Science and Catastrophism, from Velikovsky to the Present Day

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Abstract

In 1950, when the gradualist-uniformitarian paradigm was supremely dominant, as it had been throughout the previous one hundred years, a new catastrophist scenario was launched into the world by Immanuel Velikovsky, a Russian-born psychoanalyst, in *Worlds in Collision*. This immediately received a hostile reception from the academic establishment, with attempts being made to get the publication of the book withdrawn. Not only did it challenge the prevailing uniformitarian paradigm by proposing that global catastrophes had taken place in the relatively recent past, but it maintained that the causes had been extraterrestrial (an almost unthinkable concept at that time) and, furthermore, this was argued largely on the basis of myths and ancient writings. In addition, Velikovsky challenged well-established key beliefs in astronomy, physics, biology and ancient history, long after it had become generally accepted that, because of an explosion in the amount of information available, no-one could possibly be an expert in more than one subject area. Following on from that, it was supposed that only those who were specialists in a particular area were qualified to express views about topics within it, and Velikovsky, although well-educated, was not recognised as an expert in any of the areas covered in *Worlds in Collision*.

One scientist who was sympathetic towards Velikovsky was Albert Einstein, who had known him for many years. Although rejecting Velikovsky's proposed mechanism, which involved close encounters with Venus and other planets, Einstein was convinced by his arguments that there had been catastrophes of extraterrestrial origin. He emphasised to Velikovsky the importance of making correct predictions, which would not in themselves establish a scientific theory as being correct, but could play a significant part in the process. Velikovsky predicted that Jupiter would be found to emit radio waves, which was confirmed shortly before Einstein's death in 1955. A few years later, a statement in *Worlds in Collision* that the surface of Venus would be found to be hot was similarly confirmed. In 1962, *Science* published a letter from an astronomer and a physicist which pointed out Velikovsky's two successful predictions, both completely against expectations, and continued by saying that although the writers disagreed with Velikovsky's theories, they urged, in the light of this development, that his ideas be given objective consideration. During the 1960s, a number of statements and predictions by Velikovsky were confirmed, whereas others (sometimes but not always because he had accepted the orthodox view of his time) were refuted. Velikovsky had incorporated a range of theories within his complex scenario, so the fact that some of them could be seen, in the light of subsequent developments, to be incorrect did not mean that the rest could be discarded, or that because some of them turned out to be consistent with new evidence, there was justification for concluding that the entire scenario must be correct. The correct predictions did, however, provide a requirement for Velikovsky's overall scenario to be given an objective examination, regardless of the unorthodox nature of its formulation, but that failed to occur.

Up to this point, Velikovsky had operated as a lone individual. However, during the 1960s, the efforts of political scientist Alfred de Grazia in producing a special issue of the journal, *American Behavioral Scientist*, and then a book, *The Velikovsky Affair*, documenting the

unacceptable aspects of the reception given to *Worlds in Collision* and also the inherent difficulties faced by anyone trying to bring forward an interdisciplinary hypothesis in the 20th century, played a significant part in the creation of a Velikovskian movement. *Pensée*, the magazine of the Oregon-based Student Academic Freedom Forum, published a special series of 10 issues devoted to Velikovsky's ideas during the early 1970s, and there was a well-attended symposium in San Francisco in 1974 on the same theme, held under the auspices of the American Association for the Advancement of Science. This was unsatisfactory in the way it was conducted and in the way its presentations were reported, as acknowledged by conventional scientists, who nevertheless maintained that Velikovsky's theories had been considered and shown to be unsustainable.

This symposium proved to be a point of bifurcation for the Velikovskian movement. Some seized on the imperfections of the process to maintain that Velikovsky's scenario had emerged unscathed. Others acknowledged that there might have been justification in some of the criticisms expressed about component details of Velikovsky's overall scenario. Modifications were suggested to overcome perceived problems, but difficulties continued to accumulate, as new findings came to light. Few aspects were rendered impossible, but many began to seem improbable.

Alternative scenarios therefore began to be proposed, arising out of Velikovsky's original ideas, but differing significantly in important details. Examples include the "Solaria Binaria" model of Alfred de Grazia and Earl Milton, the "Saturn theory" of David Talbott, Dwardu Cardona and Ev Cochrane, and the "coherent catastrophism" model of Victor Clube and Bill Napier.

Furthermore, conventional scientific views were becoming very different from what they had been when Velikovsky was writing *Worlds in Collision.* Mechanisms, including extraterrestrial ones, are now known to exist which could have caused major catastrophes on Earth. Also, as suggested by Velikovsky, electromagnetic forces are now seen to be far more important within the Solar System and its surroundings than previously supposed. Investigations of Venus have shown it to be nothing like the "sister planet" of the Earth envisaged during the 1950s, and have revealed a number of anomalous features. More widely, ongoing investigations of large-scale aspects of the Universe and of sub-atomic structure are demonstrating unequivocally the serious limitations of the current state of our knowledge and understanding.

Two conclusions seem to stand out. One is that, to address this complex situation, ways need to be found to encourage interdisciplinary research into the various issues. The funding and reporting systems operating in each specialist area work perfectly well in the majority of situations, but are not geared to cope with interdisciplinary study, which is where most major breakthroughs are likely to occur. The other conclusion is that evidence for global catastrophes of extraterrestrial origin, at least in the prehistoric past, is now incontrovertible, even though the effects are often downplayed (for psychological as much as for scientific reasons). In the more recent past, similar considerations apply, although the evidence for an extraterrestrial catastrophe is not so clear-cut. There is reason to suppose that significant natural catastrophes occurred during the period considered in *Worlds in Collision*, although not on the scale suggested by Velikovsky, and even more reason to suppose that major catastrophes had taken place over the previous 10,000 years. However, opinions differ as to likely cause of each of the catastrophic episodes.

Whatever views, positive or negative, may be held about particular aspects of Velikovsky's theories, the general advice he offered to an audience of graduate students in 1953 remains completely valid sixty years later: "What I want to impress upon you is that science today, as in the days of Newton, lies before us as a great uncharted ocean, and we have not yet sailed very far from the coast of ignorance...The age of basic discoveries is not yet at its end, and you are not latecomers, for whom no fundamentals are left to discover...I visualize some of you, ten or twenty or thirty years from now, as fortunate discoverers, those of you who possess inquisitive and challenging minds, the will to persist, and an urge to store knowledge. Don't be afraid to face facts, and never lose your ability to ask the questions: Why? and How? Don't be afraid of ridicule; think of the history of all great discoveries...Therefore, dare...Don't persist in your idea if the facts are against it; but do persist if you see the facts gathering on your side...In science, unlike religion, the great revelations lie in the future; the coming generations are the authorities; and the pupil is greater than the master, if he has the gift to see things anew. All fruitful ideas have been conceived in the minds of the nonconformists, for whom the known was still unknown, and who often went back to begin where others passed by, sure of their way. The truth of today was the heresy of yesterday. Imagination coupled with scepticism and an ability to wonder – if you possess these, bountiful nature will hand you some of the secrets out of her inexhaustible store. The pleasure you will experience discovering truth will repay you for your work; don't expect other compensation, because it may not come. Yet, dare."

Introduction

Since this conference is being held on Naxos, a Greek island with strong echoes of the past, the place where, according to tradition, Ariadne was abandoned by Theseus and rescued by the god Bacchus, it seems appropriate to begin this contribution by quoting the final words of "Ode on a Grecian Urn" by the 19th century poet, John Keats:

"Beauty is truth, truth beauty, - that is all ye know on earth, and all ye need to know."

Staying with the same theme, let us move rapidly forward to a professorial lecture I introduced in Nottingham in February 2000. The lecture was given by a mathematician, Dave Applebaum, now of Sheffield University, who began by saying that his aim was to demonstrate the intriguing relationship between beautiful mathematics and physical applications, using Paul Dirac's equation for relativistic electrons as a case study. He went on to say that Dirac, a Nobel laureate, knew immediately that the equation he had formulated must be correct because it looked so beautiful (Applebaum, 2000).

Again, in the field of molecular biology, clues about the structure of DNA, the main component of genes, had been provided by analytical chemistry and X-ray crystallography, but the actual details were determined by James Watson and Francis Crick using a process of model-building. Watson and Crick were awarded the Nobel prize for showing that DNA had a double-helix structure, and the beauty of the double-helix was a significant factor in convincing them about the validity of their conclusions (Crick, 1990).

However, beauty is not always a guarantee of scientific truth. In one of his essays, the 19th century biologist, Thomas Huxley, referred to "the great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact" (Huxley, 1893-4).

An example of this is the demise of the theory supported by most of the scientific catastrophists of the 19th century, that of Léonce Élie de Beaumont. On the basis of observations made during geological fieldwork, Élie de Beaumont proposed that, if, as generally supposed at the time, accepting the scenario proposed by the dominant naturalist of the previous generation, the Comte de Buffon, the Earth had been gradually cooling since its formation, natural shrinkage would have given rise to episodic large-scale disruptions of the crust. During each of these intermittent upheavals, mountain-building would have taken place because of 'wrinkling' of the Earth's crust, volcanoes would have erupted in many areas, some former continental regions would have been flooded by sea-water, and many species would have become extinct. It was a beautiful hypothesis, because of the grandeur and plausibility of its overall vision, but, unfortunately, further investigations showed that mountain-building had generally been a localised, not a world-wide, process, and unrelated to episodes of species-extinction (Hallam, 1989, pp. 40-41, 56-57; Huggett, 1997, pp. 71-72, 84, 133). With the collapse of this theory, and the failure to find a replacement of similar persuasive power, catastrophism became marginalised and widely dismissed as "unscientific" during the latter part of the 19th century and much of the 20th (Hallam, 1989, pp. 52-60; James and Thorpe, 1999, pp. 5-6; Palmer, 2003, pp. 55-59).

That was the context into which Immanuel Velikovsky introduced another powerful, wide-ranging catastrophist vision, seventy years after the death of Élie de Beaumont.

Origins of Velikovsky's catastrophist theories

The circumstances were quite remarkable. In April 1940, Velikovsky, a well-educated 45-year-old, who had been born in Russia into a prosperous Jewish family, was in the library of Columbia University, New York, shortly after starting what was intended to be a brief sabbatical from his work as a psychoanalyst in the state now known as Israel. He was intending to write a book about Sigmund Freud and his heroes, addressing ideas raised by Freud in his last work, *Moses and Monotheism*. Looking for material for a chapter about Moses, Velikovsky searched for an Egyptian source that described the same catastrophic events as the book of *Exodus* in his own faith, and came across one that seemed to meet the requirements – the *Admonitions of Ipuwer*, translated in a publication by Alan Gardiner. As noted by Gardiner, it was generally agreed on stylistic grounds that this had been written during the Egyptian Middle Kingdom, which led Velikovsky to place the Israelite exodus from Egypt within the chaotic period at the end of the Middle Kingdom, just before the fall of the 13th Dynasty to Hyksos invaders, identifying these Hyksos as the Amalekites said to have been encountered by the escaping Israelites. Velikovsky was aware that the traditional date of the Exodus derived from time-spans given in the Hebrew Bible (the *Old Testament* of the Christian Bible) was *c.* 1450 BCE, whereas orthodox Egyptologists placed the end of the Middle Kingdom about two centuries earlier than that date, and the Exodus itself (if there had actually been such an event, which many doubted) at *c.* 1250 BCE, during the New Kingdom. Hence Velikovsky realised that his key linkage between Egyptian and Hebrew history, if correct, necessitated a complete revision of Egyptian chronology from the Middle Kingdom onwards. According to his own testimony, he had formulated the broad outlines of this revised chronology by the summer of 1940 (Velikovsky, 1983, pp. 27-37).

In October of the same year, Velikovsky happened to read a passage in the book of *Joshua* (chapter 10) which stated that large stones fell from the sky, after which the Sun stood still for several hours. The thought struck him that if, as with the Exodus catastrophes, this was a description of something that had actually occurred, then it should have been described in

other sources from around the world. Velikovsky soon found references to passages in Mayan documents which described a similar catastrophe, in which debris fell from the skies and the world burned, while the Sun stood still on the horizon. Indeed, a series of catastrophes was mentioned, two of which were 52-years apart, as were (in approximate terms) the Exodus and the event described in *Joshua*. The Mayan sources associated the catastrophes with names generally identified with the planet Venus, with some of them referring to comet-like characteristics, and indicating that the series of catastrophes began when this object first appeared in the sky. On this basis, Velikovsky formulated the theory that Venus was not one of the original planets of the Solar System, but appeared in recent times as a large comet, and went on to have a series of close encounters with the Earth at approximately 52-year intervals, affecting the rotation of our planet, striking it with electrical discharges and giving rise to showers of rocks when the Earth passed through its cometary tail. Then, from information obtained from other ancient sources over the following 18 months, Velikovsky concluded that Venus went on to have close encounters with both Mars and our Moon, before moving into the almost circular orbit around the Sun which it has today. As a consequence of these encounters, Mars regularly threatened the Earth during the 7th and 8th centuries BCE, the final occasion being in 687 BCE, after which Venus, Mars and the Earth settled into their present orbits, keeping them well apart (Velikovsky, 1983, pp. 38-43).

To establish his priority for these ideas, Velikovsky wrote a 9-page summary of them in November 1942 and attempted to have this accepted for secure keeping by the National Academy of Sciences in Washington. He pointed out that his detailed arguments for a revised chronology were ready for printing, under the title, *A Chimerical Millennium*, and a draft of his arguments for cosmic revolutions, bearing the title, *Worlds in Collision*, had also been written. Velikovsky's summary noted that the first encounter between the Earth and the planet/comet Venus had occurred in the 15th century BCE, expanding the orbit of the Earth from one similar to that of Venus today, changing the direction and speed of the Earth's rotation, and also bringing about a north-south reversal. The Earth's year, previously consisting of 260 days, became one of 360 days, and. since the Moon's orbit had also been affected, the length of the month increased from 20 days to 36. The next encounter, 50-52 years later, caused the Earth to stop rotating for a short time, but had no permanent effects. Later, the close encounter with Mars in 687 BCE brought about a change in the Earth's orbit and the angle of inclination of the terrestrial axis. The Earth's year shifted from 360 to 365¼ days, and there was a reduction in the Moon's orbital period from 36 to 29 days. Furthermore, before this succession of events, according to Velikovsky's interpretation of ancient sources, the Earth had suffered previous catastrophes as a result of close encounters with Saturn and then Jupiter, the former causing a great deluge. Velikovsky then went on to devote the final few pages of this summary of his ideas to a series of claims that the way the planets had behaved demonstrated that there was no such phenomenon as gravitation, Newton's mathematical arguments being fallacious. In his view, electrical or electromagnetic forces were responsible for all the attraction and repulsion occurring between bodies within the Solar System, suggesting parallels between this and the nucleus/electron system of an atom. The curator of the Academy refused to accept the document, because there was no precedent for the acceptance of a statement whose purpose was to establish intellectual priority. Velikovsky therefore sought to establish his intellectual ownership of his ideas in a different way, by means of a legal affidavit signed in December 1942, to which his statement was attached (see http://www.varchive.org/ce/affidavit.htm).

