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An Integrated Model for an Earthwide Event at 2300 BC

PART III: THE GEOLOGICAL EVIDENCE

Article from Chronology & Catastrophism
REVIEW Vol. X, 1988 - Editor: Bernard Newgrosh
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An Integrated Model for an Earthwide Event at 2300 BC

PART III: THE GEOLOGICAL EVIDENCE

by

M. M. MANDELKEHR

Introduction

The evidence presented in this article is the next step in assembling a pattern of data for determining the nature of an event that may have happened 4300 years ago. The themes of the previous two articles, dealing with archaeological and climatological evidence, were fairly self-consistent, demonstrating the effect that a changing climatic environment can have on the geographic rearrangement of cultures. The geological evidence in this chapter also provides good support for the postulated 2300 BC event. There is much data indicating that Earth may have undergone some sort of geological perturbation at that time, and I propose to discuss it under the following headings:

1) initiation of crustal movements
2) global sea level discontinuities
3) earthquake activity
4) a unique volcanic eruption pattern
5) a transient in the geomagnetic field, and
6) a transient in the atmospheric radiocarbon level

The primary dating method for geological deposits under 50,000 years old is radiocarbon dating. Radiocarbon measurements are performed on marine organisms along boundaries of oceans, lakes and rivers, on organic material adjacent to volcanic tephra (dust) or lava, and on organic material associated with objects undergoing thermoremanent magnetism measurements.

As in the earlier articles, all of my radiocarbon data is expressed in calendar year dates, either obtained directly from my sources or derived from radiocarbon dates using dendrochronologic conversion tables based on the accepted conventions of a 5568 year carbon-14 isotope half-life, and AD 1950 as the zero time reference [1]. Chronological data is presented in figures designated in either radiocarbon or calendar years, just as in the climatology article. The calendar year 2300 BC point appears in each figure.

Crustal Movements

The most significant aspect of the geological evidence is the crustal movements that apparently began at about the same time around 2300 BC at many regions on the Earth. These movements may have been detected by sea level changes along the boundaries of land areas, or by inland hydrological changes resulting in the shifting of natural water channels. The global nature of the reported crustal changes is shown in Figure 1, where shaded areas indicate regions of change. In almost all cases, the notion of crustal tilting or deformation is that determined and expressed by the investigators, rather than being interpreted or surmised by myself.

I will start with one of the better documented areas - the eastern coastal region of North America. Several teams of geologists [2] have independently concluded that the Atlantic coast of the United States encountered differential warping starting some time around 2300 BC. Figure 2 shows calibrated recorded measurements of coastal relative sea level at three geographical regions along the coast. Before 2300 BC, the sea level rise was about the same for the three regions. At 2300 BC, there was an apparent localised coastal uplift in the central eastern region followed at later times by localised uplifts in the other regions to the north and south of the central region. Each uplift is not a sudden change in vertical position, but a change in upward rate of movement. It is reflected in the curves as a decrease in the rate of sea level rise relative to the coast. One thing is certain. The three regional discontinuities, separated in time from each other by several hundred years, are not explicable in terms of global sea level change. Furthermore, the rate of relative sea level change after the uplift was not the same for the three regions. This view point is specifically stated by at least one source [3].
Further evidence for crustal deformation in this region is provided by a reported coastal sea level change at Vera Cruz, Mexico, 1600 kilometres southwest of Florida across the Gulf of Mexico. There are abundant cultural remains of a large occupational area, approximately one kilometre in length, of the Palo Hueco Phase on an island in the river delta. This culture has been determined to have occupied the island from about 4000 BC. The entire Palo Hueco Phase was found to be sealed throughout its extent by a culturally sterile sand cap after 2400 BC, apparently corresponding to a major inundation shortly after that time. The cultural remains above the sand cap are dated at about 1700 BC, indicating the length of time before being occupied by a new culture [4]. The conclusion reached by the investigator was that the Mexican coast experienced a long term subsidence at the same time that the Florida region apparently underwent uplift.

Fronting the ancient shoreline at Pampa las Salinas, on the north-central Peruvian coast, is a series of nine beach ridges extending 5 kilometres to the west. These ridges originate at the mouth of the Santa River and consist of longshore current deposits of marine sand and river cobbles. It has been suggested that these beach ridges represent lateral accretion associated with major El Nino events, possibly accompanied by episodic tectonic uplift and/or sea level lowering. The El Nino phenomenon has been described in the climatology article as a catastrophic configuration of atmospheric and ocean current flow. A radiocarbon assay on a mollusc specimen, corrected for known lower radiocarbon levels along the coast, provides a data of around 2300 BC for the oldest ridge west of the shoreline [5], possibly representing the initial El Nino event.

