A model of Mars-like protoplanets shed light on early solar activity

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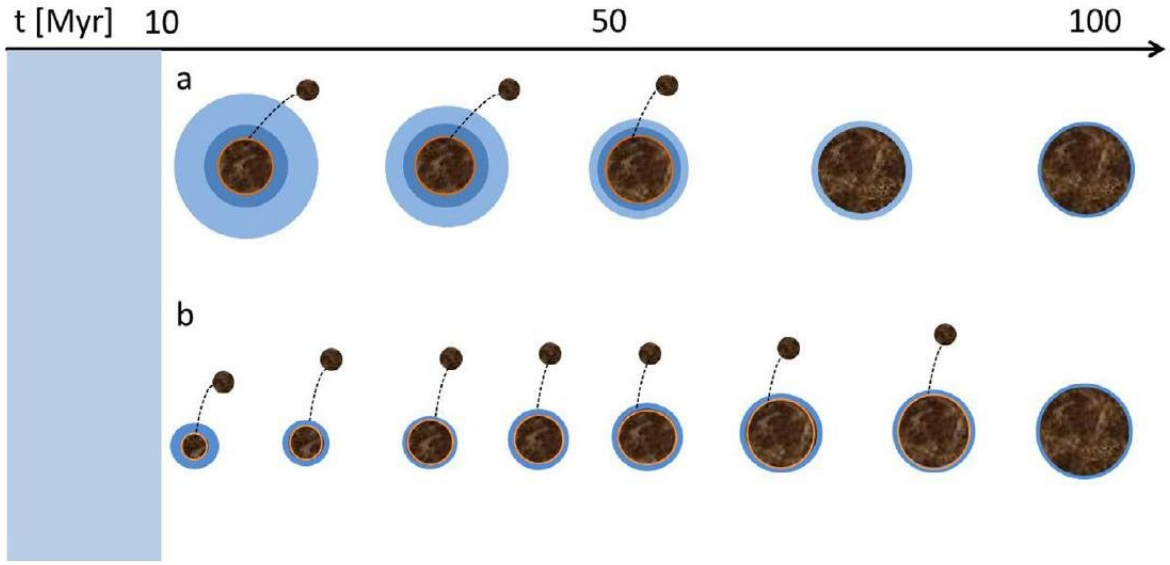

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that Mars had no chances to develop a thick atmosphere and biosphere. In the case of Venus, it depended on solar activity: According to the scientists, it managed to keep its atmosphere due to the fact that young sun was not very active. The study was published in *Icarus*.

According to the model, Mars and Venus arose from protoplanets (and they, in turn, from gas and dust clouds). Planet "embryos" collide, thus forming protoplanets. They get heated, and magma oceans are formed. During their solidification volatiles of the mantles form a thick and hot atmosphere that predominantly consists of water and carbon dioxide. However, due to the low gravity of Mars-sized planets and high stellar EUV luminosity of young stars, their atmospheres tend to escape. Hydrogen is quite light and goes first, dragging heavier elements (oxygen, carbon dioxide, and noble gases) with it. Hydrogen wind that is formed in the upper layers of the atmosphere is able to pick up heavier particles from lower ones, like a storm in Earth atmosphere can carry away dust, aerosols, and so on.

The researchers considered a wide range of possible scenarios describing changes in solar activity. They used all known empirical models of EUV dependence from the age of young stars (in millions of years). They also constrain realistic cases by comparing modeled noble gas isotope ratios with present observations. However, whatever the scenario, Mars-like planets lost their atmospheres and therefore were bound to lose water as well. It takes an atmosphere only tens of millions of years to escape, which is a very short period on the solar system timescale.

"Available data on the composition of Venus' atmosphere allowed us to look into the past and understand how the sun used to act. It seems that solar activity was quite low initially," said Nikolai Erkaev, a co-author of the article.

In some scenarios (with high solar activity), Venus would have lost its

atmosphere, while in others (moderate radiation), it would have retained it, as is the case. Generally, the results of the modeling are in favor of the scenario in which solar activity was low and the atmosphere with a small amount of residual hydrogen was formed from a protoplanetary nebula on early accretion stages. In other cases, too much CO2 is lost during planetary evolution, which does not correspond to the present state of Venus' atmosphere. According to the model, for Venus to become as it is today, the sun should have been relatively inactive during the early stages of the solar system development.

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