struck were not large, the length range of the blades is limited. The length to width ratio, however, often exceeds 3:1. The butt is generally flat, sometimes punctiform, but rarely dihedral. Most of the blades do not have parallel sides. Except for a few denticulates (artifacts 6 to 8 and 14 in Fig. 2), tools are absent.

The blade industry of Nazlet Khater 4 dates to the period between the Middle Paleolithic with Levallois technology and the much later diversified Upper Paleolithic industries (*2*). Since Levallois technology is present in some Upper Paleolithic industries of Upper Egypt, such as the Idfuan and the Sebilian, it seems that this technology was continually in use in the Egyptian Nile Valley for a long time. Earlier views on the Nile Valley provided a picture of an isolated enclave where the old techniques of the Middle Paleolithic continued to be pursued with few modifications. Even when these views were amended because of the excavation of sites with blade technology (*8*), the fact remained that until now all the blade-bearing sites were late when compared to the Levant area. The excavation of the site of Nazlet Khater 4 provides evidence that blade industries without use of Levallois technology were present along the Egyptian Nile as early as 31,500 years ago, which is in good agreement with the Levant evidence.

In North Africa very little information is available concerning human presence between 40,000 and 20,000 years ago. If eventually some of the Aterian industry occurrences can be placed in this period (*9*), which is not at all evident (*10*), it is clear that no technological affinities exist between the Aterian and the industry of Nazlet Khater 4. In the Sahara and the Maghreb (*11*) human occupations during this period are conspicuously lacking. Only in Cyrenaica, Libya, is this period documented by the Dabban industry from the caves of Ed Dabba (*12*) and Haua Fteah (*13*). The duration of the Dabban industry may be placed between about 40,000 to 38,000 years ago and about 15,000 years ago. Like the industry of Nazlet Khater 4, the Dabban industry shows no signs of Levallois technology but exhibits a fully developed blade technology. The evidence from Nazlet Khater 4 does not add new facts to the discussion of the origin of the Upper Paleolithic tradition in the large region of the eastern Mediterranean, but it is clear that in North Africa this tradition is present not only in Cyrenaica but also along the Egyptian Nile about 31,500 years ago. Whether the blade industries of Egypt from 20,000 years ago and later can be related to the Nazlet Khater 4 material is not yet clear (*14*).

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The Mount St. Helens Volcanic Eruption of 18 May 1980: Large Short-Term Surface Temperature Effects

Abstract. *The surface temperature effects of the 18 May 1980 eruption of Mount St. Helens Volcano were examined for 1 day immediately after the eruption; 24-hour temperature differences and Model Output Statistics errors as well as the detailed temporal evolution of surface temperature at selected stations were used. During the daytime hours immediately after the eruption, the temperature was suppressed by the volcanic plume by as much as 8°C. That night, low-level volcanic dust produced temperature enhancements of up to 8°C. These effects quickly diminished the next day as the volcanic dust cloud dissipated and moved toward the east. The net local effect of the eruption appears to be warming, in contrast to cooling which might be expected over climatic time scales.*

A violent eruption of Mount St. Helens Volcano began on 18 May 1980 at 1532 GMT (0732 PST), which devastated hundreds of square kilometers and sent large amounts of dust and volcanic ash into the atmosphere. The plume spread quickly to the east, bringing darkness and reduced visibility.

Although there have been many studies of the effects of volcanic eruptions on climate (*1, 2*), as far as we know there has never been a study of the local, short-term effects of a volcanic eruption on surface temperature. In this case, the Mount St. Helens eruption occurred upwind of a relatively dense network of National Weather Service, Federal Aviation Administration, and military hourly surface observation stations. We have taken advantage of this fact to establish a mesoscale network of over 90 stations in the states of Washington, Oregon, Idaho, Wyoming, and Montana to study the surface temperature effects during the first 24 hours after the eruption. We present here preliminary results of a more detailed study (*3*).