Velikovsky decided to remain in America, developing his theories about chronological revisions and cosmic catastrophes. He self-published two detailed summaries, *Theses for the*

Reconstruction of Ancient History (1945) and *Cosmos without Gravitation* (1946), sending copies to libraries and to prominent scholars (Velikovsky, 1983, pp. 165, 319-320). In *Cosmos without Gravitation,* Velikovsky extended the arguments he had made in the final pages of his 1942 summary. He referred to an association between sunspots and the Sun's magnetic field, but that was uncontroversial, because it had been demonstrated in 1908 by the American astronomer, George Hale. Other claims, however, were contemptuously dismissed by some readers of the document (http://www.varchive.org/cor/affair/500220shatha.htm).

Velikovsky stated that, contrary to what was generally supposed, the Sun carried a net negative electrical charge relative to the Earth, and all the other Solar System planets similarly carried a net electrical charge. He continued: "the sun is an electromagnet; planetary motion is due to the electromagnetic force exerted on the planets by the sun. The planets as charged bodies create magnetic fields by their rotation. It follows that (a) gravity, depending on electrical charge, varies with the charge; (b) the masses of planets are inaccurately calculated...". If that message was in any way unclear, Velikovsky went on to reiterate, "'Universal gravitation' is an electromagnetic phenomenon, in which the charges in the atoms, the free charges, the magnetic field of the sun and the planets play their parts" (http://www.varchive.org/ce/cosmos.htm).

The notion that there could be some link between gravity and electromagnetism was not in itself controversial. In 1850, the eminent physicist, Michael Faraday, had written, "The long and constant persuasion that all the forces of nature are mutually dependent, having some common origin, or rather being different manifestations of one fundamental power, has often made me think that on the possibility of establishing, by experiment, a connection between gravity and electricity..." He noted that he had tried to find such a link, but although so far unsuccessful, his view on its possibility remained unchanged (Faraday, 1855).

Later, after Albert Einstein had blended his theory of special relativity with Newton's law of universal gravitation in 1916 to form the theory of general relativity, be began attempts to formulate a Unified Field Theory which could bring together general relativity and electromagnetism (Einstein, 1950; Einstein, 1956; Porter, 1994). Efforts to develop an all-encompassing theory of this nature continued after Einstein's death in 1955. There was thus no controversy about the possibility of developing a unified theory that could encompass both gravitation and electromagnetism, but Velikovsky was claiming that gravitation was simply an electromagnetic phenomenon, influenced by electrical charges, which was a significantly different concept.

Reactions to the publication of Velikovsky's catastrophist scenario

The first complete book by Velikovsky to appear in print was *Worlds in Collision,* published in New York by Macmillan in 1950. This captured the imagination of the general public, and quickly became the national number-one best-seller (Velikovsky, 1983, p. 113). The response from professional scientists was considerably less positive, despite some actions taken by Velikovsky to try to minimise controversy.

The book as published began with two chapters in which Velikovsky argued in general terms that the Earth had suffered global catastrophes of cosmic origin in the past, before going on to discuss his theories about cataclysmic episodes involving Venus and Mars. He had accepted advice to keep things as simple as possible and leave discussion of earlier catastrophes involving Saturn and Jupiter until a later book, merely alluding to these when saying that

Venus had been ejected as a comet from Jupiter (Velikovsky, 1983, p. 64). Again, he responded to the antagonistic reaction of some physicists to his *Cosmos without Gravitation* paper by deleting a chapter on this subject intended for the Epilogue of his book, particularly because he had no quantitative solution to offer to the questions he had raised about the conventional view of celestial mechanics (Velikovsky, 1983, pp. 76-79). Although he wrote in the Preface - "Harmony or stability in the celestial and terrestrial spheres is the point of departure of the present-day concept of the world as expressed in the celestial mechanics of Newton and the theory of evolution of Darwin. If these two men of science are sacrosanct, this book is a heresy" – he nevertheless maintained in the Epilogue: "The theory of cosmic catastrophism can, if required to do so, conform with the celestial mechanics of Newton". Nevertheless, as has been well-documented, there was a hostile response to the work from a significant number of astronomers and physicists, some of whom were happy to acknowledge that they were basing their views on second-hand reports, not having taken the trouble to read the book themselves. Attempts were also made to suppress its publication, these being largely coordinated by Harlow Shapley, Director of the Harvard Observatory (Velikovsky, 1983, pp. 80-135; Juergens, 1978a; Scranton, 2012, pp. 29-33).

On the other hand, a few eminent scientists, whilst remaining unconvinced about some of Velikovsky's key proposals, found much to admire in his work, and wanted it to be given serious consideration. One of these was Einstein, who had known Velikovsky since the 1920s, and now lived close to him in Princeton, New Jersey. After reading a draft of *Worlds in Collision*, Einstein wrote to Velikovsky in July 1946 to say (when translated from the German), "There is much of interest in the book which proves that in fact catastrophes have taken place which must be attributed to extraterrestrial causes. However, it is evident to every sensible physicist that these catastrophes can have nothing to do with the planet Venus..." (http://www.varchive.org/cor/einstein/460708ev.htm).

A few years after the publication of *Worlds in Collision*, Velikovsky was putting the finishing touches to *Earth in Upheaval*, which he was writing in order to provide detailed geological evidence of global catastrophes, and he asked Einstein for his comments on the typescript drafts of chapters VIII-XII. Einstein wrote to Velikovsky in May 1954, giving constructive criticisms, and also remarking that Shapley's behaviour with regard to *Worlds in Collision* had been inexcusable, adding that it was typical of "the intolerance and arrogance together with brutality which one often finds in successful people, but especially in successful Americans." Einstein then went on to indicate that his own views on Velikovsky's theories had changed very little over the previous eight years, writing, "I can say in short: catastrophes *yes*, Venus *no*" (http://www.varchive.org/cor/einstein/540522ev.htm).

Earth in Upheaval was published in New York by Doubleday in 1955. (The publication of Velikovsky's books had been transferred from Macmillan to Doubleday because of Shapley's threat of an academic boycott. Doubleday, unlike Macmillan, had no textbook division.) As a supplement to this book, Velikovsky gave a revised version of an address entitled *Worlds in Collision in the Light of Recent Finds in Archaeology, Geology, and Astronomy*, which he had delivered to the Graduate College Forum of Princeton University in October 1953. In this address, Velikovsky had said, "In Jupiter and its moons we have a system not unlike the solar family. The planet is cold, yet its gases are in motion. It appears probable to me that it sends out radio noises as do the sun and the stars. I suggest that this be investigated."

In June 1954, in a letter to Einstein, Velikovsky wrote, "Of course, I am a heretic, for I question the neutral state of celestial bodies. There are various tests that could be made. For

instance, does Jupiter send radio-noises or not? This can easily be found, if you should wish" (http://www.varchive.org/cor/einstein/540616ve.htm). Einstein took no action but, by chance, early in 1955, astronomers Bernard Burke and Kenneth Franklin of the Carnegie Institution, who were scanning the sky in random fashion, searching for radio noises from faraway galaxies, unexpectedly found a strong signal coming from Jupiter. This was reported at the spring meeting of the Astronomical Society in Princeton. Very soon afterwards, in April 1955, Velikovsky pointed out the finding to Einstein, who was clearly embarrassed about the situation, particularly because he had stressed at their previous meeting the importance for its ultimate acceptance of a scientific theory being able to generate correct predictions, so he asked what experiment Velikovsky would like to have carried out next. Perhaps surprisingly, Velikovsky opted for radiocarbon tests to check his reconstruction of ancient history, and Einstein assured him that these would be arranged (Velikovsky, 1983, pp. 289-295; see also http://www.varchive.org/bdb/meeting.htm). However, a few days later, Einstein died from the rupture of an aortic aneurysm. A copy of the German edition of *Worlds in Collision* was found lying open on his study table (http://www.varchive.org/bdb/week.htm).

Tests of Velikovsky's theories

Velikovsky was very anxious for proper academic scrutiny to be given to the array of theories making up his overall scenario (this scenario, although having a unifying vision, being far too complex to be regarded as a single theory), and he saw prediction (which he preferred to call prognostication) as a key part of that process. Einstein's remark that an important test of a scientific theory was its ability to generate correct predictions was of course valid, but it may be useful at this point to explain in a little more detail the principle Einstein was referring to, and also place it in context. Criteria of specificity, relevance and discriminatory power all have to be taken into consideration. To be of particular value, a prediction should be worded in very specific terms, should be clearly derived from key aspects of a theory, and should be capable of discriminating between that theory and others. If such a prediction proves to be correct, it doesn't mean that the theory must be correct, but it provides a good reason for giving it serious consideration, in the light of all available evidence.

It can never be said that a scientific theory has been proved to be correct, only that it provides the best explanation of the totality of the evidence at a particular time. On the other hand, a scientific theory can be disproved if it can be shown to be inconsistent with one or more significant pieces of evidence. Reflecting that, the philosopher Karl Popper said that a theory could only be regarded as a scientific one if it was capable of being tested and shown to be false, should that be the case (Popper, 1959). Even so, it is rare for a theory to be categorically disproved. Often, rival theories co-exist, with individual judgements being made about which best fits the totality of the evidence.

In the situation where a particular theory has become well-established and achieved the status of a paradigm, it ought to be the case, in an ideal world, that if a new, alternative theory is formulated, then the new and the old theories are compared against the evidence in objective fashion, and if the new one is seen to provide the best fit against the evidence as a whole, a paradigm shift takes place. However, our world is peopled by human beings, with human failings, so the reality is somewhat different. Commitment to a particular paradigm can make a truly objective assessment of the evidence difficult, so, as pointed out by philosopher Thomas Kuhn, a paradigm can have a restraining influence on thought, resulting in a long period of stasis. Fine details might be modified on a regular basis, but the larger picture remains essentially the same, with anomalous facts being ignored and allowed to accumulate,

perhaps until a new generation appears and looks at the situation with fresh eyes (Kuhn, 1962). The renowned German physicist, Max Planck, took a similar view, writing, "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it" (Planck, 1949). Thus, a new theory might be correct yet still struggle for a long time to make progress towards general acceptance. However, it cannot be assumed that the failure of a particular new theory to make progress is solely due to the constraining influence of the existing paradigm. It might simply be incorrect.

It is particularly difficult to assess how Velikovsky fits into this picture, because he was in effect a throw-back to the natural philosophers of the 18th century, such as Buffon (mentioned previously) and his protégé Lamarck, who had the misfortune to outlive his time. These assembled all-encompassing scenarios, or "cosmogonies", on the basis of the limited amount of knowledge then available, including inputs from religion and mythology, and looked for evidence to support them. As the knowledge-base snowballed during the 19th century, the French catastrophist, Georges Cuvier, established the belief that this philosophical, generalist approach was no longer meaningful, destroying his gradualist rival, Lamarck, in the process. Then, with Cuvier's principles being carried forward into the English-speaking world by Thomas Huxley and John Tyndall, science soon separated from religion and became fragmented into academic disciplines, placing evidence before theory (Corsi, 1988; Desmond, 1998; Palmer, 2003, pp. 9-32, 67-75). Velikovsky now seemed to be trying to revert to the approach of the cosmogonists. However, regardless of approach, everything should be viewed in the light of the evidence.

Even after the death of Einstein, Velikovsky still had some influential friends within the scientific community, in particular Harry Hess, head of the department of geology at Princeton University. Hess could not accept the scenario being proposed by Velikovsky, but considered his arguments to be of great interest, and offered to help get some of his theories tested. With the International Geophysical Year approaching, Hess agreed to put some proposals to the committee on Velikovsky's behalf, since an approach by Velikovsky himself was unlikely to be successful. Velikovsky's number one proposal was: "Measurement of the strength of the terrestrial magnetic field above the upper layers of the ionosphere. It is accepted that the terrestrial magnetic field – about one-quarter of a Gauss at the surface of the earth – decreases with the distance from the ground, yet the possibility should not be discounted that the magnetic field above the ionosphere is stronger than at the earth's surface" (Velikovsky, 1972). That followed on from comments Velikovsky had made in the supplement to *Earth in Upheaval*, mentioned previously, where he wrote: "It is generally thought that the magnetic field of the earth does not sensitively reach the moon. But there is a way to find out whether it does or not. The moon makes daily rocking movements - librations of latitudes, which are explained by no theory. I suggest investigating whether these unaccounted librations are synchronized with the daily revolutions of the magnetic poles of the earth around its geographical poles". The committee agreed to carry out tests, as part of the International Geophysical Year programme, to see if the Earth's magnetic field permeated beyond the ionosphere, but in fact it was other tests which indirectly provided evidence of such a field. Geiger counters were placed on board the *Explorer 1*, *Explorer 3* and *Pioneer 3* rockets in 1958 to enable James Van Allen investigate cosmic rays, and these showed that there were two belts of energetic charged particles (subsequently known as the Van Allen belts) around the Earth beyond the ionosphere, apparently held in place by the Earth's magnetic field (Velikovsky, 1983, pp. 324-325). The outer belt stretched 60,000 km into space, one-sixth of the distance to the Moon. Evidence that the Earth's magnetosphere

reached all the way to the moon was eventually obtained in 1964, when Norman Ness of the Goddard Space Center installed a magnetometer in the IMP-I spacecraft (Ness, Scearce and Seek, 1964).

In *Cosmos without Gravitation*, Velikovsky had written that the Sun possessed a net negative electrical charge, but that view was generally dismissed. However, in 1960, physicist Victor Bailey of the University of Sydney noted in the journal, *Nature*: "It has been found possible to account for the known orders of magnitude of five different astronomical phenomena...by the single hypothesis that a star like the sun carries a net negative charge" (Bailey, 1960). Over the next few years, Bailey reported that measurements of interplanetary magnetic fields by the space probes *Pioneer 5, Explorer 10, Explorer 12* and *Mariner 2* verified predictions made on the basis of the hypothesis that the Sun carried a large net electrical charge (Bailey, 1963; Bailey, 1964). Sadly, Bailey died in 1964, on a journey to the United States to carry out further tests on his hypothesis.

