RHODES W. FAIRBRIDGE

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Introduction

Rhodes W Fairbridge, one of Australia's most accomplished intellectuals and an early expert on climate change, died on 8th November, 2006 in his home in the historic town of Amagansett, overlooking the Atlantic on the northern edge of Long Island, New York.[1] He was 92 and had remained an Australian citizen all of his life. One of Australia's most accomplished intellectuals, Rhodes W. Fairbridge was born in what is now Fairbridge Village in Western Australia in 1914 and was named after his father's friend and mentor, Cecil Rhodes. Rhodes had spent his boyhood in the idyllic setting of Fairbridge Village, working closely with his parents.

Rhodes had little formal schooling until the age of 10 when his father died unexpectedly in 1924, aged only 39. Rhodes was taken to England, where he attended a new experimental school in Hampshire. It was here that his lifelong interest in geology, science and maps was established. Whilst his undergraduate education was at Queen's University, Ontario and Oxford, he was awarded a Doctorate of Science from the University of Western Australia in 1944, at the age of 30, bypassing the usual PhD prerequisite. The main parts of the thesis, *Subaqueous Sliding and Slumped Blocks,* formed Rhodes' first two scientific publications in 1946 and 1947 (Fairbridge, 1946a, 1946b). Rhodes was also with the RAAF in General MacArthur's headquarters during 1943 to 1945, as Deputy-Director of Intelligence.

After the war Rhodes lectured in Geology at the University of Western Australia. In 1954 he accepted a post as full professor with tenure at Columbia University, eventually becoming Professor Emeritus of Geology some years before his retirement in 1982.

Fairbridge Village

Fairbridge Village,[2] located some ninety kilometres south of Perth, is a living monument to the altruistic vision, hard work and intellectual strength of his parents, Ruby and Kingsley, after whom it is named. There, in July, 1912 they founded the Fairbridge Farm School. Kingsley, a Rhodes Scholar, founded the Child Emigration Society three years earlier at Oxford University with the support of his fellow Rhodes Scholars. Kingsley, inspired by Cecil Rhodes, dedicated his life to the achievement of his vision of providing the poor and orphaned children of the slums of England with a sense of self-worth and with the opportunity to live a fulfilling and productive life. This was to be the purpose of the Fairbridge Farm School.

Fairbridge Village, the Patron of which is the Governor of Western Australia, is now the site of major cultural events including an annual festival of popular culture, organised mainly for and by young people. Dolan and Lewis (2004) point out that the

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[1] Biographic detail drawn from the papers about, and the autobiographic essays by, Professor Emeritus Fairbridge in (Rampino et al., 1987), (Finkl 1995), and (Finkl 2005), and letters about Professor Emeritus Fairbridge by Mrs Dolores G Fairbridge, Leo F Laporte and Allen Lowrie published in Finkl (2005).

[2] For a diagram of the village see http://www.fairbridge.asn.au

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architectural jewel in the crown of Fairbridge Village is a beautiful chapel,[3] built in 1930-31, whose elegant simplicity shows the admiration in which Rhodes' father, Kingsley, was held by one of the world's most famous architects of the time, Sir Herbert Baker. He designed the chapel and supervised its construction, carried out by the Western Australian Government, as a pure labour of love to commemorate the memory of Kingsley Fairbridge. It was financed by other Englishmen who shared Sir Herbert's admiration of Kingsley. Sir Herbert Baker considered that Kingsley lived the true values of altruism and honour that were central to Cecil Rhodes, who had also been his patron.[4]

The Fairbridge Curve

Rhodes Fairbridge was the first to document that the ocean levels rose and fell over long time scales. His first paper on this theme was published in 1950 (Fairbridge, 1950). The major paper that included what has become known as the *Fairbridge Curve of the Holocene Eustatic Fluctuations* was published in 1958 (Fairbridge, 1958, 1960, 1961a). He conducted detailed observations off Western Australia and drew together similar data from elsewhere in the world. On the basis of this work, Rhodes formulated the hypothesis that sea levels had been rising for the last 16,000 years and that the rise showed regular periodic oscillations of rise and fall over the period. This hypothesis, radical for its time and roundly rejected, is now acknowledged as a feature of the history of the planet. The periodic oscillations have continued throughout the last 6,000 years to the present time, but with diminishing amplitude. They show relatively rapid rises and falls of up to four metres, although up to three metres is more common. These take place over periods of no more than 10 or 20 years. Such rises or falls would now have catastrophic consequences for the world. The Fairbridge curve predicts that they will happen over the next 100 years and possibly within our lifetime.

