## Tables of Seismological Co-latitude

By Eugene Herrin and James Taggart

Bullen (1937b, p. 160) suggests the use of a new latitude for the computation of distances involved in studies of seismic travel-times. He defines the "seismological latitude,"  $\theta$ , as:

 $\theta = 1.1\theta_1 - 0.1\theta_2$ where  $\theta_1 =$  geocentric latitude and  $\theta_2 =$  geographic latitude

Geocentric latitude is defined by the following equation:

Tan  $\theta_1 = 0.99327$  Tan  $\theta_2$ 

The constant was computed from Jeffreys' (1952, p. 144) value of polar flattening.

The use of seismological latitude increases the accuracy of computations of great-circle distances and greatly simplifies the ellipticity correction for seismic travel-times. Bullen (1937b, p. 162) shows that the use of "seismological latitude" allows computations of travel-times with errors less than 0.1 second without recourse to the awkward triple-entry tables needed for complete ellipticity corrections (Bullen, 1937a).

The tables in this paper permit conversion of the geographic latitude to seismological co-latitude. The tables are entered by reading the geographic latitude to the nearest unit down the lefthand column and the nearest tenth across the page. Interpolations are possible to two or more orders of magnitude. The difference in values for an increment of 0.1 latitude are 0.099, 0.100, or 0.101 units so that interpolations may be made to sufficient accuracy by adopting a constant difference of 0.100 units. Thus reading the tables becomes very simple. For example, to find the seismological co-latitude corresponding to 65.°316 north latitude enter the northern hemisphere table (Table 1) at 65.°3 and read 25.862. The remaining digits beyond the tenth-place (0.016) are subtracted from this value to give 25.846. In the southern hemisphere table (Table 2) digits beyond the tenths-place are added to the values read. The seismological co-latitude obtained in this way is accurate ± 0.001 unit or approximately ± 100 meters and, therefore, is well within the limits of accuracy for seismological calculations.

TABLE 1

NORTHERN HEMISPHERE

For Conversion of Geographic Latitude to Seismological Co-Latitude

Deg	rees	Tenths of Degrees									
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
0	90.000	89.901	.802	.702	.603	.504	.404	.305	.206	.107	
1	89.007	88.908	.809	.710	.610	.511	.412	.313	.213	.114	
2	88.015	87.916	.816	.717	.618	.519	.419	.320	.221	.121	
3	87.022	86.923	.824	.724	.625	.526	.427	.327	.228	.129	
4	86.030	85.930	.831	.732	.632	.533	.434	.335	.235	.136	
5	85.037	84.938	.838	.739	.640	.540	.441	.342	.243	.143	
6	84.044	83.945	.846	.746	.647	.548	.448	.349	.250	.151	
7	83.051	82.952	.853	.753	.654	.555	.456	.356	.257	.158	
8	82.058	81.959	.860	.761	.661	.562	.463	.363	.264	.165	
9	81.066	80.966	.867	.768	.668	.569	.470	.370	.271	.172	
10	80.072	79.973	.874	.775	.675	.576	.4 <i>77</i>	.377	.278	.179	
11	79.079	78.980	.881	.781	.682	.583	.483	.384	.285	.186	
12	78.086	77.987	.888	.788	.689	.590	.490	.391	.292	.192	
13	77.093	76.994	.894	.795	.696	.596	.497	.398	.298	.199	
14	.100	76.000	75.901	.801	.702	.603	.503	.404	.305	.205	
15	75.106	75.007	74.907	.808	.709	.609	.510	.410	.311	.212	
16	.112	74.013	73.914	.814	.715	.615	.516	.417	.317	.218	
17	.119	73.019	72.920	.820	.721	.622	.522	.423	.323	.224	
18	.125	72.025	71.926	.826	.727	.628	.528	.429	.329	.230	
19	.131	71.031	70.932	.832	.733	.633	.534	.435	.335	.236	
20	70.136	70.037	69.937	.838	.739	.639	.540	.440	.341	.241	
21	.142	69,042	68.943	.844	.744	.645	.545	.446	.346	.247	
22	.147	68.048	67.948	.849	.749	.650	.550	.451	.352	.252	
23	.153	67.053	66.954	.854	.755	.655	.556	.456	.357	.257	
24	.158	66.058	65.959	.859	.760	.660	.561	.461	.362	.262	
25	65.162	65.063	64.963	.864	.764	.665	.565	.466	.366	.267	
26	.167	64.068	63.968	.869	.769	.669	.570	.470	.371	.271	
27	.172	63.072	62.972	.873	.773	.674	.574	.475	.375	.275	
28	.176	62.076	61.977	.877	.778	.678	.578	.479	.379	.280	
29	.180	61.080	60.981	.881	.781	.682	.582	.483	.383	.283	
30	60.184	60.084	59.985	.885	.785	.686	.586	.486	.387	.287	
31	.187	59.088	58.988	.888	.789	.689	.589	.490	.390	.290	
32	.191	58.091	57.991	.892	.792	.692	.593	.493	.393	.294	
33	.194	57.094	56.995	.895	.795	.695	.596	.496	.396	.297	
34	.197	56.097	55.997	.898	.798	.698	.598	.499	.399	.299	
3 5	55.200	.100	55.000	54.900	.801	.701	.601	.501	.401	.302	
36	.202	.102	54.002	53.903	.803	.703	.603	.504	.404	.304	
3 <i>7</i>	.204	.104	53.005	52.905	.805	.705	.605	.506	.406	.306	
38	.206	.106	52.006	51.907	.807	.707	.607	.507	.407	.308	
39	.208	.108	51.008	50.908	.808	.709	.609	.509	.409	.309	
40	50.209	.109	50.009	49.910	.810	.710	.610	.510	.410	.310	
41	.210	.110	49.011	48.911	.811	.711	.611	.511	.411	.311	
42	.211	.111	48.011	47.912	.812	.712	.612	.512	.412	.312	
43	.212	.112	47.012	46.912	.812	.712	.612	.512	.412	.312	
44	.212	.112	46.012	45.912	.812	.713	.613	.513	.413	.313	

