Journal of Astronomical History and Heritage, 15(3), 200-212 (2012).

ON THE RELIABILITY OF HAN DYNASTY SOLAR ECLIPSE RECORDS

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Abstract: The veracity of early Chinese records of astronomical observations has been questioned, principally based on two early studies from the 1950s, which suggested that political motives may have led scholar-officials at court to fabricate astral omens. Here I revisit the Han Dynasty (206 BCE-220 CE) solar eclipse reports to determine whether the charge has merit for those first four centuries of the imperial period. All 127 dated solar eclipses reported in the official sources are checked for accuracy against the "Five Millennium Catalog of Solar Eclipses" produced by Espenak and Meeus (2009). The Han Dynasty records prove remarkably accurate. Copyists' errors do occur, but there are only rare instances of totally erroneous reports, none of which is provably the result of politically-motivated manipulation.

Keywords: ancient China, Han Dynasty, solar eclipses, reliability.

1 INTRODUCTION

Studies by Wolfram Eberhard (1950) and Hans Bielenstein (1957; 1970) purporting to establish that early Chinese records of portents, including astronomical observations, were manipulated for political reasons continue to be cited as authoritative (e.g. see Steele, 2003; Stephenson, 1997). Surprisingly, until quite recently only their statistical methodology has been subjected to critical evaluation, despite the fact that in Eberhard's analysis omens of all kinds (astral anomalies, freakish weather, monstrous births, prodigies, etc.) were indiscriminately lumped together (Kern, 2000). Although Eberhard recognized that virtually any Han Dynasty (206 BCE-220 CE) official was entitled to report an omen and opine about its significance, he did not attempt to analyze separately the reliability of astronomical observations, or even just those emanating from the office of Grand Scribe-Astrologer (*Taishigong*). Nor was Bielenstein's analysis of the frequency of omens and portents methodologically adequate to support the conclusions he drew (Kern, 2000). In 1955, Homer H. Dubs (1938-1955, I: 289; III: 552) had already observed that "… during long periods all plainly visible eclipses were reported, while during other periods entire groups of eclipses were missed." In his analysis Bielenstein had assumed twenty years as the average length of reign of the Emperor, so that Dubs' observation already called into question Bielenstein's assertion about the deliberate suppression of reports during the reigns of individual rulers. Recently, Martin Kern has shown that contemporary manipulation of the records can be ruled out:

> Bielenstein's widely adopted conclusion that in Western Han times, such signs were invariably presented – or made up – by court officials in order to subtly admonish their ruler is too simple and flawed by its mechanical and ahistorical nature … First, Bielenstein, like other scholars, has been concerned only with negative and not with auspicious omens; yet only balancing the two will provide accurate figures of omen distribution … Second, the overall quotient, resulting from the number of omen reports relative to the years of a ruler, must be differentiated with respect to different phases of a ruler's reign … during which we observe shifts in the practice and ideology of rulership. Third, when considering the individual omens which are recorded in our historical sources, we need to take into account the historical moment at which a particular omen definition was actually determined as being calamitous … such interpretations often postdate by decades the reign during which the omen originally appeared; therefore, they cannot have been intended as admonishing the ruler whom they might have concerned directly. (Kern, 2000: 3).

Kern's second and third criticisms effectively vitiate Eberhard's and Bielenstein's conclusions. As a result I, too, no longer accept them.

Other scholars came to precisely the opposite conclusion from Eberhard and Bielenstein regarding the astronomical reports. For example, Needham and Wang (1959: 408) concluded:

> … certainly there was no question of a "fabrication" of an extraordinary event … occasionally there may have been a distortion of date for political reasons, as in the conjunction of –205 … but more often the records, when recalculated to-day, are found to be quite reliable, e.g., the occultation of Mars by the moon in −69 and of Venus in +361." (cf. Kiang, 1984; *Han shu* 26.1301).

Dubs was alluding here to the erroneous date for a planetary alignment recorded as "… 10th month of the First Year of Emperor Gaozu (206 BCE) …" in the *History of the Former Han Dynasty*. The actual planetary alignment occurred the following year in May 205 BCE. However, the *Han shu* date has long been known to be plainly impossible and an obvious interpolation. A century after the actual event, Sima Qian, in his *Grand Scribe's Records* (ca 100 BCE), had only written "… when Han arose." Whatever its cause, in the 5th century Gao Yun (390−487 CE) had already ridiculed the misdating, mordantly observing that in the 10th month the Sun would have been in Tail~ Winnowing Basket (lodges #6-7, Sco-Sgr), not in Eastern Well (lodge #22, Gem) where the alignment actually occurred (*Wei shu* 48.1068).

It is sometimes even claimed that the Han astronomers did not believe that solar eclipses could occur only at the new moon, but this is flatly contradicted by both Liu Xiang (ca 77−6 BCE) and Zhang Heng (78−139 CE). In fact, Wang Chong (27−ca. 100 CE), who was not proficient in astronomy, even argued *against* the correct view (Needham and Wang 1959: 411, 414). With regard to 'doctored' reports, Dubs remarked:

> … it is probable that a solar eclipse [in 186 BCE] was

> fabricated in the early years of the Han as a warning to the unpopular Empress Lü (d. 180 BCE), and … certain observations of partial solar eclipses were not recorded during the reign of the popular Emperor Hsiao-Wen. (Needham and Wang 1959: 408).

Discussing the same false eclipse record, Rafe de Crespigny said:

> As Dubs remarks in discussing a similar false report of an eclipse in 184 [*sic*] B.C., the reporting of such a false portent, should it be discovered, would almost certainly be punished by death. It was most unusual for a false eclipse to be reported, and even in the second part of the reign of Emperor Huan, when criticism by portent was at its height, the critics contented themselves with the eclipses that actually took place. (de Crespigny, 1976: 45, n. 15).

Dubs had observed that, "… according to Chinese law it was a serious and capital crime to report falsely a prodigy (such as an eclipse of the sun) …" and cited an example of a high official who was imprisoned and executed "… for having falsely reported a lesser calamity – that a fire had damaged government buildings." (Dubs 1938-1955, I: 212; III: 555). Bielenstein, too. held that "… the records, while never falsified (except in the case of the empress just mentioned), were often left incomplete." (Needham and Wang 1959: 418).

As Martin Kern has shown, however, there is no evidence to suggest that even the erroneous solar eclipse report of 186 BCE was falsely reported *at the time*. The much greater likelihood is that it was interpolated later, so that Dubs, de Crespigny and Bielenstein were all mistaken. Sima Qian, in his review of early Han Dynasty astral anomalies in the "Treatise on the Celestial Offices" (*Tianguanshu*) in his *Grand Scribe's Records* (ca 100 BCE), says only: "… when the Lü clan rebelled, the sun was eclipsed and it grew dark in the daytime." This is a reference to the total eclipse of 4 March 181 (Table 1, #6), the only one recorded by Sima Qian in his account of the Empress Dowager Lü's reign:

> … on the *jichou* day [4 Mar] the sun was eclipsed and during the day it became dark. The Empress Dowager hated it and was displeased. She said to her attendants, "this is because of me". (Nienhauser et al., 2002).

The dubious report of yet another eclipse in the Empress Dowager's reign is obviously an interpolation postdating Sima Qian's *Grand Scribe's Records*. The record in the *History of the Former Han Dynasty*, compiled a century and a half after Sima Qian, is the sole demonstrably false report of an eclipse suspected of being politically motivated during the 400 years of the Han dynasty.

As Rafe de Crespigny noted, it was in the Later Han Dynasty that political portentology reached peak intensity. Nevertheless, F.R. Stephenson (1997: 230) stressed that

> … it should be emphasized that throughout Chinese history from the Han onwards, recorded dates of solar eclipses, when converted to the Julian calendar, usually agree precisely with the calculated dates of these phenomena."

2 ECLIPSE RECORDS FROM THE WESTERN (FORMER) HAN DYNASTY (206 BCE–5 CE)

The extreme destruction visited on the hated Qin Dynasty (221–206 BCE) by the rebellions that brought it down included the massacre of the populace of Xianyang and the burning of the capital, together with its palaces, administrative archives, and libraries. History records that Xianyang, founded in 350 BCE, burned for three months. This catastrophe, following the holocaust of pre-Qin writings instigated by Chancellor Li Si in 213 BCE, would have seriously hampered early Han efforts to reconstruct the imperial administration. Consequently, many Qin laws and ordinances remained in effect for years, including, at least initially, the prohibition against private ownership of books. Surprisingly, even the Qin calendar continued in use for a century before it was finally replaced in 104 BCE, after completion of lengthy work by an imperial commission (Cullen, 1993). Then, too, the Han founder, Liu Bang (ca 250–195 BCE) was a commoner, together with many of his supporters and military commanders, so that recruiting qualified men and reconstituting the administration of the empire presented a formidable challenge. This may explain why, in his account of the history of the office of Grand-Scribe Astrologer, Sima Qian mentions no holder of that office prior to the appointment of his father in 140 BCE. Under the circumstances, it is fortunate that any reliable astronomical observations at all survive from the first half of the 2nd century BCE.

