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Earthquake models used in class: What about their weaknesses?

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A great variety of models is available to illustrate how earthquakes work and the physical principles involved in them, but not many contributions are known to the author that analyse not only the successes, but also the limitations and even the pitfalls of each model. Taking into consideration the fact that it is not only important to know what a model actually reproduces well but also what it does not reproduce accurately, in order to avoid "taking the model for just and scale reduction or translation of what happens in nature". The goal of the workshop on this subject developed by the author is to make these failures visible and use them to enhance learning and prevent the introduction of mistakes and misconceptions.

The workshop involves the use, questioning and interpretation of several common earthquake-related models that aim in helping understanding the following subjects: Accumulation and release of elastic energy, ground displacements, effects of water and fluid pressure in the behavior of materials, movement of particles, wave generation and transmission, waves and buildings, seismic-resistant building techniques. The workshop begins with a demonstration -given by the teacher- of what the participants are expected to do later on, when they have to work in groups. Each group is then given a model to analyze, starting with "just looking at how it works" and, afterwards, the group discusses what the model is supposed to be modeling and how that relates to practical and theoretical questions in the "real earthquake world". When the group assumes having finished this task the teacher discusses with them their conclusions and introduces several key questions to arise the search for limitations and pitfalls hidden in the model under investigation. The group repeats the experience with the same model, trying now to find out what the model is not doing properly and the reasons for this. Once they have finished with this task, several minutes are devoted to the discussions of how these limitations and pitfalls of the model can be incorporated to the class, giving them a "constructive" meaning, helping avoiding the introduction of misconceptions. When each group has finished the assigned task the class starts working as a whole, listening to the experiences of the other groups that summarize their findings and proposals. If the necessary time is available, a final review of the physics and geology of each of the processes and events modeled in the workshop can be addressed using abridged but accurate information.

The following models are presented and discussed: 1. ***A trembling toy-earth*** is used to show the accumulation of energy in a spring and its liberation as vibration. 2. ***Springs that deform*** when pulled or pushed illustrate that deformation follows Hook´s law. 3. ***Pulling a weight*** refers to the need to overcome frictional forces to start moving on a contact surface (horizontal or tilted). 4. ***Travelling energy*** shows how S and P waves are modeled with ropes or strings but also with a line of Christmas tree balls or even a line of students. 5. ***Waves in the pool may be misleading*** analyzes what happens when a pebble is thrown into the water. 6 ***The dog is shaking the tablecloth!*** involves the discussion of how surface waves work. 7. ***A xylophone of buildings*** illustrates the relationships between the frequency of the seismic wave and height and amplitude of vibration of each building. 8. ***Exploring seismic-proof building strategies*** addresses different engineering technics used to reduce seismic

hazards. 9. ***When the ground flows*** explores the stability of soils when a transient peak in fluid pressure is induced by seismic waves. Figure1 illustrates several of the models used in the workshop.

Figure 1: Several of the models discussed in the workshop.