INSTRUCTION MANUAL
取扱説明書

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Berek Compensator

Instruction Manual

OLYMPUS

OLYMPUS BEREK COMPENSATOR

The Olympus Berek Compensator is primarily intended for:

a) The accurate measurement of retardation in double refracting media.

b) Determining the optical character of the double refraction.

This compensator can be inserted into the slot of the intermediate polarizing tube for the Olympus Polarizing Microscope.

A calcite incorporated in this compensator is designed to be perpendicular to the optical axis of the microscope at the 30° division line for the insertion or removal of the compensator; otherwise the calcite edges might impinge against the slot of the intermediate tube and be damaged.

A. Instruction for Use

1. Align both the index lines (one on the polarizer of the condenser and the other on the analyzer of the intermediate polarizing tube) at the zero positions (this is a crossed filter position).

2. Place a specimen crystal on the stage and center it at the intersection of the eyepiece cross hairs.

3. Rotate the stage until the field is dark. This represents the position of extinction as the optic axis of the crystal is parallel to the plane of the polarizer or analyzer.

   At this position, pull the 45° click stop lever of the stage toward the observer all the way so that the stage can be click stopped at diagonal position.

NOTE: 1) This simple lever operation clicks the stage in increments of 45° from any position wherever the stop lever is pulled. To release the stage, push back the lever.

2) In case of the Polarizing Microscope Model POS, however, give the stage 45° rotation by reading the vernier, since it has no 45° stop lever.

4. Insert the compensator into the slot and rotate the vernier scale of the compensator from the 30° division line to either direction. If the interference color decreases the crystal is in the subtractive position, so proceed with the Berek readings.
If the interference color increases the crystal is in the additive position. Rotate the stage 90° in reverse to the subtractive position and take Berek readings.

B. Berek Readings

Get maximum extinction on either side of the 30° position. Let (a) and (b) represent the readings either sides of the 30° position on the vernier scale.

C. Calculation of Retardation (R):

1. Find the difference between the Berek readings (a) and (b).

2. Divide by 2 to find (i) . . . . $(i) = \frac{(a) - (b)}{2}$

3. In Table I find logarithm of (i).

4. To find log R, add log (i) + log C.

   log R = log (i) + log C

   log C = optical constant for individual Berek

   Example: Let 3.907 = the optical constant of Berek.

5. In Table II find the antilog of log R.

   You must find correct decimal point. To do this, take the difference between the mantissa and ten, augment by 1, this gives the number of decimal points. Example: Mantissa = 11, therefore 11 - 10 + 1 equal 2, or 2 decimal points (.00).

   This gives the retardation expressed in mμ.

   Example: Berek reading (a) = 35.7°, (b) = 24.5°

$$i = \frac{35.7 - 24.5}{2} = 5.6°$$

   In Table I find log f(i).

   log f(i) 5.6 = ... 7.980

   compensator constant log C = ... 3.907

   11.887

   11 is the mantissa.

   887 is the index number.

   The antilog of the index 887 = 771

   Insert decimal (.00) = 77.1 or log R = 77.1

   Retardation (R) = 77.1mμ

Retardation may be calculated with a slide rule.

Take the appropriate value of 10,000 f(i) and multiply it by the value of $\frac{C}{10,000}$. This gives the Retardation in mμ.

Example: (a) = 35.7°, (b) = 24.5°

$$i = \frac{35.7° - 24.5°}{2} = 5.6° \text{ as before.}$$

Table III gives 10,000 f(i) = 95.4

$$\frac{C}{10,000} = 0.808 \text{ (optical center 550 m}\mu\text{)}$$

Hence, 95.4 x 0.808 = 77.1

R = 77.1 mμ

Retardation may also be expressed in fractions of the wavelength used by the formula.

$$\theta = \frac{R}{\lambda}$$

θ = Birefringence or double refraction
R = Measured retardation
λ = Wavelength of light used

When the thickness of the crystal is known the amount of double refraction or birefringence may be determined from the formula.

$$\theta = Ne - No = \frac{R}{d}$$

Ne = velocity of extraordinary light wave
No = velocity of ordinary light wave
R = measured retardation
d = section thickness
(also expressed in mμ.)

DETERMINATION OF COMPENSATOR CONSTANTS

The compensator constants are found in the following manner.

