Toward a New Understanding of the Alignment of Ancient Egyptian Sites

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ABSTRACT

It is generally believed that the ancient Egyptians oriented their pyramids, temples, and other structures to the sun and stars. Yet the alignments of many sites are either unexplained or are not consistent with accepted historical timelines. Even if one knew nothing about the Egyptian civilization it can be readily determined that many sites are oriented astronomically. In a study of 650 locations throughout Egypt, we identify 113 sites that are aligned in the cardinal directions, or to solstices, or lunar standstills. Using a new shifted geographic pole alignment model based on Charles Hapgood's theory of crustal displacements and geographic pole shifts to test the remaining sites an additional 60 sites were found that could have been astronomically aligned relative to previous locations of the North Pole. We propose that when these sites were first established they were aligned relative to the location of the geographic pole at the time but are now misaligned to the current pole due to subsequent pole shifts. Based solely on their alignment we hypothesize that these sites were built tens of thousands of years ago under the earlier pre-dynastic reigns listed in the Turin Papyrus. Analyzing the geographic distribution of sites aligned to current and past poles reveals a difference in the alignment statistics between Upper and Lower Egypt that could be explained by a flood or other disaster following the last pole shift.

Introduction

Understanding the alignment of ancient Egyptian pyramids, temples, and other structures is a subject of great interest. Where most (but not all) pyramids are aligned to the cardinal directions – north, south, east, and west, sometimes with uncanny precision as those on the Giza plateau (Lehner 1997), the orientation of Egyptian temples has remained somewhat of a mystery. Lockyer (1894) was the first to propose that the ancient Egyptians aligned their temples to the sun and stars. Taking into account changes in Earth's axial tilt or obliquity he estimated that the Temple of Karnak at Luxor, which is aligned in the direction of the winter solstice sunrise, was established in 3700 BCE. Using knowledge of precessional motion he estimated that the Temple at Edfu and several other temples were built in alignment with Ursa Major around 6400 BCE. That these dates conflicted with accepted archaeological timelines led Egyptologists to dismiss his findings and later marginalize the role of archaeoastronomy in mainstream research.

In part to demonstrate the value of archaeoastronomy in Egyptology, Belmonte et al (2009) measured the orientations of temples throughout Egypt and determined that many sites were aligned in astronomically significant directions such as equinoxes, solstices, and certain stars of importance at the time. They also show that for temples near the Nile River there is a degree of correlation between the direction of the river and the orientation of the site. The authors conclude that both astronomy and geography were important factors in

the alignment of ancient sites and that the "terrestrial landscape, dominated by the Nile, and the celestial landscape, dominated by the sun and the stars, combine in order to permit the establishment of Ma'at, the Cosmic Order, on Earth."

Still, many unanswered questions remain. For example, why is the Temple of Karnak in Luxor, east of the Nile River, astronomically aligned, while "Temples of the Millions of Years" across the Nile in West Luxor dedicated to Amenhotep III, Seti I, Thutmosis III, and Ramesses II are not? The Osireion is perhaps one of the most enigmatic megalithic structures in all of Egypt. Why is the temple of Seti I in Abydos aligned in the same direction as the Osireion, a direction that is neither astronomical nor geographical?

The alignment of certain Greek temples has also puzzled scholars for more than a century. Instead of assuming that the ancient Greeks were the original builders, a recent study (Carlotto 2020a) considered the possibility that certain temples were built over the ruins of earlier structures at sites established by a previously unknown civilization that existed in Europe tens of thousands of years ago. Hapgood (1958) proposed that a displacement of Earth's crust over the mantle and the resulting shift of the location of the geographic pole could explain patterns of climate change. Testing the hypothesis that the builders had aligned the original structures to the geographic pole at the time and that the pole had since shifted revealed that almost all of the previously unexplained sites examined in Greece in some way referenced a past pole.

According to West (1994) many structures in Egypt were been built over earlier foundations. Ancient hieratic texts such as the Turin King List suggest the origin of the Egyptian civilization goes back tens of thousands of years before the rule of Menes, the first king of a unified Egypt circa 3000 BCE (Emery 1961). In this paper, we use the shifted geographic pole model (Carlotto 2019a, 2020c) used in the study of Greek temples to determine if there are sites in Egypt that were originally aligned to previous pole locations, i.e., places that could have been established before the Dynastic Period during the reign of the earliest rulers listed in the Turin King List such as the Shemsu Hor, or the Followers of Horus, the Venerables of Memphis, and the Venerables of the North (Schwaller de Lubicz 1961). We hypothesize that over time as sites fell into ruin some structures were rebuilt and others added over and around the original foundations sometimes preserving original alignments to the older poles. What exists today is thus a mixture of site alignments that reference both current and past pole locations.

Site Alignment Models

Initially, we considered eight geographical/astronomical site alignments (Carlotto 2020b)

1. Cardinal directions (i.e., facing north, south, east, and west)
2. Solstices
3. Zenith passages
4. Major and minor lunar standstills
5. Planets
6. Stars or constellations
7. Magnetic north
8. Facing other sites

Solar and lunar alignments (1-4) are perhaps most generally applicable in that they are directly observable, and are relatively stable over time, changing by only a few degrees over Earth's 41,000-year obliquity cycle. Planetary alignments (5) are in similar directions as the planets also move along the ecliptic and so their range of motion is within the same range as that of the sun.

Second to solar alignments, stellar alignments (6) are perhaps the most common in Egypt. Taking into account precessional motion, Lockyer (1894) found fifty sites that could have been aligned to northern and southern stars and constellations over the past 8,000 years. Unless the star or constellation and/or the date of construction are known with certainty it is difficult to prove a stellar hypothesis since, due to precession, alignments change over time. For example, the Temple of Hathor at Dendera is thought to have been aligned to Alkaid in Ursa Major in the first century BCE. Today it rises almost 10° south of the northeast sightline from the temple (Carlotto 2020a). Given a long enough period of time almost any circumpolar star will rise in almost any near-polar direction as illustrated in Figure 3.

Where the Chinese are thought to have positioned certain sites at the time of construction to the geomagnetic pole (7) using a magnetic compass (Charvátová 2011) there is no evidence of its use in ancient Egypt and so is not considered.

In some parts of the world, there is evidence of sites aligned to other sites or places of importance (8). In Egypt there are perhaps a few nearby sites aligned to other sites, such as the Ramessum to the Luxor Temple[1] but no widespread evidence that distant sites were aligned to one another as certain Greek temples appear to have been oriented to face older oracle sites such as Delphi and Dodoni (Carlotto 2019c).

The shifted geographic pole alignment model (Carlotto 2020c) computes solar and lunar alignments (1-4) relative to a time-varying geographic coordinate system (Figure 1) defined by the current and previous (hypothesized) pole locations listed in Table 1.

Site Data and Results

We examined 650 locations in Egypt provided in an online database[2]. The data are divided into two groups: 323 sites and landmarks, and 327 settlements. Sites and landmarks include most places of archaeological interest including artwork/infrastructure, cemeteries, fortifications, mastabas, palaces, pyramids, temples, and tombs. About 10% of the settlement locations are also archaeological sites. Most archaeological sites tend to be located in specific areas around 26° N and 30° N latitude that are relatively close to the Nile Valley. Settlements are uniformly distributed in the range of longitudes from 30° to 33° with twice as many settlements north of 31° N latitude than from 21° to 31° N (Figure 2).

Using Google Earth, and apps and algorithms for computing the directions of solar and lunar alignments (Carlotto 2019b), possible alignments of structures at these sites were determined by visually correlating computed directional overlays with the edges of rectilinear features visible in the available imagery.

[1] http://hdl.handle.net/1721.3/184914
[2] http://ancientlocations.net

Table 2 lists sites aligned to the cardinal directions, solstices, and lunar standstills relative to the current geographic pole. 113 of the archaeological sites examined are aligned in one of these directions. Representative examples are presented in Figure 4. Most of the sites (86) are aligned to the cardinal directions. Surprisingly there are more sites aligned to lunar standstills (17) than to solstices (10). There are no sites aligned to zenith passages since none of the sites are within the zone of the tropics.

