Impact features on Venus: Modeling craters and splotches

Boris Ivanov

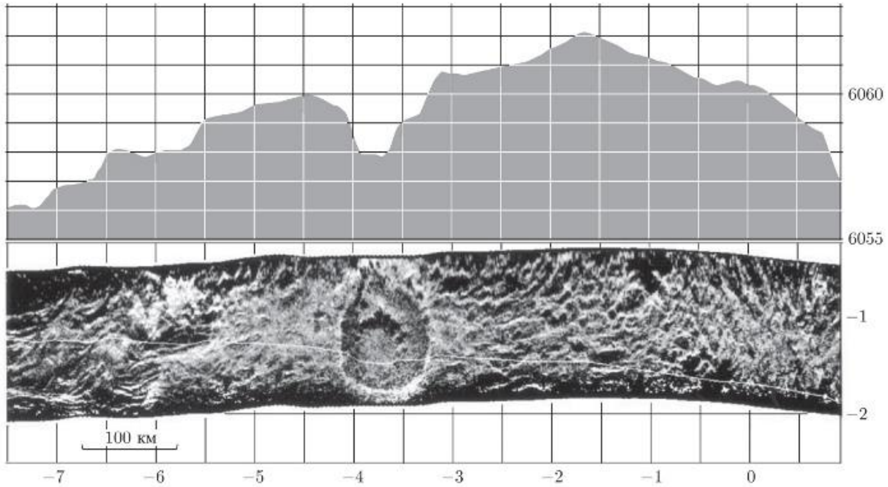
Institute of Geosphere Dynamic
Russian Academy of Sciences

baivanov@idg.chph.ras.ru
boris_a_ivanov@online.ru

Our team has discovered first impact craters under the thick Venusian atmosphere with radar images during the **Venera 15/16** mission in 1983-1985. Later **Magellan radar images** of a better quality allowed us to count all impact craters and to find amazing features, splotches, resulted most probably from “airbursts” - total explosive disruption in flight of small celestial bodies. Splotches could have a central feature (possibly caused by terminal impacts of fragments), or could be diffusive patches of increased (bright) or decreased (dark) areas of changed radar reflectivity.

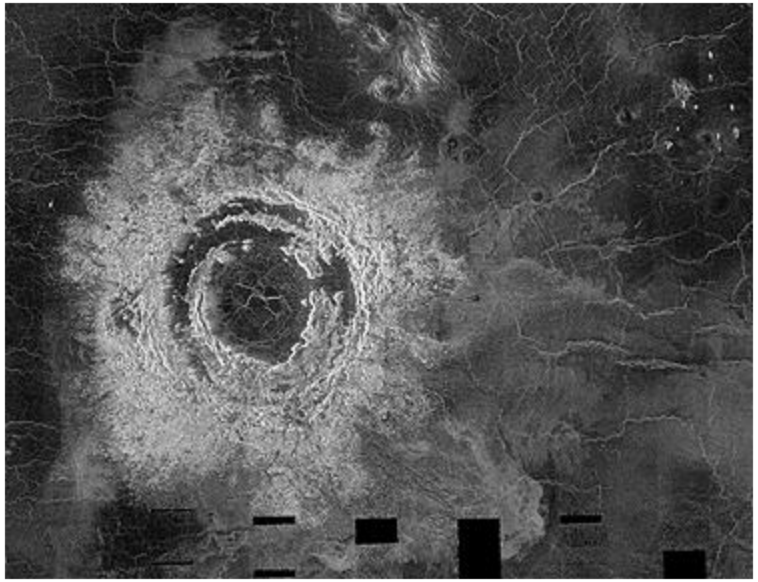
Orbital radar imaging of Venus

1983-1985.
Venera 15/16, ~2 km/pix



Cleopatra impact crater, ~100 km diameter

1989-1994 гг.
Magellan, 75 m/pix

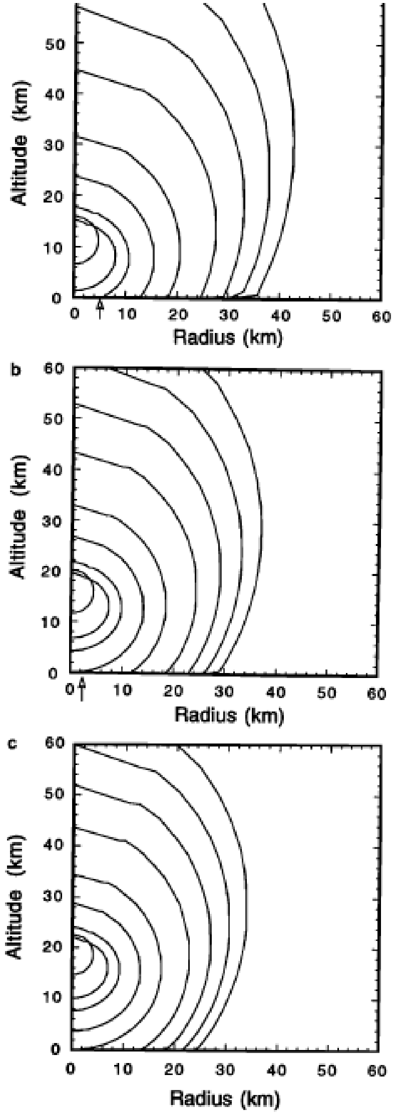


Magellan radar image of Mona Lisa impact crater, Venus. This 86 km diameter multi-ring crater is located at 25.55N,25.1E.

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 97, NO. E6, PAGES 10,243–10,255, JUNE 25, 1992

Airburst Origin of Dark Shadows on Venus

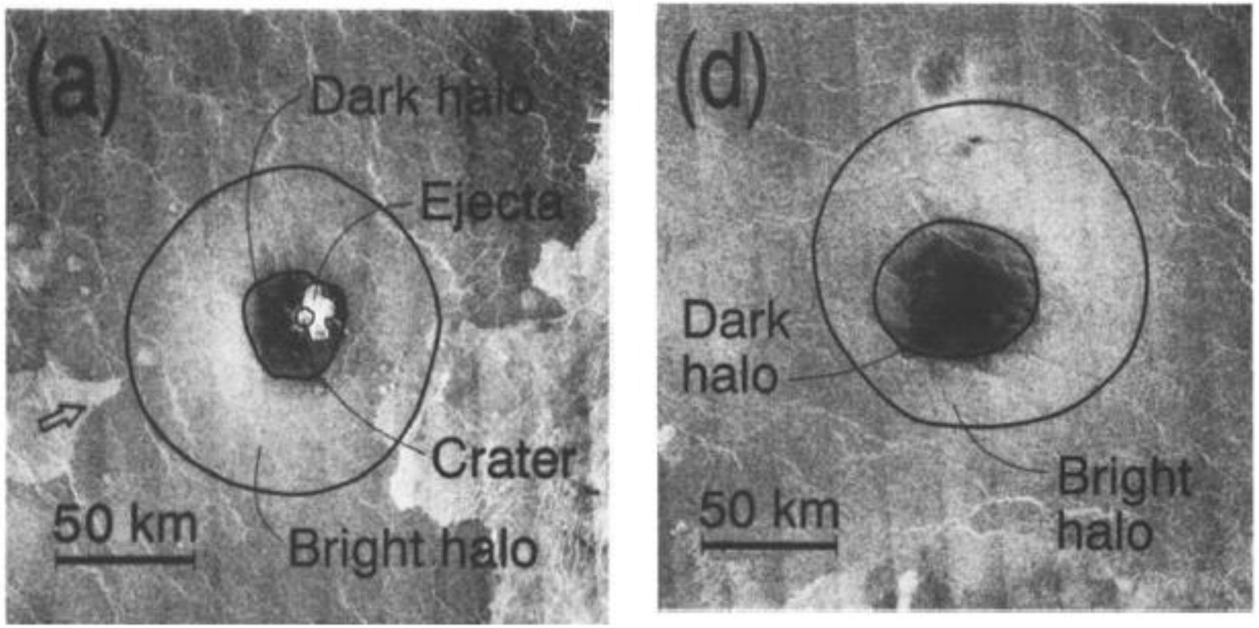
KEVIN J. ZAHNLE



JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 100, NO. E11, PAGES 23,329–23,348, NOVEMBER 25, 1995

