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# Shakeup--cultural impacts of tectonic activity in ancient complex cultures

Eric R Force

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The following are the text and illustrations for recent talks I've given on this subject (see acknowledgments). For details and references see my book "Impact of tectonic activity on ancient civilizations" published by Lexington. I think the talk format has values of its own, so am getting it more widely available. I've also reordered the presentation from the book in order to emphasize the logic—an attempt to explore a "scientific method" for historical connections of this sort.

I'll begin by telling you the conclusion I've come to, so the rest can be structured as evidence. I think antiquity tells us pretty clearly that tectonic activity was a cultural stimulant in the long term, an agent of resilience and adaptation that resulted in greater cultural complexity. This conclusion is of course counter-intuitive, so skepticism is quite understandable. People tend to hang back on this, and so my logic has to be clear. It consists of five parts: spatial distribution, insufficiency of other factors, converse cases, kinetics, and dynamics.

Tectonics and culture---I like to use an analogy with a very expensive exercise program, both taxing and costly but resulting in a kind of cultural athleticism. Athletic tectonic communities have tended to lead the way in cultural development, and in so doing molded our cultural makeup. It's a significant part, I think, of how we got to where we are culturally.

I've also found that when industrialization and technology are stripped away from our modern world, we can see that modern instincts are still the same as in the ancient world, and that our long-term responses to tectonic events follow the same paths. So it's wise to understand the dynamics at work here.

The spatial distribution data begin with figure 1, in which I have plotted the on-land tectonic plate boundaries of the eastern hemisphere and the originating sites of conventional "great ancient civilizations." You may not like this term; I don't either, but it does mean something in terms of cultural complexity. I prefer to think of these as antiquities' most athletic cultures.

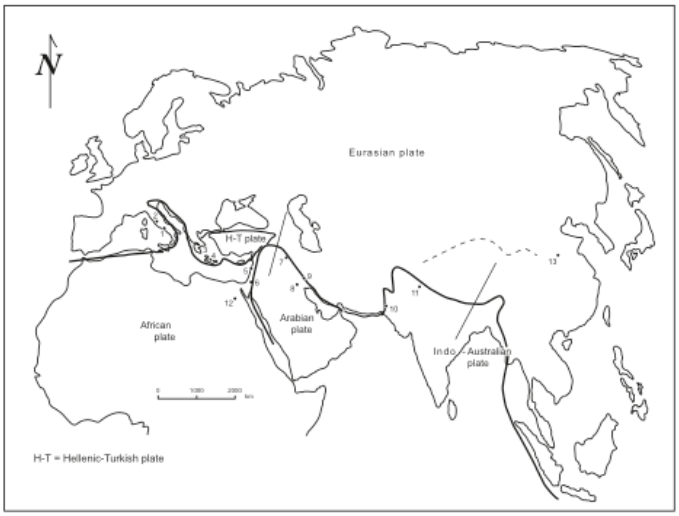


Figure 1.--Map locations of original sites of thirteen prominent ancient complex cultures of the Eastern Hemisphere relative to plate boundaries. Numbered cultures (and sites) are 1 Roman (Rome), 2 Etruscan (Tarquinia and Veii), 3 Greek (Corinth) and Mycenaean (Mycenae), 4 Minoan (Knossos-Phaestos), 5 and 6 SW Asian (Tyre and Jerusalem), 7 Assyrian (Ninevah), 8 Mesopotamian (Ur-Uruk), 9 Persian (Susa), 10 Indus (Mohenjo-Daro), 11 Aryan India (Hastinapura), 12 Egyptian (Memphis), and 13 Chinese (Zhengzhou). Dashed line represents the Altyn Tagh-Qinling escape structures. Straight lines are cultural/tectonic transects.

It's a pretty amazing spatial correspondence, eh? The average distance from dot to line is only 125 km. The chance of this being random is one in several millions or even billions, depending on your assumptions. I've varied the assumptions to provide sensitivity analyses.

Ancient China is a special case, quite consistent in one way because of the Altyn Tagh-Qinling escape structures shown dashed—plate boundaries in-process. With that in mind, Egypt becomes the main probability outlier.

