A Climatic Record from Searles Lake, California

Abstract. Data concerning past climatic conditions in arid California have been presented. Palynological and geological evidence points to the existence of past cooler moister climates and to climatic fluctuations. These have been tentatively correlated with late Pleistocene events in glaciated North America. The existence of a rather extensive woodland community at times of more favorable moisture conditions seems to be indicated.

The presence of dry lake basins in arid regions is strong evidence of a former rainfall/evaporation ratio much higher than at present (*1*). The sedimentary column in such basins should record this sequence both by inorganic and organic evidence, notably by changes in the content of fossil pollen derived from adjacent vegetation.

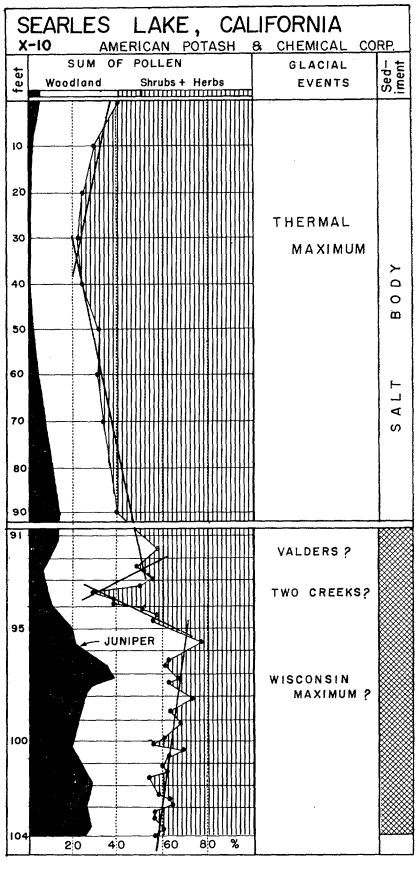

Fig. 1. Pollen diagram from Searles Lake, California. Depth in feet at left. Note change in scale at 90-foot level. All pollen percentages are measured from left (0 percent) of pollen diagram. Sediments generalized at right: 0 to 91.6 feet, salt body with thin layers of mud; 91.6 to 104.4 feet, parting mud. NAP maximum at 93 feet represents dry conditions during Two Creeks interstadial. Juniper maximum at 97 feet probably represents maximum precipitation/evaporation ratio for this basin, and should be correlative with the moisture peak of the Wisconsin maximum.

The most reasonable explanation of more humid conditions in the past is that they were associated with times of continental glaciation when precipitation was greater and temperature lower than is now the case. The analysis of sediment cores from such lakes is therefore of special interest to students of Pleistocene geology, climate, and vegetation.

The sediments in the basin of Searles Lake in the Mojave Desert of California are heavily saline as a result of intense and prolonged evaporation. Cores taken at site X-10 near the middle of the lake show an organic layer (parting mud) from about 104 to about 92 feet, while the upper 92 feet of deposit consists of saline material. This suggests that the organic layer is correlative with the most recent pluvial climate and that the salt above it is correlative with subsequent drier and warmer conditions (*2*).

Carbon-14 dating of the span of time represented by the organic deposit will, when available, confirm or discount this suggestion. Meanwhile the pollen analysis of the present core seems to exclude any other hypothesis (Fig. 1). Woodland species, save for one interesting fluctuation to be mentioned, are more numerous in the organic layer than above it, while the reverse is true of desert plants (shrubs and herbs).

Communities of woodland genera, essentially *Pinus* and *Juniperus,* do not, with one slight exception, now occur nearer the site than a distance of some 30 miles and an altitude of about 5000 feet. The core site is at altitude 1616 feet. The reasonable assumption is that vegetation zones have migrated up or down, away from or toward the basin, in response to appropriate climatic changes.

Details are reserved for later publication. Meanwhile attention is called to the woodland maximum just below 97 feet as indicative of a maximum precipitation/evaporation ratio. Further, a sharp decrease in this ratio is indicated above 94 feet, with a subsequent brief return to moister conditions. The position and character of this episode are exactly what should be expected if the episode were correlative with the Two Creeks interval of glacial retreat in the Great Lakes region, followed by an ice readvance. It further deserves notice that the Compositae, now represented by various shrubby species, reach a high level only in the upper saline deposit. A shift towards more intensified arid conditions above the 55-foot level is evidenced by a decrease in the percentage of *Artemisia* (sagebrush) and the dominance of chenopods (*3, 4*).

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4. The material reported on was obtained by Professor R. F. Flint through the courtesy of the American Potash and Chemical Corporation, to which I am indebted for assistance in field work. Many individuals contributed to the success of the field trips. Thanks are due to all of them, but especially to Dr. W. A. Gale. The analysis was made in the pollen laboratory of the botany department at Yale University. Dr. J. Gordon Ogden III prepared the graph, giving freely of his time. I am grateful to him, to Dr. Johannes Iversen for his counsel, and to Dr. Paul B. Sears for material aid and patient guidance.

