00·1(3) is not stronger than 00·1(6). These four arrangements may thus be excluded from further consideration.

Each of the four remaining possibilities (a)(h), (a)(j), (c)(h), and (c)(j) has only one variable parameter. It is consequently entirely feasible to calculate the nature of the diffraction effects to be expected from them for different values of the variable parameter u. A comparison of the results of such calculations with the principal aspects of the powder photographs and with the important intensity anomalies observed in the Laue photographs from β-quartz serves to eliminate all these structures except (c)(j). If in grouping (c)(j) the parameter u is chosen close to 0.20, then excellent agreement is found between calculated and observed intensities.[11]

It can hence be concluded that the structure of β–quartz is that of the two enantiomorphic arrangements 6D–4, (c) (j) and 6D–5, (c) (j). The coordinate positions of the atoms in the hexagonal unit of 6D–4, for instance, are

Silicon Atoms: (c) $\frac{1}{2}\ \frac{1}{2}\ \frac{1}{3}$; $0\ \frac{1}{2}\ 0$; $\frac{1}{2}\ 0\ \frac{2}{3}$

Oxygen Atoms: (j) $u\ \bar{u}\ \frac{5}{6}$; $2\bar{u},\ \bar{u},\ \frac{1}{2}$; $u,\ 2u,\ \frac{1}{6}$;
$\bar{u}\ u\ \frac{5}{6}$; $2u,\ u,\ \frac{1}{2}$; $\bar{u},\ 2\bar{u},\ \frac{1}{6}$,

where u has a value in the neighborhood of 0.20.

This structure agrees with the one deduced for β-cristobalite[12] in placing a tetrahedron of oxygen atoms about each silicon atom. In cristobalite this tetrahedron was necessarily regular; symmetry does not require such a regularity in quartz, but the value found for u is such as to bring about at least an approach to this condition. From data now being obtained through the analysis of prism face Laue photographs it is hoped to be able to limit the oxygen parameter more narrowly, and thus to gain a more quantitative measure of this approach to regularity. No molecules of $SiO_2$ could be distinguished in crystals of β–cristobalite; neither does this structure for β-quartz show clear evidence for $SiO_2$ or $(SiO_2)_x$ molecules.

Though their Laue photographs exhibit very different intensities of reflections, the powder photographs of α- and of β-quartz are astonishingly similar. This is precisely what would be expected if the change from one form of quartz to the other involves only a relatively slight atomic rearrangement. The numerous other known facts about quartz agree with this supposition.

A more detailed description of this structure, together with a statement of the extent to which it agrees with experiment, will be published in the *American Journal of Science*. This experimental evidence and a tabulation of the distinguishing criteria for all special cases of the hexagonal space groups will appear in the *Zeitschrift für Kristallographie*.

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[11] Arrangements (a) (h) and (a) (j) would not have been expected because they make the three silicon atoms all lie on a single axis and thus place them closer together than previous experience has indicated as probable; similarly (c) (h) is unlikely because it associates oxygen atoms more intimately with one another than with silicon atoms.

[12] R. W. G. Wyckoff, *Am. J. Sci.*, *9*, 448 (1925).

## A NEW METHOD FOR THE STUDY OF SOFT X-RAYS[1]

A NEW method for determining ionization and resonance potentials is found and applied in determining such critical limits of the elements composing photographic emulsions. At this writing the soft X-ray region between 100 and 750 volts has been studied.

A beam of electrons, having velocities uniformly distributed over the range under investigation, is spread into a band by means of a magnetic field. The velocity possessed by the electrons in any given part of this band is determined from the geometry of the apparatus and the strength of the magnetic

TABLE I

| Volts ± 2 | ν/R | Interpretation |
|---|---|---|
| 135 | 10 | ..... |
| 173 | 12.8 | Br; $4_1 \rightarrow 3_2$ |
| 184 | 13.5 | Br; $4_1 \rightarrow 3_2$ |
| 193 | 14.25 | Br; $M_{III}$ |
| 202 | 14.9 | Br; $M_{II}$ |
| 255 | 18.8 | C; Kα |
| 265 | 19.6 | Br; $M_I$ |
| 273 | 20.15 | ..... |
| 282 | 20.8 | ..... |
| 288 | 21.25 | C; K absorption |
| 306 | 22.6 | K; L absorption |
| 323 | 23.9 | Ag; $4_2 \rightarrow 3_3$ |
| 333 | 24.6 | Ag; $4_2 \rightarrow 3_3$ |
| 345 | 25.5 | ..... |
| 350 | 25.85 | ..... |
| 376 | 27.8 | Ag; $M_V$, or N; Kα |
| 384 | 28.4 | Ag; $M_{IV}$ |
| 404 | 29.8 | N; K absorption |
| 440 | 32.5 | ..... |
| 497 | 36.7 | O; Kα |
| 548 | 40.45 | O; K absorption |
| 562 | 41.5 | Ag; $4_3 \rightarrow 3_2$ |
| 572 | 42.2 | Ag; $M_{III}$ |
| 597 | 44.1 | Ag; $M_{II}$ |
| 664 | 49.0 | Ag; $4_2 \rightarrow 3_1$ |
| 695 | 51.2 | ..... |
| 730 | 53.9 | Ag; $M_I$ |
| 762 | 56.3 | ..... |