Rather than simply relying on methodologically-flawed statistical studies, it seems advisable to probe the eclipse records themselves. In Table 1 below are catalogued all 127 solar eclipses recorded during the Han Dynasty in the standard historical sources: *Sima Qian's* the *Grand Scribe's Records* (ca 100 BCE), the *History of the Former Han Dynasty* (*Han shu*) compiled by Ban Gu (32–92 CE), and the *History of the Later Han Dynasty* (*Hou Han shu*) compiled by Fan Ye (398–445 CE).

In his study a half-century ago Homer H. Dubs analyzed all the solar eclipses during the Western Han Dynasty (1938-1955, III: 546-59). Dubs studied 98 eclipses potentially visible from some part of China during the 200 years of the Western Han (206 BCE-8 CE) and the two decades of the usurper Wang Mang's Xin Dynasty (9-23 CE). Fifteen of these were either invisible at the Han capital or too small to be observed. Of the remaining eighty-three eclipses, fifty-five, or two-thirds, were recorded in the official sources. More than two-thirds of these again, or thirty-eight eclipses, were recorded correctly. Dubs's figure of two-thirds coverage of observed and recorded eclipses in the Western Han period agrees favourably with the 68% result computed for Chinese observation of transient objects during the 1,000 years from 600 to 1600 (Strom, 2011). Dubs concluded:

> Considering the length of time since the HS [*Han shu*] was written in the first century A.D., and the many opportunities for mistakes, both by astronomers and annalists before the *HS* was compiled and the opportunities for errors in transmitting the *HS* text, this is an excellent record. Fourteen other eclipses can be fitted into the actual dates, usually by only slight changes in the text. Only at most three recordings are hopelessly erroneous; two of these are due to errors in transmission of the data. When we consider how very easy it is to write mistakenly the number of a month or the cyclical day, the essential correctness of the *HS* is a marked evidence of the care that was exercised in compiling it and in preserving and copying faithfully its

text (Dubs 1938–55, III: 551).

Several of Dubs's specific conclusions are worth noting; namely, (i) in several cases it can be shown that the dating errors occurred before the *HS* was compiled; (ii) in other cases, minor changes have plainly been made since the *HS* was composed, as shown by quotations in other texts; (iii) the capital of Chang'an was *not* the only place from which eclipses were observed; (iv) during long periods all plainly-visible eclipses were reported (over half a century in two cases), while during other periods entire groups of eclipses were missed; (v) the Chinese clearly used special techniques to observe eclipses and must have kept a watch in advance, allowing them to spot eclipses of small magnitude; (vi) differences in the recorded magnitudes of eclipses indicate that those found in the "Treatise on the Five Elemental-Phases" (*Wu xing zhi*) were observed by astronomers at the capital, while some in the "Basic Annals" (*Benji*) were witnessed outside the capital, although in a few cases the "Treatise" also specifically identifies certain reports as coming from elsewhere; (vii) there is no evidence that the Chinese calculated any eclipse recorded during the Former Han period; (viii) based on the reported positions of the Sun among the twenty-eight lodges, it is clear these have been calculated based on the recorded dates of the eclipses, some of these calculations possibly having been done by Liu Xiang (77 BCE–6 CE) in about 27 BCE, by which time the dates of many eclipses were probably already in error.

Table 1: Han Dynasty Eclipses Recoded in the Official Souces.

	Western Han Eclipses (–205 to 5 CE)				Comments
	Emperor	Dubs, *History of the Former Han Dynasty* vol., page	Espenak & Meeus eclipse mag. (*ital*. Dubs)	Espenak & Meeus number	Notations in order: reign year, month, cyclical day number (conversion of Chinese dates for the Common Era are given by Academia Sinica, "2000-Year Chinese-Western Calendar Conversion" http://sinocal.sinica.edu.tw/; 晦 *hui* "last day of the month" or 朔 *shuo* "first day of the month"; lodge location if given (known to be interpolated); "^{d}" are Chinese *du*, or 0.9856 degrees (for the boundary stars of the 28 lodges, see Cullen [2011]); [S + page] eclipse studied in Stephenson (1997); [K + page] eclipse studied in Kawabata et al. (2003); ✓record matches Espenak & Meeus, http://eclipse.gsfc.nasa.gov/SEcat5/SEcatalog.html
	Gaozu				
WH#1	–204 Dec 20	I, 165, i	[*~0.51*]	04277	III.10 甲戌 [11] (DIPPER 20^{d}); observable at Chang-an. ✓
2	–200 Oct 8	I, 165, ii	0.284 prov. report?	04286	III.11 癸卯[40]晦; should be VI.8 癸未[20]; too small to be observable at Chang'an, but mag. 0.467 at Changchun, Yan Province (43.8134° N 125.2905° E); likely provincial report. (?)
3	–197 Aug 7	I, 166, iii	0.957	04292	IX.6 乙未[32]晦 'total' (SPREAD 13^{d}) [S 238][K 6]; observable at Chang'an. ✓
	Huidi				
4	–191 Sep 29	I, 188, i	0.223	04304	VII.5 辛丑[38]朔; scribal error, should be III.9 and 酉 for 丑; observable at Chang'an. (?)
5	–187 Jul 17	I, 189, ii	0.926/1.007	04315	VII.5 丁卯[4]晦; 'total' and 'almost total' (STARS 'initial degrees') [S 234][K 6]; observable at Chang'an, but totality in a path NW to SE across western China confirms divergent 'total' and 'almost total' comments. ✓
	Empress Lu				
6	–180 Mar 4	I, 212, ii	1.013	04331	VII.1 己丑[26]晦 'total' (HALL 13^{d}) [S 234] [K 6]; observable at Chang'an. ✓
	Wendi				
7	–177 Jan 2	I, 284, i	*[~0.20]*	04337	II.11 癸卯[40]晦 (GIRL 1^{d}); observable at Chang'an. ✓
8	–177 Dec 22	I, 284, iii	0.385	04339	III.10 丁酉[34]晦 (DIPPER 23^{d}); observable at Chang'an. ✓
9	–175 Jun 6	I, 284, iv	0.276	04342	III.11 丁卯[4]晦 (VOID 8^{d}), possibly IV.5 辛卯[28]朔; observable at Chang'an.
10	–160 Aug 17	I, 286, v	[*0.349]* prov. report?	04379	*Houyuan* IV.4 丙寅[3]晦 (WELL 13^{d}) possibly III.6 庚申[57]晦; unobservable before sunrise at Chang'an, but mag. 0.349 at Zhangye in Beidi Commandery (38.8929° N 100.5054° E). (?)
11	–154 Oct 10	I, 286, vi	0.244	04395	VII.1 辛未[8]朔 ; should be Jingdi 2nd year, 9th month, 乙酉[22]晦; small partial eclipse observable at Chang'an. ✓
	Jingdi				
12	–153 Apr 5	I, 335, i	0.803 prov. report?	04396	III.2 壬子[49]晦 (STOMACH 4^{d}); unobservable at Chang'an before sunrise, confirmed provincial report. ✓
13	–149 Jan 22	I, 336, iii	0.691	04405	VII.11 庚寅[27]晦 (VOID 9^{d}); observable at Chang'an. ✓
14	–148 Jun 7	I, 336, iv	0.427	04408	*Zhongyuan* I.12 甲寅[51]晦; possibly I.5 壬子[49]晦; sunset eclipse at Chang'an. ✓

