Advances in Historical Studies, 2015, 4, 314-319
Published Online September 2015 in SciRes. http://www.scirp.org/journal/ahs
http://dx.doi.org/10.4236/ahs.2015.44021

Study on Compilation of *Bi Li Shu Biao*

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Received 5 June 2015; accepted 28 August 2015; published 31 August 2015

Abstract

***Bi Li Shu Biao* is a logarithm table compiled by Jean Nicolas Smogolenski and Xue Fengzuo in the beginning of Qing dynasty and it has ten thousand common logarithm values of natural number. By analyzing these values, we found that they were obtained through cutting western logarithm values and adopting the method of five homes six into on the basis of reference to the Western logarithmic table. Almost logarithm values is correct, its false rate is only 0.76 percent.**

Keywords

Xue Fengzuo, Jean Nicolas Smogolenski, *Bi Li Shu Biao*, Logarithm

1. Introduction

Bi Li Shu Biao is a common logarithm table compiled by Jean Nicolas Smogolenski and Xue Fengzuo in the beginning of Qing dynasty. With this table, they introduced the western logarithm to China, and improved the development of Chinese mathematics and astronomy. Qian Baocong ever said (Qian, 1964), "It (the logarithm) is very useful, and it was used in Chinese astronomy and Calendar immediately at that time." So many researchers have studied this table, such as Mei Wending, Ruan Yuan, Li Yan and so on. Through studying this table even they have got many results, the question about how the table is compiled at that time does not have answer yet. However, it is necessary to find the answer, since it not only can improve our understanding to this table, but also help us know the works of Jean Nicolas Smogolenski and Xue Fengzuo well. So we are going to study it.

2. Content of *Bi Li Shu Biao*

Bi Li Shu Biao had definitely only one volume, even though it marked with twelve volumes on its first page (Guo, 2011). It included ten thousand common logarithm values of natural numbers which were from 1 to 10,000. The way that the numbers was arrayed was the natural numbers are on the left and their logarithm values were on the right. So indeed the table totally had twenty thousand numbers. This table is as shown **Figure 1**.

Each logarithm values of natural number in this table is reserved six digits after decimal point, so every loga-

rithm values in this table has seven digits. It is definitely different from the western logarithm table appeared at that time.

The logarithm was created by John Napier (1550-1617) in 1614, and developed by Briggs Henry (1561-1630). Logarithm can help mathematician calculate quickly when the meet large numbers, so it is quite valuable and many mathematician ever created different logarithm tables (Graham, 2003), such as John Napier, Briggs Henry and Adrien Vlacq (1600-1667) and so on. Two logarithm tables created by Briggs Henry and Adrien Vlacq respectively in 1624 and in 1628 are as shown in **Figure 2** and **Figure 3** (Herny, 1624 & Adrien, 1628).

3. Obtaining of Logarithm Values in *Bi Li Shu Biao*

Jean Nicolas Smogolenski ever said in the beginning of the table, "The old book written long time ago had one hundred thousand numbers, unfortunately I lost most of them on the way, only ten thousand numbers left." (Han 2007). So the logarithm values in *Bi Li Shu Biao* must be obtained on the basis of reference to the Western logarithmic table and by processing.

Then how did Jean Nicolas Smogolenski and Xue Fengzuo process? How many works did they do?

