usually 15 to 20 μm thick), and the microprobe must operate at the extreme limits of its capability, it seems likely that the microprobe is examining the host environment along with the inclusion.

Gentry (*4*) reported an anomalously high $^{206}Po/^{207}Pb$ ratio for one inclusion. This anomalous value may be understood in a number of ways. It can be interpreted as reflecting a supporting $^{238}U/^{235}U$ ratio higher than the usual value by a factor of 3 or more. (In addition, this would explain the reduced evidence of slow neutron fission tracks since ^{235}U would be underabundant.) While it is well known that this ratio is extremely constant over a variety of rocks, all such determinations apply to macroscopic averages (*15*). No determination of the constancy of this ratio over regions of microscopic dimensions has ever been made. The nearest such measurements are for regions more than nine orders of magnitude larger in volume. There is no reason to believe that on a scale of a few micrometers this ratio should be constant. The fact that two different samples of the same age yielded $^{206}Pb/^{207}Pb$ ratios differing by a factor of 3 can be interpreted as indicating that the supporting $^{238}U/^{235}U$ ratio does vary on a microscopic level. It is also apparent that if the microprobe is "seeing" the host as well as the inclusion, then the lead results are misleading.

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Water Content in Convective Storm Clouds

Abstract. *The condensed water content of convective storms was measured by the use of a penetrating aircraft. Regions 1 to 2 kilometers in extent and having condensed water contents of about 20 grams per cubic meter were found to be definite features of the cloud interior.*

Measurements of the condensed water content of severe convective storm clouds were carried out during the summer of 1972 as a part of the operations of the National Hail Research Experiment. These measurements were obtained by the use of an armored aircraft operated by the South Dakota School of Mines and Technology.

The aircraft was a T-28 with the leading edges armored by the addition of heat-treated aluminum 0.090 inch thick. This thickness was found to be sufficient to withstand impacts by balls of ice 7.5 cm in diameter fired into the surfaces at aircraft velocities. The canopy was replaced with flat plates of stretched acrylic 0.60 to 0.75 inch thick reinforced by a metal frame. Since the impact of hailstones would rupture the usual deicing boots, none were installed on the aircraft. The only deicing equipment installed consisted of an alcohol slinger for the propeller and an alcohol injection system for the carburetor.

The aircraft was directed to the storm and given a penetration vector by the use of a meteorological radar and a track radar on the ground. The aircraft would normally penetrate the storm at an altitude of 24,000 feet above mean sea level, fly a straight path through it, decrease its altitude by 2000 feet, and return through the storm. The penetrations were continued at altitude decrements of 2000 feet down to 16,000 feet. In some cases the penetrations at higher altitudes were dispensed with, and the penetrations started lower in the cloud. In northeast Colorado, the penetrations would roughly correspond to exterior cloud temperatures of $-22°C$ at 24,000 feet and $-1°C$ at 16,000 feet. The cloud base varied from day to day, but was approximately at 5°C and 11,000 feet. The surface elevation was 5300 feet above mean sea level.

The condensed water was measured by the use of an electrically heated evaporator mounted below and forward of the wing tip. The evaporation took place in a tube 22 cm long; lined with low-mass heating elements on the inside surface. The inner diameter of the tube was 1.8 cm, but the entrance diameter was 0.8 cm. The limitation to the latter size was dictated by power availability. Six screens, having a 1.4-mm mesh, were spaced along the length of the tube. The water drops that passed through the entrance tube struck the screens and broke up into smaller drops, which were quickly evaporated. A similar instrument has been describd by Ruskin (*1*), who found that individual drops were evaporated in 0.1 second. A thermistor at the exit of the evaporator was used in a control circuit to maintain a constant output air temperature of 90°C. The output temperature and the power supplied to the heating element were recorded on a digital tape recorder each 0.63 second along with the other required parameters of cloud temperature, airspeed, and pressure. The response time of the evaporator was limited to 3 seconds by the temperature control circuit. Feature *A* in Fig. 1 is approximately 10 seconds wide at the base, and thus illustrates that the response time is very near the 3-second limitation of the temperature control circuit.

The condensed water content was determined from the power required to supply the heat of vaporization for the water; this is the power over and above that required to heat the incoming air. This approach is practicable because water has a large heat of vaporization. Let l be the heat of vaporization of water; c_p and c'_p the specific heats of air and water vapor, respectively; and ρ the air density. If the air undergoes a temperature change ΔT in passing through the evaporator, which has an inlet area A, when the aircraft velocity is v and the power supplied is P, then the liquid water content per unit volume, L, is

$$L = \frac{P - \rho c_p \Delta T v A k}{v A (l + c'_p \Delta T)}$$

The parameter k takes into account the collection efficiency of the evaporator for air, which was determined to be 90 to 95 percent. At the typical aircraft velocity of 100 m/sec this gives an effective sampling volume of about 4.7 liter/sec. The collection efficiency for drops was assumed to be unity. The temperature at which the vaporization of the water occurred was somewhere between the input and output temperatures. The latent heat required to evaporate the water and then heat the vapor to the exit temperature, or to heat the liquid to the exit temperature and then supply the latent heat, requires about the same amount of power with very little dependence on the actual temperature of vaporization. This is because the variation of latent heat with temperature is compensated by the difference in the specific heats of the liquid and the vapor.