Baker *et al* (2005) builds on research Professor Fairbridge conducted on Rottnest Island off Perth in the late 1940s and published in 1950. This research was the basis for his pioneering theory of the Fairbridge curve. Baker *et al* (2005) used evidence of tubeworms to find evidence about sea level changes. The tubeworms attach themselves to coastal rocks at inter-tidal levels, as they have to be covered by seawater for about six hours each day. The careful study of tubeworm casings along coastlines in Australia, Brazil and South-east Asia has revealed that, even within the past thousand years, there have been several sudden changes in sea levels of up to two metres.

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3 http://www.abc.net.au/southwestwa/galleries/fairbridge/pages/Chapel.htm

4 The chapel is described as "the architectural jewel in the crown of Fairbridge Village" by the Governor of Western Australia, His Excellency Lieutenant General John Sanderson, in his Forward to Dolan and Lewis (2004). Sir Herbert Baker himself described his feelings about designing the chapel as a "labour of love" in correspondence in 1931, (Dolan and Lewis (2004), page 8), who consider that it is only architectural project Sir Herbert undertook on a voluntary basis. The money to build the chapel was donated by Thomas Wall, and English multi-millionaire who made his fortune from ice cream and sausages. Dolan and Lewis (2004) describe Sir Herbert Baker as one of the world's most famous architects of the time (p. 1); one of a tiny group of architects honoured by burial in Westminster Abbey (page 4); and at the top of his profession in 1928 when invited to design the chapel (page 51).

The UNE team has discovered that each of these large changes took less than 40 years from beginning to end. They have therefore found convincing evidence of large, rapid changes in sea levels around the world in the recent past.

"Most of the climate-change modelling done in Australia and overseas assumes a basically stable natural system underlying the man-made variable of greenhouse gases," said one of the UNE researchers, Dr Robert Baker. 'Our research indicates that the underlying system is anything but stable and that we would be well advised to take this into consideration in our planning. We're adding a destabilising factor (greenhouse gases) to a system that is already subject to large, rapid changes.'[5] Baker *et al* (2005) have been collaborating on the project for the past eight years and have published nine papers in scientific journals in relation to it.

Since his first major publication on the subject in 1958, Rhodes emphasised that changes in the average sea level involve three main categories of variables: the shape of the basins that contain the oceans; the volume of water in them; and local variations in land adjacent to the ocean basins.

During the 1980s Rhodes began to research the hypothesis already introduced into the scientific community that the movement of the Sun around the centre of mass of the solar system may have a role in shaping the Earth's climate. This motion, called solar inertial motion, is a result of the gravitational forces on the rest of the solar system tugging and dragging the Sun.[6] The Sun's barycentric motion was first demonstrated by Isaac Newton in 1687 in his *Principia Mathematica*. Newton (1687) showed that the sun is engaged in continual motion around the centre of mass of the solar system (i.e. the barycentre) as a result of the gravitational force exerted by the planets, especially Jupiter and Saturn.[7] He came to this conclusion analytically (not by observation) by working through the consequences of his law of universal gravitation. The sun is in free-fall around the barycentre as a result of planetary gravitational force.

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[5] See National Science Week article dated August 19 2005 Sea level changes give us an urgent message on the website of the University of New England: http://www.une.edu.au/news/archives/000327.html

[6] Detailed accounts of the history of this research and the development of Rhode's thinking can be found in the volumes edited by Michael Rampino et al and Charles Finkl in honour of Rhodes Fairbridge listed in Footnote 1; see also Mackey (2007).

[7] The theorem Newton proved is Proposition 12 Theorem 12: *The sun is engaged in continual motion but never recedes far from the common centre of gravity of all the planets*. Newton (1687), page 816.