6 August 1958

Saturation Curves of Orthorhombic Sulfur in the System $S\text{-}Na_2S\text{-}H_2O$ at 25° and 50°C

As a part of an investigation of the physicochemical processes involved in the origin of mercury ore deposits and associated sulfur deposits (*1*), we have determined at 25° and 50°C the saturation curves of orthorhombic sulfur in the concentration range from 100 percent H_2O to 80 percent H_2O. Previous work by Kuster and Heberlein (*2*) demonstrated that in Na_2S solutions there is a marked increase of solubility of sulfur with increasing concentration of Na_2S. Kuster and Heberlein, however, did not make a complete determination of the equilibrium relations since they did not determine the final equilibrium concentrations of Na_2S. They allowed sulfur to react with Na_2S solutions of known initial concentration until the solutions were saturated and then determined the equilibrium concentration of S in grams per cubic centimeter. Their data therefore do not make possible the determination of the exact position of the saturation curve in a triangular equilibrium diagram.

Baker reagent-grade powdered orthorhombic sulfur (99.95 percent) was used for all the solubility experiments. "Baker Analyzed" reagent-grade $Na_2S \cdot 9H_2O$ was rinsed with distilled water, and clear colorless material was set aside for use. Distilled water used to make up the experimental mixtures was boiled for at least 10 minutes to remove oxygen. The experimental samples were prepared by mixing orthorhombic sulfur, $Na_2S \cdot 9H_2O$, and boiled distilled water in Teflon (tetrafluorethane) bottles under an oxygen-free nitrogen atmosphere.

The Teflon bottles containing fine-grained orthorhombic sulfur and solutions of Na_2S were rotated in constant temperature baths at 25.00° (±0.02°)

and 50.00°C (±0.02°) for periods of 3 days to several weeks. The Na_2S and S contents of solutions allowed to react with orthorhombic sulfur for 3 days agreed with the Na_2S and S contents of solutions allowed to react for 3 weeks and longer, indicating that equilibrium was closely approximated. As a further check that equilibrium between the solid and liquid phases had been obtained, solutions initially supersaturated with sulfur were allowed to react for periods of 3 days to a week. The determined final concentration of sulfur in the solutions originally supersaturated with S agreed within ±0.01 percent with the sulfur concentrations of originally undersaturated solutions that were allowed to react for the same lengths of time. The microscope and x-ray diffractometer were used to identify the solid phase (orthorhombic sulfur) that was in equilibrium with the saturated solutions.

The saturated solutions were analyzed by a modification of a procedure of Dickson and Tunell (*3*) which involves the use of H_2O_2 to oxidize S^{--} ion to SO_4^{--} ion. In preparation for analysis the saturated solutions were filtered through a fritted glass filter to remove suspended solid sulfur and placed in a weight buret which was then allowed to come to room temperature. The filtered sample was divided into two portions, one to be analyzed for Na in the form of Na_2SO_4, and the other to be analyzed for total S in the form of $BaSO_4$. The samples were diluted with concentrated NH_4OH. Five percent H_2O_2 was added to oxidize the dissolved S and S^{--} ion to SO_4^{--} ion. The role of the NH_4OH was to prevent precipitation of sulfur when the H_2O_2 was added. One sample was analyzed for Na by weighing as Na_2SO_4, and the Na_2S concentration was calculated in weight percent. The other sample was analyzed for total S by weighing as $BaSO_4$. From the total S content was subtracted the calculated amount of sulfur contributed by Na_2S to obtain the saturation concentration of sulfur in weight percent. Water percentages were determined by difference. Table 1 presents the experimental data.

Portions of the saturation curves of orthorhombic sulfur in the system S-Na_2S-H_2O at 25° and 50°C are shown in Fig. 1. The compositions of analyzed saturated solutions are represented by points within circles for 25°C, and points within triangles for 50°C.

On the scale of Fig. 1 the data for the 25°C saturation curve appear to fall along a straight line. However, if the data are plotted on a larger scale, a slight convexity toward the unsaturated solution field is evident. The convexity indicates that the ratio of dissolved S to total Na_2S decreases with decreasing concentration of Na_2S. Therefore, diluting a saturated solution at 25°C tends to cause sulfur to precipitate, and evaporating a saturated solution at 25°C in contact with sulfur tends to cause more sulfur to dissolve. However, because the saturation curve is nearly a straight line, the amount of sulfur precipitated or dissolved as a consequence of dilution or evaporation is small.

Table 1. Solubility of sulfur in sodium sulfide solutions (percentage by weight).