The majority of archaeological sites did not appear to be aligned in any of these directions. The alignment of a significant fraction of sites could not be determined from Google Earth imagery for several reasons. Many structures are highly eroded or too small to reliably measure alignment directions. Sites having structures aligned in multiple directions were ignored. About a dozen sites misaligned by several degrees from the cardinal directions, which could have been aligned to stars such as the Temple of Horus at Edfu to Ursa Major, were not considered further in this study.

Table 3 lists 60 sites that are aligned to previous locations of the North Pole or solstices, lunar standstills, or zenith passages relative to those poles. Notice several zenith passage alignments relative to the Hudson Bay and Greenland poles[3]. Among sites of note aligned to older poles are the Osireion and Temple of Seti I at Abydos, and the Ramesseum (Figure 5). Sites aligned to previous poles are more equally distributed with 23 in the cardinal directions, 21 to solstices, and 16 to lunar standstills. Figure 6 indicates that the distribution of our astronomical directions relative to current and past poles appears to be consistent with the site alignment data collected by Belmonte et al (2009).

Define polar distribution of site alignments to a given pole(s):

$$d(\theta) = \begin{cases} 1 - \text{if an astronomical alignment exists in that direction} \\ 0 - \text{otherwise} \end{cases}$$

where θ is the azimuth angle of an alignment. Figure 7 shows polar distributions over for alignments at 26° N to the current and past poles. Alignments in the cardinal directions are precisely at 0°, 90°, 180°, and 270° but those in the directions of solstices or lunar standstills relative to either the major (long) or minor (short) axis of a site vary within a range defined by the amount of change in Earth's obliquity over the time span of the pole(s).

Assuming sites can be aligned in any direction, the probability that a site selected at random is astronomically aligned to a given pole(s) is

$$q = \sum_{\theta=0^\circ}^{360^\circ} d(\theta)$$

and is equal to 0.18 for the current pole, and 0.65 for the set of past poles listed in Table 1. Assuming that they are independent, the probability $L = 60$ sites are astronomically aligned to a past pole is $q^L = 0.65^{60} = 6{\times}10^{-12}$. Although it is not unlikely for a single site to be

[3] Pole shifts also change the latitude of a site. Using a site at a latitude of 26° N as a reference, for previous pole locations in Hudson Bay, Greenland, the Norwegian Sea, and the Bering Sea, its latitude would have been approximately 12° N, 24° N, 42° N, and 4° S.

aligned to a specific set of directions, it is not likely to find 60 sites aligned to the same set of directions.

If the number of sites built in alignment with successive poles and the fraction of sites that survive each pole shift is constant over time, then the number of sites aligned to older poles should be less than the number of sites aligned to more recent poles. Most sites (113) are aligned to the current pole. For the 60 sites aligned to previous poles, there are 19 alignments to the Hudson Bay pole, 35 to the Greenland pole, 8 to the Norwegian Sea pole, and 8 to the Bering Sea pole (some sites have multiple alignments).

Figure 8 shows the distribution of sites by pole vs. latitude. Sites aligned to the Hudson Bay, Greenland, and Norwegian Sea poles are more or less equally distributed across latitude. Almost all of the sites referencing the Bering Sea pole are located in Upper Egypt and include "The Temples of the Millions of Years" of Amenhotep III, Seti I, Thutmosis III, and the Ramesseum. Most sites that reference the current pole are pyramids in Lower Egypt aligned in the cardinal directions.

Discussion

According to the chronology in the Turin Papyrus (Schwaller de Lubicz 1961), the Shemsu Hor ruled Egypt from 16820 BCE up to the Dynastic Period. Their reign began around the time of the Hudson Bay pole shift, which is estimated to have occurred 12,000 to 18,000 years ago (10,000 to 16,000 BCE). The Venerables of the North and the Venerables of Memphis ruled Egypt after 40020 BCE, which would have been during the era when sites were built in alignment with the Hudson Bay pole. However, given the inherent uncertainty in Hapgood's pole shift chronology, these reigns could have occurred when the North Pole was in Greenland.

Sites aligned to pole locations that predate the Dynastic Period by many tens of thousands of years suggest the origin of Egyptian civilization is far older than is currently thought. An analysis of the geographic distribution of these sites also sheds new light on one of Plato's dialogs. The following excerpt from *Timeus*[4] is well known:

> "There have been, and will be again, many destructions of mankind arising out of many causes; the greatest have been brought about by the agencies of fire and water, and other lesser ones by innumerable other causes. There is a story, which even you have preserved, that once upon a time Paethon, the son of Helios, having yoked the steeds in his father's chariot, because he was not able to drive them in the path of his father, burnt up all that was upon the earth, and was himself destroyed by a thunderbolt. Now this has the form of a myth, but really signifies a declination of the bodies moving in the heavens around the earth, and a great conflagration of things upon the earth, which recurs after long intervals…"

This passage could very well be describing a crustal displacement. A rapid shift of the poles would change the apparent motions of celestial objects. The statement that there have been many destructions of mankind that occur after long intervals is not inconsistent with

[4] http://classics.mit.edu/Plato/timaeus.html

Hapgood's crustal displacement theory. Continuing, the dialog goes on to describe the aftermath of a crustal shift

> "…at such times those who live upon the mountains and in dry and lofty places are more liable to destruction than those who dwell by rivers or on the seashore. And from this calamity the Nile, who is our never-failing saviour, delivers and preserves us. When, on the other hand, the gods purge the earth with a deluge of water, the survivors in your country are herdsmen and shepherds who dwell on the mountains, but those who, like you, live in cities are carried by the rivers into the sea. Whereas in this land, neither then nor at any other time, does the water come down from above on the fields, having always a tendency to come up from below; for which reason the traditions preserved here are the most ancient."

The last part of this passage suggests that the impact of the latest destruction varied geographically. Those who survived in Greece (and Europe) lived in the mountains while others were swept into the sea. Although there is no mention of areas closer to the sea in Egypt (i.e., Lower Egypt), the last sentence implies that those who lived in Upper Egypt survived the flood to tell about it.

We can use alignment statistics to test this hypothesis. Figure 9a,b plots the histogram and cumulative distribution of all site alignments relative to the current pole vs. latitude. Figure 10a,b breaks it down by alignment. Sites aligned to solstices and lunar standstills are distributed more or less uniformly from Upper to Lower Egypt. More than 95% of cardinally aligned sites are in Lower Egypt. Figure 10c,d plots the histogram and cumulative distribution of site alignments relative to past poles vs. latitude. There are more sites aligned to the cardinal directions in Lower Egypt but more sites aligned to solstices and lunar standstills in Upper Egypt.

If we assume that the practice of building sites aligned to the cardinal directions, solstices, and lunar standstills did not change over time, why are these distributions different? One possibility is that the distributions are different due to the selection of sites (sampling). Figure 9c,d plots the histogram and cumulative distribution of sites by latitude from a different dataset (Carlotto 2020c). That the two sets of distributions are similar suggest the preponderance of sites aligned to the current pole in Lower Egypt is not a sampling artifact. One possible explanation suggested by Plato's *Timeus* is that a flood destroyed some fraction of sites in Egypt close to the Mediterranean Sea thus reducing the number of sites in that area aligned to previous poles that are in existence today. We can simulate this effect by scaling the distribution of older sites in Lower Egypt. Figure 10e,f simulates the distribution of sites before a flood that destroyed 80% of the sites above 29° N latitude. The result of the scaling is to increase the number of sites in Lower Egypt prior to the flood. Notice how the scaled pre-flood distribution (Figure 10e,f) more closely matches the current distribution (Figure 10a,b).

Summary

The validity of the results presented in this study is ultimately conditioned on the validity of Hapgood's pole shift hypothesis. If true, the alignment of 60 sites with previous locations of the North Pole provides compelling evidence that an advanced civilization existed in Egypt long before the Dynastic Period and built temples and other structures in alignment to

those poles. The geographic distribution of site alignments is consistent with the hypothesis that a flood triggered by a catastrophic pole shift destroyed about 80% of the sites in Lower Egypt. It is thus possible that sources previously thought to be myth may have a factual basis after all.