15	–146 Nov 10	I, 337, vi	0.763 prov. report	04413	III.9 戊戌[35]晦 'almost total' (TAIL 9[d]) [S 235] [K 6]; observable at Chang'an, but mag. 0.947 at Zhangshan Kingdom; probable provincial report of near totality. ✓
16	–144 Mar 26	I, 336, vii	0.506 prov. report?	04417	IV.10 戊午 [55]晦; possibly V.2 庚申[57]晦; no eclipse at Chang'an, mag. 0.506 at Sun Temple, eastern tip of Shandong (37.2408° N 122.4316° E), mag. 0.638 at coastal Kuaiji Commandery (30.9225° N 121.951° E). (?)
17	–143 Sep 8	I, 336, viii	0.619	04420	VI.7 辛亥[48]晦 (CHARIOT 7[d]); observable at Chang'an. ✓
18	–142 Aug 28	I, 339, ix	0.625	04422	*Houyuan* I.7 乙巳[42]晦 (WINGS 17[d]); observable at Chang'an. ✓
	Wudi				
19	–140 Jul 8	II, 136, i	0.277 prov. report?	04427	*Jianyuan* II.2 丙戌[23]晦 (GHOST 14[d]); alternatively Jingdi, *Houyuan* III.5 丙寅[3]朔; no eclipse at Chang'an, mag. 0.277 at Guangzhou, Nanhai Commandery. (?)
20	–137 Nov 1	II, 136, ii	0.558	04435	III.9 丙子[13]晦 (TAIL 2[d]); observable at Chang'an. ✓
21	–135 Apr 15	II, 136, iii	0.277	04438	V.1 己巳[6]朔; should be 3rd month; no eclipse at Chang'an, mag. 0.277 at Jiuquan Commandery (Inner Mongolia).
22	–134 Apr 5	II, 137, iv	prov. report?	04441	*Yuanguang* I.2 丙辰[53]晦; possibly *Jianyuan* VI.3 壬戌[59]晦; no eclipse at Chang'an, very small partial eclipse from Liaodong Commandery and eastward to the Pacific coast. (?)
23	–133 Aug 19	II, 138, v	0.709	04445	I.7 癸未[20]晦-1 (WINGS 8[d]); observable at Chang'an. ✓
24	–126 Apr 6	II, 138, vi	0.502	04460	*Yuanshuo* II.2 乙巳[42]晦; observable at Chang'an. ✓
25	–122 Jan 23	II, 139, vii	0.645	04469	VI.11 癸丑[50]晦 should be 12th month; observable at Chang'an. ✓
26	–121 Jul 9	II, 139, viii	0.966	04472	*Yuanshou* I.5 乙巳[42]晦 (WILLOW 6[d]); observable at Chang'an. ✓
27	–111 Jun 18	II, 139, ix	0.798	04496	*Yuanding* V.4 丁丑[14]晦 (WELL 23[d]); observable at Chang'an. ✓
28	–107 Apr 6	II, 139, x	0.335	04505	*Yuanfeng* IV.6 己酉[46] 晦; should be 3rd month 乙酉[22] 晦; scribal error 6 for 3, 己 for 乙; observable at Chang'an. ✓
29	–95 Feb 23	II, 141, xi	0.881	04534	*Taishi* I.1 乙巳[42] 晦; intercalation confirmed by archaeological discovery of a calendar; observable at Chang'an. ✓
30	–92 Dec 12	II, 141, xii	0.844	04542	IV.10 甲寅[51]晦 (DIPPER 19°; observable at Chang'an. ✓
31	–88 Sep 29	II, 141, xiii	0.912	04551	*Zhenghe* IV.8 辛酉晦[58] LT15-17 'not total, like a hook' (NECK 2[d]) 'at the hour of *fu* [LT=15-17h] the eclipse began from the northwest; towards the hour of sunset it was restored' [S 235] [K 6]; observable at Chang'an. ✓
	Zhaodi				
32	–83 Dec 3	II, 178, i	0.643	04564	*Shiyuan* III.11 壬辰[29]朔 (DIPPER 9[d]; observable at Chang'an.✓
33	–79 Sep 20	II, 178, ii	0.787/1.001 prov. report	04574	*Yuanfeng* I.7 乙亥[12]晦 (SPREAD 12[d]) [S 235] [K 6]; "total" and "almost total"; observable at Chang'an, but total 1.001 at Beijing, Zhangshan Kingdom; confirms divergent 'total' and 'almost total' comments. ✓
	Xuandi				
34	–67 Feb 13	II, 275, i	0.435	04602	*Dijie* I.12 癸亥[60]晦 (HALL 15[d]); observable at Chang'an (?), but 0.435 at Guangzhou, Nanhai Commandery. ✓
35	–55 Jan 3	II, 275, ii	0.92 prov. report	04632	*Wufeng* I.12 乙酉[22]朔 (GIRL 10°); no eclipse at Chang'an, mag. 0.92 at Lelang Commandery = Pyongyang (39.0328° N 125.7275° E). ✓
36	–53 May 9	II, 276, iii	0.815	04637	IV.4 辛丑[]晦 (NET 19°); observable at Chang'an. ✓
	Yuandi				
37	–41 Mar 28	II, 354, i	0.729	04667	*Yongguang* II.3 壬戌[59]朔 (PASTURE 8[d]); observable at Chang'an. ✓
38	–39 Jul 31	II, 354, ii	0.519	04674	IV.6 戊寅[15]晦 (SPREAD 7[d]); observable at Chang'an.. ✓
39	–34 Nov 1	II, 355, iii	0.825	04685	*Jianzhao* V.6 壬申[9]晦 'partial, like a hook, then set'; should be IV.9 丁丑[14]晦 [S 236] [K 6]; sunset eclipse observable at Chang'an. ✓
	Chengdi				
40	–28 Jan 5	II, 419, i	0.66	04700	*Jianshi* III.12 戊申[45]朔 (GIRL 9[d]); mag. 0.66 at Chang'an. ✓
41	–27 Jun 19	II, 419, ii	0.927	04703	*Heping* I.4 己亥[36]晦 'not total, like a hook' [S 236] [K 6]; observable at Chang'an. ✓
42	–25 Oct 23	II, 419, iii	0.786	04710	III.8 乙卯[52]晦 (CHAMBER); observable at Chang'an.✓
43	–24 Apr 18	II, 420, iv	0.557	04711	IV.3 癸丑[50]朔 (MANE); observable at Chang'an.✓
44	–23 Apr 7	II, 420, v	0.106	04713	*Yangshuo* I.2 丁未[44]晦 (TAIL); very small partial eclipse

					at Chang'an. ✓
45	–15 Nov 1	II, 420, vi	0.08	04736	*Yongshi* I.9 丁巳[54]晦; extremely small partial eclipse at Chang'an ('small magnitude shows prior watch was kept.' – Dubs).✓
46	–14 Mar 29	II, 421, vii	0.864	04737	II.2 乙酉[22]晦; observable at Chang'an. [S 231]; provincial report. ✓
47	–13 Mar 18	II, 421, viii	0.424	04739	III.1 己卯[16]晦; observable at Chang'an. ✓
48	–12 Aug 31	II, 421, ix	0.218	04742	IV.7 辛未[8]晦; observable at Chang'an. ✓
49	–11 Jan 26	II, 422, x	[*0.07*]	04743	*Yuanyan* I.1 己亥[36]朔; observable at Chang'an? ('small magnitude shows prior watch was kept.' – Dubs).✓
	Aidi				
50	–1 Feb 5	III, 43, i	0.855	04769	*Yuanshou* I.1 辛丑[38]朔 'not total, like a hook' (HALL 10[d]) [S 237] [K 6]; observable at Chang'an. ✓
51	0 Jun 20	III, 43, ii	[*0.06*]	04772	II.4 壬辰[29]晦; should be 壬戌[59] (scribal error of 辰 for 戌); observable at Chang'an? ('small magnitude shows prior watch was kept.' – Dubs).✓
	Pingdi				
52	1 Jun 10	III, 87, i	0.733	04775	*Yuanshi* I.5 丁巳[54]朔 (WELL); observable at Chang'an. ✓
53	2 Nov 23	III, 87, ii	0.904	04778	II.9 戊申[45]晦 'total' [S 238][K 6]; observable at Chang'an. ✓
	Wang Mang's Xin Dynasty Eclipses				
54	6 Sep 11	III, 544, i	0.924	04787	*Jushe* I.10 丙辰[53]朔; should be 7th month; observable at Luoyang. ✓
55	14 Apr 18	III, 544, ii	0.524	04807	*Tianfeng* I.3 壬申[9]晦 ; observable at Chang'an. ✓
56	16 Aug 21	III, 545, iii	0.833	04813	III.7 戊子[25]晦; observable at Chang'an. ✓
	Eastern Han Dynasty Eclipses (26 – 220 CE)		Magnitude	Number	Comments
					Certain eclipses not observed at the capital are explicitly recorded as 'reported by' with the location noted; R before the month number indicates intercalary month. *Sources*: "Basic Annals" and "Monograph on the Five Elemental-Phases" in the *History of the Later Han Dynasty*: Fan (1965), VI.18. 3357.
	Guangwudi				
EH#1	26 Feb 6		0.697	04838	*Jianwu* II.1 甲子[1]朔 (8[d] in ROOF); observable at Luoyang (34.6255° N 112.4451° E). ✓
2	27 Jul 22		0.519	04841	III.5 乙卯[52]晦 (14[d] in WILLOW); observable at Luoyang. ✓
3	30 Nov 14		0.653	04849	VI.9 丙寅[3]晦 (8[d] in TAIL); 'not observed by scribe-astrologer officials, reported by a commandery'; mag. 0.653 at Luoyang, mag. 0.996 at Guangzhou, Nanhai Commandery. ✓
4	31 May 10		0.721	04850	VII.3 癸亥[60]晦 (5[d] in Net); observable at Luoyang. ✓
5	40 Apr 30		~0.5	04874	XVI.3 辛丑[38]晦 (7[d] in MANE); prior to sunrise at Luoyang, large early morning eclipse at Changchun, Liaodong Commandery. ✓
6	41 Apr 19		0.789	04876	XVII.2 乙未[32]晦 (9[d] in STOMACH); observable at Luoyang.✓
7	46 Jul 22		0.167	04889	XXII.5 乙未[32]晦 (7[d] in WILLOW); very small partial eclipse at Luoyang, mag. 0.479 at Dunhuang Commandery (40.1333° 94.6362° E). ✓
8	49 May 20		0.744	04897	XXV.3 戊申[45]晦 (15[d] in NET); observable at Luoyang. ✓
9	53 Mar 9		0.713	04905	XXIX.2 丁巳[54]朔 (5[d] in E. WALL); observable at Luoyang. ✓
10	55 Jul 13		0.266	04912	XXXI.5 癸酉[10]晦 (5[d] in WILLOW); observable at Luoyang. ✓
11	56 Dec 25		0.64	04915	*Zhongyuan* I.11 甲子[1]晦 (20[d] in DIPPER); observable at Luoyang.✓
	Mingdi				
12	60 Oct 13		0.701	04924	*Yongping* III.8 壬申[9]晦 (2[d] in BASE); observable at Luoyang. ✓
13	65 Dec 16		0.94/1.007	04938	VIII.10 壬寅[39]晦 'total' (11[d] in DIPPER) [S 240][K 6]; observable at Luoyang. ✓

