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Earth, Air, Fire, and Water: The Archaeology of Bronze Age Cosmic Catastrophes

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Summary

Planetary scientists and astrophysicists recently have begun to model the potential hazards on Earth from impact by asteroids and comets. These models suggest that some 25 at least locally catastrophic impacts likely occurred in various portions of the world during the past 5,000 years, during which time occurred the major developments of modern human civilization. This paper uses these cosmic impact models, coupled with data from archaeology, palaeo-environmental studies, and the systematic analysis of cosmogonic mythology and other literary traditions, in order to identify previously unknown catastrophic Bronze Age cosmic catastrophes, the most significant being a globally catastrophic oceanic comet impact estimated at between 10^5 and 10^6 megatons that occurred in 2807 BC. These data suggest that the threat of cosmic impact is very real, that the risk posed by cosmic impact is potentially much greater than currently modeled, and that such impacts have played a critical role in the development of human civilization.

1. Introduction

Near the end of his illustrious career Plato wrote a dialogue unlike any of the others he had written, one composed of a curious blend of cosmology, physics, and biology. Plato recounts an oral tradition about the Athenian lawgiver and poet, Solon, who two centuries earlier in the 7th century BC had traveled to the city of Sais on the Nile delta in order to question Egyptian priests about their knowledge of antiquity. One aged and venerable priest made the following remarkable statement [108: 451-452]:

> "O Solon, Solon, you Hellenes are never anything but children, and there is not an old man among you....[T]here is no old opinion handed down among you by ancient tradition, nor any science which is hoary with age. And I will tell you why. There have been, and will be again, many destructions of mankind arising out of many causes; the greatest have been brought about by the agencies of fire and water, and other lesser ones by innumerable other causes. There is a story, which even you have preserved, that once upon a time Phaëthon, the son of Helios, having yoked the steeds in his father's chariot, because he was not able to drive them in the path of his father, burnt up all that was upon the earth, and was himself destroyed by a thunderbolt. Now this has the form of a myth, but really signifies a declination of the bodies moving in the heavens around the earth, which recurs after long intervals; at such times those who live upon the mountains and in dry and lofty places are more liable to destruction than those who dwell by rivers or on the sea-shore. When, on the other hand, the gods purge the earth with a deluge of water, the survivors in your country are herdsmen and shepherds who dwell on the mountains, but those who, like you, live in cities are carried by the rivers into the sea. Whereas just when you and the other nations are beginning to be provided with letters and the other requisites of civilized life, after the usual interval, the stream from heaven, like a pestilence, comes pouring down, and leaves only those of you who are destitute of letters and education; and so you have to begin all over again like children, and know nothing of what happened in ancient times, either among us or among yourselves [...] In the first place you remember a single deluge only, but there were many previous ones."

Classical scholars should recognize this as part of the prologue to *Timaeus*, the dialogue in which Plato introduces the fabled lost city of Atlantis, described further in his subsequent dialogue *Critias*. Obviously Plato was fascinated by these foreign eschatological concepts, but only a generation later such catastrophic thinking no longer had an active place in the beguiling symmetry and abstract perfectionism of the Aristotelian celestial heavens. With the coming of Newtonian physics, the Age of Enlightenment, and modern social science, eschatology has been pounded and stuffed into the role of being but a minor component of studies of mythology and religion.

Scholars have paid much attention to the cosmology and biology of *Timaeus*, but have set aside the eschatology as a mere curiosity. The connection of this eschatology to something so potentially "absurd" as the sunken capitol of a lost idyllic civilization has contributed to the purposeful ignoring by modern Western science of both the message and context of Plato's Egyptian eschatology [63]. Equally damning was the fact that the eschatological message was delivered within the "suspect" context of mythology and oral history. Unfortunately, by ignoring the wisdom of the venerable Sais priest, Western science has discarded the one element of *Timaeus* likely most heavily grounded in actual historical observation as opposed to generalized philosophical speculation.

I wish to breathe new life into the concept of cyclical (or at least periodic) destructions of the world, especially as they relate to fire and water. It is my purpose in this paper to explore the likelihood that terrestrial and oceanic impacts by comets, asteroids, and meteorites are largely responsible for the powerful eschatological visions that have been handed down to us from past civilizations.

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These impacts include a globally catastrophic oceanic comet impact in 2807 BC near the beginning of the Bronze Age (the last such catastrophe of truly global proportions, as will be defined below), along with several regionally and locally catastrophic impacts. A detailed study of all potential Bronze Age cosmic impacts lies beyond the scope of this paper, which is intended only as a preliminary examination of the issue. Also, the data are not yet sufficiently refined to reliably test whether or not these cosmic impacts are purely stochastic or instead have a non-random temporal distribution. However, if we assume that the evidence from the past 5,000 years is representative of longer term trends, these data suggest that current models substantially underestimate the risk of catastrophic cosmic impact.

2. Cosmography and epistemology

Although I am an environmental archaeologist by training, a term better suited for my research is "cosmography". The term cosmography has been in existence since the 14th century (*Webster's Ninth New Collegiate Dictionary* 1987), but is currently little used in the sciences. Cosmography is defined as "a general description of the world or of the universe". It is also "the science that deals with the constitution of the whole order of nature or the figure, disposition, and relation of all its various parts" (*Webster's Third New International Dictionary* 1993). As such, cosmography attempts to counter the tendency in modern Western science to segment the natural world into mutually exclusive knowledge arenas.

I am keenly interested in how a given society or cultural group uses and manipulates environmental events and processes as a means to guide or influence governmental policy, social action, ritual behavior, and religious and/or scientific thought. This may appear to smack of environmental determinism, a particularly unpopular topic in the social sciences during the past forty years. However, it does not require being an environmental determinist to accept that the environment pervades our lives today just as much as it has in past centuries.

Within the 20th century millions of lives have been lost to typhoons, hurricanes, cyclones, tornadoes, monsoons, floods, volcanic eruptions, droughts, and associated disease and pestilence. Hundreds of millions of people during this same period have periodically suffered due to starvation or by being left homeless due to environmental events. Because of the prevalence of wars in the 20th century, until recently we have tended to minimize the effects that the environment has had on human misery, even though at least some of the local and regional conflicts were largely the product of environmental perturbations. And when we did focus on the environment, it was primarily anthropogenic processes and events that captured our attention, such as pollution, the destruction of rain forests, and the reality of global warming. However, Hurricane Andrew, the recent eruptions of Mount St. Helens and Mount Pinatubo, and the effects of the El Niño/Southern Oscillation climate cycle have served to refocus scientific and governmental attention, especially in the United States, on the natural environment.

Cosmography crosscuts and blends a number of scientific disciplines and sub-disciplines including anthropology, archaeology, astronomy, epistemology, ecology, geography, geology, history, psychology, sociology, and theology. Cosmography likewise focuses attention on knowledge arenas not commonly used by archaeologists and the more traditional environmental sciences, including astrology, cognition, cosmogony, cosmology, mythology, and religion. Because past cultures were holistic, each of these knowledge arenas has the potential to shed a bit of light on past natural environmental events and processes, and when joined together can be most illuminating.

In particular, mythology is singled out as being a rich source of information on past major environmental events. Mythology to date has been largely under exploited as a resource because of our failure to understand its meaning and logic, and our failure to realize that the data contained in mythologies can be retrieved by systematic scientific methodology. Mythology, rather than being fanciful as is commonly believed in Western science, is actually a large multifaceted window on the major natural environmental events and processes that have shaped human history.

A distinction needs to be made between cosmography and the blossoming fields of archaeastronomy and ethnoastronomy. Beginning with the studies by Thom [188] and Hawkins [81] of Stonehenge and other megalithic sites in the 1960's, and subsequent work by scholars elsewhere such as Santillana and Dechend [166], Hadingham [78, 79], Aveni [6, 7], and Urton [190], archaeoastronomy and ethnoastronomy have steadily moved from the distant fringes of science to their current position as viable and exciting research arenas near the mainstream of the history of astronomy and of the historical social sciences [8, 9, 67, 101, 102, 185, 206]. Archaeoastronomy can be considered the science which systematically gleans the archaeological record in order to document the awareness and development of astronomy by past societies. Most work in this field has focused on the manner in which past societies viewed and measured the regularized movements of the fixed celestial heavens (e.g., Sun, Moon, planets, stars, and constellations), and on the creation of seasonal or yearly calendars. Ethnoastronomy focuses on the astronomies and cosmologies of traditional, largely Third World historic and modern cultures.

In contrast, the primary goal of my use of cosmography is to explain in behavioral and evolutionary perspective how individuals and cultural groups respond to environmental events and processes. These include not only earthly events, such as volcanic eruptions and typhoons, but also those naked eye temporary events which take place in the celestial heavens such as novae, supernovae, meteor storms, comets, fireballs, bolides, eclipses, and major planetary conjunctions. Indeed, celestial events and processes in general are a key component of the natural environment which until now have been largely ignored by science. An equally important goal of cosmography is that of the reconstruction of past environmental events and processes not presently known, or at least poorly known to science as determined from patterns elicited from the archaeological, documentary, oral historical, and paleoenvironmental record. Chief among these are cosmic impacts.

The path which led me to cosmography was circuitous and improbable for someone who for the first 15 years of my professional career was a conservative, data-oriented mainstream American Southwestern archaeologist. Like most archaeologists trained a generation ago, mythology, astronomy, and oral history were simply not part of my early professional venue. I had been taught that myth was largely psychological, that only a few of the more "advanced" past cultures had any significant notions of astronomy, and that oral traditions older than six or seven generations were likely to be at least partly distorted, with the distortion significantly increasing each successive generation. The thought of meaningful history being transmitted orally more than 200 or 300 years frankly was quite unthinkable. I did, however, differ somewhat from my Southwestern colleagues in that my fieldwork experiences led me to believe that the physical environment played a critical role in shaping the trajectory of individual cultures [119, 122].

My initial substantive foray away from normative archaeol-

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ogy occurred while conducting doctoral research in the Belau (Palau) islands of western Micronesia. Archaeological data associated with 13-14th century AD villages on long-uninhabited coralline limestone islets (*Rock Islands*) in Micronesia's Belau archipelago [121, 129], well matched the late 19th and 20th century oral traditions about warfare and settlement patterns surrounding these villages.

For example, among the village architectural features in the Rock Islands were massive defensive walls enclosing sandy coves, wall-in passes in inland areas, paired guard platforms adjacent to inland trails, and house platforms which were defensively situated. Even more poignant was the fact that our analysis of faunal remains [30, 121] demonstrated significant declines in the sizes of adult fish and shellfish food stocks along with the remarkable extirpation of pig in Belau, thus matching stories about starvation during this warfare period. I also was impressed by the finding of offertory deposits of branch coral hidden in the footings of stone house structures. This suggested that architectural remains provide insights into religious and symbolic aspects of culture in addition to the more mundane material, economic, and settlement pattern data. At this same time I perceived that historic and modern Belauan fishermen, untrained in Western science, were acutely aware of many significant aspects of animal behavior of which even experienced marine biologists were unknowledgeable [93, 120, 121].

The major breakthrough in the development of my ideas about cosmography resulted from the unique opportunity in 1989 at Hawaii Volcanoes National Park to participate in seventeen days of emergency rescue archaeology at the site of Waha'ula *heiau*. This ancient legend-laden archaeological site, purportedly the first human sacrificial temple in the Hawaiian Islands, was rapidly being overrun by lava from Kilauea Volcano.

As with the archaeology in Belau, the Waha'ula temple complex contained intriguing architectural elements that spoke to the symbolic and religious aspects of culture. Temple enclosure walls were oriented towards the cardinal directions; large blocks of bright red cinder gathered several miles from the temple were strategically incorporated into otherwise black basaltic sacred enclosure walls; paired waterworn or otherwise distinctive cobbles likewise were purposefully incorporated into the walls of enclosures and the houses of priests; and low walls marking gender and social class boundaries were used to segregate the overall temple precinct [130]. And as with Belau, I was surprised to discover how well oral histories of Waha'ula seemed to match archaeological reality.

During these seventeen frenetic days I observed close-hand the erratic and powerful behavior of living lava, complete with methane explosions, acid rain, and the destruction of a rich dryland forest. I also experienced an earthquake measuring 6.1 on the Richter scale. The earthquake collapsed the main tube system and briefly slowed the flow of lava, thus providentially allowing several extra days in which to conduct our studies.

Volcanologists, in studying the history of Kilauea volcano, had determined through radiocarbon dating of burned vegetation under lava flows of various ages, that approximately 70% of the surface area of Kilauea volcano is covered by lava younger than 500 years, while about 90% of the surface is younger than 1100 years [87]. I and my archaeological colleagues realized that such high levels of volcanic activity must have had a profound influence on traditional Hawaiian cognition and settlement patterns [29, 104, 130, 175].

In order to better understand both the significance of Waha'ula and the effects of volcanic eruption in traditional Hawaiian culture, I began to research the oral history and mythology surrounding the volcano goddess Pele. This in turn led to the realization that the majority of Hawaiian myths were firmly attached to Hawaiian chiefly genealogies, some of which were purported to go back in unbroken lineage for more than 95 generations before Kamehameha I, the monarch who unified the Hawaiian archipelago in the late 18th century. Among the myths attached to the genealogies were several Pele myths in which the volcano goddess had battles during the reigns of named genealogical chiefs (sometimes with the chiefs themselves), battles that resulted in the production of discrete named lava flows whose locations were known historically.

Much to my surprise, the radiocarbon dates for these lava flows matched not only the relative order of the named chiefs in the genealogical record, but closely matched absolute dates as well if a 22-year period were used for the length of each chiefly generation [130, 175]. Thus as with Belauan oral history, some Hawaiian myths appeared to record real environmental events which occurred up to at least 700 years in the past.

But my biggest surprise was the realization that the majority of the genealogically-fixed Hawaiian myths about powerful supernatural beings and culture heroes had little to do with earthly events such as volcanoes; rather they seemed fixated with the sky. As it turned out, an unlikely asset in my studies proved to be my unfamiliarity with archaeoastronomy and its preoccupation with the perceived more science-oriented "fixed celestial heavens". Instead, I was struck by the resemblance of the imagery of Hawaiian legendary voyages, cosmic battles between supernatural beings, and other action-filled myths with that of the nature and the occurrence of temporary celestial events such as the passage of comets and the sudden appearance of novae.

In order to refine my chronological control of mythology and historical traditions, as well as to observe and understand how various cultures respond to temporary celestial events, I created a master list of more than 1124 naked eye events recorded by Chinese, Korean, Japanese, Arab, and European observers between 200 BC and AD 1800 [123]. An updated version of this list is to appear in a forthcoming book [131]. This list of temporary celestial events is derived from data previously collected and scrutinized by astronomers and historians of astronomy [39, 89, 90, 145, 210]. These records often describe specific aspects of a particular event such as color, size, duration, and location in the sky against the backdrop of named stars, constellations, planets, Sun and Moon. Because of the largely stochastic nature of temporary celestial events, the record is marked by variation not unlike the patterns of drought and high effective precipitation found in tree rings. Some of these temporary celestial events were individually remarkable or formed unique contemporaneous clusters, while other portions of the chronological record exhibit few if any observations of temporary celestial events.

My cosmographic researches with Hawaiian, and more recently with American Southwestern oral traditions, archaeology, and ethnography revealed tantalizing patterns about how some cultures reacted to these celestial events, including as catalysts for profound culture change [123, 124, 127, 128]. It is beyond my ability in this paper to make a detailed presentation demonstrating the exact linkage between specific celestial events and specific myths; such linkage is provided elsewhere, at least for Hawaii [123, 131]. Later in this paper, I highlight a few salient aspects of this research.

By early 1991, I began to look at myths from other geographic regions besides the Pacific, and realized they,

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too, were filled with celestial imagery. Of note were myths describing catastrophic devastation caused by flood and firestorm. Realizing that myths in Hawaii and Micronesia encoded real environmental events, I made the assumption that these myths reflected one or more real disasters. Due to my familiarity with the literature on volcanic eruptions, I also realized that many myths did not well reflect volcanic eruptions or other known physical processes on Earth, but rather seemed to reflect disasters of cosmic origin. Particularly interesting were a series of myths (discussed later) that appeared to date to around 2815 BC, which seemed to correlate with substantive changes in the palaeo-environmental and archaeological record.

Unfortunately, being new to the finer details of astronomy and especially to the topic of cosmic catastrophe, and given the recent hoopla surrounding Supernova 1987A in the neighboring galaxy of the Lesser Magellanic Cloud, and especially given the fact that Hawaiian myths obviously encoded a number of novae and supernovae [123], I mistakingly first attempted to model the ca. 2815 BC event as the product of a near-Earth nova or supernova. Part of my model was based on perceived correlation between known historic nova/supernova events and pulses in the production of radiocarbon, which I attributed to increases in non-solar cosmic ray production from nearby exploding stars.

Armed with the ardent fervor that commonly adorns the naive, in the spring and summer of 1992 I put together a proposal for the Santa Fe Institute (SFI) to conduct a workshop on this hypothesized near-Earth nova-like event. While my selection of SFI may seem a bit odd to those who are aware of the long-term commitment made by SFI to the study of complex adaptive systems along with topics such as criticality and phase transitions at the edge of chaos, this was not as capricious a decision as it might at first seem. SFI is actually interested in all facets of system change, and they were somewhat intrigued by the possibility that the external natural environment was a bigger player in aspects of this change than previously envisioned.

Admittedly, however, the more compelling reason for this choice was the fact that my former dissertation chair sits on the SFI research board. I knew that he knew I was a solid scientist, and while he might think my recent ideas were a bit fringe and a real "shot in the dark", I had proved myself a competent professional archaeologist through many years of his observation, and under many, often difficult and interesting circumstances. For anyone who has attempted to introduce a new concept (or in this particular case, an older much abused concept) in business, politics, or science, the importance of networking and patronage cannot be overstated. I did not want to impose on our friendship, but I realized that without a lengthy record of publication on this topic, my chances of successfully convincing any other appropriate scientific organization to host the workshop was virtually nil. After more than a year of his deliberation as to the possibility that I was temporarily insane or was having chemical flashbacks from my days as an undergraduate in the San Francisco Bay area in the late 1960's, my former dissertation chairman encouraged me to submit my proposal. At the time I was Pacific Area Archaeologist for the Pacific Naval Facilities Engineering Command, and I used similar networking tactics to solicit the potential support of the U.S. Department of the Navy to help fund the workshop.

SFI took my proposal seriously and sent it to several knowledgeable reviewers, including noted cosmologist David Schramm at the University of Chicago. Schramm's compassionate but thorough review made it clear that nova events in particular, but supernovae as well, were highly unlikely candidates to produce the catastrophic effects that I had modeled from the archaeological, documentary, and oral historical record for the period of around 2815 BC.

The collapse of a pet theory, especially one representing many thousands of hours of personal research, is not a pretty sight. During several months of despondent denial, I checked and rechecked my data and wondered what went wrong. Then one day in March 1993, on a lengthy return flight to Honolulu from Navy duties on Guam and Tinian Islands, my ideas recrystallized. Armed with copies of Roger Penrose's *The Emperor's New Mind*, David Raups *Extinction: Bad Luck or Bad Genes*, excerpts from about 25 myths worldwide on the Great Flood, and especially the November 1992 issue of *Newsweek* magazine on "Doomsday Science", it suddenly dawned on me that my ca. 2815 BC catastrophe indeed was real, but as noted by Schramm and the other reviewers the event was not caused by a near-Earth supernova. Rather, this particular catastrophe was the product of a post-perihelion oceanic comet impact [124, 125].

Upon reaching home, a thorough review of my data and a brief check of the literature on cosmic impacts convinced me I was finally on the right track. I revised and resubmitted my proposal to SFI in September 1993, this time modeling the ca. 2815 BC event as a cosmic impact. It was also during the summer of 1993 that the name Velikovsky first came to my attention. After listening to my cosmic spiel, a close friend and fellow Southwestern archaeologist told me that my ideas distinctly reminded him of the work of Immanuel Velikovsky (discussed below), which he had read as a high school student. When told about Velikovsky, I was uncertain whether to be offended or amused at the comparison. Velikovsky sounded distinctly 'fringe' to me. This suspicion was reinforced by discussions with individuals at SFI who were openly scornful of his work. However, I made a mental note to someday get hold of Velikovsky's books, especially since several people had suggested that my work seemed perilously similar.

The end result of my second submittal to SFI was the same as the first. Of the roughly 25 scholars and scientists to whom the proposal had been sent either by myself or SFI, only a handful bothered to respond, with those few responses being equally mixed between those who were skeptical but thought the proposal had merit, and those who thought it uninteresting or even bad science.

My communication with SFI did have the positive result of networking with the archaeoastronomy community, and resulted in an invitation for me to give a paper at the conference "Inspiration of Astronomical Phenomena" held at the Vatican Observatory in 1994. It was at this time I discovered the work of Victor Clube and Bill Napier [42, 43], and subsequently the general field that is commonly now referred to as *neo-catastrophism* [147].

Although the present paper is incorporated into a volume resulting from a conference focusing on catastrophe, I am uncomfortable with the term neo-catastrophism. However, I recognize that several of my findings do, in fact, arguably support the basic tenets of neo-catastrophism. Indeed, much that I accomplished between 1989 and 1994 could be conceived as "reinventing the neocatastrophist wheel", as suggested by a valued colleague.

Nevertheless, I prefer instead to consider myself simply an environmental archaeologist who uses a cosmographic approach to science and history. This does not in any way diminish my respect for admiration of the work of others who have come to embrace the importance of mythology in the pursuit of historic reconstruction, and who have come to recognize the fact that environmental catastrophe is not an uncommon event in the history of humankind. The major difference between my fellow archaeological colleagues and me is that I subscribe to the notion that past societies were totally holistic in their treatment of science, religion, economics, and politics, which allows me to adopt the stance

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that studies of the physical environment must include the celestial heavens as well as more ground-based events and processes. And the major difference between myself and neo-catastrophists is that my cosmographic approach potentially allows for somewhat better control of the nature, context, and timing of temporary celestial events, including cosmic impacts, and thus permits at least the tentative coupling of oral historical traditions and archaeological manifestations with specific celestial and earthly events.

It is necessary to distinguish both cosmography and neo-catastrophism from the work of Erich von Däniken and other pseudo-scientists. These authors have deluged the popular press with a curious mixture of archaeological, astronomical, and historical data purposely torn from their original contexts in order to create logically flawed and scientifically untenable claims about visits from space aliens, psychic archaeology, and similar drivel [63, 182]. Unfortunately, this has given a bad reputation to virtually all serious and worthwhile studies that attempt to combine mythology and religious-ritual systems with archaeology and astronomy.

This situation was not helped by the writings of Immanuel Velikovsky in the 1950's through the 1970's, or more strictly speaking, by the scientific reaction to his work [76, 164]. Velikovsky was a European-trained psychiatrist who in preparing a treatise on Freuds own dreams and an associated comparative analysis of the lives of Oedipus/Ahkenaton/Moses, voluminously studied the eschatological myths of many cultures.

Velikovsky was struck by the possibility that the catastrophes described in these myths reflected cosmic catastrophes, a theory he thought helped to shed light on then inexplicable astronomical phenomena, such as the distinctive retrograde rotation of Venus and its likely high surface temperature, the later which Velikovsky predicted based on his model. Unfortunately, in his attempts to analyze and to explain the various data sets, he felt it necessary to manipulate aspects of archaeological and historical chronologies, and he often uncritically lumped together eschatological traditions from various parts of the world. But most damning in the eyes of astronomers and physicists, Velikovsky attempted to create a new and fatally flawed physics by which to explain objects and processes in the Solar System, including his curious notion that at some point in historical times the Earth somehow briefly stopped or significantly slowed down its rotation.

Despite my distaste for von Däniken and others of his ilk, I am willing to acknowledge that aspects of my cosmographic research were indeed thoughtfully presaged by Velikovsky. While in this vein I should also acknowledge William Whiston (A *New Theory of the Earth*, published in 1696), who succeeded Sir Isaac Newton in the Lucasian Chair of Mathematics at Cambridge, and whose work may have at least partly inspired Velikovsky's curious notions about the effects of large Earth-grazing comets.

I likewise acknowledge the earnest interdisciplinary and diverse approaches of scholars such as physicist Charles Pellegrino, the geologists Dorothy Vitaliano and Donald Patten, and the historian Vine Deloria, Jr., all of whom consider mythology to be a valuable adjunct to historical analysis. Pellegrino [154] links various environmental events, especially the eruption of Santorin volcano, with mythologies and historical texts throughout the Old World. Vitaliano [192] is particularly ambitious in creating a disciplined approach (not unlike aspects of cosmography) that she terms "geomythology". Although sometimes confusing and homogenizing the very distinct terms "mythology", "legends", and "folklore", Vitaliano nevertheless advocates that a careful study of myth, history, and geology demonstrates the keen appreciation that past cultures had for their physical world, and helps to explain the origins of specific historical geological events (e.g., volcanoes, earthquakes, floods) and specific myths or classes of myth.

The work of Patten [151] and Deloria [51] is in direct conceptual lineage with that of Velikovsky. They question the explanations provided by normative geology, particularly in their use of catastrophism as an active agent in geological change. Using the Velikovskian-like near-Earth approach of an object larger than the Moon, Patten modeled the effects of this hypothesized object as creating the Biblical Great Flood at around 2800 BC. Pellegrino [154], likewise, focuses attention on the 2800 BC date for the Biblical Flood, although he views it as a regional rather than a global catastrophe. Deloria, on the other hand, focuses attention on the the boundary between the Pleistocene and Holocene periods. He argues that the profound changes at that time, including the extinction of a number of large mammals, such as the mastodon and mammoth, were the product of catastrophe and not gradualistic factors or senseless slaughter as modeled by Paul Martin and his colleagues [118]. Deloria also effectively deals with some of the subtle ethnic biases that modern Western science has perpetuated against traditional non-Western knowledge systems. While I differ considerably from some of their modeling and especially their interpretive frameworks, I am struck by the fact that Patten comes up with a date for the Flood remarkably close to my own work on the topic [125], and am likewise intrigued by the fact that Deloria's view of the Pleistocene-Holocene boundary anticipates my belief that one or more cosmic impacts played a large role in this transition. Each author provides a number of useful observations which deserve consideration.

I especially applaud the work of geologist Russell Blong [20], whose careful research methods provide an exquisite demonstration of the value of the cosmographic approach (not labeled as such by him) to the social and physical sciences. Blong systematically studied the physical evidence and the mythology surrounding a previously unknown 17th century volcanic eruption which impacted an area larger than 100,000 km^2 along the northeastern coast and interior of Papaua New Guinea. Blong's work, which deserves a wider audience than it has apparently thus far received, provides many insights into the manner in which mythology and oral history encode environmental catastrophe. Blong's work unquestionably demonstrates the value of mythologies for providing many useful environmental details that can be systematically retrieved from oral histories and correlated with physical evidence gathered by other scientific means.