Interestingly, the nine ridges emanate from two foci at their southern terminus, with the two foci interpreted as river mouths. One focus appears to correlate with the older group of ridges while the other correlates with the younger set. From the dating of the ridges we may deduce a date for a geological event which caused the shift in river mouth location. The tectonic event can then be dated to about 100 years after the El Nino initiation. Moving to the European region, a set of curves [6] is shown in Figure 3 for measurements in the Thames Estuary (S. E. England) and the southwest coast of Wales. The two curves rise irregularly but approximately equally until about
2500 BC at which point the sea level rise rates diverge, indicating a crustal downwarping as concluded by the investigator.

There is also evidence of crustal warping along the Nigerian coast around the time period of interest. Dead coral thickets on the Nigerian continental shelf testify to the growth of coral up to about 2400 BC. The coral grew at a depth of about 40 metres in a horizontal layer where the sea temperature was suitable for its growth: this coral growth apparently occurred during a period of stable sea levels which lasted until about 2400 BC. At that time, downwarping of the region plunged the coral into lower, colder water in which the coral could not survive. Evidence indicates that the coral level dropped 15 metres, an unusually large drop in geological terms, in the first 1000 years after 2400 BC. Furthermore, a differential subsidence of the order of 15 metres along the coast has also been determined. The tilting or warping of the coast allowed some of the coral to live after other thickets further along the coast died from lower temperatures at lower depths [7].

A comparative study was conducted on sea level changes at three locations along 170 kilometres of southwestern Australian coast. As shown in Figure 4, the sea levels at each of the sites are markedly different, leading to the conclusion that local tectonic processes occurred. Of the greatest interest is the abrupt sea level drop at 2300 BC at Leschenault [8].

The West Caroline Islands, just north of New Guinea, exist on a tectonically unstable ridge. Two of the islands in the group, Koror Island and Babelthuap Island, are separated from each other by the very narrow Toegel Channel. A somewhat unusual pattern of tectonic behaviour is reported for these two islands. Koror apparently experienced crustal subsidence at an increasing rate from about 4300 BC, reaching a rate of about 6 metres per thousand years at about 2000 BC. On the other hand, Babelthuap seems to have been fairly stable from 6000 BC. Starting at about 2000 BC, both islands have been determined to have undergone uplift, with a total 2 metre cumulative to present. The authors comment that sedimentation might have been a contributor to the measurement, but that they favour tectonic processes as the causal factor [9].

Isostatic uplift of the Vestfold Hills along the coast of Antarctica south of the Indian Ocean also occurred about 4000 years ago. The date was determined from radiocarbon dating of shells in the previously submerged dunes [10].

So far, I have discussed possible crustal movements everywhere other than the area where the extensive site destruction and abandonment occurred about 2300 BC; this area extends from Greece and Anatolia (Turkey) to the Indus Valley in northwestern India. Evidence of crustal movements in these areas could be an important link to the earthquake site destruction and cultural disruption.

The first of these areas to be reviewed is India and the surrounding region as pictured in Figure 5. As was discussed in the first article, the transition point between the pre-Harappans and the Harappans in the Indus Valley is dated at about 2300 BC. The Harappan culture, although very advanced, did not last more than about 500 to 600 years. There has been considerable speculation on the causes of its fairly rapid decline and termination.

Site excavations in this region produced remarkable evidence. Mohenjo-daro, a major Harappan city, was found to have seven occupation levels, separated by unusually thick layers of fine silt. In one case, the silt layer thickness between occupation levels was two metres. The earliest occupation level was found 30 metres below present surface level. There is evidence that the Harappans struggled against the encroaching mud, at one point constructing huge mud-brick platforms [11]. Based on excavations in the region, there is evidence that other lower Indus sites were also affected by silting [12]. All indications are that the
Harappan civilisation was ultimately wiped out because of silt gradually covering their settlements. The current position on the subject is that it is highly likely there was an uplift or series of uplifts around 2300 BC that interfered with the flow of one of the branches of the Indus and caused annual shallow flooding over a fairly wide area. This shallow flooding caused deposition of silt that would normally be carried to the sea [13].

