SEARCHING FOR NUMERICAL MODELS TO REPRODUCE TERRASES IN IMPACT CRATERS. B. A. Ivanov, Institute for Dynamics of Geospheres, RAS, 119334, Moscow, Russia, baivanov@idg.chph.ras.ru, boris_a_ivanov@mail.ru.

Introduction: The prominent feature of large impact craters is a set of terrasses at the inner crater slope – see a review by [1]. The presence of terrasses has been interpreted as circular or arc-like landslides along inclined faults, giving a possibility to estimate the pre-landslide crater shape [2]. The classic soil mechanics approach results in estimates of rock cohesion values [3, 4]. Available today numerical models poorly reproduce the origin of terraces in complex craters, mostly giving smooth crater profiles. It seems that partially the lack of terraces in models results form (1) low spatial resolution of numerical grids, and (2) relatively crude acoustic fluidization (AF) model [5], controlling the rock dry friction to reproduce the transient crater floor uplift. We start a small project attempting to improve available models.

It is relatively simple to reproduce the localization of rock deformations (“faults”) in a model where rock strength gradually decreases from a high initial value to a dry friction level typical for crashed (granular) rocks – see, e.g., fig. 6 in [6]. For a “static” model of a transient crater collapse deep faults have been modeled with a set of assumptions [7, 8]..

Strain-rate softening: In a complete model run (impact-transient cavity-final collapsed crater) the deep circular fault has been reproduced in [9]. The approach we plan to use in the current project has been previously described by Senft and Stewart [10]. They have tested the model where the dynamic friction in damaged tock is controlled with slip velocity and distance, originally proposed in strain-rate softening presentation of a block over block friction sliding [11, 12].

In our approach we have tested the simplified equation for strain-rate dependence of the friction coefficient, previously used in [13]:

$$f = 0.1 + \frac{0.5-0.1}{1+{e'}/{e''}} \qquad (1)$$

where e’ is the current strain rate in a cell and e’’ is the characteristic weakening strain rate.

We have experimented with constants in Eq. 1 (e’’ around 0.01) as well as with a set of assumptions about effects of the local accumulated plastic strain. However, no solid results could be presented so far.

Numerical modeling: We use the recent updated Puchezh-Katunki impact crater modeling [14] as a starting point. Details on equation of states, rock strength and AF models are listed in [14]. In some variants we change the double-layer target to a uniform granite target. The granite spherical projectile 2 km in diameter impacts the horizontal surface with the velocity of 16 km s^{-1}. In most model runs the resolution is 16 CPPR (cells-per-projectile-radius), and the cell size dx×dy=67×67m.

Transient craters in a target with and without the AF models are formed in a similar way. The usage of the strain-rate softening (1) gives a series of straight and curved faults with well expressed strain localization (Fig. 1). However, without the AF the crater floor do not uplifts, and a crater is modified with the wall slumping.

Simultaneous usage of the strain-rate weakening and AF models results in the anticipated final crater shape with the prominent central uplift, while a set of localized strain zones (”faults”) are still visible.

Conclusion: The relatively simple strain-rate weakening rule (1) allows us to simulate fault-like localization of rock deformations around the collapsed complex crater with the central uplift. These results look similar to previously published in [10]. Similarly to [10], variations in constants in (1) without an AF softening do not result in a proper transient crater floor uplift, typical for observed complex crater. Only using strain-rate softening in parallel with the standard AF model [14] we are able to get both the proper central uplift and the prominent strain localization around a final crater (Fig. 2). However, the direct reproduction of prominent terrasses at inner crater walls has not been obtained. The spatial resolution and limitations from the axial symmetry should be discussed.

