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Earthquakes and Archaeology and the raging Uniformitarian – Catastrophism debate

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The idea that an earthquake storm helped usher in the catastrophic collapse of the late bronze age in the eastern med (Nur and Cline, 2000) gave rise to an ongoing and raging philosophical debate about Uniformitarianism vs Catastrophism.

Introduction

“Catastrophism is the theory that the Earth has repeatedly been shaped by sudden, short-lived, violent events, some of worldwide in scope. This is in contrast to uniformitarianism (sometimes described as gradualism), in which slow incremental changes, such as erosion, created all the Earth's geological features”.

For many years now we - Nur et al (see references below) - have been exploring the possibility that destructive earthquakes may have been involved in destructions that archaeologists have uncovered – not only at specific sites but also more regional impact. Specifically, we have shown how an earthquake storm COULD have helped usher in the catastrophic collapse in the eastern Mediterranean at the end of the bronze age. This idea – which we thought is pretty straight forward - has come under a variety of criticisms and even attacks. One of the more intriguing repeated attack aspects was based on the philosophical debate related to Uniformitarianism vs Catastrophism. Specifically, that our ideas re the links between earthquakes and destruction uncovered in archaeology are nothing but the convenient re-emergence of the

presumably long discarded concept of catastrophism - so we should be dismissed.

Denying Catastrophism (and Neocatastrophism)

Here are four scathing opinions by Mark Rose (1999), Nicholas Ambraseys (2006), Klaus G. Hinzen (2018), and Manuel Sintubin (2011):

1. Mark Rose, the editor of 'Archaeology' opined in 1999:

"Tired of needlessly complicated multi-causal explanations for why this civilization collapsed or that city was destroyed? How about a catastrophe?"

"Gradually, as archaeology became a profession and the pretenders were exposed, catastrophism as an explanation for past events went out of vogue, being left to cranks and fringe authors".

"To say all Neo-catastrophism is cut from the same cloth-of-doom would be incorrect; some tries to be rigorous and serious, some is undoubtedly trendy, and some is a return to Velikovsky. At best it is an acknowledgement that catastrophes happen and that we shouldn't dismiss them out of hand as archaeological explanations. This is basically an attempt to place catastrophes within the uniformitarian system".

2. Nicholas Ambraseys in 2006 pontificated:

"In the early part of the 19th century geology was under the influence of the dogma of catastrophism: the hypothesis that changes in the earth occurred as a result of isolated major catastrophes of relatively short duration, as opposed to the idea implicit in uniformitarianism, that small changes are taking place continuously. Catastrophism passed off the scene, now more

or less completely discarded, and uniformitarianism took over. However, the last few decades have seen a gradual re-emergence of neo-catastrophism, this time in the field of archaeo-seismology, particularly for earthquakes before our era in the Eastern Mediterranean, bringing back into prominence the ideas of Velikovski. The reason for the revival of catastrophe hypotheses is perhaps that they are easy to explain. They are too simple, too obvious and too coincidental and chiefly because they have become fashionable in recent years “.

3. Klaus Hinzen et al in 2018 seconded Ambraseys conviction that catastrophism is simply useless:

“As outlined by Ambraseys (2006) in the past few decades there has been a reemergence of neocatastrophism in the field of archaeoseismology, particularly for earthquakes in the eastern Mediterranean. Ambraseys attributes the revival of catastrophe hypothesis to their usefulness as easy explanations”.

4. Sintubin et al (2011) even propose that we should actually excise the whole idea of catastrophism, at least when it comes to earthquakes

“It’s therefore time to get rid of the catastrophism that has burdened earthquake archaeology for too long”

Re-emergence of Catastrophism

The authors above - as well-meaning as they may be - clearly believe that the philosophical idea of uniformitarianism is actually a sort of basic

law of nature (a-la-Newton's laws, a concept by which Hutton and Lyell were influenced), proven and broadly applicable and generally valid. However, uniformitarianism has not in fact been recognized by past as well as modern thinkers and many logical questions have been raised repeatedly about its general validity. In fact, it has been challenged for both logical as well as observational scientific reasons from the early start by Hutton (1795) and Lyell (1832) vs. Whewell (1832), Sedgwick (1831) and Hopkins (1852), to more recently e.g., by Cannon (1960), Gould (1987), and Baker (1998).