The straight lines are transects across tectonic boundaries, shown in figure 2. Two transects are plotted here, one of them for two different periods of antiquity, centered on the southern boundary of the Eurasian plate (of fig. 1) and extending out about a thousand kilometers into tectonically quiescent territory, to give these transects a sort of continental scale. On this horizontal axis the tectonic boundary is always plotted in the middle at zero no matter where the cross-section is taken. On the vertical axis is plotted cultural complexity as scored in the manner of Gordon Childe. These are classic criteria for cultural complexity—rather common-sense ones I feel, like cities, specialization, monumental public architecture, record-keeping, arts, and trade.

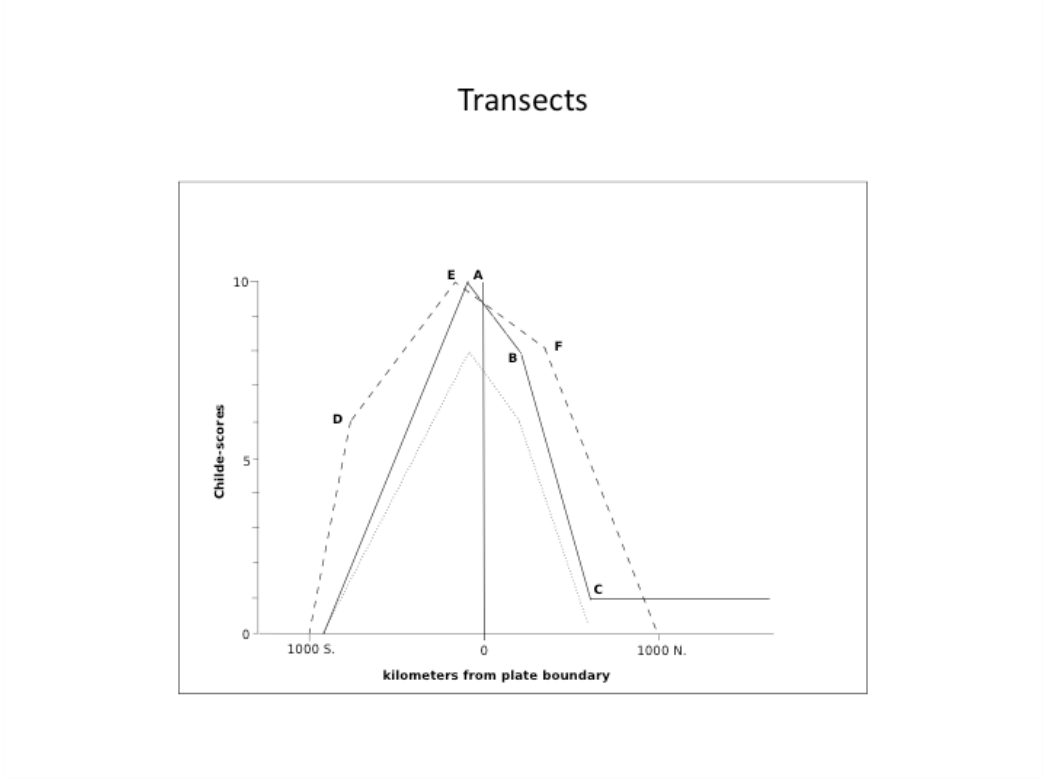

Figure 2.--Examples of continental-scale transects across some plate-tectonic boundaries showing cultural complexity in antiquity as quantified in terms listed by Gordon Childe. Superposed transects are normalized to approximate locations of plate boundaries; measurement relative to tectonic boundary is to originating site of each culture where known. Solid line is for western Asia in the 900-700 B.C. time period; dotted line is the same transect in the late Bronze Age. Lettered localities for that transect are: A, Assyria; B, Urartu; and C, Cimmerians and Scythians. The dashed transect is south Asia in the AD 400-600 period, with: D, Kalinga; E, Patna area of Guptan empire; and F, the Brahmaputra-Llasa valley of Tibet.

The point is that cultural complexity as measured by conventional criteria shows maxima near tectonic plate boundaries, where tectonic activity is greatest. So the most complex cultures evolved just where seismic damage was most frequent. The results are not sensitive to exact position, nor to time period; I've tried other plots and they end up looking similar.

