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Sonic Detection of a Fresh Water–Salt Water Interface

A sound wave transmitted from one medium to another of different physical characteristics will be partially reflected, depending on the properties of the two media and upon the thickness of the mixing volume between them. The strength of the reflection at a plane boundary layer depends on the difference in density, the difference in sound velocity, and the thickness of the mixing layer. Usually the temperature and salinity gradients in the open ocean are not sufficiently abrupt to produce an echo of detectable amplitude with conventional sonar of long pulse duration.

The depth of the Charles River basin is controlled by a lock which connects the basin to Boston Harbor. When the tide is high, the lock introduces a considerable quantity of salt water with each operation. The cold salt water apparently flows under the fresh water and, under drought conditions, may attain a considerable depth.

It has been found that the layer between salt and fresh water can be seen in some areas of the Charles River basin by a 12-kc sonar (*1*) of 0.1-msec pulse duration and recorded on an Alden chart. For example, the sonar records (Fig. 1) show a faint salt-fresh water interface at the start in the main basin. At this time, the depth of the interface from the surface is about 3.3 m in the main basin of the river. The boat entered the sailing lagoon at the east end of the basin (*A*) where the underwater dykes between the islands form a closed lagoon. The salt layer is 2.4 m down inside this lagoon and extends to the end of the lagoon at the dyke on the north side.

Notice should be taken of the irregular shape and the variable intensity of the interface sonar record. Perhaps there are intermittent clumps of material, with echo-producing properties, floating at the interface. Perhaps there is intermittent mixing of the fresh and salt water, with a thick gradual gradient between.

The short-pulse sonar system appears to be a useful method of finding fresh-salt water interfaces in rivers and in offshore aquifers. For example, a sonar presenfation of the sewer outlet near Deer Island light in Boston Harbor shows where warm fresh water pours into cold salt water. A column of fresh water can be seen rising to the surface and drifting away with the tide.

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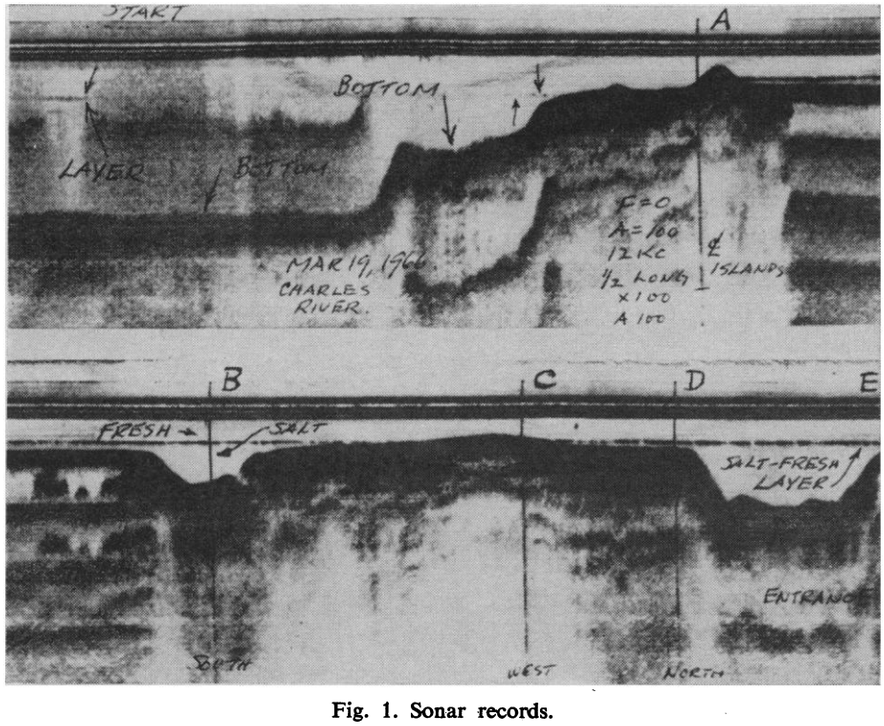

Fig. 1. Sonar records.

