The curved, reflection-type $x$-ray spectrograph is a promising tool in mineralogical research where rapid qualitative or semiquantitative analysis of $x$-ray diffraction spindles, minute grains, or crystals is needed. The nondestructive character of the method makes it of special value. The present instrument is limited to elements of atomic number greater than 23.

We wish to express our appreciation to Charles Milton of the U. S. Geological Survey for the polished sections and mineralogical data. We also wish to thank L. S. Birks and E. J. Brooks for their help and advice in assembling the spectrometer.

### References

Birks, L. S., and Brooks, E. J. (1953), Uniform plastic bending of crystals for focusing $x$-ray radiation: *Rev. Sci. Instr.*, **24**, 992.

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## INCORPORATION OF IMPURITIES IN SYNTHETIC QUARTZ CRYSTALS

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Controlled amounts of selected impurities were incorporated in synthetic quartz crystals during growth to determine their effect on the growth rate, quality and properties of synthetic quartz.

The impurity experiments were carried out under conditions generally used for the growth of quartz from sodium carbonate solutions. The concentration of the solutions was 0.5N and the degree of fill was 70%. The average temperature measured at the top and bottom of the autoclave was 350° C. Temperature gradients between the top and bottom of the autoclaves varied from 20° C. in some runs to 50° C. in others. Observed pressures were 5000–6000 *p.s.i.* The capacity of the autoclaves ranged from 250 cc.–500 cc. The quartz seeds for this work were mostly $AT$-cuts. Growth runs lasted from 8 to 15 days. Resonator plates for evaluation could be cut from the growth obtained in that period of time.

Selection of impurities for addition to solutions for quartz growth was confined to those elements which were believed to be structurally compatible in the quartz lattice with respect to ionic radius and valence. Elements used as additives in these experiments are listed in Table 1 in accordance with their grouping in the periodic table.

Group IV elements were added as oxides; the Group III elements, aluminum and boron as sodium metaborate and sodium aluminate; calcium, the only element tried in Group II, and silver, the only element tried in Group I were added as carbonates. The use of sodium carbonate

TABLE 1

| Groups | | | | |
|---|---|---|---|---|
| I | II | III | IV | V |
| Na | Ca | B | Ti | As |
| Ag | | Al | Ge | |
| | | | Zr | |
| | | | Sn | |
| | | | Pb | |

solution in all the experiments made another Group I element available for combination with Group III additives in the quartz lattice. The Group V element arsenic was added as sodium orthoarsenate. The silver ion, although considerably larger than the silicon ion, was tried because spectrochemical analysis has indicated it to be present in certain synthetic quartz crystals.

Of all the elements used in these experiments only aluminum, germanium, lead, tin, and silver were found incorporated in the crystal lattice. The crystals containing lead, tin, and silver were not of the best quality, but those containing germanium and aluminum were of radio-grade. The following table shows the concentration of impurity in the solution, impurity concentration in the crystal and the temperatures at the top and bottom of 12-inch long autoclaves during growth.

No boron was detected in the crystal grown in the run with added boron. Detection of boron by spectrochemical analysis was limited to quantities greater than 300 ppm. It is possible therefore that boron was

TABLE 2

| Run No. | Conc. of impurity in sol. | Conc. of impurity in crystal (ppm) | Ionic radius (Å) | Temp. at top and bottom of autoclave | Seed |
|---|---|---|---|---|---|
| 2636-2 | 0.2 N $Ge^{+4}$ | Ge-3000 | .53 | 339°–381° C. | Doubly oriented |
| 2636-3 | 0.2 N $Ge^{+4}$ | Ge-1000 | .53 | 344°–385° C. | Doubly oriented |
| SN-169 | 0.5 N $Ge^{+4}$ | Ge-3000 | .53 | 325°–358° C. | *AT* seed |
| 2659-1 | 0.2 N $Ge^{+4}$ | Ge-1000 | .53 | 287°–344° C. | *AT* seed |
| 2636-1 | 0.015 N $Al^{+3}$ | Al-100 | .51 | 330°–370° C. | Doubly oriented |
| SN-138 | 0.015 N $Al^{+3}$ | Al-200 | .51 | 351°–399° C. | *AT* seed |
| SN-167 | 0.03 N $Al^{+3}$ | Al-50 | .51 | 320°–376° C. | *AT* seed |
| 2659-2 | 0.015 N $Al^{+3}$ | Al-100 | .51 | 332°–348° C. | *Z* seed |
| SN-132 | 0.06 N $Pb^{+4}$ | Pb-1000 | .84 | 315°–395° C. | *AT* seed |
| SN-136 | 0.05 N $Pb^{+4}$ | Pb-200 | .84 | 345°–378° C. | *AT* seed |
| SN-165 | 0.018 N $Sn^{+4}$ | Sn-300 | .71 | 311°–341° C. | *AT* seed |
| SN-155 | 0.05 N $Ag^{+1}$ | Ag-200 | 1.26 | 350°–365° C. | *AT* seed |

present in quantities less than 300 ppm. Boron was the only impurity element which appeared to have an effect on the growth rate.

The crystal containing silver had a rose color.

Overtone *AT* resonator plates prepared from the synthetic quartz crystal containing 100 ppm of aluminum have been investigated by A. R. Chi.[1] This material showed higher inflection temperatures (75° C.) than similar plates cut from both natural quartz (20° C.) and synthetic quartz (40° C.) with no added impurities. The inflection temperature is defined as the point on the frequency temperature curve where the second derivative of frequency versus temperature is zero.

[1] Submitted for publication to *Proceedings of the I.R.E.:* Effects of impurities on resonator properties of quartz, A. R. Chi, D. L. Hammond and E. A. Gerber.

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### The Geochemical Society

A new organization known as "The Geochemical Society" was formed on November 7, 1955, during the recent convention of the Geological Society of America in New Orleans. A constitution was adopted which specifies that "the object of the Society shall be to encourage the application of chemistry to the solutions of geological and cosmological problems."

Membership will be worldwide. It is hoped that not only chemists and geologists, but also physicists, biologists, oceanographers, meteorologists, mathematicians and other natural scientists interested in joint attacks on problems in the earth sciences will join in furthering its objectives.

Additional information and membership blanks may be obtained from the Secretary, Professor John C. Maxwell, Dept. of Geology, Princeton University, Princeton, New Jersey.

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### Annual Meeting

The thirty-seventh annual meeting of the Mineralogical Society of America will be held in Minneapolis, Minnesota, Wednesday through Friday, October 31–November 2, 1956. A series of field trips is being planned for Sunday, Monday and Tuesday preceding the meeting. Detailed notices will be mailed to all members.

Abstracts of papers to be presented at the annual meeting must be received by the Secretary on or before July 15, 1956. Abstract blanks may be obtained from the Secretary.

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### Nominations of Officers for 1957

*President:* D. Jerome Fisher, Department of Geology, University of Chicago, Chicago 37, Illinois.

*Vice-President:* George E. Goodspeed, University of Washington, Seattle 5, Washington.

*Secretary:* C. S. Hurlbut, Jr., Harvard University, Cambridge, Massachusetts.

*Treasurer:* Earl Ingerson, U. S. Geological Survey, Washington, D. C.

*Editor:* Lewis S. Ramsdell, Mineralogical Laboratory, University of Michigan, Ann Arbor, Michigan.

*Councilors* (1957–1959): Samuel S. Goldich, Department of Geology, University of Minnesota, Minneapolis 14, Minnesota.

Brian H. Mason, Department of Geology, American Museum of Natural History, New York 24, New York.