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Astronomical Theories of Climate Change

During the late 1950s and early 1960s Rhodes began to explore the hypothesis that there might be a regular input of energy to the Earth of astronomical origin. According to this hypothesis, the many regular periodicities that are revealed in, for example, tree rings, ice cores, biota, rocks, sediments, sand dunes, beachridges, strandplains, geomagnetic records, glaciations, geology, geomorphology and the extensive layers of sediments that make the striking Hudson Bay varves, would require the same type of regular input of immense energy as that which drives the tides.[8] He considered that climate change was regulated by forces outside the normal terrestrial atmosphere and its dynamic systems.

Rhodes was one of the early advocates of the idea that the large scale episodes of major climate change had astronomical origins. In 1961 he spoke of Milankovitch's "elegant mathematical theory", drawing attention to its strengths and weaknesses, including some doubtful assumptions and conflict between evidence and prediction, which have only recently been addressed.[9]

By the 1960s geologists and other scientists had come to reject the Milankovitch hypothesis. This happened during the early 1950s as new techniques for dating the ice ages produced evidence that seemed to conflict with Milankovitch theory. This was in marked contrast to the attitude of geologists in the 1930s and 40s. Most European geologists came to accept the theory shortly after its publication in 1924.

It is interesting to note that Rhodes was an early champion of the ideas of the European geologist, Alfred Wegener, who in the 1920s had introduced the radical idea of continental drift.[10] Alfred Wegener and his father-in-law, the great German climatologist of the early 20th Century, Wladimir Koppen, were the first to accept the Milankovitch theory and actively promoted his ideas throughout the scientific world from 1924 onwards. They translated Milankovitch's original work, which was written in Serbian, and brought it to the attention of the European scientific community. Milankovitch had sent them a letter outlining his ideas. Much to his surprise, they accepted his theory enthusiastically and embraced him as a genius, which he probably was.[11]

When Rhodes was a young boy, Professor Nichols, the Professor of Zoology at the University of Western Australia, visited the Fairbridge family at their new village. Whilst showing the young Rhodes about the differences between millipedes and centipedes, he also excited Rhodes' imagination by telling him about Alfred Wegener and his exciting ideas of continental drift. This explained how closely related species

[8] "Varve" is Swedish for "layer" It is a pair of thin layers of clay and silt of contrasting colour and texture representing the deposit of a single year (summer and winter) in still water some time in the past. The word was introduced to the scientific lexicon by Baron Gerhard de Geer. His life's work was the original study of these sediments.
See http://www.todayinsci.com/cgi-bin/indexpage.pl?http://www.todayinsci.com/10/10_02.htm
[9] Fairbridge, (1961c).
[10] This information about Rhodes in this and the following paragraphs is derived from Finkl (1987).
[11] This historical account is based on Imbrie and Imbrie (1979).

that could not swim are found all across the Southern Hemisphere: they had been passengers on landmass life rafts that drifted around the globe.

Wegener had published in German two scientific papers about his continental drift theory in 1912 and a book *Die Entstehung der Kontinente und Ozeane*, with maps, in 1915. The idea stayed with Rhodes. Later in 1928 as a fourteen year-old he read J. G. A. Skerl's translation of Wegener, (*The Origin of Continents and Oceans* published in 1924) which made a great deal of sense to him. Rhodes became an enthusiast of Wegner's theories.

The consensus of the scientific establishment from 1912 until the early 1960s was that Wegener's ideas were "utter, damned rot" and were therefore passionately derided.[12] Rhodes was immune to this hostile consensus. According to Charles Finkl:

"In the 1940s, the distinguished economic geologist Blanchard once told Rhodes that his thoughts about continental drift should be kept to himself else he would never see a full professorship with tenure."

Charles added:

"At that time Rhodes had not made any discoveries that justified expressing these opinions, so the moral dilemma never arose."

As mentioned above, Rhodes publicly championed Wegner's continental drift hypothesis long before it became an integral part of the scientific canon, albeit modified by subsequent evidence and analysis.[13]

Rhodes recognised that the cycles of the Earth's glaciation and climate change showed some the patterns indicated by the Milankovitch theory. He had come to the view that the major periodic climate changes he could see in the geological and other records must have their origins outside the planet, just like the cycle of tides. He found that the Milankovitch cycles were about the right length to explain the sand ridges he and his colleagues found along the Australian coast line. He saw that there were other patterns for which the Milankovitch theory could not account. Since

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[12] Hughes (undated).