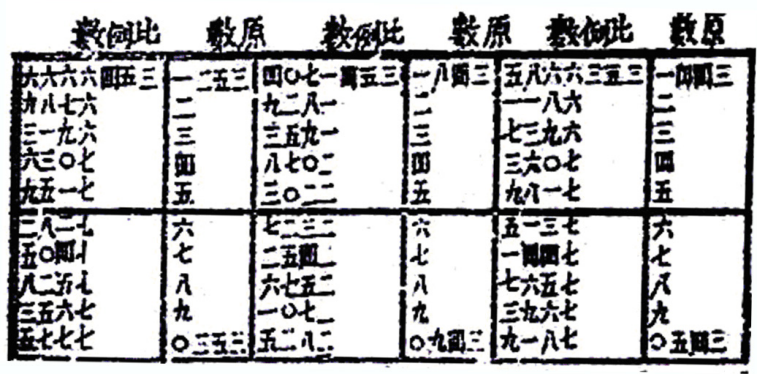

Figure 1. A part of *Bi Li Shu Biao.*

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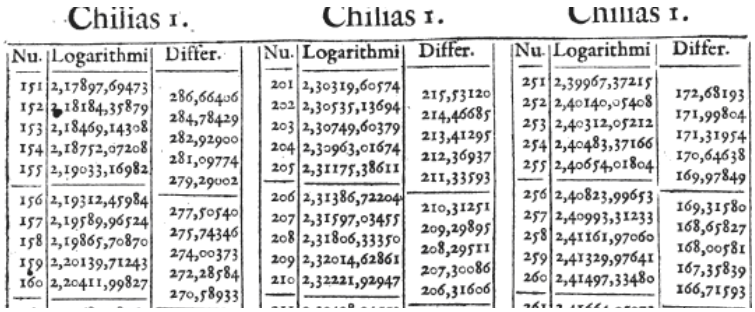
Num. abſolut.	Logarithmi.	Num. abſolut.	Logarithmi.	Num. abſolut.	Logarithmi.
97501	4, 98900, 90699, 7808	97534	4, 98915, 60355, 7952	97567	4, 98930, 29514, 6453
	44542, 3385		44527, 1680		44512, 2077
97502	4, 98901, 35242, 1193	97535	4, 98916, 04883, 0632	97568	4, 98930, 74026, 8530
	44541, 8817		44526, 8115		44511, 7514
97503	4, 98901, 79784, 0010	97536	4, 98916, 49409, 8747	97569	4, 98931, 18538, 6044
	44541, 4249		44526, 3549		44511, 2952
97504	4, 98902, 24325, 4259	97537	4, 98916, 93936, 2296	97570	4, 98931, 63049, 8996
	44540, 9680		44525, 8985		44510, 8390
97505	4, 98902, 68866, 3939	97538	4, 98917, 38462, 1281	97571	4, 98932, 07560, 7386
	44540, 5113		44525, 4419		44510, 3828
97506	4, 98903, 13406, 9052	97539	4, 98917, 82987, 5700	97572	4, 98932, 52071, 1214
	44540, 0544		44524, 9855		44509, 9267

Figure 2. A part of Briggs Henry's logarithm table.



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Nu.	Logarithmi	Differ.	Nu.	Logarithmi	Differ.	Nu.	Logarithmi	Differ.
151	2,17897,69473		201	2,30319,60574		251	2,39967,37215	
		286,66406			215,53120			172,68193
152	2,18184,35879	284,78429	202	2,30535,13694	214,46685	252	2,40140,05408	171,99804
153	2,18469,14308	282,92900	203	2,30749,60379	213,41295	253	2,40312,05212	171,31954
154	2,18752,07208	281,09774	204	2,30963,01674	212,36937	254	2,40483,37166	170,64638
155	2,19033,16982	279,29002	205	2,31175,38611	211,33593	255	2,40654,01804	169,97849
156	2,19312,45984		206	2,31386,72204		256	2,40823,99653	
		277,50540			210,31251			169,31580
157	2,19589,96524	275,74346	207	2,31597,03455	209,29895	257	2,40993,31233	168,65827
158	2,19865,70870	274,00373	208	2,31806,33350	208,29511	258	2,41161,97060	168,00581
159	2,20139,71243	272,28584	209	2,32014,62861	207,30086	259	2,41329,97641	167,35839
160	2,20411,99827	270,58933	210	2,32221,92947	206,31606	260	2,41497,33480	166,71593

Figure 3. A part of Adrien Vlacq's logarithm table.

To find the answer, we calculated the all ten thousand logarithms values with the formula $A = 10^6 \lg N$ by modern computer. The results are shown as **Table 1**.

Comparing **Table 1** and *Bi Li Shu Biao*, we found there are over thousand logarithm values of natural numbers are different. Such as the logarithm value of 231, the logarithm value of 274 and the logarithm value of 312 and so on. These new logarithm values usually are 1 bigger than old logarithm values in *Bi Li Shu Biao*.