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Table 1 Previous hypothesized locations of the North Pole (Carlotto 2019a).

North Pole	Latitude	Longitude	Approximate Date
Hudson Bay	59.75°	78°	< 12-18 Kyr
Greenland	79.5°	63.75°	< 50,000 Kyr
Norwegian Sea	70°	0°	> 125,000 Kyr
Bering Sea	56.25°	176.75°	< 125,000 Kyr

Table 2 Sites aligned to the cardinal directions (E), solstices (S), and major (M) and minor (m) lunar standstills.

Site	Latitude	Longitude	Alignment
1002) Colossi of Memnon	25.720499	32.610446	S
1006) Kheny	24.650548	32.929441	E
1013) Cemetery at Girza	29.434505	31.167509	S
1017) Kom Abu Zeid	30.485517	30.890546	E
1019) Predynastic Cemetery at Tarkhan	29.492687	31.217724	E
1029) Telll-Borg	30.923606	32.413702	m
1030) Tellr-Herr	30.967337	32.492947	M
1031) Tell Hebua II	30.931411	32.379644	m
1034) Lepsius Pyramid 24	29.893491	31.202836	E
1035) Lepsius Pyramid 25	29.893086	31.203059	E
1036) Mastaba at Darah K1	26.295308	31.771782	m
1037) Mastaba at Zawyetl-Maiyitin	28.045889	30.828821	m
1039) Mastaba of Hetepheres I	29.979108	31.13654	E
1047) Mastaba of Ptah-shepses	29.896648	31.204454	E
1049) Mastaba of Ti	29.877615	31.211784	E
1050) Meydum mastaba 17	29.389504	31.15862	E
1054) Cult pyramid of Djedefre	30.031575	31.07553	E
1055) Cult pyramid of Djedkare Isesi	29.850695	31.221495	E
1056) Cult pyramid of Khafre	29.974701	31.130728	E
1057) Cult pyramid of Khendjer	29.832895	31.224318	E
1058) Cult pyramid of Khufu	29.97805	31.135762	E
1059) Cult pyramid of Merenre	29.850214	31.215849	E
1060) Cult pyramid of Neferirkara	29.894575	31.203641	E
1061) Cult pyramid of Pepi 1	29.854123	31.219576	E
1062) Cult pyramid of Pepi 2	29.83995	31.214159	E
1063) Cult pyramid of Sahura	29.897219	31.204118	E
1064) Cult pyramid of Senusret 1	29.559688	31.221964	E
1066) Cult pyramid of Snefru (B)	29.788721	31.209473	E
1076) Pyramid atdfu (South)	24.943756	32.842032	E
1079) Pyramid at Seila	29.382618	31.053648	E
1083) Pyramid of Amenemhat 1	29.574809	31.225267	E
1091) Pyramid of Djedefre	30.032154	31.0749	E
1092) Pyramid of Djedkare Isesi	29.850985	31.220948	E
1093) Pyramid of Djehuti	29.830648	31.222459	E
1097) Pyramid of Ini	29.895656	31.203453	E
1099) Pyramid of Khafre	29.975919	31.130861	E
1100) Pyramid of Khendjer	29.832408	31.223968	E
1101) Pyramid of Khufu	29.979147	31.134342	E
1103) Pyramid of Menkaura	29.97245	31.128304	E
1105) Pyramid of Neferefra	29.893793	31.201559	E
1106) Pyramid of Neferirkara	29.895027	31.202277	E
1107) Pyramid of Pepi 1	29.854439	31.218983	E
1108) Pyramid of Pepi 2	29.840252	31.213507	E
1110) Pyramid of Rehrrychefnakht	29.853931	31.217881	E
1111) Pyramid of Sahura	29.897654	31.203214	E
1113) Pyramid of Senusret 1	29.560099	31.221229	E
1114) Pyramid of Senusret 2	29.236189	30.97069	E
1115) Pyramid of Senusret 3	29.819034	31.225648	E
1116) Pyramid of Shepseskaf	29.838922	31.215241	E
1117) Pyramid of Snefru (A)	29.388329	31.157256	E
1118) Pyramid of Snefru (B)	29.7903	31.209459	E
1119) Pyramid of Snefru (C)	29.808503	31.206151	E
1121) Pyramid of Unas	29.868219	31.214954	E
1123) Pyramid of Userkaf	29.873449	31.218786	E
1124) Pyramid SAK S 3	29.833806	31.22372	E
1125) Pyramid SAK S 7	29.829582	31.223094	E

1126) Pyramid South Dahshur B	29.780393	31.21742	E
1127) Pyramid South-Dahshur A	29.78182	31.221609	E
1129) Queen's pyramid of Khufu	29.97888	31.136223	E
1130) Queen's pyramid of Khufu	29.978327	31.136245	E
1131) Queen's pyramid of Khufu	29.97787	31.136233	E
1132) Queen's pyramid of Menkaura	29.971593	31.127338	E
1133) Queen's pyramid of Menkaura	29.971607	31.127813	E
1134) Queen's pyramid of Menkaura	29.971615	31.128335	E
1135) Queen's pyramid of Pepi 1	29.853792	31.219077	E
1136) Queen's pyramid of Pepi 1	29.853683	31.218739	E
1137) Queen's pyramid of Pepi 1	29.853713	31.218426	E
1138) Queen's pyramid of Pepi 1	29.853469	31.21839	E
1139) Queen's pyramid of Pepi 1	29.853748	31.218155	E
1140) Queen's pyramid of Pepi 1	29.853282	31.218008	E
1141) Queen's pyramid of Pepi 1	29.854171	31.217948	E
1142) Queen's pyramid of Pepi 1	29.853949	31.218191	E
1143) Queen's pyramid of Pepi 2	29.839566	31.213983	E
1144) Queen's pyramid of Pepi 2	29.840842	31.212728	E
1145) Queen's pyramid of Pepi 2	29.840994	31.213192	E
1146) Queen's pyramid of Senusret 1	29.560606	31.222422	E
1147) Queen's pyramid of Senusret 1	29.560619	31.2222	E
1150) Queen's pyramid of Senusret 1	29.560558	31.220272	E
1151) Queen's pyramid of Senusret 1	29.559337	31.220712	E
1154) Queen's pyramid of Senusret 2	29.23694	30.971411	E
1189) Qasrz-Zaiyan	25.251459	30.570933	E
1191) Serapeum at Alexandria	31.182302	29.896172	m
1192) Serapeum at Ismailia	30.468217	32.3151	E
1194) Set temple at Nubt	25.974326	32.732559	m
1195) Shesmetet temple	25.134386	32.817621	S
1196) Solar Temple of Nyuserre-Ini	29.904078	31.193792	E
1197) Solar Temple of Userkaf	29.900056	31.198933	E
1206) Temple at Senmet	24.022098	32.886371	E
1218) Temple of Sankhkare Mentuhotep 3	25.765928	32.608772	S
1223) Temple of Towseret	25.726268	32.607218	M
1231) Tomb NRT-II at Tanis	30.977	31.880636	S
1232) Tomb NRT-IV at Tanis	30.977133	31.88042	S
1233) Tomb NRT-VI at Tanis	30.976998	31.880424	S
1234) Tomb NRT-VII at Tanis	30.976995	31.880566	S
0003) Qasr Qarun	29.405564	30.419211	S
0007)	29.379347	30.466878	E
0009) Tebtunis	29.107046	30.76124	E
0013) Abu Ghurab	29.904723	31.194987	E
0014) Abu Rawash	30.040388	31.092467	E
0015) Abu Sidan	30.90436	30.195425	m
0025) Bolbitino Bolbitinum, Rashit	31.439653	30.38942	M
0026) Abusir	29.897646	31.206096	E
0155) Bubastis	30.571659	31.513126	M
0157) Pithom	30.552109	32.099126	m
0173)	29.205149	25.543594	m
0217) Tell Gumaiyima	30.893038	31.886743	E
0236) Teraniek	30.42901	30.8177	E
0240) Sile, Miktol, Migdol	30.935285	32.366893	m
0268) Tuphium	25.583069	32.533539	M
0285) Nag el-Madamud	25.734339	32.70989	m
0291) Hierakonpolis	25.097665	32.77951	E
0295) Philae	24.025698	32.884039	m,M
0308) Waset, great Amun temple	25.718202	32.65869	S

Table 3 Sites that reference previous geographic poles in Hudson Bay (HB), Greenland (GR), the Norwegian Sea (NS), and the Bering Sea (BS). "Z" denotes a zenith passage alignment.