Clearly, tectonic activity did not hamper cultural complexity, strange as that might seem. We should expect that this hemispheric distribution has corollary scenes at the scale of individual cultures, and I think we do--in several cases. For this talk I'll focus just on the Hellenic world. Figure 3 is the back side of the Lions Gate at Mycenae—not a picture you see often—to show the slickensided young fault plane on the far side. This particular fault clearly moved before construction of the gate, but others in the gorge behind the site moved during Mycenaean times and must have caused earthquakes.

Figure 3.—Back side of Lions Gate at Mycenae, showing slickensided fault plane on other side.

Greece has several different types of tectonic boundaries, and each of them in antiquity had its own cultural history. Figure 4 emphasizes the trend of Mycenaean palaces along the extension of the North Anatolian fault zone, a transcurrent fault analogous to the San Andreas fault of the western U.S. In fact these palaces were destroyed by earthquakes along the zone. So even at the scale of this individual ancient culture, a spatial correspondence of tectonism and cultural trends is apparent.

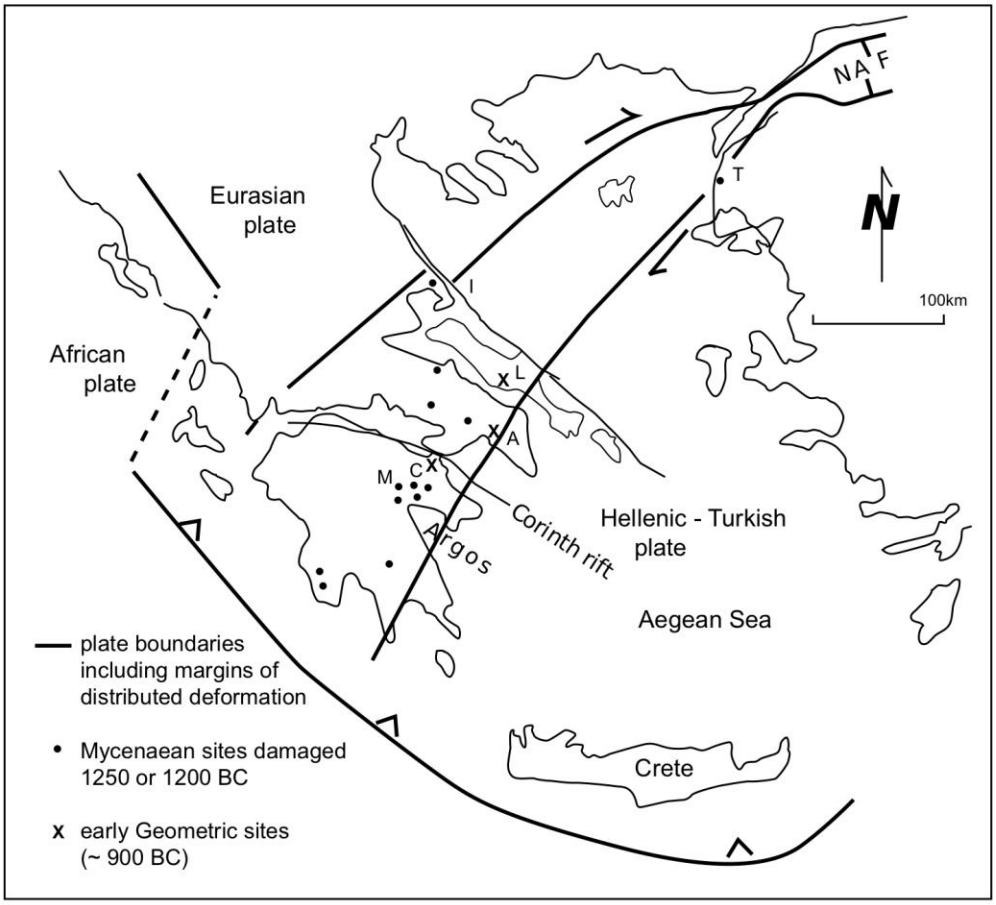
NAF
T
Eurasian plate
N
100km
I
African plate
L
A
C
M
Argos
Corinth rift
Hellenic - Turkish plate
Aegean Sea
Crete
plate boundaries including margins of distributed deformation
Mycenaean sites damaged 1250 or 1200 BC
x early Geometric sites (~ 900 BC)