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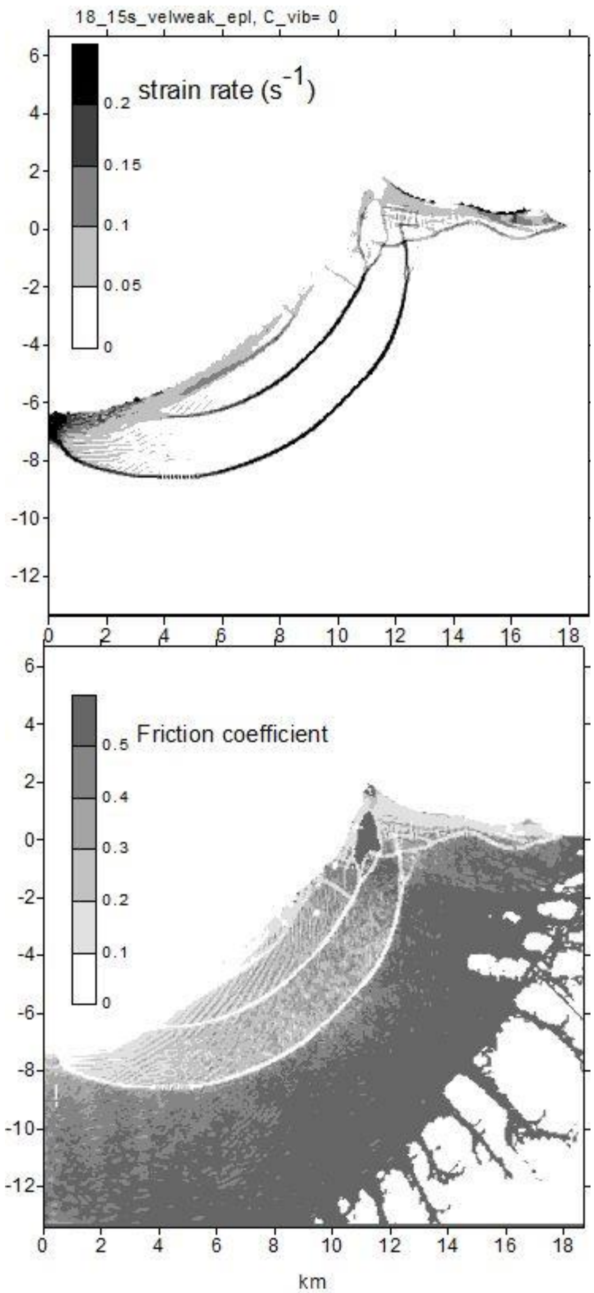

Fig.1. Transient cavity is formed in a target with the strain rate weakening (e''=0.01) but without the AF model.

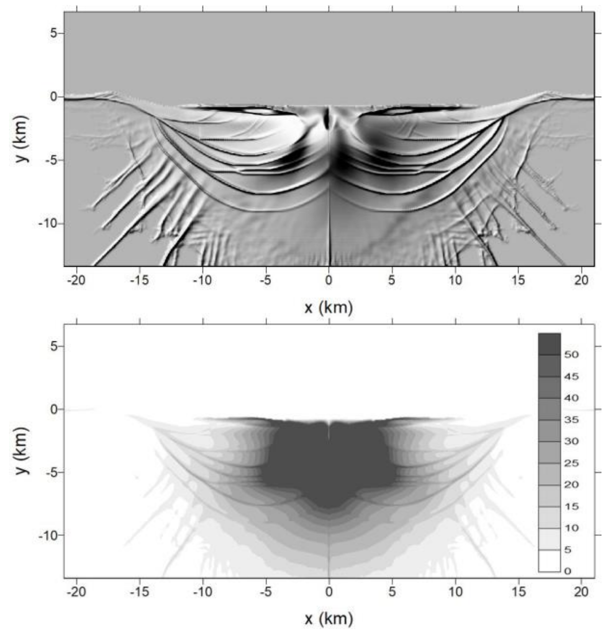

Fig. 2. The final complex crater with the central uplift formed in a target both with the AF and the strain-rate weakening (e''=0.01) models. The rock mechanical history is illustrated here as the accumulated plastic work in computational cells. The upper panel outlines the mechanical work localization as a shadowed relief. The lower panel presents rough estimate of the plastic heating assuming the heat capacity coefficient of 1 kJ/kg/K, giving the color scale in Kelvins. Note that the cell size is 67 m in this model run, and models like [12] could be used only at the post-processing sub-cell modeling.