1. In 1960 Cannon produced a detailed overview of the history of the Uniformitarian-Catastrophist Debate

“Darwin was deeply indebted to Charles Lyell for the method of accounting for large changes by summing up small changes over immense periods of time, nevertheless he did not accept the general Uniformitarian account of the history of nature. Evolution by means of natural selection involves the acceptance of the idea that some sort of cumulative development is demonstrated by geological and biological evidence- and it is just this idea that Uniformitarianism consistently denied”.

2. Victor Baker in 1998 provides a particularly insightful discussion:

“Catastrophism in the Earth sciences is rooted in the view that Earth signifies its causative processes via landforms, structures and rock. Processes of types, rates and magnitudes not presently in evidence may well be signified this way. Uniformitarianism, in contrast, is a regulative stipulation motivated by the presumed necessity that science achieves logical validity in what can be said (hypothesized) about the Earth. Regulative principles, including simplicity, actualism and gradualism, are imposed a priori to insure valid inductive reasoning. This distinction lies at the heart

of the catastrophist versus uniformitarian debates in the early nineteenth century and it continues to influence portions of the current scientific program. Uniformitarianism, as introduced by Charles Lyell in 1830, is specifically tied to an early nineteenth century view of inductive inference. Catastrophism involves a completely different form of inference in which hypotheses are generated retroductively. This latter form of logical inference remains relevant to modern science, while the outmoded notions of induction that warranted the doctrine of uniformitarianism were long ago shown to be overly restrictive in scientific practice. The latter should be relegated solely to historical interest in the progress of ideas”

3. Stephen Gould points out in 1987 the stifling impact of the uniformity assumption:

“Modern geologists do not apply uniformitarianism in the same way as Lyell. They question if rates of processes were uniform through time and only those values measured during the history of geology are to be accepted.^[44] The present may not be a long enough key to penetrate the deep lock of the past.^[45] Geologic processes may have been active at different rates in the past that humans have not observed. "By force of popularity, uniformity of rate has persisted to our present day. For more than a century, Lyell's rhetoric conflating axiom with hypotheses has descended in unmodified form. Many geologists have been stifled by the belief that proper methodology includes an a priori commitment to gradual change, and by a preference for explaining large-scale phenomena as the concatenation of innumerable tiny changes."

Conclusion

So to dismiss earthquakes and what we know today about their geography, magnitude distribution, and ground shaking as a possibly important factor responsible for collapse uncovered by archaeologists by invoking the “rule of uniformitarianism” is frankly nothing but silly. We are not pretenders, cranks, fringe authors, or amateurs. If anything, it is the blind adherence to uniformitarianism that is the actual dogma here, itself based on pseudo objectivity as opposed to suggesting that catastrophic events as opposed to gradualism could cause major or important changes, be it in archaeology, geology or society.

I also want to make sure that it is understood that my key point here is NOT to just defend my past suggestion that an earthquake storm MAY HAVE helped usher in the collapse at the end of the Bronze Age. The key point is a philosophical one - that ideas or hypothesis in general cannot be attacked or dismissed just because they involve catastrophic events. Geology, history, biology all have proven catastrophic changes (floods, super volcanic eruptions, tsunamis) that impacted nature, society, and culture.

Ironically the end of the Bronze Age itself is considered by many as catastrophic – leading to truly drastic cultural and political changes: the alphabet replacing Linear B, Athenian democracy emerges, etc. etc.

And re the possible role of an earthquake storm: I have suggested it as a possibility so the actual question is whether it did happen vs or could it have happen? We cannot prove that it did but we must consider the possibility that it could have.

A wonderful set of quotes of totally opposing views by two prominent 20th century historians highlights the obviously relevance of the unsettled debate between Uniformitarianism vs catastrophism.

