IN SEARCH OF EARLY LIFE ON PLANET EARTH

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One of the most intriguing questions posed in Science today is: *when did life first appear on planet Earth*? What might appear as an unambiguous question has generated considerable controversy amongst a diverse array of specialist scientists, including palaeobiologists, geo-microbiologists, geochemists and astrobiologists. Scientists have attempted to address this question through a number of disciplines. Astronomers monitor the sky examining distant stars, determining if the light emitted dims in a periodic cycle that might indicate the transect of a planet across the surface of a sun, thus confirming the presence of a planetary system. Planetary scientists at the SETI Institute (Search for Extra-Terrestrial Intelligence) are actively assessing the ability of newly discovered planets to support life, calculating if they occur within the 'goldilocks' zone, the distance from a star where environmental conditions can sustain life; and use the data obtained to help refine the Drake equation – a well-reasoned guess in establishing the number of habitable planets within the universe.

By contrast, earth scientists are examining ancient terrestrial rocks that occur in Canada, Greenland, Southern Africa and Australia. Principal lines of research include the search for ancient preserved fossil remains, or residual evidence of their existence from the geochemical analyses of the rocks – the so called bio-signatures. Meanwhile planetary scientists can now utilise the considerable data from planetary surface landers such as Curiosity, Sojourner, Spirit, and Opportunity that roamed and are roaming the surface of Mars, attempting to detect water or its presence in the past that may indicate that life may have flourished many millions of years ago. Another group of planetary scientists use remote sensing 'fly-by' satellites to map surfaces such as Europa, one of Jupiter's moons, which appears to have an icy frozen surface covering an ocean of liquid salty water – a potential habitat for supporting life.

Living on the extreme

If a form of life exists on Europa the organisms will probably be from a group known collectively as the 'extremophiles'. This is the term applied to organisms (usually micro-organisms) that have the ability to survive and thrive in extreme environmental conditions (high pressures, temperatures, acidic, depleted oxygen), and includes the anaerobic bacteria, chemo-bacteria. The organisms' metabolic systems use unique enzymes (called "extremozymes") which provide them with the ability to not only survive, but thrive in these hostile environments. Their study is essential to science as they provide us with data on the range of conditions that can support life, and in the discipline of bio-medicine they may provide a source for genetically based medications.

So where do earth scientists study extreme environments on planet Earth? The most common is the hydrothermal vent systems found associated with areas of volcanism and tectonic activity, such as Yellowstone Park in the United States, Iceland and in the Rotorua-Taupo volcanic and hydrothermal region of the North Island of New Zealand. This volcanic region extends into the Bay of Plenty, to the active volcano White Island situated 51km north of the coastal town of Whakatane.

Geyser 'Old Faithful' in Yellowstone National Park, SG 743, SG 1456, SG 4930 (issue specifically for express mail)

Eruption of The Great Geyser on Iceland SG 226-233. Eruption of Mt Hekla in 1947 SG 280-286

White Island. The island, a volcano of rhyolite composition (resulting in a 'sticky' lava), is known as Whakaaii to the Maoris, was first sighted by Captain James Cook on October 31 1769

New Zealand Pohutu Geyser

New Zealand, 1993, SG 1730-35: Scenic Thermal Wonders issue.

45c Champagne Pool, a 2000 square meter lake where constant thermal activity with water temperatures between 70-75°C has formed the colourful Primrose Terrace; 50c Boiling Mud, in graphite-rich pools reaching temperatures in excess of 115°C; 80c Emerald Pool, a cold water pool that gets its brilliant green and blue from the high concentrations of dissolved silica rich pumice and obsidian; $1 Hakereteke Falls, spills warm water into a pool very popular with visitors, although the presence of the protozoa Amoeba meningitis makes it unsafe for diving; $1.50 Warbrick Terraces, situated 1.5kms from Lake Rotamahana, hot springs flowing over the terrace deposit white silica on cooling, streaked with colours caused by minerals and algae; $1.80 Pohutu Geyser at Whakarewarewa irregularly erupts a water jet 18-40 metres high. It is thought that geysers erupt when an underground column of water is heated beyond boiling point and bursts into steam, violently ejecting the water contained above the 'flash' point. However, variations in atmospheric pressure may also be important, with low atmospheric pressures causing the release of gasses.

Numerous examples of hydrothermal activity such as geysers, sinter terraces, and hydrothermal mud pools are seen on the North Island of mainland New Zealand. The Pohutu geyser at Whakarewarewa, near Rotorua appeared on the $2 pictorial issued originally in 1967 (SG 862), and reissued 1968 (SG 879) with an amended colour.