Finally, I greatly admire the work of astronomers Victor Clube and Bill Napier [42, 43, this volume] who have demonstrated an excellent understanding of much of the astronomical content of mythology. Clube and Napier, in collaboration with a handful of other colleagues, have introduced the interesting concept of cycles of impacts involving the intersection of the orbit of the Earth with debris streams from the breakup of giant comets, in particular the object responsible for the Taurid meteor streams. Unfortunately, their work has suffered from the anti-mythology and anti-Velikovsky sentiment of the hard sciences [33], but especially from their failure to identify specific matches between mythology and known or reconstructible cosmic impacts, with the possible exception of recent impacts such as that in the Tunguska region of Siberia in 1908. I will return to Clube and Napier's intriguing concepts of a Taurid 'progenitor giant comet' and 'coherent catastrophism' later in this paper.

These are but some of the individuals whose work I have discovered and have come to appreciate these past few years, including of course the fellow contributors to the present

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volume. At least some such as Clube and Napier have persisted with their work despite more than two decades of not just healthy skepticism but often rancorous scorn from practitioners of normative science. Their example inspires those of us who have more recently joined in this battle between paradigms.

But regardless of whether my own particular approach to history and to biological and cultural evolution be termed cosmography, catastrophism, or even Velikovskyism, I do have some tenets that may differ, at least in emphasis, from those of my colleagues. First, I rather strictly adhere to the basic principles of my archaeological heritage: sound chronology and context are fundamental components of my research, including that dealing with mythology. In fact, my introduction to cosmography and the value of mythology came about through the attempt to use genealogically-based mythology to refine the dating of Hawaiian culture history. Second, I bring together data from a large number of different scientific fields to balance and weigh my ideas, and which eventually may be used to test my ideas. Third, I have developed a logical and compelling theoretical framework for the origin and structure of mythology in which temporary celestial events, including cosmic impacts, play a significant part [123, 124, 125, 127, 131]. The mythologies included in my research are from cultures worldwide, and are not restricted to the major Old World civilizations. Finally, in contrast especially with Velikovsky, verification of the hypotheses and results generated by my research does not require the creation of a new physics nor does it violate any standard known scientific laws or principles. Likewise, my identification of previously unknown Holocene period cosmic impacts is completely amenable to scientific testing and falsification.

In fairness to Velikovsky, I have the benefit of greatly improved contextual and chronological control over mythology and archaeology, along with the benefit of the past decade of modeling and research on cosmic impacts [68] upon which to ground my own particular vision of cosmic catastrophe. But unlike nearly all other scholars noted above, I also have the benefit of a detailed working knowledge of the manner in which historic cultures viewed both the fixed celestial heavens and especially the occasional appearance within those heavens of often dramatic temporary celestial events [123]. The importance of the full suite of these temporary celestial events to past cultures and to the very fabric of mythology cannot possibly be overstated. This knowledge facilitates the identification and reconstruction of specific dated Holocene period cosmic impact events previously unknown to science, and brings into better focus the presence of other potential impacts where data sets have not as yet been fully developed.

3. Cosmic impacts

At present, the only definitive major catastrophic environmental event known to have occurred during Bronze Age times is the cataclysmic eruption of Santorin (Thera) volcano in the Aegean sea. [*Santorin* and *Thera* are used interchangeably in the historic literature; as a matter of convention I use "Thera" to refer to the island and Santorin to refer to the volcano itself.] The absolute dating of this event is still debatable [53] but seemingly took place in the late 17th or 16th centuries B.C. It likely directly impacted (largely by tsunami and ash fall) an area much greater than 500,000 km^2. Various authors in the present volume have pointed to other time periods during the Bronze Age when seemingly catastrophic events took place at least on a *local* level (i.e., a few thousand to a few hundred thousand square kilometers), and perhaps on a regional level as well. In particular, the dates of around 2350 BC, 2200 BC, 1200 BC and 1000 BC have been singled out as worthy of detailed scrutiny. These shall be returned to below.

Apart from the Santorin eruption itself, there is no clear consensus among the authors and other Bronze Age scholars as to what specific events may have triggered the various destructive layers apparent in the archaeological and geophysical record. Invading armies, earthquakes, and internecine warfare caused by the economic and social consequences of climate change have all been postulated [186]. Cosmic impact is also occasionally mentioned as a cause for at least some destructive layers (Peiser, this volume), but we are hampered in our attempts to examine this possibility because of our poor understanding of the physical, social, and archaeological signatures of cosmic impact.

Our knowledge of the effects of cosmic impact is largely based on the evidence of a single relatively small terrestrial impact of a probable stony asteroid that occurred in the Tunguska region of Siberia in 1908 [38, 82, 171]. This event was estimated at an energy of about 15 megatons (15 MT), the equivalent of about 750 times the force of the atomic bomb dropped on Hiroshima. The Tunguska impact leveled more than 2,000 km^2 of forest largely due to the fact that the asteroid exploded some 8 km above the surface of the ground. In addition to a blindingly bright atmospheric impact fireball, an air pressure blast wave which leveled the forest, and a particulate debris cloud extending many kilometers into the upper atmosphere and which was redeposited as "black rain", local effects included multiple sonic booms, earthquakes, and the generation of thermal radiation which blistered exposed portions of trees. Strong seismic waves were felt up to 600 km from the blast, while near-hurricane gusts of wind created during the passage of the shock wave traveled nearly as far. Many people were seized with terror and thought the end of the world had come. And for several nights following the impact, midnight skies over Europe were brightened to such an extent (presumably by high altitude particulates) that stars disappeared and the sky took on pinkish cast like a bright dawn. The sky was so bright that one scientist in England could actually read a book by its light at 1:45 a.m. [10, 181]. Smaller impacts, such as the fireball shower in the Russian town of Novyre Ergi in 1662 [181: 42-43) and the as yet poorly studied 1930 impact in the Brazilian rain forest [12] produced visually spectacular but less energetic effects than Tunguska.

Until the intensely watched impact of Comet Shoemaker-Levy 9 on Jupiter during the summer of 1994, our understanding of terrestrial impacts larger than Tunguska has been based primarily on theoretical modeling. This is augmented by a scattering of studies surrounding the physical evidence for the presumed dinosaur-ending Chicxulub impact on the Yucatan peninsula some 65 million years ago at the boundary between the Tertiary and Cretaceous periods (K-T boundary), along with a few other impacts which occurred prior to the Pleistocene geological period which began some 2 million years ago.

Water covers some 70% of the Earth's surface and thus oceanic or lake impacts are more than twice as likely to occur as are terrestrial impacts. Unfortunately, we are hampered in our understanding by the very lack of documented historic oceanic cosmic impacts. Our knowledge of oceanic impacts is solely limited to computer simulation and theoretical modeling, which is still largely in its infancy. Work by Jack Hills and his colleagues [82, 83] has brought much needed attention to the devastating tsunamis that can be generated by oceanic impact from even relatively small impactors. There also has been some attention paid to the effects that oceanic impacts can have on other aspects of the environment, including the atmosphere [189]. And in 1997 the Sandia National Laboratory performed a high-resolution

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supercomputer simulation of the effects of a 1-km wide, 60-km per second comet impact in the middle of the Atlantic Ocean, whose energy yield was close to the 300,000 MT (300 gigatons) threshold thought necessary for global catastrophe.

Despite these encouraging starts at understanding the environmental effects of oceanic impact, we are hampered by our still largely rudimentary understanding of linkages within oceanic-atmospheric circulation systems. For example, to my knowledge no one has satisfactorily modeled whether a small oceanic impactor has the capability of triggering an El Niño event or similar widespread climatic disturbance.

Currently accepted models of the risk of cosmic impact (detailed at the end of this paper) suggest that a locally catastrophic Tunguska-like impact can occur somewhere on Earth on the average roughly once every 200 years. A regionally catastrophic impact, as defined here, is one which directly impacts at least 500,000 km^2 (either land or water), or about 0.1% of the surface of the Earth. This is an area considerably greater than the size of the State of California (411,000 km^2) and is nearly the size of France (551,000 km^2). The threshold for such an impact likely is between 750 MT and 1 gigaton, and would be expected to occur by present models on the average of roughly once every 10,000 years. A globally catastrophic impact, one capable of directly or indirectly causing the death of at least one quarter of the Earth's human population is modeled to occur roughly on the average of once every 300,000 years; the energy threshold for such an impact has been put at around 300 gigatons (300,000 MT), or roughly the equivalent of 1,500,000 Hiroshima atomic bombs.

As will be discussed below, these risk models seemingly are at considerable variance with the data from archaeology, palaeo-environmental studies, and mythology. But before noting the known or hypothesized cosmic impacts and their perceived risks, the critical role played by mythology in culture history requires some discussion.

4. The structure, content, and context of mythology

> "Myth [...] is not merely a story told but a reality lived. It is not of the nature of fiction, such as we read today in a novel, but it is a living reality, believed to have once happened in primeval times, and continuing ever since to influence the world and human destinies." [115: 21]

As noted above, one of my most extraordinary findings is that individual cultural mythologies concerning the actions of gods, demigods, culture heroes, and other supernatural beings are largely cosmographic observations of actual major environmental events, in particular temporary celestial events, witnessed by the members of that culture. Because Hawaiian myths are closely tied to chiefly genealogies that extend back in time more than 95 generations, it is possible by direct matching to demonstrate that famous myths and myth cycles are actually birthing and circumcision stories which encode temporary celestial events as part of the chiefly reification process and the perpetuation of royal lineages [123, 128, 131]. As part of the reification process, the literal names of deities, culture heroes, and even the symbols and signs of royal power encode specific celestial events or classes of celestial phenomena.

For example, the famous Hawaiian myth in which Kamapua'a (*ka-ma-pu-a'a:* "sparkling bundle of eyes"), a half-hog, half-man shape-changing demigod seduces and then battles the volcano goddess, Pele, is a chiefly birthing genital chant encoding the coincidence in AD 1301 of Halley's Comet with the largest rift eruption in the historical record of Kilauea volcano. Similarly, the Polynesian myth of the demigod chief Maui (*ma-ui*: "Beautiful eye") capturing fire and latter snaring the sun and holding it still so that his mother could dry her bark cloth is a chiefly birthing story which encodes the coincidence at around winter solstice in AD 684 of Halley's Comet with a bright nova event in the Pleiades.

There is a strong correlation between the degree of fame and the magnitude of personal feats ascribed to any given legendary chief in the Hawaiian genealogies and the nature and numbers of spectacular celestial events associated with that chief. Few chiefs who reigned during "quiet times" in the celestial event record became famous in Hawaiian oral history. Indeed, the chief who reigned during the middle of the longest period of the least numbers of temporary celestial events (AD 776-813) during the past two thousand years was called *Helei-pa-wa*, "Straddling the Barren Period", and it appears that the first royal birthing temple was constructed in Hawaii at this time in order to provide an alternative chiefly reification process for the failing celestial heavens. Conversely, those chiefs who reigned at the time of known visually spectacular celestial events, or especially at the time of a series of spectacular events occurring during a short period of time, almost invariably developed a rich oral history. This is not a surprising finding since royal genital and birthing chants were used as the building blocks for the creation of orally recited genealogical name chants for the royal lineages.

The *'aha* birthing and circumcision signs of royal power were recorded in the oral histories of all chiefs beginning in the 11th century AD [95], and can be directly tied to specific celestial events. Also compelling is the association of Hawaiian gods with various types of celestial phenomena. For example, war god Ku was described by Hawaiian priests as often flying through the sky trailing a long flame-like tail [61: 75). The ornately tapering hair and highly stylized scowling mouths of the few surviving wooden and feathered images of Ku [88, 191] encodes the observable features of the nucleus and coma of near-Earth comets such as illustrated by drawings of Comet 1858 VI Donati [210: 241].

Hawaiian temples dedicated to Ku were generally filled with comet-like wooden images of a variety of shapes and abstractions [61, 191]. Many of these scowling-mouthed images have elaborate, pointed headdresses of various lengths which obviously encode the tails of comets, inspired no doubt by the position and appearance of most post-perihelion comet tails which are pushed in front of the cometary head by solar winds. And in several cases the images are represent by single small, abstract mouths variously carved into the middle of lengthy, smoothly curved logs. These images are haungtingly remniscent of long-tailed small-headed comets such as that of comet 1858 VI Donati [210: 215]. Based on a literal translation of their names and on descriptions of their physical attributes, all major Hawaiian gods were associated, in part, with major naked-eye visible specific celestial objects and phenomena.

While the mythologies of Native American cultures in the American Southwest lack the detailed genealogical ordering of Polynesia, it is still possible to perform cosmographic studies for certain aspects of Southwestern culture history. Many people are likely familiar with Katsina societies in the American Southwest in which dolls and masked dancers provide a symbiotic link with deities of the earth and sky to ensure the perpetuation of the annual seasonal round and to promote general harmony with nature [168].

Due to the exquisite chronological control that blesses Southwestern archaeology, it can be demonstrated that Katsina-like imagery suddenly appearing in the Puebloan

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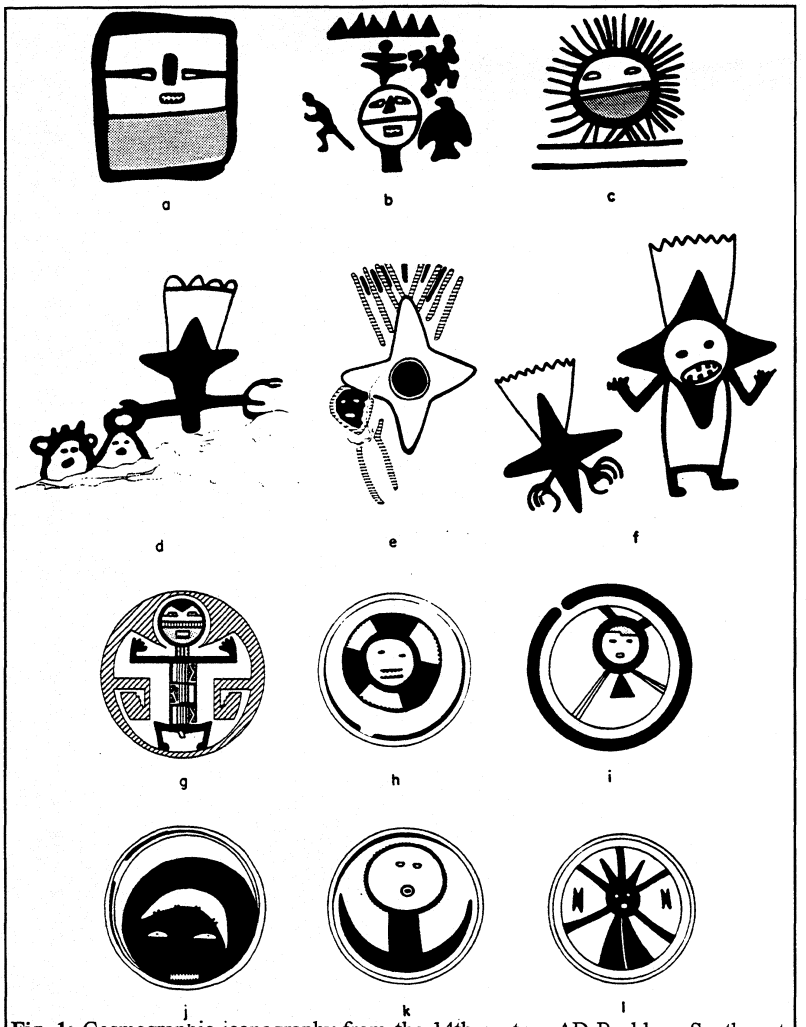

Fig. 1: Cosmographic iconography from the 14th century AD Puebloan Southwest: Figures a-c,g, possible Day-Night deity, with constellation images surrounding b. Figures d-f, eclipse star demons. Figures h-l, solar eclipse images.

archaeological record during the 14th century AD is directly correlated with the paths of three total solar eclipses [127]. The pronounced impact of eclipses on Puebloan culture may be related to the belief shared by many Native American cultures change in cosmological eras were accompanied by catastrophe and the "death" of the Sun. Many of the artistic images produced on pottery and rock art distinctly portray the actual eclipses themselves or portray "star demons", the latter which are taloned and feathered believed to appear at the time of solar eclipses (Figure 1). One of these eclipses, an event in AD 1379, is also prominently mentioned in myths surrounding the demise of the Hohokam, a major archaeological culture in southern Arizona. In fact, total solar eclipses were associated with profound social changes throughout the history of the Hohokam [124].

Other classes of celestial events are also portrayed in prehistoric Southwestern art. For example, the rapid cult-like appearance and spread of Salado polychrome pottery during the late 13th through early 15th centuries [47: Fig. 9.1) correlates well with the unique occurrence of large numbers of unusual comets. These comets are likely represented by ceramic motifs depicting feathered serpents, birds, and related celestial imagery, while other categories of temporary celestial events such as novae are also likely being depicted in Salado art. Likewise, novae and comets figure prominently in the migration legends of several Native American tribes [142, 195]. The animation and anthropomorphizing of the environment, including the celestial environment, is characteristic of early traditional societies who viewed their world holistically.

At least six compelling lessons are revealed by these various cosmographic studies. First, mythologies, at least in part, represent cosmographic records of real environmental events, especially temporary celestial events. Second, some iconographic images of gods, demigods, supernatural beings, and legendary rulers portray specific celestial phenomena and events. Third, the names of gods, demigods, supernatural beings, and legendary rulers often provide literal descriptions of specific celestial phenomena and events. Fourth, environmental events such as floods, earthquakes, volcanic eruptions, and droughts, are often cognitively linked with unusual celestial events (e.g., comets, meteor storms, supernovae, planetary conjunctions, eclipses, cosmic impacts) that may have occurred within a few years of the earthly environmental event. Fifth, oral historical records can faithfully transmit information about these events for many hundreds and seemingly even thousands of years. And sixth, even in the absence of genealogies or other means by which to chronologically fix the initial appearance of specific myths (such as provided by iconography in archaeological contexts), cosmogonic mythology is often given at least a relative ordering within each set of cultural traditions.

Thus, for example, one Cheyenne historian, in discussing the epic history of his people, provides the following remarkable sequence of events [60: 111-114]. There originally were created three types of humans - the Indian, a hairy solitary people, and fair-skinned people with long beards. They lived together in a lush and beautiful area far to the north of Montana. The hairy people moved south and were shortly followed by the Indians. The hairy people were shy and secretive, living in caves high in the mountains; eventually their population dwindled and became extirpated for a reason unknown to the Indians. At the time of a devastating flood in the south lands, the Indians moved back north and found the long-bearded white men and some wild animals were gone. The Indians increased in number and after a long period of time again moved south. While living in the south, a second devastating flood destroyed almost everything and left the Indians starving. They tried to go back to the North but discovered it to be a barren wasteland, so they returned to the south. After many hundreds of years the earth shook and fire and smoke suddenly appeared in the badlands area and destroyed the trees in the badlands area, causing a short period of starvation. Things got better and have been so up to the present.

The ethnographer who collected this epic story assumed that it represented the past 400 years of history for this particular group of Cheyenne [60]. However, as will be noted below, the earthquake and fire in the badlands likely represents a locally catastrophic terrestrial impact around 1000 BC, and the second of the two floods almost certainly is the result of a globally catastrophic oceanic comet impact in 2807 BC. And based on my present understanding of mythology and on my knowledge of Holocene period archaeology and paleoenvironment, it is my strong suspicion that the first flood event is that of another oceanic cosmic impact that I hypothesize occurred around 9300 BC. Thus this curious epic tale may in fact provide real glimpses of the past 12,000 years of human

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history.

5. Temporary celestial events and Bronze Age chronology

Few scholars would dispute the fact that the greatest obstacle standing in the way of a better understanding of Bronze Age events and processes is the lack of an accurate chronology that encompasses and unequivocally ties together the major Old World civilizations into a single unified system. Much of the passion and rhetoric of Bronze Age studies has been and continues to be focused on refinements of regional chronologies and the implications that these refinements have for explaining significant aspects of the past [92, 162]. Chinese historical studies, likewise, have been subject to intense chronological debate, in part stemming from discrepancies between the standard chronology developed during the Han Dynasty and that associated with the *Chu-shu chi-nien* (*Bamboo Annals*), the latter which considerably shortens the standard chronology [106, 148, 149]. Immanuel Velikovsky was no stranger to these chronological debates, and his adjustments to chronologies played a major role in his vision of a world filled with cosmic catastrophes.

A brief decade of archival study by no means qualifies me as an expert on Bronze Age archaeology or culture history. Nevertheless, my studies in cosmography suggest that the relationship between temporary celestial events (and earthly environmental events such as the destruction of Thera island by the Santorin eruption) and Bronze Age mythologies and religious iconography provides a potentially powerful new perspective for evaluating and testing models of Bronze Age chronology. The Hawaiian and American Southwestern systems of encoding celestial phenomena and events offer insights into how such phenomena and events may have been recorded in Bronze Age Mesopotamia, the Near East, Egypt, Europe, India, and China. Regional and globally catastrophic cosmographic events, such as the Santorin eruption and large cosmic impacts that may have occurred during the Bronze Age, are certain to appear in the cosmographic record of each affected region. The key then is to study and to identify cosmographic events within the context of each regional sequence, and to then match these against events recorded in other regional sequences.

The epigraphy, mythology, and archaeology of Bronze Age cultures are filled with images of frightful deities and beasts (Figure 2), many with destructive powers. Some of these beasts are associated with specific gods or themselves represent a specific demigod or deity. Notable is the fact that the worship or mention of these deities/beasts in documentary texts reveal that their popularity was not constant but rather waxed and waned over the centuries. In a similar vein dynastic rulers often utilized the names of certain gods as part of their royal titles; these, too, waxed and waned over the centuries.

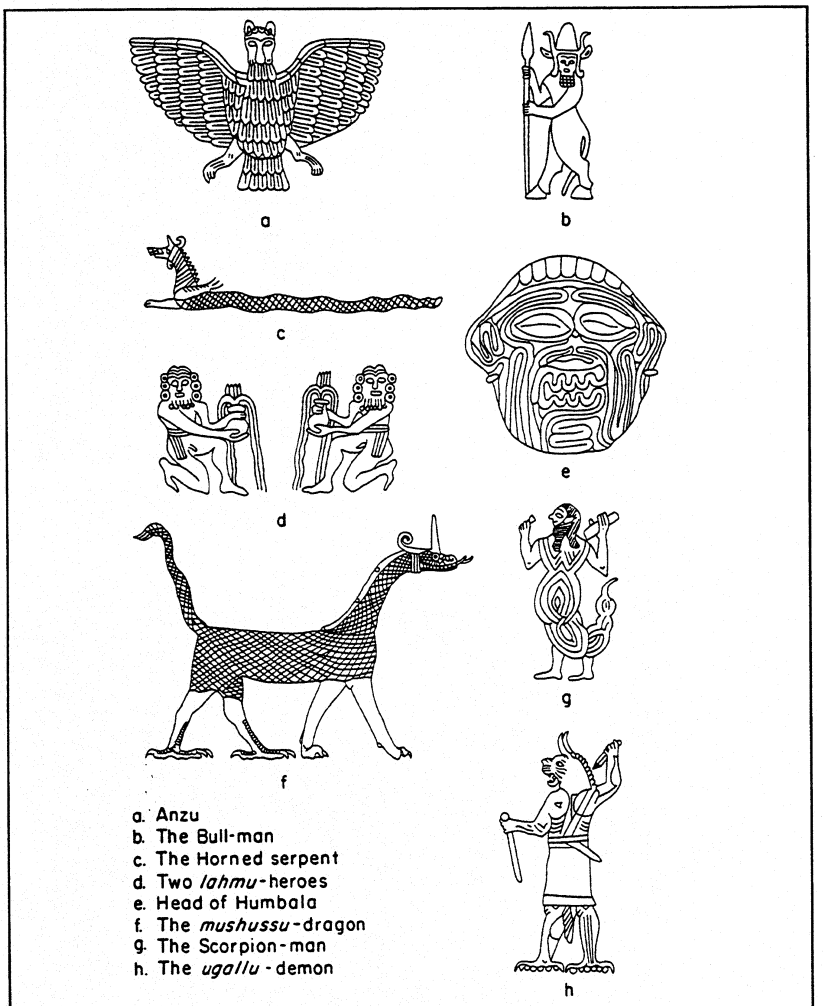

Fig. 2: Cosmographic iconography from Mesopotamia (redrawn from Dalley 1989). Images likely represent celestial phenomena, including: Sun (a), comets (b, f), supernova or nova (e), constellations (b, d, g), and possible meteorite (h).

That many of these Old World beasts/deities are cosmographic images emblematic of celestial processes and phenomena has been argued for years [3, 70], a concept which recently has been elegantly demonstrated for the previously mysterious Indus script [150]. Unfortunately, the tendency of modern science has been to has been to view the astronomical content of myth either as remnants of early observational attempts to classify aspects of the fixed celestial heavens or even as the hard-wired psychological product of the human genome. The influential mythologist, Joseph Campbell, expressed the latter position shortly before his death when attempting to explain the striking similarities between Old World and New World myths and iconography [28: 92]:

> "One can only wonder considering, as I have now been considering for some forty-odd years, the likenesses, both in breadth and in depth, of the two constellations of metaphorical images of the Old World and the New, whether the human psyche can possibly be so thoroughgoingly programmed that these two all but identical constellations might indeed have arisen independently in the separated hemispheres of our planet."

The structural anthropologist Claude Lévi-Strauss, provides a somewhat similar view which has had a profound influence on modern cultural anthropology and the thinking of Jungian psychologists [109: 240]:

> "In granting that myths have an astronomical significance, I do not propose to revert in any way to the mistaken

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ideas characteristic of the solar mythography of the nineteenth century. In my view, the astronomical context does not provide any absolute point of reference; we cannot claim to have interpreted the myths simply by relating them to this context. The truth of the myth does not lie in any special content. It consists in logical relations which are devoid of content."

Even the late Carl Sagan, who perhaps more than anyone this century has helped to define the role and importance of science, particularly astronomy, in our modern Western world, has perpetuated the notion that mythology has little explanatory value for understanding the either astronomy or the universe. A few years before his death he made the following curious observation [164: 251]:

"The myths and folklore of many premodern cultures have explanatory or at least mnemonic value. In stories that everyone can appreciate and even witness, they encode the environment. Which constellations are rising or the orientation of the Milky Way on a given day of the year can be remembered by a story about lovers reunited or a canoe negotiating the sacred river. Since recognizing the sky is essential for planting and reaping and following game, such stories have important practical value. They can also be helpful as psychological projective tests or as reassurances of humanity's place in the Universe. But that doesnt mean that the Milky Way really is a river or that a canoe really is traversing it before our eyes. / Certain kinds of folk knowledge are valid and priceless. Others are at best metaphors and codifiers. Ethnomedicine, yes; astrophysics, no. It is certainly true that all beliefs and all myths are worthy of a respectful hearing. It is not true that all folk beliefs are equally valid - if were talking not about an internal mindset, but about understanding the external reality."

