

obtained as magnificent orange needles. Their melting point was 143-144°.

0.2806 grm of the substance yielded on combustion 0.8123 grm carbonic acid and 0.1763 grm water. These results agree with those calculated on the supposition that the body is azotoluole, $C_{11}H_{11}N_2$:

	Calculated.	Found.
Carbon	80.00	79.28
Hydrogen	6.66	6.98
Nitrogen	13.34	13.51

The same body has recently been obtained by Barsilowsky* by the action of very dilute potassium permanganate solution upon toluidine sulphate. This reaction yielded a very small product, and Barsilowsky afterwards used a solution of potassium ferricyanide and caustic potash with better results. The orange crystals thus obtained melted at 144°, and were identical in their physical properties both with the parazotoluene, derived by Petrieff from the reduction of nitrotoluene, and with the substance described by the author. By the action of hydrogen peroxide, therefore, upon paratoluidine it is converted directly into parazotoluene.

The sublimate from the aniline product yielded large red crystals, together with some accompanying yellow oil. This sublimate had a melting point of 66°, showing that the body was azotoluene (m. pt., 66°.5).

XV.—ON THE EXAMINATION OF CARBON DIOXIDE IN THE FLUID CAVITIES OF TOPAZ.

BY ALEXIS A. JULIEN.

Literature.

- SIR DAVID BREWSTER. See for ref., J. D. Dana, system of Mineralogy, articles Brewsterline and Cryptolinite; also *Phil. Mag.*, 1847, 3, 31, 497; 1853, 4, 5, 235, etc.
 R. TH. SIMMLER. *Pogg. Ann.*, 1858, 105, 460.
 H. VOGELSANG and H. GRISSLER. *Pogg. Ann.*, 1869, 137, 56.
 ISAAC LEA. *Proc. Ac. Nat. Sci., Phil.*, May, 1876.

Recent studies of the fluid contents of the cavities of minerals, especially of the fluids separated in sufficient quantities for analytic examination, have established more definite views concerning their true character. The liquid first observed by Brewster in Brazilian topaz, and which has since passed by the name Brewsterline or Brewsterlinité, has been shown by Simmler, Vogelsang and Geissler,

**Ann. der Chem.*, 207, 102.

and W. N. Hartley,* to be identical in its properties with liquid carbon dioxide. The abundant dissemination of this substance has been variously and certainly confirmed through its general optical and physical properties, especially by the determination of its refractive index, by spectroscopic examination of the gas after expulsion into a Geissler tube, and even by ordinary qualitative or volumetric examination.

The dense and darker liquid commonly associated with this, first noticed by Brewster, and afterwards styled cryptoline or cryptolinite, as well as another liquid, still more thick and viscid, subsequently observed in a large cavity,† are now recognised merely as saline solutions of varying composition.

These two names are now obsolete, but the following substances may be accepted as entering into the content of these cavities in the various siliceous minerals: water, liquid and as vapor, and frequently in the form of supersaturated saline solutions, containing chlorides, sulphates, or carbonates of the alkaline metals, fluoride and sulphate of calcium, and sulphate of barium, some of these salts, especially the chlorides, being often isolated in minute crystals; carbon dioxide, liquid and gaseous nitrogen, solid bitumen, mineral oil,‡ and perhaps lighter hydrocarbons; free sulphuric and hydrochloric acids; hydrogen sulphide; and minute crystals, microliths, and tricrites, representing usually the constituent minerals of the enclosing rock, *e. g.*, hornblende, rutile, etc. Sulphurous oxide and free ammonia have been also detected in the gases expelled from the cavities by ignition,§ but may have originated in the decomposition of solid or liquid bituminous matters, such as those first noticed by Foster in smoky quartz; their actual presence in the included gases is yet to be confirmed by examination of the latter, when separated without adulteration, by products of distillation, *e. g.*, by mechanical means, as when crushed in a vacuum. Several other soluble substances of limited occurrence have been noted in the study of special minerals, *e. g.*, magnesium and calcium chlorides in the cavities of halite, zinc sulphate with sodium chloride in those of blende,|| etc

In the siliceous sedimentary and metamorphic rocks, especially in all the gneisses of the Appalachians, in the Eastern United

* *Journ. Chem. Soc.*, London, 1876.