The Scenic Thermal Wonders issue of 1993 from New Zealand illustrated the spectacular thermal attractions of the Waiotapu Thermal Reserve, near Rotorua.

The volcanic eruption of Mt Tarawera on the 10th June 1886 killed more than 150 people and destroyed three Maori villages, depositing over two million cubic metres of molten rock and ash and re-shaping Lake Rotomahana. It was thought that the eruption resulted in the destruction of New Zealand's most famous Victorian natural feature: the Pink and White Terraces. Fortunately they had been recorded by artists. The 1988 Heritage issue featured a $1.30 value illustrating the White Terraces in a painting by the Victorian traveller Charles Barraud (/Blomfield) who spent 26 years recording his impressions of New Zealand's picturesque scenery. The terraces had been visited by thousands of tourists seeking medicinal cures from the mineral enriched spa waters of the pools. Mapping of the lake floor in February 2011 re-discovered the lowest two tiers of the Pink Terraces in-situ at a depth of 60 metres, while part of the White Terraces was re-discovered in June 2011.

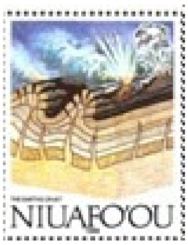
The spectacular colours of the fan-shaped staircases of algal enriched silica had been formed over many centuries, and were destroyed in a matter of hours in 1886. The destruction of the Pink and White Terraces provides a cautionary tale to today's geo-microbiologists that extremophile habitats are likely to be transient in nature, and the extremophile 'fossil-record', already difficult to construct, is probably less complete than that for higher organisms. Fortunately, both terraces were depicted on New Zealand definitive stamps commencing in 1898.

Extremophile habitats are not confined to terrestrial volcanic and hydrothermal environments. Within marine environments both black and white smokers are of considerable interest to scientists studying extremophiles. Studies of extremophiles have demonstrated that certain microbes can survive to depths of 4km below the earth's surface, and at altitudes in excess of 10km above the earth's surface. With such a wide habitable zone surrounding the planet, it is often difficult for scientists to analyze rocks that show no chemical signature attributed to a microbial form of life.

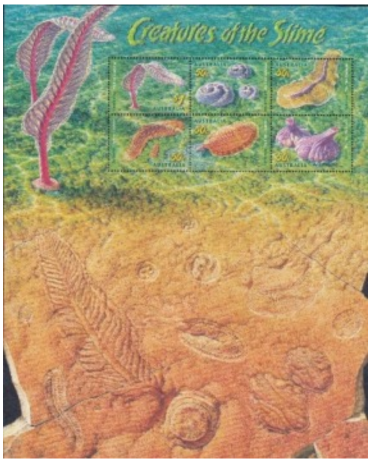
Early life on earth

The 'seeding' of life on earth is the subject of scientific debate. Were the 'ingredients' always present on earth, requiring only a 'spark of energy' to kick start the process? Between 4,000 and 4,600 million years ago, planet earth was in a period of time known as the Hadean – named after the ancient Greek god of the underworld, reflecting the "hellish" conditions that existed on Earth at this time. Although the earth was already over 12 billion years old, the crustal surface of the young planet was only beginning to form. The boundary between the Hadean and the Archaean (3,900-4,000 million years ago) was marked by a period of meteorite impact activity known as the 'late heavy bombardment'. The panspermia hypothesis, first proposed by the Swedish scientist Svante Arrhenius (1859-1927) in 1908, proposes that life exists throughout the Universe, and that interstellar activity provides a mechanism by which the biomolecules of life were transported to Earth – and is distributed by meteoroids, asteroids, comets and planetoids crashing into or coming close-to, and under the gravitational influence of planets orbiting in the 'goldilocks' zone. On November 12th 2014 the European Space Agency Rosetta mission soft landed its Philae probe on comet 67P/Churyumov-Gerasimenko, the first time that such an extraordinary feat had been achieved.

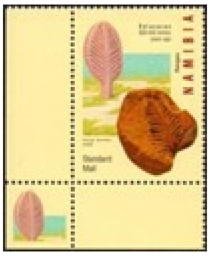
New Zealand, 1898: White (4d) and Pink (9d) Terraces, one of the world's earliest pictorial definitive issue, the Terraces were situated at the north-east corner of Lake Rotomahana. 1972 Lake Scenes: the three square mile Lake Rotomahana as seen today; prior to the 1886 eruption it was much smaller.

