

Chemistry. — Investigations about the Structure of Artificial Ultramarines, IV. On Ultramarines of Thallium and on the Analogous Derivatives of the Bivalent Metals Calcium, Strontium, Barium, Zinc, Manganese, and Lead. By Prof. Dr. F. M. JAEGER.

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§ 1. In this paper the derivatives are described obtained by substitution of the sodium in GUIMET's *ultramarine-blue* N°. 7553¹⁾ by monovalent *thallium*, or by the bivalent metals *calcium*, *strontium*, *barium*, *zinc*, *manganese* and *lead*. It appeared that the substitution of the sodium by the bivalent metals mentioned took place in an *extremely easy* and *complete* way. In some cases we started also with the *silver-ultramarine* corresponding to GUIMET's blue; the products obtained appeared in this case, however, also to contain some *silver*.

The *thallium-ultramarine* was prepared by heating 7 grammes of GUIMET's blue of the formula: $Na_6Al_4Si_6O_{24}S_3$ with 44 gr. *tallous nitrate* and 10 ccm. *water* in sealed CARIUS-tubes for 50 hours at 160° C. The splendidly reddish-violet product thus obtained was carefully washed and purified, and its ROENTGEN-spectrogram was made in the usual way. In another experiment Tl_2SO_4 was used; the product obtained possessed the same colour as the previous one, and its ROENTGEN-spectrogram appeared to be identical with that of the first mentioned preparation. The data obtained are collected in the following table I. (See p. 157.) By the substitution of *Na* by *Tl*, the grating-constant a_0 is evidently only slightly diminished; the spectrogram has, for the rest, completely preserved the character of the ordinary *ultramarines*.

§ 2. The *Ca-*, *Sr-*, *Ba-*, *Zn-* and *Mn-ultramarines* were prepared by heating every time 7 Gr. of the *silver-ultramarine*: $Ag_6Al_4Si_6O_{28}S_3$ with five times the theoretical quantity CaI_2 , SrI_2 , BaI_2 , ZnI_2 and MnI_2 and 10 ccm. *water* in sealed tubes at 160° C. for 50 hours. The products obtained were purified in the way described before²⁾, by means of *KCN*, etc. In the case of the *Ca-*, *Sr-* and *Ba-compounds* almost

¹⁾ F. M. JAEGER and F. A. VAN MELLE, Proceed. Acad. Sciences Amsterdam, **30**, (1927), 479.

²⁾ Loco cit., 483.

pure, olive-green *Ca-*, *Sr-* and *Ba-Ag-ultramaries* of the formula: $Me^{II}Ag_4Al_6Si_6O_{28}S_3$ were formed. On melting these *Ca-* and *Ba*-containing products with CaI_2 , respectively BaI_2 , colourless *Ca-* and *Ba-ultramaries* were produced, which either contained no *Ag* (*Ca*-compound) at all, or only very little of it (*Ba*-compound). The corresponding *Zn*-

TABLE I
THALLIUM-ULTRAMARINE.

N ^o . of the image:	2 <i>l</i> in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.2	6	α	12° 0'	0.0432	0.0429	(211)
2	43.6	2	β	14° 4'	0.0591	0.0596	(310)
3	48.6	8	α	15° 41'	0.0730	0.0715	(310)
4	52.8	2	α	17° 2'	0.0858	0.0858	(222)
5	57.0	1	α	18° 23'	0.0996	0.1001	(321)
6	65.4	7	α	21° 6'	0.1296	0.1287	(330) and (411)
7	85.2	1	α	27° 29'	0.2130	0.2145	(521)
8	88.7	1	α	28° 37'	0.2294	0.2288	(440)
9	91.6	2	α	29° 33'	0.2432	0.2431	(433) and (530)
10	94.5	2	α	30° 29'	0.2573	0.2574	(600)
11	97.3	1	α	31° 23'	0.2712	0.2717	(532) and (611)
12	105.8	2	α	34° 8'	0.3149	0.3146	(622)
13	118.8	4	α	38° 21'	0.3850	0.3861	(633) and (721)
14	124.2	2	α	40° 4'	0.4143	0.4147	(730)
15	128.0	1	α	41° 22'	0.4356	0.4433	(732)
16	146.6	2	α	47° 17'	0.5401	0.5434	(662)
17	159.0	1	α	51° 23'	0.6092	0.6149	(655) and (761)

Radius of the Camera: 44.4 mm. Voltage: 55 K.V. Time of Exposition: 2 hours.

