

Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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A Primitive Ocean

In the beginning, there was no ocean, and in fact, no ocean backyard. When the Earth came into existence about 4.6 billion years ago, several processes conspired to heat up the primordial planet and thereby prevent the accumulation of liquid water: bombardment by asteroids, comets and other debris from space, all warmed things up; gravitational compression of accumulating debris within the Earth was converted to heat; and decaying radioactive materials also raised the planet's temperature.

Over the next 500 million years or so, as the early Earth slowly cooled, water began to collect in the depressions and low areas. To date, the oldest sedimentary rocks found on Earth are about 3.9 billion years old. Sedimentary rock such as sandstone, shale or limestone, require water in order to form, so there is good evidence that seas or oceans have been around for nearly four billion years.

Scientists have asked for centuries, where did all this water come from? There are two likely sources, but not complete agreement on the importance of each.

The favored idea for decades was that the water at the Earth's surface in the atmosphere and oceans came from within the Earth. Magmas, which erupt from volcanoes on the surface, typically contain a few percent by weight of dissolved gases. These gases include carbon dioxide, nitrogen, sulfur dioxide, and water vapor, which is typically the most abundant.

Measurements of gases taken around volcanoes during eruptions, always a hazardous endeavor, have given us some reasonable estimates of the importance of this source of moisture over geologic time. Given the approximate amount of lava erupted by volcanoes over the history of the planet, and some average water vapor contents, the amount of water produced by volcanoes is equivalent to roughly one hundred times the volume of the world's oceans. In other words, there is no problem squeezing the world oceans out of the water contained within the Earth, all 332,000,000 cubic miles of it.

The importance of this more or less accepted source of the water in the sea has been questioned recently, however, with a less obvious source put forward- large volumes of water likely have been added over time from space. Icy comets or meteorites from the far reaches of the solar system colliding with Earth throughout its history, may well have also contributed significant volumes of water that helped cool the Earth's surface and gradually collected to help form the oceans.

As the primordial oceans began to form, their water began to dissolve minerals in the rocks at the Earth's surface. Large volumes of water were also being evaporated from the oceans, which then condensed in the atmosphere and fell back down as rain. This precipitation and runoff through the earliest rivers and streams, towards the low areas or oceans, also helped to break down the rocks and transport their constituents to the sea. In addition, many of the ions that contribute to the salinity of the oceans are believed to have come from within the Earth, from both volcanic eruptions and also thermal vents on the sea floor, over millions of years. As a result, the oceans began to accumulate these ions and become salty very early in its history.