† Brewster, *Phil. Mag.*, 1853, 4, 5, 235.

‡ Brewster, *Trans. Roy. Soc.*, Ed., 10.

§ A. W. Wright, *Amer. Journ. Sci.*, 1881, 3, 21, 212.

|| A. Schertel, *Berg und Hüttenm. Zeitung*, 1878.

States, the quartz grains generally abound in cavities, holding apparently pure water, but sometimes a saline solution with minute cubical crystals. For instance, I have found certain specimens of the triassic brown sandstone of Portland, Conn., to be remarkably rich in these fluid cavities, not only the quartz but even all the feldspar grains being saturated by them to such a degree, that they abound in every field of view throughout the thin section.

Carbon dioxide so far appears to be of much rarer occurrence in the rocks of Eastern America, having been detected mainly in quartz, and only at the following localities: in the labradorite of Labrador; in hornblende-syenite at Columbia, N. H.;* in the pegmatyte vein at Branchville, Conn.;† in the granulyte at Charlotte, N. C., and in the smoky quartz at White Plains, N. C.;‡ in the hornblende-gneiss of the Laurentian at Ticonderoga, N. Y., and in the same rock at three localities in Western N. C.; in the gneissoid-granite of the Penokie Iron Range, Wis.,§ and in granite, mica-schist, hornblende-schist, and chlorite-schist, at three localities in Mich.||

In the metamorphic and eruptive rocks of Western America, however, carbon dioxide, together with a second liquid, which is either water or a saline solution, occupies the cavities of the quartz grains at many localities—in the gneisses, granite and granite-porphyry of Marble Hill, Kinzly District, of Clover Cañon, Humboldt Mts., of Havallah Range, and of Granite Peak, Ute Range, Nev.; in the hornblende-gneiss at Davis Mt., Park Range, and in the quartz-propylite at Golconda, Col.;¶ in the smoky quartz of Pike's Peak, Col.,** and in the quartz from the gold vein at Hunter's Rest, Arizona.†† These few localities, however, must undoubtedly represent a far wider distribution of this interesting substance throughout the rocks of the continent, as their number is being constantly increased with every published report of lithological work.

The qualitative identification of carbon dioxide in the cavities of a mounted thin section of a mineral, may be determined, at least with probability, after some experience, through various optical appearances and physical characteristics which have been often described.

* G. W. Hawes, *Geol. of N. H.*, 1878, 3, 207.

† A. W. Wright, *loc. cit.*

‡ G. W. Hawes, *Amer. Journ. Sci.*, 1881, 203.

§ R. D. Irving, *Geol. of Wis.*, 1880, 3, 249.

|| A. Wichmann, *idem*, 600, 619, 635, 642, 647.

¶ F. Zirkel, *Geol. Expl. of 40th Par.*, 1876, 6, 18, 33, 44, etc.

** B. Silliman, *Science*, 1880, 1, 289.

†† G. W. Hawes, *Amer. Journ. Sci.*, 1881, 203.

It is usually effected with certainty and ease, through the rapid and enormous expansion and ultimate disappearance, either of the liquid or of the gaseous bubble, on the application of a gentle heat for a few seconds, such as that of a cigar, the heated end of a rod, a jet of hot air, or even a jet of the warm breath conveyed through a flexible rubber tube. When the slide and the thin section are thin, even the heat (37° C.) of the tip of one's finger applied for a few seconds to the bottom of the slide, without removal from the stage of the microscope, may be sufficient to produce the characteristic phenomena, *e. g.*, the contraction and disappearance of a bubble whose size is relatively small to that of the liquid in which it floats.