[1] Preliminary report.

field. Photographic plates exposed to such a band show sharp discontinuities when developed.

The photographic emulsions contain the following elements which have critical potentials within the range studied: carbon, nitrogen and oxygen in the gelatin; and silver and bromine as silver bromide. The discontinuities observed in the blackening of the photographic plate are in good agreement with observed and calculated critical potentials for these elements. Table 1 contains a list of the critical potentials observed in this work with the interpretation assigned to each.

In assigning the interpretations given in this table both the absolute values and the difference between levels have been considered.

The authors do not wish to make any claims for attainable refinements, but it is obvious that such uncertainties as initial velocities of thermally emitted electrons, contact potentials and potential drops along filaments are eliminated.

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## THE NUMBER AND ARRANGEMENT OF FLAGELLA OF THE TYPHOID FEVER GERM, BACILLUS TYPHI

IN staining various bacteria for flagella by a method developed by the writer (which will be described elsewhere), *Bacillus typhi* Gaffky (*B. typhosus* Gaffky) happened to be included. As quite a few preparations have been obtained of this germ, showing very clearly the number and arrangement of flagella, it seems desirable to call attention to the findings, especially as they are not in agreement with various statements and figures presented in quite a few well-known text-books and articles. Two cultures, at different times, were obtained from the U. S. Army Medical Museum, and the preparations obtained from both were in very close agreement. Furthermore, the same staining method has been used by several classes of students in bacteriology, University of Arkansas, using the typhoid germ and with the same results. Altogether, some fifty excellent preparations have been studied by the writer and several clear-cut microphotographs have been obtained.

From these studies the following conclusions are drawn. First, the number of flagella for each organism varies from one to several (rarely more than four), none showing as many as those figured in various texts, for example, Jordan's "General Bacteriology" (sixth edition), fig. 69, p. 299, or Migula's "System der Bakterien," vol. 1, pl. 2, fig. 6; vol. 2, pl. 7, fig. 6. Second, the arrangement of flagella is quite variable, often but a single polar flagellum is to be observed, occasionally one or more flagella appear at the sides, and not infrequently individuals occur having two flagella at one pole and with one or two at the sides. Third, there is a marked difference in the shape of the body as compared to those figured by various other investigators. In my preparations, the bodies appear very similar to those stained by ordinary, non-flagella staining methods, and compare very favorably to the figures presented by Migula, fig. 23, p. 727, vol. 2; fig. 6, pl. 7, vol. 2; or Jordan's fig. 68, p. 298. Indeed, if one carefully studies the figures given by these authors of *B. typhi*, stained by ordinary methods, and contrasts them with the figures given by these same authors, stained by flagella-staining methods, the conclusion is inevitable that either the flagella-staining methods have so distorted the shape of the organisms that they have no resemblance to the true forms, or that entirely different species are involved. The first explanation is probably the true one, for it is well known that many, if not all, of the older flagella-staining methods, such as Loeffler's or Van Ermengem's, possess a marked tendency to distort the bodies, and in addition, to deposit a more or less heavy precipitate on and around the bacteria. This last feature often renders it difficult to clearly delimit a single organism from a clump of organisms.

This has been almost entirely eliminated by the method used by the writer, as will be fully illustrated elsewhere. In all probability, then, the explanation for the difference in number and arrangement of flagella of *B. typhi* found by the writer and that given by various other writers is to be found in the degree of cleanness of preparations, particularly in freedom from deposits. In very few of the published photographs of *B. typhi* known to the writer can it be absolutely determined whether any one figure represents a single organism or a group of organisms. I am not overlooking the fact that there are other possible explanations, such as differences between strains in the number and arrangement of flagella, and that in making preparations it is very easy to destroy or render unobservable some or all of the flagella. However, the marked success in flagella staining and photographing that I have obtained with numerous and diverse organisms gives me a considerable degree of assurance that in the strains of *B. typhi* studied the flagella have been properly represented. In view of the importance of any method by which the typhoid fever germ may be accurately identified, the writer will be glad to lend preparations to others who may wish to make comparisons.

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