IS SLEET A CONTACT NUCLEATION PHENOMENON?

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"if it doesn't rattle -- rattle on the window pane -- it isn't sleet, at least not as officially used by the U.S. Weather Bureau, and as sung by poets." (Weather Music, W.J. Humphreys, 1942).

Introduction

The rattle of sleet is indeed music, when compared to the silent destruction of freezing rain. Although the term "sleet" has deviated[1] from its once precise definition as "ice pellets...frozen during the fall of the precipitation through a cold layer of air near the surface of the earth" (Humphreys 1940), the fall of these ice pellets which are frozen before reaching the ground is indeed interesting.

Sleet generally forms when liquid precipitation (perhaps formed when initially solid hydrometeors pass through a layer of air above OC) falls through a layer of subfreezing air, This requires warm air in the lower troposphere to override subfreezing air at the surface, while precipitation is occurring. The precipitation must freeze while passing through this colder layer, and reach the ground in a frozen state. Most frequently, in this observer's experience, the "warm" layer is not sufficiently thick to melt all the precipitation falling through it or the cold surface layer is insufficiently cold or deep to refreeze all the melted drops. This results in a mixture of two or more forms of precipitation (snow, sleet, freezing rain, rain) in most observations. This usually mixed form of frozen and supercooled precipitation makes it rather difficult to study the nature of sleet, and determine what processes may cause it to form, and displace the potentially more hazardous freezing rain.

Results of Experiments

Precipitation was routinely collected, in a wind sheltered basin near Glen, NY (42N, 74W, elevation 230 M above sea level) during the years 1980 - 82. A variety of collection and analysis techniques were employed, and frozen precipitation was replicated by the Schaefer (1941) formvar technique. This replication technique can be successfully applied to many forms of frozen precipitation but a modified technique (Schaefer 1962) must be used to replicate liquid precipitation. The presence of liquid water on frozen precipitation will give a milky appearance, sometimes called "frosting," to the replica. Experiments conduc-

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[1]The term "sleet" was considered abandoned during the 1950's, (Brooks 1957) but continue in frequent use in meteorological communications. Observer's Handbook of the British Meteorological Office states: "The term 'sleet' is commonly used in the United Kingdom to describe precipitation of snow and rain (or drizzle) together, or of snow melting as it falls, but it has no agreed international meaning." The former USWB definition of sleet, as given by Humphreys is used here interchangeable with the term "ice pellets" to describe quasi-spherical frozen precipitation which rattles against the windows.

ted during this period showed small frozen droplets, of 1 mm diameter or smaller could be collected and replicated by the Schaefer (1941) technique, but 2 mm or larger sleet pellets would bounce off the slide and would not be captured in the formvar film. Examination of sleet replicas collected in December 1981 showed the formvar technique faithfully replicated the spicules of Bally (1935) and Dorsey (1938), with similar appearance to those produced experimentally by Blanchard (1951) while freezing suspended supercooled droplets. Identification of frozen drops (sleet), supercooled drops which froze upon contact, but after wetting the slide, and water drops which pockmarked the formvar and/or turned it opaque was relatively certain upon microscopic examination.

Light snow and graupel fell at the site beginning 1145 EST 30 January 1982. Sleet and ice pellets were observed at 1600 EST, and light drizzle and occasional rain occurred through the evening. A light fall of ice pellets, graupel and rimed stellars was observed at 1000 EST 31 January with a surface temperature of -1C. At 1045, wind from NE increased in speed and surface temperature began to decrease. At 1220 EST there was a loud rattle of sleet that continued through 2245 EST. The sleet eroded existing snow cover on exposed surfaces, and the accumulated sleet flowed when shoveled or plowed. A snow coring at the end of the storm found 10 cm of accumulated sleet, on level ground.

A chronology of surface observations is given in Table 1. It is noted that "diamond dust" was observed concurrent with sleet at 1925 EST, when a floodlight was turned on. Examinations of replicas taken through the day show that small ice crystals were frequently present simultaneously with the sleet.