14	70 Sep 23		0.889	04948	XIII.10 甲辰[41]晦; (7^{d} in TAIL); *Annals* miswrites 壬 for 甲, *WXZ* is correct; observable at Luoyang,. ✓
15	73 Jul 23		0.828	04956	XVI.5 戊午[55]晦 (15^{d} in WILLOW); observable at Luoyang, total 1.007 at Guangzhou. ✓
16	75 Jan 5		------	04959	XVIII.11 甲辰[41]晦; (21^{d} in DIPPER) day is wrong should be 己酉[46] *; E&M show the eclipse as not visible from China.*
	Zhangdi				
17	80 Mar 10		0.269	04927	*Jianchu* V.2 庚辰[17]朔 (8^{d} in WALL); observable at Luoyang. ✓
18	81 Aug 23		0.279	04975	VI.6 辛未[8]晦; 未 error for 卯 [28]晦 (6^{d} in WINGS); observable at Luoyang. ✓
19	87 Oct 15		0.863	04990	*Zhanghe* I.8 乙未[32]晦 (4^{d} in BASE) 'not observed by scribe-astrologer officials, reported by other officials'; sunset eclipse at Luoyang. ✓
	Hedi				
20	90 Mar 20		0.277	04996	*Yongyuan* II.2 壬午[19] (8^{d} in STRIDE) 'not observed by scribe-astrologer officials, reported by Zhuo Commandery 涿郡 (Hebei, 39 29.1 N 115° 58.5' E)'. ✓
21	92 Jul 23		0.661	05002	IV.6 戊戌[35]朔 (2^{d} in STARS); observable at Luoyang. ✓
22	95 May 22		0.927	05010	VII.4 辛亥[48]朔 (in BEAK); observable at Luoyang, ✓
23	100 Aug 23		0.459	05022	XII.7 辛亥[48]朔 (8^{d} in WINGS); observable at Luoyang. ✓
24	103 Jun 22		0.794	05030	XV.R4 甲子[1]晦 (22^{d} in WELL); observable at Luoyang. ✓
	Andi				
25	107 Apr 11		0.434	05038	*Yongchu* I.3 癸酉[10] '2nd day of the month' (2^{d} in STOMACH); observable at Luoyang. ✓
26	111 Jan 27		0.77	05048	V.1 庚辰[17]朔 (8^{d} in VOID); observable at Luoyang. ✓
27	113 Jun 1		0.923	05055	VII.4 丙申[33]晦 (1^{d} in WELL); mag. 0.923 sunset eclipse at Luoyang.✓
28	114 Nov 15		0.556	05058	*Yuanchu* I.10 戊子[25]朔 (10^{d} in TAIL); observable at Luoyang. ✓
29	115 Nov 4		~0.08	05060	II.9 壬午[19]晦 (4^{d} in HEART); mag. ca 0.08 sunset eclipse at Luoyang. ✓
30	116 Apr 1		0.956	05061	III.3 辛亥[48] '2nd day of the month' (5^{d} in PASTURE); 'not observed by scribe-astrologers officials; reported by Liaodong 遼東 [bordering Korea]'; no eclipse at Luoyang, mag. 0.956 at Changchun, Liaodong Commandery. ✓
31	117 Mar 21		0.186	05063	IV.2 乙巳[42]朔 (9^{d} in STRIDE) 'not observed by scribe-astrologer officials, reported by seven commanderies'; no eclipse at Luoyang, mag. 0.186 at Guangzhou, Nanhai Commandery. ✓
32	118 Sep 3		0.557	05066	V.8 丙申[33]朔 (18^{d} in WINGS) 'not observed by scribe-astrologer officials, reported by Zhangye 張掖 [Gansu, 38° 55.5' N 100° 26.96 E]'; after sunset at Luoyang, mag. 0.535 at Zhangye Commandery. ✓
33	120 Jan 18		0.988/1.013	05071	VI.12 戊午[55]朔 'almost total, like twilight on the ground' (11^{d} in GIRL) [S 237] [K 6]; observable at Luoyang, total 1.013 60 km south at Pingdingshan (33.7623° N 113.1702° E) within the capital commandery. *Hanji* says 'the stars all appeared' signifying totality, probably within the capital commandery; Stephenson (1997: 238). ✓
34	120 ® 121 Jul 2				*Yongning* I.7 乙酉[22]朔 (15^{d} in SPREAD); should be *Yongning* II.7 辛亥[48]晦; 'not observed by scribe-astrologer officials, reported by Jiuquan 九泉 Commandery (Gansu, 39° 43.9' N 98° 29.7' E)' [S 237].' In fact, not observable at Jiuquan, but mag. 0.193 at Kunming, Yizhou Commandery (23.7492° N 100.9424° E). ✓
35	123 Nov 6		<0.1	05080	*Yanguang* III.9 庚申[57]晦; very small partial eclipse visible only from the coast north of Korea. ✓
36	125 Apr 21		1.0063	05083	IV.3 戊午[55]朔 (12^{d} in STOMACH) 'Longxi 隴西 35° 0.3' N 104° N 38.1' E, Jiuquan, and Shuofang 朔方 [near Baotou, Inner Mongolia] reported the event, the scribe-astrologer officials did not notice it'; mag. 0.314 at Luoyang, mag. 0.5 at Jiuquan Commandery, mag. 0.504 at Baotou, Shuofang Commandery. ✓
	Shundi				
37	127 Aug 25		0.961	05089	*Yongjian* II.7 甲戌[11]朔 (9^{d} in WINGS) (a doublet is

					misdated *Yangjia* II); mag. 0.961 at Luoyang. ✓
38	135 Sep 25		0.267	05108	*Yangjia* IV.R8 丁亥[24]**朔** (5^{d} in HORN) 'scribe-astrologer officials did not observe it, Lingling 零陵 [Guangxi/Hunan] reported'; no eclipse at Luoyang, mag. 0.394 at Lingling Commandery in the south. ✓
39	138 Jan 28		------	05115	*Yonghe* III.12 戊戌[35]朔 (11^{d} in GIRL; possibly 晦); 'not observed by scribe-astrologer officials, reported by Kuaiji 會計 Commandery (eastern Jiangsu)'; *E&M show eclipse not visible farther east than Ukraine*.
40	139 Jan18		0.115	05117	V.1 己丑[26]晦 '1st month' 正 miswritten as '5th month 五' (33^{d} in WELL); no eclipse at Luoyang, mag. ~0.115 at Guangzhou, Nanhai Commandery. ✓
41	140 Jul 2		0.538	05120	VI.9 辛亥[48]晦 (11^{d} in TAIL) ('6th year' should be '5th year') observable at Luoyang. ✓
	Huandi				
42	147 Feb 18		0.611	05136	*Jianhe* I.1 辛亥[48]朔 (3^{d} in HALL) 'scribe-astrologer officials did not observe it, reported by commanderies and kingdoms'; no eclipse at Luoyang, mag. ~0.611 at coastal Yangzhou Province (28.394° N 121.619° E). ✓
43	149 Jun 23		0.594	05143	III.4 丁卯[4]晦 (23^{d} in WELL); mag. 0.594 sunrise eclipse at Luoyang.✓
44	152 ® 157 Jul 24		0.161	05161	*Yuanjia* II.7 庚辰[17]朔 (4^{d} in WINGS); 'scribe-astrologer officials did not observe it, reported by Guangling 廣陵 Commandery [near Shanghai]'; scribal error; should be '*Yongshou* 3rd year, 庚辰[17]晦'; no eclipse at Luoyang, mag. ~0.161 at Yangzhou, Guangling Commandery. This is possibly a doublet of #46, also visible from eastern Jiangsu.[1] ✓
45	154 Sep 25		0.721	05154	*Yongxing* II.9 丁卯[4]朔 (5^{d} in HORN); mag. 0.721 at Luoyang. ✓
46	157 Jul 24		0.277	05161	*Yongshou* III.R5 庚辰[17]晦 (2^{d} in STARS) 'scribe-astrologer officials did not observe it, reported by commanderies and kingdoms'; no eclipse at Luoyang, mag. ~0.277 at Guangzhou, Nanhai Commandery. ✓
47	158 Jul 13		0.768	05163	*Yanxi* I.5 甲戌[11]晦 (7^{d} in WILLOW); observable at Luoyang. ✓
48	165 Feb 28		0.401	05178	VIII.1 丙申[33]晦 (13^{d} in HALL); observable at Luoyang. ✓
49	166 Feb 18		0.634	05181	IX.1 辛卯[28]朔 (3^{d} in HALL) 'scribe-astrologer officials did not observe it, reported by commanderies and kingdoms'; just prior to sunrise at Luoyang. ✓
50	167 Jul 4		0.582	05185	*Yongkang* I.5 壬子[49]晦 (1^{d} in GHOST); observable at Luoyang. ✓
	Lingdi				
51	168 Jun 23		0.33	05187	*Jianning* I.5 丁未[44]朔 (doublet mistakenly appears under Xiandi "25th year" in *Basic Annals*); unobservable at Luoyang, mag. 0.33 at Guangzhou in coastal Nanhai Commandery. ✓
52	168 Dec 17		0.71	05188	I.10 甲辰[41]晦 (with no prior intercalation this year) ; observable at Luoyang.✓
53	169 Dec 6		~0.60	05190	II.10 戊辰[5]晦 'reported by Youfufeng 右扶風 Commandery (34.3679° N 107.8816° E)'; scribal error 辰 for 戌; observable at Chang'an.✓
54	170 May 3		?	05191	III.3 丙寅[3]晦 'reported by the governor of Liang 梁 [Kingdom, eastern Henan]' (34.4248° N 115.6428° E).✓
55	171 Apr 23		0.219	05193	IV.3 辛酉[58]朔; sunrise eclipse at Luoyang. ✓
56	174 Feb 19		0.337	05199	*Xiping* II.12 癸酉[10]晦[Feb 18] (2° in VOID); mag. 0.337 at Luoyang. ✓
57	177 Dec 8		0.417	05208	VI.10 癸丑[50]朔 'reported by the Governor of Zhao 趙 [Hebei] (38.1783 N 114.3457 E)'; should be '11th month'; no eclipse at Luoyang. ✓
58	178 Mar 7		------	?	*Guanghe* I.2 辛亥[48]朔 in "Monograph"; "Basic Annals" has '5th month'. *E&M show no eclipse. Failed prediction?*
59	178 Nov 27		0.378	05210	*Guanghe* I.10 丙子[13]晦 (4^{d} in BASKET); observable at Luoyang. ✓
60	179 May 24		0.895	05211	II.4 甲戌[11]朔; observable at Luoyang. ✓
61	181 Sep 26		0.886	05216	IV.9 庚寅[27]朔 (6^{d} in HORN); observable at Luoyang, ✓
62	186 Jul 4		0.283	05227	*Zhongping* III.5 壬辰[29]晦; observable at Luoyang. ✓
63	189 May 3		0.7	05234	VI.4 丙午[43]朔; aka Shaodi, *Guangzi* 1st year; observable at Luoyang. ✓
	Xiandi				