Atmospheric effects on cratering on Venus

T. Takata [1] and T. J. Ahrens



pressure of Figure 9. In this case, the dynamic pressure of 1 MPa can induce saltation of boulders up to the order of 1 m in size. Moreover, rocks of less than 10 cm in size can be saltated within most of the area of the supersonic region. Particles of several millimeters in the

Impact craters and crater-less "albedo" patches - splotches

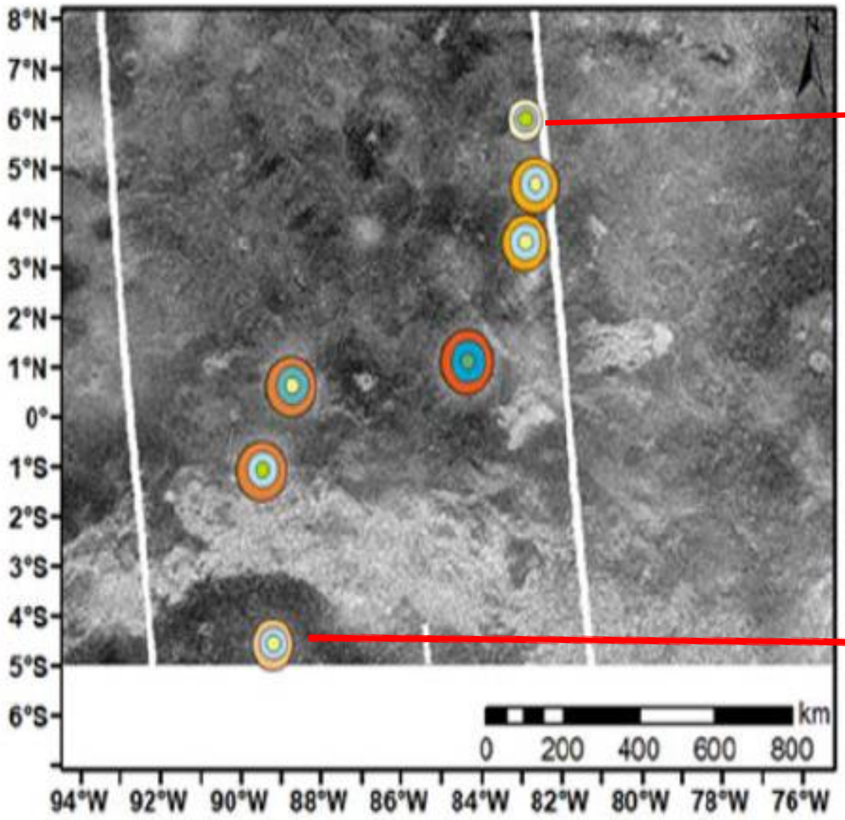
THE TWELFTH MOSCOW SOLAR SYSTEM SYMPOSIUM 2021