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00715 \cdot (h^2 + k^2 + l^2)$, for the *Cu- α* -radiation.

$\sin^2 \frac{\theta}{2} = 0.00596 \cdot (h^2 + k^2 + l^2)$, for the *Cu- β* -radiation.

Grating-constant: $a_0 = 8.98$ A.U. $\lambda_\alpha = 1.540$ A.U.; $\lambda_\beta = 1.318$ A.U.

TABLE II.
CALCIUM-SODIUM-SILVER-ULTRAMARINE.

Contains: 31.2 % Ag, and is pure: $\text{CaNa}_2\text{Ag}_4\text{Al}_6\text{Si}_6\text{O}_{28}\text{S}_3$.

Nº. of the image:	$2l$ in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.5	4	α	12° 6'	0.0439	0.0442	(211)
2	44.3	1	β	14° 17'	0.0608	0.0600	(310)
3	49.2	9	α	15° 53'	0.0749	0.0737	(310)
4	53.6	3	α	17° 18'	0.0884	0.0885	(222)
5	58.7	3	α	18° 56'	0.1053	0.1033	(321)
6	66.2	9	α	21° 21'	0.1325	0.1327	(330) and (411)
7	69.4	1	α	22° 23'	0.1450	0.1470	(420)
8	73.5	1	α	23° 43'	0.1618	0.1622	(332)
9	90.2	2	α	29° 6'	0.2365	0.2360	(440)
10	93.2	2	α	30° 4'	0.2510	0.2507	(433) and (530)
11	95.9	1	α	30° 56'	0.2642	0.2655	(600)
12	99.0	1	α	31° 56'	0.2798	0.2802	(532) and (611)
13	105.0	1	α	33° 52'	0.3105	0.3097	(541)
14	107.3	1	α	34° 36'	0.3224	0.3245	(622)
15	121.0	3	α	39° 2'	0.3966	0.3982	(633) and (721)
16	126.1	1	α	40° 40'	0.4248	0.4277	(730)

Radius of the camera: 44.4 mm. $V = 55000$ Volt. Time of Exposition: 3 hours.

$\lambda_\alpha = 1.540$ A.U.; $\lambda_\beta = 1.318$ A.U. $a_0 = 8.97$ A.U.

Quadratic Equation:

$$\sin^2 \frac{\theta}{2} = 0.007375 (h^2 + k^2 + l^2), \text{ for the } \alpha\text{-radiation.}$$

$$\sin^2 \frac{\theta}{2} = 0.005996 (h^2 + k^2 + l^2), \text{ for the } \beta\text{-radiation.}$$

ultramarine is also practically colourless, with a very feeble, pale violet hue. In the case of MnI_2 , a pale, yellowish-brown product was generated, which contained less Al than the original *Ag-ultramarine*; for the greater part it consisted of an *ultramarine*: $Na_2Mn_2Al_4Si_6O_{28}S_3$, to which some *Ag-ultramarine* was admixed. Later on we will return to the presumable

TABLE III.
CALCIUM-ULTRAMARINE.
The white compound does not contain any more Ag.

No. of the image:	$2l$ in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.2	6	"	12° 0'	0.0432	0.0435	(211)
2	42.6	9	"	13°46'	0.0565	0.0581	(220)
3	45.0	2	β	14°30'	0.0627	0.0600	(310)
4	48.9	3	"	15°46'	0.0738	0.0726	(310)
5	54.0	2	"	17°25'	0.0896	0.0871	(222)
6	61.5	1	"	19°50'	0.1151	0.1162	(400)
7	65.6	1	"	21°10'	0.1304	0.1307	(330) and (411)
8	69.8	2	"	22°31'	0.1466	0.1452	(420)
9	73.0	1	"	23°33'	0.1596	0.1597	(332)
10	76.0	1	"	24°31'	0.1722	0.1742	(422)
11	79.0	2	"	25°29'	0.1851	0.1888	(431) and (510)
12	86.7	2	"	27°58'	0.2199	0.2178	(521)
13	90.0	2	"	29° 2'	0.2355	0.2323	(440)
14	93.9	2	"	30°17'	0.2543	0.2469	(433) and (530)
15	97.0	1	"	31°17'	0.2696	0.2614	(600)
16	101.5	1	"	32°44'	0.2924	0.2904	(620)
17	107.4	1	"	34°39'	0.3233	0.3194	(622)
18	109.9	1	"	35°27'	0.3364	0.3340	(631)
19	113.9	2	"	36°45'	0.3580	0.3630	(543); (505); (710)
20	119.8	1	"	38°39'	0.3901	0.3920	(633) and (721)
21	126.0	1	"	40°39'	0.4244	0.4211	(730)
22	130.0	1	"	41°56'	0.4466	0.4501	(651) and (732)
23	138.0	1	"	44°31'	0.4916	0.4937	(644) and (820)
24	148.0	1	"	47°45'	0.5479	0.5518	(622)