Na_2S	S	H_2O (by difference)
At 25.00°C (±0.02°)		
0.86	1.33	97.81
1.38	2.11	96.51
1.97	3.03	95.00
1.98	3.05	94.97
3.19	4.98	91.83
3.51	5.45	91.04
4.17	6.45	89.38
7.42	11.48	81.10
At 50.00°C (±0.02°C)		
0.63	1.15	98.22
0.71	1.30	97.99
1.56	2.70	95.74
2.64	4.39	92.97
4.17	6.55	89.28
6.00	8.94	85.06
6.41	9.47	84.12

The 50°C saturation curve is concave toward the unsaturated solution field, indicating that the ratio of dissolved S to total Na_2S decreases with increasing concentration of Na_2S. The effect of diluting or evaporating a saturated solution at 50°C is opposite to that of diluting or evaporating a saturated solution at 25°C. Dilution of a saturated solution at 50°C in contact with sulfur will allow more sulfur to dissolve; on the other hand, evaporation tends to cause sulfur to precipitate. The stronger curvature of the 50°C isotherm indicates that the effect on the amount of sulfur dissolved or precipitated as a consequence of dilution or evaporation is greater than the effect of dilution or evaporation of saturated solutions at 25°C.

Figure 1 shows that the temperature coefficient of solubility varies with the Na_2S concentration. At concentrations of Na_2S below about 5 percent the solubility of sulfur increases with increasing temperature; above 5 percent Na_2S the solubility of sulfur decreases with increasing temperature. The maximum positive temperature coefficient of solubility is approximately 0.4 percent per degree centigrade at about 2 percent Na_2S.

The following reactions are probably involved in the heterogeneous and homogeneous equilibria:

$$S^{--} + H_2O \rightleftharpoons HS^- + OH^-$$

$$HS^- + H_2O \rightleftharpoons H_2S + OH^-$$

$$nS + S^{--} \rightleftharpoons S^{--(n+1)} \qquad (4)$$

$$4S + 6OH^- \rightarrow S_2O_3^{--} + 2S^{--} + 3H_2O$$

The reversal of the sign of the temperature coefficient of solubility and the

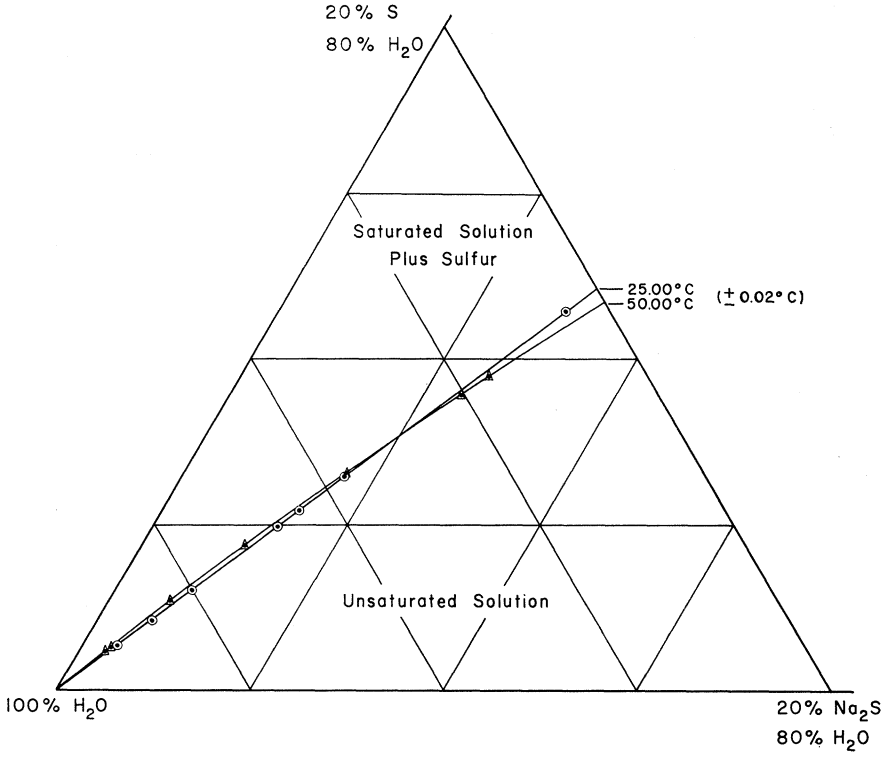

Fig. 1. Saturation curves of orthorhombic sulfur in the system S-Na_2S-H_2O at 25° and 50°C. The compositions of analyzed saturated solutions are represented by points within circles for 25°C, and by points within triangles for 50°C.

different shapes of the curves imply that the effects of various reactions which compete for sulfur shift with changing temperature and Na_2S concentration.

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28 April 1958

Occurrence of Serotonin in a Hallucinogenic Mushroom

Although some doubt has been cast recently upon the identification of *teonanacatl,* the sacred fungus of the Aztecs, as a species of *Panaeolus* (*1*), members of this genus are well known for their hallucinogenic properties and remain as the classical examples of mushrooms producing mycetismus cerebralis (*2*).

