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NUMERICAL MODELING OF THE 1956 BEZYMIANNY DIRECTED BLAST.

On 30 March 1956 a catastrophic directed blast took place at Bezymianny volcano. It was provoked by the failure of a 0.5 km^3 portion of the volcanic edifice. The blast was generated by decompression of intracrater dome and cryptodome that had formed during the preclimactic stage of the eruption. A violent pyroclastic surge formed as a result of the blast. It spreaded eastwards affecting an area of 500 km^2 on the lower flank of the volcano. Thickness of the deposits, although variable, decreases with distance from the volcano from 2.5 m to 4 cm. The volume of the deposit is calculated to be 0.2–0.4 km^3. Similar blast surges occurred at Mount St.Helens (1980) and Soufriere Hills, Montserrat (1996).

Pyroclastic surges are dilute suspension currents in which particles are carried in turbulent flows under the influence of gravity. Pyroclastic surges commonly form after Plinian column collapse, during phreatomagmatic eruptions, and as a result of directed blast. Typical velocities are usually less than 300 m/s, temperatures may be less than 300 K (wet surge) and not higher than 1000 K (dry surge), solid/gas ratio ranges between 5-50, particle size rarely exceeds a few cm, while the mass fraction of fine micron-sized particles is usually poorly defined. Important aspects of surge transport include its ability to deposit ejecta over a larger area than that typical for ballistic ejecta and deposition of multiple ejecta layers. Numerical modeling of pyroclastic surges is a useful instrument for understanding of mechanisms of explosive eruptions.

We model a high-velocity volcanic ejecta motion using three-dimensional hydrocode SOVA complemented by ANEOS equation of state for geological materials**.** We use a tracer (massless) particle technique to reconstruct dynamic (trajectories, velocities), thermodynamic (pressure, temperature) and disruption (strain, strain rate) histories in any part of the flow. The motion of ejecta in a plume is described in the frame of two-phase hydrodynamics: every ejected fragment (or representative particle) is characterized by its individual parameters (mass, density, position, and velocity) and exchanges momentum, heat and energy with surrounding vapor-air mixture. Turbulent diffusion and viscosity are taken into account in a simplified manner. Numerical technique used in this study differs substantially from previously used methods, in which solid/molten particles have been described as gas with specific properties. Our technique describes individual particles and their interaction with gas. This procedure allows us to vary particles sizes in a wide range (from a few m to a few microns) and to compare modeling deposits with geological observations (deposit thickness, granular composition, and particle velocity versus distance from the vent). A substantial advantage of our model is its three-dimensional geometry, allowing modeling of asymmetric volcanic explosion – directed blast. While large (mm-cm sized) particles are deposited at proximal distances from the volcano (in this case a direct comparison between geological data and numerical results is possible), finer particles are suspended in atmosphere for a long time, creating distal deposits..

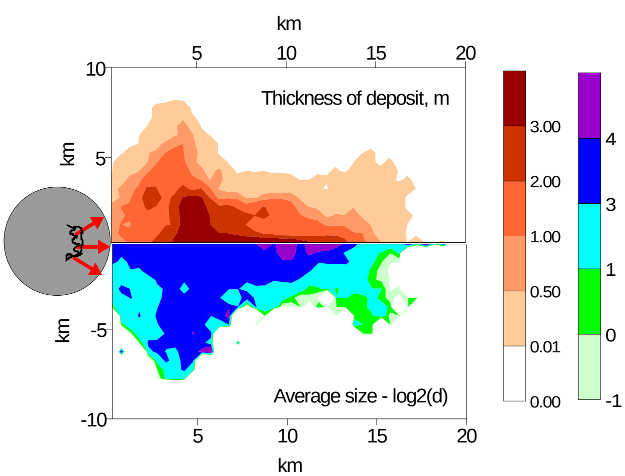

Fig.1 Modeled deposits of Bezymianny blast

We limit our consideration to a gas-particle mixture, in which direct particle-particle interactions are negligible because of low particle volume fraction.

Initial conditions: There are no detailed direct observations of Bezymianny 1956 directed blast. However, we can combine geological data from Bezymianny with observations of Mount St.Helens eruption, as both events are similar in their duration, affecting area and deposits. Gas (water vapor) flow loaded by pyroclastic particles in prescribed size range from 15 μm to 3.2 cm was ejected from 600-m-diameter vent with velocity of 100-200 m/s at 45º to horizon. Particles and gas are in thermodynamic equilibrium with temperature of 1000-1200 K. The particles/gas mass ratio ranged between 10-25. Discharge of pyroclastics lasted for 200 s with steady flux of $4.6 \cdot 10^9$ kg/s and total ejected pyroclastic volume of about 0.15-0.2 km^3.

Preliminary results: Total deposited mass depends on the solid/gas mass ratio: at the highest value of 25, ~80% of ejected mass is deposited within 10 minutes, while at lower mass ratio only 1/3 of ejecta is deposited (Fig.2). The rest is suspended in the atmosphere for minutes: final distribution of these (as a rule – finest) particles would be defined by local weather conditions. Modeled deposited area extends to 20-40 km from the vent and has a width of 10-15 km in a reasonable agreement with geological data – see Fig.1. Deposit thickness varies from several meters to undistinguishable values on the deposit edge.

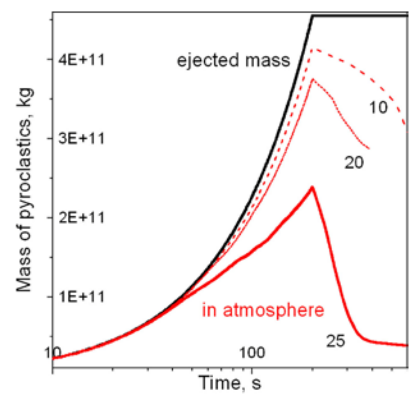

Fig.2. Mass of particles in the atmosphere versus time for various dust/gas ratios (numbers near the curves). 10%-20% of ejected tephra are suspended in the atmosphere for minutes.