Spectrogram with broad and hazy lines; inaccurate measurements.

Radius of the camera: 44.4 mm. $\lambda_{\alpha} = 1.540$ A.U.; $\lambda_{\beta} = 1.318$ A.U. $V = 55000$ Volt.

Time of Exposition: 3 hours.

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00726(h^2 + k^2 + l^2)$ for the α -radiation. $a_0 = 9.04$ A.U.

cause of this sodium-content. The data relating to the powder-spectrograms obtained with these products, are collected in the tables II—VII; the powder-spectrogram of the Ba-compound was feeble and hazy; that of the Mn-compound had a black-ground, as a consequence of the Mn-radiation excited.

Also these products all showed the original type of the *ultramarines*. Evidently in the case of the Ca-, Sr- and Ba-salts, exactly $\frac{1}{3}$ of the silver in *silver-ultramarine* is easily replaced by 1 atom of the bivalent

TABLE IV.

STRONTIUM-SODIUM-SILVER--ULTRAMARINE.

Contains: 29 % Ag and is: $\text{SrNa}_2\text{Ag}_4\text{Al}_6\text{Si}_6\text{O}_{28}\text{S}_3$ (30 % Ag).

Nº. of the image:	2l in mm.:	Estim. Intens. :	λ :	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	38.5	6	α	12°25'	0.0461	0.0444	(211)
2	44.0	2	β	14°12'	0.0602	0.0601	(310)
3	49.2	7	α	15°52'	0.0747	0.0740	(310)
4	53.5	1	α	17°16'	0.0881	0.0887	(222)
5	58.5	1	α	18°52'	0.1045	0.1036	(321)
6	66.6	6	α	21°28'	0.1339	0.1331	(330) and (411)
7	74.2	1	α	23°56'	0.1646	0.1627	(332)
8	77.8	3	α	25°6'	0.1799	0.1775	(422)
9	88.0	2	α	28°23'	0.2260	0.2219	(521)
10	92.1	2	α	29°43'	0.2457	0.2515	(433) and (530)
11	96.0	1	α	30°58'	0.2648	0.2663	(600)
12	98.0	1	α	31°37'	0.2749	0.2810	(532) and (611)
13	121.7	2	α	39°16'	0.4005	0.3995	(633) and (721)

Radius of the camera: 44.4 mm. $V = 55000$ Volt. Time of Exposition: 3 hours.

$$\lambda_{\alpha} = 1.540 \text{ A.U.}; \lambda_{\beta} = 1.318 \text{ A.U.} \quad a_0 = 8.95 \text{ A.U.}$$

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.007397 (h^2 + k^2 + l^2)$, for the α -radiation.
$$\sin^2 \frac{\theta}{2} = 0.006013 (h^2 + k^2 + l^2), \text{ for the } \beta\text{-radiation.}$$

TABLE V

POWDERSPECTROGRAM OF BARIUM-SODIUM-ULTRAMARINE.

Contains: 1.86 % Ag; consists of nearly pure: $\text{Na}_2\text{Ba}_3\text{Al}_6\text{Si}_6\text{O}_{28}\text{S}_3$.

