**EDUCATIONAL EXPERIENCE IN NUMERICAL MODELING OF IMPACT CRATERING.** B. A. Ivanov, Institute for Dynamics of Geospheres, Russian Academy of Sciences., Leninsky prospect., 38-6, Moscow, 119334, Russia (baivanov@online.ru, ivanov@lpl.arizona.edu).

**Introduction:** The growing capability of the impact crater numerical modeling makes actual questions how to attract young students to the research and how to educate students specialized in general geology and geophysics. An experience in this direction has been accumulated in September 2002 during the ESF IMPACT Short Course "Numerical Modeling of Impact Crater Formation ".

**Scope:** The goal of the short course was to introduce basics of the numerical modeling techniques to non-professionals. "Non-professional" in this context means that the course was oriented to students and post-docs without a special background in computer science, shock wave physics and rock mechanics. However, most of students have an experience in impact crater related researches. Hence, all of them was highly motivated by their previous education and current research activity.

**Attendance**: 10 students from 6 European countries attended the short course (Germany - 3, France -2, Estonia - 2, Spain - 1, the Netherland -1, Finland -1). The general information about the ESF IMPACT program is available at http://www.esf.org WEB site.

**Support and organization:** The living and housing expenses have been covered by the ESF IMPACT program. The lecture room and the computer class have been offered by Vienna University (Prof. C. Koeberl was an excellent course manager). The computer class gives an opportunity for which student to work with a personal networked computer (PC under Windows 2000). The main lecturer (B. Ivanov) has used a beamer as for lecturing and for the demonstration of the practical work at the large screen. It was very important during the installation of the software and practice - students has seen simultaneously the output of each operation at their personal terminals and at the big ("master") screen repeated the "master" computer of the lecturer.

**Short course program** includes 5 main lectures and 5 practical lessons (totally 5 days with lectures before lunch and a practice in the computer class after lunch). Lecture topics include:

1. "What and how can be modeled for impact cratering. Shock waves, excavation and modification of a transient cavity".
2. "SALE hydrocode, general logic, input file, outputs"
3. "Equation of state (EOS). Ideal gas, Murnaghan, Mie-Gruneisen, ANEOS"
4. "Rock strength. Basics (elasticity, placticity, fragmentation/damage, dry friction). Implementation into hydrocodes. Acoustic fluidization"
5. "Examples of numerical modeling implementation in a geoscience research projects: Puchezh-Katunki deep drill core analysis, trigger volcanism, penetration of the Europa ice crust".

Practice includes software (Fortran compiler and a hydrocode) installation, the code compiling with a graphic package PGPLOT [1].

**Numerical code** used for the short course is based on the SALE code [2], enhanced with options to compute multimaterial problems (2 materials plus vacuum) in the Eulerian mode with a simplified description of rock's elastic-plastic behavior. The code with a working name "SALEB" is armored with 2 kinds of EOS's: Tillotson's EOS [3] with an addition for the real temperature estimates [4], and tabulated ANEOS [5] for several types of rocks.

Practice includes the solution of 3 problems: shock recovery container (calcite in the iron container), vertical crater-forming impact, oblique 2D (planar) impact. Students have been asked to compute several variants changing the input file parameters to get an impression about sensitivity of results. Naturally, only initial stages has been modeled during the class hours.

**Handouts** included a CD ROM with the source code and a set of publications relevant to the topic. In addition, each lecture, prepared in PowerPoint has been printed out as handouts.

**Conclusion.** The experience with the short course shows that it is possible to organize a "quick entry" to the topic in a relatively short time for highly motivated students. Post-course correspondence shows that at least 4 students continue to work with the code. It is early to say is the course enough to begin a real numerical research. However, one can hope that the course will help all students to understand better publications about numerical modeling.

**References:** [1] http://astro.caltech.edu/~tjp/pgplot/. [2] Amsden A. et al.. (1980). *Los Alamos National Laboratory Report LA-8095*, Los Alamos, NM, 101pp. [3] Tillotson J. H. (1962) *Gen. At. GA-3216*, 140 pp. [4] Ivanov B. A. et al. (2002) *GSA Spec. Pap. 356*, 587-594. [5] Thompson, S. L., Lauson, H. S. (1972) Sandia National Laboratory Report SC-RR-71 0714.