Another development came in 1961, when American radio-astronomers found the surface temperature of Venus to be around 600ºF (Velikovsky, 1983, pp. 332-333). In a section entitled 'The Thermal Balance of Venus', towards the end of *Worlds in Collision*, Velikovsky had written, "Venus experienced in quick succession its birth and expulsion under violent conditions; an existence as a comet on an ellipse which approached the sun closely; two encounters with the earth accompanied by discharges of potentials between these two bodies and with a thermal effect caused by conversion of momentum into heat; a number of contacts with Mars and probably also with Jupiter. Since all this happened between the third and the first millennia before the present era, the core of the planet Venus must still be hot." Velikovsky didn't specify exactly what he meant by "hot", but was clearly suggesting that Venus must be significantly hotter than generally supposed. At that time, it was generally considered that the surface temperature of Venus was only marginally higher than the average surface temperature on Earth, significantly less than 100ºF. In 1940, astronomer Rupert Wildt noted in the *Astrophysical Journal* that carbon dioxide had recently been detected in the atmosphere of Venus, and went on to argue that the surface temperature of Venus was therefore likely to be more than 200ºF because of a carbon-dioxide greenhouse effect (Wildt, 1940), but that remained a minority view until the 1961 observations.

A joint letter from Princeton University physicist Valentine Bargmann and Columbia University astronomer Lloyd Motz was published in the journal *Science* in December 1962. This began, "In the light of recent discoveries of radio waves from Jupiter and of the high surface temperature of Venus, we think it proper and just to make the following statement". They then documented the statements made by Velikovsky which anticipated these two findings, and also mentioned what had happened prior to the discovery of the Van Allen belts. The letter concluded, "Although we disagree with Velikovsky's theories, we feel impelled to make this statement to establish Velikovsky's priority of prediction of these two points and to urge, in view of these prognostications, that his other conclusions be objectively re-examined" (Bargmann and Motz, 1962).

Hess took a similar line to Bargmann and Motz, writing to Velikovsky in March 1963 to say, "We are philosophically miles apart because basically we do not accept each other's form of reasoning – logic. I am of course quite convinced of your sincerity and I also admire the vast fund of information which you have painstakingly acquired over the years. I am not about to be converted to your form of reasoning though it certainly has had successes. You have after all predicted that Jupiter would have a high surface temperature, that the sun and other bodies

of the solar system would have large electrical charges and several other such predictions. Some of these predictions were said to be impossible when you made them. All of them were predicted before proof that they were correct came to hand. Conversely I do not know of any specific prediction you made that has since been proven to be false. I suspect the merit lies in that you have a good basic background in the natural sciences and you are quite uninhibited by the prejudices and probability taboos which confine the thinking of most of us. Whether you are right or wrong I believe you deserve a fair hearing" (Velikovsky, 1972).

The irony was that a prediction by Velikovsky which soon turned out to be false was in an area in which Hess had a special interest. Hess was a strong supporter of the theory of continental drift, which was generally shunned by orthodox opinion at the time (Hellman, 1998), and Velikovsky went along with orthodoxy, trying, in *Earth in Upheaval*, to explain phenomena such as the formation of the Himalayas in ways that ignored the possible involvement of colliding continents. In chapter VIII of this book he wrote, "The land masses of today do not change their latitudes; the motive force claimed is insufficient by far. Coal beds in Antarctica and recent glaciations in temperate latitudes in the Southern Hemisphere all conspire to invalidate the theory of wandering continents." In a letter to René Gallant (of whom more later) written on 29 October 1962, Velikovsky predicted, "The Mohole project will probably bring disappointment to the firm believers in Isostasy, and together with it, to hypothesizers of continental drift...". In fact, before the end of the decade, evidence had arisen which led to the acceptance of continental drift, and the realisation that mountain ranges such as the Himalayas had been formed as a consequence of collisions between continental plates. Similarly, it became apparent that the drifting of some land-masses towards the equator had given misleading indications that the magnetic poles were once far away from where they are now (such indications having been taken by Velikovsky as supporting evidence for his arguments that axial tilts had occurred during some episodes of global catastrophe). Eventually, tests showed clearly that some continents were moving relative to others at around ten centimetres per year (Stanley, 1986; Hallam, 1989, pp. 135-183; Redfern, 2000). Velikovsky was of course aware of this change of thinking, and when *Earth in Upheaval* was republished in 1977, he tried to make the best of the situation by writing a new Introduction, which included the sentence, "My position on continental drift was (and is) intermediate between those who reject this concept and those who support the idea." However, he couldn't un-write what he had previously written.

As with continental drift, Velikovsky similarly went along with the orthodox view of his time that impacts by asteroids posed a negligible threat to life on Earth. It was thought that impact craters should be oval in shape, indicating the direction of approach of the bolide, whereas, apart from a few of very small size, all the craters found at the surface of the Earth were circular, and contained no buried meteorites. On that basis, despite the finding of a few meteorite fragments in the vicinity, the well-known Barringer crater in Arizona was thought to have been formed by an explosion linked to volcanic activity. Similarly, the craters observed on the surface of the Moon were circular, so were generally believed to be of volcanic origin (Lewis, 1996; Steel, 2000, pp. 28-53; Palmer, 2003, pp. 135-137). This issue was raised in exchanges of correspondence between Velikovsky and René Gallant referring to the work of the French archaeologist, Claude Schaeffer, who had found evidence of catastrophic destructions having occurred, often with indications of earthquakes and fire, at sites throughout the Middle East on several occasions during the Bronze Age. One of these was at the end of the Early Bronze Age, which coincided with the collapse of the Old Kingdom in Egypt, and another was at the end of the Middle Bronze Age, when the Egyptian Middle Kingdom collapsed (*Earth in Upheaval*, chapter XII). Velikovsky corresponded with

Schaeffer, and met him in Switzerland in 1957. As well as discussing catastrophes, he presented the Frenchman with a copy of *Ages in Chaos,* the first volume of his revision of ancient history, and he read it with interest (Velikovky. 1983, pp. 318-322). However, Schaeffer formed the view that Velikovsky's revised chronology, although not impossible, was improbable. Velikovsky commented to Gallant, "I do not regard my reconstruction as possible or probable but as correct" (Velikovsky, 1959).

Gallant, a Belgian engineer and amateur geologist, was much more positive than Schaeffer about Velikovsky's chronological revisions, but he disagreed with Velikovsky about the causal mechanism of the Bronze Age catastrophes. Velikovsky, in part IV of the unpublished *In the Beginning*, linked the catastrophes at the time of the collapse of the Egyptian Old Kingdom to the planet Jupiter (http://www.varchive.org/itb/zedek.htm), and, as mentioned previously, in *Worlds in Collision* he linked the catastrophes at the time of the collapse of the Egyptian Middle Kingdom to the planet Venus, and later ones to the planet Mars, with accompanying falls of asteroids (bolides) contributing a little additional misery. However, Gallant considered it more likely that asteroid impact was the primary cause of these catastrophes. In a letter to him dated 29 July 1962, Velikovsky wrote with polite displeasure, "But with the bolides – one of the phenomena in the great catastrophes – and the only important one in your understanding of them – we have a wall between us higher than the wall of Jericho before it fell. At least would you have considered yourself as my opponent, but you insist on regarding yourself as my follower. As to *Ages* I accept you as such, but I disclaim you when the subject of worlds and Earth are considered." Gallant's book proposing asteroid impacts as a cause of major catastrophes, *Bombarded Earth*, was published in London by John Baker in 1964, but it received very little attention. It seemed an unlikely scenario to almost everyone.

Associating himself with what at the time was the orthodox view, Velikovsky had written to Gallant on 10 February 1960 to say, "You write that you are presently occupied with the problem of the catastrophic past of the earth, and you look for formations similar to those on the moon. Although hitting of the moon by large meteorites of the size of asteroids speaks for the catastrophic theory, I am more inclined to believe that the moon formations arose in a bubbling activity; the circular form of the formations requires a belief that the meteorites fell all perpendicularly from all directions, otherwise there would be oval formations, unless the meteorites exploded close to the lunar ground, never hitting the ground itself; but then we need to assume a rather dense atmosphere on the moon." However, before the end of the decade, the general belief in such a view was destroyed by the work of geologists such as Gene Shoemaker. These, by detailed examination of terrestrial sites, coupled with simulation experiments, demonstrated that most craters at the surface of the Earth had been caused by explosions arising from extraterrestrial impacts. A bolide large enough to pass through the atmosphere without being slowed down to any great extent would explode as it hit the ground, the resulting crater being formed by the explosion and not by the actual impact, so it would be circular and much larger in diameter than the impacting body (Albritton, 1989; Heide and Wlotzka, 1995; Lewis, 1996). On the moon, the lack of an atmosphere would help, not hinder, this process, so almost all lunar impacts would result in explosions and hence the formation of circular craters. Calculations have shown that the 1.2 km diameter Barringer crater (now also known as Meteor Crater) in Arizona was produced by an asteroid whose diameter as it reached the Earth's surface was less than 100 metres, yet the collision released energy equivalent to 2.5-25 megatons of TNT (depending on the velocity of impact), 150-1,500 times greater than the explosion of the atomic bomb over Hiroshima in 1945 (Lewis, 1996; Steel, 2000, pp. 52-53; Melosh and Collins, 2005).

So, asteroid impacts had the potential to devastate cities and entire regions, but of course it did not follow that they actually *had* caused the apparent catastrophic destructions of the Bronze Age. No impact crater of any significant size could be dated to that period, the Barringer crater being assigned a date tens of thousands of years earlier. Larger craters indicating impacts powerful enough to cause devastation on a world-wide scale were found dating from even earlier periods, but it was believed that even these had produced little effect on the course of life on Earth. Although the fossil record seemed to show that there were times when mass extinctions of species had taken place, this was dismissed by some as a geological artefact. Regardless of that, the prevailing gradualist-uniformitarian paradigm remained untroubled, the view being taken throughout the 1960s and beyond that the same Darwinian processes had operated, in the same way, throughout the course of evolution, and as conditions gradually fluctuated, it was inevitable that there would be times when the turnover of species was greater than at other times (Mayr, 1970; Stebbins, 1982; Palmer, 2003, pp. 133-134, 146-148). We started with a quotation from Keats, and a passage from his poem *Hyperion* is appropriate here: "So on our heels a fresh perfection treads, a power more strong in beauty, born of us and fated to excel us...for 'tis the eternal law that first in beauty shall be first in might." Keats was writing about the overthrow of the Titans by the Olympian gods in Greek mythology, but his words provide a good description of traditional Darwinian evolution, if "beauty" is taken to mean a harmonious adaptation to the environment. A similar view was taken of events which took place during the historical period, for it was generally believed that, despite the findings of Schaeffer, civilisations came to an end not because of sudden natural catastrophes but as a result of gradually changing circumstances, or because of conquest by an invading army, or a combination of the two (James and Thorpe, 1999, pp. 2-6; Schoch, 1999; Palmer, 2003, pp. 119-120).

Another area where Velikovsky's claims were not substantiated by developing evidence was in regard to his belief that there was no such thing as gravitation, with Newton's formulation of the law of gravity being fallacious. In the document attached to his 1942 affidavit, Velikovsky wrote, "As the computation concerning the Moon caused Newton to postulate a general law concerning the whole solar system and the whole Universe, it, the law of gravitation is wrong in all its applications. Velocities and masses computed with its help are probably wrong in many instances." Einstein, in his theory of special relativity, had introduced modifications to Newton's laws of motion, but these only came into effect at velocities approaching the speed of light. Similarly, in his theory of general relativity, which linked special relativity to gravitation, he had introduced modifications to Newton's law of gravitation, but these only applied under conditions where gravitational fields were exceptionally strong (Bronowski, 1973; Matthews, 1992, pp. 157-159, 190-197; Porter, 1994). Otherwise, Newtonian mechanics, uniting Newton's laws of motion with his law of gravitations, were still considered valid, and this was demonstrated to be the case during the 1960s. In this decade, Russians and Americans alike had used straightforward Newtonian mechanics to direct spacecraft to other bodies within the Solar system and in some instances then bring them back to Earth. Examples included *Luna 9*, which made the first soft landing on the Moon in 1966, *Venera 4*, whose probe sent back information about the atmosphere of Venus as it parachuted through it in 1967, and *Apollo 11*, which made the first manned landing on the Moon in 1969 (Couper and Henbest, 1985; Moore, 1986; McNab and Younger, 1999, pp. 49-61, 170-172).

On the other hand, if Velikovsky was wrong to reject Newton's law of gravity in the way that he did in the 1942 summary of his ideas, his claim in the same document that electrical and

electromagnetic forces played a far greater role in the Solar System than generally supposed at that time can be seen to have much validity. So, for example, English physicists Edward Appleton and Stanley Hey demonstrated in 1946 that solar radio noise originates in the vicinity of active regions associated with sunspots, and they also found that sudden large increases in the Sun's radio output are associated with solar flares (Lang, 2009). Later, as already mentioned, the Van Allen belts were discovered around the Earth, consisting of energetic charged particles, i.e. plasma, held in place by a magnetosphere which stretched far into space. Also, albeit in more indirect and inconclusive fashion, Bailey, in an attempt to explain certain astronomical observations, had put forward the hypothesis that the Sun carried a large net electrical charge and, on the basis of this, made predictions about interplanetary magnetic fields which were consistent with measurements made by subsequent space probes.

So, by the 1960s, an objective assessment of the situation would have to be that Velikovsky had sometimes been wrong in company with the orthodox scholars of his time, and sometimes wrong in opposition to them, but he had also made claims and predictions which turned out to be correct, completely against the expectations of most, or perhaps at times even all, professional scientists. Because of the wide range of theories which linked to form his overall scenario, the fact that some of them could be seen, in the light of subsequent developments, to be wrong did not mean that the rest could be discarded. Conversely, the fact that some of them subsequently turned out to be consistent with new evidence did not provide a justification for jumping to the conclusion that all of them must be correct. However, as Bargmann and Motz had argued in their letter published in *Science* in 1962, the correct predictions provided a strong reason for giving serious objective consideration to all aspects of Velikovsky's catastrophist model. Velikovsky followed this up by submitting a paper to *Science* which attempted to show that the points referred to by Bargmann and Motz were just a few of those now supported by independent research, but this was rejected for publication, whereas a facetious letter saying that "the accidental presence of one or two good apples does not redeem a spoiled barrelful" was printed. Velikovsky's attempts to provide a response to critical articles and reviews in other journals were similarly unsuccessful (Juergens, 1978a and 1978b). It was now the mid 1960s, 15 years or so after the publication of *Worlds in Collision*, and there had still been no proper debate about the book's contents.