Nº. of the image:	$2l$ in mm.:	Estim. Intensity:	λ	$\Sigma(\bar{h}^2)$:	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.7	4	α	6	$12^\circ 10'$	0.0444	0.0442	(211)
2	(43.8)	2	β	10	$14^\circ 9'$	0.0597	0.0598	(310)
3	(48.8)	2	α	10	$15^\circ 45'$	0.0736	0.0736	(310)
4	53.6	4	α	12	$17^\circ 17'$	0.0883	0.0883	(222)
5	58.0	1	α	14	$18^\circ 43'$	0.1030	0.1030	(321)
6	62.3	1	"	16	$20^\circ 6'$	0.1181	0.1178	(400)
7	66.3	3	α	18	$21^\circ 23'$	0.1329	0.1325	(330) and (411)
8	70.0	2	α	20	$22^\circ 35'$	0.1475	0.1472	(420)
9	73.7	2	α	22	$23^\circ 44'$	0.1620	0.1619	(332)
10	77.1	1	α	24	$24^\circ 52'$	0.1768	0.1766	(422)
11	86.6	2	α	30	$27^\circ 56'$	0.2195	0.2208	(521)
12	90.6	2	α	32	$29^\circ 15'$	0.2385	0.2355	(440)
13	(98.9)	2	α	38	$31^\circ 55'$	0.2795	0.2797	(532) and (611)
14	113.2	2	α	48	$36^\circ 31'$	0.3541	0.3533	(444)
15	(126.6)	1	α	58	$40^\circ 50'$	0.4275	0.4269	(730)

Radius of the camera: 44.4 mm. $V = 55000$ Volt. Time of Exposition: 2 hours.

$$\lambda_{\alpha} = 1.540 \text{ A.U.}; \lambda_{\beta} = 1.388 \text{ mm. } a_0 = 8.97 \text{ A.U.}$$

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00736 (h^2 + k^2 + l^2)$, for the α -radiation.
$$\sin^2 \frac{\theta}{2} = 0.00598 (h^2 + k^2 + l^2)$$
, for the β -radiation.

The film gave only hazy and broad lines; consequently only approximate estimations.

metal; but on melting these products with an excess of the iodides, practically all Ag is substituted.

The relative intensities of corresponding diffraction-images in these spectrograms are graphically represented in Fig. 1 in the usual way.

With the exception of the Ca- and Sr-compound, also in these cases no general relations seem to be present. Although the original character of the ultramarine-spectrograms is preserved throughout, yet the relative intensities of the images is different from those of the ordinary ultramarines.

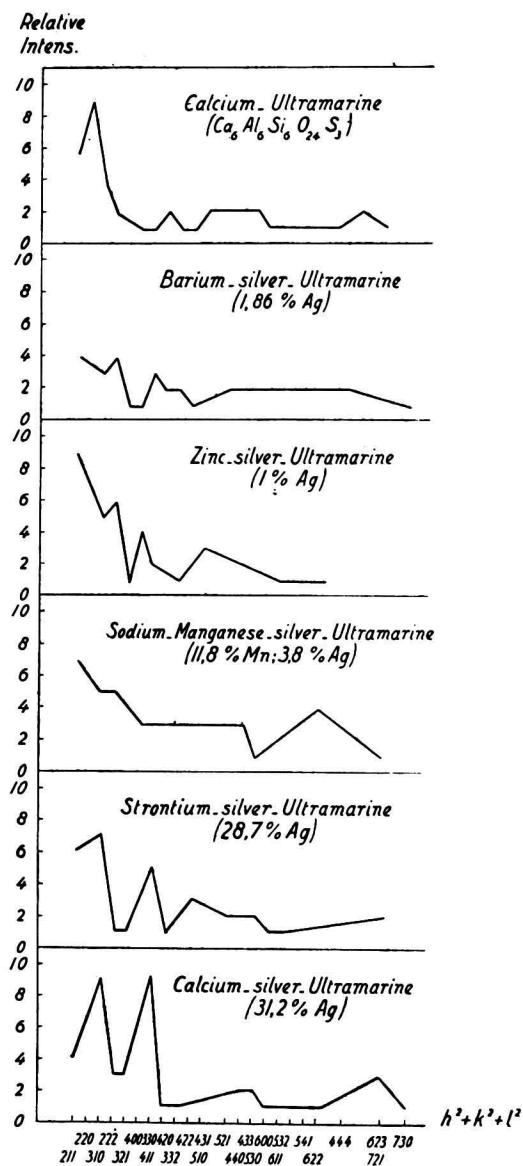


Fig. 1.

§ 3. In the case of the heavy metals, a lead-sodium-ultramarine rich in silica was prepared, by heating GUIMET's blue: $\text{Na}_6\text{Al}_4\text{Si}_6\text{O}_{24}\text{S}_3$ in

sealed tubes at 160° C. for 50 hours with five times the quantity of $Pb(NO_3)_2$, theoretically necessary for a complete substitution of the sodium present. After careful purification, a powder-spectrogram of the

TABLE VI.