Figure 4.--Ancient Mycenaean palace sites destroyed by earthquakes in 1200 or 1250 BC relative to approximate boundaries of distributed deformation along the projection of the North Anatolian fault (NAF) in the Hellenic realm. The distribution of destroyed Mycenaean palaces, with only a few exceptions, includes all the palaces of that civilization, suggesting not only ancient tectonic activity along this structural trend, but also the localization of Mycenaean civilization along it.. Localities: A, Athens; L, Lefkandi; C, Corinth; M, Mycenae; T, Troy; I, Iolkos (near Volos and Dimini).

Parenthetically, evidence like this of location and time of ancient seismic activity is an important ingredient in constructing maps of seismic risk today. So you get geologists like me combing through ancient literature and excavation reports.

Well, the spatial evidence of a connection between tectonism and cultural complexity looks strong—at several scales. But how do we know that some other factor isn't the REAL one here? Something we knew all along, like climate, coasts, rivers, soil, water supply, or minerals. And of course they ARE important; in general they are requisites for complex cultures. I have to show that these other factors can't work just as well as tectonism in producing the observed distributions.

I find that these requisites constitute necessary but not sufficient factors to explain the spatial distribution. In other words, adding tectonism to the mix does the job, and no other factor or combination of factors does; they are insufficient. Rather than recite my whole chapter 15, I think for this audience I'll just pick one important factor as an example-- coastlines. These are clearly important for trade connections in the ancient world. If you look at figure 1 again, though, you'll see that not all Mediterranean or Black Sea shores were equally propitious. The complex cultures tended to follow the tectonically active shore. I've done probability calculations of several sorts on this as well as the other requisite factors. They show that adding tectonic position greatly improves the correlation in every case. That is, both tectonics and the requisites are needed to provide both necessary and sufficient conditions.

You may also notice in figure 1 that derivative complex cultures as opposed to the primary hydraulic ones (Egypt, Mesopotamia, Indus, China) show the closest spatial relation to tectonic boundaries. This suggests a role of trade.

The work of Nicholas Coldstream helped to reconstruct incremental snapshots of trade propagation in the Mediterranean in the Greek Geometric period (figure 5). Note that this propagation mimics the shape of the tectonic southern boundary of the Eurasian plate, on both land and sea (fig. 1)—even the double-catena shape in the eastern Mediterranean. Stone anchor distribution verifies these island-hopping routes. Derivative civilizations (Phoenicia to Greece to Etruscan, for example) tend to originate along the tectonic trade routes. That's a clue to the kinetics of the relation.