1052) North palace at Akhetaten	27.669839	30.903871	Z			
1202) Temple at Deirl-Hagar	25.664764	28.813311				Z
0251) Nitsana	30.876274	34.432855	Z			
1011) Al Miallah	25.470968	32.529025	E			
1027) T-78	30.903885	32.443065		E		
1032) Tell Kedua	30.983389	32.475396		S		E
1040) Mastaba of Kagemni	29.875961	31.221421	m	E		
1043) Mastaba of Mereruka	29.875878	31.221156	m	E		
1069) Lepsius Pyramid 29	29.876716	31.222698	m	E		
1077) Pyramid atlephantine	24.085618	32.885562	m	E		
1098) Pyramid of Khaba	29.93282	31.161262		E		
1102) Pyramid of Khui	27.30783	30.871612		E		
1162) Queen's pyramid of Teti	29.876364	31.222142		E		
1163) Queen's pyramid of Teti	29.876623	31.222222		E		
1185) Nadura temple	25.46907	30.564147				E
1188) Qasr Dush	24.580004	30.717115		E		
1209) Temple at Sulb	20.436384	30.334119		E		
1225) Horemheb Memphite tomb	29.866199	31.217008			E	
0004) Narmouthis	29.193415	30.642165		E		
0071) Kom Aushim	29.517891	30.903242		E		
0175) Damietta	31.417069	31.813612			E	
0192) Tell Billa	31.057155	31.580874			E	
0237) Tell Temai el-Amdid	30.938813	31.515857	E			
0278) Hermonthis, Erment	25.621875	32.544634		E		
0283) Khemennu, Hermopolis Magna	27.781756	30.803656		E		
0302) Dendera	26.142006	32.670367				E
1038) Mastaba of Ankhmahor	29.876143	31.221873	m			
1168) Chapel of Dedwen	23.960745	32.866695		m		
1173) Enclosure of Khasekhemwy	26.189355	31.908125		M		
1180) Kiosk of Kartassi	23.960138	32.867599		m		
1182) Merenptah temple	25.724993	32.606518	M			
1190) Ramesseum	25.727586	32.610493				M
1204) Temple at Gerf Hussein	23.960266	32.866955		m		
1208) Temple at Shanhur	25.861055	32.776811		m		
1210) Temple in Wadi Hilal	25.138556	32.828627		M		
1211) Temple of Ahmose	26.176151	31.93583			M	
1212) Temple of Amenhotep 3	25.718182	32.594645				M
1221) Temple of Snefru	29.795049	31.21677	M			
1222) Temple of Thutmosis 3	25.127664	32.793093				M
0238) Tell Tinnis	31.198935	32.234298		m		
0245) Sais	30.964854	30.768727			m	
0254) Elephantine	24.08454	32.88606		M		
1041) Mastaba of Khentkaus I	29.973329	31.135486	S			
1042) Mastaba of Khentkaus II	29.894122	31.202531		S		
1046) Mastaba of Ptahhotep	29.873544	31.21338		S		
1053) Palace of Amenhotep 3	25.715472	32.590714	S			
1095) Pyramid ofl-Kula	25.133463	32.733508			S	
1169) Chapel of Ramesses 2	25.133678	32.818141		S		
1172) Enclosure of Khasekhemwy	25.091271	32.773584		S		
1179) Hierasykaminos	22.80077	32.547579		S		
1181) Luxor Temple	25.699883	32.639319	S			
1186) Osireion	26.184095	31.918444	S			
1199) Temple at Amada	22.731097	32.262561		S		
1201) Temple at Deirl Shelwit	25.695244	32.57845		S		
1205) Temple at Kalabsha	23.960882	32.867371		S		
1214) Temple of Hathor and Maat	25.728953	32.602094		S		
1215) Temple of Hibis	25.476538	30.555736	S			
1216) Temple of Ramesses 2	26.18642	31.916311			S	
1219) Temple of Seti 1	26.184537	31.91881	S			
1220) Temple of Seti 1	25.732671	32.628226	S			m
0255) Tell el Amarna	27.64529	30.896242	Z	S		
0290) Eileithyiaspolis, Lucinae Civitas	25.119193	32.797871		S		
0292) Ombos	24.452076	32.928327			S	

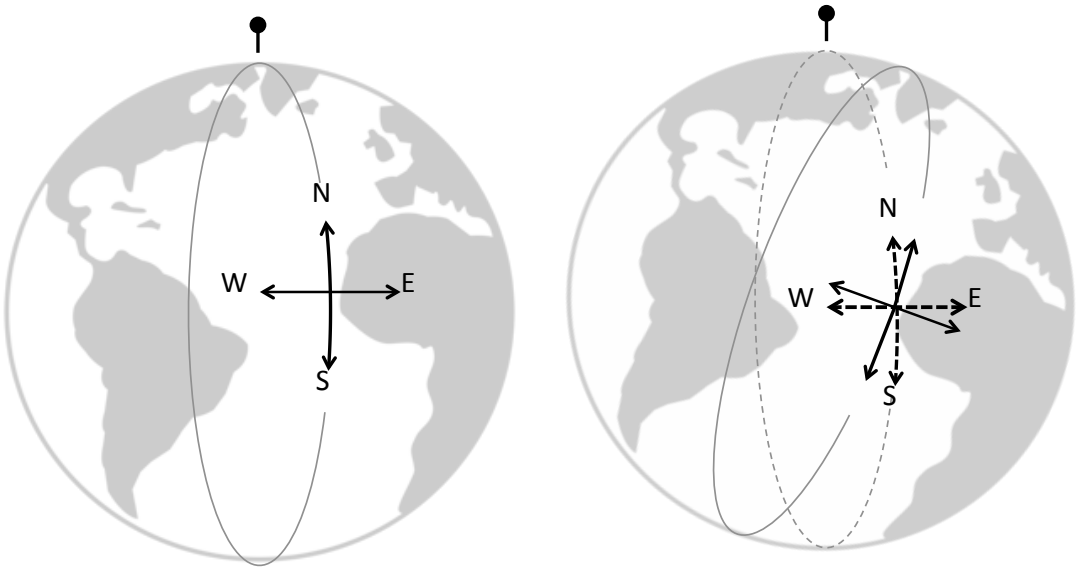


Figure 1 The effect of a pole shift is to shift and rotate the reference frame of the observer. Sites once aligned to the sun or moon are no longer oriented in those directions after a pole shift.

