Geyser as a self-oscillatory system. Randomness or dynamical chaos?

Landa P.S.

Geysers are systems exhibiting hydrothermal eruptive behavior at fluctuating instants of time. The randomness of geyser behavior suggests that it is a manifestation of dynamical chaos [1].

The process of geyser's eruptions in their form reminds of the process of noisy self-oscillations of a relaxation oscillator. We consider a model of geyser consisting from a reservoir, a pipe and, a heat source of temperature T_{h} and a source of cold water of temperature T_{c} (Fig. 1). The process of the geyser eruption consists from three stages. The first two stage are spade.

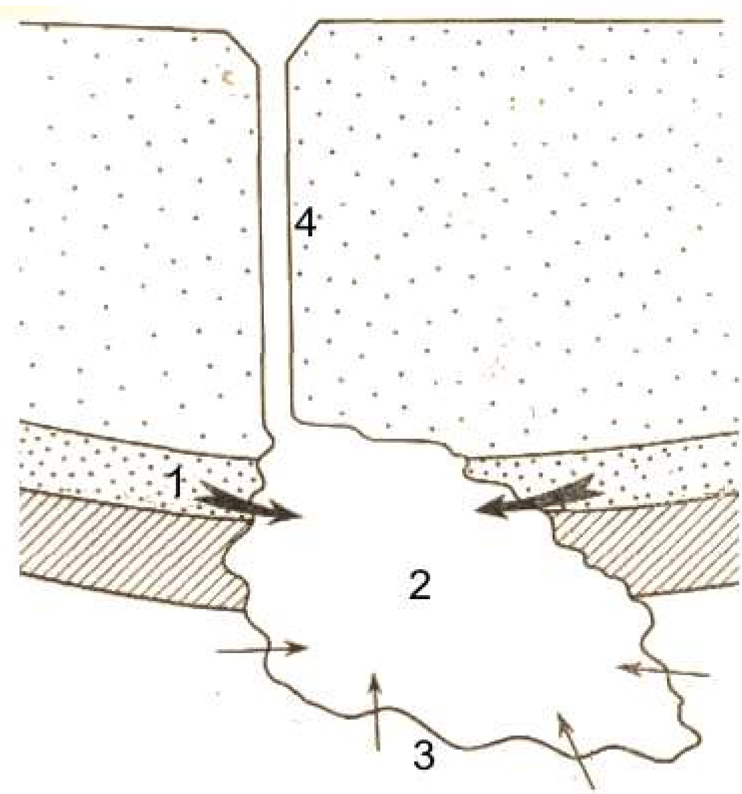

Figure 1: Schematic image of a geyser: *1* — water-bearing layer, *2* — a reservoir, *3* — heat magma contiguous with the reservoir (heat source), *4* — the channel (pipe) connecting the reservoir with the Earth surface.

They lie in filling the reservoir and pipe by water after the eruption and the heat of water until boiling. After these stages the mere process of eruption begins. As was noted, when the temperature of water in the reservoir amounts to the boiling temperature at the corresponding pressure, water in the reservoir begin boil and evaporate. The nascent vapor bubbles push out water, and, as a consequence, the pressure in the reservoir decreases. In this process water becomes increasingly superheated. As a result, boiling becomes very vigorous, reminiscent an explosion. After this, owing to strong evaporation the water temperature within the reservoir begin decreases, and when it becomes close to the boiling temperature corresponding to the atmosphere pressure the eruption stops.

As follows from aforesaid and our calculations, the increase of energy in geysers after an eruption occurs owing to slow heating of water within the reservoir to the temperature somewhat larger than the boiling temperature at the given depth. In this process water turns out to be superheated and therefore vigorous boiling begins. Such boiling just resembles an explosion. Due to intensive vaporization a part of water is fast ejected from the pipe and reservoir, the reservoir pressure falls, and the water cools to the boiling temperature at atmospheric pressure. So, the loss of the accumulated energy occurs fast (in a short time of the eruption). It follows from the Neimark energetic criterion [2] that such character of the increase and loss of energy may result in chaotization of excited self-oscillations. However, as our calculations have shown, this is not the case for the geyser model considered by us. Nevertheless, allowing for the boiling process to be random, that is always the case, the process of geyser eruptions becomes nonperiodic. As for real geysers, this reveals itself in the randomness of intervals between the consecutive eruptions, in random duration of each eruption and in random lifting height of water when geyser is erupted. It should be noted that some authors

References

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