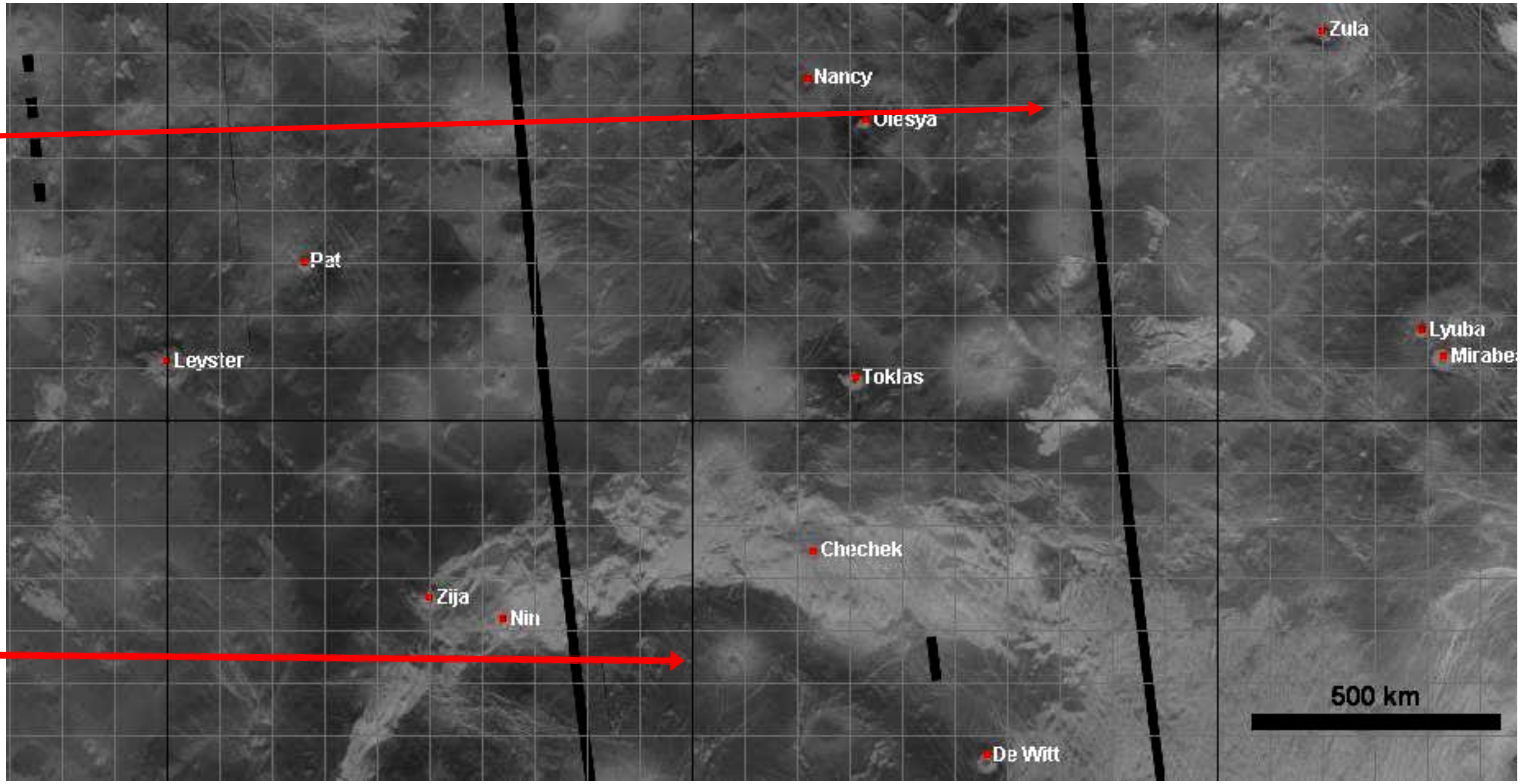
12MS3-VN-02
ORAL

ANALYSIS OF MULTIPLE IMPACT "SPLOTCHES" IN HINEMOA PLANITIA, NW AND W OF PHOEBE REGIO

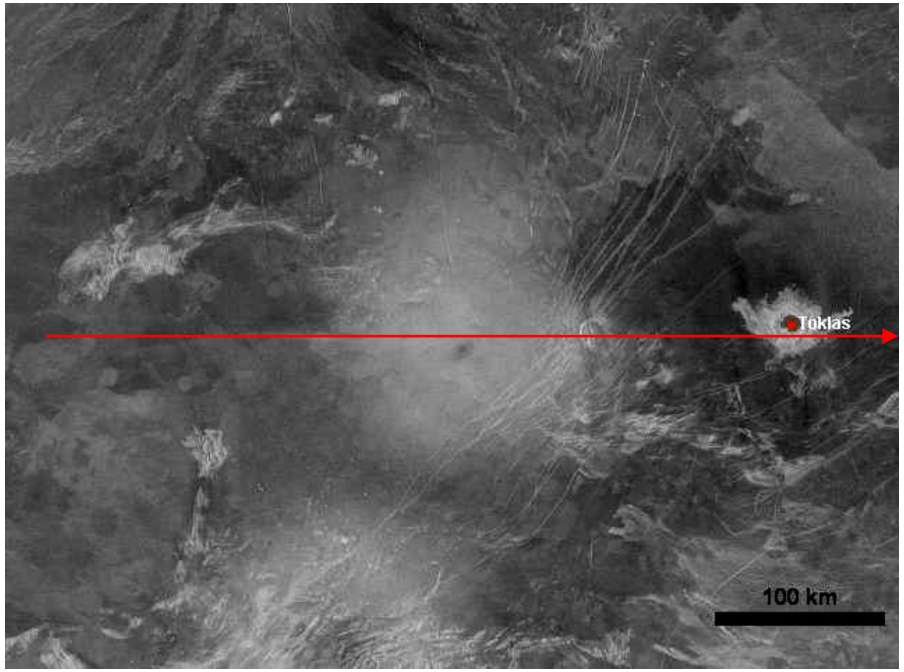
E.G. Antropova [1], C.H.G. Braga [1], R.E. Ernst [1,2], K.L. Buchan [3], H. El Bilali [2], J.W. Head [4]

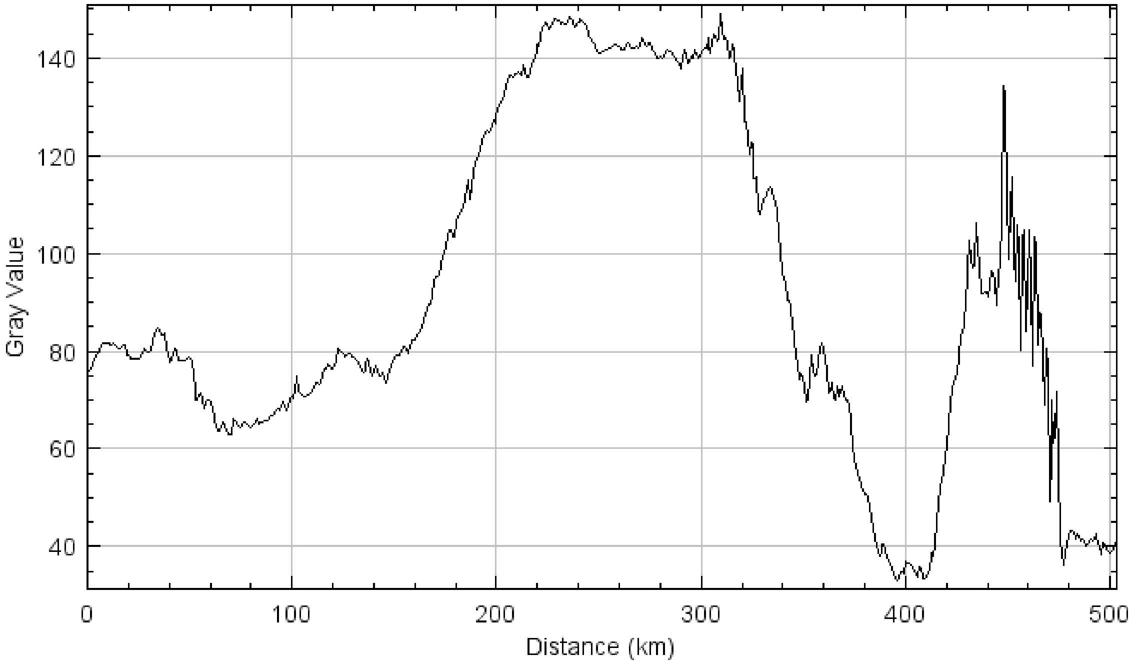
The authors suggested that 7 splotches were formed due to the destruction in the atmosphere of a single body, the fragments of which exploded above the surface and the air shock wave formed light spots with a diameter of 80 - 180 km. We model explosions in air to estimate the blast parameters in area of 50 to 100 km width.