For the determination of the temperature of disappearance of one bubble, which may vary from 20° to 32° C., several forms of stage-heating apparatus may be employed: those of Nâchet, L. Beale, and R. Fuess, in which a current of hot air from the flame of a small lamp or taper is conveyed beneath both the slide and the adjacent bulb of a thermometer; that of M. Schultze (also Chevalier, Dujardin, and Dr. Ransom), in which both slide and thermometer bulb are heated by conduction through a brass or copper plate, with two arms projecting beyond the stage over the flames of two tapers; those of Polallion and Ranvier, in which the slide rests upon the upper side of a metal box through which a continuous current of hot water is conveyed through tubes in connection with a small adjacent tank or boiler, the bulb of the thermometer being immersed in the box; and that of H. Vogelsang, in which the slide rests upon a ring-shaped thermometer bulb, with a fine and frequently bent platinum wire intervening, which is heated by a galvanic current under the control of a rheostat. The results obtained by any apparatus of these kinds are inexact, from the unequal and irregular application of heat to the thin section and to the thermometer bulb, from the interference of cooler currents in the surrounding atmosphere, and above all, from the refrigerating effect of the mass of metal of the microscopic objective in close approximation. Vogelsang admitted that with his apparatus, the one even yet considered the most accurate, from this last source the error may amount to 10° , according to the objective employed, from a No. 4 Hartnack, of 3 mms focal distance, to a No. 9 of 0.1 mm focal distance. He reduced observations with the higher powers to the standard of the No. 4, and further suggested a plus correction of 1° for those observations in which the temperature of the room and of the microscope remained at 12° to 15° , instead of his normal, 20° C. Most of the published observations on the subject

have been consequently made under the lowest powers, and it is considered sufficient to obtain results corresponding to a degree. In every case there are also additional obstacles in the inconvenience, fragility and cost of the apparatus; much time is required for satisfactory experiments, and especial annoyance is incurred by the slowness with which the apparatus cools before the temperature of the re-appearance of the bubble can be determined, as a check.

In place of all these a simple and inexpensive apparatus may be substituted, consisting of a miniature water bath in which are immersed the entire section and slide, the bulb of the thermometer, and the nose of the objective. It consists of a box of tinned copper

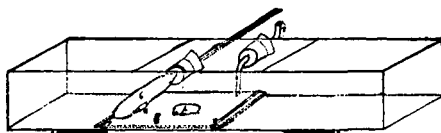


Fig. 1.

(tinned iron is liable to rust), of length sufficient to project a few centimeters on either side of the stage of the microscope employed; the one I use being 23 centimeters in length, 4 cms in width, and 3 cms in depth. This is laid across the stage of the microscope, separated from the metal by thin plates of cork, *cc*, and is heated by a short wax taper (night light) underneath either extremity. The slide *s* may rest upon the bottom guarded from the metal by little rubber bands, *rr*, beneath its ends, and wedged firmly by a little wooden wedge, *w*, beneath the horizontal thermometer bulb, *b*; or, a thermometer with ring-shaped bulb may be inserted, upon which the slide may rest directly, firmly attached by one or two slender rubber bands. The thermometer should be of guaranteed accuracy, with wide degrees, subdivided if possible, with a range which need not much exceed 20 to 32° C. The preparation is then covered by any pure and clear water, preferably filtered (distilled is unnecessary), to a depth of about 2 cms. A circular aperture in the bottom of the box 18 mms in diameter, is covered with glass attached by cement, and through this the light is thrown up from the mirror. The cavity to be examined is then carefully adjusted and focussed, a taper is lit, and the eye remains at the eye-piece until the critical point is reached. The glass tube *t*, with its point terminating just below the edge of the slide, is connected with the mouth during the experiment by a small rubber tube. As the temperature slowly

rises, a constant current of small bubbles of the warm breath (whose temperature, 32° , only assists the operation) may be blown with little fatigue through the tube to effect a thorough intermixture of unequally heated layers in the water stratum. The determination of the temperature of disappearance of the bubble is easily obtained within five minutes, and that of its re-appearance in about the same time. A low power objective may be carefully wiped if its anterior lens is dimmed by flying drops or by rising vapor, when a high temperature is being attained; but it is best to insert the whole objective in a small narrow glass beaker floating upon the surface of the bath over the preparation.