Using a monochromatic light, wavelength λ, the compensator is turned from zero or 30° position until the first dark line coincides with the intersecting cross hair of the eyepiece from either direction. Let these be (a_1) and (b_1), the angle orientation (i_1) corresponding to a retardation of λ will be:

$$(i_1) = \frac{(a_1) - (b_1)}{2}$$

From Table I find log $f(i_1)$ and subtract log λ (wavelength used).

Hence, $\log C = \log \lambda - \log f(i\ )$

Any n^{th} pair of bands may be used for determining the value of log C.

In this case:

$$(i_n)\ \frac{(a_n) - (b_n)}{2}$$

Hence, $\log C = \log n + \log \lambda - \log f(i_n)$

The value of log C determined by either formula will be identical.

DETERMINATION OF OPTICAL CHARACTER

The amount of the compensator is marked for Z' (slow) and X' (fast) axes for determining the optical character of the direction of oscillation. Therefore, by turning the vernier scale of the compensator the interference colors used for the distinction of the increase or decrease are varied within a range of 3 orders, for instance:

(a) Orthoscopic determination.

With the crystal in the diagonal; 45° to the plane of the polarizer or analyzer; and parallel to the slow axis of the compensator; while turning the compensator drum observe whether the interference color is increasing or decreasing; if increasing it follows, that the direction of oscillation is parallel to that of the compensator (additive case); if decreasing the direction of oscillation is vertical to that of the compensator (subtractive case).

(b) Conoscopic observation.

The drum of the compensator is turned to recognize the optical character by the directions of movement of the isochromates of the interference figure.

If the isochromate figure moves toward the center of the interference figure the oscillation is parallel to that of the Berek; additive position. If subtractive position the isochromates of the interference figure will move outward away from the center of the interference figure. Then, the oscillation of the lightwave is vertical to that of the Berek.

Optical Constants of Compensator No. 200825

λ	C 656mμ	D 589mμ	F 486mμ	Daylight Optical Center 550mμ
log C	3.882	3.886	3.898	3.889
$\frac{C}{10000}$	0.762	0.770	0.787	0.775

TABLE I

Logarithm f (i)

i	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
∞	—	4.484	5.086	5.438	5.688	5.882	6.040	6.174	6.290	6.392
1	6.484	6.566	6.642	6.712	6.776	6.836	6.892	6.945	6.994	7.041
2	7.086	7.128	7.169	7.207	7.244	7.280	7.314	7.346	7.378	7.408
3	7.438	7.466	7.494	7.521	7.547	7.572	7.596	7.620	7.643	7.666
4	7.688	7.709	7.730	7.750	7.770	7.790	7.809	7.828	7.846	7.864
5	7.881	7.898	7.915	7.932	7.948	7.964	7.980	7.995	8.010	8.025
6	8.039	8.054	8.068	8.082	8.095	8.109	8.122	8.135	8.148	8.161
7	8.173	8.185	8.198	8.210	8.221	8.233	8.244	8.256	8.267	8.278
8	8.289	8.300	8.310	8.321	8.331	8.341	8.352	8.361	8.371	8.381
9	8.391	8.400	8.410	8.419	8.429	8.438	8.447	8.456	8.465	8.473
10	8.482	8.491	8.499	8.508	8.516	8.524	8.532	8.541	8.549	8.557
11	8.564	8.572	8.580	8.588	8.595	8.603	8.610	8.618	8.625	8.632
12	8.640	8.647	8.654	8.661	8.668	8.675	8.682	8.689	8.695	8.702
13	8.709	8.715	8.722	8.728	8.735	8.741	8.748	8.754	8.760	8.766
14	8.773	8.779	8.785	8.791	8.797	8.803	8.809	8.815	8.820	8.826
15	8.832	8.838	8.843	8.849	8.855	8.860	8.866	8.871	8.877	8.882
16	8.888	8.893	8.898	8.904	8.909	8.914	8.919	8.924	8.929	8.935
17	8.940	8.945	8.950	8.955	8.960	8.965	8.969	8.974	8.979	8.984
18	8.989	8.993	8.998	9.003	9.007	9.012	9.017	9.021	9.026	9.030
19	9.035	9.039	9.044	9.048	9.053	9.057	9.062	9.066	9.070	9.075
20	9.079	9.083	9.087	9.092	9.096	9.100	9.104	9.108	9.112	9.116
21	9.120	9.124	9.128	9.132	9.136	9.140	9.144	9.148	9.152	9.156
22	9.160	9.164	9.168	9.172	9.175	9.179	9.183	9.187	9.190	9.194
23	9.198	9.201	9.205	9.209	9.212	9.216	9.220	9.223	9.227	9.230
24	9.234	9.237	9.241	9.244	9.248	9.251	9.255	9.258	9.262	9.265
25	9.268	9.272	9.275	9.278	9.282	9.285	9.288	9.292	9.295	9.298
26	9.301	9.305	9.308	9.311	9.314	9.318	9.321	9.324	9.327	9.330
27	9.333	9.336	9.339	9.343	9.346	9.349	9.352	9.355	9.358	9.361
28	9.364	9.367	9.370	9.373	9.376	9.379	9.382	9.384	9.387	9.390
29	9.393	9.396	9.399	9.402	9.405	9.407	9.410	9.413	9.416	9.419
30	9.421	9.424	9.427	9.430	9.432	9.435	9.438	9.441	9.443	9.446
31	9.448	9.451	9.454	9.456	9.459	9.462	9.464	9.467	9.469	9.472