What happened? Is it the method of four homes five into led to those differences? Since our default setting about carry method is four homes five into. To find the reason, we calculate all ten thousand logarithm values again. We arranged all logarithm values must be reserved three digits after decimal point at this time. New results are shown as **Table 2**.

From **Table 2**, we know that the first digit after decimal point of those different logarithm values which got after first calculation all are 5. So the logarithm values which first digit after the decimal point is 5 seems not be

Table 1. New logarithm values.

Logarithm value	Natural number	Logarithm value	Natural number	Logarithm value	Natural number
2,489,958	309	2,429,752	269	2,359,835	229
2,491,362	310	2,431,364	270	2,361,728	230
2,492,760	311	2,432,969	271	**2,363,612**	**231**
2,494,155	**312**	2,434,569	272	2,365,488	232
2,495,544	313	2,436,163	273	2,367,356	233
2,496,930	314	**2,437,751**	**274**	2,369,216	234
2,498,311	**315**	2,439,333	275	2,371,068	235
2,499,687	316	2,440,909	276	2,372,912	236
2,501,059	317	2,442,480	277	2,374,748	237
2,502,427	318	2,444,045	278	2,376,577	238
2,503,791	319	2,445,604	279	2,378,398	239
2,505,150	320	2,447,158	280	2,380,211	240

Table 2. Logarithm values reserved three digits after decimal point.

Logarithm value	Natural number	Logarithm value	Natural number	Logarithm value	Natural number
2,489,958.479	309	2,429,752.280	269	2,359,835.482	229
2,491,361.694	310	2,431,363.764	270	2,361,727.836	230
2,492,760.389	311	2,432,969.291	271	**2,363,611.980**	**231**
2,494,154.594	**312**	2,434,568.904	272	2,365,487.985	232
2,495,544.338	313	2,436,162.647	273	2,367,355.921	233
2,496,929.648	314	**2437750.563**	**274**	2,369,215.857	234
2,498,310.554	**315**	2,439,332.694	275	2,371,067.862	235
2,499,687.083	316	2,440,909.082	276	2,372,912.003	236
2,501,059.262	317	2,442,479.769	277	2,374,748.346	237
2,502,427.120	318	2,444,044.796	278	2,376,576.957	238
2,503,790.683	319	2,445,604.203	279	2,378,397.901	239
2,505,149.978	320	2,447,158.031	280	2,380,211.242	240

carried, that is all 5 that is after decimal point had been canceled. Is the carry method that Jean Nicolas Smogolenski and Xue Fengzuo adopted when they compiled *Bi Li Shu Biao* the method of five homes six into?

We checked all other logarithm values again, and found the values which first digit after decimal point are 6, 7, 8, 9 were carried, and the others values were not carried. So the previous conjecture must be true.

We calculated all ten thousand logarithm values with new carry method one more time, the results are shown as **Table 3**.

Comparing logarithm values in **Table 3** with logarithm values in *Bi Li Shu Biao*, it is easy to find that there are only several different values. Exactly the different values only are 76. They are shown as **Table 4**.

Table 3. Logarithm values obtained with new carry method.

Logarithm value	Natural number	Logarithm value	Natural number	Logarithm value	Natural number
2,491,362	309	2,429,752	269	2,376,577	229
2,492,760	310	2,431,364	270	2,378,398	230
2,494,154	311	2,432,969	271	2,380,211	231
2,495,544	312	2,434,569	272	2,322,219	232
2,496,930	313	2,436,163	273	2,324,282	233
2,498,310	314	2,437,750	274	2,326,336	234
2,499,687	315	2,439,333	275	2,328,380	235
2,501,059	316	2,440,909	276	2,330,414	236
2,502,427	317	2,442,480	277	2,332,438	237
2,503,791	318	2,444,045	278	2,334,454	238
2,505,150	319	2,445,604	279	2,336,460	239
2,450,249	320	2,447,158	280	2,338,456	240

Table 4. All false logarithm values.

