AD NUMBER: AD0144827

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to US Government Agencies and their Contractors; Administrative/Operational Use; 13 May 1957; Other requests shall be referred to US Naval Radiological Defense Laboratory, San Francisco, CA 94124.

AUTHORITY

USNRDL ltr dtd 18 Mar 1969

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
SAN FRANCISCO 24, CALIFORNIA

120
DCC:mle

OCT 1 1957

From: Commanding Officer and Director
To: Department of Defense Agencies on Distribution List for Report

Subj: U.S. Naval Radiological Defense Laboratory Report USNRDL-TR-168; forwarding of

Encl: (1) U.S. Naval Radiological Defense Laboratory Report USNRDL-TR-168 entitled "A Method for Measuring Water Content of Airborne Sea-Salt Particles"

1. Fallout particles produced by nuclear explosions in certain environments are strikingly similar to naturally occurring atmospheric sea-salt particles. Analysis of such fallout materials required a submicrotechnique for measuring water content of individual particles created by either nuclear processes or natural evolution.

2. Enclosure (1) presents a calibrated technique for the measurement of the volume of water contained in naturally occurring slurry-like sea-salt particles in the atmosphere. The measurement has on the average a standard deviation error from the mean of ± 25 per cent. The method employs a quantitative chloride reagent film on which the solids in the slurry particle leave a visible trace. The area covered by this artifact is a function of the particle water content. A curve is shown presenting the relationship of slurry artifact diameter to water content.

Paul C Tompkins

PAUL C. TOMPKINS
By direction

UNCLASSIFIED

A METHOD FOR MEASURING WATER CONTENT OF AIRBORNE SEA-SALT PARTICLES

Research and Development Technical Report USNRDL-TR-168
NS 081-001

13 May 1957

by

N. H. Farlow

Chemistry

Technical Objective
AW-7

Radiological Capabilities Branch
T. Triffet, Head

Chemical Technology Division
E. R. Tompkins, Head

Scientific Director
P. C. Tompkins

Commanding Officer and Director
Captain Floyd B. Scholtz, USN

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

UNCLASSIFIED

ABSTRACT

A calibrated technique is presented which measures the volume of water contained in naturally occurring slurry-like sea-salt particles in the atmosphere. The measurement has on the average a standard deviation error from the mean of ±25 percent. The method employs a quantitative chloride reagent film on which the solids in the slurry particle leave a visible trace. The area covered by this artifact is a function of the particle water content. A curve is shown presenting the relationship of slurry artifact diameter to water content.

SUMMARY

The Problem

Fallout particles produced by nuclear explosions in certain environments are strikingly similar to naturally occurring atmospheric sea-salt particles. Analysis of such fallout materials required a submicrotechnique for measuring water content of individual particles created by either nuclear processes or natural evolution.

The Findings

A technique was devised to measure water volumes associated with solid particles in a single droplet. As little as 1×10^{-10} cc of water can be measured with an average standard deviation of $\pm$ 25 percent. The technique is equally applicable to slurry particles of natural or artificial origin.

ADMINISTRATIVE INFORMATION

The work reported was done under Bureau of Ships Project No. NS 081-001, Technical Objective AW-7, during Fiscal Year 1957 and is described as Program 1, Problem 3, in this Laboratory's "Preliminary Presentation of USNRDL Technical Program" dated February 1956.

Acknowledgment

Appreciation is expressed to Mr. J. Todd of this laboratory for editorial guidance in the preparation of this report.

INTRODUCTION

Airborne sea-salt particles grow in size by the absorption of water from the atmosphere. The effect of this growth on the formation of rain and fog has been the subject of many investigations. Kohler[1] and Koenuma[2] use a mathematical approach in defining the water content of hygroscopic particles. Twomey[3, 4, 5] and Woodcock[6-9] use experimental methods whereby salt particle collections are treated in high humidity atmospheres. The particle size is reported relative to this humidity standard. Lodge,[10] however, using special chloride-measuring methods reports particle size of airborne sea-salts in terms of dry sodium chloride particles having equivalent chloride content. The size of hygroscopic particles in their natural environment is deducible only by calculation and approximation in these methods. The method to be described allows a direct water content measurement of airborne sea-salt slurry particles at the time of their collection.