The hypothesis of an uplift in the Indus Valley is strengthened by a similar event in a marshy salt plain called the Little Rann of Kutch, located about 250 kilometres southeast of Mohenjo-daro. The sedimentation in this area is characterised by a sandy layer extending from about 7000 to 2200 BC, overlain by a silty clay layer dating from 2200 BC to 500 AD [14]. An associated report is that the Saurashtra coast, just south of the Rann of Kutch underwent uplift some time around 2500 BC. The investigator based his finding on radiocarbon dating of coral reefs and fossil beach deposits along the coast [15]. The sedimentation stratigraphy is very likely a result of the uplift. The sedimentation dating provides a more precise date for the Saurashtra uplift, and correlates well with the Indus Valley uplift.

There is a serious speculation that, at the same time as the uplift at 2300 BC, the sea may have extended into a region in the southern Indus Valley. This speculation is based on the absence of Harappan sites in that region despite a very extensive search; and the strange distribution of other Harappan sites not located near the coast or near rivers. These sites appear to be located around the periphery of an area that might have been flooded at that time [16]. Lothal, a Harappan southern coastal city, was found to experience a first major flood about 2350 BC. Despite rebuilding of dockyard and other structures, repeated flooding apparently occurred until 1900 BC when all buildings were destroyed, and there was a virtual end to site occupation [17].

About 500 kilometres to the northwest of the Indus Valley is the Sistan region, located approximately on the border between Iran and Afghanistan. It was in this region that the Hilmand culture expanded and flourished until its decline at about 2200 BC. Two sources speculate that the depopulation at about 2200 BC was caused by a crustal movement that shifted the location of rivers in the region [18]. The combination of worsened hydrological conditions and the drier climate at that time turned the region into desert.

The possibility of tectonic movements is further strengthened by reports of similar hydrological changes in the Tezden delta, located in Turkestan, just across the northeastern Iran boundary, about 700 kilometres almost due north of the Sistan delta. Some time around 2300 BC, the Tezden delta started silting up, and established water channels apparently changed their courses. The river delta shifted considerably to the south. The investigator came to the conclusion that 'undoubtedly, the river suffered a great hydrological pressure under neotectonic phenomena in the Turasian plain.' The region was completely deserted at this
time, with the population moving to new sites. This movement coincides with the designated cultural change from Namazga III to Namazga IV [19].

Another region is the Uzboi valley, supported by the Amu Daryu river, about 500 kilometres to the east of the Tezden delta. This valley was also reported to have been affected by hydrological changes before 2000 BC, and was also deserted. There were apparently no new settlements in this region for 2000 years [20].

Possible crustal movements reported in the Mediterranean area are summarised in Figure 6. A significant crustal deformation may have occurred around 2300 BC along the eastern region of the Mediterranean Sea where a major portion of the Israeli coast was found to have been downwarped and submerged. This tectonic movement is considered to be part of a more regional process in which the coastal plain, shelf and slope of Israel were arched. About 1500 years later, a portion of the coast underwent uplift above sea level. The older marine shells collected at that time from areas that were previously submerged have been dated by calibrated radiocarbon measurements to about 2300 BC. This would indicate the most probable date for the initial crustal deformation and submergence, since the dating of the marine organisms represents the earliest time that the land was under water [21].

A relatively high general sea level starting about 2200 BC has been reported for the Mediterranean Sea [22]. This is counter to what would be expected from the onset of more arid conditions described in my previous article, and might be due to regional subsidence. The subsidence appears to be linked to the fairly sudden soil salinisation determined to have occurred in Mesopotamia shortly after 2400 BC [23]. The salinisation is thought to be the product of a rising water table relative to subsiding land.

The earliest mention of salinisation affecting agriculture occurs in the documents of Girsu, about 2400 BC. By 2100 BC, sporadic salinisation appears to be present throughout the region from the Euphrates in the west to the Tigris in the east. The situation can be dramatised by presenting records of that time of the proportion of wheat to the more salt-resistant barley. The percentage of wheat in the overall crops was 16.3 percent in 2400 BC, where salinisation was gradually increasing. It dropped sharply to 3.0 percent in 2300 BC, and then decreased to 1.9 percent in 2100 BC [24].

Radiocarbon dating of shell materials from beach deposits on the Persian Gulf coast shows a recent uplift on the western coast of Saudi Arabia, 15 kilometres north of Al Jubail. The time of the uplift is set at about 2300 BC by the dated material [25].

The last item is the crustal warping of Anatolia (Turkey) as indicated by three measured curves of relative sea level rise rates at various point on the Black Sea coast. The curves, shown in Figure 7, show dissimilar sea level rise rates starting some time around 2300 BC, indicating possible crustal warping [26].

Sea Level Changes and Glacier Activity

This area of investigation had two goals. Firstly, indications of unusual changes in sea level might be linked to geological disturbances. Secondly, a general pattern of sea level reduction could possibly result from glacier buildups. The
pattern, if it existed, would provide evidence complementary to the reported general cooler conditions on Earth starting at this time.