New value	Old value	Natural number	New value	Old value	Natural number
3,629,308	3,629,306	4259	**2,344,392**	2,344,391	221
3,652,343	3,652,341	4491	**2,363,612**	2,363,618	231
3,675,412	3,675,413	4736	**2,604,226**	2,604,221	402
3,697,229	3,697,226	4980	**2,606,381**	2,606,386	404
3,779,236	3,779,231	6015	**2,674,861**	2,674,862	473
3,809,896	3,809,806	6455	**2,732,394**	2,732,399	540
3,813,381	3,813,383	6507	**2,764,923**	2,764,933	582
3,826,852	3,826,853	6712	**2,869,232**	2,869,237	740
3,852,541	3,852,540	7121	**2,939,519**	2,939,516	870
3,889,582	3,889,581	7755	**2,972,203**	2,972,202	938
3,890,533	3,890,523	7772	**3,012,415**	3,012,425	1029
3,898,780	3,898,784	7921	**3,035,029**	3,035,025	1084

Continued

3,901,513	3,901,511	7971	**3,037,028**	3,037,029	1089
3,905,580	3,905,560	8046	**3,046,105**	3,046,103	1112
3,912,328	3,912,322	8172	**3,049,993**	3,049,992	1122
3,932,372	3,932,371	8558	**3,203,033**	3,203,035	1596
3,933,031	3,933,032	8571	**3,278,982**	3,278,983	1901
3,938,920	3,938,919	8688	**3,280,351**	3,280,353	1907
3,939020	3,939,010	8690	**3,288,920**	3,288,930	1945
3,939,419	3,939,416	8698	**3,310,481**	3,310,482	2044
3,943,791	3,943,761	8786	**3,354,493**	3,354,481	2262
3,946,010	3,946,000	8831	**3,357,554**	3,357,594	2278
3,946,452	3,946,450	8840	**3,360,593**	3,360,593	2294
3,948,511	3,948,501	8882	**3,362,294**	3,362,292	2303
3,953,421	3,953,426	8983	**3,366,423**	3,366,426	2325
3,957,368	3,957,366	9065	**3,406,029**	3,406,028	2547
3,982,859	3,982,856	9613	**3,406,199**	3,406,189	2548
3,985,965	3,985,962	9682	**3,423,410**	3,423,412	2651
3,989,227	3,989,217	9755	**3,425,045**	3,425,044	2661
3,990,561	3,990,563	9785	**3,441,538**	3,441,558	2764
3,991,713	3,991,712	9811	**3,446,382**	3,446,383	2795
3,994,361	3,994,141	9871	**3,460,146**	3,460,145	2885
3,994,405	3,994,158	9872	**3,478,711**	3,478,712	3011
3,994,449	3,994,229	9873	**3,493,319**	3,493,316	3114
3,994,493	3,994,272	9874	**3,522,314**	3,522,313	3329
3,994,537	3,994,317	9875	**3,529,302**	3,529,303	3383
3,997,998	3,997,968	9954	**3,532,882**	3,532,881	3411
3,998,782	3,998,783	9972	**3,563,481**	3,563,484	3660

4. Conclusion

Bi Li Shu Biao is an important logarithm table that is compiled by Jean Nicolas Smogolenski and Xue Fengzuo. Through analyzing the characteristic of logarithm values in *Bi Li Shu Biao*, it is known that all logarithm values are obtained on the basis of reference to the Western logarithmic table and by cutting western logarithm values and by processing with the method of five homes six into. So the course that Jean Nicolas Smogolenski and Xue Fengzuo compiled the *Bi Li Shu Biao* must be as follows: First, the Jean Nicolas Smogolenski introduced the knowledge about logarithm to Xue Fengzuo and Xue Fengzuo translated the logarithm into Chinese; secondly Xue Fengzuo cut all values and reserved six digits after decimal point with the method of five homes six into which was usually used in Chinese daily life. At last, Xue Fengzuo arranged all logarithm values according Chinese read custom. Maybe the last 76 mistakes appearing in this phase are due to haste or neglect.

Funding

Supported by “Shan Dong Province Society Science Planning program: Research on Mathematics Content in Li

Xue Hui Tong" 11CZXZ02.

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