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3 August 1966

Ice Nuclei from Automobile Exhaust and Iodine Vapor

Abstract. *When exposed to a trace of iodine vapor, the submicroscopic particles of lead exhausted by automobiles produce nuclei for the formation of ice crystals. Concentrations of particles exceeding 10^6 per liter can be directly sampled from the exhaust pipe of an idling motor. Concentrations of from 10^4 to 10^5 per liter have been found in rural air downwind of auto roads; the concentration at one rural site has increased by an order of magnitude in 13 years. The phenomenon may provide a method of modifying clouds, and of determining (and monitoring) the percentage of automobile exhaust in a polluted atmosphere. It may be an important factor in inadvertent modification by man of the climate.*

A newly discovered phenomenon produces concentrations of ice-crystal nuclei (see cover) as high as 10^6/liter in the free atmosphere where automobiles have been operating. The phenomenon may provide an important new technique for extensive overseeding in supercooled clouds; it may also present a highly sensitive and simple method for detecting submicroscopic particles of lead in auto exhaust, and thus provide a practical technique for establishing an auto-exhaust index in polluted air. It may also elucidate in an unexpected way the manner in which man is inadvertently modifying atmospheric clouds over extensive areas of the United States.

In the simplest terms, the phenomenon depends on the formation of less

than a monomolecular layer of iodine on the surface of submicroscopic particles of lead oxide emitted profusely in auto exhaust as a result of the nearly universal use of tetraethyllead in gasolines to prevent knocking.

In a typical experiment, a 5-second collection (about 80 liters) of exhaust from an idling automobile engine produces more than 10^8 ice crystals in air saturated with water at −15°C. The sample is caught in a plastic bag placed over the exhaust pipe and then expelled into a 100-liter chamber having an air temperature of −20°C. Moisture from combustion of the gasoline produces a supercooled cloud and warms the air to −15°C. When this exhaust cloud alone is in the chamber, the ice nuclei observed amount to less than one crystal per liter. About 0.1 liter of air from a bottle containing crystals of iodine, having a temperature of 25°C, is then introduced into the chamber. Within less than 10 seconds the supercooled cloud disappears and is replaced by an ice-crystal cloud containing more than 10^8 crystals—a concentration of 10^6 ice nuclei per liter at −15°C.

Measurement of the concentrations of Aitken and cloud nuclei in the 80-liter sample of auto exhaust 5 minutes after cloud formation showed concentrations of 10^9 and 5×10^7 per liter, respectively. Thus there appear to be about 50 times more cloud nuclei, and 1000 times more nuclei of all sizes, in the sample of exhaust than those available for ice-crystal formation.

In a residential area of Fresno, Calif., on 24 October 1966, under conditions of light pollution, a cold chamber operating at −20°C showed less than one crystal per liter when a supercooled cloud was formed. Ten seconds after the cap was removed from a bottle of iodine crystals held in the chamber, more than 10^7 crystals per liter appeared.

Since the iodine reaction occurs within a few seconds in the presence of a supercooled cloud, it is obvious that the particles that react with the iodine are not cloud nuclei, since the latter would be immersed or dissolved in the cloud droplets. The ice nuclei thus activated must act to form ice crystals by water-vapor deposition.

Earlier (*1*) I showed the effect of liquid water on silver and lead iodide, and the manner in which such particles behave when exposed to varying degrees of water equilibrium and supersaturation. As with silver iodide, there is variation in crystal form, temperature threshold of activity, and number of particles in the aerosol that are active at various temperatures.

Thus the sample of auto exhaust that I have just described, which after 5 minutes showed a concentration of 10^9 Aitken nuclei per liter (all being invisible and thus less than 0.1 micron in diameter), and which showed less than one ice crystal per liter before iodine vapor was introduced, showed concentrations of ice nuclei approximating 10^2, 10^4, 10^6, and 5×10^6 per liter at −3°, −7°, −15°, and −20°C, respectively. These are conservative values, since ice crystals continue to appear for many minutes after the first appear and fall out.

It is interesting that the concentration of naturally occurring ice nuclei in the free atmosphere at −20°C ranges from less than 10^{-2} to 10^1 per liter in most parts of the world where measurements have been made. Occasionally the values reach or exceed 10^2 per liter, but such unusual instances can often be related to volcanic activity, massive dust storms, or similar phenomena.