64	193 Feb 19		0.549	05242	IV.1 甲寅[51]朔 (4[d] in HALL); observable at Luoyang.✓
65	194 Aug 04		0.936	05245	*Xingping* I.6 乙巳[42]朔; mag. 0.936 sunrise eclipse at Luoyang. ✓
66	200 Sep 26		0.646	05259	*Jian'an* V.9 庚午[7]朔; mag. 0.646 sunrise eclipse at Luoyang.✓
67	201 Mar 22		0.387	05260	VI.2 丁卯[4]朔; mag. 0.133 at Luoyang, mag. 0.387 at Hanoi, Jiaozhi Commandery. ✓
68	208 Oct 27		0.749	05278	XIII.10 癸未[20]朔 (12[d] in TAIL); observable at Luoyang. ✓
69	210 Mar 13		0.816	05281	XV.2 乙巳[42]朔; sunrise eclipse at Luoyang. ✓
70	212 Aug 14		0.832	05286	XVII.6 庚寅[27]晦; observable at Luoyang. ✓
71	216 Jun 3		0.802	05295	XXI.5 己亥[36]朔; sunrise eclipse at Luoyang, ✓
72	219 Apr 2		0.512	05301	XXIV.2 壬子[49]晦; observable at Luoyang. ✓
	Concluding summation from the "Monograph on the Five Elemental-Phases," (*Hou Han shu*, VI.18.3372): "total eclipses = 72; first day of the month *shuo* = 32; last day of the month *hui* = 37; 2[nd] day of the month = 3."				

3 ON THE QUESTION OF RECORDS ORIGINATING FROM OUTSIDE THE CAPITAL

Some Western Han Dynasty eclipses records certainly originated outside the capital (Dubs, 1938-1955, III: 552). Apart from the political units called commanderies under the direct administration of the imperial court, two-thirds of the Han Empire comprised powerful, quasi-autonomous kingdoms ruled by Lord-Kings (imperial relatives) with their own courts (Figure 1). Many of these were nominally successors to the kingdoms annihilated during the course of the Qin conquest campaigns lasting more than a century, which culminated in the unification of all of China proper in 221 BCE.

From an aristocratic tomb (closed ca. 168 BCE) in the most southerly kingdom, the Kingdom of Changsha, came the trove of Mawangdui silk manuscripts discovered in the 1970s, including the most 'important' astronomical/astrological 'texts' ever unearthed: the *Prognostications of the Five Planets*, the *Xing-De*, the *Diverse Prognostications on the Heavenly Patterns and Formations of Materia Vitalis*, and an illustrated *Cometary Atlas*. From the Kingdom of Huainan, also far to the south, comes the encyclopedic *Huainanzi* (139 BCE), which documents observation of celestial phenomena during the Qin and Former Han dynasties. By then astral prognostication had been practiced for centuries. Indeed, thirty-six solar eclipses are accurately reported in the *Spring and Autumn Annals* chronicle from the court of the eastern state of Lu, far from the Eastern Zhou Dynasty capital in Luoyang, the only one of its kind to have survived intact. Moreover, several of the most important scribe-astrologers active in the Warring States of the pre-imperial period are identified by name in Sima Qian's "Treatise on the Celestial Offices" in the *Grand Scribe's Records*. The most important observational astronomer who participated in the Grand Inception calendar reform of 104 BCE, Luoxia Hong, actually hailed from Ba (Sichuan) in the far southwest.

There can be no doubt, therefore, that solar eclipses were being closely observed in kingdoms and commanderies far from the capital, as explicitly stated in several Eastern Han Dynasty records assembled in Table 1. Ample evidence exists that numerous provincial observatories were in operation during the Song Dynasty (1127–1279) and later, so the assumption that observations were not being made at them is misguided (Pankenier, 1998: 32).

4 RECORDING ERRORS IN THE PARAMETERS (REIGN, YEAR, MONTH, DAY) OF WESTERN HAN ECLIPSE REPORTS

Here, the fifteen cases of recording errors in the Western Han records excerpted from Table 1 are examined in more detail. Five elements are considered to comprise the dating parameters because the day-date is composed of two separate characters A+B, each susceptible to scribal error.

Figure 1: The Western Han Empire in 163 BCE. The shaded regions are the semi-autonomous kingdoms (after Fairbank and Twitchett, 1986: 138).

4.1 One Parameter Error

The errors, as shown in Table 2:

WH*#21, 25, 54* — 3rd month (三) miscopied as 5th (一); 12th month (十二) miscopied as 11th (十一); 7th month (七) miscopied as 10th (十), all common errors.

WH*#51* — day element B is miswritten, a common copyist's error of 辰 for 戌.

Explainable transcription errors: the observations are confirmed.

4.2 Two Parameter Error

The errors, as shown in Table 3:

#28 — mon*th* miswritte*n* as *6* (六*)* for *3* (三), day element B is miswritten 己 for 乙.

#19 — month and element B are wrong; copyist's error of year 2 (二) for 3 (三) and day 丙戌 [23] for day 丙寅 [3]; reign and year at the time of observation correctly attributed to Emperor Jing, who died in the 1st month of 141 BCE (*Houyuan* III). Emperor Wu's accession year, *Jianyuan* 1, was later variously identified as either 141 or 140, possibly causing confusion.

Explainable transcription errors: one observation confirmed, one requires corroboration of misdating.

4.3 Three Parameter Error

The errors, as shown in Table 4:

#2 — year, month, and day element B wrong; possible scribal error of day [40] *guimao* for [20] *guiwei*.

#4 — year, month, and element B wrong: possible copyist's error of 7 (七) for 3 (三), five (五) for nine (九), and day *xinchou* 辛丑 [38] for *xinyou* 辛酉 [58].

#9 — year, month, and day element A wrong; possible scribal error of day [4] for [28].

#11 — situation similar to WH*#19*; month and day are wrong, reign and year at the time of observation correctly attributed to Wendi who died in the 6th month of *Houyuan* VII. This is Espenak and Meeus (2009) 04395; mag. 0.244 at Chang'an.

#14 — day wrong, reign and year correct.

Nos. 11, 14 confirmed, nos. 2, 4, 9 require corroboration.

4.4 Four Parameter Error

The errors, as shown in Table 5:

#16 — reign, year, month and day all wrong, but the eclipse was significant on the east coast.

#39 — reign name and description correct, year, month, day all wrong; major observable sunset eclipse confirmed.

No. 39 confirmed; no. 16 possible provincial report but problematical unless corroborated.

4.5 Five Parameter Error

The errors, as shown in Table 6:

#10, 22 — reign, year, month, day all wrong.

Nos. 10, 22 unconfirmed without corroboration.

Table 2: One parameter errors.

