ASTRONOMICAL DATING AND STATISTICAL ANALYSIS OF ANCIENT CHINESE ECLIPSE DATA

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Abstract

All 13 Shang dynasty oracle bone eclipse records have been uniquely matched to 6 solar and 7 lunar eclipses in the 14-12th centuries B.C. The King Zhong Kang 5th year autumnal (Oct. 16, 1876 B.C.) and King Yu 3rd year "double sunset" (Sept. 24, 1912 B.C.) eclipses confirm the accuracy of the revised Bamboo Annals Xia dynasty chronology (Nivison and Pang, Early China 15, 1990, 87). The eclipse dates are plotted against the number of generations before 841 B.C. (earliest accurate date), the respective kings ruled. The curve of benefit has both the strengths of verified royal genealogy - continuity - and eclipse dating - accuracy. It is 99% accurate, and can be confidently used as a foundation for building a detailed absolute chronology for the Xia, Shang and Zhou dynasties, an important project in China's new 5-Year Plan (Song, Sci. Tech. Daily, May 17, 1996; Newsweek, July 7, 1997).

1. Introduction

Before the Shang oracle bones (discovered in an apothecary in 1899) were analyzed some scholars considered the dynasty to be legendary. It has now been proven that records had been accurately passed down to historian Sima Qian (91 B.C.) and the authors of the Bamboo Annals (229 B.C.). The Kinglist, compiled from them, is identical to that of Sima Qian and the Bamboo Annals. The genealogy of the Xia kings has not yet been directly verified by archaeological finds, but the absolute chronology of early Xia from King Yu to Zhong Kang, as recorded in the Bamboo Annals, has been confirmed by astronomical evidence (Nivison and Pang, 1990; Pang and Yau, 1996).

Astronomical dating involves retroactively computing and matching the circumstances of a celestial phenomenon observed by ancient people, but recorded without precise date. We can combine the strength of royal genealogy - continuity - with that of astronomical dating - accuracy - by correlating them. Our process is similar to stretching and contracting an approximately ruled and slightly flexible (genealogical) scale here and there to line up selected ticks with independent benchmarks (eclipse dates). We use solar, lunar and planetary ephemerides, e.g., JPL DE102, to compute past positions. Eclipse computing programs, with the latest lunar acceleration rate and rotational history of the Earth as input, are also used. Computer search can help us find the correct match. In the next six sections we will give specific examples of eclipse dating, beginning with fascinating records of "double dawn" eclipses at Zheng.
2. Double Dawns at Zheng and the First Year of King Yi of the Western Zhou Dynasty

The *Bamboo Annals*, entombed in 299 B.C. and unearthed in A.D. 281, states that “in the first month of spring in the first year of King Yi of Western Zhou, he ascended the throne, the day dawned twice at Zheng (34.5°N, 109.8°E)” (now Hua District, Shaanxi). *Kaiyuan zhanjing*, compiled by Indian astronomer Gautama Siddharta (A.D. 724), cites this passage and adds that “in the 2nd (actually 12th) year of Sheng Ping reign period of King Shang – (actually Early Liang King Zhang Tian Xi) the day (also) began twice at Zheng (italic ours).” These events have been uniquely matched with April 21, 899 B.C. and April 4, A.D. 368 sunrise eclipses at Zheng (Pang et al., 1995). The first year of King Yi, heretofore known only to be between 966 and 895 B.C., can now be firmly fixed at 899 B.C. We will discuss the dating of Shang dynasty oracle bone eclipse records in the next three sections.

3. Shang Dynasty Period One Oracle Bone Lunar and Solar Eclipse Records Dated

Five Period I (King Wu Ding) lunar eclipse records are listed below in the order of decreasing relative ages, ranked according to evolutionary advances in the style of calligraphy of the characters used (Takashima, 1998):

<table>
<thead>
<tr>
<th>Cyclic Day Stated</th>
<th>Lunar Month</th>
<th>Wu Ding’s Matching Eclipse Date (B.C.)</th>
<th>Local Time</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Modulo 60)</td>
<td>Stated</td>
<td>Mencioned</td>
<td>Seer Named</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>yu-wu</td>
<td>Not Stated</td>
<td>Bin</td>
<td>Dec. 25, 1322</td>
</tr>
<tr>
<td>57</td>
<td>geng-shen</td>
<td>13th (=Nov., Dec. or Jan.) Zheng</td>
<td>Nov. 24, 1311</td>
<td>4:28</td>
</tr>
<tr>
<td>20</td>
<td>gui-wei</td>
<td>Not Stated</td>
<td>Zheng</td>
<td>Feb. 27, 1278</td>
</tr>
<tr>
<td>22</td>
<td>yi-you</td>
<td>8th (=Jul., Aug. or Sept.) Zheng</td>
<td>Sept. 2, 1279</td>
<td>3:05</td>
</tr>
<tr>
<td>9</td>
<td>ren-shen</td>
<td>Not Stated</td>
<td>Not Stated</td>
<td>Nov. 4, 1282</td>
</tr>
</tbody>
</table>

The 60-day cycle has been in continuous use from time immemorial. Matching eclipse dates should range < 59 years (Wu Ding’s reign). Assuming that the Shang day was either "Egyptian" (dawn to dawn) or "Roman" (midnight to midnight) previous researchers could not find five computed eclipses that match all conditions (Chang, 1980). However the ancient Chinese day, unlike either, began at ~ 3 a.m. instead. Events occurring between midnight and dawn had a 85% probability of being recorded with the old date, and 15% with the new (King, 1981).

Armed with this new knowledge and a delta T, derived from the Period I (June 5, 1302 B.C.) Shang oracle bone solar eclipse record, that states "three flames ate the Sun, big stars were seen," Pang et al. (1989, 1995) successfully matched all five records. As they all occurred between midnight and dawn the odds are that one would carry the new date, and the rest – the old. This turns out to be exactly the case: The 1322 B.C. eclipse is the odd one. Our dates span only 44 years, and are in the same order as Takashima’s, except two of the latest inscriptions are transposed. Separated by less than four years they are simply too close together to be ranked by calligraphic change. Having successfully matched all Period I eclipse records we now go on to date the Period IV eclipse records.

4. Shang Dynasty Period Four Oracle Bone Solar and Lunar Eclipse Records Dated

Of the Period IV (Kings Wu Yi and Wen Ding) solar eclipse records listed by Zhang (1975) and Xi (1984), inscription Nos. 33694 and 33703 are only inquiries about whether an eclipse will occur. Unless otherwise noted we use Guo Moruo’s He-ji index system. Since these are not observational records they are not useful to us (Hu, 1986).

The relevant contents of the valid records are: No. 33696 – "Day yi-si (42nd day)...Sun has zhi...reported to Shang Jia that evening-night, nine oxen sacrificed.” No. 33698 – "Day geng-chen (17th day)...Sun has zhi...reported to He and Father Ding...nine oxen sacrificed...” No. 33699 – "Day wu-zi (25th day)...Sun has zhi...reported to He.” This one has been misdeciphered as day wu-shen (45th day) before (Yao and Xiao, 1988). No. 33700 – "Inquiry on day yi-chou (2nd day): ‘Will Sun have zhi?’ (verification) ‘It indeed had zhi.’” No. 33710 – “Day zin-st (18th day)...Sun (has) zhi...reported to Father Ding.” The large number of oxen sacrificed, and the prompt reporting to ancestors or deity, betray the Shang’s great concern about the changes that had occurred on the Sun.