It is fortunate for the purposes of this study that, before the eruption and during the subsequent 24 hours, there was little synoptic-scale weather activity over the Pacific Northwest. The mean sea-level pressure field just prior to the eruption was dominated by high pressure over Idaho and Colorado, and this pattern remained nearly unchanged during most of the next day. (As the high slowly drifted eastward, there was some weak

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large-scale warming.) There was thus no obvious effect of the eruption on the atmospheric circulation on this scale, and we are able to interpret any large temperature changes at the surface as volcanic and not synoptic effects.

Because the synoptic-scale flow remained relatively unchanged, we first calculated 24-hour temperature differences as a way of estimating the volcanic effect. Next we calculated the errors of the Model Output Statistics (MOS) forecasts produced by the National Weather Service. These MOS forecasts are made from multiple linear regression models whose predictors come from the Limited-Area Fine Mesh numerical prediction model (*4*). Because MOS provides an excellent objective forecast of surface temperature, we interpret its errors as volcanic effects.

Figures 1 and 2 present our results at 0000 GMT on 19 May (1600 PST on 18 May) and 1200 GMT on 19 May (0400 PST), respectively, which are approximately the times of the maximum and minimum of the diurnal temperature cycle. At these times, the volcanic effects appeared to be most intense.

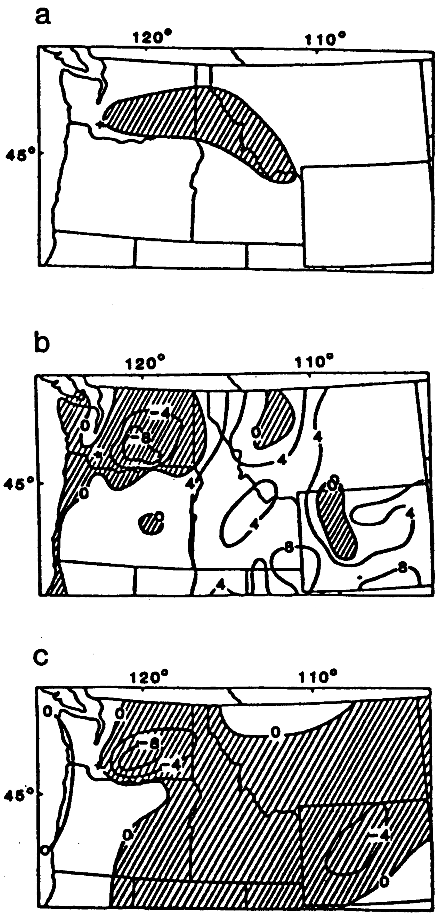
Temperature depressions larger than 8°C can be seen both in the temperature differences (Fig. 1b) and in the MOS errors (Fig. 1c) directly under the eruption cloud in eastern Washington. The next morning the temperature was more than 12°C warmer in the difference map (Fig. 2b) and more than 7°C warmer in the MOS errors (Fig. 2c). The mean absolute MOS errors for April and June 1980 for this region range between 2° and 4°C, and so the errors shown in Figs. 1 and 2 are large enough to be significant. Some of the warming shown on the difference map is caused by synoptic-scale warm advection, and so the MOS errors are probably a more realistic estimate of the volcano effect. The maximum warming effect did not correspond to the position of the higher dust cloud but rather was found in the portion of the low-level dust over areas that were able to heat without interruption the previous day.

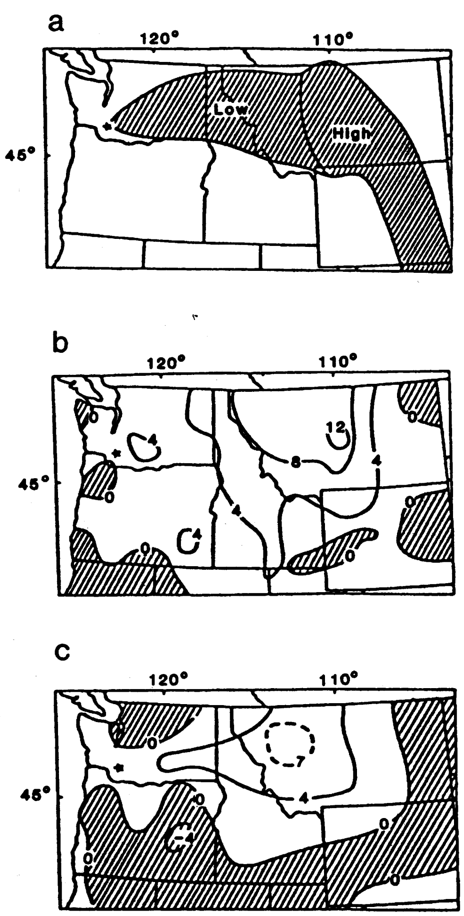
Figure 3 shows the temperature time series for four surface stations in the area: Yakima, in central Washington; Spokane, in eastern Washington; Great Falls, in central Montana; and Boise, in southern Idaho. The time of arrival of the dust cloud is indicated by arrows. Boise did not experience the dust at all and is included as a control.