[13] There is a further Rhodes/Wegener connection via Curt Teichert, one of the world's most distinguished paleontologists, who was Rhodes' long time friend and mentor. In 1946 Rhodes was appointed to the geology lectureship at the University of Western Australia previously held by Curt who had been a friend of Alfred Wegener and had adventured with him on the Greenland ice cap in the 1920s. But Curt Teichert had not been with him on Wegener's last and fatal Greenland expedition in 1930 (Finkl (1987). That honour went to another Australian, Dr Fritz Loewe then a Senior Lecturer in Meteorology at Melbourne University. A party on the summer Greenland expedition had failed to return to the base camp and it was feared that they would have to winter over on the ice with insufficient provisions. Wegener, Loewe and an Inuit guide set off with provisions and finally met up with the party but not before Loewe had severe frostbite. As the party was safe and could winter on the ice, Wegener decided to return to base with his guide. The remainder of the party were to return in spring. Unfortunately Wegener and his guide perished on the return journey. When the bodies were recovered it was surmised that Wegener had had a heart attack (derived from Kininmonth (2007) and Hughes (undated)).

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recent research extends the theory of Milankovitch, the current theoretical framework is referred to more generally as an astronomical theory of climate change.

The astronomical theory of climate change indicates that the amount and distribution of the Sun's output received by the Earth would vary in relation to the orientation of the Earth to the Sun and the distance of the Earth from the Sun. Milutin Milankovitch's basic idea was that in the northern latitudes relatively warm winters would result in heavy snow falls and relatively cool summers would mean that the snow and ice of these winters would remain, only to be added to the next winter.

The theory in its most modern form explains that the Earth's orientation to the Sun varies over time frames of tens of thousands to hundreds of thousands of years because of variations in, and slow circular motion of, the tilt of the Earth's axis and the tilt in the Earth's orbital plane in relation to the Sun. The Earth's distance from the Sun varies because the shape of the Earth's orbit around the Sun varies from almost circular to slightly elliptical. Although the total amount of the Sun's output that the Earth receives from the Sun varies with the shape of the Earth's orbit, it is not so much the variations in total output that results in the large scale climate changes of the ice ages, but the variations in the distribution of this output during the year and in latitude that effects climate.

Recent research has established that several major nonlinear processes in the climate system are activated by the variations in the Earth's orbital parameters. These processes include feedback between temperature and the reflection of sunlight by snow, ice, water and vegetation; feedback between temperature and water vapour; interactions between the frozen and icy areas of the planet (the cryosphere), and the lithosphere, the solid outermost shell of the Earth, including the rocky shell on which the oceans lie, and the landmasses; and the impact of the height of the ice sheets and their distance from the ocean on their growth.

Rhodes looked for the type of regularity that controls the daily and annual motions of the Earth, the lunar orbit and the tides. This led him to explore the periodicities of the Sun, principally the sunspot cycles, as the source.

He found that Sir William Herschel, a Fellow of the Royal Society, who had discovered the planet Uranus in 1781, had, in 1801, published papers in the *Philosophic Transactions of the Royal Society* arguing that sunspot activity would result in climate change on the Earth and was related to the positions of the planets. Being a practical man, Sir William suggested that astronomers study the connection and use it to guide the planting of wheat and predict the price of wheat.

Other contributions to science

Rhodes Fairbridge contributed to many disciplines, especially to our understanding of the periodicities of climate change. Rhodes authored or edited more than 100 scientific books, including many text books and several scientific encyclopaedias and more than 1,000 scientific papers (Finkl 1987), which also contains an annotated bibliography of all of Professor Fairbridge's main publications to 1986. He was largely responsible for the establishment of several major scientific institutions and journals such as the Coastal Education and Research Foundation that, among other things, publishes the *Journal of Coastal Research*. He held many distinguished leadership positions in the international scientific community and has made many lasting contributions to science.[14] He was editor or co-editor of eight major encyclopaedias of specialised scientific papers, many of which he authored. The encyclopaedias have been in the following disciplines: oceanography; the atmospheric sciences and astrogeology; geomorphology; geochemistry and the earth sciences; geology; sedimentology; paleontology; and climatology. He was editor of the *Benchmarks in Geology* series, with more than 90 volumes in print and was the general editor of the *Fairbridge Encyclopaedias of the Earth Sciences*. These major productions have significantly advanced and systematised each of the specialised sciences.