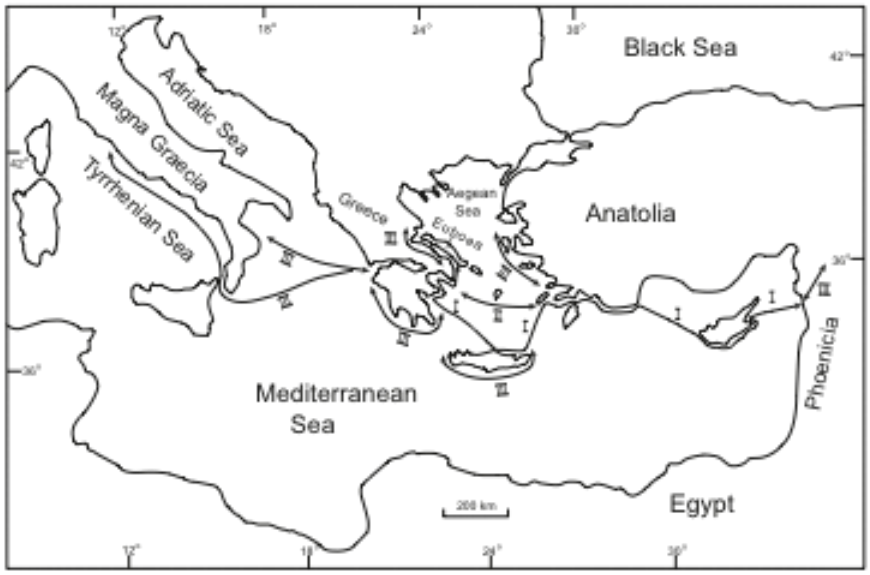


Figure 5.--Map of progressive trade-route extension from Phoenicia, then Greece in the Geometric period (900-700 BC). Symbols: I refers to trade in Early Geometric I, II to Early Geometric II, and III to Middle Geometric—each shown as additional routes (the preceding ones still active).

It appears that tectonic-boundary cultures are most responsive to influences of trade. In contrast, trade routes that project into tectonically quiescent cratonic interiors do not spawn super-complex cultures. In fact the ages of ancient cultures in some such places are defined by trade goods that originate in tectonic-boundary cultures.

This in turn implies that tectonically quiescent cultures were more static. There must be a better way to look into that, but figure 6 is what I did. If I use as a metric the length of time that a complex culture remains essentially the same, there is a fairly clear relation to tectonic environment. The cultures that remain the same for thousands of years tend to be farther from tectonic

boundaries. Thus the main converse case is covered; tectonic-boundary cultures are systematically more dynamic. Perhaps their complexities arose as a result.

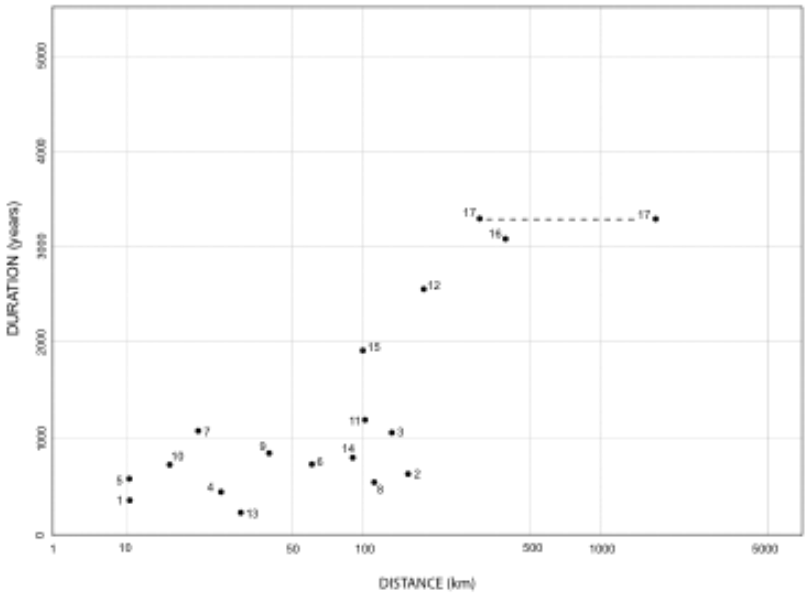


Figure 6.--Semi-logarithmic plot of the duration of ancient complex cultures plotted against the approximate distance between originating sites and tectonic boundaries. Numbered cultures are: 1, Carthaginian; 2, Etruscan; 3, Roman; 4, Mycenaean; 5, Greek; 6, Minoan; 7, Trojan; 8, Hittite; 9, Phoenician; 10, Hebrew; 11, Assyrian; 12, southern Mesopotamian; 13, Achaemenid Persian; 14, Indus-Saraswati; 15, Aryan Indian; 16, Egyptian; 17, Chinese (shown two ways).

By now we've seen a remarkable spatial correspondence of ancient cultural complexity and tectonic activity, I've shown that other factors don't do the job, and we've seen that trade propagation versus cultural stasis are involved. In other words we have evidence from distribution, necessity versus sufficiency, a converse case, and kinetics linking cultural complexity and tectonic activity. But how does it actually work; what are the cultural dynamics?