A composite of several microphotographs of the replicas obtained is shown in Figure I. Hexagonal and triangular plates and columnar ice crystals, or thick plates are visible in several of these frames. In several cases an hexagonal form is attached to a sleet drop, or appears to be part of the aggregate.

Discussion

Blanchard (1957) experimented with supercooled water drops suspended on a rising air stream. He found he could suspend supercooled drops for several minutes on calm or snowless days, in his outdoor laboratory. When it was snowing, or when fallen snow was blowing about, he could only suspend the drops for a few seconds before they froze. Blanchard observed that when freezing occurred, it always began on the outside, bottom (windward side) of the drops, and hypothesized that suspended ice crystals might nucleate the drops by contact.

Conclusion

Observations from a single storm are offerred here, which show sleet accompanied by small ice crystals, and hexagonal forms included in aggregates of sleet drops. The rarity of prolonged sleet, not accompanied by rain makes collection of supporting data difficult. This sparcity of observations does not support a unique conclusion, but does support the Blanchard (1957) hypothesis that ice crystals, acting as contact nuclei, can initiate the freezing of supercooled drops. This may be responsible, in nature, for the conversion of destructive freezing rain, to the musical rattle of sleet.

Acknowledgement

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Table 1
Meteorological Observations 31 Jan 1982 - Near Glen, N.Y.

Time-EST.	Temperature	Wind	Barometer	Precipitation and Remarks
0015	+1.0C	Calm	29.98"Hg	Few snow grains
				No new snow or crust formation overnight
1000	-2.0C	Calm	30.18"	Light precipitation as ice pellets
1045	-2.0C	NE - 5KT	30.18"	Precipitation in form of graupel, rime stellars, stellars
1145	-3.0C	ENE-5KT	30.18"	Large clumped ice crystals 1 cm accumulated
1200	-4.2C	ENE-7-12KT	30.18"	Wind increasing - visibility less than 2 km
1220				Rattle of sleet
1245	-5.0C	ENE - 12KT		Large and clumped ice crystals mixed with sleet
1345	-6.0C	ENE-12KT	30.16"	Brighter-visibility 7 km-mixed precipitation of large sleet, small drops, columnar crystals
1500	-7.2C	E - 12KT	30.09"	Sleet, frequent changes in intensity
1550	-7.5C	E - 12KT	30.08"	Heavy sleet - visibility 1 km
1655	-7.5C	E - 12KT	30.05"	Light sleet - perhaps snow - visibility 5 km - 4 cm accumulated
1810	-7.5C	E - 12KT	30.02"	Intense fall of large sleet
1855	-7.5C		30.01"	Intense sleet
1925	-7.0C	E - 12-17KT	30.01"	Intense sleet falling nearly vertically, "diamond dust" falling nearly horizontally
2000	-5.0C	E - 12-17KT	29.96"	Heavy sleet accumulating while eroding snow
2100	-3.5C		29.90"	Intense sleet, 15 cm sleet piled around rain gauge
2200-2245	-1.5C	E - 12-17KT	28.84"	Core sleet at several spots as rain begins, 10 cm average
				4.3 cm water precipitated as sleet
2330	-1.0C	E - 17KT	29.77	Rain, snow mixed precipitation, some glazing