ZINC-SODIUM-ULTRAMARINE.

(Still contains: 1% Ag. colour: very pale violet, almost white).

Is almost pure: $Na_2Zn_3Al_6Si_6O_{28}S_3$.

Nº. of the image:	$2l$ in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	38.0	9	"	12°15'	0.0450	0.0452	(211)
2	49.1	5	"	15°50'	0.0744	0.0753	(310)
3	54.3	6	"	17°30'	0.0904	0.0904	(222)
4	58.9	1	"	19° 1'	0.1062	0.1054	(321)
5	63.4	4	"	20°28'	0.1223	0.1205	(400)
6	66.8	2	"	21°33'	0.1349	0.1355	(330) and (411)
7	74.2	1	"	23°56'	0.1646	0.1657	(332)
8	81.6	3	"	26°19'	0.1965	0.1958	(431) and (510)
9	90.9	2	"	29°19'	0.2398	0.2410	(440)
10	100.1	1	"	32°17'	0.2853	0.2861	(532) and (611)
11	109.0	1	"	35°10'	0.3317	0.3313	(622)

Radius of the camera: 44.4 mm. $V = 55000$ Volt. Time of Exposition: 3 hours.

$$\lambda_\alpha = 1.540 \text{ A.U. } a_0 = 8.87 \text{ A.U.}$$

$$\text{Quadratic Equation: } \sin^2 \frac{\theta}{2} = 0.00753 (h^2 + k^2 + l^2), \text{ for the } \alpha\text{-radiation.}$$

product was thus obtained; the results of its analysis are put together in table VIII.

By melting *Ag-ultramarine* with $PbCl_2$ and extraction of the residual $PbCl_2$ by means of boiling water, a dark greyish *ultramarine*, containing Pb and Ag simultaneously, could be obtained; its powder-spectrogram showed the data collected in Table IX.

TABLE VII.

MANGANESE-SODIUM-SILVER-ULTRAMARINE.

Contains: 3.8% Ag admixed; 11.3% Mn; 4.3% Na, 10% Al; 17% Si
 and is almost pure: $\text{Na}_2\text{Mn}_2\text{Al}_4\text{Si}_6\text{O}_{28}\text{S}_3$.

Nº. of the image:	$2l$ in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.4	7	"	12°4'	0.0437	0.0435	(211)
2	48.4	5	"	15°37'	0.0725	0.0725	(310)
3	53.0	5	"	17°6'	0.0865	0.0870	(222)
4	62.0	3	"	20°1'	0.1172	0.1160	(400)
5	65.8	3	"	21°12'	0.1310	0.1305	(411) and (330)
6	72.4	3	"	23°22'	0.1573	0.1595	(332)
7	79.8	3	"	25°45'	0.1887	0.1885	(431) and (510)
8	88.7	3	"	28°37'	0.2294	0.2320	(440)
9	91.9	1	"	29°39'	0.2447	0.2465	(433) and (530)
10	106.3	4	"	34°19'	0.3175	0.3190	(622)
11	119.9	1	"	38°41'	0.3906	0.3915	(633) and (721)

Radius of the camera: 44.4 mm. $V = 55000$ Volt. Time of Exposition: 2 hours.

$$\lambda_{\alpha} = 1.540 \text{ A.U.}$$

$$a_0 = 9.04 \text{ A.U.}$$

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00725 (h^2 + k^2 + l^2)$, for the α -radiation.

§ 4. Attempts were made to prepare in an analogous way the *mercurous* and *mercuric-ultramaries* from GUIMET's blue by means of *mercurous*-, respectively *mercuric-nitrate*. At 160° C. in the case of the *mercurous* salt a pale canary-yellow product was obtained; in the case of the *mercuric* salt a dull, pale brownish-yellow compound. These products, however, appeared to be mixed with basic salts of mercury, from which they could not be freed completely, not even after being washed for a long time with a 10% solution of acetic acid, towards which these compounds seem to be stable, at least at low temperatures. However, sulphides of mercury were not generated in these reactions. But it seems, that a more profound decomposition of the *ultramarine* used occurs in

these reactions, the nature of which is not yet clear. The powder-spectrograms obtained appeared to be *different* from the usual ones and seem *not* to correspond to cubic symmetry. We are occupied in studying these reactions, and also those taking place with other bivalent metals, more in details.