If the incoming water had been frozen, the value of l should have been about 15 percent larger. The water was assumed to be liquid, but it is known that some ice was included. Ice would not wet the inner surfaces of the evaporator and evaporate with any speed. Actually, the evaporation of the ice was so slow that the screens became clogged and obstructed the airflow on many occasions. It should be emphasized that this results in values of L that are too small rather than too large. The actual output of the instrument was indicative in particular cases that most of the water was in the liquid state. On the other hand, there were cases when the instrument output indicated the presence of considerable ice. If the water passed through the evaporator without being evaporated completely, then a smaller than actual condensed water content was indicated.

On 9 June there were two penetrations of a storm which had features characteristic of storms observed on several other days during the summer. Figure 1 is a plot of the condensed water content and of the rate of climb of the aircraft against time. The aircraft velocity varied somewhat during the penetrations, but may be taken to be 100 m/sec. The penetrations were carried out with constant power and attitude settings, and so the rate of climb was within approximately 10 percent of the vertical velocity of the air in the cloud. Measurements of the rate of climb for values between -2 and $+2$ m/sec were in error because the instrument stuck at a reading of -2 m/sec for values in that range.

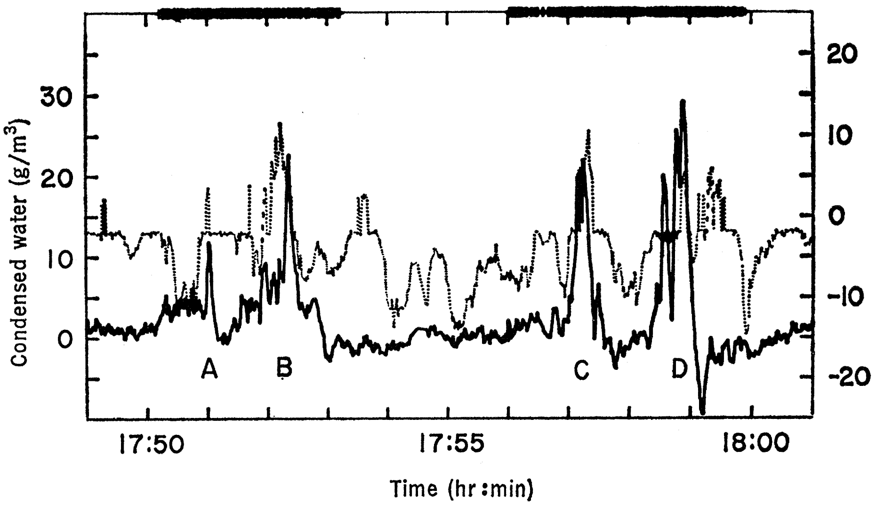

Fig. 1. The condensed water values are represented by the solid line, the rate of climb by the dotted line. The darkened areas at the top represent time in the cloud. For explanation of A, B, C, and D, see text.

The first penetration was at 18,000 feet above mean sea level and in a northwest direction (see Fig. 2). After this, the aircraft descended to 16,000 feet and went through the storm again, in the opposite direction. During this time, the radar reflectivities at a wavelength of 10 cm at the penetration altitudes were approximately 45 dbZ (2).

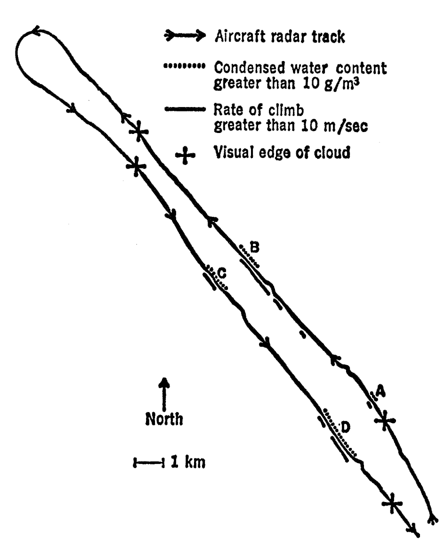

Fig. 2. Radar track of the position of the penetrating aircraft. Positions A, B, C, and D correspond to the measurements marked by the same letters in Fig. 1.

The darkened areas at the top of Fig. 1 indicate the times when the aircraft was in the cloud. Immediately on entering the cloud, the aircraft measured condensed water contents of 3 to 4 g/m^3; a downdraft of roughly 10 m/sec was also observed. At point A in Fig. 1 a narrow region of water content as high as 12 g/m^3 was observed. A second region of high water content, with a peak value of 23 g/m^3, was measured at B. The second region was located on the edge of an updraft of 10 m/sec.

After leaving the cloud, the aircraft descended to 16,000 feet. This descent was made between 17:54 and 17:56, where the rate of climb shows negative dips. These negative rates of climb were due to aircraft maneuvers rather than to downdrafts.