“.. the causes of the breakdowns of civilizations are not acts of God .. neither

are they the vain repetitions of senseless laws of Nature”
(Toynbee, *A Study of History IV*, 1939)

*“Civilization exists by geological consent, subject to change
without notice”* (Attributed to Will Durant, 1885-1981)

Appendix:

SOME MAJOR NATURAL CATASTROPHIC EVENTS IN HUMAN HISTORY AND EARTH HISTORY

Compiled by Amos Nur

*“Civilization exists by geological consent, subject to change
without notice”* (Attributed to Will Durant, 1885-1981)

Re questioning the historical impact of catastrophes: here are some
natural disasters that actually did cause major political, economic, global
climatic, geological or societal upheavals:

TANGSHAN CHINA EARTHQUAKE 1976 THAT LED TO THE DEMISE OF MAO’S RULE IN CHINA

Although Chinese scientists say that Warning signs were observed
before the Tangshan earthquake of July 28, 1976, the scientific
leadership in Peking was so paralyzed by efforts of the “Gang of Four”
to seize power that no action was taken.

The catastrophe, in which it is believed more than 650,000 died, was one
of the most devastating in recorded history.

In the power struggle, Chinese research institutes were disrupted and
even dispersed, according to accounts in Chinese periodicals and relayed
by foreign visitors, Since the four, led by Mao Tse-tung's widow, Chiang

Ching, were arrested last October, scientists have spoken openly about the turmoil earlier in 1976.

There is much evidence that major changes are being made in the directions and goals of Chinese science. Its renewed importance to the Peking Government was made apparent by the appointment of Fang Yi, the man who in effect leads China's scientific establishment, to the Communist Party Politburo, the highest policy-making body in China.

1931 CHINA FLOOD – DEVASTATED AN AREA THE SIZE OF ENGLAND, 4M DEAD

In 1931 Central China experienced a devastating flood that inundated an area equivalent in size of England and half of Scotland, affected the lives of an estimated 52 million people, and killed as many as 2 million. In Chinese this event is usually described as the Yangzi-Huai Flood (*Jiang-Huai shuizai*), yet the disaster was not limited to these two rivers. The Yellow River and Grand Canal also experienced major flooding, whilst there were lesser inundations from as far south as the Pearl River (*Zhu Jiang*), which flows through the city of Guangzhou (Canton), to as far north as the Songhua and Yalu Rivers, which flow to the north of Korea.[1] Although the flood affected much of the country the core disaster zone was concentrated in eight central provinces. As such, it is referred to here as the 1931 Central China Flood.

https://en.wikipedia.org/wiki/1931_China_floods

TAMBORA INDONESIA VOLCANIC ERUPTION 1815 - GLOBAL ECONOMIC EFFECTS

Areas that were hit particularly hard by the effects of the Tambora eruption were New England and Europe. Frosts and snow in June, July and August destroyed almost all crops and farmers were forced to

slaughter animals due to the lack of corn crops. The widespread crop failures in Europe occurred just as it was beginning to recover from the effects of the Napoleonic Wars and Ireland experienced its first great famine. India's monsoon season was interrupted and China also felt the effects through devastating floods.

The Mount Tambora eruption sent huge amounts of volcanic ash into the upper atmosphere, leading to a temperature drop because less sunlight could get through the stratosphere. Prof John D Post's book, *The Last Great Subsistence Crisis in the Western World* (1977), looked at how northeastern America and parts of western Europe, in particular, were the worst affected by the consequences of the eruption.

In May 1816, snow and frost killed off crops in the upland areas of Massachusetts, New Hampshire and Vermont, with Atlantic Canada suffering similarly. Snow and especially frost continued into June, July and August, with lake and river ice observed as far south as Pennsylvania and Virginia. The destruction of crops led to food shortages and starvation for many, especially the poor. The famine led to a major typhus epidemic occurring between 1816 and 1819; it is estimated that up to 100,000 people died.