Professor Emeritus Fairbridge had the honour of having three volumes of papers specially prepared to celebrate his life and work (Rampino, *et al* 1987), (Finkl, 1995), and (Finkl, 2005), in honour of his 70th, 80th and 90th birthdays respectively.

Throughout his long scientific career, Rhodes Fairbridge drew attention to a vast mass of scientific evidence about the periodicities of climate change. In 1957 he and Roger Revelle published the first scientific paper reporting the oceans' limited capacity to absorb Carbon Dioxide.[15] Rhodes Fairbridge showed that the periodicities are revealed in a rich variety of sources, including: geology; geomorphology; glaciations; sediments; sand dunes; beach rock; the circulation of the ocean; geomagnetic records; the records of the isotopes of carbon, oxygen, beryllium, chlorine and hydrogen in tree rings, ice cores, biota, rocks, air and water (Finkl 1987, 1995 and 2005).

Speak to the Earth, and it shall teach thee[16]

Australia has a living memorial, Fairbridge Village, to the noble creative goodness of the parents of Rhodes Fairbridge, who has shown the same creative goodness in his life. But it has not been directed at creating new and better opportunities for the

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[14] An account of these positions in contained in the papers by Charles Finkl about Rhodes Fairbridge in (Rampino et al., 1987), (Finkl 1995), and (Finkl 2005). Examples include President of the Shorelines Commission of the International Union for Quaternary Research (INQUA) (1961 to 1969); President of the INQUA Neotectonic Commission (1970 to 1974); leader of the joint geological-archaeological expedition in connection with the Aswan dam project and the UNESCO "Save the Monuments" campaign (1960-1961); co-founding editor of the *Journal of Coastal Research* and co-founding trustee of the Coastal Education and Research Foundation.

[15] Dr Revelle is generally recognised as the first scientist to bring the scientific community's attention to the likelihood of human activity generating quantities of Carbon Dioxide too large for the oceans, atmosphere, plants and animals to absorb with possibly adverse environmental consequences for the planet.

[16] Book of Job 12, 8 King James Version. Charles Finkl wrote that although Rhodes Fairbridge could not provide the solar physicists with the proofs they required about the relationship between solar inertial motion and solar activity (*qv* Mackey (2007), he always said to them that he trusted the rocks. For it is in the rocks that the records of the event about which he theorised is written. Charles Finkl noted that these words from the Book of Job are engraved in stone over the front door of Schermerhorn Hall University, Columbia University. Schermerhorn Hall contains the Department of Geology in which Rhodes served as professor since 1955 and as Emeritus Professor at the time he retired in 1982.

disadvantaged orphan children of industrial England. It has been directed at creating an enduring understanding of our environment, its ancient past and mysterious future. He has shown humbleness before nature that has enabled him to see beyond the narrow artificial boundaries of the disciplines and beyond the technically confined theorising of many of his predecessors and peers. Throughout his distinguished career he has challenged prevailing dogmas, creating novel but ultimately valid theories of phenomena that will not be tamed by the various specialised disciplines or technical scientific specialisations.

Rhodes and his many colleagues have outlined the elements of an explanation of many of the regularities of our environment based on the thesis that the solar system regulates our climate.

Rhodes expressed his hope that one day some scientists newly emerging in their careers might achieve a synthesis of the outline he helped to sketch. Perhaps the Intergovernmental Panel on Climate Change and a new generation of scientists will look with humility at nature, as Rhodes has done, will look out into the solar system, as Rhodes has done, and will, as Rhodes has done, *Speak to the Earth, and it shall teach thee*.

Hopefully, this paper has given readers a sense of that teaching.

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