The plan of immersing the preparation at once in a bath previously heated, and then allowing it to cool under observation, has already been used with indifferent results. Brewster "plunged the topaz in heated water," and thus determined the point of re-appearance of the bubble at $26^{\circ}.4$ C., and, in another deep cavity, at $28^{\circ}.8$ C. Vogelsang placed it in 6 to 8 c.c. of glycerine, previously warmed to 60° , in a layer 4 to 5 mms in depth above the preparation; this he stirred up with a slender thermometer, which, however, greatly interfered with observation. He obtained the following results, corresponding to the Hartnack objectives employed, for the temperature of re-appearance of the bubble:

Objective No. 4, ocular No. 3, lens above the liquid	$31^{\circ}.5$ -(32)
" " 4, " " 4, " just in the liquid	$.34^{\circ}.5$ -(36)
" " 5, " " " " " hardy down to	45° .

As the range of error amounts to 13° , even without the use of an objective of much power, he recommends the employment in this method of such an objective as will remain above the liquid, but considers his galvanic apparatus as preferable. Sorby* explains that he examined the fluid cavities in sapphire, by immersing the preparation in a beaker of water, under a low power of the microscope, and raising its temperature very slowly, but gives no details concerning the method or the accuracy of his results. A bath may, indeed, be heated up by repeated additions of small quantities of warmer water, but this process is apt to be tedious and slow. With my apparatus above described, an accuracy within one-tenth of a degree was readily and constantly obtained, both with a one inch and a one-eighth inch immersion objective. It will suffice to present, out of a large number of unusually good results on a fluid cavity of 0.54 mm diameter,

* H. C. Sorby and P. J. Butler, *Proc. Roy. Soc.*, London, 1869, 17, 297.

those obtained by means of the Fuess apparatus (*F*), the one most commonly used, and others by means of my own (*J*), the temperature being noted both of the disappearance (*d*) and re-appearance (*r*) of the bubble. The objective used was a one inch of Wm. Wales, with a working distance of 13 mms in the air, and 15 mms over a stratum of water 7 mms deep.

	<i>F.</i>	<i>J.</i>		
<i>d</i>	26.7	26.5	26.5	26.5
<i>r</i>	26.4	26.3	26.4	26.4

In place of the blowing tube a little agitator or churn at the end of the box had been previously tried, to produce the intermixture of the contents of the bath, but was given up on account of the inconvenient vibration and frequent dislodgement of the slide.

The apparatus, as thus constructed, I have long used, and may be found the most convenient warm stage when high temperatures are required; but another still more simple, lately devised, will best serve for the determination of carbon dioxide, and consists of the following parts :

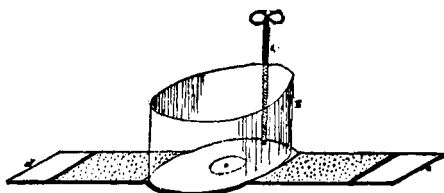


Fig. 2.

First. A shallow glass tank with thin and well annealed sides, of size sufficient to enclose the slide upon which the thin section is mounted. For this purpose I use a small chemical beaker *B*, with the thinnest bottom, and with its upper portion cut off, forming a thin round glass tank, about 6 centimeters in diameter and 3 cms deep.

Secondly. A plate of copper or brass like that used in Schultze's apparatus, or more simply one of the form represented in the figure, *d e*. Its dimensions, proportioned to those of the beaker-tank and of the stage of a large microscope, are as follows; length, 23 cms; diameter at center, 6.5 cms; width of arms, 3.5 cms; central aperture, 2.5 cms; height of wire support, 13 cms; thickness of plate, 1 mm. Each arm is wrapped in pasteboard, to prevent radiation, to the extent indicated by the shaded portion.

Thirdly. A delicate thermometer (made by Henry Green, of New York), with a small short bulb bent at right angles to the stem, and a very fine column, to obtain sufficient sensitiveness to minute varia-

tions of temperature, and complete immersion of the bulb in the small volume of liquid employed in the bath. The scale need not exceed in range from about 20° to 32° C., the thermometer being of such length that, when in position, the scale from 27° to 30° C. may be on the level of the eye-piece of the microscope, and readily visible without motion of the head. Each degree of the column should be about a cm in length and subdivided to tenths. The instrument used was standardized, and had a plus error of about $0^{\circ}.05$ at the portion of the scale employed.