TABLE II

Logarithm Of The Natural Numbers

N	0	1	2	3	4	5	6	7	8	9
10	000	004	009	013	017	021	025	029	033	037
11	041	045	049	053	057	061	064	068	072	076
12	079	083	086	090	093	097	100	104	107	111
13	114	117	121	124	127	130	134	137	140	143
14	146	149	152	155	158	161	164	167	170	173
15	176	179	181	185	188	190	193	196	199	201
16	204	207	210	212	215	217	220	223	225	228
17	230	233	236	238	241	243	246	248	250	253
18	255	258	260	262	265	267	270	272	274	276
19	279	281	283	286	288	290	292	294	297	299
20	301	303	305	307	310	312	314	316	318	320
21	322	324	326	328	330	332	334	336	338	340
22	342	344	346	348	350	352	354	356	358	360
23	362	364	365	367	369	371	373	375	377	378
24	380	382	384	386	387	389	391	393	394	396
25	398	400	401	403	405	407	408	410	412	413
26	415	417	418	420	422	423	425	427	428	430
27	431	433	435	436	438	439	441	442	444	446
28	447	449	450	452	453	455	456	458	459	461
29	462	464	465	467	468	470	471	473	474	476
30	477	479	480	481	483	484	486	487	489	490
31	491	493	494	496	497	498	500	501	502	504
32	505	507	508	509	511	512	513	515	516	517
33	519	520	521	522	524	525	526	528	529	530
34	531	533	534	535	537	538	539	540	542	543
35	544	545	547	548	549	550	551	553	554	555
36	556	558	559	560	561	562	563	565	566	567
37	568	569	571	572	573	574	575	576	577	579
38	580	581	582	583	584	585	587	588	589	590
39	591	592	593	594	595	597	598	599	600	601
40	602	603	604	605	606	607	609	610	611	612
41	613	614	615	616	617	618	619	620	621	622

TABLE II

(Continued)

N	0	1	2	3	4	5	6	7	8	9
42	623	624	625	626	627	628	629	630	631	632
43	633	634	635	636	637	638	639	640	641	642
44	643	644	645	646	647	648	649	650	651	652
45	653	654	655	656	657	658	659	660	661	662
46	663	664	665	666	667	667	668	669	670	671
47	672	673	674	675	676	677	678	679	679	680
48	681	682	683	684	685	686	687	688	688	689
49	690	691	692	693	694	695	695	696	697	698
50	699	700	701	702	702	703	704	705	706	707
51	708	708	709	710	711	712	713	713	714	715
52	716	717	718	718	719	720	721	722	723	723
53	724	725	726	727	728	728	729	730	731	732
54	732	733	734	735	736	736	737	738	739	740
55	740	741	742	743	744	744	745	746	747	747
56	748	749	750	751	751	752	753	754	754	755
57	756	757	757	758	759	760	760	761	762	763
58	763	764	765	766	766	767	768	769	769	770
59	771	772	772	773	774	775	775	776	777	777
60	778	779	780	780	781	782	782	783	784	785
61	785	786	787	787	788	789	790	790	791	792
62	792	793	794	794	795	796	797	797	798	799
63	799	800	801	801	802	803	803	804	805	805
64	806	807	808	808	809	810	810	811	812	812
65	813	814	814	815	816	816	817	818	818	819
66	820	820	821	822	822	823	823	824	825	825
67	826	827	827	828	829	829	830	831	831	832
68	833	833	834	834	835	836	836	837	838	838
69	839	839	840	841	841	842	843	843	844	844
70	845	846	846	847	848	848	849	849	850	851
71	851	852	852	853	854	854	855	856	856	857
72	857	858	859	859	860	860	861	862	862	863
73	863	864	865	865	866	866	867	867	868	869

