up into teams of two or three and have each team consider the question: "Why do earthquakes occur in **intraplate regions**, far away from plate boundaries?" At this point the instructor will have emphasized that most earthquakes are explained by interactions between plates (plate boundary earthquakes) and this is where more than 90% of earthquakes occur. And, importantly, the occurrence of plate boundary earthquakes is well understood. The instructor should give each team about 5 minutes to discuss this issue and then ask the teams to explain their ideas. It is not likely that students, even with scientific backgrounds, will beware of the latest thoughts ideas on this subject. **The primary purpose of this exercise is to foster interactions of the students, pique their interest, and develop an appreciation for the relative uncertainty involved with intraplate earthquakes (and therefore, our difficulty in assessing seismic risks in these regions).**

Following each team's presentation of ideas, the instructor should present a summary of the latest scientific thoughts about this issue as shown below, but it should be emphasized that the ideas are still largely speculative.

I. Possible Reasons for Intraplate Earthquakes in the U.S.

A. An irrefutable explanation of the mechanisms that cause intraplate earthquakes has not yet been presented; however, there are some possibilities that have been presented for intraplate events in the US:

B. Ancient "rifts" – very old fractures in crust related to previous episodes of continental spreading. Rifts are created as a continent breaks apart in tension due to dissimilar rates of spreading beneath the crust. Rifts can be found in the interior portions of continental plates. Earthquakes in New Madrid and Charleston are probably associated with faults from rift zones created due to spreading associated with what is now the Atlantic Ocean (i.e., Iapetan Ocean preceded Atlantic).

1. New Madrid and St. Lawerence Valley: Earthquakes here are associated with faults initially formed during the rifting of the proto-North American continent (Laurasia) during the formation of an ancient ocean called Iapetus, approximately 700 million years ago.

2. Charleston, SC: probably associated with faults that formed in the mid-Mesozoic Era (Mesozoic faulting 100-200 mill. yrs. ago) during rifting of Pangaea accompanying the formation of the modern Atlantic Ocean.

C. "Weak spots" – heating up and thinning of lower crust such that the brittle-ductile transition (molten rock-crust boundary) migrates to a higher level. Because the overlying crust becomes thinner during this process, stresses become more concentrated in the crust.

D. Thermal destabilization - sinking of mafic rock mass (rock mass of heavy minerals) into underlying molten rock. As mafic block sinks, stresses are concentrated in overlying crust. Process thought to be due to rock density anomalies combined with thermal processes.

E. Other localized mechanisms. Mississippi Embayment (weight of sediments caused fracture that generated New Madrid earthquakes?)

Following this exercise, emphasize the point that there is significant **uncertainty,** even among the seismological, scientific, and engineering communities, about the specific causes of earthquakes in intraplate regions, such as the central and eastern U.S. This greater uncertainty presents major challenges in terms of assessing earthquake risks in these regions and determining appropriate levels of seismic protection for buildings and lifelines, etc. The instructor also may elect to pose additional discussion questions such as: "In cases of great uncertainty, coupled with a demonstrated large earthquake potential (i.e., the eastern U.S.), how should limited resources be best allocated to prevent earthquake disasters?" and "What unique challenges are presented in terms of developing mitigation plans and conducting preparedness activities in these regions?" These questions will offer a flavor of issues, such as the increased importance of prioritization tools (such as earthquake hazard studies that quantify relative risks) to optimize resources in regions where uncertainties are larger, to be discussed in the remainder of the course.