TABLE VIII.

YELLOW LEAD-SODIUM-ULTRAMARINE.

(Contains: 43.4 % Pb; calculated for: $Pb_3Na_2Al_4Si_6O_{24}S_3$: 42.9 % Pb.

Nº. of the image:	$2l$ in mm.:	Estim. Intensit.:	λ :	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	37.5	2	α	12° 6'	0.0438	0.0426	(211)
2	43.1	3	α	13°54'	0.0577	0.0568	(220)
3	48.1	9	α	15°31'	0.0715	0.0710	(310)
4	52.7	7	α	17° 0'	0.0855	0.0852	(222)
5	57.6	1	α	18°35'	0.1015	0.0994	(321)
6	64.7	8	α	20°52'	0.1269	0.1278	(330) and (411)
7	79.5	1	α	25°37'	0.1869	0.1846	(431) and (510)
8	88.0	2	α	28°23'	0.2260	0.2272	(440)
9	91.0	3	α	29°21'	0.2402	0.2414	(530) and (433)
10	93.8	2	α	30°15'	0.2538	0.2556	(600)
11	96.7	3	α	31°12'	0.2684	0.2698	(532) and (611)
12	105.3	1	α	33°58'	0.3122	0.3124	(622)
13	114.0	1	α	36°43'	0.3574	0.3550	(505) (543) and (710)
14	118.3	4	α	38°10'	0.3818	0.3834	(633) and (721)
15	146.3	1	α	47°12'	0.5383	0.5396	(662)

Radius of the camera: 44.4 mm. $V = 50000$ Volt. Time of Exposition: 2 hours.

$$\lambda_\alpha = 1.540 \text{ A.U.}; \quad \lambda_\beta = 1.318 \text{ A.U.}; \quad a_0 = 9.14 \text{ A.U.}$$

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00710 (h^2 + k^2 + l^2)$, for the α -radiation. $\sin^2 \frac{\theta}{2} = 0.00577 (h^2 + k^2 + l^2)$, for the β -radiation.

TABLE IX.

LEAD-SILVER-ULTRAMARINE.

Obtained by melting *Ag-Ultr.* with $PbCl_2$ and extraction with water; still contains *Ag*. Colour: dark greenish-grey.

Nº. of the image:	$2l$ in mm.:	Estim. Intens.:	λ :	$\frac{\theta}{2}$:	$\sin^2 \frac{\theta}{2}$ (observed)	$\sin^2 \frac{\theta}{2}$ (calculated)	Indices:
1	36.7	5	α	11°50'	0.0421	0.0427	(211)
2	43.2	2	β	13°54'	0.0578	0.0588	(310)
3	47.7	9	α	15°22'	0.0702	0.0712	(310)
4	53.1	7	α	17° 8'	0.0868	0.0854	(222)
5	57.8	7	α	18°39'	0.1023	0.0997	(321)
6	65.0	7	α	20°58'	0.1280	0.1282	(330) and (411)
7	67.8	1	α	21°58'	0.1400	0.1424	(420)
8	72.1	1	α	23°16'	0.1560	0.1566	(332)
9	75.7	1	α	24°25'	0.1709	0.1709	(422)
10	79.6	1	α	25°41'	0.1878	0.1851	(431) and (510)
11	83.1	2	α	26°48'	0.2033	0.2136	(521)
12	88.6	1	α	28°35'	0.2289	0.2278	(440)
13	91.2	2	α	29°25'	0.2412	0.2421	(433) and (530)
14	94.4	3	α	30°27'	0.2568	0.2563	(600)
15	97.3	2	α	31°23'	0.2712	0.2706	(532) and (611)
16	118.5	3	α	38°14'	0.3830	0.3845	(633) and (721)

Radius of the camera: 44.4 mm. Voltage: 55 K.V.. $a_0 = 9.12$ A.U.

Time of Exposition: 2 hours.

Quadratic Equation: $\sin^2 \frac{\theta}{2} = 0.00712 (h^2 + k^2 + l^2)$, for the α -radiation.

$\sin^2 \frac{\theta}{2} = 0.00588 (h^2 + k^2 + l^2)$, for the β -radiation.

Finally it may be remarked here, that the magnesium-ultramarine has a pale blue colour; in this respect it is obviously different from the other ultramarines derived from the bivalent metals.

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