Sagan, in his notable attempt to purge the "demons" of pseudo-science and superstition from modern knowledge systems, made the proverbial mistake of throwing out the baby with the bath water. This apparently is an easy thing to do when the "baby" (i.e., the very real scientific observational core of mythology) is hidden by the suds of metaphor and religious symbolism. In fact, Sagan and modern archaeoastronomers (from whom Sagan's ideas were apparently developed) largely miss the point when it comes to the nature of mythology, as did Lévi-Strauss and Campbell.

Traditional cultures from their holistic perspective indeed viewed the heavens as a real cosmic ocean. This was an otherworld filled not only with static astral images of gods, rivers, boats, and the normal sacred pathways of Sun, Moon, planets, and stars, but was alive with sentient beings. The real power and vitality of the celestial pantheon does not come simply from observations of the largely static slow processes of the fixed celestial heavens (i.e., movement of constellations, stars, planets, Sun and Moon). Rather, these deities and beasts are energized and transformed by the observed actions of temporary celestial events, including the physical sounds and fury of cosmic impacts. It is the interplay between the temporary celestial events and the fixed celestial heavens which animated the sky for all past civilizations and which created the primary backdrop for the development of mythology, religion, and science [123]. Admittedly this relationship has been somewhat obscured because in a holistic world these deities also had earthly as well as celestial manifestations, such as storms, lightning and volcanic eruption.

A brief examination of two Old World deities, Set and Marduk illustrates this interaction between temporary celestial events, the fixed celestial heavens, and earthly physical processes. Marduk, the patron god of Babylon [19, 48, 73, 144], is one of many similar examples of Bronze Age deities who suddenly appear or become dominant in the archaeological and documentary record and who have variable popularity through time. Marduk is usually portrayed as an agricultural god, although in both myths and in titular symbols he is represented as a powerful being, sometimes as a storm god. In the striking *Epic of Creation* [48, 74, 176], Marduk battles the evil ocean goddess Tiamat, who personifies chaos. Marduk is described as having four eyes; he breathed fire and his body was filled with ever-blazing flame; "terrible" celestial radiance emanated above him in the form of five bright rays; and his weapons included great winds (tornado and unfaceable facing winds) and the "flood-weapon", and he rides about in a "storm chariot". As a prelude to his battle with Tiamat, he makes an unnamed constellation disappear and then reappear. Tiamat creates 11 zodiacal beasts in addition to herself to take part in the battle with Marduk.

Marduk slays Tiamat with an arrow and then sets about to create a new cosmos, and indeed a new astronomy for the people of Babylon. Marduk then is elevated to the station of king of the gods and he adopts the *mušhuššu* dragon (originally created by Tiamat) as his animal emblem. The *mušhuššu* ("furious snake"), is a dragon-like creature of tremendous power (see Figure 2). The name and the actual depiction of this horned snake-dragon, is strongly suggestive of a post-perihelion comet. In fact, the whole pantheon of Mesopotamian deities (Figure 2) is richly interwoven with astral imagery.

In a similar vein for Egyptian mythology, it is no accident that the Egyptian god Set (Seth) became manifest in the Pharaonic iconography and mythology of the Second Dynasty, immediately following a catastrophic oceanic comet impact (discussed below). Set, the enigmatic and complex god of chaos, has fascinated scholars over the years as to what animal, if any, that his form may symbolize, and as to his role(s) in Egyptian cosmology and religion [24, 25, 62, 91, 113, 161, 205].

Set had a dualistic and largely antipathetic relationship with Osiris (god of agriculture, the Nile, and the underworld) and Horus (god of the Sky and of the morning Sun). Set was commonly viewed in political terms as the major deity of Upper Egypt, while Osiris and Horus were aligned with Lower Egypt. In addition to representing chaos, Set was variously considered the god of the desert; the god of the "cruel sea"; the god of storm; and the god of metal (the "bones" of Set were considered to be made of iron ore). As god of metal and with bones of iron ore, it is probable that Set had a direct association with meteorites. And like the Chinese god of water, Kung Kung, Set was envisioned as having red hair and red eyes, the very personification of evil. Animals associated with Set were dangerous creatures such as the crocodile and the hippopotamus, but also swift animals such as the ass, antelope, pig, and fish.

Returning, once again, to the issue of chronology, it should be obvious that if mythological beasts/deities do represent (at least in part) naked eye visible temporary celestial events, and if certain spectacular events (e.g., bright supernovae) can be viewed over much of the Earth, then this creates a potential for establishing concordances between mythologies and archaeological materials, and thus between the culture histories of various geographic regions.

Despite some compelling arguments put forward by the chronological revisionists, I largely employ the traditional standard chronologies unless otherwise noted. This choice is by no means arbitrary and reflects what I perceive to be strong patterns apparent in my cosmographic data sets across widely disparate regions worldwide. For example, my data support an approximate 2920 BC date for the start of

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Egypts First Dynasty, a mid 27th century BC date for the reign of Gilgamesh in Uruk; and approximately 2700 BC for the beginning of the reign of Huang Di in China. Hopefully, the discussions that follow will make clear the reasons for keeping the main tenets of the standard chronologies for Bronze Age cultures. I by no means argue that the chronologies suggested in this paper are absolutely definitive. They will require much future testing and refinement as more cosmographic data sets become established and are subjected to detailed scrutiny.

In order to set the tone for further discussion of Bronze Age chronology and cosmic impacts, Table 1 highlights those physical effects of environmental catastrophe, including cosmic impact and volcanic eruption, which are most likely to leave a lasting impression on eyewitness observers. These physical effects represent the building blocks of mythology and are among the structural determinants for the science of cosmography.

Table 1: Likely major physical effects with largescale catastrophic environmental events

EARTHQUAKE	MONSOON FLOODS	VOLCANIC ERUPTION	TERRESTRIAL COSMIC IMPACT	OCEANIC COSMIC IMPACT	HUMAN WARFARE
building fires by upset lamps and hearths		house fires by pyroclastic flows, incendiaries, lava	widespread structure fires by thermal radiation	structure fires by thermal radiation, ejecta re-entry	selected structure fires, occasional town burnings
		forest fires by pyroclastic flows, incendiaries, lava	widespread forest fires by thermal radition/ejecta	possible forest fires by thermal radiation/ejecta	selected burning of fields and arboreal crops
tusnami possible along coasts and lake margins	possible coastal storm surges	tsunami with underwater eruption and earthquakes	tsunami may be produced by coastal earthquakes	huge tsunami with inland surges; splash re-entry	
	intermittent torrential rainfall over several days		"black rain" from debris particulates for few hours	steady torrential rainfall for several days	
occasional low dense smoke from fires		high altitude ash plumes	high altitude clouds of debris particulate ejecta	high altitude clouds of debris and steam ejecta	occasional low dense smoke from fires
	thunder and lightning	massive electrical discharges and thunder	massive electrical discharges and thunder	massive electrical discharges and thunder	
earthquakes between ca. 7.0-8.5 on Richter scale		earthquakes possible to ca. 8.5 on Richter scale	earthquakes between ca. 8.0-10.0 on Richter scale	earthquakes between ca. 8.0-10.0 on Richter scale	
	intermittent hurricane force winds	blast wave creates local hurricane force winds	air pressure blast wave and large storm fronts	major cyclonic storms of super hurricane force	
		brilliant sunrises/sunsets	brilliant atmospheric displays day and night	brilliant atmospheric displays day and night	
		low altitude pyroclastic glows with incediaries	high altitude fireball before and after impact	high altitude fireball before and after impact	glow associated with largescale burning
booms and structure collapse noises	roar of wind and rain	claps, booms, whistles, hisses, roars	rapid sonic booms, roars, wind shrieks	rapid sonic booms, roars, wind shrieks	noise of battle
	darkness for couple of days during storm	darkness for days/months from periodic ash plumes	darkness for days/weeks by debris ejecta plume	darkness for days/weeks by debris/cyclonic storms	darkened battle smoke lasting a day or two

6. Oceanic cosmic impacts

As noted earlier, oceanic and large lake cosmic impacts should be at least twice as common as terrestrial impacts given the watery composition of much of the surface of the earth. The fact science has not yet been able to provide definitive evidence for a single oceanic or lake impact during the past 5,000 years is most curious, especially given the prevalence of flood myths worldwide [56, 65] . I suggest that this situation tells us something both about science and about the physical signatures of oceanic impacts.

The 'Flood Comet' Impact of 2807 BC

The myth of a single catastrophic Flood which devastated the whole Earth stands out above all other myths for several reasons. First, it is a truly universal myth, one which occurs in virtually all cultures. In Western society the most common version of the story is that of the Biblical Great Flood of Noah, but it can be demonstrated that the Flood myth occurs completely independent of Biblical tradition in most non-Western cultures [56, 65].

In many sets of cultural traditions, the Flood is identified as the last in a sequence of global catastrophes. Although other more recent catastrophes are noted in some sets of cultural traditions, these are usually defined as being of less magnitude than the Flood. Likewise, although some sets of cultural traditions discuss worldwide cataclysms prior to the Flood, the Flood is generally viewed as the last such cataclysm and therefore initiated the present age or era in which we now live.

For more than 2,500 years the Flood has been discussed and debated by Western scholars. Ironically, for the past 150 years the Flood has become the linchpin for both fundamentalist religion and for science. Christian fundamentalists, such as creation scientists [143, 208] not only believe that the Flood was a real event, but argue that it occurred exactly as related in the Bible. Indeed, a strangely convoluted mix of geology and fundamentalism has emerged in the attempt by fundamentalists provide a scientific basis for the Flood and for Biblical history in general [202]. Science, on the other hand, has used the presumed absence of geological deposits indicative of a universal Flood event to demonstrate the power and logic of scientific method and theory over that of religious fundamentalism. Equally ironic is the fact that modern social science, historical geology, and even aspects of comet research all at least partly had their roots in the refutation of the Flood myth.

There have been many studies of Flood mythology during the past 100 years. I single out especially that in 1919 by Sir James George Frazer, an eminent graduate of Trinity College and long-time professor of anthropology at Cambridge University [65]. Frazer prepared a detailed anthology

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of Flood myths from approximately 127 different cultures worldwide, along with at least 41 variants of those myths. Frazer's anthology constitutes the largest single compendium of Flood myths in the English language. This work, along with more recent studies [56], has established beyond doubt that Flood myths are indeed indigenous to most cultures and are not simply the result of diffusion spread by Christian missionaries.

I have elsewhere performed a detailed environmental and cosmographic analysis of the Frazer Flood myths, along with a sizable number of additional myths not available or known to Frazer [125, 126]. The analysis focused on the nature of a number of environmental variables in the Flood myths. These included the intensity and duration of rainfall and hurricane force winds; the obscuration of the sun by darkness; the time, direction and nature of the initiation of the Flood storm; the nature of probable tsunami events; the presence of fire and/or hot rainfall as part of the initiation of the Flood storm; the description and physical nature of supernatural beings associated with the Flood; the season and lunar phase during which the Flood took place; the date or genealogical position of the Flood event in oral traditions and documentary records; and the presence of temporary astronomical events associated with the Flood storm such as eclipses, planetary conjunctions, and meteor storms.

As an example of my cosmographic analyses, I briefly note some of the findings of one category, that of descriptions of supernatural beings or deities associated with the Flood event. The Flood was most commonly attributed to the actions of "giants" or large supernatural horned beings with snakelike bodies. Thus Kung Kung, a Chinese god of water who knocked over one of the pillars of heaven, was described as having "a snake's body with a human head and bright scarlet hair" [212: 9], and is elsewhere described as having a prominent horn on his head [36: 54]. The Vedic Hindu creator god, Prajapati, who saved Manu (humankind's progenitor) from the Flood, took the form of a rapidly growing giant horned fish with a golden body and lotus eyes [65: 183-193]. Sehkmet, the Egyptian lion-headed arrow-shooting goddess of the Memphite triad, was described as having a fiery glow that emanated from her body, and was also associated with the fire-spitting uraeus headdress worn by kings [113: 106].

These and dozens of similar images from a variety of cultures (such as the horned water serpent in North America) are associated with the beginning of the Flood. Each of these images is consistent with the character and general appearance of post-perihelion comets whose tails are thrust in front of the nucleus due to the force of solar winds, thus looking very much like a horn (or a headdress in the case of Hawaii).

The consistency between myths from widely separate geographic regions is striking in other environmental information categories as well. In fact, a precise date for the hypothesized comet impact, 10-12 May 2807 BC, was ascertained [125] from the concordance within the mythologies of calendrical, seasonal, and verifiable astronomical indicators (i.e., lunar phase, the presence of solar and lunar eclipses, and the presence of planetary conjunctions within ascribed constellations). It is of some interest to note that Chinese myths indicate that the Flood event occurred at the end of the life of Nu Wa, consort of first Chinese emperor Fsu Hsi (2953-2838 BC according to standard chronologies), and who herself allegedly lived until about the year 2810 BC. Thus there is only three years difference between the actual impact date and the date generally assigned to the event by at least some Han Dynasty chronologists. The date of 2807 BC likewise fits well with archaeological data from Egypt, as is discussed below.

Even the probable location (Atlantic-Indian basin near Antarctica) and general magnitude of the impact (between 10^5 and 10^6 MT, or 100 and 1000 gigatons) could be roughly estimated from the patterning within the mythology. The Flood Comet impact apparently produced massive tsunami and several days of torrential rainfall worldwide through the injection of water vapor into and through the upper atmosphere, and likewise created vast cyclonic storms which persisted for between five to seven days [125, 126]. The Flood mythology in aggregate (based on the relative numbers of deaths described in each set of myths) suggests approximately 80% of humankind perished as a direct or indirect (i.e., starvation, disease) result of the Flood comet impact.

I fully discuss elsewhere [125, 126] the Flood mythology, the nature of my analyses of these data, cosmic impact modeling, and the nature of supporting palaeo-climatic data, such as that palynology, geomorphology, and from absolute chronological referents such as Bristlecone pine tree-rings. I do not wish to repeat this information and instead refer the interested reader to the two cited papers, which are currently being revised for publication. Of particular note, however, is the fact that the date of the Flood event, 2807 BC, roughly coincides with the boundary of the last significant change in worldwide climate, that between the middle and the late Holocene periods. The transition to late Holocene may have begun as early as 3000 BC, and virtually all geologists agree that modern climate conditions were fully in place by 4000 radiocarbon years ago, which calibrates to about 2500 BC. This date range also encompasses the hypothesized beginning date for the El Niño/Southern Oscillation [165]. I believe that the Flood comet impact is largely responsible for both the change to modern climate and the beginning of the El Niño/Southern Oscillation cycle [126].

In the remainder of this section I focus on the archaeology of the Flood Comet impact. Of immediate concern is that despite the suggestion based on the mythology that four out of every five persons died at the time of the Flood Comet impact, none of the other authors in this volume identified a "catastrophe" of any kind as having occurred in the archaeological record at around 2800 BC. Likewise, although a 10^5-10^6 MT cosmic impact should generate long-term climate effects, none of the other authors in this volume identified climate change at around 2800 BC, although several authors suggested climatic disruptions at other times during the Bronze Age. Logic therefore dictates that either I have misdated the Flood Comet impact or that there was no such single "Flood Comet impact" at any time.

Three major circumstances together form a rationale for the apparent "invisibility" of the 2807 BC Flood Comet impact in the archaeological and geological record. The first is the simple fact that the 2807 BC impact date falls into a period of time during which there was an unusual rapid rise in natural radiocarbon production [152, 183, 184]. Carbon samples formed during the year of the comet impact could be represented by radiocarbon ages anywhere between 4300 and 4080 BP. In this particular case, even fine-tuned high precision calibration of the radiocarbon samples from deposits containing impact-related charcoal would likely yield a wide distribution of radiocarbon ages. This would make it difficult to directly compare and link archaeological strata from different sites and different regions. The impact may even have somehow contributed to the increase in radiocarbon production by injecting large amounts of nitrogen into the atmosphere thus forming a larger than normal pool of nitrogen atoms subject to conversion by cosmic rays into carbon-14.

A second confounding situation is that humans, like most mammals, have the capacity to rapidly rebound after

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catastrophic population loss. If 20th century population growth rates of 2.0% per year [211: 317-351] were applied to the presumed post-comet impact period, it would take less than 85 years, only four human generations, to fully recover the pre-impact population levels. In addition, both fertility and fecundity can increase under certain conditions, such as during periods of improvements in health and increases in food supply, thus the growth rate can be considerably higher than 2.0%. Likewise, population growth rates can increase when cultural behaviors are modified. In this regard, a large number of Flood myths indicate that incest prohibitions were removed during the generations immediately following the Flood [125]. When these possibilities are coupled with the fact that the dating of most archaeological sites from this general time period is quite course-grained, the deaths of 80% of the human population at 2807 BC may be difficult to observe in the palaeo-demographic record.

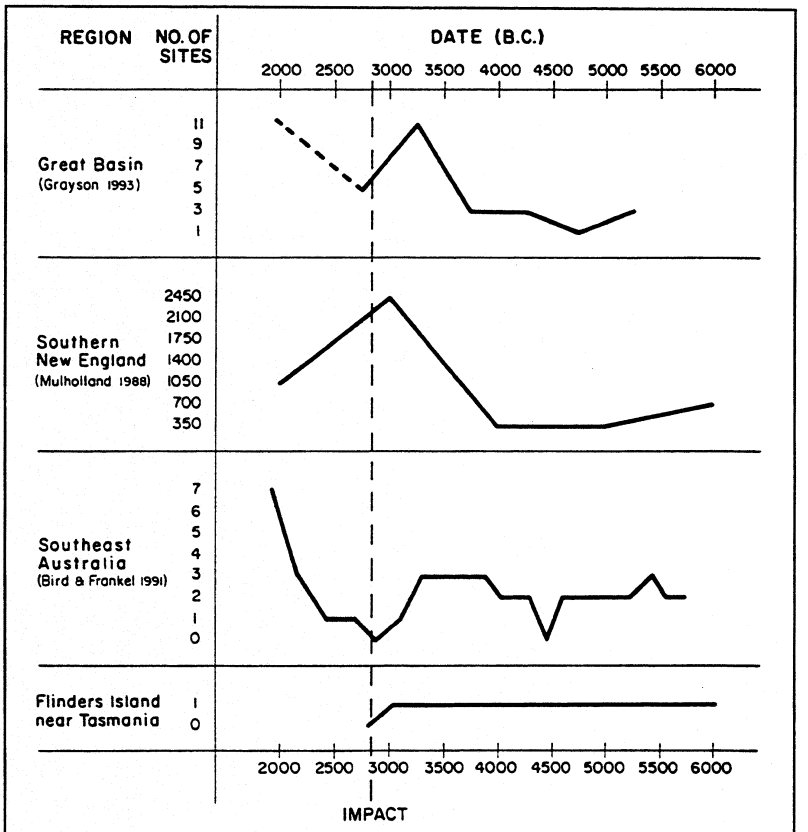

Fig. 3: Rough population estimates for selected geographical regions before and after the hypothesized 2807 BC oceanic comet impact. Based on total numbers of archaeological sites assigned to a given period (by the authors of the cited work). Flinders Island (J. Diamond, *Discover Magazine*, 1993) based solely on presence/absence of cultural remains.

For example, using a sigma (variance) of only 50 years for pertinent radiocarbon ages, good by radiocarbon dating standards, hypothetical population profiles divided into 100-year increments and based on an 80% die-off in 2807 BC would not dip below 63%. Such a signature would be difficult to distinguish from more "normal" population shifts caused by changes in settlement and subsistence patterns or by warfare, the most common non-catastrophic explanations invoked to explain demographic change in the archaeological record. Despite these difficulties, crude regional demographic studies have been undertaken in the archaeological record of North America and Australia that show an apparent dip in population (usually expressed as numbers of archaeological sites) at around 2800 BC (Figure 3). These results at the very least do not preclude the possibility that human population did indeed suffer a sizable die-off at about this time, and that 80% extirpation is not completely unreasonable. And of course, if the human mortality of the hypothesized Flood Comet impact was somewhat lower, say around 50% rather than 80%, this halving of humanity would become virtually impossible to recognize and measure in the archaeological record without greater precision and control over stratigraphy and dating than currently practiced.

The third circumstance adding to the present invisibility of the Flood Comet impact is the previously mentioned fact that a regionally or globally catastrophic oceanic impact will likely leave a very different palaeo-environmental and archaeological signature than would a terrestrial impact. Except for the actual impact crater itself a terrestrial cosmic impact would tend to primarily affect the surface of the ground and objects on that surface (i.e., buildings, trees, people) rather than to alter the subsurface. Despite the severity of a terrestrial impact, surface cultural materials will largely remain *in situ*, although these materials may show the disruptive effects of atmospheric pressure waves, thermal radiation, and earthquakes associated with the impact.

Oceanic or large lake impacts, on the other hand, have the ability to produce vast columns of water through coastal tsunami, by torrential rainfall from the injection of water vapor into and the supersaturation of the upper atmosphere, and by the re-entry of splash ejecta into the lower atmosphere. The injection of such large volumes of water vapor into and occasionally through the atmosphere conceivably may serve to purge the atmosphere of certain types of particulates (e.g., dust) that might be deleterious to the growth of surviving plants, although the formation of upper atmospheric ice crystals may partly obviate this benefit. Floods are notorious for their ability to alter landscapes by cutting, filling, and slumping, and no two landscapes will receive identical treatment. In addition, oceanic impact craters are difficult to detect. As of 1993, oceanic craters made up only about 2% of the approximately 140 Earth impact craters known by that date [77].

Although circumstances conspire to make it difficult to perceive the location or the physical signature of an oceanic impact, there are indeed several aspects of the Bronze Age archaeological record which appear to support a 2807 BC oceanic impact. An example is the massive flood deposit discovered earlier this century at the site of Shurrupak (Fara), home of the legendary Mesopotamian Flood hero Atrahasis [105]. This deposit is placed in the middle or latter part of the Early Dynasty I period [209], which scholars variously date between 3000-2750 [157] and 2900-2700 BC [103]. It is possible, although not certain that similar flood deposits date to this time period at Tell Oheimir, the site that many scholars believe to be legendary Kish [156: 110]. This possibility is given added poignancy in that the *Sumerian King List* states [146: 265]: "After the Flood had swept over (the earth) (and) when kingship was lowered (again) from

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heaven, kingship was (first) in Kish". The present estimated dating for the earliest substantive deposits and construction at the archaeological site believed to be Kish is indeed at around 2800-2700 BC [156].

However, not all flood-related deposits in Mesopotamia date to this time, such as the massive deposits at Ur [209] dating to the Ubaid period (ca. 4000 BC), and at least some deposits at Kish date to around 2650 BC [156]. I would expect that most alluvial flood deposits in the archaeological record are related to factors other than oceanic or large lake cosmic impacts. Nevertheless, based on our current understanding of cosmic impact, it can be assumed that at least some of the deposits in Mesopotamia and elsewhere have a basis in cosmic impact events, including impacts other than that of the Flood Comet itself. Due to the biases prevalent among archaeologists and geomorphologists (and among scientists in general) concerning the historicity and basic reality of the Flood, much remains to be accomplished before alluvial deposits in Mesopotamia and elsewhere will be thoroughly studied and satisfactorily evaluated against the cosmic impact paradigm.

A date of 2807 BC would fall near the end of the First Dynasty of Egypt, which is currently dated by many Egyptologists to between about 2950-2920 and 2800-2770 BC [172, 205]. If we were to split the difference (2935-2785 BC) and to assign an arbitrarily equal reign to each of the eight kings of this dynasty, then the seventh king, Semerkhet, would have ruled between approximately 2821-280 3 BC. The 3rd century BC historian, Manetho (according to Eusebius), provides us with this brief but notable chronicle for Semerkhet [193: 33): "In his reign there were many portents and a very great calamity."

Nowhere is this "calamity" precisely defined in historical documents, but several lines of evidence suggest that the Flood Comet impact terminated the reign of Semerkhet. Among the indicators of a untimely end for Semerkhet is the fact that of all of the First Dynasty Kings and the first two kings of the Second Dynasty, he is the only one not to be represented by a mastaba tomb at Saqqara [84]. Another more subtle difference is based on Paul Reisner's detailed examination of servant or retainer burials at Abydos associated with First Dynasty royal tombs [86: Table 12]. Reisner noted that while only a portion of the retainers associated with the second through sixth Kings exhibited evidence of *sati* or human sacrificial burial, this percentage is increased to 100% with that of Semerkhet and that of the eighth and final King, Qa'a. In addition, the tomb of Qa'a exhibits an unusual episode of remodeling during its construction. These and other bits of information noted below suggest that the Abydos tombs, which likely housed the actual bodies of the kings, were built early during the reign of each king, and were then consecrated on the death of each king by the act of sacrificing selected retainers to accompany the king into the afterlife. The Saqqara tombs, apparently built to honor royal officials upon the death of each king, were seemingly not constructed until later in the reign or upon the death of the pertinent king.

If these scenarios are correct, the fear created by the Flood Comet impact may have enhanced the need for retainer sacrifice at Abydos, and would have obviated the need to erect a post-death tomb for his officials at Saqqara. Also, the remodeling of the tomb of Qa'a may have been necessitated by actual damage sustained from the torrential rainfall or other effect of the Flood Comet impact. Also, since we know that Egyptian kings were closely associated with celestial phenomena, the differential mortuary treatment given Semerkhet may simply be indicative of being too closely associated with the Flood Comet impact and having fallen out of favor in the eyes of his priests and by the general populace. Curiously, the term *merkhet* means 'astronomer's staff' [70: 190-191], but it is unclear if this term can be logically derived from the name *semerkhet*. More significant from an etymological standpoint is the possibility that the title of the succeeding king, Qa'a, translates as meaning 'abundance' in the sense of 'flood' [198].

Of considerable interest is the pattern of destruction visible for First Dynasty tombs at both Abydos and Saqarra, as well as for other First Dynasty structures elsewhere, such as the upper class graves at Helwan [161, 176]. First Dynasty structures consistently show the effects of *intentional* burning, and most, especially those at Helwan, appear to have been razed. This strikingly differs from the Second Dynasty tombs which do not show the effects of fire and the walls of which still stand substantially above the ground surface. Also of interest is the fact that the fragmentary Palermo stone [198] records both a break in the recording of Nile River water levels after the reign of Semerkhet as well as a lowering of the water level of the Nile by approximately 1.0 meter between the reign of Semerkhet and the middle of the Second Dynasty [22: Fig. 4]. While by no means conclusive, these patterns are logically consistent with thermal radiation, flooding, earthquakes, and climate change associated with a cosmic impact at the end of the First Dynasty.