Although investigators have reached general agreement on early Holocene global sea level movements, no agreement has been reached on changes during the last 6000 years. The investigators are mainly divided into three groups, each one supporting one of the following theories on past sea levels:

- a) the sea level reached current level about 6000 BC,
- or
- b) the sea level slowly rose to its present level,
- or
- c) the sea level encountered a discontinuity c. 2300 BC

Each of the groups have valid curves with continuous dated measurements to support their own contention. Although I have only presented curves from the third group here, the other curves do exist, and appear to be equally valid. It is important to understand that the different sea level curves occur at different coastal locations. There is very little controversy among investigators over a given location.

The curves showing the discontinuities in the rate of rise of sea level around 2300 BC are shown in Figure 8. The curves represent a wide spread of geographical localities - Florida on the east coast of the United States [27], Brazil [28], the Netherlands [29], the Eastern Caroline Islands in the western Pacific Ocean about 1000 kilometres north of New Guinea [30], and New Zealand [31]. The curves show a common trend in that a relatively high rate of rise occurs prior to about 2500 to 2000 BC. The Earth ended a major ice age about 10,000 years ago, with the last of the glacier melting about 6000 years ago. The sea level rise after 6000 BC is considered to be the result of isostatic rebound of the ocean floors after responding earlier to loading due to the post-glaciation melting. The general sea level rise between 7000 BC and 2500/2000 BC is about 35 to 40 metres [32]. As can be seen from the curves, at about 2500/2000 BC there is a relatively sudden decrease in the rate of rise of sea level.

In addition to the graphical data reflected in Figure 8, investigations in other geographical locations also report similar local sea level discontinuities between 2500 and 2000 BC: United States northern Pacific coast [33], isthmus of Panama [34], France [35], Netherlands [36], southwest England [37], west coast of Africa [38], Trucial coast of Arabia [39], Japan [40], Oahu, Hawaii [41], French Polynesia [42], Australia [43], and New Zealand [44].

The sea level data from the various geographical regions fall into three sets as regards the discontinuities that occurred between 2500 and 2000 BC, typified by Figure 8 and the twelve reports. All reports except one (Gatun Basin, isthmus of Panama) refer to a maximum sea level at the time period of interest, described variously as (I) a sea level peak, or (ii) the end of a sea transgression, or (iii) the beginning of a sea regression. The end of a transgression or the beginning of a recession would be indicative of a local sea level peak. The Panama item is the only one that represents an acceleration in rate of rise in sea level at the time period of interest. The curves in Figure 8 together with 11 of the 12 items can be grouped into three sets. One set of data shows a discontinuity at about 2500 to 2000 BC, with a slower rate of rise to the present level. In the second set, the sea levels come up to present level and essentially stay at that level to the present. The third set shows a maximum at that time and then a decrease to the present level.

Insofar as the discontinuous curves are concerned, the first step is to recognise that they all have one thing in common - with the one exception - the rate of rise in sea level always decreases after the discontinuity. An argument might be made that there was a general global sea level change at that time, evidenced by a decrease in the rate of rise in sea level.

However, there appear to be three difficulties with the concept of a general global sea level change around 2300 BC causing the discontinuity in each of the curves.

A. The discontinuities do not occur at the same time but are spread over several hundred years. From the supporting detailed data, the divergence in dating is not simply a result of variation in radiocarbon measurements.

![Figure 8. Reported discontinuities in rate of sea level rise around 2300 BC (Illust. J. Abery)](image-url)
B. As earlier stated, discontinuities did not show up in all of the published coastal sea level curves. A number of authors report localised continuous sea level rise during the past 5000 years to the present level, or attainment of the present sea level a thousand or more years before 2300 BC.

C. The causal agent for the negative change in the rate of rise in sea level would be glacier build-up, which would take water out of the oceans and thereby decrease the rate of rise in sea level. Most authors who advocate a continuous global sea level rise relate the sudden decrease between 2500 and 2000 BC to glacier build-up at the beginning of the Sub-Boreal period when general conditions on the Earth became cooler. I have not found any author, however, that has provided factual substantiation of this build-up. I have come across two global surveys of glacier activity covering the last 5000 to 10,000 years [45]. Neither survey was able to detect any significant glacier synchronisation in the time period of interest, even though there was a recognition in both cases of a sizeable climate change about this time.