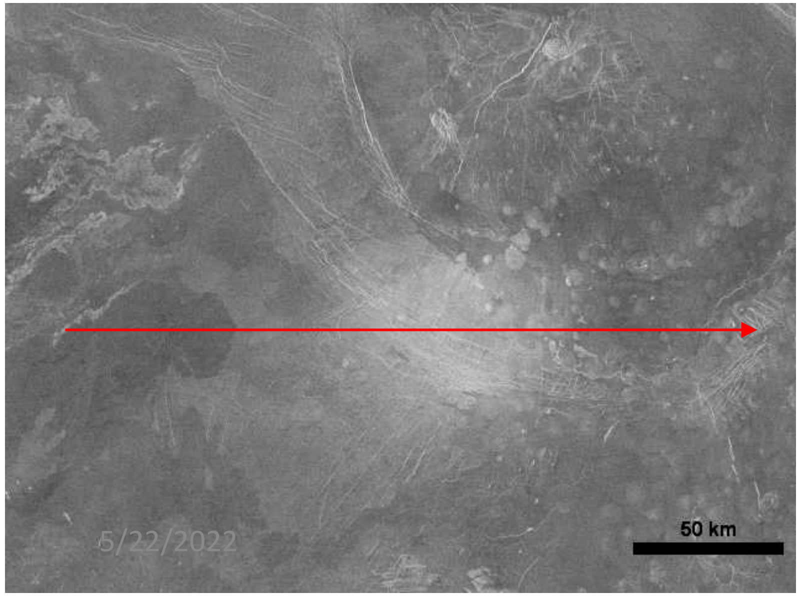


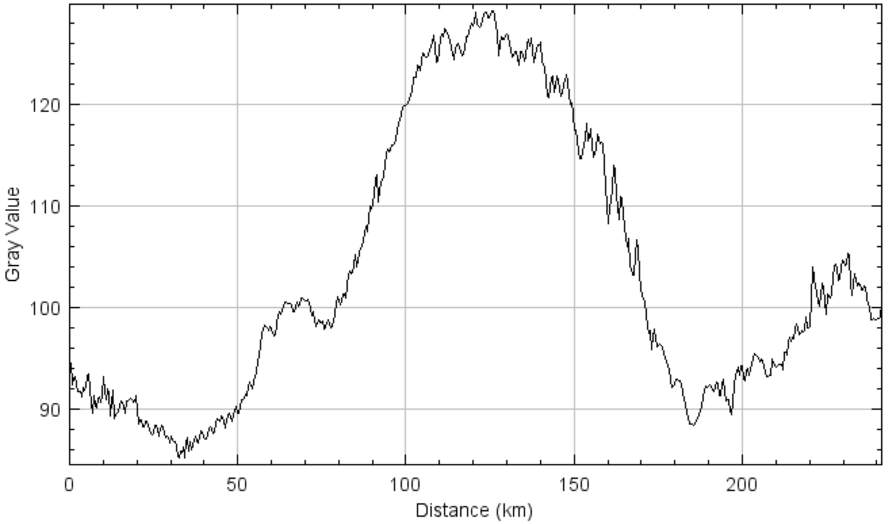


«Splotches» processed with JMars/Venus



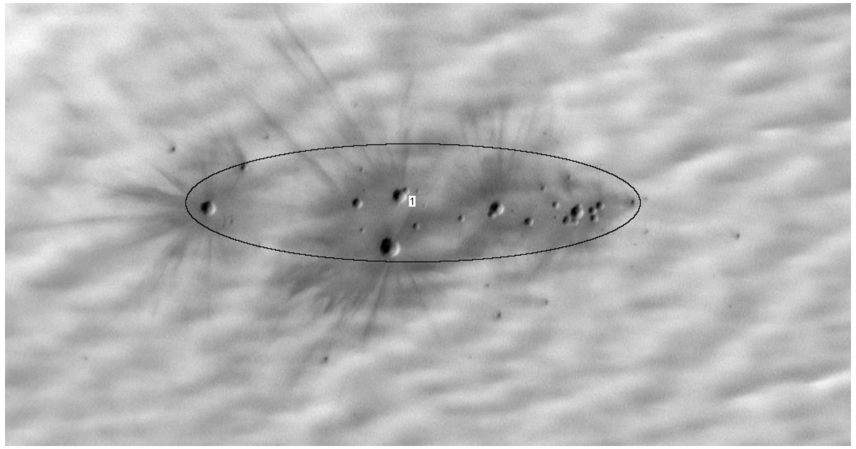


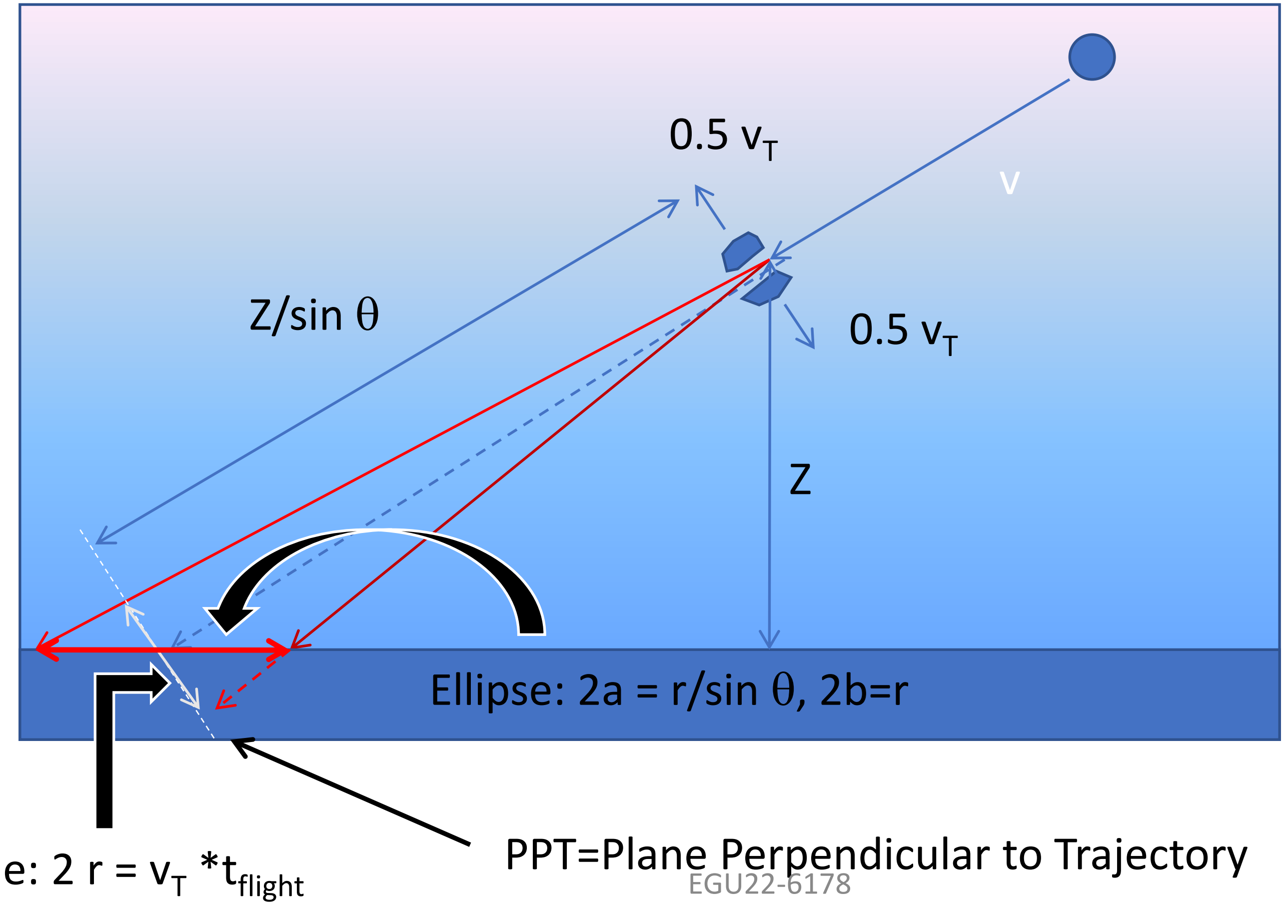




Atmospheric breakup

Passey&Melosh, 1980, Icarus *42* (2), 211-233





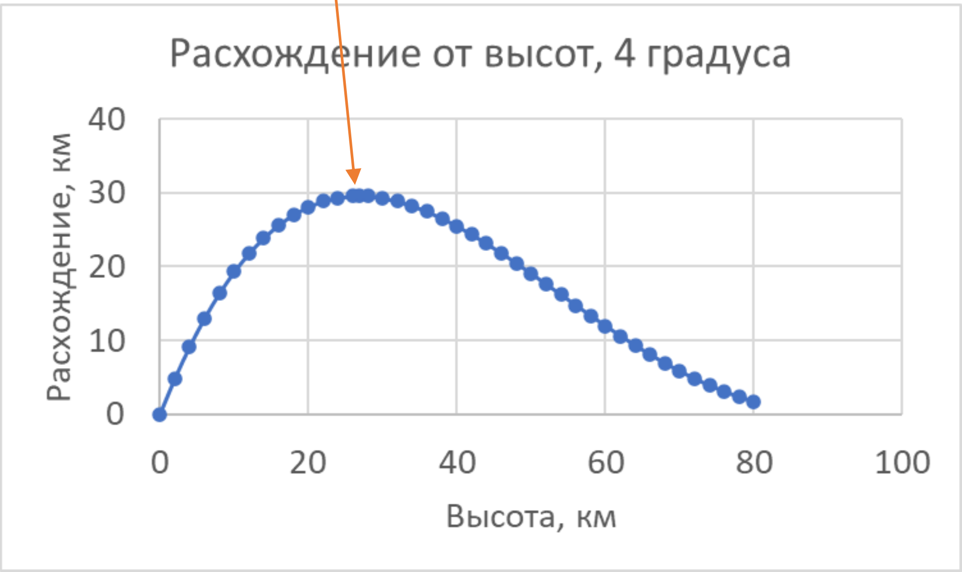
PSP_09185_1770
Ellipse 137x37 m
Apparent angle ~15°