Some belated progress

Although Velikovsky had sympathetic friends, including prominent scientists such as Einstein and Hess, he had, up to 1963, operated essentially as a lone individual. Then he came into contact with Alfred de Grazia, who at that time was Professor of Social Theory at New York University and editor of the journal, *American Behavioral Scientist*. Looking back, de Grazia wrote in 1984 in his book, *Cosmic Heretics*, "Alfred de Grazia was entering his forty-fourth year when he met a self-styled cosmic heretic, Immanuel Velikovsky, who was already sixty-seven, and for the next twenty years a wide band of life's spectrum was colored by their relationship" (de Grazia, 1984, p. 10). Despite being generally well-informed and an avid reader, de Grazia had never heard of Velikovsky until shortly before their meeting, but when he became aware of the details of the hostile reception given to Velikovsky's ideas, he decided immediately to devote a special issue of the *American Behavioral Scientist* to this topic. At this point, de Grazia considered it possible that, despite their unacceptable behaviour, Velikovsky's critics might have been making valid points. However, when he read *Worlds in Collision*, he became convinced by Velikovsky's arguments that catastrophes of extraterrestrial origin had produced very significant effects on the Earth and its inhabitants in

the geologically-recent past (de Grazia, 1984, pp. 10-24). Two decades later, he went on to term this "quantavolution", i.e. evolution by quantum leaps (de Grazia, 1981, pp. 10-16).

Early in 1963, the plans for a special issue of the *American Behavioral Scientist*, which was to include an article on Velikovsky's prognostications, stimulated Velikovsky to approach journalist Eric Larrabee, who had written a sympathetic article about *Worlds in Collision* in *Harper's Magazine* in 1950, to write another one about the successful predictions, and this was published within a few months. Once again, though, there was a hostile reaction from some professional scientists, particularly Donald Menzel, who occupied the post formerly held by Shapley, Director of the Harvard Observatory, and behaved exactly like his predecessor towards Velikovsky (Juergens, 1978b).

In contrast to the article in *Harper's*, the special issue of the *American Behavioral Scientist*, published a month later in September 1963, was generally well-received, and formed the basis of a book called *The Velikovsky Affair*. This was edited by de Grazia and published by University Books of New York in 1966. It proved to be a significant catalyst in stimulating consideration of the theories presented in *Worlds in Collision*. The number of people interested in Velikovsky's theories began to grow, in Europe as well as in America, due to a reaction against the intolerant attitude of establishment scientists brought to the public's attention in *The Velikovsky Affair*, as well as by the positive features of his own books (de Grazia, 1984, pp. 90, 264-265).

Also, the collaborative work carried out for the special issue of the *American Behavioral Scientist* encouraged Velikovsky to see the potential benefits of involving teams of helpers in his activities. Warner Sizemore, a Professor of Religion at Glassboro State College, New Jersey, organised a loose network of supporters, who operated under the umbrella title, *Cosmos and Chronos*, holding local meetings and sending out responses to criticisms of Velikovsky's ideas. Velikovsky was re-invigorated by the existence of such groups, but had little direct contact with them (de Grazia, 1984, pp. 263-264).

In May 1972, David and Stephen Talbott, brothers who published and edited *Pensée*, the magazine of the Student Academic Freedom Forum based in Portland, Oregon, brought out the first of what was to be a 10-issue special series giving consideration to the works of Velikovsky over a period of 2½ years, the individual issues being numbered *IVR (Immanuel Velikovsky Reconsidered)* I – X. After the publication of the first issue, the astronomer and atmospheric physicist, Walter Orr Roberts, approached Stephen Talbott to suggest a symposium on the subject of Velikovsky's theories. This eventually took place in San Francisco in February 1974, under the auspices of the American Association for the Advancement of Science (AAAS), and was entitled "Velikovsky's Challenge to Science" (*Pensée IVR* VII, 1974, pp. 23-30; Goldsmith, 1977). To an audience of more than a thousand people, Velikovsky began his presentation by emphasising that it was conventional science he was challenging, not science itself, and went on to point out his successful prognostications (Velikovsky, 1974). The main opponent of his ideas at the symposium was the Cornell University astronomer, Carl Sagan. He maintained that "in *Worlds in Collision* there is not a single correct astronomical prediction made with sufficient precision for it to be more than a vague lucky guess", and he drew attention to ten particular areas where he said the claims made by Velikovsky could be shown to be false (Sagan, 1977).

After the symposium, and the publication by Cornell University Press of the anti-Velikovsky papers in a volume entitled, *Scientists Confront Velikovsky* (the pro-Velikovsky papers being

published in *Pensée IVR* VII), professional scientists generally considered that Velikovsky's scenario had now been given appropriate consideration and found to be unsustainable. Nevertheless, some acknowledged, while maintaining that it didn't affect the overall conclusions, that Sagan had made several mistakes and had also used unfair tactics in his presentation (Jastrow, 1985). Looking back over the 50 years since the publication of *Worlds in Collision*, NASA astronomer David Morrison, in an article in *Skeptic* magazine, accepted that, while most of the ten problems raised by Sagan against Velikovsky's scenario were valid, Sagan had on occasions attacked models which were not necessarily identical to the ones Velikovsky had in mind, and his use of rough-order-of-magnitude calculations sometimes gave an exaggerated impression of the weakness of aspects of Velikovsky's scenario (Morrison, 2001).

So, Velikovsky's theories had finally received a high-profile public hearing, but the meeting had consisted largely of highly-polarised presentations. There was little or no constructive discussion as to whether there might have been merit in *any* of Velikovsky's challenges to conventional science (de Grazia, 1984, pp. 347-351). In that respect, nothing had really changed.

Fragmentation of the Velikovskian movement

Following the AAAS symposium of 1974, many of Velikovsky's supporters seized on the dubious scholarship of Sagan and took it as justification for believing that none of the criticisms expressed about Velikovsky's theories had any substance. However, as documented by de Grazia in *Cosmic Heretics*, this symposium was to be a point of bifurcation for the Velikovsky movement. The followers of Velikovsky, like conventional scientists, were human beings, so a similar range of behaviour was only to be expected. These cosmic heretics may all have accepted the three key points listed by Velikovsky in the Preface to *Worlds in Collision*: (1) that there were physical upheavals of a global nature in historical times; (2) that these catastrophes were caused by extraterrestrial agents; and (3) that these agents can be identified", but that still left plenty of scope for disagreement (de Grazia, 1984, pp. 315-388).

Initially, the choice had seemed to be a straightforward one between the conventional view as it existed at the time and Velikovsky's catastrophist scenario, with those opting for the latter generally accepting the full package as presented in *Worlds in Collision*. Inevitably, therefore, this became established as something akin to a paradigm amongst Velikovsky's followers. To Velikovskians and conventional scientists alike, the AAAS debate was seen essentially as an all-or-nothing contest between two rival scenarios. Afterwards, it was not surprising that some cosmic heretics found justifications for keeping their original beliefs intact. Others, however, began to consider the possibility that there might have been justification for at least some of the criticisms raised by Sagan and others, for no wide-ranging scenario, whatever the brilliance of the overall vision, was likely to be correct in every detail, and much had been discovered in the 25 years since the publication of *Worlds in Collision*. According to de Grazia, the most effective scientific criticisms of Velikovsky came from those who were sensitive to his work, and such criticisms came as part of a positive process (de Grazia, 1984, p. 330). Modifications to Velikovsky's scheme began to be suggested, to eliminate aspects that seemed particularly problematical, and eventually this led to the creation of alternative catastrophist models, albeit ones arising out of Velikovsky's original ideas.

These developments were unwelcome to many traditionalist Velikovskians, for whom the journal *Kronos* became an important medium for the expression of their views. *Kronos* was set up in 1975, with the active involvement of Velikovsky, after the appearance of the last of the special Velikovsky issues of *Pensée*, with Lewis Greenberg, a Philadelphia art historian, as editor-in-chief, and Warner Sizemore as executive editor (de Grazia, 1984, pp. 93-94). Velikovsky, now in his 80th year, still welcomed debates, but his main concern was the establishment of his own ideas, and he expected his supporters to concentrate on the achievement of that aim. In the words of de Grazia, Velikovsky "would have been outraged if any of his circle, and certainly *Kronos*, would have assayed to count him as only a leading figure among cosmic heretics, rather than their *raison d'être*" (de Grazia. 1984, p. 62). In 1977 and 1978, *Kronos* devoted two special issues (volumes III:2 and IV:2) to providing responses to criticisms of Velikovsky's theories made at the AAAS symposium, these being entitled *Velikovsky and Establishment Science* and *Scientists Confront Scientists who Confront Velikovsky*.

The Society for Interdisciplinary Studies (SIS), founded in the UK in 1974, had a more open agenda, its stated objective being simply to "promote the active consideration...of alternatives to the theory of uniformity". It was, nevertheless, formed essentially to provide a forum for debates about Velikovsky's ideas, and its members, from the start, were generally sympathetic to Velikovsky. However, a wide range of ideas and opinions were presented in its main journal, the *SIS Review*, later renamed *Chronology and Catastrophism Review* (de Grazia, 1986, pp. 90-97, 99-100; Tresman, 1993; Tresman, 2000).

In these and other journals, and at meetings, discussions took place about the relative merits of the various modifications and alternatives being proposed to Velikovsky's original theories. Once again, as with the actions of conventional scientists, these discussions, since they involved human beings, were not always conducted as objectively and fairly as ought to have been the case. In *Cosmic Heretics*, de Grazia wrote, "What has been shown here is that the establishment has violated most rules of logic and fair play in literary and scientific intercourse, but, further, I have shown that the heretics, in dealing with the outer world and among themselves, have also violated most rules of logic and fair play in their literary and social intercourse" (de Grazia, 1984, p. 386).

However, let us concentrate on the ideas and the evidence, in going on to consider developments relating to some aspects of Velikovsky's theories, from the time of the AAAS symposium to the present day.

Venus

At the AAAS symposium in 1974, the first of Sagan's ten major objections to Velikovsky's scenario was that Venus could not have been ejected from Jupiter, because there was no mechanism by which a body the size of Venus could have achieved the escape velocity necessary to break free from the gravitational bonds of the giant planet (Sagan, 1977). Morrison, in his *Skeptic* article, gave this as an example of poor scholarship, because Sagan had only considered the ejection of Venus from Jupiter without the involvement of any other cosmic body, which was probably not what Velikovsky had in mind. Sagan had also used an incorrect value for the escape velocity of Jupiter, although that did not affect the overall conclusions (Morrison, 2001).

Laird Scranton, an American software designer, suggested in his 2012 book, *The Velikovsky Heresies*, that Velikovsky had pointed out in *Worlds in Collision* the fact that, according to Greek mythology, Zeus devoured Metis, the pregnant mother of Pallas Athena, after which Pallas Athena sprang fully-armed from the head of Zeus. According to Scranton, Velikovsky concluded from this myth that a cosmic body (Metis) had struck and apparently been absorbed by Jupiter (Zeus), which caused Venus (Pallas Athena) to be ejected (Scranton, 2012, pp. 22-23). In fact, Velikovsky had never mentioned Metis, either by name or description, but since he derived the theory of the ejection of Venus out of Jupiter from myths such as the birth of Pallas Athena, Scranton may have assumed the events prior to her birth to have been implied. What is certain is that Velikovsky wrote, in *Kronos* "In my reconstruction of the past the fission of Jupiter followed, though not immediately, from close encounters between the giant planets Jupiter and Saturn, followed by a collection by Jupiter of the spread matter of Saturn" (Velikovsky, 1977). Since there could be an unlimited range of specifications for collisions of debris from Saturn with Jupiter in the theoretical scenario outlined by Velikovsky, it obviously cannot be concluded with certainty that none of them would have resulted in the ejection from Jupiter of an object the size of Venus.

Further considerations involving escape velocity apply to Velikovsky's theory that the object which became the planet Venus left Jupiter as a comet. In part I chapter II of *Worlds in Collision*, Velikovsky wrote that red dust, followed by gravel, fell on Egypt as the Earth entered deeper into the tail of this comet at the time of the Exodus. Five chapters later, he stated that stones from the same cometary tail fell on the Canaanites in the days of Joshua. It has now been established that cometary tails are formed by the evaporation of volatile material from the nucleus as it passes close to the Sun, with non-volatile material such as dust and gravel being carried along with the escaping gases. Typical comets, with nuclei a few kilometres in diameter, have two tails, one consisting of the gases, which are ionised (i.e. electrically charged), this tail always pointing directly away from the Sun, and the other consisting of dust, gravel and perhaps larger stones, this tail trailing behind the comet in its orbit, and normally appearing as the more spectacular of the two (Burnham, 2000; Steel, 2000, pp. 74-75; Man, 2001). A comet the size of Venus, i.e. one very much larger than a typical comet, could still have an ion tail, but not one containing dust and larger solid material, because the evaporation process could not possibly raise it to a speed in excess of 37,000 km/hr, the escape velocity necessary for solids to escape the gravitational constraints of a body like Venus. Thus, the possibility that Venus once had a cometary tail cannot be excluded, but it would not have been a particularly conspicuous one, and it could not have contained dust, gravel and stones to deposit on the Earth.

Charles Ginenthal, who began to publish the journal *The Velikovskian* in 1993, claimed in the following year that Velikovsky had never said that Venus had begun its existence as a comet. Ginenthal wrote, "Venus was never a comet! It was, as Velikovsky proposed, an incandescent planet that looked like a comet on a cometary orbit". He added, "Although Venus could have some cometary material or comets in orbit around it, it was never a comet, based on Velikovsky's theory" (Ginenthal, 1994). In fact, Velikovsky stated, without qualification, in *Worlds in Collision* (part I chapter VIII), "During the centuries when Venus was a comet, it had a tail". However, regardless of what Velikovsky actually wrote, we cannot entirely exclude the possibility that there was a cloud of dust, gravel and stones following Venus, which may have looked like a cometary tail, even though it could not have been thrown out from the planet.