In Yakima, on the day of the eruption, the normal morning rise of temperature was completely halted by the arrival of the volcanic dust cloud. The temperature dropped slowly and then remained at 15°C for 11 hours. That night the temperature did not fall very much, but these effects were short-lived as the normal diurnal cycle resumed by 20 May. The amplitude of the diurnal temperature cycle (beginning at 0900 PST) for 17 through 20 May was 16°, 3°, 9°, and 15°C, respectively.

Spokane, about 300 km to the northeast, showed a similar effect. The temperature increased normally during the morning of the eruption but began to fall immediately upon the arrival of the volcanic dust and fell gradually until the next morning. The nighttime temperatures were, as at Yakima, enhanced by the dust. The diurnal temperature ranges (beginning at 1500 PST) from 17 through 20 May were 12°, 3°, 10°, and 12°C, respectively.

Farther eastward at Great Falls, Montana, the dust was not observed until about midnight PST. Before this time the temperature had been falling rapidly, but with the first sign of the plume the temperature began a slow rise which continued through the night. On the next day (19 May), the temperature rose to nearly the previous day's level, but that night the temperature drop continued to be





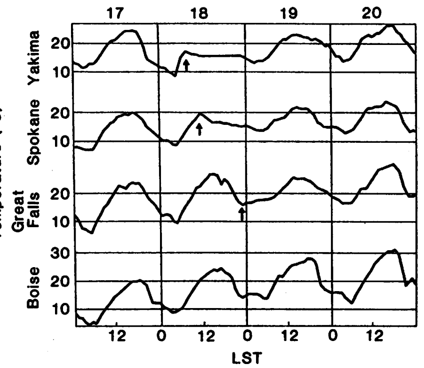


Fig. 1 (left). (a) Dust plume boundary as determined from satellite photographs; (b) 24-hour surface temperature differences (in degrees Celsius) (the actual temperature less the previous day's temperature); (c) MOS errors (the observed temperatures less the MOS forecasts) for 0000 GMT on 19 May 1980 (1600 PST, 18 May). The dust cloud in (a) and the negative areas in (b) and (c) are shaded. Fig. 2 (middle). Same as Fig. 1, but for 1200 GMT (0400 PST) on 19 May 1980. "Low" and "High" in (a) refer to cloud heights. Fig. 3 (right). Surface temperature variation from 17 through 20 May 1980 at Yakima and Spokane, Washington; Great Falls, Montana; and Boise, Idaho. The arrows indicate the times of arrival of the Mount St. Helens plume (*LST*, local standard time).

suppressed. The diurnal temperature ranges (beginning at local midnight) from 17 through 21 May were 18°, 17°, 9°, 13°, and 20°C, respectively.

Boise, which was never exposed to the dust, exhibited a gradual warming trend. The temperature ranges (beginning at local midnight), for 17 through 20 May, were 16°, 15°, 14°, and 19°C, respectively.

The dust cloud from the Mount St. Helens volcanic eruption produced cooling of surface air temperatures during the daytime and warming at night. Warming at the surface at night is produced by enhanced downward longwave emission; when the sun is shining, this effect is overwhelmed by albedo enhancement, causing net cooling at the surface.