It is likely that only a few thousand iodine molecules serve to form an effective patch of lead iodide on the surface of a particle of lead oxide. In fact, the formation is probably most effective when only small molecular patches occur, since it is likely that their edges are the most effective nuclei for formation of ice crystals.

The reaction of free iodine with microscopic particles of silver oxide was first developed by Vonnegut (*2*) as a method of generating large numbers of particles of silver iodide for the seeding of clouds. He used electric sparks, with silver electrodes in the presence of iodine crystals, as one of a number of techniques for producing silver iodide nuclei. This reaction was subsequently cited by Schaefer (*3*) to explain a strange residual effect of production of ice-crystal nuclei in the laboratory.

During the intervening 13 years, my observations in a rural community (site of my laboratory) have shown an increase per liter from 10^4 to at least 10^5 particles of lead in the air that react with iodine vapor to form ice nuclei at −20°C. In a ponderosa pine forest, 5 km north of Flagstaff, Arizona, on 29 August 1966 I measured a concentration of 10^5 per liter at −18°C. During early November I have made 20 measurements in eastern New York, most of them in open fields 5 km northwest of Schenectady, using a portable cold chamber operated at −20°C; concentrations of ice crystals formed on nuclei exposed to iodine vapor have ranged from 5×10^5 to more than 10^6 per liter.

There has been no adequate study of the concentration of free iodine vapor in the atmosphere, but values cited by Junge (*4*) range from 0.05 to 0.5 $\mu g/m^3$ as typical background levels. More recently Duce *et al.* (*5*) reported similar values in air over the Hawaiian Islands. Iodine in the atmosphere comes from the burning of fossil fuel, as effluent from growing plants, and as residues from airborne particles of soil; sources more closely related to man are the burning of seaweeds, the processing of natural nitrates, the effluent of nuclear reactors, and the operation of silver iodide burners.

All these sources produce localized effects, but detailed aerial and ground measurements are needed in such areas to establish the degree to which molecules of iodine vapor, adsorbed on surfaces of aerosols, trees, and precipitated globules of water, can again evaporate to affect other surfaces. Four years ago I found that 10 drops of hydroiodic acid (HI), dissolved in 250 cm^3 of water and placed in the bottom of a cold chamber, produced the same ice-nucleation activation of the then-unknown metallic particles in my laboratory air as did the vapor from iodine crystals.

While I have not yet conclusively established that all the nucleation effect that I report is caused by lead residues from auto exhaust, the evidence so far strongly favors this conclusion. My experiments indicate that extremely small amounts of iodine can produce striking effects, and it is important that this subject should receive more attention.

To establish the fact that the iodine reaction was due to lead particles from the exhaust, a grounded lead wire of 0.05-cm diameter was sparked by passing it a distance of 1 cm five times across the 22.5-volt terminal of a dry battery. After the formation of a supercooled cloud at −20°C, about one ice crystal per liter was observed after 20 seconds. When iodine vapor was introduced into the cloud, more than 10^7 ice crystals per liter were observed after the same period—five

to ten times the number formed (as I have mentioned) from the auto exhaust. The type of ice crystals observed and the relation between the numbers produced by various ambient temperatures were essentially the same as the exhaust experiments had shown.

The vast amount of automobile exhaust rising throughout North America could profoundly influence supercooled cloud systems if the atmosphere also contained free iodine vapor. There is a strong possibility that Grant's (*6*) "carry over" effect can be explained by this mechanism; small amounts of free iodine released by the decomposition of silver iodide could easily activate large numbers of lead particles (from auto exhausts) drifting across the mountains where this phenomenon was observed.

The massive glaciation of cumulus clouds, occurring at relatively warm temperatures (−6° to −15°C), also may be caused by this effect. Since 1 g of iodine probably suffices to activate at least 10^{18} submicroscopic particles of lead, it is obvious that such activation may be an important procedure for making large numbers of ice nuclei available in free atmosphere containing engine exhaust.