During the return pass through the cloud, the updraft feature previously encountered at B was encountered again at C. The high water content was still located on the same edge of the updraft, but it appears to be 1.3 km wide (0.5 km wider than on the first pass) at the 10 g/m^3 points, while the updraft had about the same vertical velocity as on the first pass. The instrument provided no information about the size distribution of the water, but the radar reflectivities indicate that the drops cannot be very large. Even if the water was all in the form of drops 5 mm in diameter, the feature at *C* would correspond to about 20 drops. At *D*, a position in the cloud corresponding to the location of *A* on the first penetration, there was a wider, structured region of high water content, with values as great as 28 g/m^3. The structure at *D* is an indication that the large value for the condensed water content did not result from an overshoot in the reading of the instrument, but since it is possible that there was some overshoot we prefer to say only that the water content was at least 20 g/m^3. How closely *A* and *D* corresponded, relative to the cloud, is difficult to determine because of inaccuracies in our knowledge of the aircraft track and the cloud motion. Just after *D* the indicated water content was negative. We believe that this was due to ice particles blocking the flow of air inside the evaporator. There are smaller indications of this effect after each of the regions of high water content. This is in accord with the observation of the pilot (W.R.S.) that many of the drops appeared to be mushy. It should be noted that the regions of high water content corresponded almost exactly with the pilot's reports of rapid icing; one such report referred to an accumulation of 1.3 cm of ice during a 30-second period.

A narrow region with a high condensed water content located on the edge of an updraft was observed on several occasions, and is thought to be a recurring feature in severe convective storms in northeast Colorado. The observation of narrow regions of high condensed water content not located near an updraft is more difficult to explain, but there could have been an updraft nearby, which the aircraft just missed. There is an indication of some updraft activity at times near 17:59, but this explanation requires the existence of two updrafts in the storm. The regions of high water content must have a considerable vertical extent, since they were still observed several minutes later. [Dennis *et al.* (*3*) describe areas of high reflectivity descending through the cloud at about 10 m/sec.] In addition, they must have a larger horizontal extent perpendicular to the direction of penetration than along the aircraft track; otherwise, the chance of encountering them the second time, or even the first time, would be very small.

It is not clear how these observations relate to accumulation zones as visualized by Sulakvelidze (*4*). These zones would be expected at higher altitudes, and in some cases they appear to exist partly outside the updraft. It is possible that the accumulation zone is at a higher altitude and spills a shaft of water down the edge of the updraft, but there are problems connected with this description. However, the observations do show that there are regions of very high water content in the cloud, and these can occur in clouds that do not have very high radar reflectivities (*5*). We may have failed to observe high reflectivities because the horizontal extent of the region of high water content was too small for the radar resolution. Our observations are consistent with a report of hail occurring near the edge of an updraft at the base of a cloud (*6*).

It remains to compare the observed structure with the radar reflectivity. The small horizontal extent of the regions of high water content parallel to the direction of penetration will prevent a direct comparison of the reflectivity and the water content, but the relation of these regions to the general structure of the storm will be instructive.

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Ionic Conductivity of Yttrium Fluoride and Lutetium Fluoride

Abstract. *At the transitions from the low-temperature orthorhombic forms of lutetium fluoride and yttrium fluoride to the high-temperature hexagonal forms, there are increases of several orders of magnitude in the ionic conductivities. In the high-temperature phases the conductivities are comparable to those of typical ionic melts. These fluoride compounds are therefore solid electrolytes.*

It has been known for a number of years that some solids have anomalously high ionic conductivities. A number of salts of Ag are particularly well known and well studied in this respect (*1*). In these salts the ionic conductivities are comparable to those of ionic melts, that is, of the order of 10^2 ohm^{-1} m^{-1} (*2*), and the diffusion coefficients of the conducting ions are in the range normally found in liquids (1×10^{-9} to 10×10^{-9} m^2 sec^{-1}). Such salts are conveniently called solid electrolytes. By way of contrast, the ionic conductives of "normal" salts just below the melting point (*3*) (for example, the alkali halides) are smaller by a factor of 10^2 to 10^5 than those of the melts.

Often, as in AgI (*1*), there is a transition from a low-temperature structure to the solid electrolyte phase,

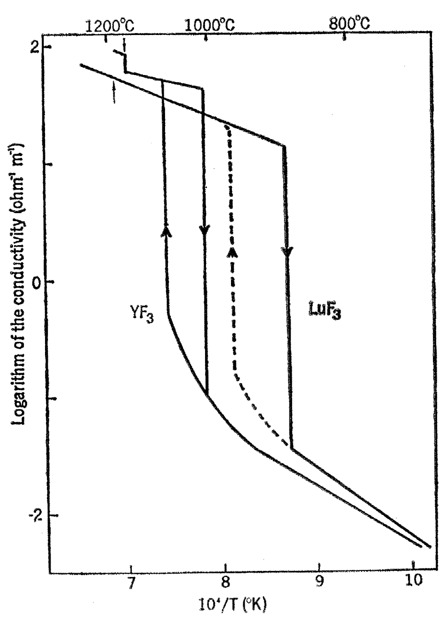

Fig. 1. The logarithms of the specific conductivities of YF_3 and LuF_3 as a function of reciprocal temperature. The arrows indicate the melting points of the two salts.