THE LISBON 1755 EARTHQUAKE THAT USHERED IN THE MODERN WORLD

The November 1, 1755, Lisbon earthquake may have had more influence on Western thought than any other quake, for it was "an event which indirectly changed men's thinking about their own place in nature" (Besterman, 1969). Because such earthquake catastrophes are rare in Western Europe, this one stimulated great scientific interest for centuries afterward (Richter 1958), kindling fierce debates between "common sense" and "natural law," and between theologians and Enlightenment philosophers.

In Portugal, the Marquis of Pombal shared with the enlightened elite an experimental conception of nature. In January 1756, he designed a national survey to discover the causes and origin of the natural disaster, minimize future risks and assess the damage the earthquake had caused. Through another scheme, the enlightened minister of King José I attempted to legitimate history on the basis of the doctrinal work of his direct advisers. The statesman, who efficiently managed the crisis by solving the immediate effects of the cataclysm, rebuilding the capital according to a plan, silencing his rivals and publicizing his policies internally and internationally, enhanced the idiosyncrasy of the enlightened absolutist rule of King José I. He also adopted a modern attitude by clearly separating the purpose of God from the signs of nature and the will of human beings. From this point onwards, the "victory of the Marquis of Pombal" – in the words of Susan Neiman (Neiman 2005: 279) – arose from the development of a coherent political agenda which was founded on past events and, in the aftermath of the earthquake, focused on the dissemination of Natural Philosophy, the enhancement of knowledge that could be of use for the State, legislative reform and on imposition of the History of National Rule.

Like many ancient earthquakes, the Lisbon event caused great physical devastation and human suffering. However, it was unusual in that it also changed the course of world events. By striking at a time when there was a particularly delicate balance of power between church and state, and between science and religion, the earthquake tipped the scales and changed society around the world. The old power would never again enjoy such dominance over the new. There has been no other such event in recent times, when natural and political factors combined to such a far-reaching effect. However, several earthquakes have had smaller-scale political implications, and have influenced the local power balance in regions affected by the quakes.

MOUNT VESUVIUS 79AD ERUPTION – POMPEI DESTROYED FOR GOOD

Pompeii was an ancient city located in what is now the comune of Pompei near Naples in the Campania region of Italy. Pompeii, along with Herculaneum. It was founded in the 6th–7th century BC and abandoned in 79 AD.

Of the many eruptions of [Mount Vesuvius](#) in [Italy](#), the most famous is the eruption in 79 AD. This eruption is one of the [deadliest](#) in European history.[\[1\]](#)

Mount Vesuvius violently spewed forth a deadly [cloud](#) of super-heated [tephra](#) and [gases](#) to a height of 33 km (21 mi), ejecting [molten rock](#), pulverized [pumice](#) and [hot ash](#) at 1.5 million tons per second, ultimately releasing 100,000 times the [thermal energy](#) of the [Hiroshima-Nagasaki bombings](#).[\[2\]](#) The event gives its name to the [Vesuvian](#) type of volcanic eruptions, characterized by eruption columns of hot gases and ash exploding into the [stratosphere](#), although the event also included [pyroclastic](#) flows associated with [Peleian eruptions](#).

Several Roman cities were obliterated and buried underneath massive [pyroclastic surges](#) and [ashfall deposits](#), the best known being [Pompeii](#) and [Herculaneum](#).[\[1\]\[2\]](#) After archaeological excavations revealed much about the lives of the inhabitants, the area became a major tourist attraction, and is now a UNESCO [World Heritage Site](#), and part of [Vesuvius National Park](#).

The total population of both cities was over 20,000.[\[3\]\[4\]](#) The remains of over 1,500 people have so far been found at Pompeii and Herculaneum, although the total death toll remains unknown.

BAY OF ABU QIR, EGYPT – THE 6-8 METERS SUNKEN CITIES 1ST MILLENNIUM AD

Ancient Egypt's gateway to the Mediterranean – submerged and buried under layers of sand – is an eerie reminder of how vulnerable cities are to nature's forces.