The obvious question that could be raised at this point is the extent to which an absence of unusual cumulative glacier activity would negate the possibility of the cooler environment covered in the article on climatology. One answer would be the large body of data supporting the global cooling, independent of glacier activity. A second answer would lie in the nature of the glacier phenomenon itself. Glaciers go through cycles of build-up, movement and recovery. There is general agreement amongst investigators in this field that whereas glaciers do respond to changes in climate, glacial movements cannot be used to obtain precise and unambiguous confirmation of a climate change.

Summarising, the sea level data presents a unique pattern. An explanation of the pattern has not been developed by the investigators in this field.

Earthquakes

Earthquake evidence is an important contributor to the event model, since it is a direct indicator of crustal disturbances on Earth, and therefore of unusual influences affecting the Earth.

As I stated in the first article, the dating of past earthquake events is essentially dependent on historical records and archaeologically determined structural damage such as cracked or slanting foundations and walls. In the first article, evidence was presented for earthquake damage at a number of sites destroyed at 2300 BC, e.g. the walls of Jericho. At many sites there was strong evidence of extensive and violent conflagrations, which normally occur as a result of earthquakes. Furthermore, continuing earthquake destruction for at least 200 years afterwards is reported by Schaeffer. The reported earthquake activity did not occur continuously, but rather on a recurring basis, allowing cultural growth in the intervening periods. This is consistent with expected earthquake behaviour.

The crustal deformations taking place about 2300 BC in the regions of site destruction provide strong support for earthquakes over a wide area occurring over an extended time period. Further confirmation is based on the proximity of the destroyed and abandoned sites to regions of recognised high seismicity. According to currently accepted theory, the Earth's crust is made up of a number of tectonic plates: major earthquake action usually occurs on or near the boundaries of these plates. All of the site destructions reported on in the first article lie along the Alpide zone, starting at the Mediterranean Sea and extending through Asia.

The high incidence of reported crustal movements in India, the Mediterranean and surrounding areas is largely due to the small size of the tectonic plates in the general Alpide region, and their consequent vulnerability to pressure.

Figure 9. Correlation between tectonic plate boundaries and the destroyed abandoned sites at about 2300 BC (Illust. J. Abery)
from the larger surrounding plates. The tectonic configuration in this geographical region is shown in Figure 9 where the tectonic plates are superimposed on the destroyed and abandoned sites delineated in the first article. Further confirmation of the high seismic activity coinciding with the boundaries and site locations is provided by a number of sources [46] based on relatively recent earthquake statistics.

The following points are made by these references:

i) There is an earthquake region running through Baluchistan (Pakistan) coinciding with the site destructions and the tectonic plate boundary in that region.

ii) There is a dense earthquake region to the southeast and southwest of the Mediterranean coinciding with the site destructions in Syria and Palestine, and the tectonic plate boundary extending through that region.

iii) There is heavy earthquake activity reported in most of Anatolia and Iran, complementing the site destructions in that region.

iv) There is also heavy earthquake activity in Greece, with greater density in the south, corresponding to the comparatively greater site destruction reported in the southern region.

The correlation between crustal plate boundaries, reported seismic activity and reported site destruction could be a fairly powerful indicator for earthquakes as a major cause of site destruction. It must be tempered to some extent by the fact that the majority of settlements around 2300 BC appear to be situated about the tectonic plate boundaries because of favourable geographic conditions. However, the pattern of tectonic boundaries and destroyed sites is still impressive.

**Volcanic Eruptions**

Recognising the link between the reported crustal movements and the evidence for possible earthquake activity over a wide geographical area around 2300 BC, the next step was to look for large scale volcanic activity that might also have occurred at that time. It did not take very long to discover that volcanic eruption data was pretty scarce in general, because of the difficulty in obtaining dating measurements.

Nevertheless, there appears to be some indication of greater volcanic activity around 2300 BC based on a recent study [47] involving the compilation of all known dated eruptions in the past. The investigators recognised from the data that the number of reports of volcanic eruptions decreased as a function of time in the past. They therefore generated a normalised reference base of expected volcanic eruptions. They then counted the actual 'observed' number of eruptions in the past. They therefore occurs in Figure 10 at about 2300 BC, although the plotting granularity would place it somewhere between 2200 and 2300 BC. With the exception of two peaks occurring within the last thousand years, the 2200 BC peak is the most significant peak over the last 8000 years. It should be remembered that the curve represents values referred to smoothed reference curve and are not absolute values. The more recent large peaks therefore do not necessarily indicate a higher volcanic activity.

The peak at 2300 BC could be a significant indicator of unusual volcanic activity, even if it represents only a moderate increase in volcanic eruptions. The obvious question arises as to why there was not a much higher volcanic activity commensurate with what appears to be extensive earthquake activity at about the same time. As in the case of the glaciers, the question may lie in the nature of the phenomena associated with volcanic eruptions.