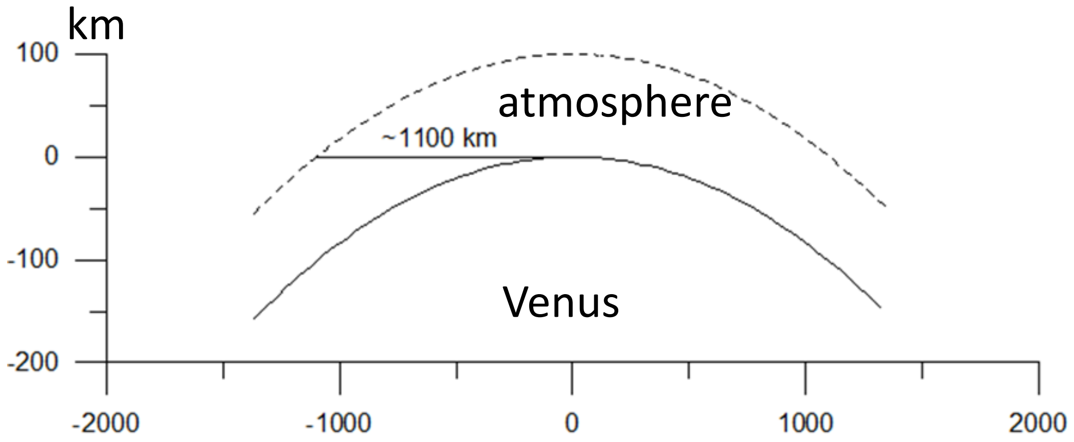
$$2r = \frac{v_T}{v \sin\theta} Z$$

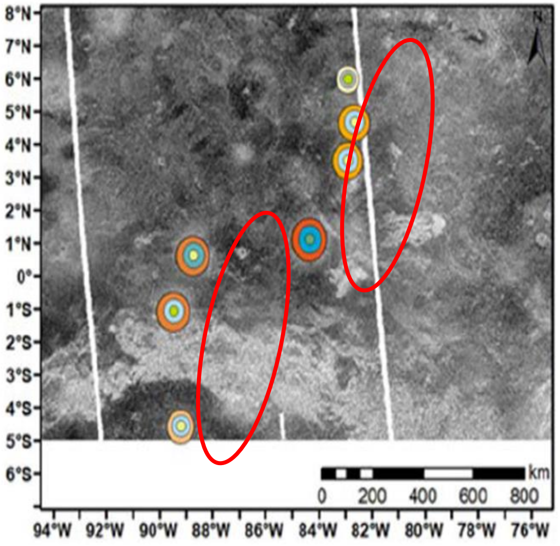
The divergence of debris in the atmosphere of Venus is maximum during destruction at an altitude of ~26.8 km

For a flat atmosphere, the path length is equivalent to an entry angle of about 4°

For a meteoroid density of 2 g/cm^3, the maximum divergence (the small axis of the scattering ellipse does not exceed 30 km







km The boldest assumption is the entry into the atmosphere of two bodies. Then bound ellipses of the clusters are estimated as 670x160_km, which corresponds to the entry angle of ~14°. But the lateral divergence of ~150 km is **five times greater than the maximum**.

We have to assume that the parent body was destroyed even before entering the atmosphere.

Illustrative computer modeling based on the classic Point explosion in an exponential atmosphere (Kompaneets, 1960)

$$\tau = \nu \, (\varrho_c \Delta^5 / E)^{1/2}$$

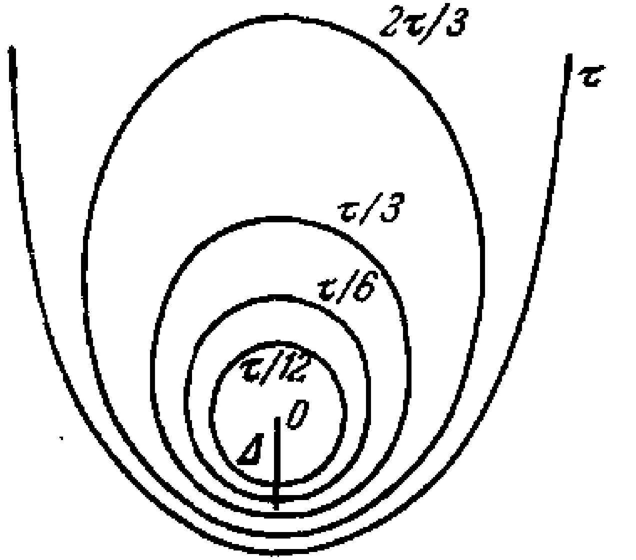


Рис. 12.21. Разрез поверхно-

Finite time for the "atmosphere breakthrough"

ν ~ 24 for γ =1.2

Δ = h_0 ~ 15 km

E ~ 10^{22} J

τ ~ 60 s

ρ_a ~ 64 kg/m3

A POINT EXPLOSION IN AN INHOMOGENEOUS ATMOSPHERE

A. S. Kompaneets

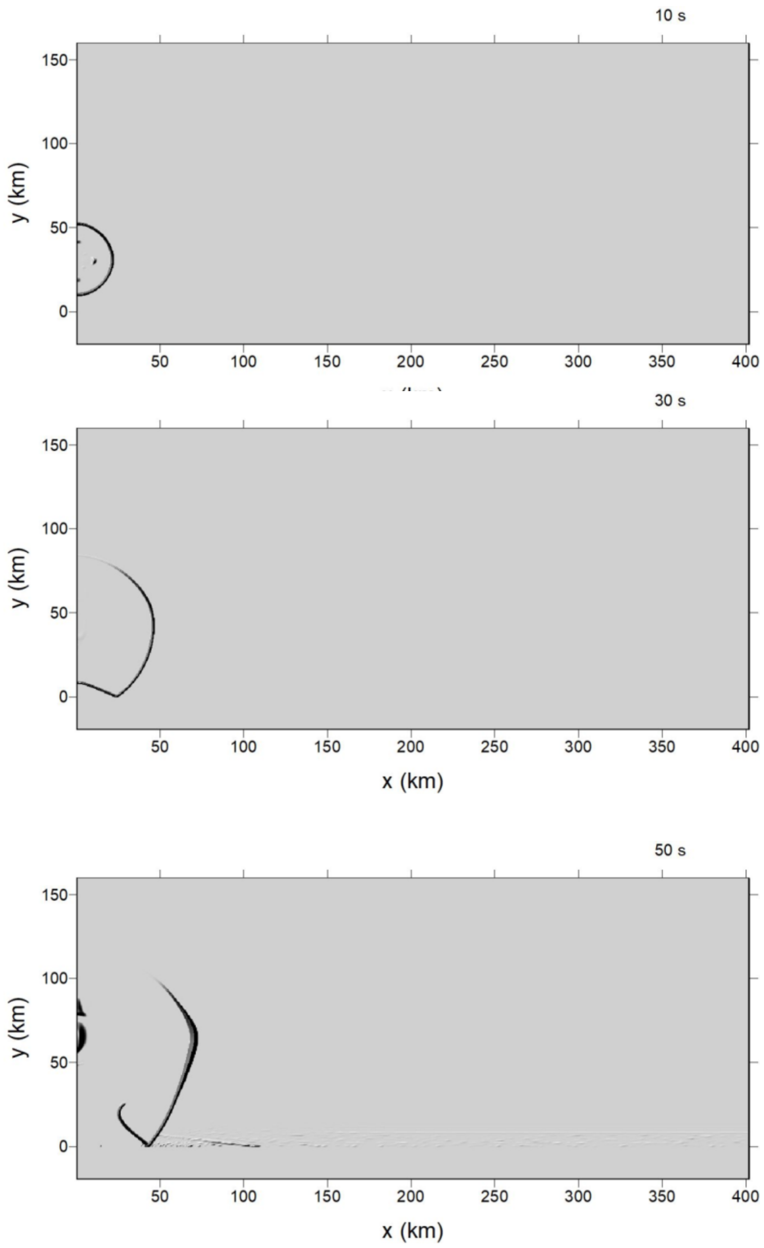
Chemical Physics Institute, Academy of Sciences, USSR