PRINCIPLE OF THE METHOD

The technique utilizes a quantitative chloride reagent film [11] developed previously by the author. Salt water droplets impinging on this film spread over a definite area related to the quantity of water present.[12] Droplets which contain suspended solids leave a trace equivalent in area to the droplet spread. This trace has been termed the slurry artifact.[13] The diameter or area of this trace is calibrated as the measure of the water content in the slurry droplet. Droplets striking the film surface perpendicularly have circular artifacts; large droplets impinging on the film at a glancing angle leave elliptical traces.

When a portion of sea water evaporates to approximately one-fifth its original volume, gypsum begins to precipitate[14] and slurry of solid and water is formed. Evans,[15] using the film technique, has observed

that airborne particles collected in the Marshall Islands at humidities above 75 percent are all slurry-like and leave sharply resolved artifacts (Fig. 1). A similar observation has been made in San Francisco during periods of high humidity. Because of the artifact-producing properties of naturally occurring atmospheric sea-salt slurry particles, their water content may be measured with the calibrated reagent film.

CALIBRATION

The approach for relating the area of the slurry artifact to droplet water content is a simple one. Quantitative chloride reagent film is used as a collecting device for slurry droplets aspirated[12] from a suspension which contains a measured quantity of levigated aluminum oxide. A definite quantity of sodium chloride is added to the suspension to trace the water volume of the slurry droplet. Each small droplet aspirated from the master suspension then has a proportional amount of solids, sodium chloride, and water. The droplets landing on the film form typical slurry artifacts which are measured with a microscope fitted with a micrometer eyepiece. The soluble chloride diffuses and reacts in the reagent film. Measuring the droplet chloride content in this film gives the quantity of water in the slurry particle. This independent measure of each droplet water content can be plotted versus the area of its slurry artifact.

Levigated aluminum oxide was selected because of its inert qualities and small particle size. Suspensions containing variable quantities of this solid were aspirated and the slurry droplets collected on the film. Observations were made to detect any variation in artifact area versus water content due to increasing solids content. The volume percent of these solids was varied from 3 to 23 percent without affecting this relationship.

Variation of sodium chloride content up to saturation had no effect on the calibration.

Treatment of the reagent films both in high and low humidity chambers just before impingement of the slurry droplets did not influence the size of the artifact produced.

Each slurry artifact and the volume of water as deduced by chloride content were measured on 610 particles. These particles represented

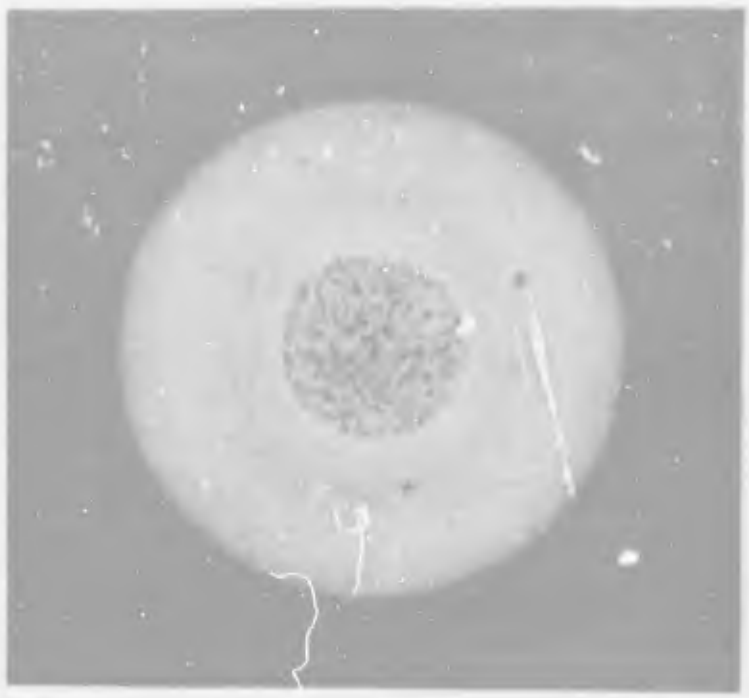

Fig. 1 Sea-salt Slurry Droplet Reaction on Reagent Film. The white circular area (258 u) is a halide reaction representing 2.7×10^{-8} g NaCl; the central granular area (92 u) is a slurry artifact representing 7.8×10^{-8} cc water.

