SHIYLI DOME, KAZAKHSTAN: ORIGIN OF CENTRAL UPLIFT BY ELASTIC RESPONSE. S. A. Vishnevsky[1], [1]Inst. of Geology & Mineralogy, 3 Koptug pr., Novosibirsk-90, 630090, RUSSIA (svish@uiggm.nsc.ru).

Introduction: Origin of central uplifts in complex astroblemes is still debatable [1-3], and a whole rank of hypotheses was proposed in this connection. Among the most important among them there are the hypothesis of elastic response, still proposed by Baldwin [4] and the hypothesis of crater's gravity collapse under the action of acoustic dilution, which is developing by Melosh [1]. Shiyli Dome in Western Kazakhstan is a unique model object for the studies on the problem and for the development of the elastic response hypothesis. Well-known regional stratigraphy and geologic history as well as detailed geophysical and boring data provide favorable testing support for the conclusion.

Description: The Shiyli Dome is a heavily eroded impact structure represented by a central uplift of 1.2 km in diameter, with center co-ordinates 49^{o}10' N and 57^{o}51' E **(Figs. 1,2).** Its target is made up of dense

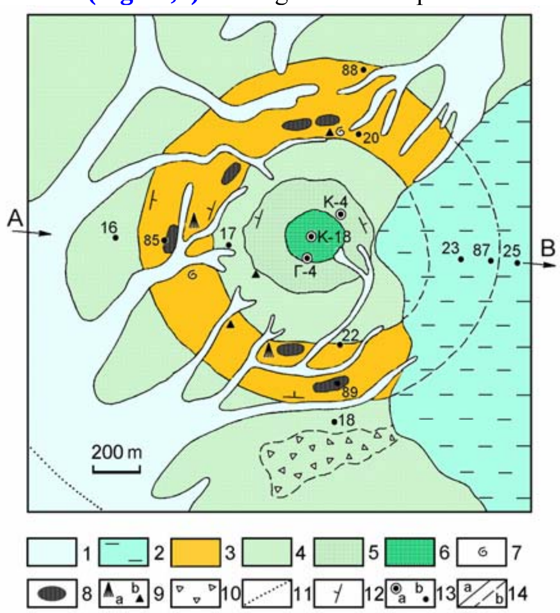

Fig. 1. Geologic map of the Shiyli Dome. Legend. *Sedimentary members:* 1 – Holocene, Q_{IV}; 2 – Pliocenian-Quarternary, N_2-Q_1; 3 – Paleocenian-Early Eocenian, Ꝑ_2-E_1; 4 – Campanian, K_2c; 5 – Santonian, K_2s; 6 – Albian, K_1alb; *Other units:* 7 – fauna; 8 – "gries" brecciation; 9 – shatter cones (a) and PDFs in quartz (b); 10 – brecciation zones; 11 – supposed limit of impact dislocations; 12 – strike and dipping of rocks; 13 – deep (a) and shallow (b) boring holes; 14 – observed (a) and supposed (b) geological boundaries.

Paleozoic basement (strongly dislocated Devonian+Carboniferous sequence) and loose Mesozoic+Cenozoic cover rocks (marine E_{1-2} clays, Ꝑ_2-E_1 sandstones+opoka, K_2c gypsum-bearing clays, K_2s clays, sands and sandstones, K_1alb clays+sands, K_1apt clays+sands, K_1h clays). We have to note that the members of the cover are very monotonous in thickness and have sub horizontal bedding. Earlier, the

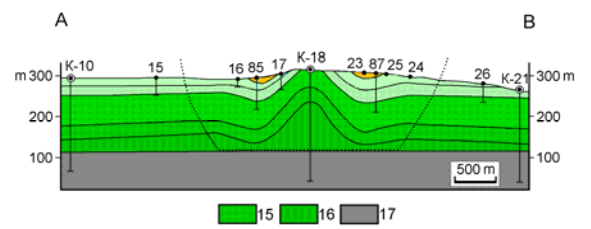

Fig. 2. Geologic cross-section of the Shiyli Dome from A to B (see Fig. 1). Legend. *Sedinebtary members:* 15 – Aptian, K_1apt; 16 – Hauterivian, K_1h; 17 – Paleozoic basement. Other units see on Fig. 1.

Dome was considered to be a salt diapir with oil and gas potential. Geophysical and boring prospecting found that there are no salt bodies in the basement but the Dome itself, surrounded by the ring of Paleogene rocks, is a non-root structure localized in the cover rocks only. For a long time, the Dome was considered as a non-explained geological phenomenon, until the macroscopic (shatter cones, "gries" breccias, shock slickensides) and microscopic (PDFs in quartz) evidences of weak shock metamorphism were found in its rocks [5]. Regional geologic history and impact cratering theory allow obtaining the useful reconstructions of the Shiyli impact event. Following to them, it was the marine impact event equal to explosive crater of ~3.2 km in diameter in energy equivalent. It took place in shallow, ~350 m deep, Eocene marine basin **(Fig. 3).** Upper horizons of the sedimentary cover, preserved both in the Dome and the ring subsidence around it, indicate that the underwater crater was either very shallow, <50 m in depth, or was absent at all. In the last case, one can suppose that except for the central uplift, the excavation was limited by centrifugal near-bottom turbid flows only. Following to presence of upper horizons of the sedimentary cover in the Dome, and the marine basin at the time of impact, the age of the Shiyli astrobleme is estimated to be from Early to Middle Eocene (39-53 Ma).

