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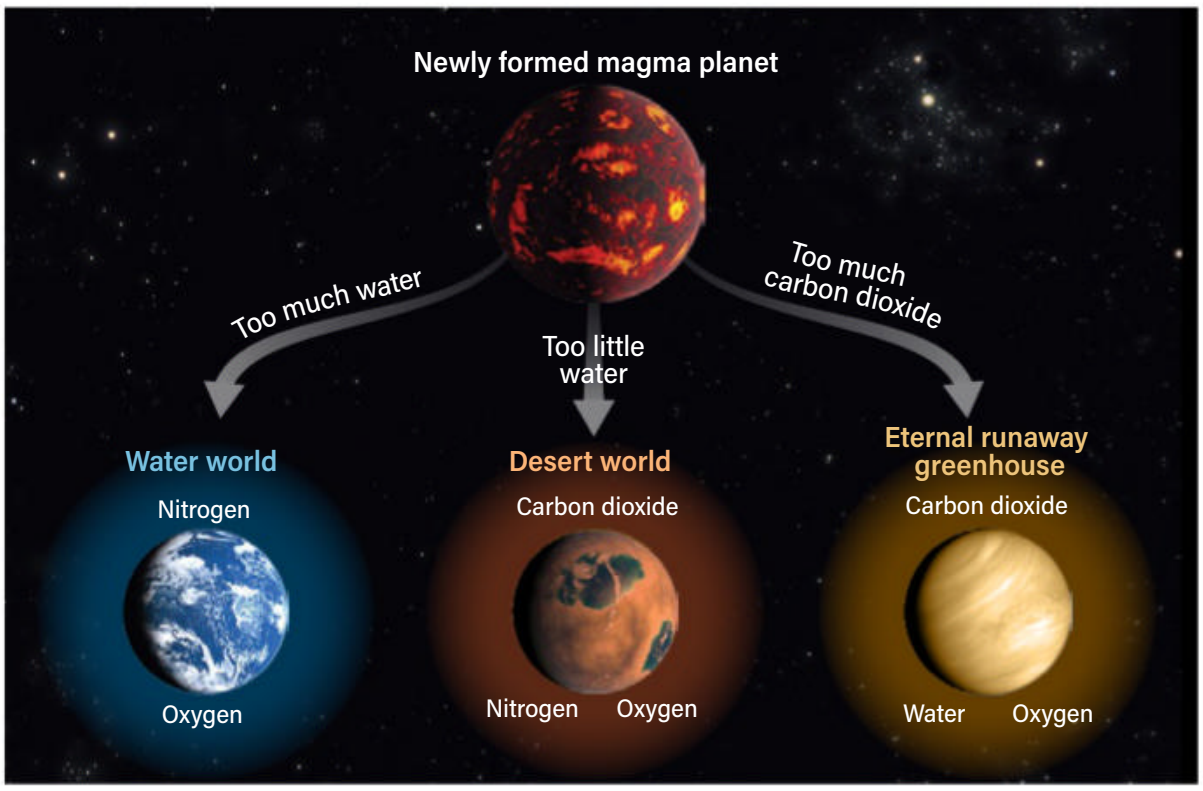
Oxygen may not be a sure sign of life



ASTRONOMY: ROEN KELLY, AFTER J. KRISSANSEN-TOTTON

THREE ROADS. New research has found three ways for an Earth-like planet around a Sun-like star to boast an oxygen atmosphere without life providing it. A lifeless planet with too much water, too little water, or a different initial makeup of elements could retain plenty of oxygen in its atmosphere.

Before life emerged on Earth, our planet's atmosphere was nearly devoid of oxygen. What little oxygen existed was taken up by the young planet's oceans of magma and, later, other forms of geological activity, keeping it locked in the surface, rather than remaining in the air. That only changed a little more than 2 billion years ago, when cyanobacteria appeared, which convert carbon dioxide to oxygen. Over 10 million years, life produced enough oxygen for it to become the second-most prevalent component of Earth's air.

Due to this history, astronomers have long believed oxygen is an excellent marker of life, or biosignature. They have even designed many next-generation telescopes with the ability to detect it in exoplanet atmospheres. But a new paper published April 13 in *AGU Advances* uses computer modeling to show that, in a variety of scenarios, rocky Earth-mass planets around Sun-like stars can develop oxygen-rich atmospheres without the presence of life. This means oxygen might not be the smoking gun researchers once hoped.

One such scenario is a water world with oceans whose volume is 50 times greater than Earth's oceans. All that water exerts pressure on the planet's crust, shutting off the geologic processes that remove oxygen from the atmosphere, like weathering and the melting of rock.

The second scenario is the opposite: A desert world with less than three-tenths the water in Earth's oceans that ends up with a solidified surface and a "steam atmosphere" of water vapor for a period of about a million years. This temporarily provides a big reservoir of atmospheric oxygen, as sunlight breaks up the water molecules and the planet's solid surface can't remove any oxygen, so it stays in the atmosphere.

Finally, a world with a higher concentration of carbon dioxide than early Earth can experience a runaway greenhouse effect that prevents oceans from forming in the first place. It's also too hot for elements to exist in the planet's mantle that would normally sequester oxygen through chemical reactions.

Despite these results, the prognosis for oxygen as a biosignature is still good. "There are other observations you can make to help distinguish these false positives from the real deal," study first author Joshua Krissansen-Totton of the University of California, Santa Cruz, explained in a press release. It seems astronomers will simply have to be a bit more discerning once they finally get a good peek inside the atmosphere of a promising Earth-like exoplanet.

—ALISON KLESMAN

BINARY BLACK HOLES: NASA'S GODDARD SPACE FLIGHT CENTER/JEREMY SCHNITTMAN AND BRIAN P. POWELL.

COSMIC DANCE OF BINARY BLACK HOLES

Like two ballet dancers spinning on a grand stage, these supermassive black holes gracefully sweep toward one another in a visualization created by NASA's Goddard Space Flight Center. Surrounding each black hole is an accretion disk, a superheated soup of material that swirls around before flowing inward like water disappearing down a drain. Light from the accretion disks, colored blue and red, shows how the extreme gravitational forces of the objects distort their appearance when one black hole crosses in front of the other. —HAILEY ROSE MCLAUGHLIN