Acknowledgements.—Mr. Charles F. Brown of the Southern Methodist Computing Laboratory assisted in the computation of the tables. The work was supported by National Science Foundation Research Grant 11426.

TABLE 1 (Continued)

Degrees		Tenths of Degrees									
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
45	45.213	.113	45.013	44.913	.813	.713	.613	.513	.412	.312	
46	.212	.112	44.012	43.912	.812	.712	.612	.512	.412	.312	
47	.212	.112	43.012	42.912	.812	.712	.612	.512	.412	.312	
48	.211	.111	42.011	41.911	.811	.711	.611	.511	.411	.311	
49	.211	.110	41.010	40.910	.810	.710	.610	.510	.410	.310	
50	40.209	.109	40.009	39.909	.809	.709	.609	.509	.408	.308	
51	.208	.108	39.008	38.908	.807	.707	.607	.507	.407	.307	
52	.206	.106	38.006	37.906	.806	.706	.605	.505	.405	.305	
53	.205	.104	37.004	36.904	.804	.703	.603	.503	.403	.303	
54	.202	.102	36.002	35.902	.801	.701	.601	.501	.400	.300	
55	35.200	35.100	34.999	.899	.799	.699	.598	.498	.398	.298	
56	.197	34.097	33.997	.897	.796	.696	.596	.495	.395	.295	
57	.194	33.094	32.994	.894	.793	.693	.593	.492	.392	.292	
58	.191	32.091	31.991	.890	.790	.690	.589	.489	.389	.288	
59	.188	31.088	30.987	.887	.787	.686	.586	.486	.385	.285	
60	30.184	30.084	29.984	.883	.783	.683	.582	.482	.381	.281	
61	.181	29.080	28.980	.879	.779	.679	.578	.478	.377	.277	
62	.177	28.076	27.976	.875	.775	.674	.574	.474	.377	.277	
63	.172	27.072	26.971	.871	.771	.670	.574	.469	.369	.268	
64	.168	26.067	25.967	.867	.766	.666	.565	.465			
					./00	.000	.)6)	.46)	.364	.264	
65	25.163	25.063	24.962	.862	.761	.661	.560	.460	.359	.259	
66	.158	24.058	23.957	.857	.756	.656	.555	.455	.354	.254	
67	.153	23.053	22.952	.852	.751	.651	.550	.450	.349	.249	
68	.148	22.048	21.947	.846	.746	.645	.545	.444	.344	.243	
69	.143	21.042	20.942	.841	.740	.640	.539	.439	.338	.238	
70	20.137	20.036	19.936	.835	.735	.634	.534	.433	.332	.232	
71	.131	19.031	18.930	.829	.729	.628	.528	.427	.327	.226	
72	.125	18.025	17.924	.823	.723	.622	.522	.421	.320	.220	
73	.119	17.019	16.918	.817	.717	.616	.515	.415	.314	.214	
74	.113	16.012	15.912	.811	.710	.610	.509	.409	.308	.207	
75	15.107	15.006	14.905	.805	.704	.603	.503	.402	.301	.201	
76	14.100	13.999	.899	.798	.697	.597	.496	.395	.295	.194	
77	13.093	12.993	.892	.791	.691	.590	.489	.389	.288	.187	
78	12.087	11.986	.885	.785	.684	.583	.483	.382	.281	.181	
79	11.080	10.979	.879	.778	.677	.576	.476	.375	.274	.174	
80	10.073	9.972	0.72	771	<b>670</b>						
81	9.066	9.972 8.965	.872	.771	.670	.569	.469	.368	.267	.167	
82	8.059	7.958	.864	.764	.663	.562	.462	.361	.260	.160	
83	7.052	6.951	.857	.757	.656	.555	.454	.354	.253	.152	
			.850	.749	.649	.548	.447	.347	.246	.145	
84	6.044	5.944	.843	.742	.641	.541	.440	.339	.239	.138	
85	5.037	4.936	.836	.735	.634	.533	.433	.332	.231	.130	
86	4.030	3.929	.828	.727	.627	.526	.425	.325	.224	.123	
8 <i>7</i>	3.022	2.922	.821	.720	.619	.519	.418	.317	.216	.116	
88	2.015	1.914	.813	.713	.612	.511	.410	.310	.209	.108	
89	1.007	0.907	.806	.705	.604	.504	.403	.302	.201	.101	
90	0.000										