A place written into the legends of antiquity – the site of the divine hero Heracles' first footsteps in Africa, and where Sparta's Helen famously sought refuge with her abductor, Paris of Troy – disappeared completely under water and was buried, seemingly forever, by layer upon layer of sand and silt.

By the second century BC, Thonis-Heracleion's era of pomp and prestige was already fading. Further along the coast, the new metropolis of Alexandria was rapidly establishing itself as Egypt's preeminent port, while the hybrid foundation of land and water upon which Thonis-Heracleion was built had begun to feel less secure. It wasn't a single natural disaster – an earthquake, tsunami, rising sea levels, or subsidence – that doomed the city, but rather a combination of them all.

EARTHQUAKES AND CIVILIZATIONS OF THE INDUS VALLEY, 1ST-2ND MILLENIA AD

The examples presented here demonstrate that earthquakes have produced direct damage at several historical archaeological sites in the Indus Valley region. In addition, ancient earthquakes, similar to the 1819 Runn of Kachchh event, the 1945 Makran coast event, and the 2001 Bhuj event, may also have produced significant ground uplift and deformation affecting the geographic setting of early settlements. We here point to significant changes over historical time of the fluvial system of the Indus River, the consequences of river damming and subsequent flooding, and coastal elevation changes.

See: Robert L. Kovach* , Kelly Grijalva ,Amos Nur

THE CATASTROPHIC MISSOULA FLOODS, CA. 15,000 YBP

The Missoula floods were cataclysmic [glacial lake outburst floods](#) that swept periodically across eastern [Washington](#) and down the [Columbia River Gorge](#) at the end of the last [ice age](#) resulting from periodic sudden ruptures of the ice dam on the [Clark Fork River](#) that created [Glacial Lake Missoula](#). After each ice dam rupture, the waters of the lake would rush down the Clark Fork and the [Columbia River](#), flooding much of eastern Washington and western [Oregon \(covering around 16,000 sq. miles \(equal to the combined areas of Mass and Conn\)\)](#). After the rupture, the ice would reform, creating Glacial Lake Missoula again.

Geologists estimate that a cycle of flooding and re-formation of the lake lasted an average of 55 years and that the floods occurred several times between 15,000 and 13,000 years ago. At least twenty-five massive floods occurred, the largest discharging about 10 cubic kilometers per hour (13 times the [Amazon River](#)).^[1] The maximum flow speed approached 36 meters/second (130 km/h or 80 mph) - more than the combined flow of every river in the world.^[8] Estimates place the flow rate at ten times the flow of all current rivers combined. The evidence suggest that 500 cubic miles of water raged across eastern Washington State in just 48 hours to produce the world's biggest flood for which scientists have geological evidence.

[Geologist J Harlen Bretz](#) first recognized evidence of the catastrophic floods, in the 1920s. He published a paper in 1923, arguing that the Channeled Scablands in Eastern Washington were caused by massive flooding in the distant past. Bretz's view was seen as arguing for a [catastrophic](#) explanation of the geology, and ran against the prevailing view of [uniformitarianism](#).

James Gilluly, one of the better known of Bretz's numerous antagonists, arrived in the field in @1950, where he stood for a long time looking at the falls before muttering, "How could I have been so wrong!"

At the age of 97, J Harlen Bretz received the prestigious Penrose medal of the Geological Society of America.

AKROTIRI, THIRA, GREECE EARTHQUAKE AND ERUPTION @1600BC – TAKEN OUT OF HISTORY

Akrotiri ([Greek](#): Ακρωτήρι, pronounced Greek: [[akro'tiri](#)]) was a [Minoan Bronze Age](#) settlement on the volcanic Greek island of [Santorini](#) (Thera).

The settlement was destroyed in the [Theran eruption](#) sometime in the 16th century BC [\[1\]](#) and buried in volcanic ash, which preserved the remains of fine [frescoes](#) and many objects and artworks. The settlement has been suggested as a possible inspiration for [Plato's](#) story of [Atlantis](#). Akrotiri has been excavated since 1967.