Similar processes have been discussed on climatic time scales, but there are crucial differences between the two cases in the particle size distribution and the vertical distribution of the volcanic aerosol. During the first day the troposphere was full of large particles (*5*); in contrast, very small particle sulfate aerosols form as a result of gas-to-particle conversions in the stratosphere months after large eruptions. According to the calculations of Pollack *et al.* (*2*), large particles characteristic of the early period of a volcanic plume would produce warming strong enough to cancel or even overwhelm the cooling due to scattering and reflection of the visible radiation. Later, as the large tropospheric particles precipitate out, leaving the far smaller stratospheric aerosols, the cooling effects would dominate.

The cooling effects of the volcanic cloud lasted for only 1 day, while the nighttime warming persisted for at least 2 days, as low-level particles remained in the atmosphere (Fig. 3). Although large warming and cooling were produced by the eruption cloud, the net effect of this volcanic eruption was warming for the first few days, in contrast to cooling which might be expected on climatic time scales.

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Venus Was Wet: A Measurement of the Ratio of Deuterium to Hydrogen

Abstract. *The deuterium-hydrogen abundance ratio in the Venus atmosphere was measured while the inlets to the Pioneer Venus large probe mass spectrometer were coated with sulfuric acid from Venus' clouds. The ratio is* $(1.6 \pm 0.2) \times 10^{-2}$. *The hundredfold enrichment of deuterium means that at least 0.3 percent of a terrestrial ocean was outgassed on Venus, but is consistent with a much greater production.*

One of the most significant problems related to the origin and evolution of Venus is that of its "missing" water. There certainly is no liquid water on the surface of Venus today and the water vapor content in the atmosphere is probably not more than 200 ppm by volume (*1, 2*). Either Venus was formed of material very poor in water (*3*) or whatever water was originally present has since disappeared, the hydrogen into space and the oxygen into the interior (*4*). It has long been recognized that measurement of the ratio of deuterium to hydrogen in the atmosphere of Venus today would discriminate between these alternatives. There are various ways in which gases escape from a planet's atmosphere, ranging from classical Jeans escape to hydrodynamic outflow at a supersonic velocity. Most mechanisms identified as potentially important for escape of hydrogen from Venus discriminate strongly against loss of deuterium and heavier gases with one conspicuous exception. Hydrodynamic flow would have carried HD away along with H_2. This mode of escape would have prevailed in an atmosphere in which hydrogen was a dominant constituent. The velocity of the flowing H_2 would have become too low to sweep HD along when the mixing ratio of H_2 dropped below about 2 percent by volume (*5*). Subsequent escape of hydrogen should have resulted in an enrichment of deuterium in the hydrogen compounds residing in the atmosphere. The atmosphere of Venus now contains two orders of magnitude less hydrogen (in the form of H_2O) than that corresponding to the critical mixing ratio of 2 percent. Thus a hundredfold enrichment of deuterium is the most that can be expected even if Venus outgassed an appreciable fraction of the equivalent of a terrestrial ocean of water. If the initial ratio of D to H on Venus was about 1.5×10^{-4}, as it is on the earth, the present ratio could be at most about 1.5×10^{-2}. In this report evidence will be presented that the ratio of D to H on Venus is $(1.6 \pm 0.2) \times 10^{-2}$.

Data obtained by the Pioneer Venus large probe neutral mass spectrometer (LNMS) were scrutinized in the hope of using them to deduce the ratio of D to H on Venus. This mass spectrometer and its mode of operation during its descent to the surface of Venus have been described fully (*6*). The instrument was a magnetic sector device that scanned the mass spectrum in 236 discrete steps from 1 to 208 atomic mass units once every 64 seconds. Gas from the atmosphere was admitted to the ionization chamber of the LNMS through two microleaks and pumped internally by chemical getter and ion sputter pumps. The leaks were opened at about 63 km in the upper cloud layer of Venus and data obtained in 51 mass spectra between this altitude and the surface. Just as the probe entered the lower cloud layer at about 50 km the inlet leaks became clogged with a substance that was almost surely sulfuric acid from cloud droplets. Evidence for this event was a dramatic drop in CO_2 and noble gas counting rates and similarly striking increase in counting rates in channels appropriate to H_2O and SO_2. One inlet leak was closed off by a valve at 47 km; the other was cleared between 29 and 26 km.

Attempts to measure the D/H ratio from the mass spectrometer data were

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