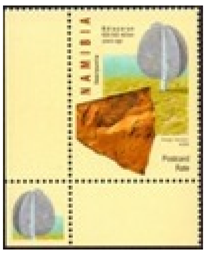


The Evolution of the Earth, Niuafo'ou (Tonga): 1989, SG 117-130a, re-issued as a mini sheet MS 132 with different values and some new images, to commemorate the 20th Universal Postal Union Congress, Washington. 32s the formation of the Earth's surface during the late 'heavy bombardment'; 32s cross-section of the Earth's crust; 32s cross section of earth during cooling; 45s early marine life during the Cambrian; 42s Cambrian life forms and fossils.



Australia: 2005, (SG 2510-2515): Creatures of the slime, a set of six stamps illustrating Ediacran fossils (50c Tribrachidium heraldicum, 50c Dickinsonia costata, 50c Spriggina, 50c Kimberella, 50c Inaria karli, $1 Charniodiscus).





Namibia 2008 (SG 1110 - 1113): Ediacaran fossils of Namibia: stamps from the corners of sheets with additional illustrations of the fossils at each corner: $2 Rangea schneiderhoehni; $3.90 Swartpuntia germsi; $18.45 Pteridinium simplex, $22.95 Ernietta.

Once conditions of crustal stability had been established signs of biochemical and molecular activity may be in evidence from as early as 3,500 to 3,600 million years ago. However, supporting evidence from the 'fossil record' is not seen for another 500 million years. The microbial mats of laminated organo-sedimentary structures are formed through the process of trapping and binding of particles, and are collectively known as stromatolites. In rocks of Archean age from Africa, North America and Australia stromatolite structures are considerable rock builders.

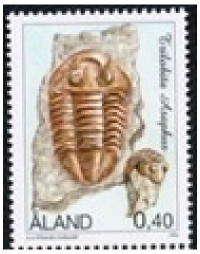
The Ediacaran – natures experiments with evolution

Environmental conditions supporting a 'slow-burning-fuse' leading to the development of multi-cellular life on Earth existed for the next 2,000 million years. During this time the earth was accumulating free oxygen, and the continental land masses were coalescing and breaking up forming the supercontinents of Nuna and then Rodina. Strange multicelled organisms evolved during the Ediacaran (635-541 million years ago). These soft bodied organisms are only preserved where environmental conditions (no oxygen) and rapid burial coincide. Ediacaran assemblages from Australia and Namibia have been illustrated on stamps.

The Ediacaran assemblages died out around 547.5 million years ago, and as faunal diversification continued into the Cambrian, the first stage of the Phanerozoic Eon, the effects of the 'Cambrian Explosion' are preserved in the fossil record. In North Greenland the Sirius Passet lagerstätte (a deposit of exceptionally preserved fossils, often including soft tissues) contains the most complete specimen of an organism whose affinity is thought to be an early mollusc: the 'slug-like' *Halkieria evangelista* is part of the halkieriid group of animals with a segmented outer surface of hardened plates.

The fauna of the 505 million year old Cambrian Burgess Shale of British Columbia, Canada, was discovered by Charles Doolittle Walcott (1850-1927) in 1909. Between 1910 and 1924 Walcott and his sons collected over 65,000 specimens. Following his initial descriptions and the importance of the site and his fossils, they were not re-described until the late 1960's when Harry Whittington (1916-2010) the Woodwardian Professor of Geology at Cambridge University re-evaluated the assemblage and theorised about the 'Cambrian Explosion', a period in time when it appears that all the major phyla known today first appeared in the geological time scale. The rapid faunal diversity and evolution of organisms appeared over a 70-80 million year period commencing approximately 580 million years ago, with most of the complex organisms recognised today appearing during the first 20 million years. As with the debate on the origins of early life on earth, controversy surrounds the rapid radiation of life: is it real or an artefact of the fossil record?

A 'global explosion' of stamps illustrating other Palaeozoic faunas, mainly trilobites can now be found.



Stamps illustrating Palaeozoic trilobites:
Asaphus: Aland 1996 SG 113. Selenopeltis buchi buch: Czechoslovakia, 1968 SG 1764. Paradoxides davidis: Canada, 1990 SG 1393. Eurypterus remipes, a marine scorpion from the Silurian Period from 432-418 million years ago, Canada 1990 SG 1390.