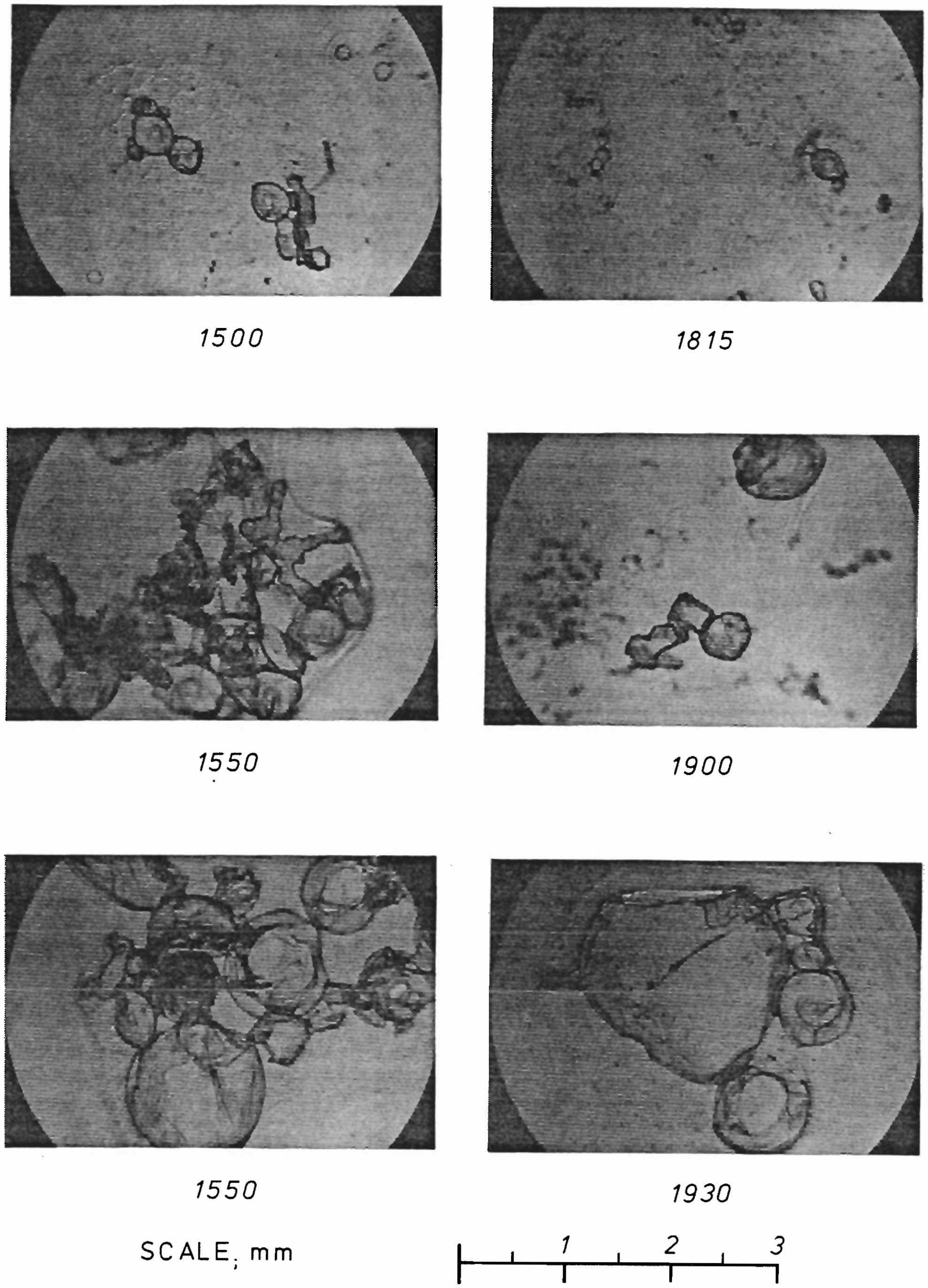

Figure I. Microphotographs of frozen hydrometeors replicated on 31 January 1982. Each frame is identified by the Eastern Standard (75th meridian) Time of replication. Beginning with the upper left frame, the photos show in chronological order: a) upper left-combination of .5mm ice pellets with a hexagonal ice crystal in contact with one aggregate, and three additional hex plate crystals; b) center left-an aggregate of .5 to 1mm ice pellets about the remnant of a 2mm stellar ice crystal remnant; c) lower left-an aggregate of .5 to 1.5mm pellets, in contact with a .5mm hex plate crystal at 4 o'clock; d) upper right-an aggregate of several .1mm ice crystals and a .5mm ice pellet in contact with what appears to be a thick plate or column; 3) center right-a .5mm ice pellet aggregated with a slightly smaller columnar crystal; f) a 2mm ice pellet, which has ejected a spicule, aggregated with smaller ice pellets and a .3mm hexagonal plate. The aggregation shown here supports the idea that collisions among frozen hydrometeors and liquid drops initiate contact nucleation and the chaining of the ultimate sleet particles.

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