Lastly. A pointed glass tube, with flexible rubber connection for blowing, and a wire support, *s*, to receive both this and the thermometer, attached to the metal plate.

The latter is laid upon the stage of the microscope, separated by thin plates of cork or a perforated piece of pasteboard; the tank, supplied with about 40 c.c. of water, is placed over the central aperture, *a*, and a taper beneath an extremity of one arm of the plate, and the apparatus is then ready for use in the way already described; the water of the tank being heated by conduction through the metal plate. The section of the mineral is best mounted upon a very thin slide, 45×26 mms, and this is guarded as before by rubber bands and held down by one or two little brass weights. Only a single taper is necessary for the low temperature required in the examination of carbon dioxide cavities, and even with this, a temperature of 43° C. may be obtained in the bath within a few minutes. The disappearance of the bubble may be completed in less than five minutes, the taper being removed as soon as the rising column approaches within 2 or 3 degrees of the critical point, roughly determined by a previous trial. If two tapers are used, the temperature of the water may be raised to 55° in about 20 minutes, or even much higher by the use of Bunsen gas burners. In summer the temperature of the atmosphere alone may be sufficient, especially if assisted merely by the current of warm breath, to obliterate the gas bubble. Its return may be readily caused, in a warm atmosphere, by adding from time to time a few drops of cool water to the bath, while the eye remains at the eye-piece, and a steady current of air is blown through the glass tube. Mounted slides used for such experiments must be labelled by writing with a diamond, or the paper label may be rendered waterproof by being coated successively with weak size and any transparent varnish, such as copal or shellac. To ascertain the limits of accuracy, the following determinations were made of the temperatures of disappearance (α) and re-appearance (σ) of the bubbles in two cavities,

A and *B*, of the same thin section, with a variety of objectives, on two stands made by Fuess, of Berlin, and Powell & Lealand, of London, the objective being usually immersed in water, but sometimes not immersed. For comparison, the experiments of Vogelsang were exactly repeated with this apparatus, using two objectives of the same kind immersed in glycerine.

Objective.	Cavity A.			Cavity B.		
	<i>d</i>	<i>r</i>	Mean.	<i>d</i>	<i>r</i>	Mean.
Hartnack, No. 2	28.30	28.00	28.15	27.60	27.50	27.55
" " 4	28.40	28.20	28.30	27.60	27.70	27.65
" " 4, in glyc.	28.32	....	28.32	27.95	....	27.95
" " 7	28.40	28.10	28.25	27.95	27.80	27.82
" " 7, in glyc.	28.28	....	28.28	27.80	....	27.80
" " 9	28.35	28.32	28.33	27.80	27.60	27.70
W. Wales, 3 inch, not imm.	28.40	28.35	28.37	27.97	27.92	27.94
" " 1 "	28.40	28.35	28.37	27.96	27.92	27.94
" " 1 " not imm.	28.39	28.38	28.39	27.65	27.80	27.72
" " $\frac{2}{8}$ "	28.35	28.37	28.36	27.96	27.96	27.96
" " $\frac{1}{10}$ "	28.10	27.90	28.00	27.80	27.82	27.81
Pow. & Leal. $\frac{1}{4}$ " imm.	28.35	28.36	28.36	27.72	27.70	27.71
Average	....	....	28.33	....	....	27.79

From these experiments it may be inferred that with this apparatus, which may be called the immersion warm bath, it matters little for most purposes what liquid, stand or objective is employed; that water is preferable to glycerine from its greater mobility, convenience, and lack of cost, but its bulk is immaterial, so long as the bulb of the thermometer is covered; that it is decidedly advantageous to immerse the anterior lens of every objective in the bath, to avoid the annoying interference with observation produced by the vibration of the surface, and by the necessity for repeated re-focussing, when the objective is above the surface of the liquid; that careful determinations on minute cavities, with high powers, carried on slowly to enable the preparation, objective and thermometer to assume the same temperature, may be as accurate as any others; and that there is no difficulty in obtaining satisfactorily the two determinations within ten minutes to an approximation of about one-twentieth of a degree. The influence upon the temperature of the disappearance of the bubble exerted by forced dilatation,* producing adherence to the side of the cavity, appears to be very small, never exceeding a few hundredths of a degree, probably because the walls of these cavities

* Berthelot, *Ann. Chim.*, (3.) 30, 232.

are not dry, but always lined by at least an imperceptible film of another liquid, the brine or saline solution.