a slurry droplet size range from 6 to 115 μ. Circular artifacts required only a diameter measurement while elliptical ones required measurement of major and minor axes. These measurements then were converted to the diameter of an equivalent-area circle. Measurements were tabulated in order of increasing diameter, then grouped and averaged at regular intervals. These mean artifact diameter-water content values were then plotted (Fig. 2). For a water volume greater than 1×10^{-8} cc a straight line on log-log paper fits the data. The empirical equation for this portion is $y=11.1 \times 0.433$, where y is artifact diameter in centimeters and x is water volume in cubic centimeters. For values less than the limiting volume, a smooth curve is drawn through the points; no empirical equation has been fitted.

LIMITATIONS

Sea-salt particles which are in a low humidity environment and therefore have little water associated with them will not produce a measurable artifact. The chloride content is still quantitatively assessed by the reagent film. Particles which are in a very high humidity environment will perhaps grow to the point where all solids will redissolve. However, collections made at San Francisco during a rainstorm revealed no chloride reaction areas which did not contain a visible slurry artifact.

Each water volume value derived from the calibration curve (Fig. 2) by measurement of artifact area has on the average a standard deviation error from the mean of ± 25 percent. This error represents the cumulation of errors inherent in the method together with operator-microscope measurement biases and errors peculiar to the reagent film technique.

APPLICATIONS

Radioactive fallout from nuclear detonations fired in certain environments is composed of slurry particles similar in properties[13] to naturally