A very general model can be developed comprising the gradual rise of magma from deep sources to shallow levels. This magma ascent process is apparently not affected to any great extent by external stimuli. There seems to be some degree of accord that an external stimulus becomes effective in triggering an eruption only when the volcano has achieved a state of readiness because of its own fundamental processes [48]. A reasonable hypothesis might be made that in the event that a geological transient did occur at about 2300 BC, it would have been able to trigger only that portion of the volcanos that had reached a responsive stage in their magma build-up. The peak at about 2300 BC in Figure 10 could then possibly be a significant indicator of unusual volcanic activity even though it represents only a moderate increase in volcanic eruptions.

The above line of argument might be supported by the detailed unique pattern of volcanic eruptions that appears to have occurred at that time, shown in Table 1. From 2470 BC up to (but not including) 2340 BC there are a known total of eight volcanic eruptions, approximately one eruption every 16 years. There is a cluster of eruptions dated at 2340 BC with a gap of 145 years between 2340 and 2195 BC when no eruptions at all occurred. The eruptions start again at that time at about the same rate: from 2195 BC to 2080 BC there are nine eruptions, or one every 12 years.

The pattern might be interpreted as follows. If the geological transient occurred around 2340 BC, it could have been sufficiently large to trigger a number of volcanos that were in the final stage of magma transfer and would normally have erupted during the following 145 years. This would explain the number of eruptions at 2340 BC as well as the absence of eruptions in the following period, and the continuation of eruptions in the following period.
Table 1. Chronology of Volcano Eruptions

<table>
<thead>
<tr>
<th>Location</th>
<th>Volcano</th>
<th>Calendar Date</th>
<th>Variance (Years)</th>
<th>Supporting Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>Pahala</td>
<td>2470 BC</td>
<td>±90</td>
<td>Charcoal in ash</td>
</tr>
<tr>
<td>St Vincent Islands, West Indies</td>
<td>Mt Soufrière</td>
<td>2455 BC</td>
<td>±300</td>
<td>Wood from mudflow deposit</td>
</tr>
<tr>
<td>France</td>
<td>Puy-de-Dôme</td>
<td>2455 BC</td>
<td>±110</td>
<td>Carbonised wood near volcanic ash</td>
</tr>
<tr>
<td>Southwest Alaska</td>
<td></td>
<td>2415 BC</td>
<td>±90</td>
<td>Volcanic ash</td>
</tr>
<tr>
<td>Washington State, US</td>
<td>Sand Mountain</td>
<td>2405 BC</td>
<td>±215</td>
<td>Charred root bark mixed with soil</td>
</tr>
<tr>
<td>Iceland</td>
<td>Hekla</td>
<td>2405 BC</td>
<td>±150</td>
<td>Sample underneath tephra layer</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Mauna Loa</td>
<td>2400 BC</td>
<td>±110</td>
<td>Thermoluminescence measurement on lava</td>
</tr>
<tr>
<td>Idaho State, US</td>
<td></td>
<td>2390 BC</td>
<td>±130</td>
<td>Material in lava flow</td>
</tr>
<tr>
<td>Hawaii Puu</td>
<td>Kinikini</td>
<td>2340 BC</td>
<td>±90</td>
<td>Charcoal fragments in volcanic ash</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Pahala</td>
<td>2340 BC</td>
<td>±70</td>
<td>Charcoal in ash</td>
</tr>
<tr>
<td>Japan</td>
<td>Mt Fuji</td>
<td>2340 BC</td>
<td>±130</td>
<td>Wood overlain by volcanic mudflow</td>
</tr>
<tr>
<td>Washington State, US</td>
<td>Mt St Helens</td>
<td>2195 BC</td>
<td>±250</td>
<td>Charcoal from within tephra</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Kilauca</td>
<td>2180 BC</td>
<td>±70</td>
<td>Charcoal beneath lava flow</td>
</tr>
<tr>
<td>Italy</td>
<td>Astoni</td>
<td>2180 BC</td>
<td>±130</td>
<td>Carbonised wood from crater</td>
</tr>
<tr>
<td>Northern Honshu, Japan</td>
<td></td>
<td>2170 BC</td>
<td>±180</td>
<td>Black soil layer between two volcanic ash layers</td>
</tr>
<tr>
<td>Thera, Cyclades, Greece</td>
<td>Akrotiri</td>
<td>2150 BC</td>
<td>±94</td>
<td>Carbonised ash and organic material</td>
</tr>
<tr>
<td>St Kitts, West Indies</td>
<td>Mt Misery</td>
<td>2100 BC</td>
<td>±140</td>
<td>Carbonised wood in ash layer beneath pumice layer</td>
</tr>
<tr>
<td>Japan</td>
<td>Kaimondake</td>
<td>2090 BC</td>
<td>±60</td>
<td>Taken from lowest part of ash fall</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Kilauca</td>
<td>2090 BC</td>
<td>±60</td>
<td>Charcoal in ash beneath lava flow</td>
</tr>
</tbody>
</table>