In the "Saturn Theory" developed during the 1980s by David Talbott and colleagues from the initial ideas of Velikovsky (and to which we shall return later), Venus was no longer thought to have been ejected from Jupiter as a comet, nor to have been a newcomer to the Solar System at the dawn of civilisation. As the theory developed, it was argued that the comet-like appearance of the planet inferred from ancient writings and depicted in rock-art images was the result of the discharge of plasma streamers, this relating to a period much earlier than the time of Velikovsky's supposed Venus catastrophe (Talbott and Cochrane, 1984; Cochrane, 1988; Talbott, 2008).

Scranton, in *The Velikovsky Heresies*, returned to Velikovsky's original model and suggested that the ionotail of Venus, discovered in 1997, was a "remnant cometary tail" (Scranton, 2012, pp. 116-117). Like the ion tail of a comet, the ionotail of Venus points away from the Sun, but that is hardly surprising, because the mechanism is much the same, the effect of the solar wind (the stream of charged particles ejected by the Sun) on the ions being released by a comet in one case and the ionosphere of a planet in the other. Mars and Titan (a satellite of Saturn) have similarly been shown to have ionotails. Scranton also argued that the discovery in 2008 of hydroxyl radicals in the atmosphere of Venus could be an indication of the planet's cometary origin, because hydroxyl radicals are known to be present in the coma of comets, formed from water by solar UV radiation (Scranton, 2012, pp. 113-114). In fact the reason the European Space Agency were looking for hydroxyl radicals in the atmosphere of Venus in 2008 was because they had previously been found in the outer atmosphere of the Earth, formed by the action of ozone. A link with comets seems unlikely.

At the AAAS symposium, Sagan outlined another of his major objections to Velikovsky's scenario as follows: "The idea that Venus could have been converted, in a few thousand years, from an object in a highly elongated or eccentric orbit to its present orbit, which is – except for Neptune – the most nearly perfect circular orbit of all the planets, is at odds with what we know about the three-body problem in celestial mechanics. However, it must be admitted that this is not a completely solved problem and that, while the odds are large, they are not absolutely overwhelming against Velikovsky's hypothesis on this score. Further, when Velikovsky invokes electrical or magnetic forces, with no effort to calculate their magnitude or describe in detail their effects, we are hard pressed to assess his ideas" (Sagan, 1977). That, despite the confrontational tone, remains a fair assessment of the situation.

In 1972, Ralph Juergens, a retired civil engineer, who had written the historical account in *The Velikovsky Affair* of the reception given to *Worlds in Collision*, attempted to reconcile the fact that planets and other bodies moved within the Solar System entirely in accord with Newtonian mechanics (as by this time had been clearly established) with Velikovsky's belief, for which he saw much evidence, that the Sun and planets were electrically charged. Juergens proposed that each planet was surrounded by a space-charge sheath, which would insulate the planet's electrical charge, so only on close approach, when the sheaths would be disrupted, would electrical interactions take place between the planets (Juergens, 1972). That mechanism could not, however, help to explain how Venus had moved so quickly into a circular orbit.

Eric Crew, a British electrical engineer, was enthused by Velikovsky's arguments about the importance of electricity in the Solar System, and his talks and articles on this subject were a regular feature in the early days of the SIS. He developed a computer program to see if was possible, if Juergens' proposed space-charge sheath insulation could be disregarded, for Venus to move into an almost circular orbit in the timescale required by Velikovsky's theory,

on the assumption that the Sun had a constant charge but the charge on Venus gradually leaked away. His model showed that there could be a significant move towards circularisation, but by no means enough, within this timescale (Crew, 1988).

Australian computer systems engineer, Wal Thornhill, who (as we shall see later) played a major role in taking forward Velikovsky's concept of an electrical universe, acknowledged in 1998 that there were serious problems in explaining a rapid change in the orbit of Venus to its present one by the laws of physics as currently understood. He added, however, that because of the strength of the mythological evidence, "it is time to re-examine those 'laws', or long held beliefs that have diverted scientific curiosity away from uncomfortable questions about the safety of our spaceship Earth" (Thornhill, 1998).

Regardless of timescale, British mathematician, Laurence Dixon, showed that considerations of the principles of conservation of energy and angular momentum demonstrated that it would have been possible for Venus to have moved to its present orbit following encounters with the Earth and Mars, but, assuming the masses of the planets remained constant, only if the first contact took place when the Earth was in an orbit in which its average distance from the Sun was around half of what it is now (Dixon, 2001). That is roughly consistent with what Velikovsky wrote in his 1942 summary, but, as currently understood, it would have put the Earth's position at the time well outside of the "habitable zone", where water could exist in liquid form at the surface of the planet (Fogg, 1992; Kasting, Whitmire and Reynolds, 1993; Weed, 2002). Neither human beings nor any other animal life could have existed under those conditions.

Another of Sagan's "ten problems" related to the composition of the clouds of Venus. When Velikovsky wrote *Worlds in Collision*, it was already established that a significant component of the atmosphere of Venus was carbon dioxide, but, in part II chapter IX of the book, Velikovsky argued, on the basis of other indications, "I assume that Venus must be rich in petroleum gases. If and as long as Venus is too hot for the liquefaction of petroleum, the hydrocarbons will circulate in gaseous form". Reports from the American *Mariner 2* mission to Venus appeared to confirm this in 1962, but Sagan claimed that the reports had been based on a misunderstanding. Lewis Kaplan of the Jet Propulsion Laboratory, the spokesperson at the post-mission press conference, had been trying to explain how the findings fitted in with the new theory that the high surface temperature of Venus could be due to a runaway greenhouse effect, and he said there was an information gap about what atmospheric component could be absorbing radiation in the vicinity of 3.5 microns (micrometres). One solution to the problem would be the presence of hydrocarbons, and on that basis it was reported that hydrocarbons had been found in the atmosphere of Venus (Sagan, 1977). The situation was very confused for a number of years, but after Velikovsky's death in 1979, it was eventually established, after further missions to Venus, that the planet's atmosphere consisted of more than 96% carbon dioxide, with almost all of the rest being nitrogen. The clouds in the atmosphere consisted of a mixture of water vapour, sulphur dioxide and sulphuric acid, which together provided the absorbance capacity at 3.5 microns to link with the effect of the carbon dioxide and explain the runaway greenhouse effect (Henbest, 1994; Moore, 2001; Rees, 2011).

In *The Velikovsky Heresies,* Scranton drew attention to a possible way of reconciling the present-day absence of hydrocarbons from the atmosphere of Venus with Velikovsky's theory: large hydrocarbons may have been "cracked" by strong electrical discharges (Scranton, 2012, p. 115). However, that would simply result in the production of smaller

hydrocarbons, which are also absent from the atmosphere of Venus. In any case, it was turning one of Velikovsky's arguments on its head, because he proposed that particular mechanism for the synthesis, not the breakdown, of large hydrocarbons, writing in *Pensée*, "I have assumed that by electrical discharges in the atmosphere of methane and ammonia (known ingredients of the Jovian atmosphere), hydrocarbons of heavy molecular weight could have been created" (Velikovsky, 1973/4a).

It cannot be said with absolute certainty that Velikovsky's belief about the atmosphere of Venus being rich in hydrocarbons 3,500 years ago has been proved wrong by discoveries about the present-day Venusian atmosphere. However, one theory that seems totally unsustainable, as Sagan pointed out, is his suggestion that the Earth may have been infested by flies and other vermin from Venus. Velikovsky wrote, in part I chapter IX of *Worlds in Collision*, "The question arises here whether or not the comet Venus infested the Earth with vermin which may have been carried in its trailing atmosphere in the form of larvae together with stones and gases. It is significant that all around the world people have associated the planet Venus with flies". Even apart from the fact that such larvae would have been incinerated by frictional heat as they passed through the Earth's atmosphere, it is inconceivable that complex organisms adapted for life on Venus could survive in the very different environment at the Earth's surface. Velikovsky's suggestion, however, cannot be considered an essential aspect of his scenario. Its elimination would not result in the complete negation of Velikovsky's Venus model. Nevertheless, as we have seen, this model is not in a strong state at the present time. On the basis of current evidence and knowledge, it seems that the most positive thing that can be said about some of Velikovsky's theories relating to Venus is what Schaeffer wrote about his revised chronology: not impossible but improbable.

On the other hand, it should not be overlooked that conventional ideas about Venus at the present time are far different from what they were when Velikovsky wrote *World's in Collision*, and, at least in general terms, have aspects in common with Velikovsky's vision (Couper and Henbest, 1985; Moore, 2001; Chown, 2011). Venus, supposedly a "sister-planet" of the Earth, is now known to have many anomalous features. For example, it is acknowledged that the planet's surface is far hotter than previously realised, with an atmosphere much more dense and hostile to life than supposed, its rotation is retrograde, and its surface was molten relatively recently, on a geological time scale. That has been deduced on the basis of a low and evenly-spread density of impact craters, compared to other bodies in the Solar System. Estimates suggest that the surface solidified between 200 million and 800 million years ago, but no dating studies have yet been carried out on material from the planet (McNab and Younger, 1999, pp. 87-88, 170-173, 177-180; Harfield, 2011; Rees, 2011). It is now generally accepted that the high surface temperature can be explained on the basis of a runaway greenhouse effect caused by the gases known to be present in the planet's atmosphere, but there could be alternative causes, and suggested explanations of some of the other unexpected findings involve much speculation. Work on understanding how Venus arrived at its present state has hardly begun.

Earth

At the AAAS symposium, one of the problems raised by Sagan against Velikovsky's theories was the lack of archaeological or geological evidence of a global catastrophe during the fifteenth century BCE or, in archaeological terms, the end of the Middle Bronze Age. If the event had occurred as Velikovsky described, the evidence for it should have been easy to find. So, for example, in his 1942 summary, Velikovsky outlined the scenario in the

following words: “To begin with, our Earth collided (contacted) in the fifteenth century before this era with a comet. The head of the comet exchanged violent electrical discharges with our planet, and also with its own tail. The Earth changed the poles, south becoming north, changed axis, changed the orbit of revolution, changed speed...Iron near to the core of the Earth, appeared in upper layers. Neft poured from the sky and built the present deposit. Meteorites fell in abundance...Lava streamed on the surface of the Earth not only from volcanoes, but also from clefts. Continents and seas changed places...A major part of human kind perished. A double tide of immense height swept seas and continents. In general conflagration woods burned down, rivers boiled...Air became filled with clouds of carbons or hydrocarbons, and Earth was enveloped in them during a number of years...”. Where, asked Sagan, was the scientific evidence for such a scenario?

Velikovsky responded to Sagan’s criticism by pointing out that he had provided abundant archaeological and geological evidence of major catastrophes in *Earth in Upheaval* (Velikovsky, 1977). Indeed, *Earth in Upheaval* was an impressive compilation of such evidence. However, Velikovsky acknowledged in the Preface that he was not restricting himself to evidence for the two catastrophes he had written about in *Worlds in Collision*, but was also including evidence for earlier catastrophes. In many cases Velikovsky gave no indication as to which catastrophe he associated with a particular piece of evidence, and in some cases his linkage of evidence to the “Venus catastrophe” was controversial, e.g. in chapter X he included in this context findings relating to the end of the last Ice Age, generally believed to have been thousands of years earlier. For his archaeological evidence, he relied heavily on the findings of Schaeffer, mentioned previously, but these too were controversial.

At the first SIS Cambridge Conference in 1993, John Bimson and Bob Porter, separately, gave assessments of Schaeffer’s findings in the light of subsequent developments in archaeology. They agreed that there was strong evidence of widespread catastrophic destructions of cities at the end of the Early Bronze Age, but the evidence for similar destructions at the end of the Middle Bronze Age, the time of the Venus catastrophe, was much more tenuous. Although there was evidence of earthquake damage at many of the sites, there was nothing to indicate the kind of cosmic catastrophe envisaged by Velikovsky, and the main reason why the destructions at the end of the Middle Bronze Age had seemed of particular significance to Schaeffer was that he found evidence to suggest they had been followed at each site by an occupational gap of 100 – 150 years. However, to Porter, it seemed likely that this apparent hiatus was simply an artefact of the dating procedure used by Schaeffer (Bimson, 1993; Porter, 1993).

Velikovsky had supposed that a geomagnetic reversal took place at the time of the Venus catastrophe, and one of the proposals he sent via Hess to the organising committee for the International Geophysical Year was for this to be investigated (Velikovsky, 1972). It never became part of the programme, but subsequent investigations showed that the most recent geomagnetic reversal occurred during the Pleistocene epoch, long before the events at the end of the Middle Bronze Age (Stanley, 1986; Hallam, 1989, p. 165; Shackleton, Berger and Peltier, 1990; Cande and Kent, 1995).

Geomagnetic reversals were linked to inversions of the Earth in the theory of British physicist Peter Warlow, who argued that the close approach of another planet could cause the Earth to behave like a tippe top, and either turn over completely or wobble and return to its original position, without any change of rotation in either case. The first situation could explain the north-south and east-west reversal which Velikovsky claimed had happened at the time of the

Exodus, and the second the temporary anomaly of the Sun's movement in the sky in the days of Joshua (Warlow, 1979; Warlow, 1982). One of the ten objections raised by Sagan to Velikovsky's theories was the impossibility of the Earth having stopped rotating and then starting again, which is what he took Velikovsky to be claiming had happened when Joshua was at Beth-horon, but Warlow argued that the tippe top model provided a viable mechanism to explain the biblical passage within the framework of Velikovsky's scenario. However, physicist Victor Slabinski maintained that the forces which would be required to invert the Earth were so great that Warlow's theory was untenable (Slabinski, 1981), and, from the other side, the tippe top model was attacked in *Kronos*, Lynn Rose writing that it was "neither necessary nor sufficient for Velikovsky's scenario" (Rose, 1982). Responding to Rose, Warlow wrote that there was simply no alternative model which could explain Velikovsky's scenario (Warlow, 1987). Two decades later, in a paper presented at the 3rd SIS Cambridge Conference in 2007, Warlow argued that, because of an important point Slabinski failed to take into account, the fact that the Earth was not a perfectly rigid body, his model remained viable, and he believed that inversions, or partial inversions, of the Earth had taken place in the distant past, giving rise to sudden climate changes. However, on the basis of the lack of geological evidence for recent geomagnetic events, he now doubted whether any such inversions had taken place within the last 10,000 years (Warlow, 2008).

