THE IMPACT OF NUMBERS.

N. A. Artemieva[1,2]. [1]Planetary Science Institute, Tucson. E-mail: artemeva@psi.edu. [2]Institute for Dynamics of Geospheres RAS, Moscow.

Introduction: Impact processes are rarely observed in situ (a few exceptions include Shoemaker-Levy 9 comet impact on Jupiter, an airburst of the Chelyabinsk meteoroid, formation of the Carancas crater). Hence, impact-related hypotheses are usually based on nonimpact analogs such as nuclear explosions, pyroclastic/melt flows generated by volcanic eruptions, shooting stars, etc. To become a theory the hypothesis has to be tested either in a laboratory experiment or in a numerical model. The latter has been widely used as an important tool in impact research since the early 1960s.

How it works: Numerical models are based on first principles and are complemented by specific equations describing material behavior under extreme impact conditions (such as high pressure and/or high temperature). Programs which solve these equations (and generate numbers) are traditionally called hydrocodes. To ensure reliability of results produced by numerical models, thorough verification, validation, and benchmarking of different codes are crucial. Ideally, dynamic simulations reveal how a particular object or phenomenon evolves in time and space. I will show how numbers generated by hydrocodes help us: 1) to understand formation of the K-Pg boundary layer and to quantify factors crucial for mass extinctions; 2) to produce tektites strewn fields on Earth; 3) to transfer meteorites from Mars and from the Moon; 4) to solve the Tunguska enigma. Some of these simulations confirm and quantify long-living hypotheses, while others jeopardize old-fashioned paradigms.

How it does not work: Computer simulations mimic the natural processes only to the extent of our knowledge of the physics that governs the process. If the model does not account for a specific process or misses an important parameter, the dynamic simulation fails. In this case hydrocodes produce accurate results, but our starting models are incomplete. Moreover, there is always the possibility that a new observation or a new experiment may conflict with well-tested models.

What's next? Smart impact hydrocodes running on modern powerful computers produce billions and billions of numbers in the blink of an eye. To sort them out and to generate new knowledge we have to work in close collaboration with geologists, geochemists, seismologists. It's not easy but there is no other way to succeed. Let's trust the first principles, but let's be skeptical to distinguish our best models from nature.