The descriptions of this method, and of these forms of apparatus, have been given in the more detail, inasmuch as they may be of service in many other branches of thermal microscopy where the exact determination of the temperature applied is desirable, *e. g.*, as suggested by my friend, Mr. Arthur H. Elliott, in the determination of the melting point of rare chemical substances, etc. For this purpose, the apparatus in Fig. 1 might be supplied with another tube, on the opposite side to those represented, through which might be inserted, beneath the objective, a small glass tube, containing the substance to be examined, and thus immersed, by the side of the thermometer bulb, in the water, oil, paraffine, or other liquid which the circumstances may require for the bath.

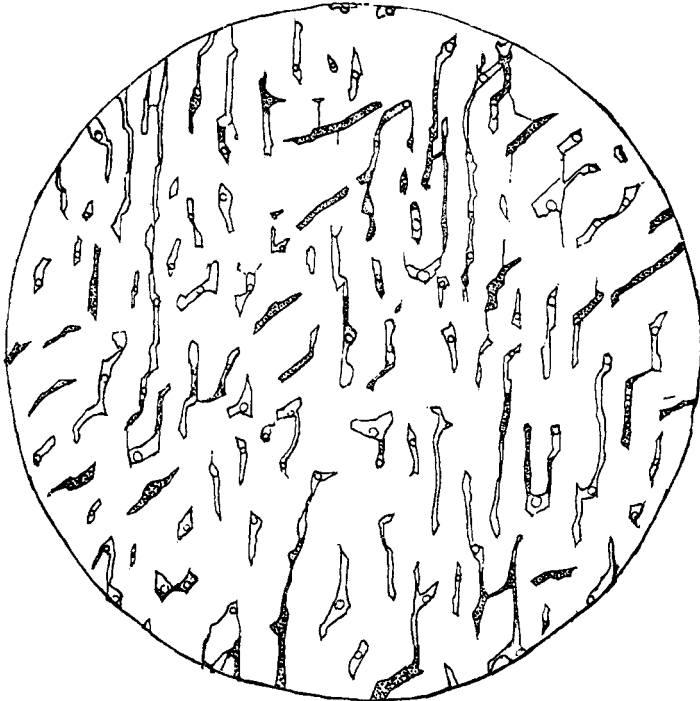
The liquid inclusions in the white topaz of Rio Belmonte, Brazil, have been already the subject of considerable investigation by Brewster, and others; but the recent study of a large number of cleavage slices from fifty pebbles of this mineral, labelled "Minas Geraes, Brazil," peculiarly rich in fluid cavities, has presented several facts of some interest which have not been recorded by these observers.

Although it can hardly be claimed that the mysterious spontaneous motion which very commonly affects the gas bubbles in the most minute microscopic cavities, usually but a few thousands of a mm in diameter, has yet received a complete and perfectly satisfactory explanation, there can be little doubt that its essential dependence upon slight changes of temperature* has been sufficiently demonstrated. This view is confirmed by the fact that in a cavity 0.03 mm in length, in one of my slices of the topaz, the bubble, quiescent at ordinary temperatures, passes into active motion when the temperature is slightly raised, so that observation of this spontaneous motion becomes possible—a unique instance so far as I am aware—with a magnifying power of only 65 diameters. Several other like instances have been noted in these slices.

It is well known that the fluid cavities of most minerals lie to a large extent in planes, and that those of rounded symmetrical form predominate. Beautiful crystalline forms—in quartz, inverted crystals—often occur, and Brewster and Vogelsang have pointed out their occasional presence in topazes, exhibiting the contour of "negative rhombic tables and distorted octahedra." In a few choice slices of

* G. W. Hawes, *Am. Journ. Sci.*, *loc. cit.*

my specimens of topaz, however, many extremely angular, elongated, branching and even reticulated forms of considerable size and novelty abound. Their outline is at many points decidedly crystalline, with



One Mill.