In the Palestine archaeological record, the Flood Comet impact would have occurred during the middle of the Early Bronze II period, which has been assigned a date of approximately 3050-2700 BC [132, 178]. The end of this period is notable for the unique large-scale movement of people (50% of all regional population) to the hill country of Galilee, Samaria, and Judah [132: 112]. In fact, the period of 2800-2700 BC witnessed substantive population movement and changes in settlement systems worldwide. For example, settlements in the southern Sinai and Negev contain extensive evidence of contact with Egypt during the First Dynasty, but this dramatically disappears in the Second Dynasty [159: 33-37, 132: 108-117]. In Central Europe, the abrupt appearance and rapid spread of the Corded Ware/Single Grave complex has been dendrochonologically dated to between 2800-2750 BC [203]: 284-288].

Indeed, the Flood Comet impact conceivably is responsible for the widespread and rapid dispersal of at least four large language groups worldwide, along with the material and socio-cultural trappings represented by these groups. In each case the initial spread of these languages has been independently judged to have occurred during the period of 3000-250 0 BC. These language movements include the spread of Indo-European language speakers throughout Europe [116, 117, 160], the spread of Austronesian speakers throughout the western Pacific [14: 121-132], the spread of Bantu speakers throughout Africa [155], and the spread of Uto-Aztecan speakers in Mesoamerica and the Southwest (Jane Hill, personal communication 1996).

Languages dispersals are not be surprising given the potential for "bottlenecking" of language and population created by the hypothesized globally catastrophic oceanic comet impact at 2807 BC. In fact, many of the Flood myths themselves describe a proliferation of languages and dialects once populations had stabilized and started to grow again after the Flood [125].

Another indication of population/language flux is attested by the sudden appearance of thick walls and fortifications. Such features are often seen as a response to the threat or reality of raids and other unpleasant incursive encounters by peoples who have been displaced from their homelands or who otherwise covet the resources of their perhaps more centralized and sedentary neighbours. Hadrian's Wall in Britain, the Great Wall of China, and the so-called "Amorite Wall" in Mesopotamia [157: 42-43] are examples of such defenses.

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Between Early Dynastic I and II and in the latter portion of Early Bronze II, the archaeological record exhibits the first wave of massively walled cities and other substantive fortifications springing up throughout the Near East and Mesopotamia [2, 132, 159] and perhaps southern Europe and the Mediterranean as well [53, 203], including apparently at the Egyptian city of Hierakonpolis [173: 26]. It is likely that the first massive community walls in China were erected at this time [32: 248-249]. This is not to say that walls and fortifications did not exist prior to 2800 BC, especially in Mesopotamia, but rather that the period of 2800-2600 BC witnessed an unprecedented proliferation and strengthening of such features.

Other possible Oceanic Cosmic Impacts

The Flood Comet impact is not the only "flood" event described in mythology and historic traditions, although usually it is considered the greatest of flood events if multiple floods are recorded within a single tradition, or the last of the worldwide flood catastrophes. Native American traditions, especially those from Mesoamerica and North America, typically encode three and occasionally four creations prior to our modern era, the latter which arguably began with the Flood of the Flood Comet impact [125]. The prior creations are associated with various combinations of the elements fire, flood, and hurricane force winds, all of which are components of cosmic impact. Hindu traditions likewise include previous sets of creations, with four different ages or eras belonging to each set. The third age was destroyed by water, and we are now in the fourth or last age of the current set of creations. And as noted in the quote at the beginning of this paper, Egyptian traditions include recognition of multiple catastrophic floods and conflagrations, but contend that their effects have not been as severe in Egypt as in surrounding regions.

Chinese traditions appear to record multiple flood episodes which are a bit confused [36: 84-90], but may represent four somewhat distinct flood events [18: 146]. These seemingly begin with the previously discussed Flood Comet impact of 2807 BC, associated with the knocking over the pillar of heaven by the god of water, Kung Kung, leading to the collapse of the sky and its eventual repair by empress Nu Wa at the end of her reign. The second, also attributed to Kung Kung, may have occurred during the reign of Chuan Hsu (2514-2436 BC according to standard chronology). The third and fourth floods are associated with the successive reigns of legendary emperors Yao and Shun [212: 92]:

> "The whole world was submerged and all the world was an endless ocean. People floated on the treacherous waters, searching out caves and trees on high mountains. The crops were ruined and survivors vied with fierce birds and beasts for places to live. Thousands died each day".

The myths are associated with the heroic efforts to stop the floods by Kun, and especially by his son Yu, the later who succeeded Shun as emperor of China. In some versions of the myth, Kung Kung is again seen as the villain who created or enhanced the flood. The myths seem to indicate two or three peaks to the flooding, which may represent point events (such as would occur from cosmic impact), but in general the flooding is described as occurring off and on over several decades of time as opposed to being a single flood occurring during a single given year. The dating of these flood "peaks" and that of the general period of flooding itself seemingly includes the last portion the reign of emperor Yao and the first 22 years of the co-regency of Yao with his successor Shun [195: 96; 212: 91-97]. This translates to around 2297-2265 BC according to standard chronology, and is potentially significant because it falls within a general time period (2350-2000 BC) corresponding to several defined impacts in Mesopotamia and the Near East, discussed below in the section on terrestrial cosmic impacts.

Greek mythology and early Christian tradition each recognizes three major flood events [65: 157-174], although it is not entirely certain that these represent different events within each tradition. The earliest Greek flood event is that during the reign of Ogyges (Ogygus), said to be the first king of Thebes in Boetia. The second and most familiar of the Greek flood legends is that of Deucalion, a legendary king of Phthia. Both Frazer [65: 146-157] and Graves [72: 138-143] suggest that the flood of Deucalion is the same as the Noachian Flood, thus this event would be that of the Flood Comet impact of 2807 BC. The third flood event is attributed to the time of Dardanus, a legendary king of Arcadia who was driven from his homeland by a flood which submerged the lowlands [65: 163], and who later helped found the city of Troy [72: 621-630]. The current view of the infamous destruction of Troy, immortalized by the Greek poet Homer, is that it occurred sometime around the 12th century BC. This then should put the flood event of Dardanus in the century or two before that time.

Roman and early Christian scholars recognized the floods of Ogyges and Deucalion as being separate from the Noahs Flood, but seemingly did not recognize the flood of Dardanus [65]. The Roman scholar Varro, writing around 36 BC, indicates that the flood of Ogyges occurred some 2100 years before his time, or around 2136 BC. It is a curious coincidence that shortly before the destruction of Sodom and Gomorrah (an apparent terrestrial impact described below) at around this same general time period, Abraham lived "near the Oak called Ogyges" [94, I: 35]. However, other authors, such as the Christian scholar Julius Africanus writing in the third century AD, provide other dates for the Ogygian flood, which according to Africanus occurred 1020 years before the first Olympiad, or at about 1796 BC [65: 158]. Isidore, bishop of Seville at the beginning of the 7th century AD stated that the first flood was that of Noah, followed by the flood of Ogyges at the time of the patriarch Jacob, and with the last flood being that of Deucalion at about the time of Moses. The Church historian Eusebius, writing in the fourth century AD, believed the flood of Ogyges to have occurred 2200 years after the flood of Noah, and was followed some 250 years later by the flood of Deucalion.

It is clear that the dating of these several flood traditions is confused and is not to be trusted without a much more detailed and exhaustive cosmographic study. However, what does seem to be clear is the fact that early scholars recognized several catastrophic flood events separate from that of the Flood Comet impact (i.e., the flood of Noah), which for the most part were not quite as devastating as the Flood Comet impact.

There is much still to learn about oceanic and large lake impacts. The Flood Comet impact demonstrates that the very recognition of such impacts in the palaeo-environmental and archaeological record is fraught with difficulty. Of course it is also important to remember that not all flood events in mythology and oral history necessarily relate to cosmic impact. The Mediterranean and Near East are crossed by major faults and the boundaries of crustal plates (see Nur, this volume) which have the potential to create horrific tsunami, through earthquakes and volcanic eruption. It will undoubtedly take years of detailed study of coastal (including lakeshore) margins and other appropriate geological deposits to begin the process of identifying and separating out tsunami caused by cosmic impact from tsunami caused

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instead by earthquake, landslips, and volcanic eruptions.

7. Terrestrial cosmic impacts

Before exploring the possibility of Old World Bronze Age terrestrial cosmic impacts, I discuss two late Holocene period terrestrial impacts in the Americas which are instructive regarding the nature and consequences of terrestrial impacts as well as illustrating the richness of details preserved in oral traditions. The first is a substantive regionally catastrophic impact in northern Argentina perhaps dating to around 2000 BC, with the second being a locally catastrophic impact in Nebraska likely dating to the beginning of the first millennium BC.

The Rio Cuarto, Argentina Impact

The cover of the 16 January 1992 issue of the journal *Nature* was graced by a remarkable aerial photograph of a portion of a meteoritic crater field in the Rio Cuarto watershed on the Pampas of northern Argentina [170]. This crater field consists of a linear alignment of more than 11 distinctly elongated craters covering an area roughly 50-km long and 10-km wide, with the largest individual crater being 4.5 km long by 1.1 km in width. Based on the nature of the craters and on experimental evidence, it was deduced by the authors that the crater field was formed by a disintegrating object with an angle of impact of less than 7° from the horizontal, and which was traveling from the northeast to the southwest. The energy released during the impact was very conservatively estimated at 350 MT, or about 23 times the magnitude of the 1908 Tunguska impact or 1150 times the magnitude of the Hiroshima atomic bomb. In terms of geological dating, while the authors of the article did not attempt to precisely define the date of impact, it was clear that it took place during the last 12,000 years of the Holocene period.

In the mythology of South America are pan-regional myths about natural disasters which destroyed most or all of human life at some time in the remote past. The most prevalently mentioned disasters are the Great Flood and the "Great Fire" (or "World Fire"), with other disaster motifs including the "Great Darkness" (or "Long Night") and the "Great Cold" [16]. Each disaster is viewed as a distinct event separated by lengthy periods of time, although a few of the Flood myths indicate the Flood was immediately preceded (1-3 days?) by a conflagration which appears to be different from the Great Fire.

The myths regarding the Great Fire clearly encode a cosmic impact, as is evident from the Toba and Toba-Pilagá cultural groups in the Gran Chaco region of western Paraguay, southern Bolivia, and northern Argentina [204]:

> "The people were all sound asleep. It was midnight when [...] the moon [took] on a reddish hue [...] Fragments of the moon fell down upon the earth and started a big fire. From these fragments the entire earth caught on fire. The fire was so large that the people could not escape. Men and women ran to the lagoons covered with bulrushes. Those who were late were overtaken by the fire. The water was boiling, but not where the bulrushes grew. Those who were in places not covered with bulrushes died and there most of the people were burned alive. After everything had been destroyed the fire stopped. Decayed corpses of children floated on the water. A big wind began to blow and a rainstorm broke out. The dead were changed into birds. The large birds came out from corpses of adults, and small one from the bodies of children. / Norkaló is the great fire, Netatlta is the great flood./ The great fire was coming, and in order to escape it the people crawled into a very deep hole in the ground. The entire earth caught fire and was burned; everything burned, even the fish. With everything on fire, the intense heat brought the water in the lagoons and rivers to a boil; the fish were burned and died, and the boiling water turned into steam./ When the great fire was over the people had to wait before getting out of the hole, for everything was still hot. [...] / The whole earth lay in ashes; nothing was left but a tiny tree, a little algarrobo tree. / When the earth was full of people a dog appeared. It was mangy and dirty, but it had a beautiful face, with a beard like a monkey's. It was covered with mud and fleas as well as being mangy. Nobody liked the dog; people feared that it might be carrying some disease. / A man called the dog. He had been notified by his daughter who seemed to know who the animal really was. Affectionately he covered the dog with his mantle and invited it to stay in his house. As it was already night, the man went to sleep. / That same night a handsome and well-dressed man appeared from the dog, and he said to the kind man Get up, my son, for tomorrow all those people will be burned, and no mercy will be shown them! That dog was God. / Those people will be burned, he said, but you are going to dig a well for yourself, and you will stay inside it with whole family until the fire is over. Put a gourd outside, and when it bursts the fire will be burned out. Still, you mustn't go out right away, for if you're in a hurry you will emerge in the form of an animal. You will find it easy to stay inside for one day, but you must wait for three days. During that time you must not go out! [...] / When the remaining people emerged after the three days had passed the earth was completely bare, as it had been after the flood, except that now there were ashes everywhere. These people began to multiply; every year another child was born, until once more there was a large population." [204: 64-79]

As noted by Metraux [146: 36]:

> "Outside the Chaco the story of the World Fire was found among the following tribes: Tupinamba, Apapocuva-Guaraní, Tembé, Shipaya, Caraja, Mura, Cashinaua, Witoto, Paulipang, Arawak, Yuacare [...].Various causes are given for the disaster. According to some stories it was sent by the culture hero or some supernatural being (Yuracare, Tupinamba, Arawak). In the opinion of the Cashinaua it was started by a spark fallen from the sky. The Tembé say that a child set a river aflame, and then the earth, with a 'candle' given to him by a mysterious stranger. The Witoto provoked a general conflagration when they attempted to burn the sky god Huisiniamui. The Apapocuva-Guaraní believe that a Big Fire will sweep the world soon after 'Our Father Great' removes one of the props which support the earth. [....] / The only survivors of the cataclysm were the individuals who hid in some underground cave or dwelling (Arawak, Mura, Yuracare). In the Tupinamba version, the culture hero saves only one man, by taking him to the sky. The Tembé say that a pregnant woman and a boy escaped death by hiding in a banana grove. Later they found untouched manioc cuttings which they planted anew. The Mura family was helped in their distress by a spirit who gave them water and plants."

John Bierhorst [16: 19] has defined a number of broad cultural areas in South America based on the sharing of myth motifs and on the general coherence of mythological tale types. These "mythological regions" are depicted in Figure 4. A striking aspect of this attempt to create cultural groupings based on myths is the fact that the area in Chile and Argentina immediately south of the Gran Chaco lacked coherence and therefore could not be placed into a defined

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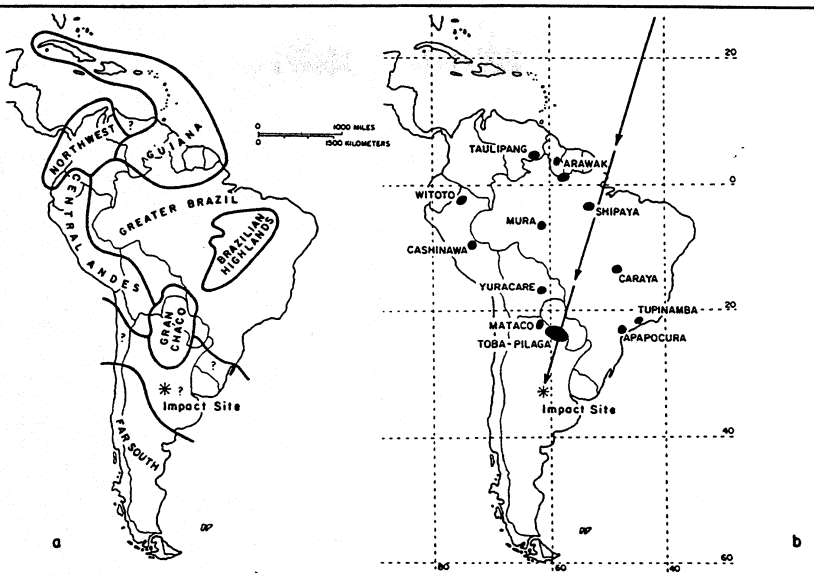

Fig. 4: Comparison of South American "mythological regions" with the distribution of "Great Fire" myths and the location of the Rio Cuarto impact crater field. Figure a depicts the boundaries of mythological regions (adapted from Bierhorst 1988: 19), Figure b depicts the historic locations of South American tribal groups with "Great Fire" myths in relation to the reconstructed path of the Rio Cuarto impactor (derived from Schultz and Lianza 1992).

mythological region. Linguists have likewise met with little success in their attempts to define historical language groups in this region [180: 23]. This mythological and linguistic "no man's land" takes on added significance when it is realized that the Rio Cuarto impact crater field lies at its very heart (Figure 4).

It is virtually certain from the reconstructed path of the Rio Cuarto impactor and from the distribution of Great Fire myths that the Rio Cuarto impact is the source of the Great Fire myths. Since these impact myths are part and parcel of Bierhorsts mythological regions, the failure by Bierhorst to place northern Argentina and northern Chile into one or more definable regions is undoubtedly related to the level of direct disruption of cultural systems caused by the Rio Cuarto impact event.

The sample of Great Fire myths noted here come from ral groups representing at least nine completely separate linguistic families: Arawakan (Arawak); Bora-Huitotoan (Witoto); Cariban (Taulipang); Guaycurú-Charruan (Toba-Pilaga); Macro-Ge (Caraya); Macro-Pano-Tacanan (Cashinawa, Yuracare); Mataco-Maccá (Mataco); Mura-Matanawí (Mura); and Tupian (Apapocura, Shipaya, Tembe, Tupinamba). Therefore, one cannot assume a simple diffusionist model within one or two language groups by which to explain this distribution.

Indeed, the widespread distribution of so many Great Fire myths across such a large and linguistically complex region suggests that the direct physical effects from the impact (e.g., thermal radiation, air pressure blast waves; ejecta) may have been felt over an area of between 1,000,000 km^2, the approximate size of the disrupted mythological and linguistic region, to perhaps more than 4,500,000 km^2, the latter representing the area in which myths relate a great loss of life, but which is only roughly half of the maximum extent of Great Fire myth distribution. Assuming that 4,500,000 km^2 represents the general extent of direct impact destruction, this is an area 6.5 times the size of the State of Texas or more than 14 times the combined size of the United Kingdom and Ireland. This suggests that the 350 MT figure derived for the impact by Schultz and Lianza [170] is substantively underestimated. It is possible that the size of the affected Rio Cuarto impact area may have been exaggerated by the extremely low flight angle of the impactor, or perhaps additional as yet undefined hits from the fragmenting impactor occurred in Brazil, therefore the original object was much larger than currently hypothesized.

As for dating the Rio Cuarto impact, the South American myths that I have scrutinized are somewhat equivocal regarding the order in which the various types of "world-wide" disasters occurred, although there is a tendency to place the Flood prior to the *Great Fire*, and to put both of these events prior to the *Great Darkness*. The Flood Comet impact is securely dated to 2807 BC, while the Great Darkness possibly correlates with a year-long diminishing of sunlight observed throughout Europe and the Middle East in AD 536-537 [169, see also Baillie, this volume].

More recent analysis of the impact site by Peter Schultz apparently places the dating tentatively at around 4000 BP (Peiser, this volume), which fits comfortably within the date range provided above. An absolute date for this event may be possible through the examination of ice-cores and tree-rings, and from a more exhaustive of study of the mythology. For example, one step toward potentially more precise dating is the realization that the impact coincided with a partial lunar eclipse [204: 69]:

> "Long ago Moon was attacked and wounded, and thus the great fire originated. As soon as people noticed blood on Moon [i.e., the reddish cast of a lunar eclipse], they started to chant and to shout and they struck their dogs to make them bark. [...] A fragment of Moon fell down and caused a fire."

The Broken Bow, Nebraska Impact

A 1.6-km wide depression west of Broken Bow, Nebraska, and some 300 km southwest of the badlands of South Dakota, has recently been pointed out as a candidate Holocene period impact crater [140]. This suggestion has met with skepticism, including that by the late Eugene Shoemaker. The estimated date of the geological formation is about 3,000 years old (1000 BC), and the energy released from an impact of this size would have been more than one hundred times that of the Tunguska impact.

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Despite the current aura of skepticism by some specialists, there is, in fact, evidence from Native American oral traditions to support the impact crater claim. The following is from the 1937 publication of a tale collected earlier from then very old Sioux oral historian, Red Bird [40: 309-310]:

> "Long ago the Badlands did not exist. Instead there was a high plain covered with grass or with trees. Much game could be found there - deer and elk and buffalo. So each autumn many tribes camped there to hunt and to make ready their winter supply of meat. Tribes that were at war with each other at other times of the year met peacefully on the plains in the autumn and enjoyed friendly powwows. Quarrels were forbidden. / But after many snows, a fierce tribe from the mountains toward the setting sun came and disturbed the peace of the plains. Wanting the high tableland for themselves only, they drove off the other people. They claimed all the grass for their own horses [sic], killed the best of the game, and refused to allow other tribes to set up camp as in the old days. / Again and again the Sioux and their friends from the north and the east fought for their ancient hunting ground, but the mountain tribe from the west defeated them. Many of their warriors died in battle. At last the men of the plains held a great council of all the tribes. To appease the spirits, people fasted for many days. Some tortured themselves. The medicine men did everything they could to win the favor of the spirits, but they received no answer. Their people were in despair. / At last the spirits sent their answer. The midday sky became as black as a midnight sky. Lightning flashed, seeming to come from the ground, and thunder rolled. Strange fires lighted the entire country with their flames. The earth shook. Where the western tribe had their camp, waves of land like waves of a great water rolled back and forth. In the troughs of these gigantic waves, the whole warring tribe with their tipis and their horses [sic] sank and were engulfed by the next waves. With them went the grass, the trees, the streams, the game animals - everything that had been on the high plain. / As the frightened people from the north and the east watched from a distance, the great commotion suddenly stopped. The fires burned themselves out. When dawn came, the peace loving tribes saw that the rolling waves of earth had become fixed, bare rocks. Their beautiful plain was now a wasteland on which nothing could ever grow."

As noted earlier, a similar legend existed among the Cheyenne, as part of a long oral history of the Cheyenne people published by George Dorsey in 1905 [60: 113]:

> "The people returned to the south and lived as well as they could, in some years better, in others worse. After many hundreds of years, just before the winter season came, the earth shook, and the high hills sent forth fire and smoke. During that winter there were great floods. The people had to dress in furs and live in caves, for the winter was long and cold. It destroyed all the trees, though when spring came there was a new growth....The people continued to live in the south, and they grew and increased. There were many different bands with different languages, for the red men were never united after the second flood."

The hypothesized Broken Bow impact crater is admittedly a substantive distance (300 km) from the "Badlands" presumably being described in these epic tales. However, an impact near to the Badlands certainly could be easily linked to the badlands themselves by the very fact that the area of devastation around the impact crater would appear similar to the desolate Badlands. Alternatively, the Badlands may have themselves been directly affected by fragments of or ejecta from the Broken Bow impact, or by an as yet unidentified separate impact.

Armed with knowledge of the cosmographic parameters of the Flood Comet impact of 2807 BC and the terrestrial impacts in Argentina and Nebraska, I now turn to the evidence for other impacts during Bronze Age times. The emphasis of this exercise is to compare roughly contemporaneous myths from widely separate regions which treat cosmic battles or natural disasters, and to model the possibility that they may encode the same events. Another goal of this exercise is the attempt to refine Old World Bronze Age chronologies.

8. Celestial events of circa 2700-2650 BC

Several distinct sets of epic tales from widely separated cultures and regions are seemingly reliably dated to the 27th century BC. In each case the main plot of the story is said to have taken place within a few generations after a great flood had swept the Earth. These tales are remarkable not only because they are among the earliest known epic literature, but also because of the sobering fact that there are several general consistencies in their story lines. These parallels are numbered below for sake of discussion. Although the evidence for actual cosmic impacts based on these particular stories is somewhat weak, the analysis performed here demonstrates the utility of the cosmographic approach to elicit details of celestial events encoded in worldwide mythology.

China: Yellow Emperor, Huang Di

I begin with myths surrounding Huang Di, the legendary "Yellow Emperor" of China [212]. The standard chronology places his reign at about 2697-2597 BC [194, 200]. My choice of Huang Di as the first epic for discussion is due to the simple fact that the astronomical connections between his exploits and likely contemporary celestial events are made surprisingly clear in the *Bamboo Annals* [106]. The Bamboo Annals are the 3rd century BC official history of the State of Wei, which escaped the notorious burning of historical texts by emperor Ch'in Shih-huang-ti in 213 BC [45] by virtue of being buried in a tomb prior to that date. Therefore, the Bamboo Annals story line of the Huang Di epic serves as a springboard for discussion of the other geographically separated epics [106: 108-109]:

(1) *Ursa Major Supernova or Nova-like Event* (ca. 2697 BC). Huang Di, as is the case for virtually all demigods and culture heroes, had a miraculous birth. His mother became pregnant after witnessing "a great flash of lightning" around the star, Dubhe (part of the bucket of the Big Dipper asterisim in Ursa Major). It is clear from other stories that this event was an exceptionally bright nova or supernova, which I suggest may have been the event which led to the creation of the modern Owl Nebula (see discussion below). This event occurred at around 2697 BC based on the assumption that Huang Di began his "reign" at birth. The presumed nova event may have been visible for at least 25 months, the length of time given for Huang Di's gestation period. Huang Di could speak at birth, his countenance was "dragon-like", and he had four faces.

(2) Simultaneous Supernovae or Nova Events (ca. 2677 BC). In the 20th year of Huang Di's reign, "brilliant clouds" appeared in the heavens. The Bamboo Annals note:

> "The auspicious omen of brilliant clouds was in this way: The vapours of the red quarter [the south] extended

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> so as to join those of the green [east]. In the red quarter were two stars, and in the green, one; - all of a yellow colour, which appeared on a day when the heavens were clear and bright, in Shê't'e [likely *shê-thi-ko*, the first year in the 11-year Jupiter cycle; see 141: 251-252], and were named the brilliant stars. The emperor in yellow robes fasted in the Middle palace" [circumpolar stars immediately around the pole star, then in Draco].

This passage would appear to encode three simultaneous nova or supernova events. Based on the names and nature of the Gods associated with these three stars, I elsewhere have suggested that the events took place in the constellations Sagittarius, Draco, and Leo [123: 474].

(3) Taurid Meteor Storm (ca. 2647 BC). The Bamboo Annals state that in the autumn of the 50th year of Huang Di's reign, the heavens were "wrapped in mist" for three days and three nights. Along with the mist there appeared a number of male and female phoenixes (*Feng* bird), unicorns (*Ch'i-lin*), unidentified creatures with four horns termed *Lo*, and creatures termed *yin* worms which appeared like rainbows.

The nature of this "mist" is not clear, but there is reason to believe that it encodes a meteor shower, as suggested by the following imagery of part of a celestial battle between Huang Di and Chi You [212: 43]:

> "These wars were full of tricks and subtle maneuver. One time Chi You [Chhih-Yu] covered the whole battlefield with thick, white fog until the Yellow Emperor's troops could see nothing at all. The horned oxen troops appeared and disappeared in the fog, slashing, slicing, stabbing into thin air. Unearthly shrieks and groans of battle filled the fog [...]."