No.	Date	Comments
WH 2	–200 Oct 8	III.11 癸卯[40]晦; should be VI.8 癸未[20]; too small to be observable at Chang'an, but mag. 0.467 at Changchun, Yan Province (43.8134° N 125.2905° E); likely provincial report.
4	–191 Sep 29	VII.5 辛丑[38]朔; scribal error, should be III.9 and 酉 for 丑; observable at Chang'an.
9	–175 Jun 6	III.11 丁卯[4]晦 (VOID 8^{d}), possibly IV.5 辛卯[28]朔; observable at Chang'an.
11	–154 Oct 10	VII.1 辛未[8]朔 ; should be Jingdi 2nd year, 9th month, 乙酉[22]晦; small partial eclipse observable at Chang'an. ✓
14	–148 Jun 7	*Zhongyuan* I.12 甲寅[51]晦; possibly I.5 壬子[49]晦; sunset eclipse at Chang'an. ✓

Table 3: Two parameter errors.

No.	Date	Comments
28	–107 Apr 6	*Yuanfeng* IV.6 己酉[46] 晦; should be 3rd month 乙酉[22]晦; scribal error 6 for 3, 己 for 乙; observable at Chang'an. ✓
19	–140 Jul 8	*Jianyuan* II.2 **丙戌**[23]晦 (GHOST 14^{d}); alternatively Jingdi, *Houyuan* III.5 丙寅[3]朔; no eclipse at Chang'an, mag. 0.277 at Guangzhou, Nanhai Commandery.

Table 4: Three parameter errors.

No.	Date	Comments
2	–200 Oct 8	III.11 癸卯[40]晦; should be VI.8 癸未[20]; too small to be observable at Chang'an, but mag. 0.467 at Changchun, Yan Province (43.8134° N 125.2905° E); likely provincial report.
4	–191 Sep 29	VII.5 辛丑[38]朔; scribal error, should be III.9 and 酉 for 丑; observable at Chang'an.
9	–175 Jun 6	III.11 丁卯[4]晦 (VOID 8^{d}), possibly IV.5 辛卯[28]朔; observable at Chang'an.
11	–154 Oct 10	VII.1 辛未[8]朔 ; should be Jingdi 2nd year, 9th month, II.9 乙酉[22]晦; small partial eclipse observable at Chang'an. ✓
14	–148 Jun 7	*Zhongyuan* I.12 甲寅[51]晦; possibly I.5 壬子[49]晦; sunset eclipse at Chang'an. ✓

Table 5: Four parameter errors.

No.	Date	Comments
16	–144 Mar 26	IV.10 戊午 [55]晦; possibly V.2 庚申[57]晦; no eclipse at Chang'an, mag. 0.506 at Sun Temple, eastern tip of Shandong (37.2408° N 122.4316° E), mag. 0.638 at coastal Kuaiji Commandery (30.9225° N 121.951° E).
39	–34 Nov 1	*Jianzhao* V.6 壬申[9]晦 'partial, like a hook, then set'; should be IV.9 丁丑[14]晦 [S 236] [K 6]; sunset eclipse observable at Chang'an. ✓

Table 6: Five parameter errors.

No.	Date	Comments
10	–160 Aug 17	*Houyuan* IV.4 丙寅[3]晦 (WELL 13^{d}) possibly III.6 庚申[57]晦; unobservable before sunrise at Chang'an, but mag. 0.349 at Zhangye in Beidi Commandery (38.8929° N 100.5054° E).
22	–134 Apr 5	*Yuanguang* I.2 丙辰[53]晦; possibly *Jianyuan* VI.3 壬戌[59]晦; no eclipse at Chang'an, very small partial eclipse from Liaodong Commandery and eastward to the Pacific coast.

Table 7: Three problematical cases.

No.	Date	Comments
16	75 Jan 5	XVIII.11 甲辰[41]晦; (21^{d} in DIPPER) day is wrong should be 己酉[46] *; E&M show eclipse not visible farther east than Caspian Sea.*
39	138 Jan 28	*Yonghe* III.12 戊戌[35]朔 (11^{d} in GIRL; possibly 晦); 'not observed by scribe-astrologer officials, reported by Kuaiji 會計 Commandery (eastern Jiangsu)'; *E&M show eclipse not visible farther east than Ukraine.*
58	178 Mar 7	*Guanghe* I.2 辛亥[48]朔 in "Monograph"; "Basic Annals" has '5th month'. *E&M show no eclipse. Failed prediction?*

4.6 Summary

Re-examination of the original records from the Western Han and checking with Espenak and Meeus's catalogue of solar eclipses hardly affects Dubs's sixty-year-old conclusions. Virtually all the matches Dubs was able to make between the Chinese records and actual eclipses are confirmed (in some cases refined), as are his general conclusions. Of the fifteen erroneous records seven are too problematical to be accepted without further corroboration. The other eight contain one or more common scribal errors, but each provides sufficient information to confirm that the record corresponds to an actual observation. Detailed examination of the mistakes in the defective records mainly points to copyists' errors in transmission. One record (WH*#19*) provides convincing evidence of a distant observation subsequently reported to the capital (as do WH*#5*, *12*, *15*, *21*, *33* and *35* in Table 1). In two cases (WH*#11* and *19*) confusion about the date may be attributable to the fact that the eclipse was observed and recorded during the partial last year of an emperor, which year was subsequently also attributed by some to his successor. In the one surprising case (WH*#39*), the unique comment that the Sun set during a large eclipse observable throughout western and central China is enough to show that the event was certainly witnessed, even if the record contains numerous errors. In only two cases (WH*#22* and *10*) are all five parameters (reign, year, month, day elements A+B) wrong.

In an Appendix in his translation of *The History of the Former Han Dynasty*, Dubs (1938-1955, III: 559) concluded:

> The outstanding impression left by the Chinese recordings of eclipses in the Former [Western] Han period is their high degree of fidelity to fact. The Chinese were not to any great extent interested in fabricating eclipses as portents and it was dangerous to do so. They had not yet begun to predict eclipses. They watched for eclipses, at times with great pertinacity, and succeeded in observing eclipses that were quite small and required the use of special means to be seen. It is but natural that the original records should have suffered errors of transmission; as a whole they are surprisingly correct. This fact constitutes an unimpeachable testimony of the fidelity of the HS [*Han shu*] …

5 ECLIPSE RECORDS FROM THE EASTERN (LATER) HAN DYNASTY (26–220 CE)

The records in the "Monograph on the Five Elemental-Phases" in the *History of the Later Han Dynasty* are usually more complete by comparison with the "Basic Annals" of the individual emperors. With very few exceptions, all the Later Han records can be readily matched with eclipses observable in China. By comparison with the surviving Western Han accounts one notices significant improvement in the records in terms of accuracy and fidelity of transmission.

Remarkably, three reports during the usurper Wang Mang's Xin Dynasty (9–23 CE) and all eleven from the reign of Emperor Guangwu (25–57), first emperor of the Eastern Han, are entirely free of error. This seems to indicate that the bureaucracy survived the interregnum more or less intact.

In individual cases the Eastern Han records prove illuminating, especially where the observation is noted as coming from far afield. In a number of cases (e.g., EH#19, 20, 30-32, 36, 38, 44, 53, 54 and 57) the report states explicitly that the eclipse was not witnessed at the capital of Luoyang, but at some distant location, even as far west as Jiuquan in Gansu, over 1,700 km from the capital in Luoyang, and as far north as Shuofang (near present-day Baoding) in Inner Mongolia. Officials in Liao-dong, near the border with present-day North Korea, 1,300 km to the northeast, must have reported the eclipse of 116 CE (EH#30), even though this is not indicated in the record. But numerous other observations, which were also probably made outside the capital, are not specifically identified as such (e.g., EH#5, 13, 35, 40, 42, 46, 49 and 51). The eclipse of 2 July 121 (EH#34) was not visible from the recorded location of Jiuquan in the far west, but only from Yunnan in the far south (Kunming and southward). A clustering of remote records during the reigns of Andi (107–125), Shundi (126–133), and Huandi (147–167), suggests that remote reporting during those sixty years was particularly accurate. This illustrates how easily one can be led astray by the presumption that reports derive exclusively from observations made at the capital, even when this is not stated explicitly (Stephenson, 2012).

Three cases, EH#16, 39 and 58 (see Table 7), are most problematical, since no eclipse was visible in China on those dates. Of course, one could dismiss these out of hand, as has been done in the past. A focused look at the records indicates that deliberate misrepresentation is unlikely. Report EH#58 may simply be a garbled record of one of the other observations from years I-II of the *Guanghe* reign period (178–183). Records EH#16 and EH#39 are quite different, however, and bear closer scrutiny since the two January observations are strikingly similar. The dates are found to correspond to actual eclipses, the first (EH#16) is miswritten as 31 December 74 although the new moon actually occurred on 5 January 75. The second date, 28 January 138 (EH#39), is correct even though the observation is mistakenly attributed to Kuaiji Commandery on the east coast. Figures 2 and 3 show the tracks of these two total eclipses, both of which ended in Eastern Europe. The contradiction cannot be explained by false reporting. Even if fabrication had been rampant, the sheer improbability of invention by a court official resulting in a correct eclipse date effectively rules out that possibility. The most likely explanation is that both cases represent unsuccessful predictions.