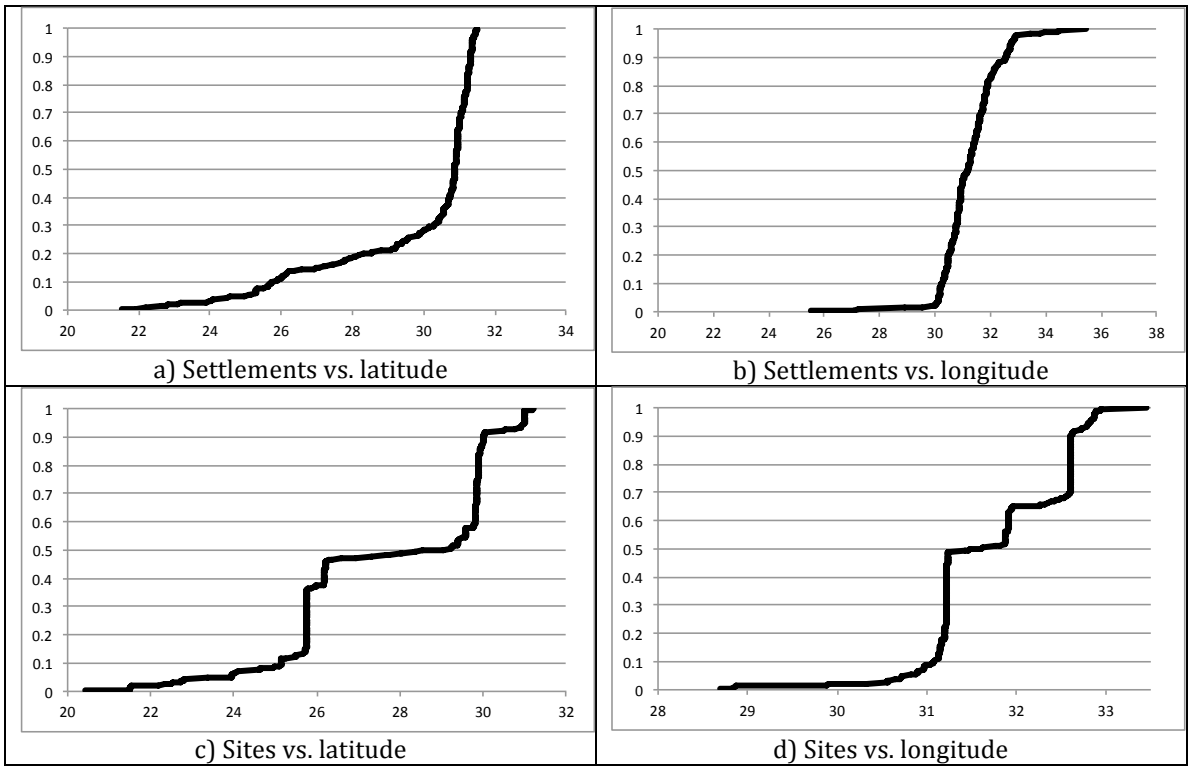
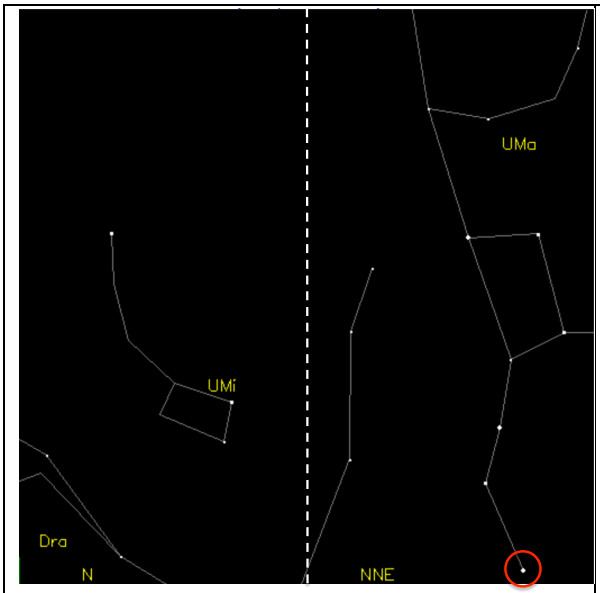
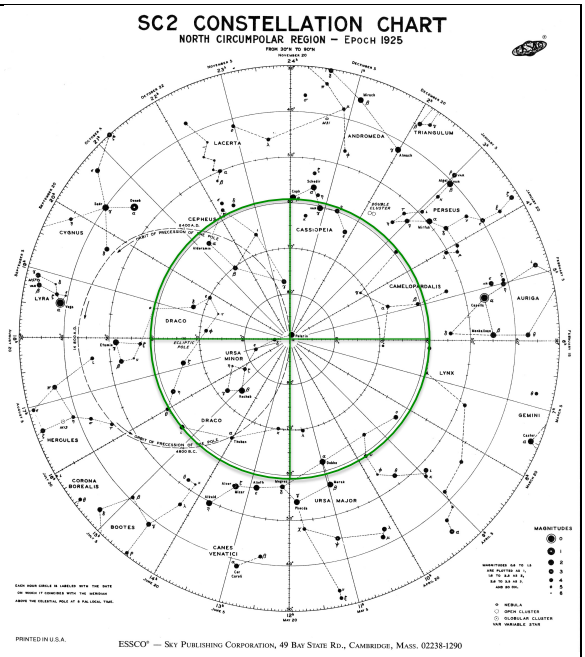


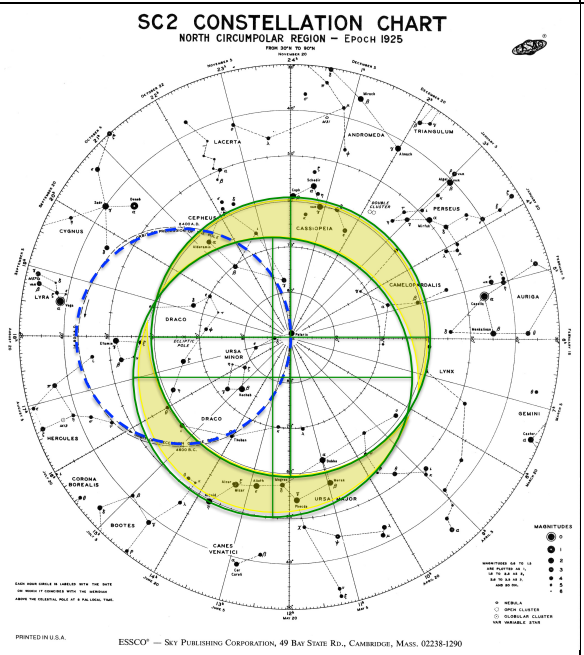
Figure 2 Geographical distributions of settlements and sites in Egypt.



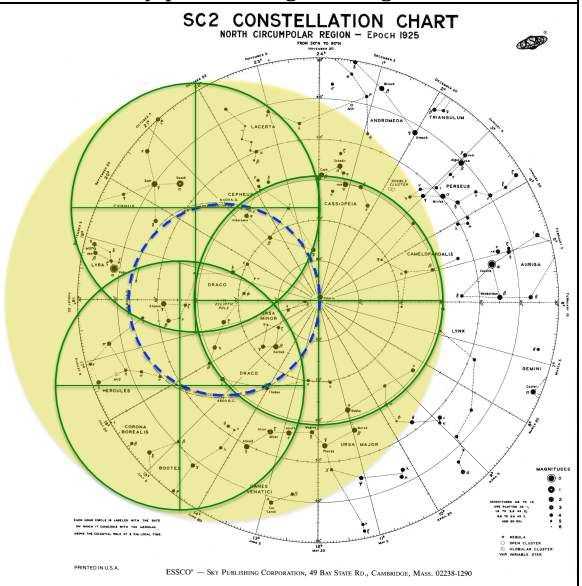
a) Alkaid (circled in red) currently sets about 10° away from a north-northeast sightline from Temple of Hathor at Dendara.



b) The green circle represents the path of stars that currently pass through the sightline.

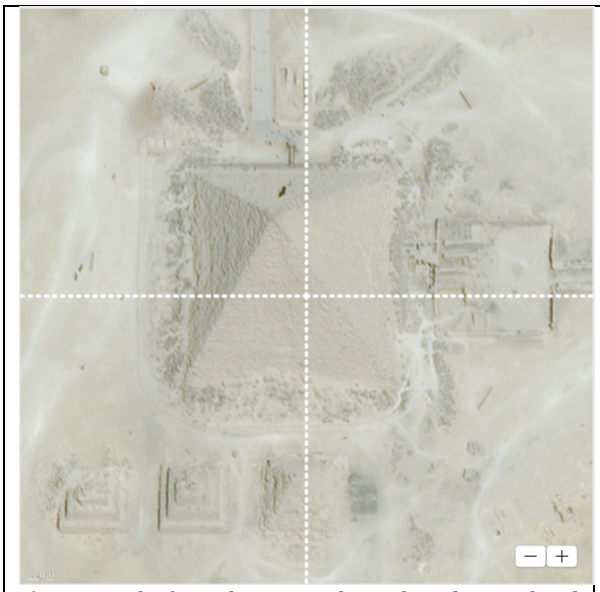


c) Precession causes the green circle to revolve around the ecliptic pole (blue dotted line). In time all stars within the yellow region will pass through the sightline.