Velikovsky had hoped to find confirmation of his Venus catastrophe theory in a discovery made by Lamar Worzel, a geophysicist from the Lamont Observatory, off the coast of Central and South America in the late 1950s. Sedimentation cores showed the presence of an ash, subsequently known as the "Worzel Ash", at various locations, and Worzel speculated that it was an extensive, and possibly worldwide, deposit, of volcanic or perhaps cometary origin (Worzel, 1959). In a footnote in *Stargazers and Gravediggers*, Velikovsky wrote, without any qualification, "In 1959, J. L. Worzel discovered a layer of ash of extraterrestrial origin underlying all oceans" (Velikovsky, 1983, p. 194), and in an article in *Pensée*, he remarked, "The 'small dust like ashes of the furnace' which fell 'in all the land of Egypt' (*Exodus* 9:8) and throughout the globe is, I surmise, still preserved at the bottom of the ocean", adding that it was called Worzel Ash after its discoverer (Velikovsky, 1973/4b). Unfortunately, further investigations soon demonstrated that the Worzel Ash was volcanic in origin, and found only in a few locations (Bowles, Jack and Carmichael, 1973; Ninkovich and Shackleton, 1975), a point subsequently noted in catastrophist journals (Kloosterman, 1977; Ellenberger. 1984).

In *Worlds in Collision* part I chapter VI, Velikovsky wrote that, after the Exodus, "For a long time there was no green thing seen; seeds would not germinate in a sunless world. It took many years before the earth again brought forth vegetation". However, living bristlecone pines have been found with more than 3,500 annual growth rings, showing that they lived through the time of the Venus catastrophe (Ellenberger, 1984; Jastrow, 1985). It has been argued that these hardy trees may have been able to "shut down" for a number of years, until sunlight was once again able to penetrate through the atmospheric dust (Kogan, 1988). Such behaviour is known to be possible for a year, but thought unlikely to be able to be sustained for much longer than that. In any case, growth would have had to be resumed with full vigour, because there is no indication of a period when growth rings were narrower than normal. Tree rings in Irish oaks preserved in bogs, linked to ones in living oak trees by finding overlapping patterns of broad and narrow rings, similarly showed no indication of a major environmental crisis during the 15th century BCE (Baillie, 1999, pp. 23-25, 53-55).

As with tree rings, layers in ice-cores, e.g. from central Greenland, provide a year-by-year record of climate and other environmental factors (Lamb and Sington, 1998; Macdougall,

2004, pp. 164-186). There is a difference in appearance between summer snow and winter snow, which enables the annual ice-layers to be observed. Almost a metre of snow settles in central Greenland in a year, which subsequently compresses into about 30 cm of ice over a period of years, as more snow accumulates on top of it. As the process continues, the increased pressure from above squeezes the ice in the layer out laterally, some of it eventually ending up in the sea. Thus the thickness of each layer decreases with time, but a 10,000-year-old layer, more than 1 km down, will still be around 2 cm thick, so visible to the eye if brought carefully to the surface (Alley, 2000). Analysis of ice-core layers has not revealed any significant change in climate during the fifteenth century BCE, or any major anomaly involving atmospheric dust or acidity content during this period (Ellenberger, 1984; Zielinski, Mayewski *et al*, 1994; Clausen, Hammer *et al*, 1997). Attempts have been made to reconcile this situation with the Velikovsky scenario (Rose, 1986/1987), but counter-arguments have been raised against these (Mewhinney, 1990), and whilst it cannot be said that the ice-core evidence has provided conclusive proof against the theory of a global catastrophe in the fifteenth century BCE, it is evident that it has not provided any positive support for the notion.

According to Velikovsky, the close approach of Venus to the Earth stimulated extensive volcanic activity. In *Worlds in Collision* part I chapter IV, he wrote, "In the days of the Exodus...all volcanoes vomited lava". Scranton, in *The Velikovsky Heresies*, claimed to have found evidence to support this view, not only in relation to the Venus catastrophe but also the Mars catastrophe. The list of large Holocene eruptions given on the web-site of the Global Volcanism Program, which operates under the auspices of the Smithsonian Institution (http://www.volcano.si.edu/world/largeeruptions.cfm), showed a record of widespread significant volcanic eruptions for both of these periods. To be precise, there were 23 for the period from 1820 to 1430 BCE, including the largest from the whole of the Holocene, Thera, and 23 for the period from 950 to 550 BCE (Scranton, 2012, pp. 63-65, 92-93). When I checked these figures on 8 July 2012, it transpired that they had changed very slightly, showing 22 large eruptions from 1820 to 1420 BCE and 25 from 950 to 550 BCE, both 400-year periods. To test whether the numbers were significantly high, I then compared them with those from 400-year periods immediately before 1820 BCE and immediately after 550 BCE, as well as the 400-year period in the middle of the interval between 1420 and 950 BCE. The outcome was that, according to this same source, and comparing like with like, there were 27 large eruptions between 2230 and 1830 BCE, 24 between 1380 and 980 BCE and 30 between 540 and 140 BCE. Thus the supposition that the numbers of large eruptions were particularly high in the two periods highlighted by Scranton is without foundation.

Scranton went on to suggest that Velikovsky may have got the date of the Venus catastrophe wrong, because he associated it (in the supplement to *Earth in Upheaval*) with the massive eruption of Thera on the island of Santorini, and this is now dated at around 1627 BCE, which also roughly corresponds with the generally agreed date for the end of the 13th Dynasty of Egypt, similarly linked by Velikovsky to the same catastrophe (Scranton, 2012, pp. 23-24). Mike Baillie, an environmental scientist from Queen's University Belfast, had previously drawn attention to the correspondence between the scientific date for the Thera eruption and the accepted date for the end of the 13th Dynasty, suggesting the possibility that this could have been the time when the Exodus took place (Baillie, 1999, p. 106). That would have obvious implications for Velikovsky's revised chronology. However, this scientific date for the eruption of Thera, obtained from radiocarbon, tree-ring and ice-core evidence (Baillie, 1999, pp. 48-59, 76-77; Friedrich, Kromer *et al*, 2006) is just as much of a problem for orthodox scholarship as it is for Velikovsky's theories, because it is difficult to reconcile with

archaeological evidence which indicates that pumice from Thera reached Egypt, downwind from Santorini at the time of the eruption (as indicated by the direction of the ash-fall), during the reign of the 18th Dynasty. It has been argued that radiocarbon dates from the vicinity of Thera could be too old, because trees and plants growing close to a volcano may incorporate carbon dioxide from volcanic emissions as well as from the atmosphere, whilst narrow tree rings at around 1627 BCE in Irish oaks and an acidity spike in Greenland ice-cores at around 1645 BCE could have resulted from a volcanic eruption far to the north of Santorini (Porter, 2002; Rohl, 2007). More generally, suspicions have been raised by conventional archaeologists and unorthodox scholars alike that scientific dating procedures have yet to be developed to the point where the results they give can be considered truly objective and reliable (Porter, 2002; Curnock, 2009; James, 2012).

Alternative catastrophist scenarios

Velikovsky's book on the catastrophes which he believed had preceded the Venus catastrophe, involving Jupiter, Saturn, and also Mercury and Uranus, was never published (except, after his death, on the Velikovsky Archive web-site: http://www.varchive.org/itb/). However, in 1979, an article based on the chapter dealing with Saturn and the Flood appeared in *Kronos* (Velikovsky, 1979). Velikovsky's reading of myths from around the world convinced him that, before the time of the catastrophes linked to Jupiter, when the Old Kingdom of Egypt came to an end and the cities of Sodom and Gomorrah were destroyed, there had been a Golden Age on Earth, when gods associated with the planet Saturn were pre-eminent. Velikovsky formed the view that Saturn had then been much larger than it is today, and the Earth may have been its satellite. However, an encounter between Jupiter and Saturn caused the latter to become a nova (i.e. to emit light) for a period of time, losing much of its mass, and also its hold on the Earth, under conditions which gave rise to the story of the Deluge.

In 1981, in *Chaos and Creation*, and the subsequent volumes which comprised the quantavolution series, de Grazia, in cooperation with the Canadian physicist, Earl Milton, extended Velikovsky's ideas backwards in time and developed the notion of Solaria Binaria. According to this model, before the time in which Saturn (or rather Super-Saturn) had been the celestial body which dominated the Earth, there had been a binary system involving the Sun and Super-Uranus, held together largely by electromagnetic forces. At that time the Earth had been close to Super-Uranus, so it was that body which dominated the sky. Solaria Binaria began to disintegrate around 14,000 years ago, with Super-Uranus losing a significant part of it mass and becoming Super-Saturn. Then, before Super-Saturn, as in the Velikovsky scenario, also lost part of its mass and became a nova, a fragment of Super-Uranus passed close to the Earth and tore away part of the crust, resulting in the formation of the Moon. The present continents were formed by continental drift from the splitting of the super-continent Pangaea, as in the conventional theory, but at a much faster rate (de Grazia, 1981, pp. 103-118, 165-181).

Independently of this, David Talbott, Dwardu Cardona and Ev Cochrane, in books (Talbott, 1980; Cochrane, 1997, 2000) and various journals, particularly *Aeon*, founded in 1988 (Talbott, 1988; Cardona, 1988, 1991; Cochrane, 1988), also developed Velikovsky's ideas about significant changes taking place within the Solar System in early historical times, to formulate the "Saturn theory" . Their studies of myths led them to conclusions which differed in some important respects from Velikovsky's. According to Talbott, "It is now clear that Velikovsky was not correct on many details, but his best critics are those who have devoted

their lives to investigating questions and possibilities arising from his work. They know that he was closer to the truth than his scientific critics" (Talbott, 2008).

It seemed to Talbott, Cardona and Cochrane that, at the dawn of civilisation, most of the planets, including Venus, had been constrained in a cluster in the direction of the polar region, with Saturn being the most prominent of them. Despite some disagreements of detail between Talbott and Cardona, this led to the "polar configuration" hypothesis, which maintains that Jupiter, Saturn, Venus, Mars and Earth once orbited the Sun as a single linear unit, rotating about a point close to Saturn. Jupiter did not appear prominent from Earth, being largely hidden behind Saturn, whereas Venus and Mars lay between Saturn and the Earth. This stable arrangement lasted throughout a period which was seen in retrospect as the Golden Age on Earth, since the breakdown of the polar configuration resulted in battles between the planetary gods, with thunderbolts and missiles being slung around, causing havoc on Earth, before the Solar System settled into its present, relatively quiescent, form.

The first major discussion of the Saturn theory in Britain took place at the SIS Silver Jubilee conference in 1999. At this conference, Cardona said that the theory raised demands relating to mythological and physical evidence for the formation and destruction of the polar configuration, and argued that these demands could be met (Cardona, 2000). Cochrane also outlined evidence supporting the theory, but acknowledged, "The most obvious objection to the Saturn theory is its apparent incompatibility with conventional astrophysics. This is indeed a formidable objection, one deserving of serious attention and, ultimately, a valid answer, ideally in terms of offering a viable physical model for the polar configuration" (Cochrane, 2000). An early attempt at such a model (Grubaugh, 1993) was found by Slabinski to be untenable (Slabinski, 1994). In the year 2000, Italian mathematicians Emilio Spedicato and Antonino Del Popolo developed a model which showed that the polar configuration could hold together, but only for a very short period of time (Spedicato and Del Popolo, 2000). This model did not take into account tidal effects or electromagnetic forces, which offered some hope to the supporters of the Saturn theory, but the formulation of a viable physical model is still awaited.

Speaking after Cochrane at the SIS Silver Jubilee conference, historian Peter James said that the most obvious problem with the Saturn Theory was not the lack of a viable physical model, nor the shortage of specific details which had so far been supplied, but how to explain how the Earth - and its inhabitants - could possibly have survived the upheaval of being wrenched from its position which was always close to Saturn and hurled into an independent orbit around the Sun. James suggested that the apparent description of Saturn in ancient writings as a brilliant object could be explained if a large body had crashed into Saturn at around this time and turned the planet into an incandescent ball of vapour, out of which Saturn's rings were eventually formed (James, 2000).

Another challenge to the Saturn theory and, indeed, planetary catastrophism in general, has been posed by patterns of temperature fluctuations, as indicated by oxygen isotope ratios, in both ice-cores and deep-sea sedimentation-cores, and also by sea-level data from coral terraces, which are generally consistent with predicted Milankovitch cycles (Shackleton and Opdyke, 1973; Kerr, 1978; Pillans, Chapell and Naish, 1998). These cycles were derived by the mathematician Milutin Milankovitch on the basis of characteristics of the Earth's current orbit (Lamb and Sington, 1998; Macdougall, 2004, pp. 115-140, 164-186). They do not provide a complete explanation for temperature change, because there were occasions when the records show a dramatic disruption to the effects of the Milankovitch cycles, but the

existence of underlying patterns of temperature fluctuation as predicted by Milankovitch suggests that the Earth has been in its present orbit for a very long time. This was referred to recently by physicist Bob Bass, who has been a long-time advocate of the view that Velikovsky's scenario could not be said to be impossible – he made that point, for example, at SIS conferences in 1978 and 2007, almost thirty years apart (Bass, 1982; Bass, 2008). However, in an email circulated in November 2009, he attached a comparison of predicted temperature fluctuations over the past 200,000 years and temperature fluctuations inferred from oxygen-isotope ratios in ice-core layers for the same period, and asked: "See the attached *a priori* prediction versus the measurement and tell me if you aren't convinced of the Milankovitch theory of Solar Insolation as dominating earth's temperature variations? But doesn't that preclude disruptive global catastrophism for the past 200,000 years?" Taken in isolation, the agreement between the temperature fluctuations inferred from ice-cores and the theoretical predictions might be brushed aside, but the fact that there is similar agreement when the temperature fluctuations are inferred from deep-sea sedimentation cores and coral terraces makes it much more difficult to do so. There is an issue which needs to be properly addressed.

Moving on, Talbott teamed up with Thornhill in 1997 to begin arguing that several of the regular motifs found in inscriptions of a mythological nature and also in rock art are depictions of plasma-discharge streamers between planets (Talbott and Thornhill, 2005; Talbott, 2008). Tony Peratt, a recognized authority on plasma-discharge formations and instabilities, acknowledged in 2000 that the same patterns are regularly found in laboratory experiments (Peratt, 2003; Peratt, McGovern *et al*, 2007). Rens van der Sluijs has made a particular study of the *Axis Mundi*, now regarded as the imaginary extension of the axis of rotation of the Earth, but which, on the basis of mythology and rock art, seems to have been clearly visible around the end of the Neolithic period. In the polar configuration scenario, that could have been due to electrical discharges along the axis between the Earth and the other planets, but other explanations are possible. Peratt has shown that an aurora would take the form of an enormous column if the solar wind was one or two orders of magnitude greater than it is at the present time, so the ancients may have witnessed a long-lasting high-energy auroral storm (Sluijs, 2008).