A preliminary chromatographic survey of a number of toxic mushrooms collected in western Washington (*3*) revealed the presence of several compounds in *Panaeolus campanulatus* (Fr.) Quélet (*4*) which gave, with Ehrlich's reagent, color reactions characteristic of indole derivatives. Subsequent investigation revealed that the most abundant of these compounds exhibited properties identical with those of serotonin (5-hydroxytryptamine). Although this compound has previously been detected in animals (*5*) and higher plants (*6*), this is the first report of its occurrence in a fungus. Its dimethyl derivative, bufotenin, has been reported to exist in certain species of *Amanita* (*7*).

It should not be assumed that serotonin, per se, is the hallucinogenic principle in *Panaeolus campanulatus* since Waalkes *et al.* (*6*) have established that large (20 mg) oral doses of the compound do not produce physiologic effects in human beings. The presence of serotonin may be indicative of the presence of related indole compounds, possibly of the type recently isolated from *Psilocybe mexicana* Heim (*8*). This compound, which has been named psilocybin, causes psychotropic effects in human beings following oral administration.

One gram of the dried mushroom was extracted with 70 percent ethanol, the extract was concentrated in a vacuum at 45°C, and the residue was purified by partition between n-butanol and water essentially as described by Udenfriend *et al.* (*5*). The purified extract was concentrated, and the entire quantity deposited as a line on a sheet of Whatman No. 3 filter paper which was subjected to ascending formation with a wash liquid composed of n-propanol and 1N ammonia (5:1). The section of the sheet corresponding to serotonin was eluted with water, concentrated, and again purified by partition between n-butanol and water.

The residue thus obtained was identical chromatographically with serotonin (*9*) in four solvent systems: the n-propanol–ammonia system described above, n-butanol–acetic acid–water (4:1:5), n-butanol saturated with 1N hydrochloric acid and methyl ethyl ketone–acetone–water (20:2:5). It gave reactions identical in all respects with serotonin with Ehrlich's reagent, Pauley's reagent, cinnamic aldehyde followed by hydrochloric acid, and with Jepson and Stevens' reagent, the latter being highly specific for certain tryptamines (*10*).

The ultraviolet absorption spectrum of an aqueous solution of the compound at pH 5.4 had a minimum at 250 mμ, a maximum at 275 mμ, and a shoulder with a point of inflection at 300 mμ. This is in good agreement with the absorption characteristics previously reported for serotonin (*11*). From these data it was concluded that the compound obtained from *Panaeolus campanulatus* was serotonin.

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5 May 1958

Passage of Bacteriophage Particles through Intact Skin of Mice

It has long been known that two highly infectious species of bacteria, *Pasteurella tularensis* (*1*) and *Brucella melitensis* (*2*), can set up systemic infections in experimental animals when suspensions of such organisms are placed in contact with the apparently normal skin of animals. Rickettsia producing Rocky Mountain spotted fever can infect guinea pigs through the unabraded skin (*3*). Since bacteriophage particles are within the size range of most animal viruses but do not undergo either specific adsorption or multiplication in sensitive host tissues and have the added advantage of being assayed by relatively easy and accurate techniques, they lend themselves admirably to studies on the physical interactions of viruses in animals. Recent results from this laboratory (*4*) present evidence that bacteriophage particles can pass rapidly through the gastrointestinal barrier and into the blood circulation of mice. In view of the afore-mentioned results, experiments were initiated to ascertain whether particles of the size of bacteriophage could pass through the intact skin of mice.

The phage strain utilized in this study was derived from *Bacillus megatherium* 899a (lysogenic) and is the clear plaque mutant, strain C, as described by Gratia (*5*). The sensitive indicator strain *Bacillus megatherium* KM growing on a medium containing 2 percent Bacto Peptone was used for the production of phage stock suspensions, and assays were made by the pour plate method. Two different anatomical sites of adult white Swiss mice, strain C.F.W., Carworth Farms, were chosen as experimental areas—namely, the tail and the abdomen. These areas were not manipulated by any means such as depilation, shaving, or clipping of hair. In fact, great care was taken to choose only mice which by gross observation manifested normal and continuous dermis in these areas. In order to minimize the obvious effect that microscopic abrasions would have on these experiments, mice utilized in the tail experiments were isolated for 2 days prior to the experiments.

The mice were anesthetized for the duration of each experiment by the intraperitoneal administration of Pentathal sodium. In the first set of experiments the tail of each mouse was exposed to the virus solution (approximately 1×10^{10} phage/ml) by immersing it in a test tube to a level approximately 1 inch from the body proper. The tail was allowed to stay in contact with the virus solution for 15 minutes. In the second set of experiments, which were concerned with passage of bacteriophage through