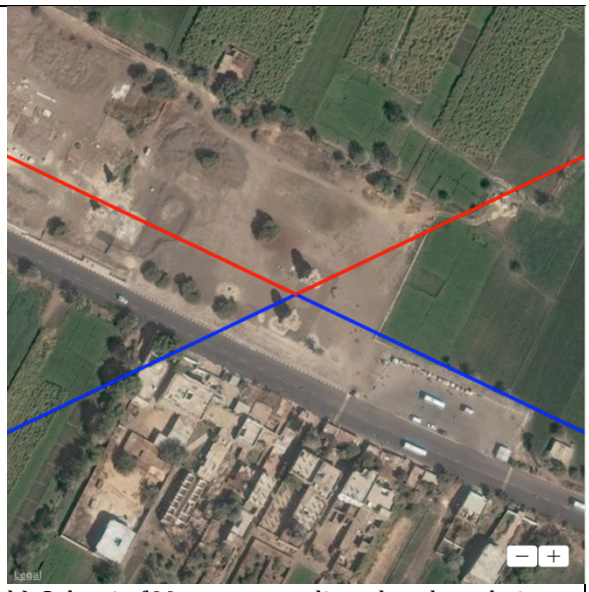


d) Over the full 25,000-year precessional cycle all stars within the yellow circle will pass through the sightline.

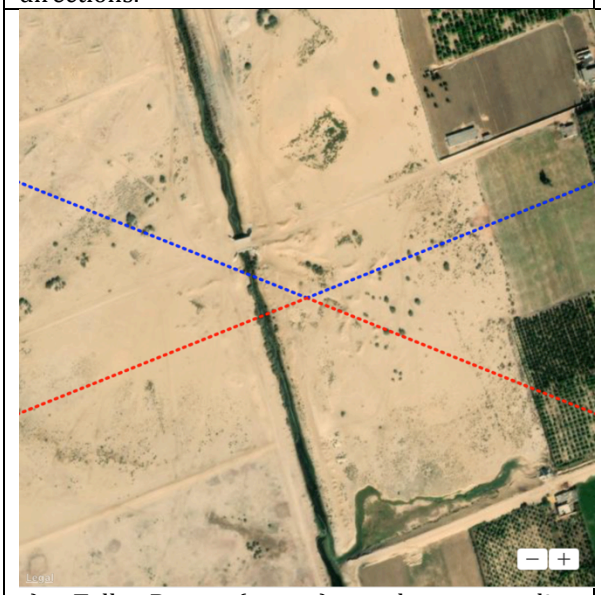
Figure 3 Stellar alignments change over long periods of time due to precessional motion. (Base chart in black-and-white courtesy Sky Publishing Corporation)



a) Pyramid of Menkaura is aligned to the cardinal directions.



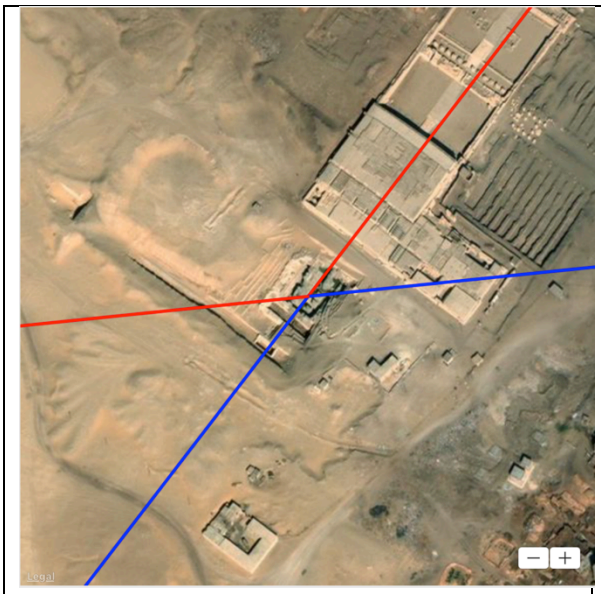
b) Colossi of Memnon are aligned to the solstices.



c) Tell Borg (center) and surrounding agricultural fields are aligned in minor lunar standstill directions.

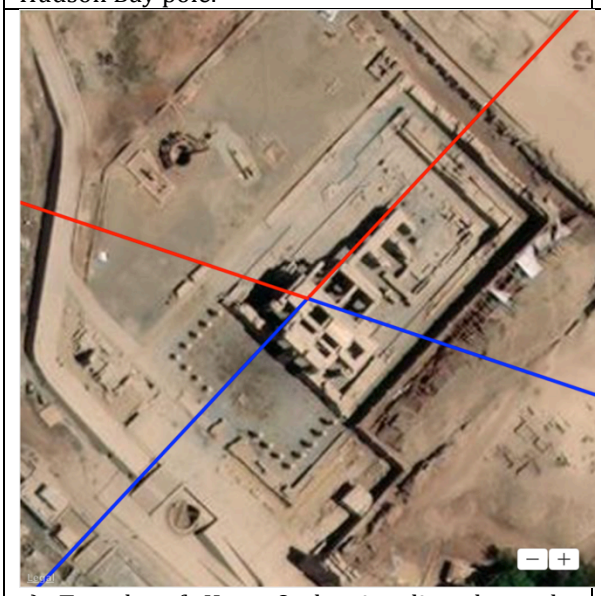
d) A wall of the top structure at Philae is aligned to major lunar standstills. A wall of the bottom structure is aligned to minor standstills.

Figure 4 Examples of sites aligned to cardinal directions, solstices, and lunar standstills relative to current pole. (Apple Maps)

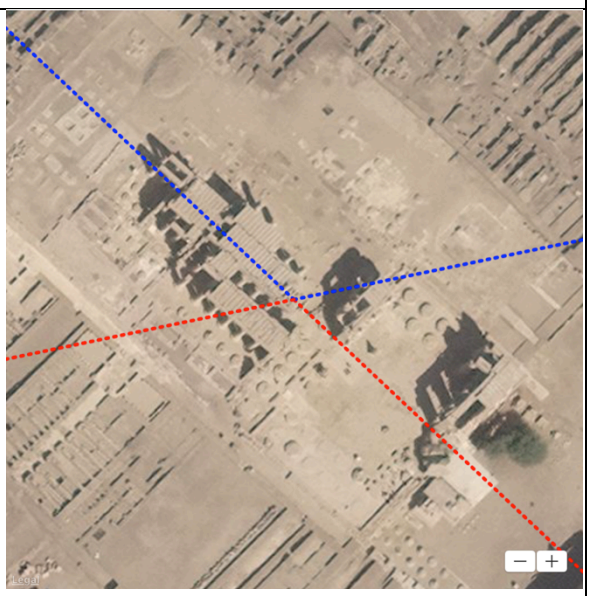


a) Osireion (center) and Temple of Seti I (upper right) are aligned to the solstices relative to the Hudson Bay pole.

b) Pyramid of Khui is aligned in the direction of the Greenland pole.



c) Temple of Kom Ombo is aligned to the solstices relative to the Norwegian Sea pole.



d) The Ramesseum is aligned to major lunar standstills relative to the Bering Sea pole.