A few of the clues can come from archaeology. Klaus Kilian presented a chronology of destruction levels at Mycenaean Tiryns (figure 7), three out of four corresponding with a new pottery style (or three out of five styles corresponding with destruction levels). Well, such ceramic punctuation occurs with modern earthquakes, too -- all the broken pots are replaced with the current style. The cultural implications are modest, but do imply great

tenacity in inhabiting a favored site despite the need to rebuild. We see the tenacity theme repeated again and again.

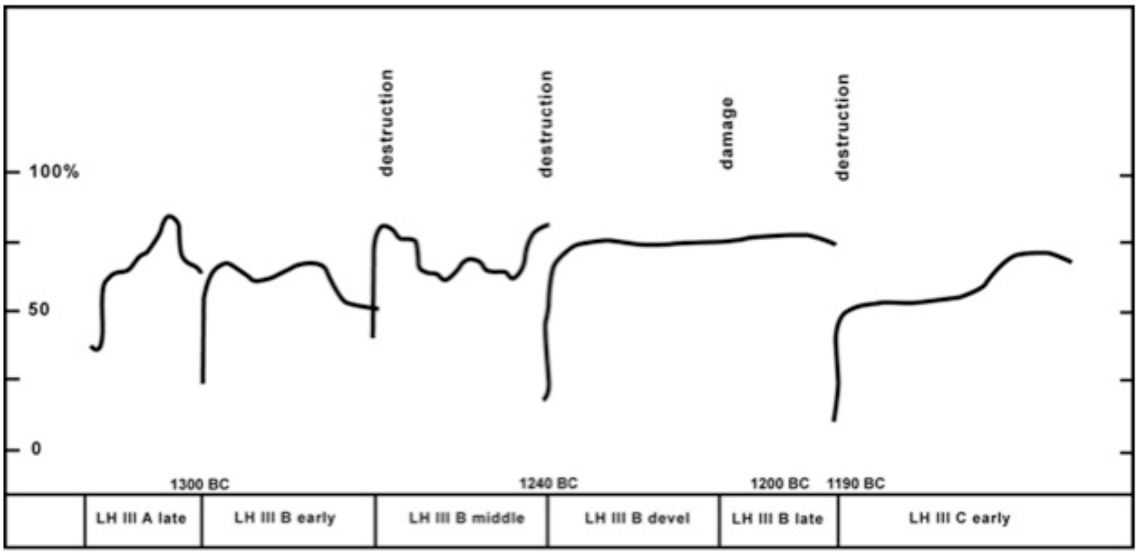


Figure 7.—Seismic destruction levels plotted against abundance of new pottery styles at Mycenaean Tiryns.

We can also see an evolution of methods to make continued occupancy possible (figure 8). These dog-bone-shaped slots accommodated bronze keys wrapped in lead to impart both strength and cushioning between blocks.

Figure 8.--Photo of "antiseismic devices", i.e., channels in stone foundations and column drums, in order to accept dog-bone-shaped bronze pins, wrapped in lead, that link two stone blocks. The example shown here is from Hadrian's library in Athens. Examples earlier than about 400 BC had more rudimentary devices.

How do we know what these discontinuities mean in cultural terms? At some sites we know more about, we see tenacity recorded in historic context. Figure 9 is Delphi, showing architecture before (Archaic wall below) and after (temple ruins above) the 373 BC earthquake. For this we have a voluminous literature with several tectonic chapters.

Figure 9.—Archaic foundation of the Temple of Apollo at Delphi, surmounted by Doric columns of a younger temple built atop these foundations after the earthquake of ca. 373 B.C. The younger temple was itself damaged by an earthquake of ca. 86 B.C. Delphi is at an intersection of NAf and Corinth-rift faults (fig. 4).

Ancient literature can clarify how cultures dealt with earthquakes, and two cultures have voluminous literatures on the subject. Greek mythology and literature is full of earthquakes—Aeschulus, Herodotus, Thucydides, Euripides, Aristotle, and many Greeks of the Roman era. Several thought earthquakes were important in cultural evolution—Herodotus and Thucydides each had a favorite earthquake to divide Greek history into

segments, but picked different ones. Thanks to the Greek drive to understand nature, we see an evolution in their history from Poseidon fitfully causing earthquakes, eventually to Thucydides giving an essentially modern explanation of how tsunami work (figure 10).