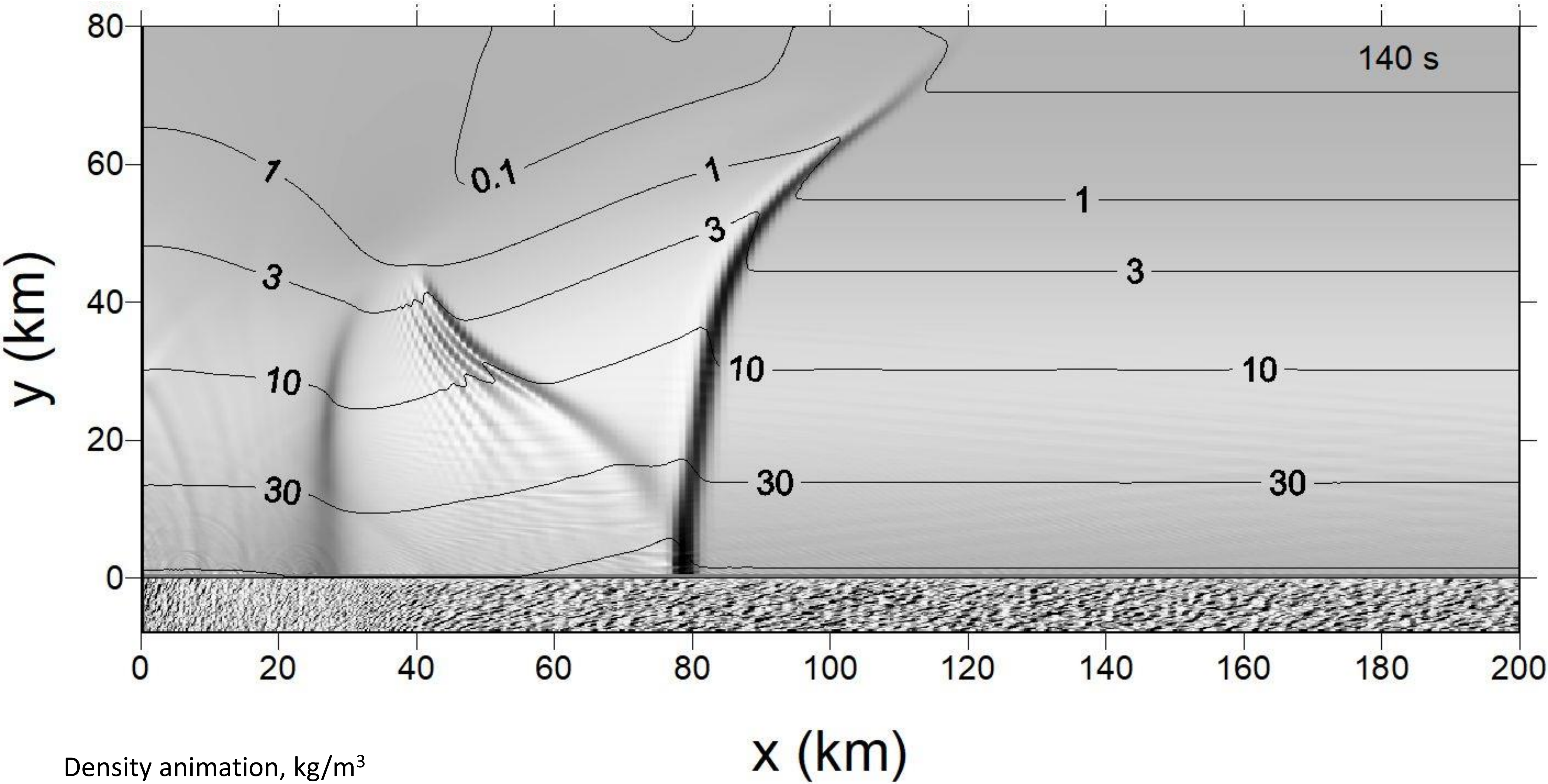
(Presented by Academician Ya. B. Zel'dovich, October 19, 1959)

(Translated from: Doklady Akademii Nauk Vol. 130, No. 5, pp. 1001-1003, February, 1960)

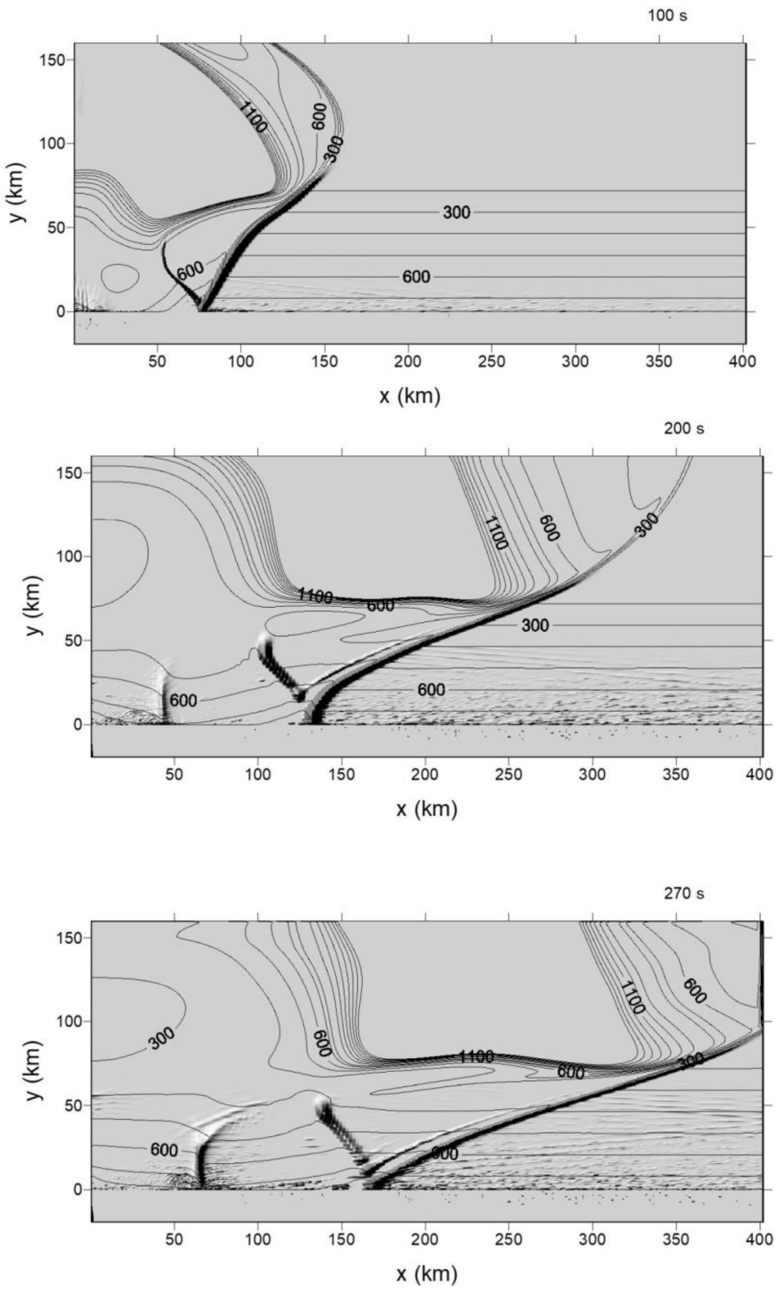
(Original article submitted October 11, 1959)