In order to escape from the fog, the "South-pointing chariot" was invented. This had a mechanical finger which always pointed South regardless of the direction the chariot was pointed. The imagery of the "horned oxen troops" with their bronze ox heads conjures up the image of Shen Nung, Chhih-Yu's father who is likely related to the constellation Shen (Orion). The South-pointing chariot possibly refers to an alignment of circumpolar stars, such as the "Chariot Pole" [114: 80-81], a grouping of stars closely identified with the Yellow Emperor ("Yellow Thearch"). This fits comfortably with the fact that Huang Di is credited with inventing the first wheeled vehicle.

(4) Oceanic or Lake Cosmic Impact (ca. 2650 BC). After the mists ended, Huang Di went to the Lo River and saw a great fish. He sacrificed five victims to the fish, upon which torrents of rain came down for seven days and seven nights and the fish floated off to sea.

In other versions of the mist and torrential rain stories [18, 212], we learn that the events during the 50th year of the Yellow Emperor's reign were actually part of a cosmic battle between Huang Di and Chhih-Yu. Chhih-Yu is said to be the name of either a tribe of giants, or that of a ferocious god in heaven, the son of ox-headed second sovereign and Fiery Emperor, Shen Nung (and thus likely associated with the ox constellation Orion). He is described as having one or more horns on a bronze head, and a skull consisting of iron. This particular demigod likely represents the apparition of a particular form of comet, also called *Chhih-Yu*, referred to as "banner" comets. Ho Peng Yoke [89: 136] has reported this cometary form as a tailed comet, with its tail being "bent like a flag".

Chhih-Yu had as supporters the gods of Wind and Rain, while Huang Di had the Ying Long dragon, who was a water-gatherer and could cause heavy rains. After fighting for several days, Huang Di finally won by using the skin of the *kui* beast as a large drum. Chhih-Yu's army was paralyzed by the sound of the drum striking nine times, which caused the valleys and the mountains to quake and the sky to change color. Yuan Ke [212: 45] provides us with this most interesting description of the *kui*:

> "It was grey and looked like an ox without horns. Although it had only one leg, it sometimes rushed out of the sea leaving violent storms in its wake. It would open its mouth to roar like thunder, and its body shone like the sun and the moon".

Mesoamerica: Seven Macaw and the Hero Twins

The *Popul Vuh* is the Quiche Mayan creation epic copied and translated by a Dominican friar, Francisco Ximénez, between 1701-1703 [187: 28-30]. Of interest is in the story line of what happened immediately following a worldwide flood which destroyed the wooden manikin people of the Earth.

(1) Ursa Major Supernova or Nova-like Event (ca. 2697 BC). A deity by the name of Seven Macaw (Big Dipper), who is married to Chimalmat (Little Dipper) decides to become the new Sun and Moon [187: 86]. The imagery quoted below is an apt description of the bright Ursa Major nova-like event:

> "I am great. My place is now higher than that of the human work, the human design. I am their sun and I am their light, and I am also their months. / So be it: my light is great. I am the walkway and I am the foothold of the people, because my eyes are of metal. My teeth just glitter with jewels, and turquoise as well; they stand out blue with stone like the face of the sky./And this nose of mine shines white into the distance like the moon. Since my nest is metal, it lights up the face of the earth. When I come forth before my nest, I am like the sun and moon for those who are born in the light, begotten in the light. It must be so, because my face reaches into the distance, say Seven Macaw./ It is not true that he is the sun, this Seven Macaw, yet he magnifies himself, his wings, his metal. But the scope of his face lies right around his own perch; his face does not reach everywhere beneath the sky".

Seven Macaw is wounded in the jaw by a blowgun dart from Hunahpu, one of a pair of twin boys (warrior gods) who want to restore things to their natural order. Hunahpu and his brother Xbalanque remove his precious shining teeth and eyes and Seven Macaw fades away. The location of where Seven Macaw is wounded is on top of his giant nance tree [187: 90-91], which Freidel and his colleagues convincingly argue is likely a metaphor for the World Tree composed of the Big Dipper, the Milky Way, and the Ecliptic [67: Fig. 2.13]. As for the Hero Twins themselves, they too are celestial in that they eventually become the Sun and the Moon. Whether or not they may also represent other types of celestial phenomena, such as novae and comets (including perhaps paired comets), is unknown.

An intriguing possible additional confirmation of the association of the Seven Macaw with the Big Dipper is that of a curious scorpion motif that accompanies Classic Mayan depictions of this myth [187: 90-91]. Although Freidel, Schele, and Parker [67: 75-76] build a convincing argument for the Scorpion image to represent the constellation Scorpius, I am struck by the fact that early historic period Nahuatl speakers of Mexico seemingly interpreted Ursa

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Major as representing a scorpion [4: 66].

(2) Simultaneous Supernovae or Nova Events (ca. 2680 BC). There are no unmistakable equivalents in the Popul Vuh for the hypothesized three simultaneous novae in the 20th year of the reign of Huang Di. On the other hand, the two sons of Seven Macaw, Zipacna and Earthquake, were said to have "magnified" themselves to some degree, perhaps not unlike Seven Macaw himself (Tedlock 1986: 99). This suggests that the sons of Seven Macaw constituted two of the three simultaneous novae, a possibility further supported by the fact that a typical human generation (between father and first-born son) is approximately 20 years, roughly the amount of time between the Ursa Major event and the three simultaneous nova events.

(3) Taurid Meteor Storm (ca. 2650 BC). The elder son of Seven Macaw is Zipacna, maker of mountains. This is a creature likely similar to the cipactli, a Nahua mythological creature similar to a crocodile or a shark, and which possibly represents an unidentified constellation or perhaps is representative of comets. Sometime after the death of his father, Zipacna is encountered by the Four Hundred Boys 'bathing on the shore' (of the Milky Way?). The Four Hundred Boys try to kill Zipacna by shoving a tree onto Zipacna who has dug a deep pit. After three days, the boys think that Zipacna is dead and celebrate by getting drunk. Zipacna kills them by shoving their hut down on top of them and crushing them. The boys then enter the constellation, Hundreth or Motz, which is the Pleiades. Hunahpu and Xbalanque then kill Zipacna by building a giant artificial crab (a favorite food of Zipacna) and placing it under a mountain. Zipacna tries to catch the crab and is instead himself trapped under the mountain, at which point he turns to stone.

This sequence appears to encode a three-day long great meteor storm associated with the two Taurid streams near the Pleiades, and closely matches the event in the Gilgamesh epic described below.

(4) There are no known correspondences between the Bamboo Annals and the Popul Vuh regarding the 'battle' between Chhih-Yu and the Yellow Emperor, unless it is with the actions and adventures surrounding the Hero Twins in the land of the underworld, Xibalba.

Mesopotamia: Gilgamesh and Enkidu

The epic of Gilgamesh has fascinated Western civilization since the discovery of the original clay tablets at Nineveh by Hormuzd Rassam in 1864 and their initial translation eight years later by George Smith [31: 264-278]. The Gilgamesh epic [48, 97], in much the same manner as was the case for the Mauiakalana epic in Polynesia, is a story of multiple spectacular temporary celestial events. The epic was created both to explain these events and to honor the King in whose reign these events occurred. As history tells us, the story takes place during the reign of Gilgamesh, a legendary but still historical ruler of the Mesopotamian city of Uruk during the 27th century BC, and who several centuries later was worshiped as a god [57: 53].

Gilgamesh had a miraculous birth. In the Sumerian King List [146: 265-266], the father of Gilgamesh was identified as a *lillû* spirit/demon (unidentified as to meaning). Another myth states that the grandfather of Gilgamesh, a king of the Babylonians, was warned by his magicians that a son born to his daughter would one day usurp the throne. The newborn Gilgamesh was thrown from the top of the acropolis, but was saved by an eagle. In addition, the adult Gilgamesh is described as having been a giant, nearly 5 m tall.

The epic begins with the hero having two dreams. In the first dream, the stars suddenly appeared in the sky and a meteorite fell from the sky and landed next to Gilgamesh. In the second dream an axe appeared next to Gilgamesh. (Early civilizations often confused or equated meteorites with polished stone axes of Neolithic cultures [141: 435]). Both of these were seen by the mother of Gilgamesh as symbols of the wild man Enkidu, who was to become the beloved friend of Gilgamesh. The pairing of Gilgamesh and Enkidu may be analogous to the pairing of the Hero Twins in the Popul Vuh, presumably with similar celestial overtones.

(1) Ursa Major Supernova or Nova-like Event (ca. 2700 BC). The first adventures of Gilgamesh and Enkidu is that of the killing of mighty Humbaba (Huwawa, Humbala), giant guardian of the cedar forest. Humbaba was said to have been clothed in seven layers of "terrifying radiance", spouted fire when he talked, and the "flood-weapon" was employed when he shouted. On the journey to kill Humbaba, Gilgamesh had three dreams, two of which are poorly preserved, but the third of which is of some interest [97: 34]:

> "The heavens roared and the earth rumbled; (then) it became deathly still, and darkness loomed. A bolt of lightning cracked and a fire broke out, and where(?) it kept thickening, there rained death. Then the white-hot flame dimmed, and the fire went out, and everything that had been falling around turned to ash."

A Hittite version of the killing of Humbaba [97] suggests that this took place in the celestial heavens in that Humbaba, standing on his "mountain" told Gilgamesh and Enkidu: "I shall carry you off and cast you down from the sky, smash you on the head (?) and drive you down into the dark earth." Despite this threat, Enkidu had no problem cutting off Humbaba's head with his sword.

The description of Humbaba as guardian of the cedar forest with seven bright rays is analogous to the description of Seven Macaw in the Popul Vuh. In fact, a cylinder seal depicting the slaying of Humbaba [97: Fig. 3] contains a motif of two rows of dots totaling seven dots, which parallels images that Parpola [150: 194-195] has argued represents Ursa Major in both Mesopotamian and Harrapan script.

The face of Humbaba, as illustrated in Figure 2 (and in other representations) is striking in that it seems to be alive and to pulsate with energy. This vibrancy is echoed in a surviving fragment of Tablet V of the Gilgamesh epic [97: 42]: "Gilgamesh spoke to Enkidu, saying: My Friend, Humbaba's face keeps changing!" Unfortunately the remainder of the description is lost.

(2) There is no apparent equivalent in the Gilgamesh epic for the hypothesized three simultaneous novae in the 20th year of the reign of Huang Di.

(3) Taurid Meteor Storm (ca. 2650 BC). The next adventure of Gilgamesh and Enkidu is that of killing the Bull of Heaven, sent down to Earth by the goddess Ishtar (Inana), goddess of love, because Gilgamesh has spurned her advances. The sky god Anu gives the reigns of the *Bull of Heaven* to Ishtar to lead down to earth. The Bull of Heaven snorts three times, the first two which creates a huge pit into which 100 and then 200 young men of Uruk, respectively, plunge into each time. At the third snort Enkidu falls in the pit. Enkidu then climbs out of the pit, grabs the tail of the Bull of Heaven in both hands, and then Gilgamesh kills it with a sword between the shoulders.

The similarity between this story and the death of the 400 boys in the Popul Vuh is striking. Thus it should be no surprise that Ishtar ("Queen of the Stars" according to Allen [3: 463], is associated with the planet Venus and the Bull of

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Heaven) is the term commonly ascribed to the constellation Taurus. The story undoubtedly encodes an early observation of a dramatic Taurid meteor storm.

(4) Oceanic or Lake Cosmic Impact (ca. 2650 BC). Gilgamesh has additional exploits which do not seem to correlate well with the above defined actions of Huang Di. These include his attempted seduction by the goddess Ishtar (Venus); the death of his friend Enkidu; a long and treacherous journey to visit with Utanapishtim, the survivor of the Flood; and his recovery of the "plant of rejuvenation" from the waters of death, only to have it snatched from him by a snake. It is possible the the purpose of retelling the story of the Flood in the Gilgamesh epic, a lengthy sub-story not directly involving either Gilgamesh or Enkidu, is due to the occurrence of a moderate (large local or regional) oceanic or lake cosmic impact at around 2650 BC. In fact, fear of a repeat of the 2807 BC. Flood Comet impact itself may have played a substantive role in the creation of the Gilgamesh epic. This would correspond to the copious rainfall noted in the Huang Di myth as well as the previously mentioned alluvial flood deposits at Kish dating to around 2650 BC.

Egypt: Horus and Set

While Egyptian mythology regarding the 27th century cosmic events is perhaps more subtle than the Huang Di, Gilgamesh, and Popul Vuh epics, the cosmographic relation between these cosmic events, Egyptian religion, and Egyptian culture is extraordinary and most compelling. The mythology concerning these cosmic events is enshrined as a series of stories about the sky-god Horus and the great cosmic disturber, Set.

(1) Ursa Major Supernova or Nova-like Event (ca. 2700 BC). I begin this analysis with the only event chronicled by the Egyptian historian, Manetho (Eusebius version), for the first king of Egypt's Third Dynasty, Sanakhte [193: 43] "[...] in whose reign the Libyans revolted against Egypt, and when the moon waxed beyond reckoning, they surrendered in terror." This unusual "waxing" of the Moon is almost certainly the Ursa Major nova-like event described above. Current dating puts the beginning of the Third Dynasty and Sanakhte's reign at about 2700 BC [96], which well matches the Chinese date for the Ursa Major nova-like event. It is likely that Sanakhte's brother, Djoser, second king of the Third Dynasty, would have witnessed this celestial event as well.

The Manetho reference may be paralleled in the myth of Horus Behdety [26: 56-95, 91: 67-68], which has been dated to the Third Dynasty [64], presumably to the time of King Djoser since the myth is directly linked to his minister and chief architect, Imhotep [161: 143-144]. In this myth there is a revolt against the King of Egypt, Ra, while visiting Nubia. The King sails down to Edfu, where he orders his son, Horus to fight the enemy. In some versions of the myth the god Set is considered the leader of the enemy, with his army being composed of demon-like creatures. Set turned himself into a serpent, while his supporters became crocodiles and hippopotami and attacked the solar boat of Ra. Horus takes the form of a winged sun-disk, and chases the enemy through Upper and Lower Egypt, and all the way to the frontiers of Asia. Eventually, the insurrection is put down, Set is beheaded, and Ra orders that the winged sun-disk be placed in the temples and on the shrines of all deities to ward off enemies.

In terms of a link between the Ursa Major nova-like event and the Horus Behdety myth is the possibility that the name Horus is derived from the word, *hor*, meaning "face" [91: 67]. In fact, Djoser was the first Egyptian king to adopt the curious title of *Golden Horus*. Also of interest is the description of the winged disk as "shining with very many colours" [26: 59]. These images are suggestive of a near-Earth nova-like event. Also, it is notable that Imhotep, the minister to Djoser (and who later himself became deified), was also a noted astronomer and "magician."

But more intriguing is the fact that the Ursa Major nova-like event is seemingly contemporary with the construction of Djoser's temple complex, that of the famous so-called *Step Pyramid* [84: 64-67, 161: 171-182, 177: 98-105, 174: 102-113]. This assumes that the Third Dynasty begins at around 2700 BC, as suggested by Kitchen [96], and likewise assumes that the initial construction of Djoser's original mastaba tomb had begun before the appearance of the Ursa Major nova-like event.

By all accounts the Step Pyramid, the first pyramid-like structure in Egypt, signals a major shift in cosmology and world view. Prior to the Step Pyramid, Egyptian rulers and high officials were buried in massive mud-brick tombs, the largest of which was some 67 m in length, 37 m in width, and perhaps 4-5 m in height. Beginning with the Step Pyramid, for the first time mortuary edifices were constructed entirely of stone, and at a scale far greater than anything done previously in the history of civilization. The Step Pyramid complex is situated in a massive walled enclosure 545 m in length and 270 m in width, which enclosure an area of nearly 16 hectares. The Step Pyramid itself rises in six levels to a height of more than 62 m. As such, it has been aptly described as "a gigantic stairway for the monarch's ascent into the sky" [80: 62].

The relationship between the king and the sky is particularly interesting, although there is a debate as to whether the emphasis was in connection with the Sun or with the stars, or both [13, 58, 158, 161]. As noted by Rice [161: 195-196]:

> "Some authorities have proposed that the early royal religion in Egypt up to and including the Third Dynasty, was linked with the stars. The evidence, either way, is slender but certainly the Pyramid Texts, assuming these to be more ancient than the time in which they were first inscribed on the walls of the Sixth Dynasty pyramids, seem to identify the divine King as a star and it is amongst the stars, or even beyond them, that he seeks his eternal habitation. The stars are valuable instruments for measurement and the Egyptian engineers and architects of even the earliest periods seem to have been capable of making complex and sophisticated empirical observations which they used to align their buildings. The precision with which the monumental buildings of the Archaic period and the early Old Kingdom are aligned is legendary; that precision was achieved by careful sitings on selected stars and the skilful [sic] use of water channels, the consequence of the careful observation of the behavior and properties of water which large-scale irrigation projects and techniques had made familiar. With the advent of the Fourth Dynasty, however, the sun cult, the perogative [sic] of the hierophants of Heliopolis, began to rise above the other cultures of national or royal status."

Contrary to Rice and other scholars, I suspect that the Pyramid Texts, beginning with the tomb of King Unas at the end of the Fifth Dynasty, are indeed original to that period (ca. 2350-2200 BC) and for the most part do not represent earlier texts.

A simple test of the emphasis on Sun versus stars would be that of checking the symbolism of location, that is, whether or not critical aspects of the complex are oriented sensitive to the path of the Sun (generally east-west, and specifically

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toward solstitial and equinoctial points), or are instead oriented north toward the circumpolar stars. As noted by Wilkinson [205: 60-73], both strategies are utilized variously throughout Egyptian culture history. The answer to this question may well reside with the nature of the architectural features of the Step Pyramid complex [174: 102-113].

The first item of note for the Djoser Step Pyramid complex is that the single entry is indeed from the east. However, the long axis of the overall complex runs north-south. In fact, the majority of features appear to be in a north-south orientation. This includes the extraordinary *heb-sed* courtyard, a full-scale replica for the king to perform his ritual festival for renewal of his rulership rights in the afterlife; the doors of this replica were left permanently ajar [64: 79-88]. The *sed* festival began around the middle of September and may have coincided with the autumnal equinox. More important, however, is the *saite* or funerary temple on the north side of the pyramid, and the north orientation of the entryway tunnel(s) from the kings burial chamber beneath the Step Pyramid. While later entryway tunnels almost always were placed on the north side of pyramids, beginning in the Fourth Dynasty the funerary temple uniformly shifted to the east side.

Of special interest is Djoser's *serdab*. The *serdab* is a small, completely enclosed tiny chamber, attached to the east side of the funerary temple and against the northern base of the pyramid itself. A life-size seated statue of Djoser next to and facing the north wall of the *serdab*; two small holes were drilled through the inward slanted wall in direct orientation with the eyes of the statue. Clayton [41: 35] suggests that the holes were drilled to enable the *ka* or spirit of Djoser (as manifested through the statue) to partake of food offerings and incense placed on an alter outside the *serdab* by mortuary priests. While this may indeed have been part of the ritual, it is also true that the crystal eyes of the statue would have been oriented upwards toward the circumpolar stars.

It is also of some interest that relatively rare depictions of the baboon god Hedjwer ("Great White"), suddenly appear on Third Dynasty reliefs of King Djoser's pyramid [177: 73]. Hedjwer, like the more commonly known baboon deity, Thoth, is believed to be a personification of the Moon. Also intriguing is the fact that Hedjwer was depicted in the royal title of Semerkhet, the seventh king of First Dynasty, and the unfortunate recipient of the Flood Comet impact described above.

But perhaps the most intriguing architectural detail about the Step Pyramid is its construction history. The Step Pyramid began as a large but otherwise typical mastaba tomb not unlike all others of the First and Second Dynasties, and that of Djoser's brother, Sanakhte, first king of the Third Dynasty. As this original mastaba was nearing completion, it was remodeled twice and then suddenly and hugely transformed into the first ever pyramid complex which itself went through a couple remodelings. While some of the minor architectural elements of the Djoser Step Pyramid complex are presaged in the first two dynasties and in the mastaba tomb of his brother, Sanakhte, the major elements are all new, including the *saite* funerary temple, the replica of the *heb-sed* court, the *serdab* chamber, the enormous enclosure wall, the complete use of stone for all construction, and of course the pyramid itself.

In the words of Michael Rice [161]:

> "But it was not until the beginning of the Third Dynasty, around 2680 BC, that the titanic complex that was to preserve for all eternity the body of the second King of the dynasty, the Golden Horus, Djoser Neterikhet, was suddenly to appear on the Saqqara escarpment, built entirely of stone, on a scale never before contemplated on the face of the earth. [...] The Djoser complex is unique. Once again, it is totally without precedent, not merely in Egypt but in the entire world."

It is not very a satisfactory explanation to attribute this construction endeavor simply to the coincidence of a wealthy and powerful monarch with the genius of his principal architect, as has been commonly done for Djoser and Imhotep. What is the source of their inspiration, but even more critical is how did they willingly convince the populace of Egypt to support them in this ambitious endeavor?

(2) Simultaneous Supernovae or Novae Events (ca. 2700 BC). There is no definitive record in the myths or historical literature of Egypt of the three simultaneous supernova or nova-like events reported in the Bamboo Annals. However, one or more of these may have been observed in Egypt. For example, the hypothesized supernova or nova event in Draco [123] would have been circumpolar and perhaps was not too far from the circa 2697 BC. Ursa Major nova-like event witnessed as scant generation earlier. This event, had it actually happened, would surely have further encouraged the architectural and religious expression begun with the Step Pyramid complex. It may even be possible that the hypothesized simultaneous events of circa 2677 BC were the penultimate trigger for the final construction phases of the Step Pyramid complex.

(3) Taurid Meteor Storm (ca. 2650 BC). Clear and unequivocal descriptions of the Taurid meteor storm of circa 2647 BC are lacking in Egyptian mythology. However, there is reason to believe that the greatest Egyptian myth of them all, that of the murder of Osiris by Set, is a cosmographic encoding of this cosmic event.

There are a number of versions of this popular story scattered throughout the history of Egyptian literature, beginning with the Pyramid Texts at the end of the Fifth Dynasty [25, 80, 91]. In brief, Osiris was an enlightened king of Egypt, who was married to the goddess Isis, and who taught his subjects how to become civilized. After a period of travel abroad to teach the rest of the world, Osiris returned to Egypt where his brother Set was planning to overthrow him and seize the throne. On the seventeenth day (of the lunar cycle) of the month Hathor (believed to be October), Set and his fellow conspirators challenged Osiris to see if he could fit into a coffin-like chest. Once inside the chest, the conspirators nailed it shut, weighted it down with lead, and threw it into the Nile. Isis spent a long time searching for Osiris, and discovered the chest in Byblos. Through magic Isis managed to conceive from her dead husband. Isis then took refuge in the Egyptian Delta to give birth to and to raise her son Horus because she knew that Set would kill Horus if he got the chance. Set found the chest and tore Osiris's body into a large number of pieces, scattering them throughout the kingdom. Isis recovered the pieces of Osiris's body, except for his phallus, and was able to resurrect him. Set discovered the baby Horus and, taking the form of a viper, bit him. Isis called upon Ra, who stopped the sun and it became dark in daytime until he was able to cure Horus. Isis continued to protect Horus. Isis finally ends up poisoning Ra so that she could obtain his powers. From his spittle and dust she fashioned a viper which bit Ra. The fire departed from him until he started shivering and his eyes trembled so much that he could not see the sky. After obtaining the secret words of Ra, Isis counteracted the poison and then restored Ra to his full strength.

This story is laden with veiled cosmographic meaning. First, Osiris is identified with the constellation Orion, Isis is identified with Sirius, and the Venus is identified with the

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bennu, a heron-like bird related to the fabled Phoenix [70, 110]. Previously we have learned that Set, himself, is associated with meteorites. Another curious fact is that the sacred *benben*, makes its first appearance about the time of the Third Dynasty. These are cone-shaped capstones for pyramids, and a critical component of Fifth Dynasty solar temples and other Old Kingdom special structures [13, 64, 205]. It is clear from a number of sources that *benben* are meteorites shaped by their passage through the atmosphere. This relationship is enhanced by the likelihood that the term *benben* itself is derived from *weben*, which means "to shine" [158: 27].

The key to understanding the origin of the Osiris-Set conflict is contained in the following passage from the Pyramid Texts and associated discussion by Quirke [158: 54):

> "Egyptian texts tend to reticent on the catastrophic moment of murder [of Osiris], but the ritual for the 'end of (mummification) operations' gives a brusque summary, from the moment that Osiris first arrived at Abydos: *Osiris then said how great is this land, which is called Tawer (great land = the province of Abydos) to this day; then Osiris was perfect within it exceedingly greatly; then Seth heard him; Seth came in haste, and arrived against Osiris within Nedyt in Hatdjefau (two places in the area of Abydos) under a tree called* aru *in the first month of inundation, day 17, and committed an act of great violence against him, and had him sunk in the waters; then Nun rose to cover him exceedingly greatly, and he was borne away to hide his mysteries.../* The text goes on to describe the cosmos in chaos at the death of Osiris, and the tears of the gods turning into materials used in mummification such as honey, resins and incense; the rest of the ritual prescribes the fashioning of statues of enemies, to be destroyed, and of Osiris, to be mummified and buried./ The date in the ritual does not agree with the usual date given for the death of Osiris, presumably because the ritual tailored the myth to suit the time of year that it was due to performed."

This date, the 17th day of the first month of inundation, is actually most likely the correct date for the "death" of Osiris. I suspect that scholars have likely confused the month of Hathor (October) with the "first month of the inundation", a very special time for the sky-goddess Hathor in her role as fertility goddess. Hathor, when associated with the rise of the Nile and the Dog-star Sothis (Sirius), is depicted lying in a ship as a cow with a star between her horns.

The rise of the Nile typically occurs in late June or July [27, p. 447]. This also coincides with the date of the very important New Year's Festival [64]. However, most extraordinarily, around 2650 B.C., the 17th day (two days after Full Moon) of the first month of inundation would have also coincided with one of the greatest fireworks displays ever witnessed on Earth. By figuring in approximately 102 days difference for precession, the Taurid meteor stream, whose modern maximum occurs around 3 November, and whose modern range encompasses the period of 15 October to 25 November [21, Table 5.1], would have been in full bloom in late July of circa 2650 B.C. It is small wonder that Osiris, as the constellation Orion, was virtually annihilated by Set, the latter who in addition of being the god of meteorites may possibly have been envisioned as a neighboring constellation incoporating portions of Taurus, including the Pleiades and the Hyades. Given its seeming source for the Taurids, it is little wonder that the Egyptians gave the name 'thousands' to the Pleiades asterism [70, Table 21].