Geomagnetic Variation

The next category of evidence addresses the possibility that the event at 2300 BC included a geomagnetic transient. My investigations turned up several items of evidence that might point to a transient around 2300 BC.

The smoothed geomagnetic field variation has appeared to investigators in the past to have a cyclic variation. A number of investigators have come to the conclusion, however, that the cyclicity of the geomagnetic field apparently should be discounted [49]. The following statement has been made as part of the US National Report to the International Union of Geodesy and Geophysics 1979-1982 [50]:

For at least 40,000 years prior to 5000 BP, the dipole moment has generally been smaller than the present day value. A specific statement has been made that high dipole moments during the last 4000 years thus appears to be an unusual feature of the geomagnetic field, and speculations about 8000 year cycles in dipole moment must be discounted.

My investigations have yielded two types of data with no clear relationship between them. Cumulatively they provide an indication that something may have happened to the geomagnetic field some time between 2500 and 2000 BC.

The first set of data consists of three historical curves shown in Figures 12, 13 and 14. The geomagnetic intensity measurements were obtained at specific geographical locations from thermoremanent magnetism measurements on clay objects or lava; Czechoslovakia [51], Australia [52] and Japan [53] respectively. The measurements are plotted with respect to time along a general curve reflecting long-term dipole field variation. Time determination of the points is based on a combination of cultural synchronisation and radiocarbon dating. The three curves have something fairly unusual in common - they show an indication of a possible momentary transient in the Earth's geomagnetic field around 2300 BC.

A word of caution should be advanced on a limitation of the first three historical curves, representing individual geographical locations on the Earth. For each geographical area, the geomagnetic measurement is comprised of a localised rapidly varying non-dipole field combined with the slowly varying centralised dipole field existing on a global basis. Even though an interesting transient may appear on a localised basis, it may be an effect of the non-dipole field and not necessarily reflect a far more significant global event.

Now that the cautionary statement has been made for a single localised set of measurements, transients occurring essentially simultaneously at three widely spaced geographical locations may actually represent a global transient.

The time curve shown in Figure 14 is similar to the previous three curves. However, rather than consisting of measurements made at only one geographical location, the time curve was derived from a cumulative statistical treatment of measurements from a large number of locations on the Earth [54]. Again, a distinctive transient shows up at 2300 BC.

Figure 11. Historic curve of geomagnetic intensity in Czechoslovakia showing vertical spread of measured points around 2300 BC (J. Aber, after Bucha [51])
The second type of data is derived from thermoremanence measurements of kiln sites and fireplaces in Iran. From the measured values of inclination and declination, the drift in the virtual geomagnetic pole relative to the rotational axis was determined to follow the path shown in Figure 15. In the figure, the drift in the virtual pole exhibits a sudden change in direction at 2300 BC [55].

[Note : The two virtual geomagnetic poles define a dipole extending through the Earth, inclined about 11 degrees from the rotational axis. The dipole, in very simplistic terms, operates as a bar magnet to create the geomagnetic field. The dipole orientation has been found to vary with time.]
Summarising, a number of geomagnetic events appear to have occurred around 2300 BC. The closeness in time for the events is indicative of a cumulative geomagnetic transient. The individual reports are then outward manifestations of the transient.

**Radiocarbon Levels in the Atmosphere**

As part of my general investigation, I looked for transients in the atmospheric radiocarbon level around 2300 BC to obtain support for a geomagnetic transient occurring about that time. Since the geomagnetic field deflects incoming charged particles that create the carbon-14 isotope, a positive geomagnetic transient should result in a negative transient in the atmospheric radiocarbon level. The transient does exist, as shown in Figure 16, and is considerably larger that that which would be expected from sunspot activity [56]. Another investigator specifically references the transient [57]:

The irregularities in the correlation curve imply alternative dates for the measured discontinuities, with particular puts uncertainties on any samples from calendar dates of 2500-2100 BC.