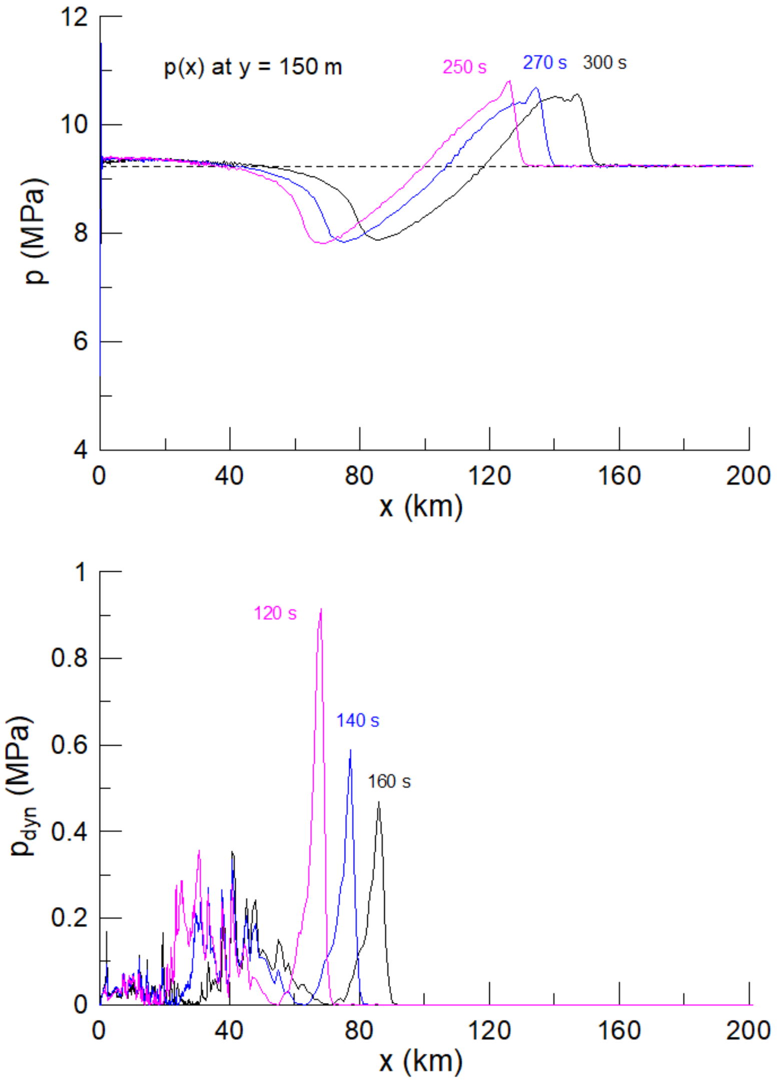
A general picture of shock wave propagation in the atmosphere after an airburst. The large-scale hot gas bubble from the source zone creates a n x 10 km plume (a kind of a classical "mushroom"), which effectively expands laterally at high altitudes, pushing forward an enhanced shock wave. This wave is looking like a gradual conversion of the main shock wave from a hemispheric one to a conic front, returning back to surface.