MOHENJO DARO, PAKISTAN @2500BC – THE BURIAL OF ONE OF THE MOST ADVANCED CITIES UNDER MANY METERS OF SILT

This enormous complex, especially if it surrounds the entire lower town area of Mohenjo-Daro, cannot be explained merely as a defensive structure against military attack. It appears that the walls and platforms were intended to artificially raise the level of the city as protection against floods. It is still too early to outline in detail the sequence of natural events which could have produced the flooding around Mohenjo-Daro but some tentative suggestions should be made. “That the prime cause of the floodings was of a tectonic nature cannot, on present evidence, be reasonably doubted,” says Raikes in his Interim Report. These uplifts, or rather series of uplifts, occurred between Mohenjo-Daro and the Arabian Sea, possibly near the modern town of Sehwan. Whether these uplifts were the result of bedrock faulting or of eruptive extrusions of “volcanic” mud remains to be seen. Geologists agree,

nonetheless, that the uplifting did occur. The “dam” created by this uplift process backed up the waters of the Indus River. The degree of evaporation, sedimentation, and water losses through the “dam” itself are technical matters requiring much more study. These factors are important in estimating the rate of water rise and spread in the reservoir created behind the “dam.”

THE CHICXULUB CRATER, MEXICO 66MYA – METEOR IMPACT

The Chicxulub crater [/'tʃi:kʃulu:b/](#) (Mayan: [\[tʃ'ikʃuluʃ\]](#)) is an [impact crater](#) buried underneath the [Yucatán Peninsula](#) in [Mexico](#).[\[4\]](#) Its center is located near the town of [Chicxulub](#), after which the crater is named.[\[5\]](#) It was formed when a large [asteroid](#) or [comet](#) about 11 to 81 kilometers (6.8 to 50.3 miles) in diameter,[\[2\]](#) known as the [Chicxulub impactor](#), struck the Earth. The date of the impact coincides precisely with the [Cretaceous–Paleogene boundary](#) (commonly known as the "K–Pg boundary"), slightly less than 66 million years ago,[\[3\]](#) and a widely accepted theory is that worldwide [climate disruption](#) from the event was the cause of the [Cretaceous–Paleogene extinction event](#), a [mass extinction](#) in which 75% of plant and animal species on Earth became extinct, including all non-[avian dinosaurs](#).

EARTH’S BIG FIVE MASS EXTINCTIONS – WHERE LIFE ON EARTH ALMOST GOT WIPE OUT

. Earth has witnessed five major catastrophic mass extinctions, when more than 75% of species disappeared. Palaeontologists spot them when species go missing from the global fossil record. Even today we don’t always know what caused them:

LATE DEVONIAN, 375 million years ago, 75% of species lost. ...

END PERMIAN, 251 million years ago, 96% of species lost. ...

END TRIASSIC, 200 million years ago, 80% of species lost. ...
END CRETACEOUS, 66 million years ago, 76% of all species lost.

References:

Alvarez, L.W.; Alvarez, W.; Asaro, F.; Michel, H. V. (1980).
"Extraterrestrial cause for the Cretaceous–Tertiary
extinction". *Science*. **208** (4448): 1095–1108.

Ambraseys, N.N., (2006), Earthquakes and Archaeology, *J. of
Archaeological Science*, 33, pp. 1008-1016

Baker, Victor R., (1998), catastrophism and uniformitarianism: logical
roots and current relevance in geology, Geological Society, London,
Special Publications, 143, 171-182

Bretz, J Harlen (1923). "The Channeled Scabland of the Columbia
Plateau". *Journal of Geology*. 31 (8): 617–649

Bretz, J Harlen (1925). "The Spokane flood beyond the Channeled
Scablands". *Journal of Geology*. 33 (2): 97–115, 236–259.