TABLE II

(Continued)

N	0	1	2	3	4	5	6	7	8	9
74	869	870	870	871	872	872	873	873	874	874
75	875	876	876	877	877	878	879	879	880	880
76	881	881	882	883	883	884	884	885	885	886
77	886	887	888	888	889	889	890	890	891	892
78	892	893	893	894	894	895	895	896	897	897
79	898	898	899	899	900	900	901	901	902	903
80	903	904	904	905	905	906	906	907	907	908
81	908	909	910	910	911	911	912	912	913	913
82	914	914	915	915	916	916	917	918	918	919
83	919	920	920	921	921	922	922	923	923	924
84	924	925	925	926	926	927	927	928	928	929
85	929	930	930	931	931	932	932	933	933	934
86	934	935	936	936	937	937	938	938	939	939
87	940	940	941	941	942	942	942	943	943	944
88	944	945	945	946	946	947	947	948	948	949
89	949	950	950	951	951	952	952	953	953	954
90	954	955	955	955	956	957	957	958	958	959
91	959	960	960	960	961	961	962	962	963	963
92	964	964	965	965	966	966	967	967	968	968
93	968	969	969	970	970	971	971	972	972	973
94	973	974	974	975	975	975	976	976	977	977
95	978	978	979	979	980	980	980	981	981	982
96	982	983	983	984	984	985	985	985	986	986
97	987	987	988	988	989	989	989	990	990	991
98	991	992	992	993	993	993	994	994	995	995
99	996	996	997	997	997	998	998	999	999	000

TABLE III

1000f (i)

i	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.5
1	3.0	3.7	4.4	5.1	6.0	6.9	7.8	8.8	9.9	11.0
2	12.2	13.4	14.7	16.1	17.5	19.0	20.6	22.2	23.9	25.6
3	27.4	29.3	31.2	33.2	35.2	37.3	39.5	41.7	44.0	46.3
4	48.4	51.2	53.7	56.3	58.9	61.6	64.4	67.2	70.1	73.1
5	76.1	79.1	82.3	85.5	88.7	92.0	95.4	98.6	102.3	105.9
6	109.5	113.2	116.9	120.7	124.6	128.5	132.5	136.5	140.6	144.8
7	149.0	153.3	157.6	162.0	166.5	171.0	175.6	180.2	184.9	189.6
8	194.5	199.3	204.3	209.3	214.4	219.5	224.6	229.9	235.2	240.5
9	245.9	251.4	257.0	262.6	268.2	273.9	279.7	285.5	291.4	297.4
10	303.4	309.5	315.6	321.8	328.1	334.4	340.7	347.2	343.7	360.2
11	366.8	373.5	380.2	387.0	393.8	400.8	407.7	414.7	421.8	428.9
12	436.1	443.4	450.7	458.1	465.5	473.0	480.6	488.2	495.8	503.5
13	511	519	527	535	543	551	559	567	576	584
14	592	601	609	618	626	635	644	653	661	670
15	679	688	697	706	716	725	734	743	753	762
16	772	781	791	801	810	820	830	840	850	860
17	870	880	890	901	911	921	932	942	953	963
18	974	985	996	1006	1017	1028	1039	1050	1061	1072
19	1084	1095	1106	1118	1129	1141	1152	1164	1175	1187
20	1199	1211	1222	1234	1246	1258	1270	1283	1295	1307
21	1319	1332	1344	1357	1369	1382	1394	1407	1420	1432
22	1445	1458	1471	1484	1497	1510	1523	1537	1550	1563
23	1577	1590	1603	1617	1631	1644	1658	1672	1685	1699
24	1713	1727	1741	1755	1769	1783	1797	1812	1826	1840
25	1855	1869	1884	1898	1913	1927	1942	1957	1972	1987
26	2001	2016	2032	2046	2062	2077	2092	2107	2123	2138
27	2153	2169	2184	2200	2215	2231	2247	2262	2278	2294
28	2310	2326	2342	2358	2374	2390	2407	2422	2439	2455
29	2471	2488	2504	2521	2537	2554	2570	2587	2604	2620
30	2637	2654	2671	2688	2705	2722	2739	2756	2773	2791
31	2808	2825	2843	2860	2877	2895	2912	2930	2947	2965

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