As well as claiming evidence of plasma-discharge streamers, Thornhill and Talbott have also addressed more general issues about electricity in the Universe, developing a model proposed by Juergens in *Pensée* (Thornhill and Talbott, 2007). Juergens adopted a controversial idea proposed during the 1950s by Melvyn Cook, a chemist at the University of Utah, that the Sun had an external source of energy, not an internal one driven by thermonuclear reactions, as generally believed. Juergens also maintained that *Mariner 2* had demonstrated in 1962 that interplanetary space was not a near-vacuum, as previously supposed, but full of plasma, making it an electrified medium. In his model, the Sun, although already negatively charged, acted as an anode to collect more negative charges, because of its interstellar environment, and in this way provided the mechanism to drive solar radiation (Juergens, 1972).

During the past twenty years, there have been tremendous advances in our knowledge of the Universe, the Hubble space telescope and other sensitive instruments revealing features that were totally unexpected, including immense clouds and streamers of hot ionised gas. Conventional scientists attempt to explain the emerging picture in terms of concepts such as black holes, dark matter and dark energy, but accept that there are currently many aspects of the Universe that are poorly understood (Henbest and Couper, 2001, pp. 140-189; Baldwin and Cooper, 2009; Achenbach, 2012; Frank, 2012). Similar considerations also apply to

investigations of sub-atomic structure (Hawking, 1988, pp. 63-79; Matthews, 1992, pp. 153-197; Baggott, 2012). Amongst the heretics, much work has been carried out by Thornhill, Talbott and others in developing the Electric Universe concept from the theory of Juergens, as well as previously-neglected ideas of physicists such as Hannes Alfvèn and Halton Arp (Scott, 2006; Thornhill and Talbott, 2007). However, Thornhill acknowledged at a meeting in London in 2009 that there was not, as yet, a complete, coherent "big picture" of the Electric Universe theory (*Chronology and Catastrophism Review* 2010, pp. 75-76).

Thornhill has said he is convinced, from the mythological evidence, that planets have changed orbits, but he considers that the rapid recovery of stability defies our present understanding of gravity-dominated mechanics, and he also believes that Velikovsky's analogy between the planets in the Solar System and the electrons in an atom was unhelpful. According to Thornhill, the electrical theory of magnetism and gravity proposed by Ralph Sansbury, an independent New York physicist, could be of great importance, but so far other scientists have remained unconvinced by this theory, and also by Sansbury's claims that it has been possible to modify gravity in laboratory experiments (Thornhill, 1998; Thornhill, 2008).

A model of cosmic catastrophism which followed Velikovsky's approach of taking ancient myths as indications of real events, but which was entirely consistent with conventional views of celestial mechanics, and with observational evidence, was proposed in 1982 by British astronomers Victor Clube and Bill Napier in their book *The Cosmic Serpent* and developed eight years later in *The Cosmic Winter* (Clube and Napier, 1982; 1990). Shortly before the publication of the first of these books, Clube outlined the theory at a meeting of the SIS in London (Clube, 1984). Estimates of the range of diameters of cometary nuclei in the regions beyond Jupiter suggested that, although most would be between 1 and 10 km, there were likely to be a significant number as large as 200 km. Although small by planetary standards, a giant comet of this size could pose a very serious threat to Earth if propelled into the Inner Solar System. Even if there was no direct collision with the Earth, the giant nucleus could well disintegrate under the gravitational influence of the Sun, releasing large amounts of dust and boulders, to cause significant problems for life on Earth. Such a scenario, involving devastation on Earth because of a cluster of impacts over a short period of time, couple with global cooling caused by the dusting of the upper atmosphere, has been termed *coherent catastrophism* (Steel, 1995).

Clube and Napier have argued that the present orbits of Comet Encke, the Taurid meteor stream and several asteroids, e.g. Oljato, indicate that they were all part of the same body, probably the nucleus of a giant comet, a little over 20,000 years ago. This giant comet, proto-Encke, came into the Inner Solar System and began to disintegrate during the Pleistocene epoch. They linked the glacial conditions of the Late Pleistocene to the dusting of the Earth's atmosphere by some of the breakdown products. This situation eased around 10,000 years ago, allowing temperatures to rise, but remnants of the giant comet continued to threaten the Earth. Clube and Napier have suggested that the Earth encountered a swarm of meteors and cometary debris between around 2,500 and 2,100 BCE, when there appeared to have been a general deterioration in climate, and again at the time of the Exodus, which they dated to 1369 BCE. At times during the Early and Middle Bronze Ages, Comet Encke would have appeared as a brilliant object in the morning and evening sky, so myths and legends arising from catastrophes during this period may subsequently have been transferred to deities associated with the planet Venus, which would have been the brightest object in the morning and evening skies after Comet Encke dimmed following further disintegration (Clube and

Napier, 1990, pp. 181-204). As for events before that time, van der Sluijs has suggested that the disintegration of proto-Encke could provide a possible cause of the huge auroral storm of the Late Neolithic (http://www.mythopedia.info/aurora.html; see also McCafferty and Baillie, 2005). However, questions have been raised about how well the Clube-Napier theory can explain details of ancient literature and ancient art (Cochrane, 1998).

The existence of the Taurid-Encke complex is well-established, but its origins remain uncertain, and there is as yet no clear evidence to link it to catastrophic episodes on Earth. The Clube-Napier theory has received support from some British astronomers, but not to any significant extent from American ones.

Conclusions

Now let us move towards some conclusions and statements of personal belief. First let me say that I fully agree with de Grazia with regard to the stance he took concerning interdisciplinary research in his paper on "The Scientific Reception System", which formed part of the special issue of the *American Behavioral Scientist* and also the book, *The Velikovsky Affair*. There may have been perfectly good reasons for scientists to concentrate on their chosen specialist area, after the time when, during the early 19th century, the amount of information available became too great for many to be able to claim with any justification that they were experts in more than one area. The peer-review scientific reception system introduced into each specialist area still works perfectly well in the majority of cases. However, as de Grazia pointed out, it cannot cope with interdisciplinary research, which is where the majority of key breakthroughs are likely to take place, because they are the product of truly original thinking (de Grazia, 1978). Classicist Bill Mullen, who has been a tutor in interdisciplinary studies, came to similar conclusions in an article in *Pensée* (Mullen, 1972).

Specialists can perhaps be forgiven for being suspicious of an opinionated outsider who comes along and tells them that their carefully assembled models are worthless. In most cases, such outsiders will just be revealing their profound ignorance. However, sometimes an outsider will be able to see genuine flaws in an established model, and perhaps provide a better one, by looking at the situation from a different perspective. For this reason, particularly for the investigation of topics which lie at the interface between traditional subject boundaries, interdisciplinary teams are now occasionally set up, allowing cross-fertilisation to take place in discussions between specialists from different disciplines. However, where are the results of interdisciplinary research projects to be published, since most journals cater for a narrow specialism, and how is the work to be judged?

In the UK, research in each subject in each university is graded by peer-review every five years or so, as part of the government's "Research Assessment Exercise". Initially (although subsequently less so), substantial government funding was made available for groups who were given high grades. Statements were made about the importance of interdisciplinary research, and appeals were made for interdisciplinary projects to be submitted for assessment. However, these were then judged by passing them between different specialist panels, and there is a widespread perception that they generally finished up with unfairly-low grades (Loder, 1999; Elton, 2000; Gilbert and Lipsett, 2007). So, in the UK, and no doubt elsewhere, despite the payment of lip-service to the importance of interdisciplinary research, nothing has yet been done to allow it to be properly funded or for the outcomes to be properly propagated and judged. That situation needs to change.

I also agree de Grazia and, indeed, Velikovsky, in believing that catastrophes of extraterrestrial origin have had, or at least are very likely to have had (since nothing can be proved with certainty), a significant effect on the Earth and its inhabitants in the geologically-recent past. When Velikovsky wrote *Worlds in Collision*, it was almost universally believed that no such catastrophes could have taken place, whether of extraterrestrial origin or otherwise. Today the situation is very different, at least in some respects. It is now accepted, in principle, that mechanisms exist which could give rise to such catastrophes. So, for example, it has been established that the threat from asteroids and comets is far greater than had been supposed, because they explode with great power on impact with the Earth, and also, it is now accepted that similar levels of destruction could arise from explosive eruptions of volcanoes, a fact not previously realised. Nevertheless, when it comes to investigating any particular episode of apparently rapid change, there is a clear reluctance to take seriously the possibility that it might have been caused by a natural catastrophe. Some beliefs from the past have become so firmly embedded into the culture of scholars that they persist long after any justification for them has disappeared. One of these is the supposition that uniformitarianism is in some way more scientific than catastrophism, established by Charles Lyell in the 19th century. Lyell had been trained as a lawyer before becoming a geologist, and he used all his lawyer's tricks to get across the beguiling message that although the geological record seemed to reveal some times of sudden change, anyone who was clever enough to look beyond the obvious would find reasons to conclude that all change was gradual. He also established the false belief that the catastrophists of his time were not objective scientists, but men driven by religious dogmatism (Gould, 1988; Huggett, 1997, pp. 85-87; Palmer, 2003, pp. 45-51).

The belief amongst scholars that there was no threat to the Earth from the skies had been established for even longer than uniformitarianism, by a wide margin. Aristotle, as part of his theory that the universe consisted of a series of concentric spheres, with the Earth at the centre, taught that nothing could pass from the perfect heavens to the corrupt Earth, and, despite the superstitions of common folk, that doctrine was accepted by scholars throughout the medieval period. Then, when Newton introduced his model of a mechanical universe, operating according to natural and unchanging laws, he maintained that God, who had set it up in the first place, was a benign deity, so would have taken care to avoid the possibility that a comet could crash into the Earth and cause catastrophes. On the authority of Newton, therefore, the notion that the Earth was safe from the threat of a cosmic catastrophe remained a core belief among scientists (James and Thorpe, 1999, pp. 2-5; Palmer, 2003, pp. 8-13; Cohen and Whitman, 1999).

Thus, although the origins of the belief might not have been realised, scientists in the first half of the 20th century and beyond had a mindset which made it difficult for them to contemplate the possibility that a major catastrophe, particularly one of extraterrestrial origin, had affected the course of life on Earth at some point in the past.

Even when it became established that mass extinction episodes were real events, not just artefacts of the fossil record, or peaks in the natural fluctuation of turnover rates of species, it was generally supposed that they must have occurred over a substantial period of time, as a result of slow climate change, perhaps linked to continental drift (Hallam, 1989, pp. 184-193; Briggs, 1994; Gould, 2002, pp. 1296-1320). Challenging this view in 1980, Luis and Walter Alvarez, father and son, but also constituting an interdisciplinary team of a Nobel-prize-winning physicist and a geologist, both from Berkeley, argued that the extinction of the dinosaurs and many other species at the end of the Cretaceous period had been caused by the

impact of an asteroid 10 km in diameter, and they produced evidence in the form of raised levels of iridium (an element associated with extraterrestrial materials and normally found in only trace amounts in the Earth's crust), at the Cretaceous-Tertiary boundary at sites throughout the world (Alvarez, Alvarez *et al*, 1980; Alvarez, 1997). However, most geologists continued to suggest that it was somehow more scholarly to think that the iridium had been released from the Earth's core by volcanic activity associated with continental drift, than to suppose that the terminal Cretaceous extinctions could have been caused by a catastrophe of cosmic origin. So, for example, Beverly Halstead of Reading University wrote in 1981: "The asteroid or giant meteor explanation has the great popular appeal of high drama...Such theories are certainly an advance on invoking the wrath of a Deity but not very much...The other type of theory involves a careful consideration of all the evidence that can be accumulated, drawing both from biology and geology. These more synthetic theories tend to be less exciting but are more likely to approximate to what actually happened" (Halstead, 1981). Others used less emotive language, but the message was still the same. During the 1990s, it became established that a 10 km cosmic object had struck the Earth near Chicxulub in the Yucatán at the very end of the Cretaceous period, producing an enormous crater 180 km in diameter (Hildebrand, Penfield *et al*, 1992; Swisher, Grajales-Nishimura *et al*, 1992; Sharpton, Dalrymple *et al*, 1992; Alvarez, 1997). This would have required an explosive force equivalent to around 100 million megatons of TNT, 6 billion times that of the Hiroshima atomic bomb, and 4-40 million times greater than that which produced the Barringer crater in Arizona. Even so, many still maintain that the dinosaurs were on the way to extinction anyway, so this impact just made a contribution to the process, and not necessarily a major one (Hallam and Wignall, 1997; Courtillot, 1999; Palmer, 2003, pp. 197-205, 228-243; Hallam, 2004).

Nevertheless, it is now firmly established that the death of the dinosaurs led to the emergence of the mammals, not the other way round, as had been supposed on the basis of traditional Darwinian evolution (Haines, 2001; Gould, 2002, pp. 1296-1343, Palmer and Barrett, 2009). It now seems, just as Velikovsky argued in chapter XV of *Earth in Upheaval*, that natural selection generally constrains major evolutionary developments. Velikovsky suggested that the key points in evolution were linked to catastrophes, these wiping out many existing species, whilst radioactivity associated with the catastrophes caused multiple mutations, giving rise to their successors. Radioactivity certainly causes mutations, but generally in a destructive way. In any case, it eventually became apparent that, at the end of the Cretaceous period and also at other mass-extinction horizons, there is a substantial gap in the fossil record between the disappearance of one group of species and the emergence of their successors (Eldredge, 1989; Benton, 1991; Janis, 1993). That is now taken to indicate that, when there is plenty of ecological space following a mass-extinction episode, natural selection can operate in a much more positive fashion than at other times, giving rise to a wide range of novel forms in a relatively rapid, but far from instantaneous, fashion (Raup, 1991; Eldredge, 1992; Palmer, 2003, pp. 244-251). There have also been some recent indications that a major catastrophic event, as well as creating ecological space, could also contribute to the overall process by giving natural selection more variant forms to work on, since it has been shown that severe stress can increase the rate at which random mutations occur, and can also give rise to inheritable epigenetic changes (Palmer, 2010). However, many orthodox geologists and evolutionary biologists are still reluctant to think that catastrophes of extraterrestrial origin could have been the cause of mass extinction episodes.