Byrne, R., (1988), 1,911 best things anybody ever said, New York
Fawcett Columbine

Cannon, W.F., (1960), The Uniformitarian- Catastrophist Debate, *The
Uniformitarian-Catastrophist Debate*, Vol. 51, No. 1 (Mar., 1960), pp.
38-55 (18 pages), The University of Chicago Press on behalf of The
History of Science Society, <https://www.jstor.org/stable/227604>

Darwin, C., (1845), *Journal of researches into the natural history and
geology of the countries visited during the voyage of HMS Beagle
round the world* (2nd Ed.). In: (G. Y. Craig and E. J. Jones, Comps.) *A
Geological Miscellany*, 33–34. Oxford: Orbital.

Gould, Stephen J (1987). *Myth and Metaphor in the Discovery of Geological Time*. Cambridge, MA: Harvard University Press. p. 174.

Gould, J., (1994) "The Evolution of Life on the Earth" in *Scientific American* 271, 4, 84-91 (October 1994)

Hinzen, Klaus-G. et al., (2018), Reassessing the Mycenaean Earthquake Hypothesis: Results of the HERACLES Project from Tiryns and Midea, Greece, *Bulletin of the Seismological Society of America*, vol. 108, issue 3A, pp. 1046-107, June 2018

Hopkins W., (1853), Address of the President, *Quar. Jour. Geo. Soc.*,

Hutton, J., (1788), *Theory of the Earth; or investigation of the laws observable in the composition, dissolution, and restoration of land upon the globe*, *Transactions of the Royal the Royal soc. Of Edinburgh*, 1, 209-304

Kendrick, T. D.

1956 *The Lisbon Earthquake*. London: Methuen.

Kovach, Robert L., Kelly Grijalva , Amos Nur (2010), Earthquakes and civilizations of the Indus Valley: A challenge for Archaeoseismology , *Special Paper of the Geological Society of America* 471:119-127

Lyell, C., (1830), on the proof of a gradual rising of the land etc., *Phil. Trans. Abstracts*

Lyell, c., *Principles III*

Lyell, C., Address of the President, *Proc. Geo. Soc*, 1833-1838

NAS, (2020), A vision for NSF Earth Sciences 2020-2030: Earth in Time, in press.

Nur, A. (2008). *Apocalypse. Earthquakes, Archaeology, and the Wrath of God*. Princeton University Press, Princeton.

Nur, A, Cline, E. H. (2000). Poseidon's Horses: Plate Tectonics and Earthquake Storms in the Late Bronze Age Aegean and Eastern Mediterranean. *Journal of Archaeological Science* 27, 43-63.

Nur, A. (1991), And the walls came tumbling down. *New Scientist* 1776, 45–48.

Nur, A., 1998 The end of the Bronze Age by large earthquakes? In: (M.Bailey, T.Palmer, and B. J. Peiser, Eds.) *Natural Catastrophes during Bronze Age Civilizations*, 140–149. British Archaeological Reports. Oxford: Archaeopress.

Nur, A., and Z. Reches, (1979) The Dead Sea rift: Geophysical, historical and archaeological evidence for strike slip motion. *Eos, American Geophysical Union Transactions*, 60, 18, 322.

Nur, A., and H. Ron (1996), The walls came tumbling down: Earthquake history of the Holy Land. In: (S. Stiros and R. E. Jones, Eds.), *Archaeoseismology*, 75–85.

Nur, A. and H.Ron (1997), Armageddon's earthquakes. *International Geology Review* 39, 532–541.

Rose, Mark (1998), Godzilla Attacking Babylon?
Archive.archaeology.org/online/features/Godzilla/

Sedgwick, A., (1831), Address of the President, Proc. Of the Geological Soc. Of London

Sintubin, Manuel; Jusseret, Simon; Driessen (2011), Reassessing Ancient Earthquakes on Minoan Crete – Getting rid of Catastrophism, 2nd INQUA-IGCP-576 International Workshop on Active Tectonics, Earthquake Geology, Archaeology and Engineering, Corinth, Greece Jan, 2011

Toynbee, A. J., (1939) Study of history. Vol. 4 London: Oxford University Press

Velikovski, (1950), *Worlds in Collision*. New York

Whewell, W., (1832), Review of Lyell, 1830-3, vol. ii, *Quarterly Review*, 47, 103-132