Iodine vapor may be introduced in many ways because of the high vapor pressure of crystalline iodine and the relatively easy decomposition of many of its chemical products. Although the iodine molecule adsorbs readily on atmospheric particulates, it can also transfer easily from one compound to another, especially in the presence of sunshine.

Such a new method of seeding clouds wherever auto exhaust diffuses into the atmosphere is obviously important, but other potentially important aspects need exploration. The method might be developed, in conjunction with an ice-nucleus detector, as a technique for monitoring the auto-exhaust component of polluted air. Since the automobile engine is probably the greatest source of lead particles in most urban smog, spot or continuous monitoring could indicate its contribution to the total mass of particles and show whether control methods are effective. And experiments might use this reaction to assess the effect of these hitherto-undetectable particles on respiratory ingestion.

The conversion of the particles of lead oxide to lead iodide, which then serves as a nucleation center for formation of ice crystals, is so sensitive that it is difficult to visualize its effectiveness. With the initial particle of lead iodide having an effective diameter of 0.01 μ when introduced into a supercooled cloud, it will grow to 100 μ within 30 seconds—four orders of magnitude, like a golf ball swelling to the volume of the Empire State Building.

The importance of this tremendous rate of growth is that particles that normally remain airborne for long periods, and cannot be seen or detected chemically, can be "trapped" in the centers of visible ice crystals; thus they can be collected on slides as fallout or counted by an acoustic or light signal. By replication of the crystals (*7*), the particles subsequently can be viewed under the electron microscope.

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Puromycin and Cycloheximide: Different Effects on Hippocampal Electrical Activity

Abstract. *Mice were injected in the temporal region of the brain with cycloheximide or puromycin; both agents markedly inhibit protein synthesis in the brain. Recordings of electrical activity were made in the hippocampal region 5 hours after injection of these drugs. The amplitude and frequency observed in records from mice injected with cycloheximide were indistinguishable from those injected with saline alone. Records from puromycin-injected mice were strikingly abnormal. This finding may contribute to the differences in behavioral effects of intracerebral injections of the two inhibitors of protein synthesis studied.*

Mice injected with puromycin in the temporal region of the brain learn to escape shock normally by choosing the correct limb of a maze when trained 5 hours after injection, but they have markedly impaired retention 3 hours later (*1*). Since puromycin inhibits cerebral protein synthesis (*2, 3*) this finding is consistent with a requirement for protein synthesis for the "consolidation" of memory. To test this interpretation a similar study was made with cycloheximide in doses which inhibit cerebral protein synthesis at least as extensively as puromycin does (*2*). Cycloheximide did not have an amnesic effect in this paradigm (*2*). This suggested that the puromycin effect on memory might not be due to interference with the synthesis of protein specifically required for memory storage, but, rather, to some other action. Because of the different effects of puromycin and cycloheximide on memory we studied the effects of these drugs on the electrical activity of the hippocampal region of the mouse brain. We now report the results of this study.

Male Swiss albino mice (30 to 40 g, Charles River Breeding Co.) were anesthetized with ether. Holes were made in the skulls with a stainless steel needle, and injections were administered bilaterally in the "temporal" region at a depth of 2 mm from the surface of the skull (*1, 2*). Each injection (10 μl) contained 0.04*M* NaCl either alone or in combination with 100 μg of puromycin (*4*) or 100 μg of cycloheximide. Five hours after injection, each mouse was replaced in a stereotaxic instrument after having been lightly anesthetized with ether, and a hole was made in the skull 2 mm anterior to one of the injection sites. Electrodes were then inserted at one injection site and in the hole 2 mm anterior to it. The mouse was allowed to awaken and, after a few moments of initial activity, remained docile in the apparatus.

Recordings were made of electrical activity between the two electrodes with a Grass model III electroencephalograph. In some experiments concentric electrodes were used so that activity somewhat localized to the immediately surrounding region could be recorded. Electrodes were inserted 2 mm from the outer surface of the skull and lowered by 0.05 mm every 3 to 5 minutes while continuous recordings were made. The characteristics of such records (amplitude and frequency) were similar in all mice.

After the recordings were completed, the brains were marked by direct current at each electrode site. The mice