This attitude has been demonstrated over the past few years in relation to investigations of the theory put forward by Berkeley physicist, Rick Firestone, and some colleagues (Firestone,

West and Warwick-Smith, 2006), following on from a suggestion made previously by the Dutch geologist, Han Kloosterman (Kloosterman, 1976; Kloosterman, 1999). It was proposed that a cometary catastrophe at the end of the relatively-warm Bølling-Allerød interstadial around 12,900 years ago was the cause of extinction of the Columbian mammoth and other American large animals, as well as a return to extremely cold conditions in the Younger Dryas, the final stage of the Pleistocene epoch (Firestone, West *et al*, 2007; Bunch, Hermes *et al*, 2012; Lecompte, Goodyear *et al*, 2012). Much geological evidence of a significant extraterrestrial impact at this time has been produced, but it has generally been dismissed by others (Surovell, Holliday *et al*, 2009; Kerr, 2010; Pinter, Scott *et al*, 2011; Pigati, Latorre *et al*, 2012). Sometimes even the finders of such evidence have sought an alternative explanation. For example, Annelies van Hoesel and other geologists from Utrecht recently found nanodiamonds, a known product of impacts, at the Usselo horizon in Holland, generally believed to correspond to the boundary marking the beginning of the Younger Dryas in other parts of the world. This boundary is often characterised by a carbon layer, the product of wildfires, which frequently follow an impact. However, the Dutch team concluded that the nanodiamonds had probably been formed *by* the wildfires (Hoesel, Hoek *et al*, 2012), even though there is no known mechanism by which this could happen. They also stated that their radiocarbon-dating studies showed that the wildfires had occurred 200 years after the start of the Younger Dryas, without acknowledging that this apparent 200-year difference could be largely explained away by the fact that they had used a different calibration curve from the teams who had dated the beginning of the Younger Dryas (Howard, 2012).

Napier has produced evidence to suggest that the event 12,900 years ago, which produced the harsh conditions of the Younger Dryas, was caused by debris from the disintegrating giant comet, proto-Encke, in line with the Clube-Napier scenario (Napier, 2010). After that, according to the same scenario, the return to warmer conditions at the end of the Younger Dryas, around 11,500 years ago, came when dust from an encounter with this disintegrating comet began to clear from the Earth's atmosphere. According to Greenland ice-core data, average temperatures rose at this time by almost 10º C in a short period of time, probably less than a decade (Severinghaus and Brook, 1999; Mithen, 2003, pp. 12-13; Fagan, 2004). This might indicate a more specific event at the end of the Younger Dryas than that suggested by Clube and Napier, and possibly one unrelated to the mechanism which produced the cold conditions during that period. In 1990, Emilio Spedicato attributed the warming to the effects of asteroid impact in an ocean (Spedicato, 1990). Seven years later, Flavio Barbiero suggested that a rapid pole-shift had taken place at this time, caused by an asteroid impact (Barbiero, 1997). More recently, geologist Robert Schoch has argued that only something akin to a major plasma event, resulting from emissions from the Sun or some other cosmic body, could explain the rapid rise in temperature which occurred at the end of the Younger Dryas (Schoch, 2012; http://www.robertschoch.com/plasma.html). The dangers from such events are becoming increasingly apparent (Henbest and Couper, 2001, pp. 140-152; Clark, 2009), but not uniquely so. At this present conference in Naxos, in an earlier presentation, Spedicato suggested another possible scenario, involving an encounter with a large cosmic body.

Velikovsky, in the final section of part II chapter VII of *Worlds in Collision*, argued that the last glaciation in North America and Europe (i.e. the Younger Dryas) persisted until the time of either the Venus or the Mars catastrophe, when an axial shift resulted in a movement of the polar circle from northeastern America to northeastern Siberia, exterminating the mammoths. That scenario is not supported by Greenland ice-core evidence, which indicates that temperatures began to rise sharply around 11,500 years ago, and have remained at

significantly higher levels ever since (Mithen, 2003, pp. 12-13; Fagan, 2004). It is now generally accepted that the melting of the polar ice-sheets as a consequence of this climate change 11,500 years ago caused sea-levels throughout the world to rise by around 100 metres (Officer and Page, 1993; Ryan and Pitman, 1998; Gornitz, 2007). Although this took place rapidly by geological standards, and in spurts rather than at an even pace, inhabitants of low-lying coastal regions would generally have had no problem in moving back to higher ground before their villages were swallowed up by the rising seas. However, on occasions, the sudden collapse of natural barriers which had been holding back the advancing waters must have led to catastrophic flooding, possibly giving rise to legends of a Universal Deluge (Officer and Page, 1993; Mithen, 2003, pp. 150-157; Palmer, 2009).

Velikovsky's proposed mechanism for the Universal Deluge – Noah's Flood – was the transfer of water from the atmosphere of Saturn. He suggested it was quite possible that the Earth's water content had more than doubled by this mechanism at some time between five and ten thousand years ago, probably closer to the latter than the former (Velikovsky, 1973). Whatever the mechanism, there was undoubtedly wide-scale flooding, sometimes of a catastrophic nature, during this period.

Moving forward a few thousand years, Lonnie Thompson, a geophysicist and climatologist at Ohio State University, has assembled evidence from around the world of an abrupt climate change at approximately 3200 BCE, which was co-incident with structural changes in several emerging civilisations (Thompson, Mosley-Thompson *et al*, 2006; Thompson, 2010). Plants were covered by the Quelccaya ice cap in the Peruvian Andes at this time, and the Sahara switched from a habitable region to a barren desert. Also, tree rings from Ireland and England were unusually narrow, and there was an acidity peak in Greenland ice-cores (Baillie, 1999, pp. 51, 54). Thompson attributed the various indications of climate change and its consequences at around 3200 BCE to a dramatic fluctuation in solar energy reaching the Earth (http://www.researchnews.osu.edu/archive/5200event.htm). The University of Vienna geologist, Alexander Tollmann, together with his wife, Edith, had previously proposed that there had been an impact event at around 3150 BCE, following a larger one at around 7640 BCE (which they linked to the legend of Noah's Flood) (Tollmann and Kristan-Tollmann, 1994). More recently, British engineers Alan Bond and Mark Hempsell have argued, on the basis of their claimed decipherment of an Assyrian inscription, that Sumerian astronomers in 3123 BCE recorded the passage of a fireball across the sky in a low, flat trajectory, heading in the direction of Austria. Bond and Hempsell went on to deduce that the fireball, an Aten asteroid, exploded in the vicinity of Köfels, causing an enormous landslide, of which evidence still exists (Bond and Hempsell, 2008). That is controversial, but there are clear indications of climate change at around this time, although the rate of change is a matter of argument.

Clear indications of climate change, coincident with the collapse of civilisations, are also found at the end of the Early Bronze Age, dated to around 2300 BCE by conventional scholars, and also by Velikovsky in chapter XII of *Earth in Upheaval*. This was the period of Velikovsky's proposed catastrophic episode associated with "Jupiter of the Thunderbolt", when the Old Kingdom of Egypt fell, the impressive Troy II civilisation ended, and the cities of the Jordan plain, including Sodom and Gomorrah, were destroyed by fire from above.

Irish oaks show an episode of reduced growth centred on 2345 BCE (Baillie, 1999, p. 54), and the American engineer, Moe Mandelkehr, compiled a wealth of evidence of catastrophic events and rapid climate change at this time, this being presented in a series of papers in the

publications of the SIS from 1983 to 2007, and towards the end of that period as a book in three volumes (Mandelkehr, 2006). Similar evidence was also presented by others at the 2nd SIS Cambridge Conference in 1997 (Peiser, Palmer and Bailey, 1998, pp. 93-139).

Investigations by Fekri Hassan of University College London have demonstrated that the Old Kingdom of Egypt came to an end at a time of droughts and famine (Hassan, 2007). Similarly, a detailed examination at Tell Leilan in northern Syria by a team led by Yale archaeologist Harvey Weiss, showed that the climate in the region of this previously thriving site had suddenly become arid at the end of the Early Bronze Age, resulting in its abandonment for a period of several centuries (Weiss, Courty *et al*, 1993; Kerr, 1998; Marshall, 2012). This seemed to be typical of what happened throughout the Middle East, and a layer of tephra particles at the level of climate change at several sites implicated a volcanic eruption as the cause. On the other hand, Peter James and Nick Thorpe considered it more likely that the prime cause had been an extraterrestrial impact (James and Thorpe, 1999, pp. 50-58). Mandelkehr suggested that, at this time, there had been an encounter with the Taurid complex (Mandelkehr, 2001, 2006), as in the Clube-Napier model. French geologist Marie-Agnès Courty, who had worked with Weiss, found that a dust layer at Tell Leilan and other sites in the Middle East showed evidence of having been formed as a result of an impact into igneous rock (Peiser, Palmer and Bailey, 1998, pp. 93-108). However, no appropriate impact crater has yet been discovered.

In the middle of the next millennium came the end of the Middle Bronze Age, the time of Velikovsky's Venus catastrophe, which has already been discussed, and after that came the end of the Mycenaean period in Greece, which Velikovsky associated with the time of his Mars catastrophe. Orthodox scholars date the end of the Mycenaean culture, and of the Late Bronze Age, to around 1200 BCE, whereas Velikovsky placed the end of the Mycenaean period in the 8th century BCE. On the basis of current archaeological and geological evidence, it would appear that the end of the Middle Bronze Age and the end of the Mycenaean age were not cataclysmic periods on the scale envisaged by Velikovsky, but natural catastrophes and cultural upheavals nevertheless occurred on both occasions. A catastrophist scenario to explain the events on the former occasion, involving asteroid impacts, has been proposed at this present conference by Spedicato. The latter occasion was characterised by a change to cooler and drier climates in the Mediterranean region, accompanied by large earthquake storms (Peiser, Palmer and Bailey, 1998, pp. 140-147; Nur, 2008; Marshall, 2012).

There are thus a number of occasions from the start of the Younger Dryas to the end of the Mycenaean period when quantavolutions, i.e. significant changes to life on Earth linked to environmental upheavals, have taken place. Because of the continuing influence of the uniformitarian paradigm, there is still widespread resistance to the notion that the changes could have been rapid, or caused by natural catastrophes. However, if they really were sudden catastrophic events, as seems to me to be likely, then accumulating evidence must eventually bring about a paradigm change, although this will not happen easily or quickly. Establishing the prime cause or causes of the catastrophes is likely to be particularly difficult, because different catastrophists will no doubt be supporting different theories, all of them beautiful to their adherents, and indeed to many others, but they cannot all turn out to be correct. It is even possible that the prime cause of one or more of the catastrophic episodes may prove to be something that no-one has yet thought of, particularly since recent discoveries about the Solar System, the Universe and, at the other end of the scale, the nature of matter itself, have brought home the realisation of just how little we know, rather than how

much. At the beginning of the 20th century, reflecting the general belief of the time, the American physicist, Albert Michelson, wrote, "The more important fundamental laws and facts of physical science have all been discovered, and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote" (Michelson, 1903). A century later, it can be seen that such confidence was misplaced, for significant advances are still occurring (Hawking, 1988, pp. 171-175; R. Matthews, 1992, pp. 219-259; Baldwin and Cooper, 2009; Achenbach, 2012; Frank, 2012). As to the best way for young researchers to proceed in this context, I can do no better than quote the final paragraphs of Velikovsky's address to the Graduate College Forum of Princeton University in 1953:

"What I want to impress upon you is that science today, as in the days of Newton, lies before us as a great uncharted ocean, and we have not yet sailed very far from the coast of ignorance. In the study of the human soul we have learned only a few mechanisms of behaviour as directed from the subconscious mind, but we do not know what thinking is or what memory is. And in biology we do not know what life is. The age of basic discoveries is not yet at an end, and you are not latecomers, for whom no fundamentals are left to discover. As I see so many of you today, I visualize some of you, ten or twenty or thirty from now, as fortunate discoverers, those of you who possess inquisitive and challenging minds, the will to persist, and an urge to store knowledge. Don't be afraid to face facts, and never lose your ability to ask the questions: Why? and How? Be in this like a child.

Don't be afraid of ridicule; think of the history of all great discoveries. I quote Alfred North Whitehead: 'If you have had your attention directed to the novelties of thought in your lifetime, you will have observed that almost all really new ideas have a certain aspect of foolishness when they are first produced.' Therefore, dare.

And should even the great ones of your age try to discourage you, think of the greatest scientist of antiquity, Archimedes, who jeered at the theory of Aristarchus, twenty-five years his senior, that the earth revolves around the sun. Untruth in science may live for centuries, and you may not see yourself vindicated, but dare.

Don't persist in your idea if the facts are against it; but do persist if you see facts gathering on your side. It may be that even the strongest opposition, that of figures, will crumble before the facts. The greatest mathematician who ever walked on these shores, Simon Newcomb, proved in 1903 that a flying machine carrying a pilot is a mathematical impossibility. In the same year of 1903, the Wright brothers, without mathematics, but by a fact, proved him wrong.

In religion, the great revelations and the great authorities – the founding fathers – belong to the past, and the older the authority, the greater it is. In science, unlike religion, the great revelations lie in the future; the coming generations are the authorities; and the pupil is greater than the master, if he has the gift to see things anew.

All fruitful ideas have been conceived in the minds of the nonconformists, for whom the known was still unknown, and who often went back to begin where other passed by, sure of their way. The truth of today was the heresy of yesterday.

Imagination coupled with scepticism and an ability to wonder – if you possess these, bountiful nature will hand you some of the secrets out of her inexhaustible store. The pleasure

you experience discovering truth will repay you for your work; don't expect other compensations, because it may not come. Yet, dare."

Those words are as true today as when Velikovsky spoke them in 1953. Regardless of the controversies surrounding Velikovsky, in this passage, he surely pointed the way forward to the future, in inspiring fashion. However, despite the satisfaction that cosmic heretics may justifiably feel when it finally becomes established that catastrophes of extraterrestrial origin have occurred in the not-too-distant past, each one by a clearly-established mechanism, there will also come increased realisation that what has happened before can happen again. Having begun this presentation with a comforting quotation about beauty from a 19th century poet, let us end with two quotations, more disconcerting in nature, from 20th century poets. However awesome the sight of an approaching cosmic body might be, the possible consequences for Earth and its inhabitants could be fearful. What would be in store for humanity when, in the words of Willian Butler Yeats, "a terrible beauty is born"? The final quotation, possibly answering that question, is an extract from a poem by Rainer Maria Rilke, used previously by Bill Mullen in *Pensée* (Mullen, 1972). Rilke wrote (in translation): "For beauty is nothing but the beginning of terror which we are barely able to endure" (Young, 2006). Let us hope that we ourselves do not have to experience such an event.

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