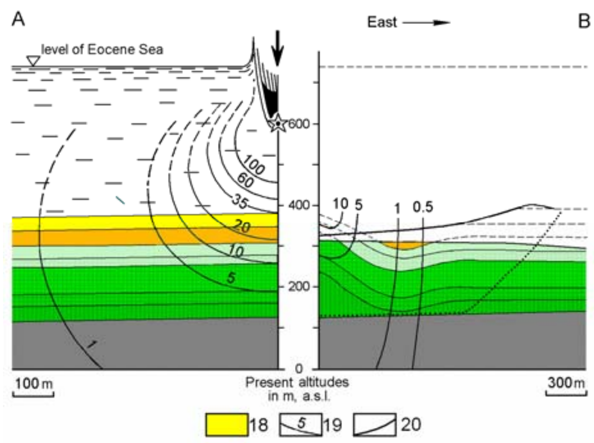

Fig. 3. Reconstruction of the Shiyli impact event (variant of shallow crater). A – pre-impact state of target; B – present state of astrobleme.
Legend: 18 – Low-Middle Eocenian, $E_{1\text{-}2}$; 19 – shock wave isobars, in GPa, in target (A) and their traces in present structure of Dome (B); 20 – supposed line of crater bottom. Other units see on Figs. 1 and 2.

Origin of the Shiyli central uplift: Following to geological data, the Shiyli Dome originated as a result of centripetal movement of the sedimentary cover rocks. The traces of the movement are evident both from the axial symmetry of the Dome **(Fig. 2)** and rock slickensides met in the boring cores. Layers of plastic Hauterivian clays in the base of the sedimentary cover were subjected to a maximal shift. Their thickness on the axis of the structure increased up to 120 m vs. 20-30 m in the frame of the Dome. Axial centripetal shift of Hoterivian clays provided compensating subsidence of uppermost layers with the origin of annual trough around the Dome **(Figs. 2,3).** However, more hard rocks of the target basement did not react on the excavation force. Since the Shiyli crater was either very shallow or was absent at all, its gravity collapse as a course of central uplift origin has to be ruled out. Hypothesis of elastic response is the only possible alternative here. Within the frames of this hypothesis and based upon cratering mechanics after [6], the uplift-forming centripetal shift of the disturbed ground is supposed to take place within any spherical segment under the center of the impact, where the shock and the release wave isobars were parallel to each other. Resulting ground motion within the segment was summarized from the particle velocity behind the shock front (centrifugal vector) and velocity of quasi-elastic expansion in release waves (centripetal vector). Similar ground motion takes place in deep seated underground explosions, where the influence of a free surface is ruled out. Schematic ground motion for the Shiyli impact event is shown on **Fig. 4.** Wide enough, ~120°, the spatial angle of the spherical segment where the centripetal ground motion took place, is attractive. Probably, it is due to relatively deep penetration of the projectile into the water part of the target.

Conclusion: The example of the Shiyli Dome shows that the elastic response is one of the real causes for the origin of central uplifts in terrestrial impact structures, and it should not be ignored. In this aspect, the Shiyli is interesting model object for testing the hypothesis of elastic response. One can add also, that there is another one impact structure - the Upheaval Dome – which is very similar to Shiyli in geological aspect, and for which authors [7] also suppose similar to our mechanism of the origin of the central uplift.

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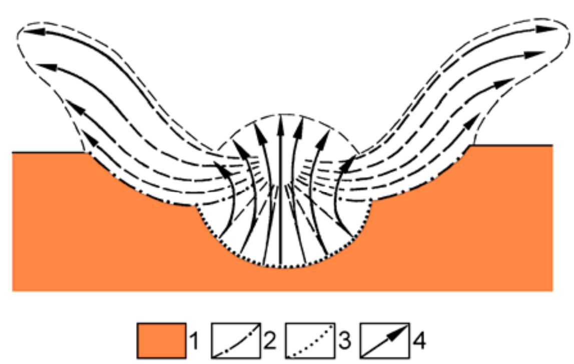

Fig. 4. Schematic ground motion at the Shiyli impact event, with the origin of central uplift by elastic response of target rocks. Legend: 1 – target rocks; 2 – limit of lateral centrifugal flow; 3 – limint of any spherical segment in compression zone of target, where shock wave and rarefaction wave isobars were parallel to each other; 4 – trajectories of ground motion.