Figure 5 Examples of sites aligned to cardinal directions, solstices, and lunar standstills relative to previous poles. (Apple Maps)

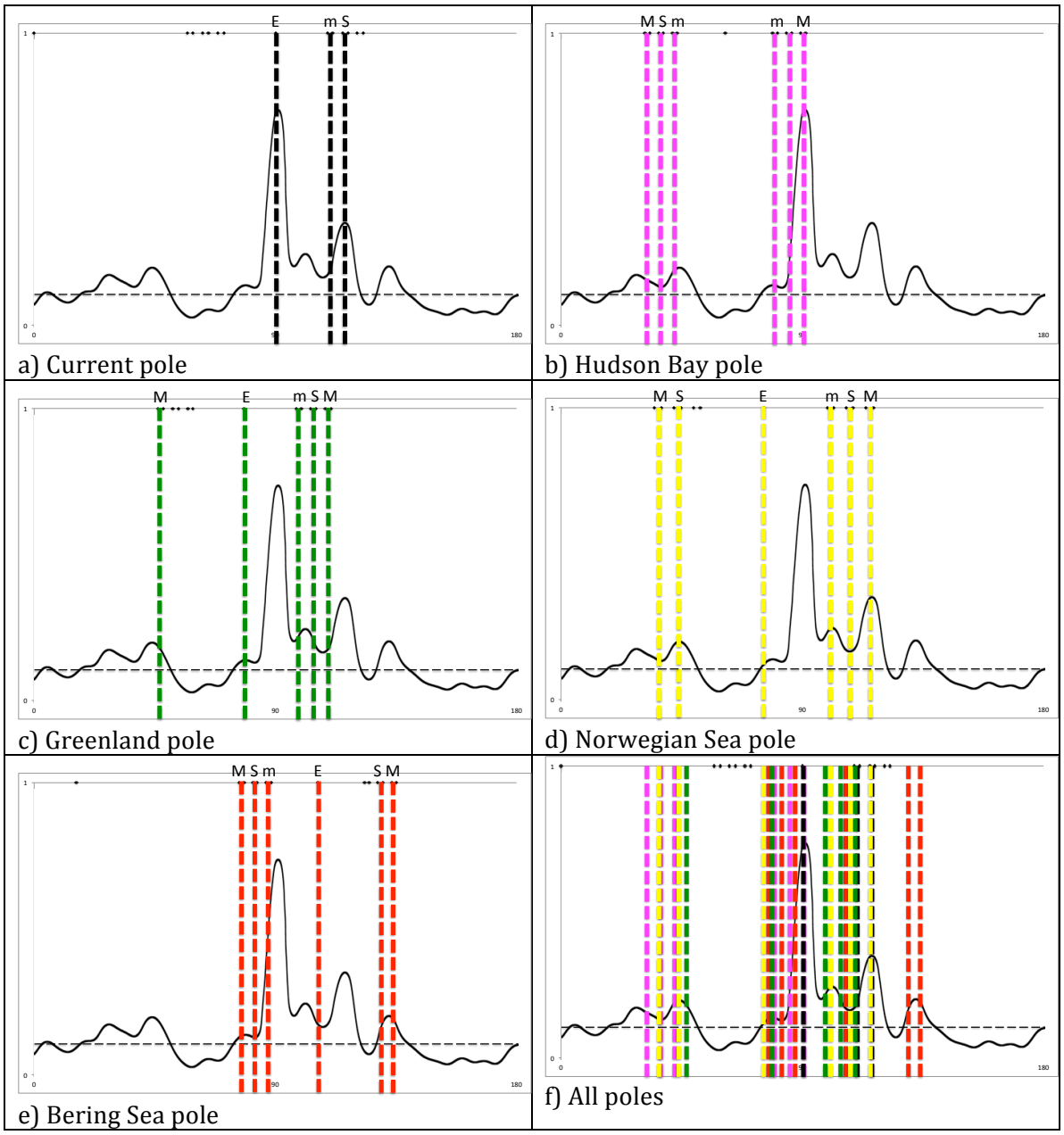


Figure 6 Astronomical directions relative to current and past poles overlaid on site alignment histogram reproduced from Belmonte et al (2009).

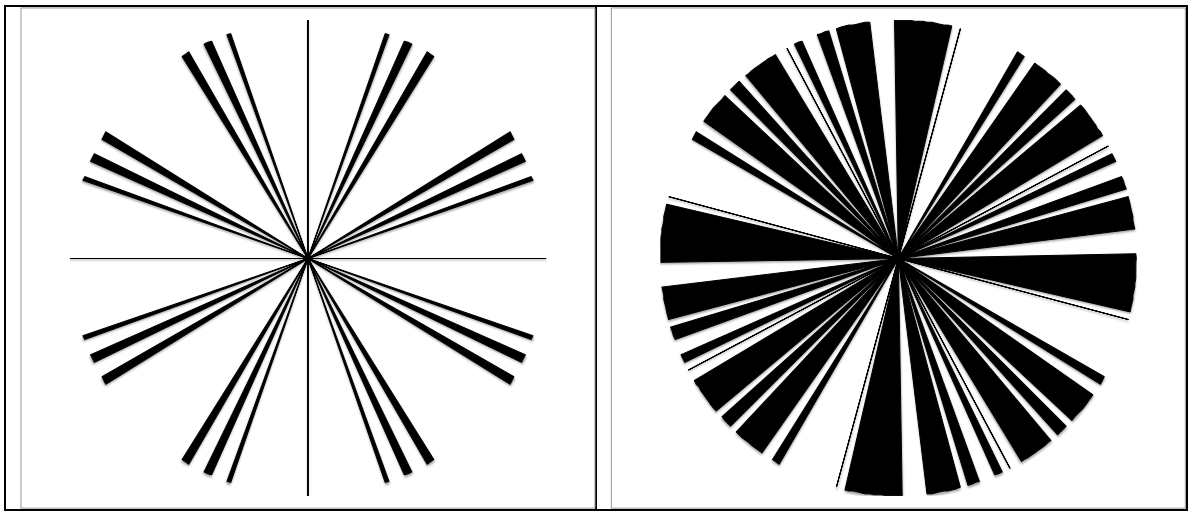


Figure 7 Polar diagrams showing alignments of a rectangular structure to the cardinal directions, solstices, or lunar standstill relative to the current geographic pole (left) and previous poles (right).

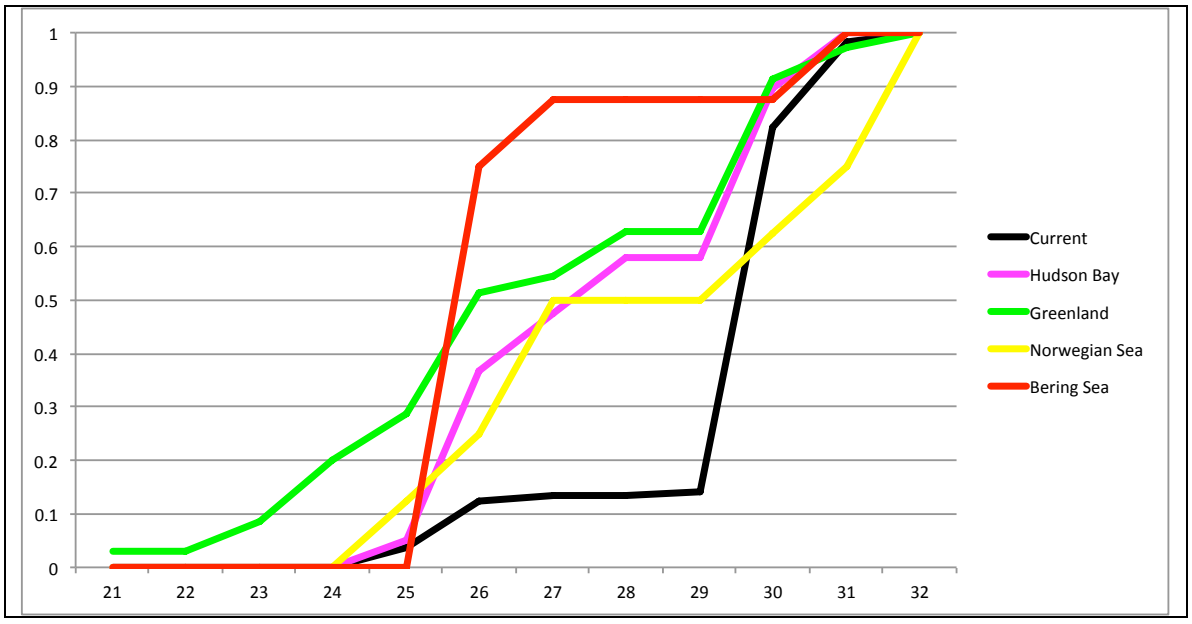
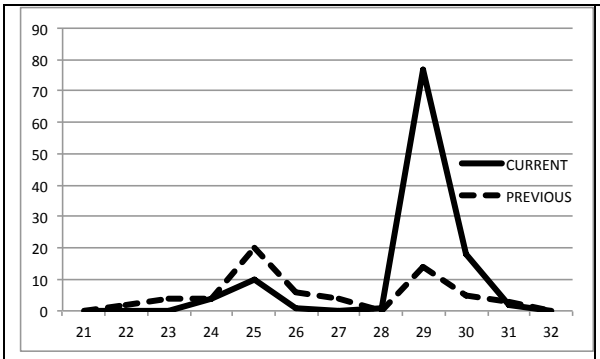
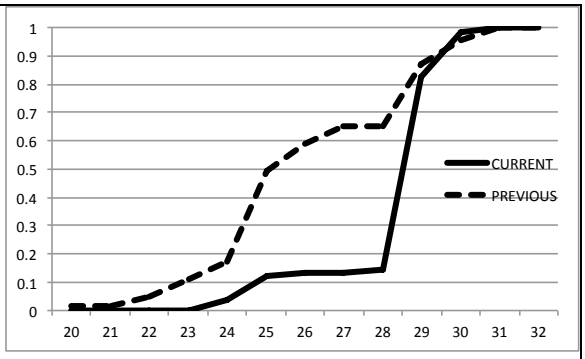