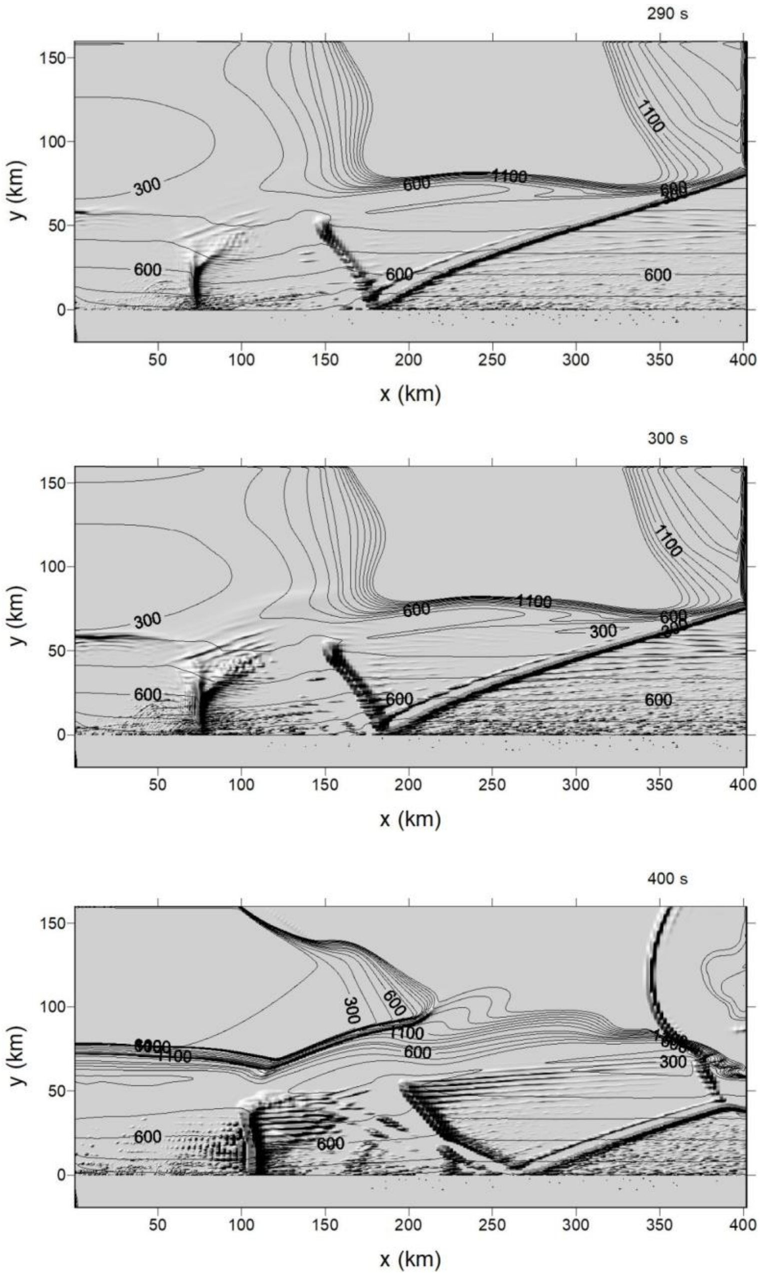




Density animation, kg/m^3





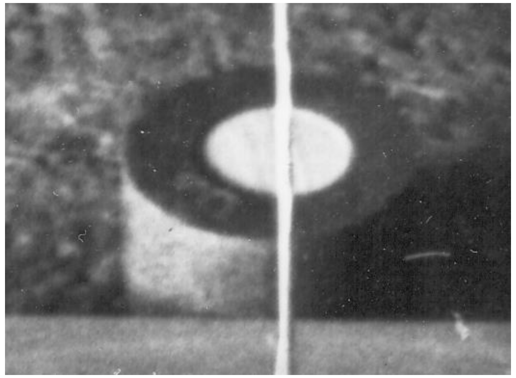


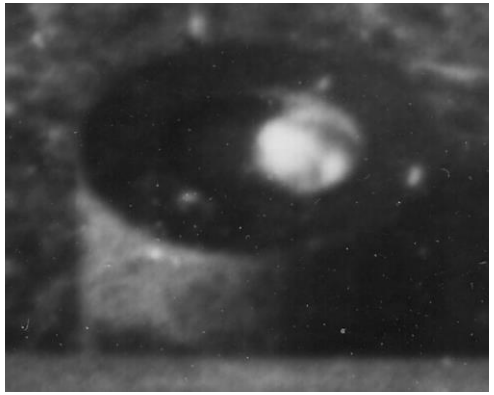
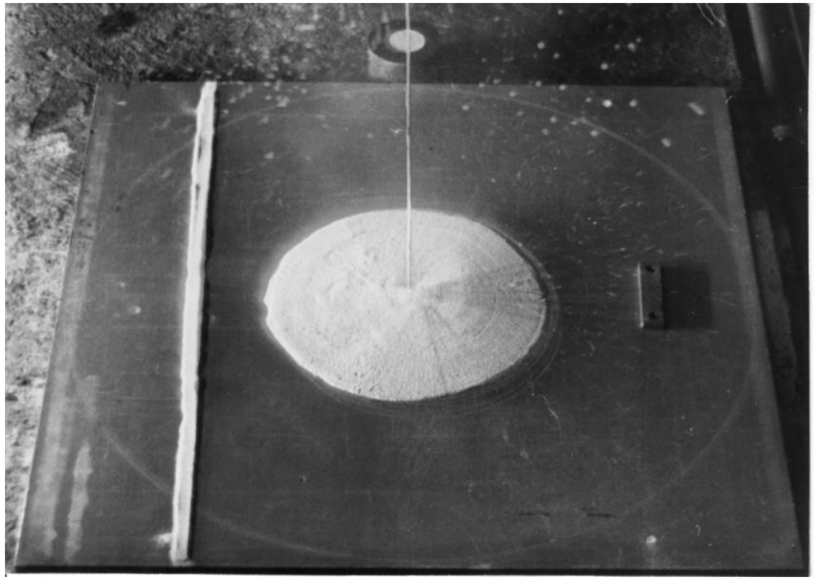
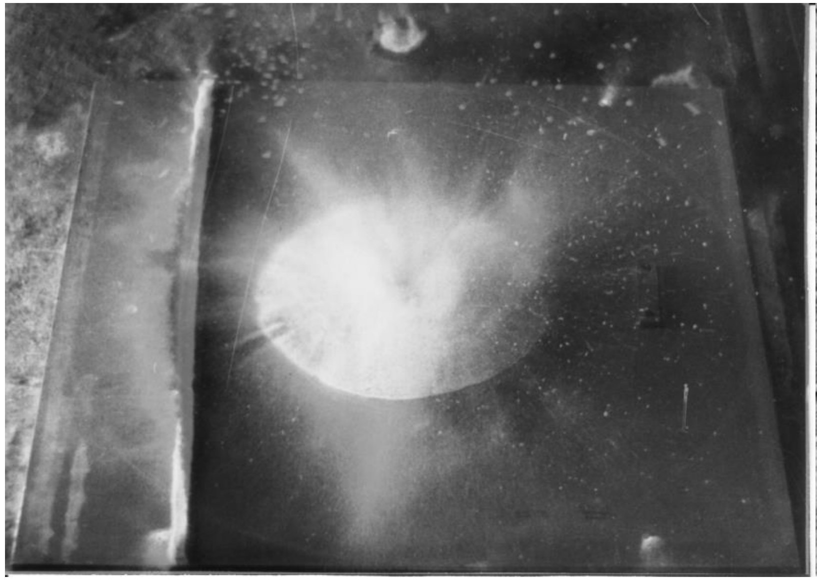
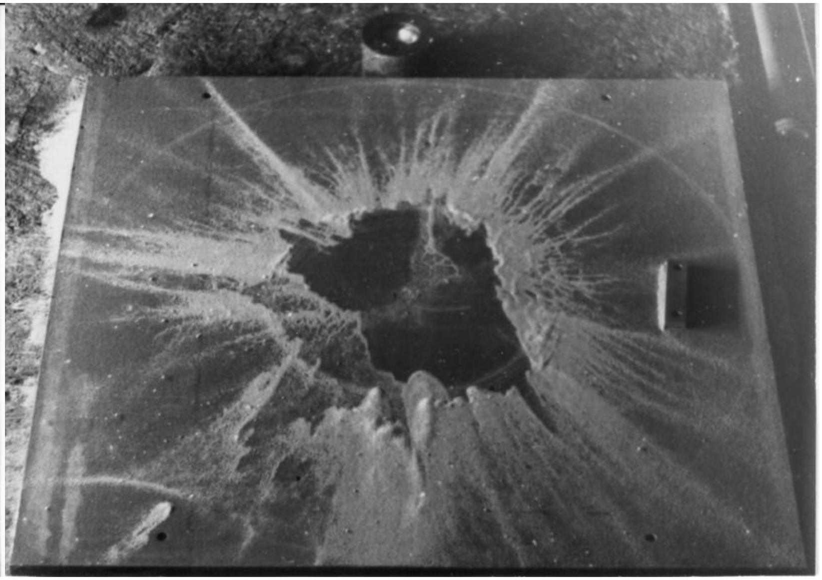
At distances of ~100 км p-p0 ~ +/- 1 MPa
Dynamic pressure ~ 0.5 МПа
The problem – is it enough to change the Venusian surface radar reflectivity?

An old experiment – linear RDX explosion imitates the meteoroid atmospheric passage

Provalov, A.A., Ivanov, B.A., Impact disturbance of the Venus atmosphere, Proc. Lunar and Planetary Science Conference 24, 1993, p. 1187-1188

Dry sand sucked out of a metal cast in a negative pressure phase

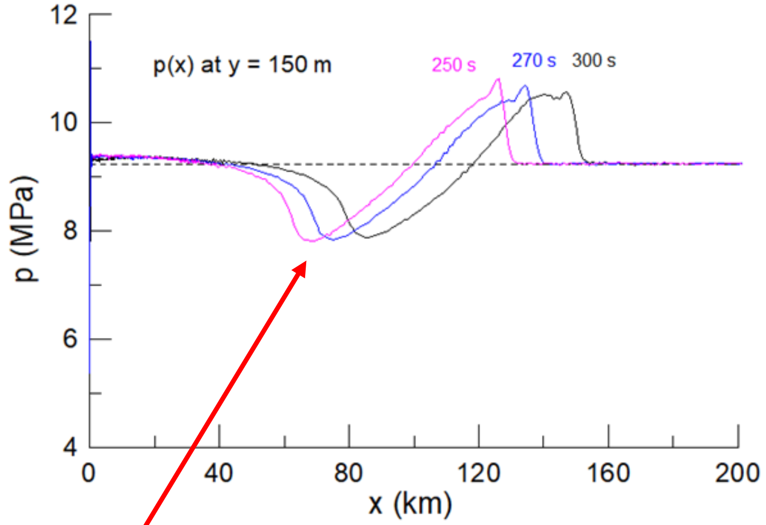


Current results

1. The observed "cluster of splotches" is hardly formed with atmospheric breakup of a single body.
2. Sizes of individual splotches of 80 to 180 km in diameter could be formed as air blast footprints assuming that surface scratches are limited with air shock waves with

shock pressure jump	$p\text{-}p_0 \sim 1$ MPa
dynamic pressure	$\rho * u^2 \sim 0.5$ MPa



Problems for a future study

1. Meteoroid breakup BEFORE atmospheric entry ???
2. More detailed analysis of air shock action at the Venusian surface
3. Better analysis of how rarefaction blast phase with ~ 1 MPa amplitude could redistribute fines at the Venusian surface