References:K. E. Bullen (1937a) The ellipticity correction to travel-times of P and S earthquake waves. Mon. Not. Royal Astron. Soc., v. 4, no. 2, p. 143-57; (1937b) A suggested new "seismological latitude." Ibid., v. 4, no. 2, p. 158-64. Harold Jeffreys (1952) The Earth. Camb. Univ. Press, p. 184.

TABLE 2
SOUTHERN HEMISPHERE
For Conversion of Geographic Latitude to Seismological Co-Latitude

Degrees			Tenths of Degrees								
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	
0	90.000	.099	.199	.298	.397	.496	.596	.695	.794	.893	
í	90.993	91.092	.191	.290	.390	.489	.588	.687	.787	.886	
2	91.985	92.085	.184	.283	.382	.482	.581	.680	.779	.879	
3	92.978	93.077	.176	.276	.375	.474	.574	.673	.772	.871	
4	93.971	94.070	.169	.268	.368	.467	.566	.665	.765	.864	
5	94.963	95.063	.162	.261	.360	.460	.559	.658	.757	.8 <i>57</i>	
6	95.956	96.055	.155	.254	.353	.452	.552	.651	.750	.850	
7	96.949	97.048	.147	.247	.346	.445	.545	.644	.743	.842	
8	97.942	98.041	.140	.240	.339	.438	.53 <i>7</i>	.637	.736	.835	
9	98.935	99.034	.133	.232	.332	.431	.530	.630	.729	.828	
10	99.928	100.027	.126	.226	.325	.424	.523	.623	.722	.821	
11	100.921	101.020	.119	.219	.318	.417	.517	.616	.715	.815	
12	101.914	102.013	.113	.212	.311	.411	.510	.609	.709	.808	
13	102.907	103.007	.106	.205	.305	.404	.503	.603	.702	.801	
14	103.901	104.000	.099	.199	.298	.397	.497	.596	.695	.795	
15	104.894	104.993	105.093	.192	.292	.391	.490	.590	.689	.788	
16	.888	105.987	106.087	.186	.285	.385	.484	.583	.683	.782	
1 <i>7</i>	.882	106.981	107.080	.180	.279	.379	.478	.577	.677	.776	
18	.876	107.975	108.074	.174	.273	.373	.472	.571	.671	.770	
19	.870	108.969	109.068	.168	.267	.367	.466	.566	.665	.764	
20	109.864	109.963	110.063	.162	.262	.361	.460	.560	.659	.759	
21	.858	110.958	111.057	.157	.256	.355	.455	.554	.654	.753	
22	.853	111.952	112.052	.151	.251	.350	.450	.549	.649	.748	
23	.848	112.947	113.047	.146	.246	.345	.444	.544	.643	.743	
24	.842	113.942	114.042	.141	.241	.340	.440	.539	.639	.738	
25	114.838	114.937	115.037	.136	.236	.335	.435	.534	.634	.733	
26	.833	115.932	116.032	.132	.231	.331	.430	.530	.629	.729	
27	.828	116.928	117.028	.127	.227	.326	.426	.525	.625	.725	
28	.824	117.924	118.023	.123	.223	.322	.422	.521	.621	.721	
29	.820	118.920	119.019	.119	.219	.318	.418	.517	.617	.717	
30	119.816	119.916	120.016	.115	.215	.315	.414	.514	.613	.713	
31	.813	120.912	121.012	.112	.211	.311	.411	.510	.610	.710	
32	.809	121.909	122.009	.108	.208	.308	.40 <i>7</i>	.507	.607	.706	
33	.806	122.906	123.006	.105	.205	.305	.404	.504	.604	.704	
34	.803	123.903	124.003	.102	.202	.302	.402	.501	.601	.701	
35	124.801	124.900	125.000	.100	.200	.299	.399	.499	.599	.698	
36	.798	898	125.998	126.097	.197	.297	.397	<b>.</b> 497	.596	.696	
3 <i>7</i>	.796	.896	126.996	127.095	.195	.295	.395	.495	.594	.694	
38	.794	.894	127.994	128.094	.193	.293	.393	.493	.593	.692	
39	.792	.892	128.992	129.092	.192	.292	.391	.491	.591	.691	
40	129.791	.891	129.991	130.091	.190	.290	.390	.490	.590	.690	
41	.790	.890	130.990	131.089	.189	.289	.389	.489	.589	.689	
42	.789	.889	131.989	132.089	.188	.288	.388	.488	.588	.688	
43	.788	.888	132.988	133.088	.188	.288	.388	.488	.588	.688	
44	.788	.888	133.988	134.088	.188	.288	.388	.488	.588	.688	
45	134.788										