(4) Oceanic or Lake Cosmic Impact (ca. 2650 BC). It is not so clear, however, from the Egyptian myths as to whether or not the Taurid storm was accompanied by one or more actual cosmic impacts on Earth. However, this is certainly a reasonable supposition and would help to explain the association of the Taurids and the 'fire-drill' constellation (Pleiades) with actual meteorities. The fact that the step pyramid of Djoser's successor, Sekhemkhet, was never finished, and the substantive differences in the pyramid construction techniques of the last two kings of the Third Dynasty, Khaba and Huni [41], may have been influenced by the Taurid storm and possible associated impacts.

India: Rahu

As with the Egyptian traditions, I have not yet had the opportunity to fully analyze Hindu traditions in relationship with the celestial events of the 27th century BC. However, I am particularly struck by the legends surrounding Rahu, an eclipse demon who is considered of importance equal to the five naked eye visible planets, the Sun, the Moon, and Ketu, a deity representing comets [150: 199-201].

(1) Ursa Major Supernova or Nova-like Event (ca. 2700 BC). Rahu appears in association with the tortoise Kurma, the second of the twelve avatars or incarnations of the Vishnu, and immediately following Matsya, the fish avatar associated with the Flood [54: 67-75]. Rahu is associated with the illicit drinking of Soma, the nectar of the Moon whose loss causes the Moon to wane or eclipse [49: 316]:

> "While the gods were sharing the nectar, a *danava* [genii] named Rahu, disguised as a god, was drinking his share; the Sun and the Moon discovered him when the nectar had only reached his throat, and they informed the other gods. Vis[hnu] instantly cut off with his discus the *danavas* head, which was thrown into the sky and began to utter piteous cries, while the headless trunk fell upon the ground and, rolling thereon, made the earth tremble, with her mountain, forests, and islands. From that time a quarrel has existed between Rahu's head and the sun and the moon. And to this day it always attempts to swallow the sun and the moon." (*Bhagavata Purana* 10.8.9.)

The tail of Rahu became Ketu, the monster which gives birth to comets and meteors.

Presumably when Rahu drank the Soma, his countenance was much like that described for the nectar itself [197: 4]:

> "The poets never tire of stressing Soma's sensuous appeal. In appearance it was brilliant, reminding them of the Sun, of Fire, of the rays of the Sun, of the round bowl of the heavenly firmament, the 'back of the sky'".

This description, a head-shaped brilliant celestial object sounds very suspiciously like the nova-like event in Ursa Major, although I have not yet been able to establish a clear link in Hindu mythology between Rahu and this constellation.

Evaluation of 2700-2600 BC celestial events: Taurids, Owl Nebula, and oceanic impact?

The myths detailed above for the period of 2700-2650 BC encode nova-like events and meteor storms, and possibly the passage of paired or otherwise unusual comets. The evidence is compelling that the various sets of myths are indeed describing the same events, and thus can serve at least as indicators for the construction of regional chronologies. The several descriptions of an early episode of the Taurid meteor showers at around 2650 BC is notable.

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Especially impressive are the several myths which appear to identify a nova-like event in Ursa Major, in particular the "bucket" area of the Big Dipper asterism. It is significant that only a single notable nebula is known from the region of the bucket of the Big Dipper. This object is the peculiar Owl Nebula (Messier 97; NGC 3587), located about 2.5° southeast of the star Merak (*beta ursa majoris*) and approximately 11° south of Dubhe (*alpha ursa majoris*). The Owl Nebula, situated some 1600 light years from Earth, is remarkable in three respects [1, 37, 138]. First, it is one of the largest known planetary nebula, being nearly 3.5 light years in diameter (170"). Second, the multiple shell structure of the still expanding object is complicated and turbulent. Third, the shape of the nebula, nearly circular with two dark eye-like spots, is remarkably like that of a face (thus the appellation "owl"). It is believed that the nebula was initially formed about 6,000 years ago (ca. 4000 BC).

Leaving aside, form the moment, the puzzling issue of the mechanics of shell formation, the similarity of the images of Humbaba (Fig. 2) to that of telescopic photographs of the Owl Nebula [134: Fig. 47, 138: Fig. 26], is remarkable. The similarity is further illustrated by the striking similarity between Humbaba and a drawing of the Owl Nebula sketched in 1848 by William Parson, the 3rd Earl of Rosse. Given the strong documentary evidence for the appearance of a face-like, nova-like event in Ursa Major at around 2700 BC, and given the lack of other notable nebula, including supernova remnants, around the vicinity of the bucket of the Big Dipper, I suggest that the formation of the Owl Nebula is indeed the Chinese birth event of Huang Di, and therefore the event which inspired the creation of Seven Macaw in the Popul Vuh and Humbaba in the Gilgamesh epic.

Acceptance of this relationship, however, requires a satisfactory explanation for the rapid production of a naked eye visible gas shell of sufficient size, brightness, and duration (perhaps visible for 25 months) for people to see actual structures (e.g., dark spots and filaments) that might create the impression of a human face. The myths strongly suggest that the naked eye visible temporary object was comparable to or even larger than the size of the full Moon, and thus much larger than the image now seen through optical telescopes. While it is possible that these myths encode a nova-like event completely distinct from the Owl Nebula, the possibility that the myths encode an early eruptive episode in the evolution of the Owl Nebula itself is deserving of further investigation. I leave this puzzling but most intriguing mystery to my colleagues in astronomy and astrophysics.

Much less secure is the evidence for encodings of cosmic impacts in the myths dating to the 27th century BC. The vivid description of "unearthly shrieks and groans" during the cosmic battle between Chhih-Yu and Huang Di suggests the presence of bolides in conjunction with the presumed Taurid meteor storm(s), but clear evidence of actual ground-disturbing impacts is lacking in the myths used in my analysis. However, as previously noted, there is some suggestion of an oceanic or large lake cosmic impact at around 2650 BC, of substantially less magnitude than the Flood Comet impact of 2807 BC.

9. Celestial events of circa 2350-2000 BC

The period between 2650 BC and 2350 BC seems to lack definitive supernovae/bright novae and cosmic impacts, which may be one reason for the fact that there are few myths about rulers during this period, with the possible exception of Khufu and Khafre (the builders of the great pyramids of Giza). However, as with the myths discussed earlier for the period of 2700-2650 BC, the period of circa 2350-2000 BC witnessed spectacular temporary celestial events amenable to cosmographic study and comparison. I once again begin with descriptions in the Chinese Bamboo Annals [106].

China: Yao, Shun, and Yu

Yao, Shun, and Yu are among the most famous legendary rulers of ancient China, with the majority of extant myths relating to Shun and especially Yu rather than to Yao [18: 74]. According to standard chronology, Yao's reign began in 2357 BC, and lasted a full one hundred years. Yao was followed by Shun, who began his reign in 2255 BC, who in turn was followed by Yu in 2205 BC, the later who died in 2197 BC.

Yao, in typical fashion, had a miraculous birth, his mother purporting to have been impregnated by a red dragon. He was said to be of giant stature, and had the virtue of a sage. Among other things, he is credited for astronomical observations and for an elaborate system of canal works. Shun is likewise credited with a miraculous birth, being born with double eyes, and the countenance of a dragon with a large mouth and black body. Shun was chosen by Yao for succession over Yao's own son, and became famous for his good and humane governance. Yu's mother became pregnant after seeing a falling star go through the Pleiades. Yu was born from his mother's back, and he had a tigers nose and a large mouth. His head bore the resemblance of the stars *kou* (Sagittarius) and *ke'en* (cancer), while his breast resembled Ursa Major. Yu is best known for his success in stopping floods that were threatening all of China.

Notable events during the reigns of these three rulers include the following:

(1) Possible Terrestrial Cosmic Impact (ca. 2345 BC). In the 12th year of his reign (ca. 2345 BC), Yao meets the Divine Archer, Yi (*Shên-I*). According to myths assembled by Werner [199: 180-182]:

> "At this time terrible calamities began to lay waste the land. Ten suns appeared in the sky, the heat of which burnt up all the crops; dreadful storms uprooted trees and overturned houses; floods overspread the country. Near the Tung-t'ing Lake a serpent, a thousand feet longs, devoured human beings, and wild boars of enormous size did great damage in the eastern part of the kingdom. Yao order Shên I to go and slay the devils and monsters who were causing all this mischief, placing three hundred men at his service for that purpose. / Shên I took up his post on Mount Ch'ing Ch'iu to study the cause of the devastating storms, and found that these tempests were released by Fei Lien, the spirit of the Wind, who blew them out of a sack. As we shall see when considering the thunder myths, the ensuing conflict ended in Fei Zlien suing for mercy and swearing friendship to his victor, whereupon the storms ceased. / After this first victory Shên I led his troops to the banks of the Hsi Ho, West River, at Lin Shan. Here he discovered that on three neighboring peaks nine extraordinary birds were blowing out fire and thus forming nine new suns in the sky. Shên I shot nine arrows in succession, pierced the birds, and immediately the nine false suns resolved themselves into red clouds and melted away."

(2) Crater Supernova (ca. 2314 BC). A likely supernova appears in the constellation, "*I*" (Crater), perhaps lasting 14 months. [This event seems very similar to that encoded in point 5 below].

(3) Possible Oceanic or Lake Cosmic Impact(s) (ca. 2297-22 65 BC). Kwan (Gun) attempts to regulate the Ho river

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during a period of disastrous flooding (ca. 2295-2287 BC), but does not succeed. Kwan is then sacrificed. His son Yu, is born from Kwan in the shape of a dragon. Yu continues to battle the flooding and finally succeeds around 2265 BC.

(4) Crater Supernova or Nova (ca. 2286 BC). A supernova or nova appears in the constellation Crater. This event occurs during the first month of spring, at a time when the five planets look like "threaded pearls". A check with a software astronomy program (Redshift Multimedia Astronomy, version 1.2°, by Maris) indicates that at dawn on 25 March 2284 BC, four of the five naked eye visible planets (Mercury, Jupiter, Venus, Mars) were evenly spread out over a space of about 10° in the constellation Pisces, like threaded pearls; only Saturn was missing from this alignment.

(5) Scorpius Supernova or Nova (ca. 2254 BC). A "brilliant star" (presumably a nova or supernova) appears in the constellation Scorpius at the beginning of Shun's reign.

(6) Terrestrial Cosmic Impact (ca. 2240 BC). "Auspicious clouds" appeared during the reign of Shun. These auspicious clouds are described by the following note in the Bamboo Annals [106: 115-116]:

> "In the 14th year of Shun's reign, at a grand performance with bells, musical stones, organs, and flutes, before the service was concluded, there came a great storm of thunder and rain. A violent wind overthrew houses and tore up trees. The drumsticks and drums were scattered on the ground, and the bells and stones dashed about confusedly. The dancers fell prostrate, and the director of the music ran wildly away; but Shun keeping hold of the frames from which the bells and stones were suspended, laughed and said, 'How clear it is that the empire is not one mans empire! It is signified by these bells, stones, organs, and flutes.' On this he presented Yu to Heaven, and made him perform actions proper to the emperor; whereupon harmonious vapors responded on all sides and felicitous clouds were seen. They were like smoke, and yet not smoke; like clouds, and yet not clouds; brilliantly confused; twisting and whirling....When the essential brightness was exhausted, the clouds shriveled up and disappeared. Thereupon the eight winds all blew genially, and other felicitous clouds collected in masses [...] When the day declined, there came a fine and glorious light."

Mesoamerica: The Corn People

After the earlier described stories of the hero twins (the period of circa 2700-2650 BC), the Popul Vuh next describes a sequence of events relating to the early years of the people created from cornmeal, that is, modern humans [187]. These events appear to follow the same basic sequence identified in the Bamboo Annals. While direct allusions to cosmic impacts are difficult to interpret from this sequence and some of the matches with the Chinese myths are a bit tenuous, it at least suggests that myth cycles based on cosmic events witnessed in different parts of the world can be usefully compared.

(1) Crater Supernova (ca. 2314 BC) [187: 181]:

> "And here is the dawning and showing of the sun, moon, and stars. And Jaguar Quitze, Jaguar Night, Machucutah, and True Jaguar [the first of the modern humans] were overjoyed when they saw the daybringer. It came up first. It looked brilliant when it came up, since it was ahead of the sun."

(2) Possible Terrestrial Cosmic Impact (ca. 2345 BC) [187: 182]:

> "And then the face of the earth was dried out by the sun. The sun was like a person when he revealed himself. His face was hot, so he dried out the face of the earth. Before the sun came up it was soggy, and the face of the earth was muddy before the sun came up. And when the sun had risen just a short distance he was like a person, and his heat was unbearable. Since he revealed himself only when he was born, it was only his reflection that now remains. As they put it in their own words: 'The sun that shows itself is not the real sun.'"

(3) Possible Oceanic or Lake Cosmic Impact(s) (ca. 2297-2265 BC) [187: 187-188]:

> "And then comes the killing of the tribes. This is how they died: when there was just one person out walking, or just two wer out walking, it wasnt obvious when they took them away [...] The way was not clear [for people attempting to track and to kill the four heroes): It would get cloudy. It would get dark and rainy. It would get muddy, too. It would get misty and drizzly."

(4) Crater Supernova or Nova (ca. 2286 BC) [187: 189]:

> "First the tribes tried to plan the defeat of Tohil, Auilix, and Hacauitz. All the penitents and sacrificers of the tribes spoke to the others. They roused and summoned one another, all of them [...]. Let it be this way: if the fiery splendor of Tohil, Auilix, and Hacauitz is so great, then let this Tohil become our god! Let him be captured! Dont let them defeat us completely!"

(5) Terrestrial Cosmic Impact (ca. 2240 BC) [187: 197-198]:

> "We are going back to our own tribal place. Again it is the time of our Lord Deer, as is reflected in the sky. We have only to make our return. Our work has been done, our day has been completed. Since you know this, neither forget us nor put us aside. You have yet to see your own home and mountain, the place of your beginning. Let it be this way: you must go. Go see the place where we came from, were the words they spoke when they gave their advice. And then Jaguar Quitze left a sign of his being: This is for making request of me. I shall leave it with you. Here is your fiery splendor. I have completed my instructions, my counsel, he said when he left the sign of his being, the Bundle of Flames, as it is called. It wasnt clear just what it was; it was wound about with coverings. It was never unwrapped. Its sewing wasnt clear because no one looked on while it was being wrapped. In this way they left instructions, and then they disappeared from there on the mountain of Hacauitz. Their wives and children never saw them again. The nature of their disappearance was not clear. But whatever the case with their disappearance, their instructions were clear, and the bundle became precious to those who remained."

Mesopotamia: Destructions of Ur

The epic stories gathered thus far from Mesopotamia, the Near East, and Egypt do not exhibit meaningful chronological patterning, unlike those from China and Mesoamerica. This situation is likely simply the result of the archaeological record rather than the failure of Near Eastern cultures to recite epics in purposeful chronological order. Because of the lack of well defined chronological order, each story is here treated without reference to the numbering used for the Chinese myths.

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Standard chronology places the rise and height of Mesopotamias Agade empire at around 2340-2159 BC, followed by the Third Dynasty of Ur at around 2112-2004 BC [103: 44-56]. There is a seeming interruption in normal activities and polities both before and after the Third Dynasty of Ur, and perhaps just before the beginning of the Agade empire. The Agade or Akkadian empire included the reigns of Sargon and his two sons, Rimush and Naram-Sin. There is a sizable mythology surrounding Sargon and especially Naram-Sin, the later who was deified in his own lifetime. In several respects, the stories about Sargon and Naram-Sin parallel those of Yao, Shun, and Yu, suggesting contemporaneity between the two sets of rulers.

Of special note in the literature surrounding the Third Dynasty of Ur is a long lament of some 436 lines, which has been entitled by it translator Samuel Kramer as *Lamentation Over the Destruction of Ur*. The tablets upon which this work was imprinted come primarily from Nippur, and have been dated to the period between the fall of the Third Dynasty of Ur and the beginning of the Kassite period in Mesopotamia (ca. 2000-1600 BC). Although the tablets do not refer to a specific ruler by which to tie the events being depicted, it does refer to depredations by Elamites and Subarians (Assyrians), whom scholars have mistakingly believed were the primary causes of the destruction to Ur [98: 455-463]:

> "Enlil [powerful Sumerian deity sometimes referred to as raging storm and wild bull] called the storm; the people groan. The storm of overflow he carried off from the land; the people groan. The good storm he carried off from Sumer; the people groan. To the evil storm he issued directions; the people groan. To Kingaluda, the tender of the storm, he entrusted it. The storm that annihilates the land he called; the people groan. The evil winds he called; the people groan. Enlil brings Gibil [god of fire] to his aid. The great storm of heaven he called; the people groan. The land-annihilating storm roars below; the people groan. The evil wind, like the rushing torrent, cannot be restrained; the boats of the city it attacks (and) devours, At the base of heaven *it made the...whirl*; the people groan. In front of the storm *fires burned*; the people groan. To the battling storms was joined the scorching heat. [...] fires burned. The day *was deprived* of the rising of the bright sun, *of* the good *light*, in the land the bright sun rose not, like the evening star it shone. The night *was deprived by* the South Wind of *its customary feasts and banquets; at the side of their cups* dust was piled high; the people groan. [...] The destructive storm makes the land tremble and quake; Like the flood storm it destroys the cities. The storm ordered by Enlil in hate, the storm which wears away the land, covered Ur like a garment, *enveloped* it like linen.[...] Its people, not potsherds, filled its sides; its walls were breached; the people groan. In its lofty gates, where they were wont to promenade, dead bodies were lying about; in its boulevards, where the feasts were celebrated, *scattered they lay*. In all its streets, where they were wont to promenade, dead bodies were lying about; in its places, where the festivities of the land took place, the people lay in heaps. The blood of the land, like bronze and lead...its dead bodies, like fat placed in the sun, of themselves melted away....My houses of the outer city have been destroyed - 'alas for my city', I will say; my houses of the inner city verily have been destroyed - 'alas for my house', I will say....In the rivers of my city dust has gathered, into *fox-dens* verily they have been made; in their midst no sparkling waters flow, gone is its *riverworker*. In the fields of the city there is no grain, gone is its fieldworker, my fields verily like fields torn up by the pickaxe have brought forth....My palm groves and vineyards that abounded with honey and wine verily have brought forth the mountain thorn. My plain where the *kazallu* and *strong drink were prepared* verily like an oven has become parched. My possessions like *heavy locusts* on the move verily...*have been carried* off - 'O my possessions', I will say....Verily my (precious) metal, stone, and lapis lazuli have been scattered about - 'O my possessions', I will say....*Woe is me*, the city has been destroyed, the house too has been destroyed; O Nanna [Moon god and patron of Ur], the shrine of Ur has been destroyed, its people are dead."

Most aspects of this lament refer to the "storm" as originating in Heaven, separate from human influence. The fact that the spoils of the city, such as precious metal, stone, and lapus lazuli are described as laying scattered over the ground likewise appears to support a natural versus human agency for the cause of destruction. The lament likely describes a terrestrial cosmic impact and its devastating effects, as is evidenced by fires, hurricane-force winds, dust obscuration, and the destruction of the cities themselves. Several specific cities are mentioned in the lament as having been destroyed and/or abandoned (e.g., Nippur; Kish; Isin; Uruk; Ur, Eridu; Larak; Umma, Lagash). These cities occupy an area of the Sumerian plain covering about 17,000 km^2, indicating that the impact was of at least of substantive local nature.

The Lamentation Over the Destruction of Ur bears at least superficial resemblance to another lengthy text, similarly entitled *Lamentation Over the Destruction of Sumer and Ur* [99], suggesting that the two laments describe the same event or series of events. However, the second lament omits any discussion of heavenly fire or scorching winds as part of the destruction, and makes the curious implication that Ur was being destroyed for a second time by the Elamites. (The "first" time may coincide with the lamentation, *The Curse of Agade*, discussed below). This second Ur lamentation is also of considerable interest in that it strongly suggests that a human hand, the Gutians, the Elamites, and other "men of the mountain", played a major role in the destruction, although perhaps as scavengers rather than as the originators of the destructive storm itself.

The *Lamentation Over the Destruction of Sumer and Ur* refers specifically to events which took place during or immediately after the last ruler of the Third Dynasty of Ur, Ibbi-Sin, at or around 2000 BC [99]:

> "An [Sumerian sky god] has made the Sumerians tremble in their dwelling places, the people are terrified. Enlil has made the day break bitter, has struck the city dumb [...] Enki has deprived the Tigris (and) the Euphrates of water [...] on the Land fell a calamity, one unknown to man, one that had never been seen (before and) for which there were no words, one could not be withstood. On all the lands, the terrified, a disruptive hand was placed, in their cities their city-gods stood aside, the people, the terrified, could hardly breathe. The storm *fettered* them, it returns not the day to them, the 'returned day' that it obtained for them *came* not *as* a [...] day. Enlil, the shepherd of the blackheads [Sumerians], this is what he did - Enlil, in order to destroy the righteous houses, to decimate the righteous, to set an evil eye on the sons of the righteous, the noble - On that day Enlil brought down the Guti from the mountain; and, whose coming is the Flood of Enlil, that none can withstand. They filled the steppe with great winds of the steppe [...] They *laid waste* to the [steppe] (and) whatever *flourished* in it, none could travel there. The [...] in the dark, dark days, They *overwhelmed* readily the bright day with *tumult* [...] On that day Heaven was crushed, Earth was smitten, the face was *blinded by the*

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storm. Heaven was darkened, was overcast in shadow, it was turned into the nether world. Utu [Sun god] lay (motionless) on the horizon [...] Nanna [Moon goddess] lay in [...] was terrified. [Missing lines 87-93]. The...were piled up in heaps. The [...] were spread in heaps [...] In the Euphrates there were cadavers...are massacred [...] On Kazallu, the *awe-inspiring* city, a disruptive hand was placed [...] Its river has become empty, it poured no water. Like a river cursed by Enki, it came to an end at its source. In the field there was (neither) grain (nor) vegetation, the people had nothing to eat. Its orchards (and) gardens are parched like an oven, their *produce perished* [...] On that day the word - who knows its meaning? - attacked like a storm. The word of Enlil that winds to the right, *knows* the left. Enlil who decrees the fates, this is what he did: Enlil brought down Elam, the foe, from the mountain [...] On the bank of Idnun of Nanna a heavy arm was placed. The settlements of the Edanna of Nanna were destroyed like a distended stall. Those who fled from it were devoured by the wild beasts like fleeing kids [...] In Ur, no one took charge of food, no one took charge of water. Who was (formerly) in charge of food, stood away from the food, pays no *heed* to it. Who was (formerly) in charge of water, stood away from the water, pays no *heed* to it. Below, the Elamites are in charge, slaughter follows in their wake. Above, the Halma-people , the men of the mountains, took captives. The Tidnumites daily fastened the mace to their loins. Below, the Elamites, like those who bring forth woe, *brandish* their *weapons*. Above, like chaff blown about by the wind, the steppe [...] Zur, the great wild ox that (formerly) stepped forth confidently (in combat), has been made prostrate. Enlil, he who decrees the fates, this what [he did]: For a second time he brought down the Elamites, the men of the mountain from the mountain."

This second Ur lament, in its suggestion of strong winds and "dark, dark days" evokes the effects of a distant terrestrial impact, perhaps that of the Rio Cuarto impact in far away Argentina. If this is indeed the case, then the devastating drought noted in the text may be due to the disruptive effects on climate of the Rio Cuarto impact.

There is yet a third text which invokes the desstruction of cities in Mesopotamia. This is *The Curse of Agade* whose tablets date to the 18th century BC [100: 646-651]. This text is of interest for several reasons. First, it specifically links one period of widespread destruction in Mesopotamia to sometime during the reign of Naram-Sin, grandson of Sargon and fourth king of the Agade Dynasty. Standard dating [144: 199] places his reign at around 2254-2218 BC. Second, *The Curse of Agade* invokes the Gutians as at least partial causative agents for the destruction of Agade, thus lending a new dimension to the second Ur lament which states that the Gutians had ransacked Mesopotamian cities at least once prior to the destruction of Ur at around 2000 BC.

Yet another interesting aspect to *The Curse of Agade* is that the first nine lines of text provide some context for Sargons rise to power [100: 647]:

> "After the frowning forehead of Enlil had killed (the people of) Kish like the 'Bull of Heaven', after he had ground the house of Erech into dust, like a giant bull, after in due time, to Sargon the king of Agade, from below to above, Enlil had given him lordship and kingship, then did holy Ianna, the shrine of Agade, erect as her nobel chamber, in Ulmash did she set up a throne."

The imagery of this passage lends some support for the reality of a cosmic impact at around 2345 BC. Given the association of Enlil with the snake-dragon, given his attribute of being the "raging storm", and coupling these with the "other gods not being able to look upon his splendor" [19: 166], the "frowning forehead of Enlil" invokes an image possibly that of an impact fireball. Also of significance is the phrase "Bull of Heaven" which suggests an association with the Taurid meteor showers, or at least with a meteor shower not unlike the Taurids.

The remainder of the text of the *The Curse of Agade* conveys little imagery suggestive of cosmic impact. Therefore although the reign of Naram-sin presumably brackets the Chinese impact of circa 2240 BC., *The Curse of Agade* seemingly cannot be used to lend support to the Chinese data.

Ancient Palestine: The Destruction of Sodom and Gomorrah

One of the most poignant passages of the Bible (Revised Standard Version) is that in Genesis 19 which describes the fiery destruction of the cities of the Vale of Siddim: Sodom, Gomorrah, Admah, and Zeboiim; a fifth city in the vale, Zoar, was spared so as to provide sanctuary for Lot and his daughters:

> "Then the Lord rained on Sodom and Gomorrah brimstone and fire from the Lord out of heaven; and he overthrew those cities, and all the valley, and all the inhabitants of the cities, and what grew on the ground [...] And Abraham went early in the morning (24 hours later according to the JPS Torah Commentary [167: 139]) to the place where he had stood before the Lord; and he looked down toward Sodom and Gomorrah and toward all the land of the valley, and beheld, and lo, the smoke of the land went up like the smoke of a furnace."

The Jewish historian, Flavius Josephus, writing in the 1st century AD, describes this event as follows [94, I: 38-39]:

> "God then cast a thunderbolt upon the city, and set it on fire, with its inhabitants; and laid waste the country with the like burning [...] Now he and his daughters fled to a certain small place, encompassed with the fire, and settled in it: it is to this day called *Zoar*, for that is the word which the Hebrews use for a *small thing*. There it was that he lived a miserable life, on account of his having no company, and his want of provisions."