Fig. 3.

arms projecting at an angle of about 135° . As the preparation in which those figures occur, is a natural cleavage slice on the basal plane, this disposition of the cavities seems to have been guided by a parallelism to prismatic faces—it may be, on the planes $i - \bar{i} \wedge i - \bar{2} = 136^\circ 35\frac{1}{2}'$. If so, the generalization of Brewster may have been pressed too far, that the cavities were generally “capriciously distributed, when the substance of the crystal was in a soft or plastic state.” There is also a curious partial division of the two liquids, in regard to distribution in the cavities, the limpid and colorless carbon

dioxide, generally including a bubble, being mainly concentrated in the longer tubes, vertical in the figure, with a little brine at their extremities, while the thick and dark saline solution is mainly confined to the arms which project at the angle stated, and fills completely, always without bubbles, those which are straight, short, and lie entirely in that direction. This may indicate the result of molecular pressure in two directions, differing greatly in degree upon two liquids of widely differing density, the lightest and most mobile having been squeezed into the plane of least pressure. In general, the larger expansions of the cavities are mostly occupied by brine, while their attenuated extremities and fine tubular connections are filled by liquid carbon dioxide, occasionally including a bubble due to contraction.

The intricate connection of adjoining tubes may even produce cavities of unusual length, so that one containing both brine and

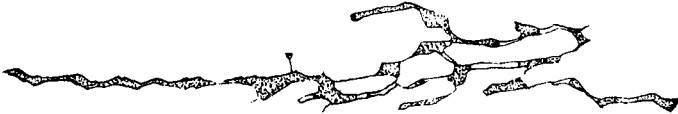


Fig. 4.

carbon dioxide, is 2.28 mms in length. The largest cavities noted by Brewster contained only the dense liquid; the largest observed by Vogelsang in topaz reached only 0.5 mm in one direction. Brewster however found in sapphire a cavity one-third inch in length, two-thirds full of a liquid expanding at 28° C. Fine capillary tubes project from many angles of these cavities, often directly toward each other in exact line from adjacent cavities, hinting at a broken connection. Such a relation seems to be indicated by the tubules between the main cavity in Fig. 4, and the shorter one in the lower right-hand part of that figure. The abundance and direction of these tubules plainly show that at the original conditions of temperature during the formation of the topaz crystal, parts of its mass were filled by anastomosing canals occupied by the two fluids, which have been mostly shut up by compression during the ensuing contraction of the mass. That these still remain as imperceptible fissures, was shown by one of Brewster's observations: on heating a small cavity, the liquid was forced along into the apparently compact topaz, through a latent fissure which opened to receive it as it advanced, and then closed up behind it.

The connection or coalescence of straight adjoining cavities at one extremity, frequently results in U-shaped or hook-shaped forms. If

expansions occur at or near the upper ends of the U or hook, and these are occupied by large bubbles of the gas, their contents are naturally in a state of unstable equilibrium, readily subject to movement by changes of temperature in the topaz matrix. This explains the partial transference of contents I have occasionally observed in U-shaped cavities of this kind, portions of the liquid carbon dioxide, or minute bubbles of the gas passing along an arm from one expansion to the other, as in a naturally formed differential thermometer.

In one slice of the topaz the temperature of the disappearance of the gas bubbles was determined on ten cavities, chosen at random, at the following points : 26.6, 27.1, 27.1, 27.1, 27.3, 27.6, 27.6, 27.6, 27.7, 27.8. Though these cavities varied greatly in size, the figures are seen to be very close—within a degree—the gas bubble in the first one noted being proportionately of unusually large size. Several instances of this kind observed incline me to suspect that the wide divergence in the results obtained from cavities in the same slice of rock or mineral, reported by other observers, may have been due, in some cases at least, to the coarse and inexact methods and apparatus hitherto in use.