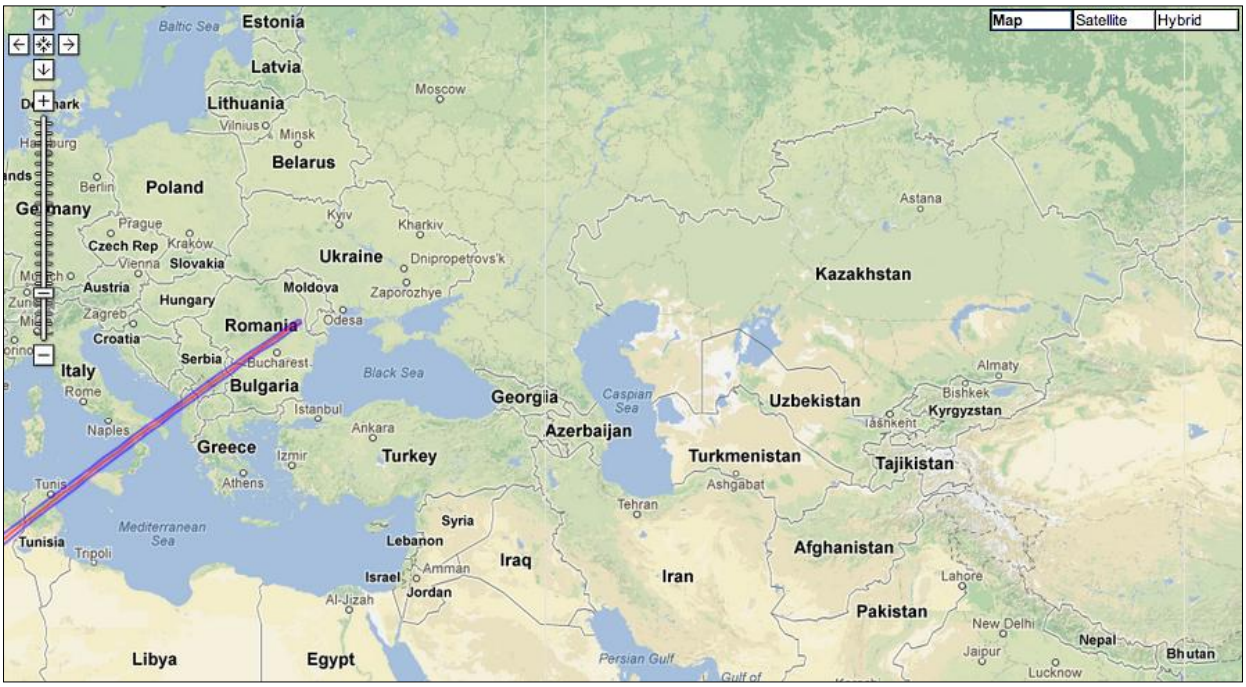

Figure 2: The path of the total eclipse of 5 January 75. The map shows the eastern end of the eclipse track across Earth's surface. (Eclipse Predictions by Fred Espenak (NASA's GSFC); map from Google Earth).

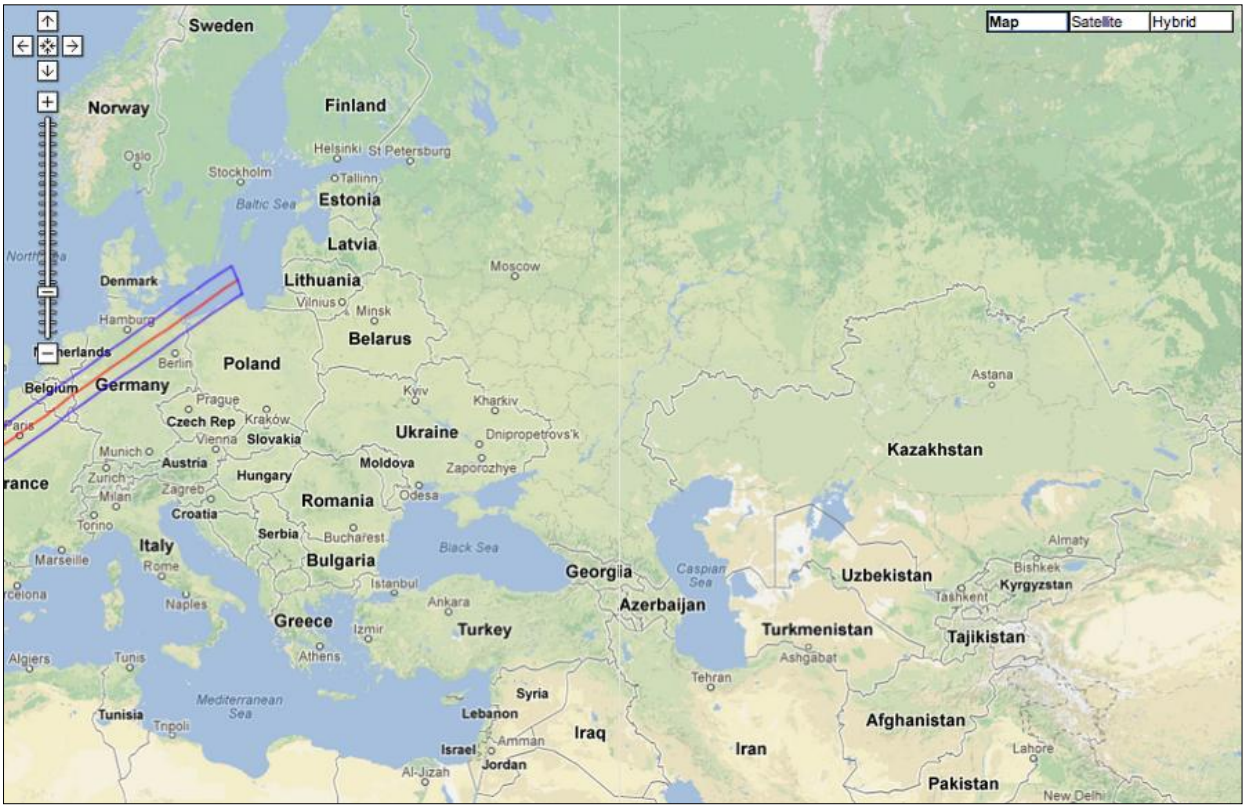

Figure 3: The path of the total eclipse of 28 January 138. (Eclipse Predictions by Fred Espenak (NASA's GSFC); map from Google Earth).

This is especially true in the case of the eclipse of 28 January 138. At precisely this time one of China's greatest polymaths, Zhang Heng (78–139 CE), was active and serving in an official capacity at court for the second time in his career. Zhang was exceptionally accomplished both as an astronomer and a mathematician, having already served during Emperor Shun's reign (126–133) as Chief Astronomer/Astrologer. He was famous for his persistent criticism of the inaccuracies of the calendar in the face of opposition at court, as well as for his unrelenting advocacy of new, more rigorous computational methods. An error of a few hours in the calculated time of the 28 January 138 eclipse would be well within the realm of possibility at this date. This is a plausible hypothesis worth pursuing.

Those who would claim reports with multiple dating parameter errors are fictitious, lacking in scientific value and may be dismissed out of hand, need to address two fairly straightforward questions: if those records are fabrications, how can it be that even when four or five dating parameters are wrongly recorded an observable eclipse actually did occur in China in the year in question? Or, put another way, how can it be that only two reports (138, 178 CE) are found for dates when no eclipses could possibly have been observed anywhere in China, but in both those cases eclipses did occur just a few hours to the west? The most likely explanation is not that they are faked, but rather that they give evidence of failed predictions. If so, the reports offer valuable historical evidence of the ability of the Chinese astronomers to calculate eclipses. In any case, the above results show that arbitrary invention can be ruled out. The default assumption should be that texts have simply become corrupted, not that erroneous records are deliberate fabrications. That is the premise this study was designed to put to the test.

No doubt, as we have seen, there is much more of interest to be gleaned from the records, even the defective ones, as well as from the associated astrological prognostications in the "Monograph on the Five Elemental-Phases." But here my primary purpose was to re-examine the assumption that eclipses were falsely reported for political reasons. Simply dismissing outliers as fakes or assuming on no good evidence that the records refer only to eclipses observable at the capital is not only ahistorical, but also forecloses the possibility of discovering historically-interesting developments. There are numerous mistakes in the reports, but it is well to remember that these are not pristine texts archaeologically excavated in recent years, like the Mawangdui silk mss. These records were copied and recopied for over 1,000 years, and then carved and re-carved in mirror image onto wooden printing blocks (often by illiterates) for another 1,000 years. As Dubs (1938-1955, III: 559) observed: "… it is but natural that the original records should have suffered errors of transmission; as a whole they are surprisingly correct."

6 ON THE LIKELIHOOD OF FALSE REPORTING

My "Planetary portent of 1524" (Pankenier, 2009) provides an illustration of how, in 1524, under one of the most repressive regimes in Chinese imperial history, even an invisible (!) five-planet cluster in February of that year was duly reported as ominous, based on the prognostication manuals (*zhan shu*). Le Huo (*jinshi* degree 1522), a scholar-official in the Bureau of Astrology and the Calendar in 1524, was banished by Emperor Shizong (1507–1567) simply for honestly reporting that the planetary massing was inauspicious. Interpretations calculated to flatter the emperor were generally offered by those who were *not* serving in the Bureau (Wu, 1990). Accurate reporting of the observations themselves was the norm. Indeed, as both de Crespigny (1976) and Dubs (1938-1955) point out, it would have been suicidal to attempt to fake a report of an eclipse, comet, or nova—all of which were easily detectable. Sunspots on the face of the Sun would also reflect on the rulership and might be easier to fake, and yet, as Joseph Needham remarked about the records:

> … if they were not more accurate than would appear from some of their severest critics, it would have been impossible to find known periodicities in them, as has been done, e.g., in the case of the sun-spot cycle. (Needham and Wang, 1959: 419-420, 435).