Elsewhere, Josephus makes the following comments based on his own visit to the area [94, IV: 130]:

> "The country of Sodom [...] was of old a most happy land, both for the fruits it bore and the riches of its cities, although it be now all burnt up. It is related how, for the impiety of its inhabitants, it was burnt by lightning; in consequence of which there are still the remainder of that divine fire, and the traces [or shadows] of the five cities are still to be seen."

Josephus also refers to the destructions as having been caused by thunder [94, IV: 269].

It appears from these passages that the Sodom and Gomorrah story encodes the observation of a terrestrial cosmic impact event not unlike that recorded for the Rio Cuarto and Broken Bow impacts and for the 1908 Tunguska impact. The gross magnitude of the event can be estimated from the story line. The impact was seemingly more energetic than

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Tunguska, perhaps similar to that of Broken Bow, and clearly less substantial than Rio Cuarto. This is based on the presumption of the complete destruction of four or five cities and surrounding fields and other plant life in a single valley; burning lasting at least into the next day; the hiding in a cave; and the failure of regional populations to reoccupy the impact region, the location of which could still be identified two thousand years later.

Although the cosmic impact signature is manifest, what is not clear is the date of the impact event and the exact location of the impact. The impact occurred during the life of Abraham, which has been variously dated to between about 2300 and 1800 BC. Standard biblical chronology based on Bishop Ussher's genealogical date of 2348 BC for Noah's Flood, would place the birth of Abraham in the year 2056 BC, and would place the actual destruction of Sodom and Gomorrah in 1957 BC. And while most scholars believe the Vale of Siddim and the cities of Sodom and Gomorrah included the region around the southeastern portion of the Dead Sea, Pellegrino [154] and presumably others have suggested instead that the fertile plains of the Tigris and Euphrates rivers were the site of the doomed cities.

Additional details and potential resolution to these questions are provided in the remarkable collection of Jewish oral history gathered by Louis Ginzberg [69] at the beginning of this century. The first clue is the association of the birth of Abraham (Abram) with the sudden appearance of a bright new star while his father served in the court of Nimrod. If we accept the logic of a number of scholars that Nimrod was in fact the famous historical Naram-Sin, fourth king of the dynasty of Akkad in Mesopotamia, this would place Abraham in the middle of the 23rd century BC according to standard chronology [144].

We know from the Chinese Bamboo Annals that in the 42nd year of the reign of emperor Yao (ca. 2315 BC according to standard chronology), a likely brilliant supernova occurred in the constellation Crater; likewise, another supernova or nova event occurred in the constellation Scorpius in the 1st year of the reign of emperor Shun (ca. 2255 BC according to standard chronology). These are the only new stars unambiguously mentioned in the extant Chinese records between the reign of Huang Di (ca. 2357 BC) and that toward the end of Zhou Dynasty in approximately 532 BC, with the exception of a possible nova in Scorpius recorded on oracle bones from the Shang Dynasty in the 14th or 13th century BC [39, 141]. While there were surely other significant naked eye novae and supernovae between 2650 BC and 532 BC, we can assume that the three noted in the 24th and 23rd century BC were of special character and are likely candidates for the birth star of Abraham. This would then suggest that the destruction of Sodom and Gomorrah, which allegedly occurred in the 99th year of Abrahams life, took place during the period of around 2216 BC to 2156 BC. Given the emphasis by the Chinese on the supernova or nova-like event of circa 2287 BC, which occurred at the time of the ascension of Emperor Shun to power, the most likely date for the Sodom and Gomorrah impact would be that of circa 2188 BC.

Egypt: End of the Old Kingdom

I have not yet been able to perform a detailed analysis of Egyptian myth and archaeology during the period of 2350 BC to 2000 BC. However, it is noteworthy that according to standard chronology [96] the beginning of this period of time, 2350 BC, marks the transition between the Fifth and Sixth Dynasties, and that the weak Seventh and Eighth Dynasties and the turbulent First Intermediate Period follow shortly after 2200 BC and reach their conclusion at around 2000 B.C. Thus the dates of 2350 BC, 2200 BC, and 2000 BC represent times of substantive change in Egypt.

It is also of interest that after the steller orientation of Third dynasty architecture and cosmology and the subsequent change to more solar emphasis with the Fourth and Fifth Dynasties, with the development of the Pyramid Texts at the time of King Unas at the end of the Fifth Dynasty there is again a return to stellar imagery. This steller imagery persists throughout the Sixth Dynasty. It is my belief that this reorientation towards stars reflects first the hypothesized cosmic impact at around 2345 BC, and then the three subsequent supernovae or novae-like events in Crater and Scorpius noted in the Bamboo Annals between 2314-2254 BC.

One of the utterances in the tomb of Unas may even reflect the cosmic impact of circa 2345 BC. The beginning of utterances 273-274 ("The King Feeds on the Gods") is very suggestive in its imagery [110: 36], and invokes aspects of the earlier noted tale of Yi, the Divine Archer:

> "Sky rains, stars darken, the vault s quiver, earth's bones tremble, the planets stand still at seeing Unas rise as power, a god who lives on his fathers, who feeds on his mothers! Unas is master of cunning whose mother knows not his name; Unas's glory is in heave, his power is in lightland; Like Atum, his father, his begetter, though his son, he is stronger than he! The forces of Unas are behind him, his helpers are under his feet, his gods on his head, his serpents on his brow, Unas's lead-serpent is on his brow, soul-searcher whose flame consumes, Unas's neck is in its place. Unas is the bull of heaven who rages in his heart, who lives on the being of every god, who eats their entrails when they come, their bodies full of magic from the Isle of Flame [...] Unas eats their magic, swallows their spirits: Their big ones are for his morning meal, their middle ones are for his evening meal, their little ones for his night meal, and the oldest males and females for his fuel. The Great Ones in the northern sky light him fire for the kettles' contents with the old ones' thighs, for the sky-dweller serve Unas, and the pots are scraped for him with their womens legs [...] Unas has risen again in heaven, he is crowned as lord of lightland [...]."

There is one other interesting Egyptian text that although written in the Nineteenth or Twentieth Dynasty (1295-1069 BC, according to Kitchen [96], may reflect the period of 2350-2000 BC. I suspect, however, that the text can also equally as well reflect the Second Intermediate Period at the time of the Hyksos This is the text referred to as *The Admonitions of Ipu-wer* [207: 441-44, 110: 149-163]. This text is in the same genre as the second Ur lamentation and especially *The Curse of Agade*. While there is nothing that specifically encodes a cosmic impact, it is clear that Egypt is undergoing at least some form of social disruption. Unlike the views of Lichtheim [110: 149-150], I see no reason to assume that the text is literary propaganda or ahistorical in content. Based on my cosmographic researches, the text represents an individual's (Ipu-wer) view of the state of his society at some point between 2350-1550 BC.

Evaluation of the 2350-2000 BC cosmic impacts

In each case presented above, that of the destruction of Ur (especially the first lament), the destruction of Sodom and Gomorrah, and the great windstorm witnessed by Chinese emperor Shun, the mythic story line is indicative of a cosmic impact. The question then becomes: How many impacts? - when? - where? - and of what magnitude?

The impact witnessed by Shun (ca. 2240 BC) appears most

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similar in magnitude and effect to the Tunguska impact described above, a distant impact as witnessed several hundred km from the impact site itself. It does not seem likely that this impact is directly connected with the Ur or the Sodom and Gomorrah impacts (which would imply a regional impact significantly larger than that of Rio Cuarto, for which there is no good evidence based on the lack of recognizable craters), unless as part of a single swarm of Tunguska-like meteorites with multiple impacts. The lack of definable cosmic impact language (other than that for Sargon) in *The Curse of Agade* reinforces the limited nature of the circa 2240 BC impact.

The Ur impact (of the first lament) and the Sodom and Gomorrah impact describe the direct effects of terrestrial impacts, but there is ambiguity about both the dating and the magnitude of the events. If we assume that the birth of Abraham did coincide with one of the bright nova/supernova events in the Bamboo Annals, and if we assume that Abraham was indeed 99 years old at the time of the destruction of Sodom and Gomorrah, then this event took place at around 2215 BC, 2188 BC, or 2155 BC, with the 2188 BC date being most likely given the great significance given by the Chinese to the supernova or nova-like event of circa 2287 BC in the 70th year of the reign of Emperor Yao.

Using the standard "middle" chronology for Mesopotamia, the date of the impact of the second Sumer and Ur lament would have occurred at around 2000 BC, at the end of the reign of Ibbi-Sin. As previously noted, there are enough differences between the two laments to suggest that two different impacts are represented. The first impact may be the same as that described for Sodom and Gomorrah, which in keeping with the logic of Pellegrino [154] who has argued that Sodom and Gomorrah, in actuality, are referents to cities on the Mesopotamian plain. The archaeological evidence for widespread destruction layers at around 2300 BC discussed by Peiser (this volume), suggests that a cosmic impact may have been a factor, a date which fits well with the estimate of 2188 BC for the Sodom and Gomorrah impact and possibly with the impact described in the first Ur lament.

However, a date of around 2345 BC is also possible for the first Ur lament, since it cannot be directly ascertained from the list of destroyed cities that what was destroyed represented either the Agade Empire or that of Dynasty III at Ur. This dating then raises the specter that the reference in the Bamboo Annals (the story of Archer Yi killing the nine suns) to a brief period of "intense heat" and abnormal solar activity at around 2345 BC, is the product of a cosmic impact rather than some kind of unusual solar activity. A clay plaque from the Mesopotamian city of Khafajah depicts a god armed with a bow and a knife killing a fiery cyclops [144: Fig. 36], possibly alludes to this same story.

In sum, the period of 2350-2000 BC witnessed at least four cosmic impacts (ca. BC 2345, 2240, 2188, 2000), and perhaps a fifth (ca. BC 2297-2265). The circa 2000 BC event is linked with that of the large regional terrestrial cosmic impact at Rio Cuarto, Argentia.

The circa 2345 BC destructive layers throughout much of the Near East and Mesopotamia are arguably the result of a large local or regional cosmic impact. The lack of a known crater associated with this hypothesized regional impact is admittedly disturbing, with one possible explanation being that the impact occurred in or next to a body of water, such as a large lake (e.g., the Dead Sea, Lake Baikal), or the edge of an ocean (e.g., Red Sea, Persian Gulf, the Mediterranean Sea) which has helped to hide the crater. Alternatively, a crater could be hidden by sand, such as was the case for the Wabar crater in Saudia Arabia [85: 118-119]. Another possibility is that rather than a single impact, the circa 2345 BC event was the product of a swarm of Tunguska-like impacts such as modeled by Clube and Napier [43] and other advocates of coherent catastrophism.

The event of circa 2240 BC is likely a local terrestrial cosmic impact restricted to Asia, while the circa 2188 BC event is seemingly a local terrestrial cosmic impact near the southeastern shores of the Dead Sea.

The circa 2297-2265 BC event is the least well documented of the five hypothesized cosmic events and may represent an oceanic (or large lake) cosmic impact in the vicinity of Southeast Asia. An example of the mythology associated with this lengthy period of "flooding" is as follows [212: 98]:

> "The regulation of the rivers was fraught with dangers and setbacks. One year Yu and his people were working in Ba Zhu at the foot of Wushan Mountain (now in Sichuan Province). They were cutting trees and digging the earth when a sudden violent strom blew up. Black clouds darkened the sky, rocks flew through the air on heavy winds, the very cliffs and mountains trembled. Rough waves blew up like hills, and Yu's people scattered out of the way of disaster like autumn leaves. Powerful as he was, Yu could not control the storm."

Perhaps rather than flooding caused by cosmic impact, these stories simply reflect a lengthy period of unusual weather events and conditions caused by factors similar to those producing El Niño and similar climatic perturbations. However, there are enough tantalizing images so as to not be able to entirely rule out one or more oceanic/large lake cosmic impacts, such as the presence in some stories of Kung Kung (who represented the Flood Comet impactor of 2807 BC), and the fact that Yu had a miraculous birth in which he was born in the shape of a dragon.

10. Cosmic impacts of circa 1800 BC

The *Bamboo Annals* and other Chinese sources suggest that several striking celestial and environmental events occurred during the reign of Jie, the last emperor of the Xia Dynasty. Standard chronology indicates that this reign occurred between 1818-1766 BC, although the Bamboo Annals indicates a reign of 31 years for Jie rather than the 52 years of the standard chronology. Of interest are three passages in the *Bamboo Annals* [106: 125-127]. The first reads:

> "In his 10th year, the five planets went out of their courses. In the night, stars fell like rain. The earth shook. The E [I river] and Loh [Lo river] became dry."

"Stars falling like rain" is an apt description of a great meteor storm. Unfortunately, there is not enough detail (e.g., month, constellation, season) provided to suggest a particular meteor shower. The earthquake associated with the meteor storm may be indiciative of meteorite or even larger cosmic impact. The description of the five planets going out of their courses is odd. We do know that the period of 1794-1793 BC witnessed an unusual triple conjunction of Jupiter and Saturn in the constellation Leo, near Regulus, and that four of the five planets were in Leo just prior to summer solstice in 1793 BC (Multimedia Astronomy Redshift version 1.2°, by Maris). Since the constellation Leo is representative of a lion in Mesopotamian astronomy [3, 70], the presence of conjunctions or other unusual celestial events in and around Leo may have played a role in the prevalence of lions and griffins displayed on cylinder seals [44].

The second passage reads: "In his 29th year, the forces of Shang took Koo. Three Suns appeared together". Yuan Ke

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[212: 136] describes this event as follows:

> "One of King Jie's trusted followers was a man called Fei Chang. One day as he was strolling on the bank of the Yellow River, he noticed two suns in the sky, one rising brilliantly in the east amid coloured clouds, the other setting into a grey mist in the west. Terrible thunder echoed from the heavens, and Fei Chang was deeply troubled by the strange power of these signs. He thought to himself, 'There cannot be two suns in the sky; the people cannot be governed by two monarchs.'"

The third passage reads:

> "In his 31st year, Shang proceeded by way of Orh against the capital of [Xia]; and overcame [King Jie]. Amid great thunder and rain a battle was fought in Ming t'eaou, when the army of [Xia] was defeated."

The speech of King Cheng Tang, who ousted King Jie and founded the Shang Dynasty , is recorded in the *Shu Ching* or Book of History [107: 186-187]:

> "The way of Heaven is to bless the good and to punish the bad. It sent down calamities on the House of [Xia], to make manifest its crimes. Therefore, I, the little child, charged with the decree of Heaven and its bright terrors, did not dare to forgive the criminal."

While the above descriptions are not nearly so convincing as those for the 2350-2000 BC period, it is possible that "Heavens calamities and bright terrors" may describe, among other things, a Tunguska-like impact. Unfortunately, the Egyptian and Mesopotamian literature appear silent in this regard. However, it is of interest that the period of ca. 1800-1750 BC is a time of considerable flux in Egyptian history (the end of the Twelfth Dynasty and the start of the Second Intermediate period), and in the Near East (the rise of the Hittite kingdom), as is also the case for China.

The one possible allusion to this hypothetical impact event outside of China is that of a fragmentary Hittite myth [71: 120], which is suggestive of an oceanic or large lake impact:

> "The Moon-god [...] fell down from heaven. He fell upon the *kilamma.* But no one saw him. The Storm-god [...] sent rain after him, he sent rainstorms after him so that fear seized him. [...] The storm-god [...] saw him and he sent rain after him, he sent rainstorms after him, he sent the winds after him so that fear seized him (and) fright seized him."

Unfortunately, the text does not specify a particular ruler or other chronological referent by which to approximate a date for the presumed impact, although it is from an archaeological context suggesting sometime between 1800 and 1200 BC Also in possible support of an oceanic or large lake impact at around 1800 BC is the fact that once impressive cities in the Indo-Iranian borderlands, such as Mohenjo-daro, suffered one or more devastating floods at or shortly before this time. These flood events apparently led to the dissolution of the once fluorescing Harrapan culture [150: 24].

11. Other potential cosmic impacts and volcanic eruptions

With the exception of the mythology of the Flood Comet impact, which is detailed elsewhere [125], the texts discussed above provide the clearest depictions of cosmic impact events. Nevertheless, it is possible that even rather innocuous-seeming statements about unusual weather or atmospheric conditions in traditional histories may relate to cosmic impact effects.

For example, several passages in the *Chinese Spring and Autumn Annals* (*Ch'un ch'iu*) and the *Bamboo Annals* (*Chu-shu chi-nien*) describe the Milky Way and other celestial objects as being invisible at midnight on cloudless nights. I strongly suspect that this statement refers to the curious atmospheric effect describe above for the Tunguska impact. In a similar vein, it is stated for Shang Dynasty King, Wu Yi, in the Bamboo Annals that around 1200 B.C. (According to standard chronology) that Wu Yi [106: 138]: " [...] was hunting between the Ho and the Wei [rivers], when he was frightened to death by a great thunderstorm." Wu Yi's curious death could be attributable to the effects of a distant Tunguska-like impact event.

It is important to emphasize that not every description of spectacular temporary celestial events in mythology is necessarily an encoding of a cosmic impact event. For example, several of the authors in this volume have highlighted the period of 1200-1000 BC as having witnessed catastrophic destruction throughout much of the Near East. Because of striking celestial phenomena described in Chinese and Biblical sources for this time period, I assumed that at least some of the destruction observed during this period was due to cosmic impact.

I early on thought that the famous battle (ca. 1122 BC.) between Chou Wang (Chou Hsin), last emperor of the Shang Dynasty, and Wu Wang, founder of the Zhou (Chou) Dynasty, wold contain evidence for impact events (still a remote possibility). During this epic battle, the forces of the tyrannical Chou Wang were routed at the Huang Ho river. Allegedly Chou Wang returned to his pleasure palace, built a huge funeral pyre on one of its terraces, and immolated himself.

The main reason for my interest in this battle was the fact that there is a rich mythology about a mighty cosmic battle taking place at the same time as the Earthly battle. Wu Wang and Chou Hsian employed the aid of legions of supernatural and celestial spirits [194: 123-125]:

> "Li No-cha overcame the soldier-immortal Feng-lin by means of a Heaven-Earth bracelet. The soldier called on his superior, Chang Kuei-fang to assist him, but Li No-cha mounted his Wind-Fire wheel, on which he could travel about at rapid speed. Although Li No-cha heard his name called out three times, he continued to fight, and eventually broke Chang Kuei-fang's arm with his Heaven-Earth bracelet. [...] / On arriving at K'un Lun, he [Chian Tzu-ya] made his way to the Jade Palace, and was presented to Yüan-shih. The Old Man of the South Pole [ruling deity of the Star of Longevity] gave him a list of Promotions to Immortality, and was told to erect a Spirit Terrace to display the list of honored names....Shen Kung-pao also tried to coax Chiang Tzu-ya into giving up the list of Promotions to Immortality. When Chiang Tzu-ya resisted, Shen Lung-pao offered to wager his magical skills against those of Chiang Tzu-y, telling the general that he could take off his head and cause it to float through space [...] Shen Kung-pao took his sword and cut off his own head, and threw it into the air. Fortunately, the Old Man of the South Pole had been keeping a careful watch, and seeing that Chiang Tzu-ya was about to lose the vital document, sent the White Crane Youth, Pai-ho T'ung-tzu to carry off the head....[T]he Old Man of the South Pole challenged Chang Shao, who tried to destroy him with hot sand. The venerable immortal easily encountered the attack with his seven-feathered fan, and was unharmed, while the attacker was swiftly dispatched by the White

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Crane Youth's jade scepter."

It is likely that large near-Earth comets and novae/supernovae, are represented in this story, but there are no clear indications of actual impact events. Likewise, the documentary record strongly implicates the hand of real armies in the 1200-1000 B.C. destruction in the Near East, rather than supernatural (i.e., cosmic) forces [55, 103].

Nevertheless, it is curious that the hypothetical cosmic battle around 1122 BC would create such a large body of myths in Chinese literature, as well as being the presumed subject matter of other great epics dating from this approximate time period, including the Sanskrit poem *Mahabhaata*, and the Homerian epics of the Iliad and the Odyssey. Because there is such a great literature on presumably this same set of celestial events, detailed cosmographic analysis should provide at least partial reconstruction of the temporary celestial events themselves. It may well prove once this analysis is done that bolides and/or Tunguska-like events may have played a role in the seemingly spectacular nature of these celestial events.

Future cosmographic analyses of many basic mythological motifs, such as the battles or adventures of supernatural hero twins or pairs, should tell us much about spectacular celestial phenomena and events that have been observed for countless millennia. In the specific case of twins or pairs, I suspect that at least some of these epics may shed light on the history of our encounters with giant and/or fragmenting comets. Biblical statements such as "Enoch walked with God; and he was not for God took him" (Genesis 5:24, RSV) and related texts such as the Enochic Book of the Giants [59], the pseudepigraphal Books of Enoch [35], and the legends compiled by Ginzberg [69] are replete with imagery suggestive of the observation of giant comets and other celestial objects and phenomena.

Once we have completed such analysis, we should have an improved understanding about much of what has been mysterious in the past. For example, curious images of the late 4th millennium BC from the Temple of the Eyes at Tell Brak (Figure 5), are obvious representations of tailed comets, and are strikingly similar to Hawaiian wooden image depictions of comets. Some of these images have multiple or paired eyes suggesting paired or fragmenting comets. This may also be the inspiration for multiple-eyed or multiple-faced deities (e.g, the Roman god of gates, Janus), demigods, and culture heroes. For example, the *Bamboo Annals* describe several of the legendary early rulers as having multiple eyes, pupils, and faces. However, at least some of this symbolism, such as that with Janus, may simply reflect cardinal directions or the path of the Sun.

The volcanic destruction of Thera Island

Returning to the topic of the nature of environmental events encoded in mythology, it is important to emphasize that not every description of a major environmental catastrophe in mythology is necessarily an encoding of a cosmic event. For example, those familiar with the descriptions and photographs of the 1980 eruption of Mount St. Helens and the 1991 eruption of Mount Pinatubo should appreciate the eruption encoded in the following passage from Hesiod's *Theogony* [23: 76-77]. Contained in this passage are all the elements of a massive volcanic eruption on an oceanic island: The hiss and roar of billowing clouds of steam; the roar of snake-like jets of dark ash; the whistling of incendiary volcanic bombs; the terrifying deadly rush of pyroclastic flows (nuée ardente); earthquakes; violent tsunami; dazzling electrical storms triggered by the uplifting and wide spreading ash column; the eerie glow of magma spilling out the bowels of the Earth; forest fires sparked by magma, pyroclastic flows, and incendiary bombs; and finally, the eventual destruction and subsidence of much of the island itself. This passage is given in its entirety so as to better distinguish the mythology of violent eruption from that encoding the effects of cosmic impact catastrophe:

> "After Zeus had driven the Titans from the sky, monstrous Earth gave birth to her youngest child Typhoeus [Typhon], after being united in love by golden Aphrodite with Tartarus [a Hell-like region of the underworld]. Typhoeus is a god of strength: there is force in his active hands and his feet never tire. A hundred snake heads grew from the shoulders of this terrible dragon, with black tongues flickering and fire flashing from the eyes under the brows of the prodigious heads. And in each of those terrible heads there were voices beyond description: they uttered every kind of sound; sometimes they spoke the language of the gods; sometime they made the bellowing noise of a proud and raging bull, or the noise of a lion relentless and strong, or strange noises like dogs; sometimes there was a hiss, and the high mountains re-echoed. The day of his birth would have seen the disaster of his becoming the ruler of men and gods, if their great father [Zeus] had not been quick to perceive the danger. He thundered hard and strong, so that Earth and broad Sky above, Sea and Ocean-streams, and the Tartarus region below the earth, all rumbled with the awful sound. Great Olympus quaked under the divine feet of its royal master as he rose up, and the earth groaned also. The heat from both sides, from the thunder and lightning of Zeus and from the fiery monster, penetrated the violet deep and made the whole earth and sky and sea boil. The clash of those immortal being made the long waves rage round the shores, round and about, starting a convulsion that would not stop. Trembling seized Hades, king of the dead in the underworld, and the Titans who stood by the Cronus and who live at the bottom of Tartarus. When Zeus' energy had risen to the peak, he took his weapons, thunder and lightning and the smoking thunderbolt, and jumped on his antagonist from Olympus and struck. He blasted all those prodigious heads of the terrible monster and dealt him a flogging until he was tamed. Typhoeus fell down crippled, and the monstrous earth groaned underneath. Flame streamed from the once powerful potentate, now struck by lightning, in the dim clefts of the rocky mountain where he fell. Large tracts of the monstrous earth were set on fire by the prodigious heat and melted like tin heated in moulded crucibles by skillful workmen, or like iron, the strongest metal, softened by the heat of fire in some mountain-cleft; even so did the earth melt in the flame of the fire then kindled. Zeus, in the bitterness of his anger, threw him into the abyss of Tartarus."

That this powerful myth encodes a cataclysmic volcanic eruption is nothing new and has been deduced by a number of other scholars [72], some of whom even link the tale specifically to the regionally catastrophic Bronze Age eruption of the Santorin stratovolcano on Thera island in the Aegean Sea [112, 154, 192]. There are several reasons to associate Typhon with the destruction of Thera.

The imagery of the Typhon myth closely reflects what we know and can reconstruct about the Santorin eruption, including the devastating nature of tsunami associated with the eruption [154: 207-231]. Second, the relative placement of this myth in alleged chronologically ordered cosmographic compendia such as Hesiod's *Theogony* and Ovid's *Metamorphoses* is between the Flood (2807 B.C.) and the fall of Troy (12th century BC. This can be further refined by linking the myth of Yi the Divine Archer shooting nine of ten suns from the sky in 2345 BC, with that of the disastrous sun-chariot ride and fall from the sky by Phaeton, an event

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which occurred prior to the appearance of Typhon in *Metamorphoses* [133]. The destruction of Thera in the 17th or 16th centuries BC seemingly represents the largest eruptive event in the Mediterranean during the Middle and Late Bronze Age, matching the image of Typhon as "the largest monster ever born" [72]. Also of interest in later versions of the Typhon story [72: 134] is reference to Zeus placing northeastern Sicily's Mount Etna (Aetna) on top of Typhon so that he cannot escape. This allusion may take on meaning in that evidence suggests that while Mount Etna first erupted some 2.5 million years ago, the present eruptive cycle for Mount Etna began around 1500 BC, with some 150 recorded eruptions since then to the present [50: 258]. I suspect that part of the purpose of the Mount Etna portion of the Typhon story is to formally transfer the role of "mightiest volcano" from Santorin to Mount Etna (the highest active volcano in Europe) after the destruction of Thera island and the beginning of the most recent eruptive cycle of Mount Etna around 1500 BC.