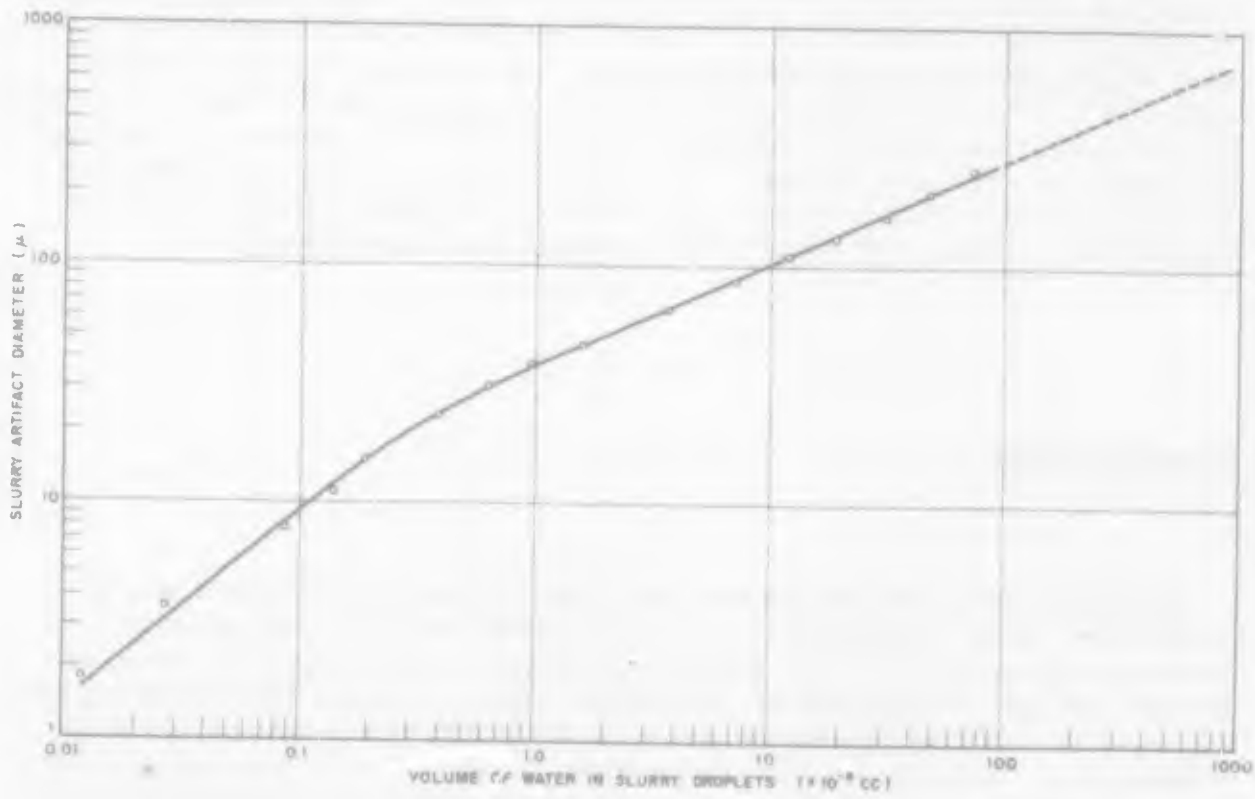

Fig. 2 Chloride Reagent Film Calibration Curve to Determine Water Content of Sea Salt Slurry Particles

occurring atmospheric sea salts. The measurement of water and chloride content of these slurry masses has been successfully accomplished with the above described film technique.

This laboratory is completing a study[15] of atmospheric sea-salt particles occurring up to 300 ft in the Marshall Islands using the reagent film method.

Approved by:

E. R. Tompkins

E.R. TOMPKINS
Head, Chemical Technology Division

For the Scientific Director

REFERENCES

1. Kohler, H. The Nucleus in and the Growth of Hygroscopic Droplets. Trans. Faraday Society. 32: 1152-1161 (1936).

2. Koenuma, K. On the Stability and Variation of Fog Particles. Geophysical Magazine. 373-377 (1951).

3. Twomey, S. Identification of Individual Particles in the Atmosphere by a Phase-transition Method. J. Applied Phys. 24: 1099-1102 (1953).

4. Twomey, S. The Composition of Hygroscopic Particles in the Atmosphere. J. Meteor. 11: 334-338 (1954a).

5. Twomey, S. The Distribution of Sea Salt Nuclei in Air over Land. J. Meteor. 12: 81-86 (1954b).

6. Woodcock, A.H., and Gifford, M.M. Sampling Atmospheric Sea Salt. J. Marine Res. 8: 177-197 (1949).

7. Woodcock, A.H. Sea Salt in a Tropical Storm. J. Meteor. 7: 397-401 (1950).

8. Woodcock, A.H. Atmospheric Salt Particles and Raindrops. J. Meteor. 9: 200-212 (1952).

9. Woodcock, A.H. Salt Nuclei in Marine Air as a Function of Altitude and Wind Force. J. Meteor. 10: 362-371 (1953).

10. Lodge, J.P. A Study of Sea Salt Particles over Puerto Rico. J. Meteor. 12: 493-499 (1954).

11. Farlow, N.H. Quantitative Analysis of Chloride Ion in 10^{-6} to 10^{-12} Gram Particles. Anal. Chem. (29: 883-885) (1957).

12. Farlow, N.H. An Improved Halide Ion-sensitive Sampling Surface for Water Aerosols. Rev. Sci. Instr. 25: 11, 1109-1111 (1954).

13. Farlow, N.H., and Schell, W.R. Physical, Chemical, and Radiological Properties of Slurry Fallout Collected During Operation REDWING. U.S. Naval Radiological Defense Laboratory Technical Report USNRDL-TR-170, 5 May 1957.

14. Thompson, T.G., and Robinson, R.T. Chemistry of the Ocean. Nat'l. Res. Council Bull, No. 85, p. 188 (1932).

15. Evans, E.C., III. Salt Concentration in the Air at Bikini Atoll, U.S. Naval Radiological Defense Laboratory Technical Report USNRDL-TR-166, 15 May 1957.