**The Pattern of the Evidence**

Six aspects of geological evidence have been outlined above; crustal deformations, sea level discontinuities, earthquakes, volcanic activity, a geomagnetic transient and a transient in the atmospheric radiocarbon concentration. All of these elements are interesting and may be relevant to the model. The first two aspects, however, are by far the most important.

Starting around 2300 BC, there is a sizeable number of reports of differential coastal sea level changes and hydrological shifts in many regions of the Earth. The crustal changes in essentially all cases are only in the order of metres. However, the changes are definitely noticeable, and were responsible for major cultural changes. A large number of these geological events occur in the cultural regions of previously reported site destruction and abandonment. The crustal movements in some cases were probably a major causal agent for earthquake and site destruction. In other cases, the resultant hydrological changes made it impossible for the people to stay in the region. The geological evidence then establishes an associative link to the archaeological evidence as did the climatological evidence in the previous article.

It must be stressed that a great number of separate crustal movements occurred over a short time around 2300 BC. The relatively small magnitudes of the movements should definitely not be considered to be negligible: the number and global distribution of the crustal movements is unique in recent geological history, and forms a central body of evidence for something unusual happening at that time.

The pattern of changes in sea levels is not as explicit as the crustal movements in providing evidence of unusual geological disturbances. However, the sea level pattern is also unique in terms of the large number and global extent of the discontinuities. The sea level changes have not been able to be explained in terms of either general global sea level variations or glacial advances. Viewing these discontinuities against the background of geographical areas in which a discontinuity did not occur, the alternative explanations would be local tectonic processes. Since the tectonic processes produced discontinuities in the rate of rise in sea level which are negative in almost all cases, the discontinuity pattern may be a critical indicator of what may have happened to the Earth at 2300 BC.

The peak in volcanic activity at about 2300 BC is modest but significant. The absence of volcanic activity for 150 years following 2300 BC may actually be more important than the activity peak, in that it verifies the triggering of ready volcanos at that time. The 150-year pattern represents a personal speculation, and is not endorsed by a specialist in the field. As such, the viability of the pattern should be further assessed.

There are three manifestations of a possible transient in the geomagnetic field at about 2300 BC. They consist of sharp transients in local non-dipole fields, a noticeable transient in the cumulative geomagnetic field, and a discontinuity in the angular movement of the geomagnetic dipole. The negative transient in the atmospheric radiocarbon level also points to a positive geomagnetic transient. Together, they provide further support for a geological disturbance.

Summarising, there is a sizeable body of geological data that could support the 2300 BC event model, with crustal movements being the most important aspect, both in terms of the volume of existing evidence and potential correlation with archaeological events.

**References**

3. Redfield: *op. cit.* [2], pp. 690, 691; see also Newman, Rusnak: *op. cit.* [2], p. 1466
Northwestern North America and Patagonia", contained in F. N. Furness  
Niger Delta',  
Anthropologist  
Asian Archaeology  
Civilization', contained in R. Berger, H. E. Seuss (eds):  
Measurements I',  
36. J. A. Catt:  
R.  W.  Fairbridge   (ed):  
1983), pp. 314, 321  
37. H. Barker, C. J. Mackey: 'British Museum Natural Radiocarbon  
of Panama During the Past 12,000 Years', contained in A. Graham (ed):  
34. A. S. Bartlett, E. S. Barghoorn: 'Phytogeographic History of the Isthmus  
Caroline Islands',  
Irrigation Agriculture in Antiquity',  
Gofna: 'Recent Faulting Along the Mediterranean Coast of Israel',  
25. A. P. Ridley, M. W. Seeley: 'Evidence for Recent Coastal Uplift Near Al  
USSR in Relation with Processes of Sedimentation and Condition of  
50 (1971), pp. 706, 711  
20. J. A. Catt: 'Sitting of the Rann of Kutch During Holocene', Indian  
Journal of Earth Sciences 2 (1975), pp. 163, 188; see also S. K. Gupta:  
Holocene Sinking in the Little Rann of Kutch', contained in D. P. Agarawal,  
B. M. Pande (eds):  
Radiocarbon  
20. J. A. Catt: 'Sitting of the Rann of Kutch During Holocene',  
25. A. P. Ridley, M. W. Seeley: 'Evidence for Recent Coastal Uplift Near Al  
USSR in Relation with Processes of Sedimentation and Condition of  
50 (1971), pp. 706, 711  
20. J. A. Catt: 'Sitting of the Rann of Kutch During Holocene', Indian  
Journal of Earth Sciences 2 (1975), pp. 163, 188; see also S. K. Gupta:  
Holocene Sinking in the Little Rann of Kutch', contained in D. P. Agarawal,  
B. M. Pande (eds):  
Radiocarbon