Also, it is of some note that in some versions of the myth [133: 109] the Olympian gods flee into Egypt to escape Typhon's wrath, a situation that Graves [72] sanguinely suggests represents the flight of frightened priests and priestesses from the path of the eruption and ash fall. This general time frame is unquestionably tied to the *Hyksos* period of Egypt during the Second Intermediate Period (Thirteenth Dynasty through the Seventeenth Dynasty), with a beginning date of around 1786-1720 BC to an ending date of about 1550 BC [96, 103]. The Hyksos period is presumed to represent the intrusion into Egypt of possibly Semitic peoples from the Levant and elsewhere [103: 173-182], who actually acceded to the kingship of Egypt (the "Shepherd Kings" so-called by Manetho).

Of particular interest in this regard is a passage from the historian Manetho (as cited by Josephus), dating from the reign of an obscure Egyptian king "Tutimaeus" during the Second Intermediate Period. This passage appears to allude to the Santorin eruption and to the movement of peoples in its wake [193: 79]:

> "Tutimaeus. In his reign, for what cause I know not, a blast of God smote us; and unexpectedly, from the regions of the East, invaders of obscure race marched in confidence of victory against our land."

I am especially struck by the name Tutimaeus, which other translations have recorded as "Timaus" [94, IV: 425). The similarity between this name and Plato's *Timaeus* of the infamous Atlantis dialogue is most intriguing. This possible etiological relationship is even made more intriguing by the fact that Plato's *Timaeus* is an unknown personage who does not appear in any other of his dialogues [108: 450-451]. I expect that future more detailed cosmographic analyses will eventually convincingly couple the Atlantis myth with the destruction of Thera island by Santorin volcano.

Further discussion of these issues and this general time period lie beyond the scope of this paper. My preliminary cosmographic researches indicate that there is great potential for the reconciliation of regional chronologies. For example, the seven year-long famine detailed in the Biblical story of Joseph (Genesis 41-47, R.S.V.) is seemingly related to a similar seven-year drought recorded in the Bamboo Annals during the reign of Shang Dynasty emperor Tang [106: 129]. The date for the drought in China is around 1746-1739 BC according to standard chronology. Likewise, my data generally agree with a late 17th century BC date for the cataclysmic destruction of Thera island. However, there are other events, perhaps including cosmic impacts and/or other eruptions, likely taking place during the period of about 1800 to 1500 BC, thus confounding our understanding. We have much still to learn about this most interesting time period.

12. Giant comets, the Taurids, and coherent catastrophism

Clube and Napier [42, 43] have long pointed out the potential danger to Earth posed by large comets and their debris streams, singling out especially the Taurid meteor streams as a potential hazard. In collaboration with their colleagues [5, 11] they have created the concept of *coherent catastrophism* in which the periodic but regularized disintegration of giant comets (comets whose initial diameters exceed about 100 km) poses a particular threat to planets in the inner Solar System, including Earth. This disintegration process is modeled as taking place over the course of about 20,000 years on the average for each giant comet.

In order to provide support for their model, they have focused on the history of the Taurid meteor streams and likely related objects (e.g., Comet Encke and a number of other Earth-crossing objects). It is their belief that these objects and debris streams represent a late stage in the disintegration of a Taurid giant progenitor comet, and that some known historic impacts are related to the Taurid meteor streams, including the 1908 Tunguska impact.

While my cosmographic research has not yet exhaustively focused on the topic of coherent catastrophism, the general data collected so far do, in fact, provide some support for the reality of giant comets (as defined above) and the historic importance of the Taurid meteor streams. It is noted that the Taurids are composed of a double radiant, the northern of which drifts westward adjacent to the Pleiades and the southern which drifts westward through the Hyades [21]. The Earth passes through these debris streams twice a year, with activity peaks currently in early November and at the end of June.

Various cultures worldwide, but especially in Australia and in North and South America, connect the Pleaides with the origin of fire [66], including the fact that the Pleiades is considered an actual representation of a fire drill. The imagery surrounding the Pleiades and the origin of fire is that of a great meteor storm. I rather expect that the previously described stories from the Popul Vuh and from the Gilgamesh epic (and possibly the Bamboo Annals) encode the first-ever Taurid event, or at least a very early episode of the Taurids. Curiously, a Nahuatl myth states that this event happened in the second year after the Flood [16: 142-145]. In addition, Jewish legends suggest a clear relationship between the Flood, the Ursa Major nova-like event of ca. 2700 BC, and events in the Pleiades, although the Pleiades events may represent novae rather than Taurid meteor showers [69: 162]:

> "The flood was produced by a union of the male waters, which are above the firmament, and the female waters, issuing from the earth. The upper waters rushed through the space when God removed two stars out the constellation Pleiades. Afterward, to put a stop to the flood, God had to transfer two stars from the constellation of the Bear to the constellation of the Pleiades. That is why the Bear runs after the Pleiades. She wants her two children back, but they will be restored to her only in the future world."

The range of dates indicated by these various stories - no earlier than 2805 BC (for the Nahuatl story suggesting the creation of fire two years after the Flood) and not much later than 2650 BC - are remarkably close to the original estimate

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made by Fred Whipple and Salah Hamid [201] for the breakup of the progenitor to Encke's Comet and the creation of the Taurid streams. Whipple and Hamid came up with a date of about 2700 BC for this event.

The Pleiades asterism (and its parent constellation, Taurus) is a prominent fixture throughout worldwide mythology and early astronomies, which is curious for a asterism with no star brighter than the third magnitude. The significance of the Pleiades goes beyond its utility as a seasonal marker. I suggest that its importance for virtually all cultures is due in large part to the appearance and character of the Taurid streams during the past 4700 years, although the Pleiades may also be unusual in terms of the production of bright nova-like events such as occurred around winter solstice in AD 684 [123, 131].

Further cosmographic analyses should help us to understand just how big of a threat to the Earth that the Taurid streams have posed. The theories of Asher *et al.* [5] and Bailey *et al.* [11] are likely testable through more detailed cosmographic analysis. However, by factoring in precession (in which meteor streams advance calendrically approximately 22 days per millennium), it can be determined that several of the larger impacts of the past 5,000 years do not appear likely Taurid candidates. The Flood Comet impact does not appear to be associated with any modern meteor stream (the equivalent today of ca. 26 January); the Broken Bow impact (which occurred in late fall) would possibly be associated with meteor streams occurring in the period of late July through early September.

The season and dates of the Rio Cuarto impact and those impact(s) which occurred during the period of 2350-2200 BC are presently unknown, although additional texts may be found which encode such information. And it is possible that some of the potential smaller impacts are associated with the Taurid complex. It would prove valuable for Chinese historians to more closely study the original texts so as to attempt to derive firmer lunar and monthly dates to compare against the annual cycle of cometary debris streams.

13. The rates, effects, and risks of cosmic impacts

"Risk" is the degree of probability to which a dangerous element or factor (a "hazard") can create a specified loss. Anyone who has seriously studied the subject of risk in the arenas of health, communication, and public policy realize that meaningful models of risk assessment require the careful gathering, analysis, and interpretation of pertinent data, and likewise require an objectively dispassionate presentation of the results to the public. The consequences for improperly assessing or for miscommunicating risk are profound and potentially harmful in and of themselves.

Currently accepted models of the risk of cosmic impact [34, 136, 137] are carefully and soundly based on cratering rates defined for the Moon, Earth and other planetary bodies, on assumptions regarding the total numbers of Earth-crossing asteroids and long-period comets, and on theoretical models of effects on Earth by different types of impactors. These models suggest that a locally catastrophic 15 megaton (MT) Tunguska-like impact can occur somewhere on Earth on the average roughly of once every 200 years. A 100 MT impact, which is still considered a modest local impact, is expected on the average of about one per 1,400 years. The threshold for a regionally catastrophic impact, as previously defined, lies at about 750 to 1000 MT (1 gigaton), and would be expected to occur by present models on the average of one per 10,000 years. A "globally" catastrophic impact is defined as an impact directly and indirectly capable of causing the death of at least one quarter of the Earth's human population (Chapman and Morrison 1994); the energy threshold for such an impact has been put at around 300 gigatons (300,000 MT), or roughly the equivalent of 1,500,000 Hiroshima atomic bombs. Present risk models suggest that globally catastrophic impacts occur roughly on the average of once every 300,000 years. However, because of the uncertainties in the data base, the risk models allow that the actual risk could be somewhat higher (up to twice as high), or could also be somewhat lower.

I sincerely hope that my archaeological and historian colleagues can get past the issue of chronology in this paper and the question of whether "standard" chronologies are operative in the Old World or should be revised upward or downward in various regions. Absolute chronology is indeed important, but it is not essential for assessing the general risks of cosmic impact.

Leaving aside for the moment the present imprecision for the dating of some of the impacts described in this paper, the past 5,000 years of human history has been shaped, at least in part, by at least two and likely three or more cosmic impacts of unusual magnitude. These include the globally catastrophic impact Flood Comet impact in 2807 BC, an event which is supposed to take place on the average only once every 300,000+ years; the regionally catastrophic Rio Cuarto impact, possibly of 2000 BC, an event which is supposed to take place in the neighborhood of about once every few tens of thousands of years. In addition; a large local/regional catastrophic impact or swarm of smaller local impacts likely occurred in the Near East and possibly western Asia around 2345 BC, an event which should take place about once every 10,000 years or so. And based on my analysis of the Flood Comet impact [125, 126], it is likely that the Younger Dryas geological event [111: 342-356] was precipitated around 9300 BC by a globally catastrophic oceanic impact of considerably greater magnitude than the Flood Comet impact. The Younger Dryas represents a thousand-year blip of cooler temperatures in the warming trend that began at the end of the last ice age. Notable is the fact that worldwide temperatures plunged drastically up to 7° at the very beginning of the Younger Dryas during a period of less than 20 years. Also notable is the fact that several species of large mammals were extirpated or became extinct at about this time, especially in the New World.

Setting aside the unresolved issue of the Taurid meteor streams and coherent catastrophism, and for the moment assuming a model of simple stochastic flux for cosmic impacts, the risk to human life posed by cosmic impacts currently is underestimated by a factor of between about 15 and 30. Rather than globally catastrophic impacts occurring on the average of about once every 300,000 years, I instead conservatively suggest that such impacts occur on the average of about once every 10,000 to 20,000 years. If we were to simply and to uncritically use the impact data from the past 12,000 years, presuming the reality of the hypothesized Younger Dryas oceanic impact, the rate of globally catastrophic cosmic impact actually increases to that of once every 5,000 to 6,000 years.

Soberingly, the range of 6,000 to 20,000 years suggested here for the average rate of globally catastrophic cosmic impact matches the general incidence of periods of rapid substantive change in climate observed in the palaeoclimatic record of the Pleistocene and Holocene periods [111: 324-373]. This is not to imply that every Quaternary period climate change signals a cosmic impact. However, in those several cases in which change is perceived to be extremely rapid, occurring in the space of a few decades as opposed to centuries, cosmic impact should be considered a likely contributing cause.

Equally sobering is the prevalence of eschatological tradi-

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tions which tell of multiple catastrophic destructions (followed by new creations) of the world. For most cultures the last such creation matches the last globally catastrophic cosmic impact, that of the Flood Comet impact of 2807 BC. In humankind's role as cosmographic observers of the universe around us, this situation is best explained by assuming that the last three or four large regional or globally catastrophic cosmic impacts, ending with the Flood Comet impact, have become enshrined in traditional cosmogonic histories. In addition, local cosmic cataclysms are common enough and of such striking character so as to reinforce humankinds eschatological traditions about multiple destructions and creations.

In terms of actuarial tables [52: 105], instead of the presently modeled rate of death by cosmic impact at 1 in 20,000 (the same as the chances of dying in a passenger aircraft crash), the adjusted rate would be somewhere between 1 in 1,333 (nearly twice as great as the chances of dying in a firearms accident) and that of 1 in 400 (slightly larger than the chances of death by murder), or about the same as that for a lumberjack dying on the job, which is one of the most dangerous professions. Even the lesser of these various rates has rather profound implications for both cultural and biological evolution.

It is particularly noteworthy that I have not yet been able to positively identify a historic oceanic or large lake cosmic impact during the past 5000 years, other than that of the Flood Comet itself. There are some indiciations of oceanic or large lake impacts at around 2650 BC and around 2280 BC, and possibly at around 1800 BC, but these are equivocal at best. This suggests that we still have much to learn and to model in terms of being able to identify the signatures of such impacts in the archaeological and documentary record.

Oceanic impacts, such as that in 2807 BC, also contribute to the difficulty of identifying the remnants of local and regional terrestrial impacts by resculpting landforms and thus obscuring the very presence of earlier impact craters. Likewise, even if oceanic impacts produce a sea-floor crater and send sea-floor debris into and through the upper atmosphere, the presence of large quantities of water vapour in association with the debris particles may operate like a filter to quickly remove the particulates (as rainfall) and thus to reduce the potential for impact dust to accumulate in recognizable concentrations in polar ice. This may explain why multiple cosmic impacts have not been previously identified in ice core studies.

14. Conclusions

> "Those who are good at discussing antiquity must demonstrate the validity of what they say in terms of modern times; those who are good at discussing Heaven must show proofs from the human world. In discussions of all kinds, men value what is in accord with the facts and what can be proved to be valid. Hence if a man sits on his mat propounding some theory, he should be able to stand right up and put it into practice, and show that it can be extended over a wide area with equal validity", Hsün Tzu, 4th century BC, [196: 163].

The art and science of eliciting underlying meaning from potentially cosmographic oral and written traditions is fraught with difficulty, and one should not be overzealous in such interpretations. Nevertheless, the examples cited here indicate that cosmographic contextual reconstruction and dating is not only possible but can be accomplished with a fair degree of certainty. Cosmography can help to isolate contemporary traditions from widespread regions that together provide enough details to reasonably define previously unknown temporary celestial events, including cosmic impacts.

The *Huainanzi*, a philosophical treatise written in the Han Dynasty during the second century BC, provides us with an important perspective on traditional Chinese cosmology and cosmography, which as with Plato's *Timaeus* quoted at the beginning of this paper, contains much more observational knowledge and wisdom than modern Western scholars have previously recognized [114: 65]:

> "The sun is the ruler of yang. Therefore, in spring and summer animals shed their fur; at the summer solstice stags' antlers drop off. The moon is the fundament of yin. Therefore, when the moon wanes, the brains of fish shrink; when the moon dies, wasps and crabs shrivel up. Fire flies upward, water flows downward; thus the flight of birds is aloft, the movement of fishes is downward. Things within the same class mutually move each other; root and twig mutually respond to each other. Therefore, when the burning-mirror sees the sun, it ignites tinder and produces fire. When the square receptacle sees the moon, it moistens and produces water. When the tiger roars the valley winds rush; when the dragon arises the bright clouds accumulate. When *qilins* wrangle, the sun or moon is eclipsed; when the leviathan dies, comets appear. When the silkworm spins cocoons (shaped like) ear ornaments, the *shang* string (of a stringed instruments) snaps; when meteors fall, the sea suddenly swells up."

Let us assume for the moment that a 'rising dragon' is a logical descriptor for a Tunguska-like impactor with its subsequent bright fireball and upper atmospheric displays ("bright clouds"), and that the 'swelling of the sea' is in fact a tsunami. One can only marvel and wonder how many different cosmic impacts over countless hundreds of years went into the simple observed correlation between the fall of 'meteorites' on land and the billowing of impact fireballs, or the fall of 'meteorites' into the ocean and the subsequent devastating effects of tsunami. Clearly scholars have been aware of cosmic impacts and their destructive tendencies for much more than 2,000 years.

That the effects of cosmic impact have been considerably underestimated by modern science is arguable by our seeming inability to recognize the full extent of the devastation caused by the Rio Cuarto impact, and especially by the complete failure of modern science to even begin to recognize the nature and date of the Flood Comet impact. When we add to this situation the possibility that the rate of cosmic impact has likewise been underestimated, given uncertainties in the numbers of Earth-crossing asteroids and in the numbers of long period comets which may periodically be flung into the inner Solar System, the implications are disquieting.

But by far the greatest risk we face is that of complacency. The cosmic impact risks outlined above are high enough to warrant an immediate vigorous and thorough evaluation of possible regional and globally catastrophic impacts during the Holocene period. Currently, few palaeo-environmental researchers are aware of the Holocene period record of cosmic impacts, and most substantive current texts which attempt to explain climate change during the Quaternary period fail to consider cosmic impacts whatsoever [111]. We need to greatly expand our efforts to identify cosmic impacts in the archaeological and palaeo-environmental record, especially oceanic impacts such as that hypothesized for 2807 BC and for the beginning of the Younger Dryas event at around 9300 BC. We likewise need to increase the effort being expended in the search for potentially hazardous

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asteroids and comets. And we need to expand our efforts to couple computer simulations of oceanic and terrestrial cosmic impacts with our modeling of global climate change.

Cosmic impacts are inevitable. While we cannot presently prevent the occurrence of cosmic impact, we can at least begin the process of serious contingency planning to reduce the overall consequences of such impacts, in particular oceanic impacts. And by embarking on such a process, we will finally do justice to our many forgotten ancestors who bravely strove to warn us of our impending fate of cosmic impact, a fate which is as natural and as normal as the daily workings of the Solar System itself. In a holistic world, where science, nature, religion, and politics were part of an observational continuum, the myth-makers and story-tellers were the scientists, poets, and the true heroes of our mythological past.

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I dedicate this work to my son, Jeffrey. I challenge his and future generations to have the wisdom and grace to squarely face both the challenges and the joys afforded to the human species on this tiny but most interesting piece of the universe called Earth. As Confucius is alleged to have said, and as I have long attempted to practice: "Our greatest glory is not in never falling, but in rising every time we fall." This sage advice is appropriate not only for individuals, such as myself, but perhaps also for our species as a whole.

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Table 2: Tentative Concordance of Bronze Age Historical Figures, Myths, Archaeology, and Celestial Events

DATE B.C.	SUGGESTED CELESTIAL EVENT	EGYPT	NEAR EAST, MESOPOTAMIA	CHINA, INDIA	OTHER	CONFIDENCE SCALE* 5= certain 3= likely 1= poor or uncertain
May 2807 B.C.	Globally catastrophic oceanic comet impact in Atantic-Indian Basin, with magnitude of between 10^5 to 10^6 gigatons.	Ended Semerkhet reign, First Dynasty 7th King. "Many portents and a great calamity". Entrenchment, lowering of Nile. Myth of sky goddess Hathor turning into the raging lioness, Sekhmet.	Flood stories of Noah, Atrahasis, Utnapishtim. Massive Flood deposits at Ur, Uruk, Shuruppak, and Kish. Largescale movement of people into hill country of Galilee, Samaria, and Judah.	Ended reign of Nu Wa, consort of Fu Hsi and first Empress of China. Cosmic battle between Gong Gong (God of Water) and Zhu Rong (God of Fire), after which Nu Wa mended the damage to the heavens.	Worldwide Flood myths; boundary event between Middle and Late Holocene geologic period; Beginning of El Niño/Southern Oscillation climatic cycle.	comet impact Date = 5 Event Type = 5 Magnitude = 5 Location = 3
ca. 2700 B.C.	Ursa Major supernova or nova-like event; possible eruptive phase of Owl Nebula. May have exceeded naked eye visible size of apparent diameter of Full Moon.	"Moon waxes unseasonably" during reign of 1st king of Third Dynasty. Likely immortalized as the myth of Horus Behdety, winged solar disk. Possible inspiration for ultimate construction of Djoser's Step Pyramid.	Immortalized in myth as the death of Humbaba, the demon guardian of the cedar forest, at the hands of Gilgamesh and Enkidu.	Celestial portent and birth event of Yellow Emperor, Huang Di. [Bamboo Annals].	Immortalized in the Popul Vuh as the death of Seven Macaw (Big Dipper), who tried to be brighter than the Sun and Moon, at the hands of the hero twins.	Nova-like Event Date = 4 Event Type = 4 Magnitude = 3 Location = 4
ca. 2680 B.C.	Multiple simultaneous supernova or nova-like events.	May have served to reemphasize importance of the circumpolar celestial heavens associated with the Ursa Major nova-like event of 2697 B.C.		Seen as auspicious portent for the Yellow Emperor, Huang Di. [Bamboo Annals].		Simultaneous Novae Date = 4 Event Type = 2 Magnitude = 1 Location = 1
ca. 2650 B.C.	Likely first-ever Taurid meteor storm, which appears to have lasted full force for three days.	Immortalized in Egyptian mythology as the killing of Osiris by Set. Beginning of use of *benben* stones (meteorites) as an important architectural element and symbol.	Immortalized in Gilgamesh epic as the attack on Uruk by Ishtar using the "Bull of Heaven".	In 57th year of Yellow Emperor, Huang Di, the heavens were "wrapt in mist" for three days and nights. [Bamboo Annals].	Immortlization in Popul Vuh as the killing of the 400 boys by son of Seven Macaw. Many myths worldwide note the origin of fire from the Pleiades, the "fire-drill" asterism.	Taurid Storm Date = 4 Event Type = 5 Magnitude = 4 Location = 5
ca. 2650 B.C.	Possible oceanic or deep lake cosmic impact, or multiple small impacts associated with Taurid meteor storm.	Mention of the Moon wxing unseasonably during the reign of the first king of the Third Dynasty. Perhaps terminated the reign of Sekhemkhet., the successor to Djoser.	Exploits of Gilgamesh and Enkidu. Death of the giant guardian of the cedar forest, Humwawa. Massive flood deposits at Kish.	Seven days of torrential rainfall. [Bamboo Annals]. Other myths note this was part of a cosmic battle between Chi You (the "Fiery Emperor", a ferocious god in the heavens) and Huang Di.		cosmic impact Date = 4 Event Type = 2 Magnitude = 2 Location = 3

*Confidence scale based on the author's qualitative perception of the reliability and depth of the overall database for each specific event identified in this study.

DATE B.C.	POSSIBLE COSMIC EVENT	EGYPT	NEAR EAST, MESOPOTAMIA	CHINA, INDIA	OTHER	CONFIDENCE SCALE 5= certai n 3= likely 1= poor or uncertain
ca. 2345 B.C.	Terrestrial cosmic impact by fragmenting comet.	Possible inspiration for the Pyramid Texts of the last king of the Fifth Dynasty, Unas, and the use of such tomb texts throughout the Sixth Dynasty.	Possible basis for the cosmic battle in the epic myth of Anzu, lion-headed doorkeeper for Ellil (Dalley 1989:203-227). Also likely basis for the first lament about the destruction of Ur.	Immortalized as the myth of the Divine Archer, Yi, shooting down nine of ten suns which appeared simultaneously in the sky and which threatend to burn up the Earth.	Possibly the basis of the Greek myth of the tragic sun-chariot ride of Phaëton, which threatened to burn up the Earth.	cosmic impact Date = 4 Event Type = 3 Magnitude = 2 Location = 2
ca. 2315 B.C.	Crater supernova or nova-like event; possibly visible for 14 months. [Duplicate record of 2287 B.C. event?].	Possible inspiration for the common reference to stars in the Pyramid Texts of the Sixth Dynasty.		Celestial portent during 42th year of reign of Emperor Yao. [Bamboo Annals].		Nova-like Event Date = 4 Event Type = 3 Magnitude = 3 Location = 4
ca. 2297-2265 B.C.	Possible oceanic or large lake cosmic impact(s) in or near China.			Possible inspiration for the battle(s) between god of water, Kung Kung, and Kun and his son Yu who attempted to control devastating floods throughout China.		cosmic impact Date = 3 Event Type = 1 Magnitude = 1 Location = 3
ca. 2287 B.C.	Crater supernova or nova-like event. [Duplicate record of 2315 B.C. event?].	Possible inspiration for the common reference to stars in the Pyramid Texts of the Sixth Dynasty.		Celestial portent during 70th year of reign of Emperor Yao. [Bamboo Annals].		Nova-like Event Date = 4 Event Type = 3 Magnitude = 2 Location = 4
ca. 2254 B.C.	Scorpius supernova or nova-like event.	Possible inspiration for the common reference to stars in the Pyramid Texts of the Sixth Dynasty.		Celestial portent during at the beginning of the reign of Emperor Shun. [Bamboo Annals].		Nova-like Event Date = 3 Event Type = 4 Magnitude = 4 Location = 4
ca. 2240 B.C.	Local probable Tunguska-like atmospheric cosmic impact in China.			Occurring during ceremonies being performed by Shun. Caused Shun to name and introduce his ultimate successor, Yu. [Bamboo Annals].		cosmic impact Date = 4 Event Type = 3 Magnitude = 3 Location = 3

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Table 2: Tentative Concordance of Bronze Age Historical Figures, Myths, Archaeology, and Celestial Events

DATE B.C.	SUGGESTED CELESTIAL EVENT	EGYPT	NEAR EAST, MESOPOTAMIA	CHINA, INDIA	OTHER	CONFIDENCE SCALE* 5= certain 3= likely 1= poor or uncertain
ca. 2188 B.C.	Local terrestrial cosmic impact in or near southern portion of the Dead Sea.	Beginning of First Intermediate Period.	Destruction of Sodom and Gomorrah.	Approximate beginning of Hsia Dynasty.		cosmic impact Date = 3 Event Type = 4 Magnitude = 4 Location = 4
ca. 2000 B.C.	Regionally catastrophic terrestrial cosmic impact at Rio Cuarto, Argentina.	Approximate beginning of the Middle Kingdom, or at least the boundary betwen the Eleventh and Twelth Dynasty.	Darkened skies noted as an aspect of the second destruction of Ur lament during the reign of Ibbi-sin.		This event is preserved throughout much of South America as the myth of the "Great Fire".	cosmic impact Date = 3 Event Type = 5 Magnitude = 4 Location = 5
ca. 1800 B.C.	Locally catastrophic oceanic or large lake cosmic impact.		Possibly preserved in Hittite myth about the fall of the Moon.	Possibly related to the destruction, by flooding, of Mohenjo-Daro and Harrapan culture in India.		cosmic impact Date = 2 Event Type = 3 Magnitude = 2 Location = 2
722 B.C.	Large probable bolide heard in China.			Thunder without clouds (Bamboo Annals).		cosmic impact Date = 5 Event Type = 2 Magnitude = 2 Location = 3
686 B.C.	Meteor storm with possible associated Tunguska-like atmospheric cosmic impact.			Summertime meteor storm and regular stars invisible at night (Bamboo Annals).	possible association with the Piscids or Orionids, and perhaps with Taurids.	cosmic impact Date = 5 Event Type = 2 Magnitude = 1 Location = 1
505 B.C.	Possible Tunguska-like atmospheric cosmic impact in Europe or Asia			Milky Way not visible in the [night] sky (Bamboo Annals).		cosmic impact Date = 5 Event Type = 1 Magnitude = 1 Location = 1

*Confidence scale based on the author's qualitative perception of the reliability and depth of the overall database for each specific event identified in this study.

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