Attempting to deceive the emperor was always a capital crime, and factional rivalry at court virtually guaranteed that any attempt at deception would be exposed. Furthermore, the fact that solar eclipses were simultaneously observed and reported from distant locations means that any falsification would have required a nation-wide conspiracy, which is an impossibly far-fetched assumption.

De Crespigny (1976) demonstrates that it was the *interpretation* of astral anomalies that was manipulated, not the fact of their occurrence. Often the motive for such 'spin' was to deflect ominous implications arising from the standard prognostics. As Martin Kern (2000) and Yi-yi Wu (1990) show, such controversy could arise in the context of political debates long after the fact. It was in the very nature of policy arguments at court that illustrative precedents had to be cited to support one's position. No proponent of a new policy proposal would submit a memorial and expect it to be taken seriously on its own merit. Justification had to be based on documented historical precedent or the Confucian canon. There were periods in Chinese imperial history when the quality of record-keeping deteriorated due to cronyism, laxity, political unrest, and so on, most of which episodes are familiar to historians. It was standard practice for the official history of a dynasty to be compiled by its successor, so that scholars selected and edited records from archival material long after the observations were made, and in some cases would 'correct' the records or render moral judgments. In later periods one can find, for example, that even if predicted eclipses were sometimes recorded without always being identified as such, the record shows that at times conscientious officials also took pains to correct miscalculations in the record (e.g., see Xu et al., 2000: 40-41). A record of a failed prediction does not mean there was intent to deceive (Stephenson, 1997). Moreover, the inclusion of unmarked predictions among the eclipse reports, like the interpolations of the position of the Sun in the Western Han records, could simply be the result of inadvertent inclusion of interlinear comments years later, a common enough occurrence in ancient Chinese texts. Copyists possessed neither the technical skill nor the motivation to check centuries-old reports for accuracy.

7 CONCLUSION

We conclude, then, that the solar eclipse records for all four centuries of the Han Dynasty as a whole are remarkably accurate. In view of the above, it is misleading to generalize from the few instances of inaccuracy among 127 observations that the astronomical records in the early Chinese dynastic histories were freely manipulated for political reasons (Steele, 2000), especially when noted historians like Bielenstein, Dubs and de Crespigny had concluded that the records were never falsified.

Given the overall quality of the observational records, if an erroneous report like that of 178 CE is alleged to be a deliberate fabrication, the onus is on the critic to provide proof of misrepresentation based on

historical evidence. In view of the methodological problems with the statistical studies, the typical transcription errors found in the records and their high degree of fidelity even when political portentology peaked in the Eastern Han Dynasty, it is unacceptable simply to assume that false reporting was common, all the more so when based on the faulty assumption that the recorded observations were all made at the capital.[2] Certainly, the official who was executed for falsely reporting an omen in the Western Han Dynasty, Gao Yun, who ridiculed erroneous dating in the 5th century and Le Huo, who suffered banishment for proffering an honest opinion in the 16th century, would all be shocked to learn that in their 'cultural context' faking reports was "… obviously perfectly acceptable …" (Steele, 2004: 347).

8 NOTES

1. Regarding this observation de Crespigny remarks 'the false report of 152 is a remarkable exception to the general reliability of Chinese observations' (de Crespigny, 1976: 45). I suspect this entry is just a garbled duplicate of the record documenting the eclipse of 157 CE.
2. This assumption is probably fundamental to N. Foley's 1989 survey as well, though I have not seen it, since as of this writing theses and dissertations are not available from the University of Durham.

9 REFERENCES

Bielenstein, H., 1950. An interpretation of the portents in the Ts'ien Han Shu. *Bulletin of the Museum of Far Eastern Antiquities*, 22, 127-143.

de Crespigny, R., 1976. *Portents of Protest in the Later Han Dynasty: The memorials of Hsiang-k'ai to Emperor Huan*. Canberra, ANU Press.

Cullen, C., 1993. Motivations for scientific change in ancient China. *Journal for the History of Astronomy*, 24, 185-203.

Cullen, C., 2011. Understanding the planets in ancient China: prediction and divination in the *Wu xing zhan*. *Early Science and Medicine*, 16, 218-251.

Dubs, H.H., 1938-1955. *The History of the Former Han Dynasty*. Three Volumes. Baltimore, Waverly.

Eberhard, W., 1957. The political function of astronomy and astrologers in Han China. In Fairbank, J.K. (ed.). *Chinese Thought and Institutions*. Chicago, University of Chicago Press. Pp. 33-70.

Eberhard, W., 1960. Beiträge zur kosmologischen Spekulation in der Han Zeit. *Baessler Arkiv*, 16, 1-100. Reprinted in Eberhard, W., 1970. *Sternkunde und Weltbild im alten China: Gesammelte Aufsätze von Wolfram Eberhard*. Taipei, Chinese Materials and Research Aids Service Center.

Espenak F., and Meeus, J., 2009. Five Millennium Catalog of Solar Eclipses. http://eclipse.gsfc.nasa.gov/SEcat5/ catalog. html.

Fairbank, J.K., and Twitchett, D., 1986. *The Cambridge History of China, Volume 1, The Ch'in and Han Dynasties (221 B.C. – A.D. 220)*. Cambridge, Cambridge University Press.

Fan, Ye 范曄, 1965. *Hou Han shu* 後漢書. Beijing, Zhonghua shuju.

Foley, N.B., 1989. A Statistical Study of the Solar Eclipses Recorded in Chinese and Korean History During the Pretelescopic Era. M.Sc. thesis, University of Durham.

Kawabata, Kin-aki [河鰭公昭], Tanikawa, Kiyotaka [谷川清隆], and Sōma, Mitsuru [相馬充]. 2003. 中国・日本の古代日食から推測される地球慣性能率の変動 [Secular Change in the Moment of Inertia of the Earth Derived from Chinese and Japanese Records of Ancient Solar Eclipses]. 天体力学 N 体力学研究会 [*Collected Papers of Celestial Mechanics Study Group N, Mechanics Research Institute*], 3, 6-8.

Kern, M., 2000. Religious anxiety and political interest in Western Han omen interpretation: the case of the Han Wudi 漢武帝 Period (141–87 B.C.). *Chūgoku shigaku*, 10, 1-31.

Kiang, T. 1984. Notes on traditional Chinese astronomy. *Observatory*, 104, 19-23.

Needham, J., with the research assistance of Wang, L., 1959. *Science and Civilisation in China. Volume 3, Mathematics and the Sciences of the Heavens and the Earth*. Cambridge, Cambridge University Press.

Nienhauser, W.H. Jr., Cao, W., Galer, S.W., and Pankenier, D.W. (trans.), 2002. *The Grand Scribe's Records*. *Volume 2, The Basic Annals of Han China*. Bloomington, Indiana University Press.

Orchiston, W., Stephenson, F.R., Débarbat, S. and Nha, I-S. (eds.). 2004. *Astronomical Instruments and Archives from the Asia-Pacific Region*, Seoul, IAU Commission 41.

Pankenier, D.W., 1998. The mandate of Heaven. *Archaeology*, 51(2), 26-34.

Pankenier, D.W., 2009. The planetary portent of 1524 in Europe and China. *The Journal of World History*, 20.3, 339-375.

Steele, J.M., 2003. The use and abuse of astronomy in establishing absolute chronologies. *La Physique au Canada*, 59, 243-248.

Steele, J.M., 2004. Applied historical astronomy: an historyical perspective. *Journal for the History of Astronomy*, 35, 337-355.

Steele, J.M., 2000. *Observations and Predictions of Eclipse Times by Early Astronomers*. Dordrecht, Kluwer.

Stephenson, F.R., 1997. *Historical Eclipses and Earth's Rotation*. Cambridge, Cambridge University Press.

Stephenson, F.R., and Baylis, J.T., 2012. Early Chinese observations of occultations of planets by the Moon. *Journal for the History of Astronomy*, 43, 455-477.

Strom, R.G., 2011. Statistics of Oriental astronomical records: what can they tell us? In Orchiston, W. et al. (eds.) *Highlighting the History of Astronomy in the Asia-Pacific Region. Proceedings of the ICOA-6 Conference*, New York, Springer (Astrophysics and Space Science Series). Pp. 53-57.

Wei, Shou, 1974, 2003. *Wei shu* (*History of the* [*Northern*] *Wei*), (*551-554*). Beijing, Zhonghua,

Wu, Yi-yi, 1990. Auspicious Omens and their Consequences: Zhen-Ren (1006–1066) Literati's Perception of Astral Anomalies. Ph.D. thesis, Princeton University.

Xu, Z., Pankenier, D.W., and Jiang, Y., 2000. *East Asian Archaeoastronomy: Historical Records of Astronomical Observations of China, Japan and Korea*. Amsterdam, Gordon & Breach.

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