## TABLE 2 (Continued)

Degrees		Tenths of Degrees								
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900
45	134.788	.888	134.988	135.088	.188	.288	.388	.488	.588	.688
46	.788	.888	135.988	136.088	.188	.288	.388	.488	.588	.688
47	.788	.888	136.988	137.088	.188	.288	.388	.488	.588	.689
48	.789	.889	137.989	138.089	.189	.289	.389	.489	.589	.689
49	.790	.890	138.990	139.090	.190	.290	.390	.490	.590	.691
50	139.791	.891	139.991	140.091	.191	.291	.391	.492	.592	.692
51	.792	.892	140.992	141.092	.193	.293	.393	.493	.593	.694
52	.794	.894	141.994	142.094	.194	.295	.395	.495	.595	.695
53	.796	.896	142.996	143.096	.196	.297	.397	.497	.597	.698
54	.798	.898	143.998	144.098	.199	.299	.399	.499	.600	.700
55	144.800	144.900	145.001	.101	.201	.301	.402	.502	.602	.702
56	.803	145.903	146.003	.104	.204	.304	.404	.505	.605	.705
57	.806	146.906	147.006	.107	.207	.307	.407	.508	.608	.708
58	.809	147.909	148.009	.110	.210	.310	.411	.511	.611	.712
59	.812	148.912	149.013	.113	.214	.314	.414	.515	.615	.715
60	149.816	149.916	150.016	.117	.217	.318	.418	.518	.619	.719
61	.819	150.920	151.020	.121	.221	.321	.422	.522	.623	.723
62	.824	151.924	152.024	.125	.225	.326	.426	.526	.627	.727
63	.828	152.928	153.029	.129	.230	.330	.430	.531	.631	.732
64	.832	153.933	154.033	.134	.234	.335	.435	.535	.636	.736
65	154.837	154.937	155.038	.138	.239	.339	.440	.540	.641	.741
66	.842	155.942	156.043	.143	.244	.344	.445	.545	.646	.746
67	.84 <i>7</i>	156.947	157.048	.148	.249	.349	.450	.550	.651	.752
68	.852	157.953	158.053	.154	.254	.355	.455	.556	.656	.757
69	.858	158.958	159.059	.159	.260	.360	.461	.561	.662	.763
70	159.863	159.964	160.064	.165	.265	.366	.467	.567	.668	.768
71	.869	160.969	161.070	.171	.271	.372	.472	.573	.674	.774
72	.875	161.975	162.076	.177	.277	.378	.478	.579	.680	.780
73	.881	162.982	163.082	.183	.283	.384	.485	.585	.686	.786
74	.88 <i>7</i>	163.988	164.088	.189	.290	.390	.491	.592	.692	.793
75	164.894	164.994	165.095	.195	.296	.397	.497	.598	.699	.799
76	165.900	166.001	.101	.202	.303	.403	.504	.605	.705	.806
77	166.907	167.007	.108	.209	.309	.410	.511	.611	.712	.813
78	167.913	168.014	.115	.215	.316	.417	.517	.618	.719	.820
79	168.920	169.021	.122	.222	.323	.424	.524	.625	.726	.826
80	169.927	170.028	.129	.229	.330	.431	.531	.632	.733	.834
81	170.934	171.035	.136	.236	.337	.438	.538	.639	.740	.841
82	171.941	172.042	.143	.243	.344	.445	.546	.646	.747	.848
83	172.949	173.049	.150	.251	.351	.452	.553	.654	.754	.855
84	173.956	174.056	.157	.258	.359	.459	.560	.661	.762	.862
85	174.963	175.064	.165	.265	.366	.467	.567	.668	.769	.870
86	175.970	176.071	.172	.273	.373	.474	.575	.676	.776	.877
87	176.978	177.079	.179	.280	.381	.482	.582	.683	.784	.884
88	177.985	178.086	.187	.287	.388	.498	.590	.690	.791	.892
89	178.993	179.093	.194	.295	.396	.496	.597	.698	.799	.899
90	180.000									