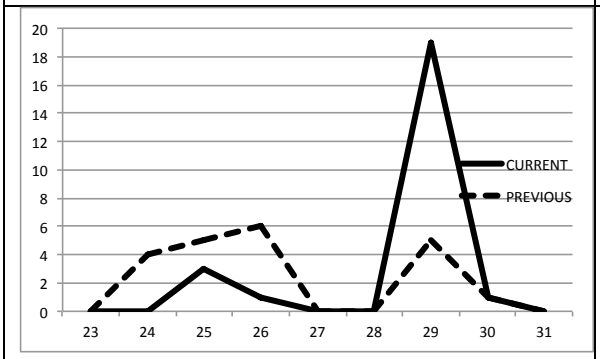
Figure 8 Distribution of sites aligned to current and previous poles vs. latitude.



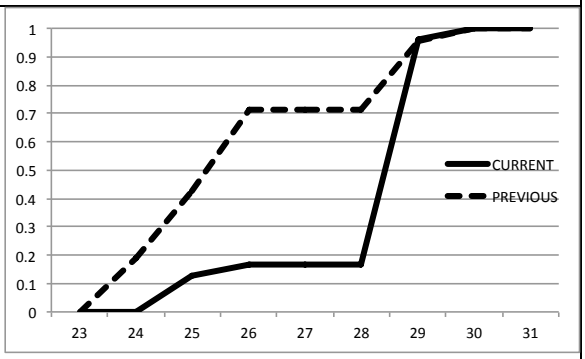
a) Histogram of all alignments relative to current and previous geographic poles vs. latitude.



b) Distribution of all alignments relative to current and previous geographic poles vs. latitude.

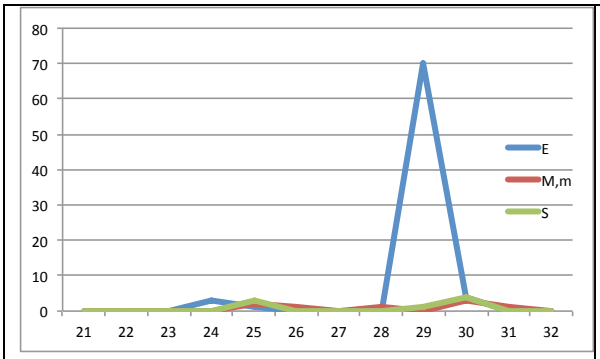


c) Histogram of all alignments relative to current and previous geographic poles vs. latitude.

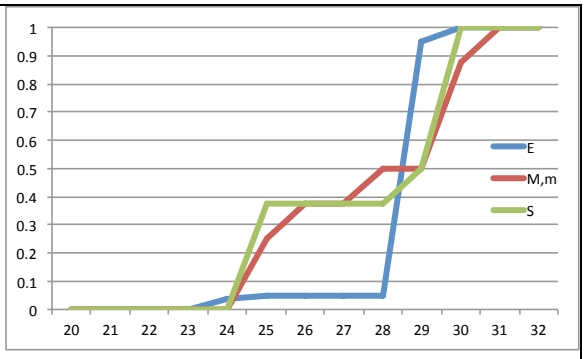


d) Distribution of all alignments relative to current and previous geographic poles vs. latitude.

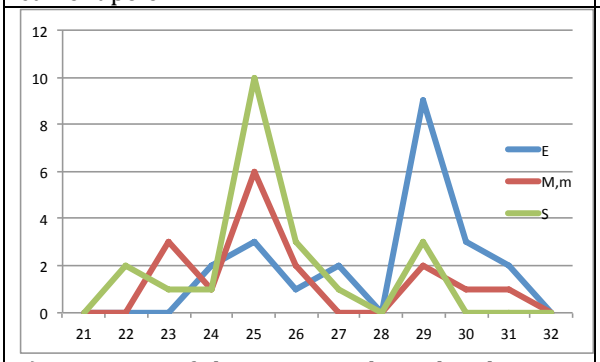
Figure 9 Summary of all alignments to current and previous poles for the sites in this study (top) and a previous study (bottom).



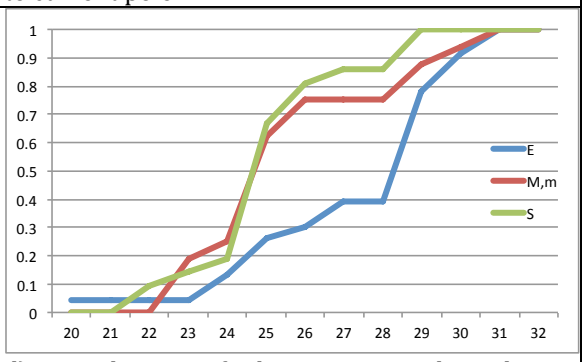
a) Histogram of alignments vs. latitude relative to current pole.



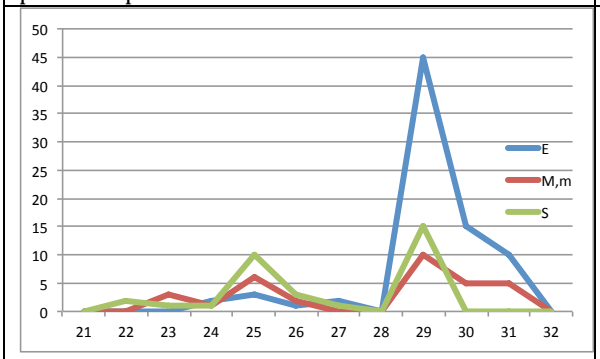
b) Distribution of alignments vs. latitude relative to current pole.



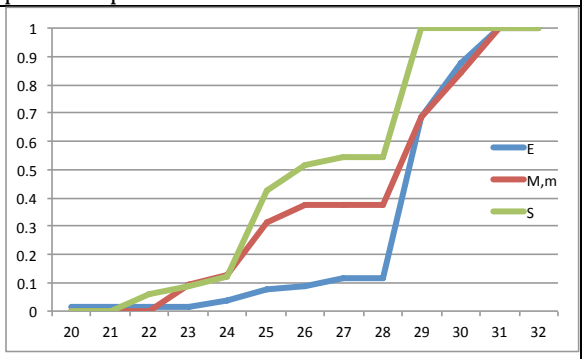
c) Histogram of alignments vs. latitude relative to previous poles.



d) Distribution of alignments vs. latitude to previous poles.



e) Simulated pre-flood histogram of alignments vs. latitude relative to previous poles.



f) Simulated pre-flood distribution of alignments vs. latitude relative to previous poles.

Figure 10 Geographic distributions of equinox (E), solstice (S), and major/minor lunar standstill (m,M) alignments.