- "The cause in my opinion of this phenomenon must be sought in the earthquake. At the point where its shock has been the most violent, the sea is driven back, and suddenly recoiling with redoubled force, causes the inundation."

Figure 10.—Thucydides on tsunami (from his History III (xi) 89)

The record of earthquakes in Hebrew literature is even more striking. The bible records its own evolution of earthquake description, eventually of manipulation by zealous prophets threatening the next earthquake if people don't take the next step of reform. Zechariah, seemingly the smartest one, craftily forecasted the correct sense of ground motion for the local boundary between African and Arabian plates (figure 11). But even this is not in terms of natural process, and it's the only Biblical passage I've found that's even vaguely scientific. Overall, the prophets racheted observance toward the God-FEARING religion we can still find in Judeo-Christian traditions. A sort of cultural evolution, I suppose.

- And (the Lord's) feet shall stand that day upon the Mount of Olives . . . And it shall cleave in the midst thereof . . . And half of the mountain shall remove toward the north, and half of it toward the south.

Figure 11.—Zechariah 14: 4-5 (KJV)

Both the Greeks and Hebrews show us the deep roots of tectonism in their cultures, and an evolution in how those roots took hold. But here's another way to look at it: these same two cultures that provide the most literature evidence are also those that most influenced our modern western culture. So in some ways we inherit tectonically-molded attitudes.

The modern world would seem to have little resemblance to these ancient responses. But the economic literature has focused on recovery from seismic events in our world, and to lesser extents the philosophical and psychological literatures have too. Several modern political upheavals were catalyzed by tectonic activity, and sometimes these look remarkably similar to those in the ancient world—compare Sandinistas to Spartan helots, both breaking off with an earthquake. Religious responses have also been common in both the modern and ancient worlds. These too can look remarkably similar—compare Pat Robertson to Jeremiah or Zechariah.

So the behavior of our world does give some clues to responses to tectonism in the ancient world. No-one would dispute that in the modern world the responses are cultural. It's not a pretty sight to individual victims, of course. That's probably why so many of the upbeat descriptions are by economists, not anthropologists.

In the modern world a lot of this response takes a different path, along plate margins around the Pacific--and not just California and Japan (figure 12).


Figure 12.—New Zealand Herald, Mar. 2014 (three years after Christchurch earthquake)

Literature vignettes and modern evidence do flesh out the distribution and kinetic information, and help us see what the links look like. The dynamics they suggest take the shape of an evolution of responses to change.

There seem to be different types of cultural response with different tectonic environments. Figure 13 is a simplistic cross-section of a typical subduction-type convergent tectonic boundary. For the culture on the left, the response is to seismicity, whereas to one in the middle it is a mostly a response to volcanism. For the culture to the right, there is no response; they do everything just like they always did.

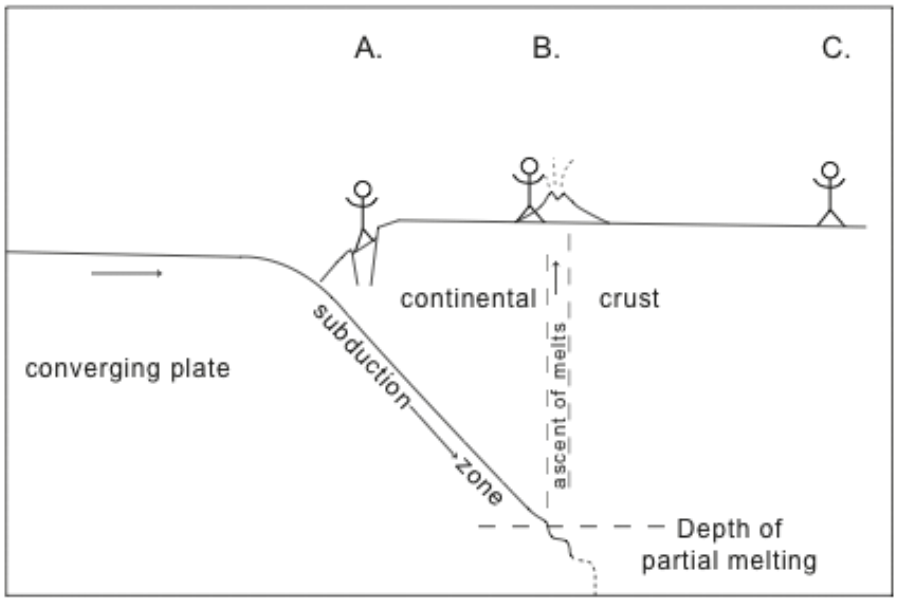


Figure 13.--Diagram of converging tectonic plates showing subduction, melting, and volcanism, along with apparent cultural tendencies in antiquity. Site A is most seismically active, site B is mostly volcanic, and site C is quiescent.

The guy on the left sometimes has earthquake gods, whereas the guy in the middle has volcano gods. In such cases two tracks of response (projecting into the diagram), especially religious response, can be recognized along the same tectonic boundary. But this diagram is just a simplistic view of one type of tectonic boundary.

An aside—the guy on the left may be drinking an anomalous water, especially if the dip of the tectonic boundary is steep. Faults that penetrate the whole crust of the earth carry water with anomalous isotope values in their voluminous springs. If the difference is preserved in skeletal material, we could begin to quantify tectonic effects.

We've now seen several lines of evidence that connections between tectonic activity and cultural complexity were direct, and basically cultural. I've tried to come at the question from several independent angles. Starting with the modern world where we can see that the responses to tectonism are cultural; in the ancient world stasis vs. dynamism is a cultural contrast; trade was driven by cultural imperatives; the ancient literary descriptions are in cultural terms; and of course the transect geometries are culturally defined.

Exactly what is the pertinent cultural factor? The most obvious one is that tectonism forces the pace of change, eventually resulting in a culture with built-in resilience. We've actually seen this in ancient literature, architecture, and receptivity to trade. We can expect that tectonic-village elders would not be telling their youngsters that old ways are best, like they do elsewhere, but to be prepared for change. There is a tendency for tectonic communities to be dynamic—or athletic—or environmental opportunists.

I suspect that the relation of event recurrence interval to generational succession produces a threshold factor. In other words if event recurrence is too long, people will have forgotten (figure 14). Where recurrence is longer than two generations, elders who remember have passed on. This might be especially so in pre-literate societies. I speculate that short recurrence intervals best correspond to accelerated change.

•"*Natural calamity strikes at about the time when one forgets its terror*"
Figure 14.—Traditional Japanese proverb

I also wonder whether tectonic communities are systematically different from quiescent communities, whether or not they qualify as great civilizations. This seems a promising avenue for anthropological research.

So it looks like tectonism has helped to mold our cultural makeup. Realizing this should be useful in new ways-- dealing with long-term aspects of disaster recovery for example. Archaeologists address the subject via the field of archaeoseismology but anthropology has generally focused only on short term responses--except to volcanism and tsunami.

Incidentally, there's evidence from earlier periods in hominid history that implicates tectonism--along with other factors. So earth's basic machinery has been a factor in both our physical and cultural development, and still is to some degree in our own complex culture.

The logic behind my presentation here consists first in showing that tectonism is necessary for a complete explanation of the spatial distribution, then that the converse case looks very different, then that we can see this unfold kinetically, and last that several ways of looking at the dynamics show us that the relation to tectonism is cultural, and has to do with response to change. This suggests new ways of looking at antiquity, and at the modern world through the evidence from antiquity.

I think the logic is pretty tight considering these historical connections are untestable in the strict sense. There are more aspects of my hypothesis that are indirectly testable--I'm doing one such test now, and I'd like suggestions for others. But in the meantime it looks like tectonism accelerated change in some ancient cultures, and those were the ones that systematically contributed far more than quiescent cultures in leading the way into our own cultural trajectory.

Acknowledgements—The talks on which this manuscript is based were delivered at the American Institute of Archaeology in Tucson AZ, Feb. 2016, and the Society for Applied Anthropology in Vancouver BC, Apr. 2016. The time for delivering the former was far greater, and this manuscript generally follows its format. References documenting illustrations and text appear in my book.